Examiner's commentary

The ability to organize a very wide-ranging research base is a necessary skill in world studies essays, which demand an interdisciplinary response. This essay is a powerful example of how to use concise analytical writing to do that. The student controls the research by having selected pivotal aspects of it and structured these into an argument that continually opens into discussion and analysis. The sources are also critiqued as evidence is weighed so that judgment can follow in an informed and comprehensive manner. The student continually challenges their own findings and looks to triangulate research whenever they can. The sifting of knowledge and understanding through different subject filters captures the essence of the interdisciplinary essay and this is a remarkably adept example of how this can be done. Long and detailed conclusions are often a feature of sophisticated research in this context. In that respect the conclusion is a model of its kind.

An investigation on the extent to which biotechnology development affects the combat of Ebola Virus Disease

To what extent has the development of biotechnology, in the late 20th and early 21st centuries, affected the combat of Ebola Virus Disease in Sub-Saharan Africa, compared to other factors?

World Studies Extended Essay

Health and Development

History and Biology

Word Count: 3998

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Introduction

On the 24th of July, 2018, the "most recent outbreak of Ebola Virus Disease (EVD) in Équateur Province, Democratic People's Republic of Congo (DRC) has been declared officially over" (Boseley). Lasting two months since May, the outbreak caused "53 cases and 29 deaths" (Boseley), yet a massive containment effort successfully limited the outbreak from causing further casualties. However, the WHO has also acknowledged the effectiveness of a new Ebola vaccine in combating EVD, stating that "Ring vaccination is a new and vital tool in the control of Ebola...this is a major milestone in public health" (WHO). These sources suggest that advances in medicine and the effectiveness of response efforts both helped to suppress the 2018 EVD outbreak with relatively few casualties. However, this was not always the case for previous EVD outbreaks, with some causing thousands of deaths and massive economic losses to the Sub-Saharan region.

EVD first began as an outbreak in Zaire, now the DRC, in 1976. The main reasons for EVD's lethality is its tendency to reappear intermittently in previously infected areas, especially Sub-Saharan Africa; its highly variable mortality rate, ranging from 25% to an astonishingly high 90%; and its highly contagious nature. Some studies have suggested that the "perceived threat of bioterrorism associated with these viruses … have triggered tremendous interest in these viruses" (Hoenen et al.). Therefore, it is of utmost importance to identify the key methods of limiting the spread of such diseases to prevent further damage to society.

As such, this Extended Essay explores the question: **To what extent has the development of biotechnology, in the late 20th and early 21st centuries, affected the combat of Ebola Virus Disease in Sub-Saharan Africa, compared with other factors?** This Extended Essay will focus on three major local outbreaks of EVD, namely Zaire, 1995; West Africa, 2013-2016, and the DRC, 2018. The essay will evaluate the extent to which biotechnology impacted the epidemics by contrasting this

with the quality of health infrastructure and response efforts, and finally the relationship with local populations. By approaching the investigation from the perspectives of History and Biology, the essay provides a multifaceted perspective on how viral outbreaks may be best contained, and how future outbreaks may even be prevented. In this investigation, I explore the pathophysiology of EVD, in addition to the mechanism of the *rVSV-ZEBOV* vaccine. I will also analyse secondary data pertaining to the efficacy of the *rVSV-ZEBOV* virus and explore its implications and limitations. Furthermore, from a historical perspective, I aim to contrast the relative importance of biotechnology with other factors, such as the quality of healthcare infrastructure, response times and local relationships in each outbreak. This will be compared to the results of previous outbreaks to determine the overall relative importance of biotechnology in supressing EVD outbreaks. I will use a variety of sources, including books, academic journals and memoirs to draw meaningful conclusions, and these sources will be evaluated and analysed. In the conclusion, I aim to conclude whether or not developments in biotechnology can be argued to be the major factor in the repression of EVD outbreaks, or if other factors were more important, and finally to suggest actions for future outbreaks of EVD or similar diseases.

