

The Methods Used for Eradication of Polio Versus the Defense Efforts That Are Being
Conducted for Global Defense Against Ebola

by

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A CAPSTONE PROJECT

submitted in partial fulfillment of the requirements for the acknowledgement

Honors Distinction

Natural Sciences-Biology
School of Engineering, Mathematics, and Science

TYLER JUNIOR COLLEGE
Tyler, Texas

2017

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Abstract:

Poliovirus eradication has been a long-lasting and difficult process that has become a global issue. The World Health Organization and the European Union have been trying to end the terrible reign of this abhorrent disease since the 1980s and are continually fighting the virus today. Poliomyelitis is an Old World disease, much like smallpox. It has been easily, through a twenty year process, eradicable through mass vaccination and circle vaccination.

However, as poliovirus is coming to the end of its reign, a more recent danger lurks nearby. Ebola virus is considered a non-traditional disease in that it requires more developed methods for eradication and control. It is more developed and resides in nature, beyond human control. This is importantly different because natural viral reservoirs are imperative to the eradication and viral elimination process. If a virus exists in an animal species outside of humans, then it makes viral elimination and eradication significantly more difficult because the virus cannot be completely eliminated. Because of this, new tactics must be used rather than those used in the eradication of polio or smallpox.

The purpose of this study is to use historical comparative analysis of the methods of eradication used to eliminate polio, such as traditional vaccination methods, to the methods being used to try and eliminate Ebola as a more recently arisen global threat. What changes in methodology can be done to eliminate Ebola from nature? What limitations are there on the eradication of Ebola today? These are the questions that are the focus of the literature review as methodology and data collection are reviewed and analyzed throughout this study. It is hoped that alternative methods suggested by this study could be considered as possible resolutions to the Ebola epidemic rising in the world.

Introduction:

As poliovirus is becoming less of a global issue and is reaching the end of its eradication, Ebolavirus has reemerged from the jungles of Africa to become a great contender for the next major virus to hit the world. Poliovirus reaches significant widespread decline with a few questions and a few issues that need to be addressed before it is considered completely eradicated. Development for better vaccines and alternative solutions are being considered in the event that something goes awry in the end of poliovirus eradication. The most distinctive discrepancy between the two viruses is the persistence outside of the human population. Poliovirus is not zoonotic, therefore does not live in other animal species and is derived from human interactions and persistence in people. Ebola, however, is zoonotic and lives in bat species, and recently discovered monkey species, making elimination or protection against the virus very difficult. For Ebola the greatest tool that has been implemented is contact tracing while vaccines and control methods are being developed and researched. Both viruses are still of great concern and are high priority in the war on viruses.

Literature:

Polio is considered one of the old world diseases, much like smallpox, and is reaching the end of its reign in this world as polio eradication is nearing the final stages. The last reported case of serotype 1 wild poliovirus in Africa was in Somalia in August 2014 (1). There are quite a few ways to defend and vaccinate against the terrible debilitating virus. The use of an inactivated strain of poliomyelitis as a vaccine has been the main defense against polio since the largest, although not the first, campaign against the disease began in 1988. Mass vaccination with this vaccine has been greatly successful in eradicating polio so far and has become the primarily

method used in polio eradication. Incidence of wild poliomyelitis has decreased from about 350,000 cases in 1988 to 74 cases in 2015. There are now only four countries that still exhibit transmission of wild-type poliovirus: Nigeria, India, Afghanistan, and Pakistan (2).

Outbreaks in these areas have not seen interruption in the polio outbreak persistence yet and risks associated with the vaccine can hinder eradication more. People can become infected from a vaccine derived strain of the virus. How this works is a vaccine developed from a weakened strain of poliovirus can repair and revert itself back into the previously virulent form of the strain. Thus, repeating the infectability cycle of the supposedly safer viral strain as it was to protect against similar more virulent strains. It is supremely important for healthcare providers in these areas of great polio concentration to report when children are representing symptoms of acute flaccid paralysis (AFP). Surveillance methods are being used to ensure the status of polio concentration in these areas so that proper medical responses can be taken. Surveillance methods include scanning and reporting symptoms of AFP and the use of environmental surveillance by testing sewage for indication of poliovirus. The main goal at the time in the polio eradication efforts is to analyze and ensure a maintained, high-quality surveillance system for polio outbreaks in these areas of still high concentration of the virus so that the global eradication of poliovirus will be attained (1).