Ebola Virus Pathophysiology and analysis of rVSV-ZEBOV

Pathophysiology

EVD is a viral hemorrhagic fever, and can be found in humans and other primates. The disease if left untreated is oftentimes fatal, with a case fatality rate ranging from 25% to 90% depending on the level of treatment. The disease often begins with a sudden fever. Internal bleeding develops in 5-7 days, often resulting in death caused by multi-organ failure from “rapid viral infection of multiple cell types and unusually high rate of viral replication in infected cells” (Sridhar). Ebola was first transmitted to humans from fruit bats, which are natural hosts of the Ebola virus, through contact with bodily fluids (WHO Fact Sheet). Humans may be infected if they come into direct contact with bodily fluids of the

infected, or with contaminated surfaces and materials. This means that healthcare workers are at extreme risk of being infected, as they are in frequent contact with infected patients.

After entering the body, the virus first attacks dendritic cells, which act as the 'brains' of the immune system (Roghanian). These infected cells carry the virus to various lymph nodes in the body, where they mature and replicate, spreading throughout the body. This prompts the body to initiate apoptosis (programmed cell death) in white blood cells, weakening the immune response. Endothelial cells, which constitute membrane linings, also undergo apoptosis which causes internal bleeding in many parts of the body, eventually leading to organ damage and failure (Baize et al.), while the attack on the innate immune system indirectly suppresses the adaptive immune response as T-cells are no longer activated, suppressing B-cell and plasma cell activation. Essentially, widespread immunosuppression due to EVD causes a dysfunctional innate immune response, leading to little to no adaptive immune response, causing multiple organ failure.

rVSV-ZEBOV Analysis

As of 2018, The rVSV-ZEBOV ('Recombinant vesicular stomatitis virus - Zaire Ebolavirus') vaccine provides high levels of protection against EVD in clinical trials. The vaccine consists of a vesicular stomatitis virus which has been genetically engineered with *Zaire ebolavirus* antigens (Jones et al.), which refers to a particle used by cells to identify foreign pathogens in the body. This allows the vaccine to provoke a more effective immune response, since the viral vector is alive and specifically tailored to *Zaire* ebolavirus, while VSV is harmless to humans. This causes an adaptive immune response as B and T lymphocytes fight off the infection. Some B and T cells differentiate into memory B and T lymphocytes and stay present in the blood for long periods, ensuring an accelerated and stronger immune response in the presence of an actual EVD infection in the future.

To corroborate this, below is data from a study conducted by Henao-Restrepo et al. in Guinea, testing the efficacy and effectiveness of an rVSV-vectored virus in preventing EVD in randomized trials.

Group A	Cluster 1	Cluster 2	Cluster 3	Cluster 4
	All vaccinated in immediate (group A)	All vaccinated in immediate (group A)	All eligible in immediate (group A)	All contacts and contacts of contacts in immediate (group A)
No. of individuals	2108	2108	3212	4513
Cases of EVD	0	0	7	10
Attack rate / %	0.00	0.00	0.22	0.22

Fig 1. Table showing EVD statistics for Group A randomized clusters. Cluster refers to the patient in addition to of all their contacts and contacts of contacts (Henao-Restrepo et al.)

Group B	Cluster 1	Cluster 2	Cluster 3	Cluster 4
	All eligible and consented on day 0 visit in delayed (group B)	All eligible in delayed (group B)	All eligible in delayed (group B)	All contacts and contacts of contacts in delayed (group B)
No. of Individuals	1429	3075	3075	4529
Cases of EVD	10	16	16	22
Attack rate / %	0.70	0.52	0.52	0.49

Fig 2. Table showing EVD statistics for Group B randomized clusters.