Live-attenuated oral polio vaccines are more likely to revert to the neurovirulent form of the virus after immunization and replicate in the vaccinated individual. This reverted neurovirulent form of the oral vaccine can be transmitted from person to person. The main problem of a reverted form of the vaccine is that it can replicate for long periods of time before causing infection or paralysis. This is problematic because there is no current treatment that will effectively stop excretion of the reverted vaccine to other individuals. One such case had an

individual excreting type 2 vaccine-derived poliovirus for twenty eight years. This is the longest period of time for an individual to excrete this form or a similar form of the virus. Thus, the production of alternative vaccines is imperative for the total eradication of poliovirus (3).

The Global Polio Laboratory Network (GPLN) and the World Health Organization's Polio Eradication Initiative (GPEI) are greatly concerned with the detection of all vaccine-derived polioviruses (VDPVs). There is much concern with these particular strains of poliovirus as the eradication of the agent is coming to a close. People with immunodeficiency diseases can get poliomyelitis from live oral poliovirus vaccines (OPV) and can be persistently infected to form VDPVs. If VDPVs are not controlled, then the long fight for the eradication of polio could become much harder and much longer because the VDPVs could develop resistance and persist in people with immunodeficiency diseases (4).

Polio is still endemic to but four countries: Nigeria, India, Pakistan, and Afghanistan. It was concluded by a panel convened by the National Research Council that the development of an antiviral drug against poliovirus infection and its symptoms needed to be done. The use of an antiviral drug would not prevent the infection by poliovirus but could protect against infection by the inactivated polio vaccine used to build poliovirus immunity. This concern is especially related to those who are immuno-deficient. The development of an antiviral drug could not only assist with the final efforts of total eradication of poliovirus but could also be a preventative measure against reemerging vaccine-derived strains of the virus (5).

Inactivated poliovirus vaccines (IPV) have been in use in Nigeria and Pakistan since 2014. In more tropical areas and warmer climates make the use of the traditionally successful live attenuated oral poliovirus vaccine (OPV) less effective. Hence, the need for the inactivated poliovirus vaccine arose. In a study of the use of the IPV in children previously

vaccinated with OPV, which provided intestinal mucosal immunity, intestinal immunity was boosted and IPV gave a greater boost in intestinal immunity than a second dosage of the OPV. Thus, the use of IPV in mass vaccination was introduced in 2014. Comparative analysis was done between the effectiveness of vaccination of IPV+tOPV and tOPV alone. To conduct such analysis, data collection of vaccination data in Nigeria and Pakistan through surveillance study of acute flaccid paralysis in vaccination campaign districts and the presence or absence of poliovirus in waste water/sewage channels as part of an environmental survey were done. In Nigeria, five campaigns using the IPV+tOPV vaccination method resulted in a decrease in poliomyelitis infection detected and reduction of circulating VDPV serotype 2 (cVDPV2) in environmental samples. Campaigns with only tOPV used as the vaccination method did not have significant reduction of poliomyelitis incidence of cVDPV2, but there was significant reduction in environmental samples. Pakistan's results yielded that use of the IPV+tOPV had no significant apparent effect on wild-type poliovirus serotype 1 (WPV1). Use of the tOPV alone gave significant, but not greatly significant, effect on the poliomyelitis case incidence of WPV1. Increasing the time period examined for IPV+tOPV showed significant effect on poliomyelitis infection incidence. All of this information is imperative for the end of poliovirus as threat because the use of combination vaccines that include both the inactivated poliovirus vaccine and the oral poliovirus vaccine alongside the use of a developed antiviral drug could quite potentially eliminate poliovirus altogether (6).