Vaccine effects	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Vaccine efficacy / %, 95% CI	100 (63.5 to 100.0)	100 (68.9 to 100.0)	64.6 (−46·5 to 91·4)	64.6 (−44·2 to 91·3)
p-value	0.0471	0.00450	0.34400	0.37610

Fig. 3 Table showing vaccine efficacies. Clusters 1 and 2 are calculated using a β-binomial distribution, clusters 3 and 4 using a Cox Proportional Hazards Model.

In biology, a common method of testing for validity is to use p-values and confidence intervals (CI). This study utilizes a 95% CI, which indicates that “there is a 95% chance that the range calculated contains the mean” (GraphPad). In clusters 3 and 4, we can observe that the range of values is significantly larger than clusters 1 and 2. This suggests that in the former, there is a wider spread of data around the mean. In clusters 1 and 2, the reported vaccine efficacy is 100%, suggesting that there is conclusive evidence to show that there is a causal relationship between immediate vaccine implementation and the chance of developing EVD. This is adduced by a p-value of 0.0471. The p-value is a probability which reflects the measure of evidence against the null hypothesis. If the p-value is below a predefined limit, the results are designated as "statistically significant" (Prel et al.). By general consensus, the p-value was set to 0.05, and thus we can see that the results of Clusters 1 and 2 are statistically significant, but not for Clusters 3 and 4. This poses a problem when comparing Clusters 2 and 3, as they have different Group A variables yet identical Group B variables.

However, we may still conclude that based on observation of the cases, the vaccine, when administered immediately after EVD confirmation, is still largely effective for EVD prophylaxis. This is supported by Cluster 4, where the attack rates of all individuals in contact with the patient, in addition to their contacts, has risen from 0.22% in the immediate group to 0.49% in the delayed group. However, the conclusion is limited, as the researchers were forced to end randomized trials in favour of immediate vaccination for the remaining sample due to health concerns. In addition, the study may potentially be biased, as medical study teams remained with the immediate group to detect additional side-effects, and this continuous interaction “would have affected the knowledge and behaviour (eg, awareness of disease symptoms) of the participants, which in turn would have affected disease transmission” (Metzger et al.). Yet, we can still conclude that the rVSV-ZEBOV is highly protective against EVD in infected populations, although not reaching 100%. Metzger et al. also highlighted the need for the vaccine to be used in conjunction with the support of medical teams and the co-operation of locals. In addition, a historical analysis is needed to contrast the efficacy of the vaccine with other factors that could impact the transmission of EVD, such as the quality of health infrastructure and response timings in order to reach a fully evaluated conclusion.

Zaire Outbreak - 1976

In 1976, the first outbreak of EVD was recorded in Zaire, now the DRC, in a town named Yambuku. Out of a recorded 318 patients, 88% died by the end of the epidemic, almost reaching a 90% mortality rate (Oldstone, 130). The virus had originated from a school headmaster who had sought treatment at a local hospital (Piot), but due to the disease being hitherto undiscovered, containment procedures were not available and the disease rapidly spread to other patients.

Some sources argue that the lack of biological understanding of EVD was a key factor in the emergence of the epidemic. Laurie Garett notes that due to EVD being an unknown disease, many cases were misidentified as malaria, and patients were given quinine (Garett,100). Quinine is an antimalarial drug which is effective against parasites such as *Plasmodium* by interfering with their ability to digest haemoglobin (Foley). Viruses lack their own metabolism; thus they remain unaffected. This perspective is supported by Breman et al., noting that “Several patients… were given vitamins and other medicines by injection; injections were favoured by patients and medical staff”. The source emphasizes the lack of medical knowledge in the hospital staff and patients, in addition to the flouting of medical protocol. Therefore, we may observe that contemporary biotechnology and medicine was lacking at the time, as medical professionals could not accurately determine diseases such as EVD and prescribe effective treatments for those infected.