The use of inactivated poliovirus vaccines is generally more successful in eradicating or controlling the disease, however, the development of the vaccines is dangerous and presents a biosecurity risk. New strains of IPV have been produced to have almost no risk to the human population if they were to escape development facilities. There is also great possibility that the

vaccines can revert back to their wild type virulent forms. Because of the use of virulent wild type poliomyelitis to develop vaccines, the risk of outbreak from production facilities is great. Also, because of the extensive use of the Sabin serotype 2 wild type poliovirus, new strains of the poliovirus need to be used for vaccine development. The use of new strains could produce safer and more effective vaccines to be used. The strains studied in this article were modified V structures of the type 3 vaccine that are successfully weaker (named S15, S17, S18 and S19). S18 and S19 strains caused no paralysis on mice used for the experimentation and testing of the different strains. S15 demonstrated similar characteristics to the Sabin type 3 vaccine strain and S17 had about $4\log_{10}$ more than S15 of 50% paralytic dosage. Which means that about 4 more mice per total were paralyzed than those that received S15 or Sabin 3 strains of the poliovirus. Thus, the S18 and S19 derived strains were the most successful new strains being explored. It is important to recognize the need for these new potential vaccines as previous discussion indicates the implications for continued use of the current vaccines and their probability for incidence of infection from vaccine-derived strains of poliovirus. With the use of the modified type 3 vaccines, successful and safer preventative measures against the last of poliovirus can effectively be used (7).

Of course as one virus is exiting the stage, another has to join the stage. Following poliovirus is the devastating Ebolavirus. The show "Spillover — Zika, Ebola & Beyond" was published by PBS and discusses the emergence and spread of Zikavirus and Ebolavirus. Specifically of interest is Ebolavirus and its beginnings as well as its continued spread as a new viral force that is certainly one to be reckoned with. The major outbreak of 2014 came about in West Africa, far from the typical areas of Ebola infection in Central Africa, and spread more quickly because the outbreak occurred in a heavily populated area that was not expecting for the

viral outbreak to occur. Since its discovery in 1978 in Zaire, Ebolavirus typically created outbreaks in isolated areas that would not allow for expansive spread of the virus. However, the virus made its way into fruit bat species during these small, isolated outbreaks and led to the greatest outbreak of its history in 2014. In 2014, a small boy from the village Meliandou in Guinea was near the jungle and had interacted with a fruit bat in some way. The fruit bat was carrying the Zaire strain of Ebolavirus and the little boy got the virus. When at home, he got his family ill and one of his family members took a bus to a hospital, spreading the virus more. While at the hospital, the virus spread further, thus resulting in the major outbreak in West Africa that had the whole world shocked, scared, and feeling unprepared for the future. The main method of Ebolavirus control that is currently being implemented is contact tracing. Through contact tracing, it is determined exactly who those that have been infected with Ebola have been in contact with and getting those affected individuals treated before spreading the virus further (8).

The outbreak in 2014 of Zaire of Ebolavirus was just a wakeup call for the whole world to start paying attention to viruses and disease outbreaks more, especially in the developing world. Although the outbreaks have died down since the major outbreak in 2014, Ebola is nowhere near being eradicated or controlled. The slow down right now is because of the information and preparation tactics that countries have taken for disease outbreak because of the campaign for eradicating polio increased awareness of these things. The Ebola outbreaks are only a glimpse of what is to come in the future of the world and the diseases that may breakout and cause the next epidemic. All over the world, especially in the developing world, there needs to be epidemic preparation tactics, information spreading for such events, and allocation of funds towards vaccination production implemented for readiness of the next breakout of Ebola or

another disease that causes similar or worse effects (9).

The major outbreak of Ebola in 2014 was at least thirty times larger than the largest outbreak previously recorded in history. As the new largest outbreak of Ebola in history, the 2014 outbreak occurred in Zaire was a spillover from bat species of the Zaire Ebolavirus. Zaire Ebolavirus is the most deadly strain of the virus, hence why the outbreak was so widespread and dangerous. The 2014 outbreak of Zaire Ebolavirus was not very large in comparison of a pandemic scale and disease epidemics that have happened in the past. Despite this, with 30-90% mortality rate, Zaire Ebolavirus is considered one of the most feared pathogens to date. Despite the use of models to determine and develop eradication methods for Ebolavirus, the outbreak is still very complex and difficult to predict, especially as the problem is currently persisting and WHO personnel and U.S. Army units are going out and isolating infected individuals to treat them. The frequency and growth rates of the virus vary greatly across the different regions of West Africa. As the epidemic continues the use of models and the continued treatment of infected individuals, isolation of the infected individuals, continued development on vaccines, and data collection are the most that can be done at the time for eradication efforts of Ebolavirus (10).