However, some argue that another factor was the poor quality of health infrastructure in the region. Breman et al. argued that the DRC was not equipped with a functioning health system capable of countering an unknown disease, noting: “Five glass syringes and metal needles… were used repeatedly without sterilization and only occasionally were rinsed.” (Breman et al.). The source highlights the appalling medical protocol in local hospitals, and suggests that this was a key factor in the spread of the epidemic. This perspective is supported by Peter Piot, a member of the team which

discovered EVD in Zaire, noted that "[hospital staff] had used unsterilized syringes that freely passed on infection…thus, almost certainly, they had unwittingly killed large numbers of people." (Piot). Piot suggests that the use of unsterilized syringes, among other failures in medical protocol, was a key factor that lead to the deaths of hundreds. Yet, we can still observe that general infrastructural weakness in local healthcare was a key factor in the exacerbation of the epidemic.

Others argue that relationships with the locals and their indigenous practices also contributed to the spread of EVD. Piot notes that: "many of the dead had been present at the funeral of a sick person or had close contact with someone who had". The source suggests that the burials of patients were mishandled and this exposed the virus to their relatives and funerary workers. This is corroborated by Michael Oldstone, who notes that "those with diseases were stigmatized and did not come to seek medical help in the city…the local government also under-reported cases to prevent economic losses to the region" (Oldstone). Oldstone suggests that in addition to unsafe funerary practices, the stigmatization of patients and the inaction of local governments further worsened the situation. Therefore, we may observe that indigenous practices and local perceptions of the disease was important in the spread of EVD. However, the epidemic was eventually contained through the assistance of a WHO team which isolated villagers and quarantined those infected. Yet, we can still conclude that in the primary stages of infection, the lack of good health infrastructure and unsafe indigenous practices were arguably more important in spreading EVD than the lack of biotechnology and medical treatments.

West African Outbreak, 2013-2016

The West African Ebola epidemic was most severe Ebola epidemic in history, beginning in 2013 and ending in 2016, with approximately 28,616 cases and 11,310 deaths in Sierra Leone, Guinea and Liberia; however, these figures understated the magnitude of the outbreak (Meltzer et al.). Although the years between the outbreaks saw developments in biotechnology and funding for health agencies such as the WHO and *Médecins Sans Frontières* (MSF), many sources point to the inaction of the WHO and its oversights in organization for the large number of casualties, causing a major paradigm shift in public health doctrine. Sources note that "the West African Ebola Outbreak was one of the worst disease outbreaks in history" (Siedner et al.).

Some sources argue that the stagnation of biotechnological development into EVD was a main factor in its spread. Coltart et al. noted that "clinical trials [of vaccines] occurred too late to have any significant impact on this outbreak." This suggests that although there was research into EVD vaccines, none of them proved safe enough for clinical use (WHO Statement on Ebola Therapies). However, a limitation of the source is that it does not go into detail about the science behind the clinical trials of vaccines during that time. This source is substantiated by Folayan et al., who noted that "At present, there is no approved specific therapy or vaccine for EVD…Supportive clinical care… [has] been the most promising care for EVD patients in the affected West African countries." This suggests that even with the development of EVD vaccines, it has not been effective enough as evident by the continuing use of supportive care as a main form of treatment. Therefore, we may argue that the delay in biotechnological development - specifically EVD vaccines - played a role in the outbreak's emergence, as they could have potentially saved more lives than pure supportive therapy. However, we must acknowledge the fact that the vaccines were in clinical trials, thus the problem arises in the implementation of vaccines, not their development; unknown side-effects could also arise due to its unlicensed nature, and some facilities were not technologically advanced enough to

implement the logistical procedures needed, such as cold-chain transport. Nevertheless, the inability to deploy EVD vaccines in the West African outbreak was still a crucial factor in managing the spread of the outbreak into other countries.

Others argue that the inadequate and protracted early response by the WHO coupled with the location of the disease, mainly Guinea, Sierra Leone and Libya, countries classified as low-income countries (World Bank), was the main reason for the outbreak's exacerbation, in comparison to the Yambuku outbreak. Breman et al. notes that "[the Zaire outbreak's waning] was undoubtedly due to the isolation of the affected Yambuku community, effective control measures … and relatively low transmission potential" (Breman et al.), suggesting that the effective isolation of patients decreased EVD's transmission potential in Yambuku. The notion that location was a main factor is supported by Siedner et al., noting that "Guinea, Sierra Leone, and Liberia are all recovering from prolonged periods of civic unrest and suffering from decimated health systems with limited human resource capacity" (Siedner et al.), suggesting that due to the sizes of the countries afflicted, controlling the spread of the epidemic was substantially harder than in Yambuku.

Siedner et al. also noted that "regional health infrastructure was quickly overwhelmed, [teaching] us that a need for external assistance ought to become a primary condition for declaring a PHEIC." Here, PHEIC refers to a 'Public Health Emergency of International Concern'; the source emphasizes the fact that the WHO had prioritized the present number of cases instead of the need for external assistance. This led to the severe underestimation of the epidemic's scale as it quickly overran neighbouring countries with similarly weak health systems. Although a PHEIC may only be declared when "outbreaks transcend a national border" (WHO), Siedner et al argued that the West African epidemic had already killed many in Guinea and severely destabilized the region even before its spread to Sierra Leone and Liberia. They conclude that "delaying an announcement [of PHEIC]

imperils lives… and does more economic damage and undermines political legitimacy in the long run" (Siedner et al.).

Another closely-linked factor was the people's distrust of health authorities and international agencies. Siedner et al. notes that "hospital and school closures, …quarantines, and border closures…engendered widespread public distrust of health authorities", suggesting that a failure to reassure local populations heavily impacted containment efforts. This is supported by The Lancet's report of families forcibly removing their relatives from health facilities as health workers were preoccupied with other patients (The Lancet). The source contrasts the West African outbreak with the previous Zaire Outbreak, noting that the Zaire response prioritized early co-operation with local authorities, along with effective leadership, logistics and communication [with] local villagers to "ensure that control measures are culturally appropriate". Therefore, there is substantial evidence to suggest that a protracted early response coupled with fraught relations with the locals were the main reasons for the spread of EVD. However, we must consider the fact that EVD vaccines were not employed in this outbreak, which could have potentially saved many lives. Yet, we must also acknowledge that a protracted early response would have significantly hampered the administration of treatments to the local population, and that EVD vaccines in 2016 had not yet shown remarkable efficacy even in clinical trials.

DRC Outbreak, 2018 - present

The 2018 Ebola outbreaks consists of the May - July Équateur outbreak and the August Kivu Outbreak, which is currently ongoing at the time of writing. The outbreak marks the first time an EVD vaccine has been used in an effort to combat EVD. The outbreaks are the largest since the West African Outbreak of 2016, however compared to the West African outbreak, the Équateur outbreak was contained in a relatively short time, causing only 33 deaths.

Sources argue that the main factor leading to the quick suppression of the epidemic was the early utilization of the rVSV-EBOV vaccine. A WHO situation report notes that “since the launch of the vaccination exercise on 21 May 2018, a total of 3,330 people have been vaccinated” (WHO External Situation Report 07), a mere 10 days after the outbreak’s announcement. The source is valuable as it is an official WHO account detailing the successes of the ring vaccination programme, which was effective due to its early implementation. The source suggests that the international community has learnt from its failures during the West African outbreak, and this is corroborated by a Reuters article, noting that [redacted] (Ross). Therefore, we can see that the vaccine was highly successful in containing the disease within limited areas and was a main factor in the quick suppression of the outbreak.

Despite the vaccine’s relative success, others argue that the main factor was the swift response by the WHO. Nature notes that “the speed with which the WHO responded to the outbreak…releasing US$2 million...within hours and deploying additional personnel, will have been a major factor in limiting the spread of infection” (Nature). The source suggests that the WHO has learnt from its failures in previous years and now strives to predict and prevent possible health emergencies. This is supported by a WHO statement: “WHO continues to support neighbouring countries to…take action on Ebola preparedness, and to develop national contingency response plans” (WHO). However, a statement from the WHO itself can imply bias as they are less likely to report any major shortcomings in the procedure. Nevertheless, the time frame of this outbreak was much shorter than the West African outbreak, and the number of casualties also dropped significantly, and this can be attributed to the quick response by international agencies along with landmark utilization of EVD vaccines.