Following is a proposal for the eradication of Ebola. The first step of the proposal is the development of a model combining nonlinear incidence and maximum treatment capacity. The second is the separation and filtering of birth and natural death rates and assigning them to specific variables. The third step is to build the epidemic model. The fourth step is to use the equations developed to determine the R_0 value. This value gives the reproduction number for the epidemic. If the value is less than 1, then the epidemic gets controlled and remains at equilibrium, without disease. If the value is greater than 1, then the epidemic continues to spread

with equilibrium upset and disease is caused. The last step in developing the epidemic model is to analyze the stability of the epidemic as represented by the model. Using the information demonstrated using the model, one can understand that learning how to decrease the reproduction rate of Ebola, increasing the number of people contained that are carriers of the disease, and increasing the production and distribution of drugs that help inhibit the disease will speed up the process of Ebola eradication. Another model was developed to determine how to distribute Ebola inhibiting drugs quicker and more reasonably. This model utilizes dynamic programming to determine the best routine for drug distribution. Assuming that there is a constant and sustained drug and vaccine production and no increase in infection, the epidemic would be completely controlled in 42 days. Of course this is based on a model that assumes there are not any extenuating circumstances or increases in infectability or infectious cases. These models, however, help establish the goal of Ebola eradication initiatives and what steps need to be taken or moved towards to attain Ebola eradication (11).

Even though there is not exactly a vaccine that is being implemented widespread for protection against Ebolavirus, a lot of research is going into producing one and several candidate vaccines are in testing and research to be used. Heinz Feldmann of the National Institute of Allergy and Infectious Diseases in Hamilton, Montana is one of the individuals working on the development of vaccines against Ebolavirus. He and his team tested the VSV-EBOV vaccine, which was used effectively in a trial on 4,000 people in Guinea, on 15 rhesus macaques (*Macaca mulatta*) and concluded that all but one died after vaccination and infection of the Zaire Ebolavirus of the 2014 major outbreak. The vaccine specifically allowed the innate immune systems of the monkeys to be able to control the rate of replication of the virus during the first few days of infection while allowing the rest of the immune systems of the monkeys to form the

Ebola-specific antibodies for protection (12). VSV-EBOV is just one of the vaccines being tested for effectiveness in the defense against Ebolavirus.

Implications:

Although poliovirus is no longer a threat across the world, it is still a threat in Nigeria, Pakistan, Afghanistan, and India. The campaign for its eradication has been very successful and effective. However, fear of reoccurrence is on the rise and development of protection methods is of great concern. Assuming that the developed secondary defense tactics set in place and those that are being developed are successful when implemented, concern for reoccurrence should go down. However, if the secondary defense tactics do not work, there is great possibility that poliovirus could rise again as a great viral force globally. Because of the implications of future reoccurrence, there is still a lot of work being put into ensuring that poliovirus stays gone and never comes back again as an issue in this world. For Ebola, its story is only beginning in this world. Many efforts are being put into place to develop proper elimination and protection programs against Ebolavirus. The better protected people are, then the less likely occurrence from natural viral reservoir will happen. Vaccines cannot be completely developed because animal species harbour ever-changing strains of the virus. This inhibiting factor of Ebolavirus makes it especially difficult to protect against, but all efforts to do so must be greatly considered and implemented. The use of contact tracing and isolation is greatly effective for now, but in the instance of another wave of an outbreak occurring would cripple the current efforts. That's why continued and eventual development of a vaccine is imperative to global control over the spread of Ebolavirus.

Conclusion:

Polio and Ebola are both very frightening diseases caused by very disturbing viruses. In order for complete comfort and protection to be instilled globally, eradication and preventative efforts must meet poliovirus and Ebolavirus head on and with great force. These viruses are not going to disappear overnight, nor do they have any regard for the regular workings and operations of the basic human infrastructure established globally. They both easily have the ability to rip apart communities and tear down the always important human connection. It is imperative that the world comes together against these two agents because they are not going away on their own. Continued efforts and developments should be encouraged as the battle continues and cooperation from global citizens against these viruses will ensure that poliovirus and Ebolavirus are eliminated as threats.

Resources:

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