Conclusion

The three major EVD outbreaks have each had multifactorial causes, and each can be argued to have had a significant impact. Through the perspective of biology, we have analysed data pertaining to the efficacy of the Ebola Virus, and have concluded with the use of confidence intervals and p-values, that the rVSV-ZEBOV vaccine does have a significant effect on the prevention of EVD, with a reported 100% efficacy, although this is disputed due to numerous aforementioned limitations of the study. However, through the perspective of history, the essay has contrasted the biological analysis with a historical investigation of multiple factors affecting the combat of EVD outbreaks, including the development of the rVSV-EBOV vaccine, the quality of local health infrastructure, response timings, and the relationships with local populations. A combination of both primary and secondary sources allows for a broader understanding into public health policy. For example, primary sources were used in describing the challenges faced by WHO personnel in establishing local relationships and administering treatments, while secondary sources were used in the analysis of WHO response procedures and in the consideration of other perspectives. Thus, both types of sources are useful, as they ensure that the essay reaches a valid and purposeful evaluation. However, we must acknowledge that each type of source has potential bias, and that the historian cannot force a balance when considering each perspective.

We can therefore conclude that the development of biotechnology has not successfully impacted the majority of EVD outbreaks in the late 20th to early 21st centuries. The spread of an Ebola outbreak is often influenced by a variety of factors; the rVSV-EBOV vaccine is expensive to produce and requires extensive storage and transport procedures; a small spread may not justify the costs of using the vaccine. We must also acknowledge the stagnation of biotechnology in the West African Ebola outbreak of 2013-2016, showing limited advancement from the previous Zaire outbreak. One may also observe that with regards to EVD, vaccines and potential treatments have only been

deployed in 2018 and have not been licensed, pointing to potential flaws in their design and long-term use.

However, there is substantial evidence to suggest that early response time is the most significant factor in combating EVD outbreaks, as in each of the three outbreaks analysed, early response timings in Yambuku and Équateur managed to decrease the number of casualties along with the support of decent health infrastructure and correct medical protocol, while in the West African outbreak, evidence indicates that a late declaration of a public health emergency from the WHO lead to an inadequate early response, indirectly resulting in many casualties.

Despite this, this conclusion has limitations. The essay does not consider the effect of geopolitics and environmental conditions during outbreaks, which have a large impact on vector transmission. The essay also has not considered other smaller EVD outbreaks, thus the sample size from which this essay draws conclusions is quite small. In addition, the essay does not provide detail on the causes of local tensions, such as traditional African religion and indigenous practices.

Nevertheless, based on the limited scope of this investigation, it is prudent to suggest that factors such as response time, relationships with locals and good healthcare infrastructure play a far more important role than biotechnology in quelling EVD outbreaks in less economically developed areas, such as Sub-Saharan Africa. Yet, we must not deny the role of biotechnology in providing effective and accurate cures for EVD. In case of future outbreaks, efforts should be more focused on educating the local population about EVD, ensuring effective medical infrastructure and declaring public health emergencies earlier, along with the simultaneous early use of biotechnology to suppress outbreaks. Further study is also needed to evaluate factors in epidemics in more economically developed areas, and with different disease vectors.

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Candidate personal code:

Extended essay - Reflections on planning and progress form

Candidate: *This form is to be completed by the candidate during the course and completion of their EE. This document records reflections on your planning and progress, and the nature of your discussions with your supervisor. You must undertake three formal reflection sessions with your supervisor: The first formal reflection session should focus on your initial ideas and how you plan to undertake your research; the interim reflection session is once a significant amount of your research has been completed, and the final session will be in the form of a viva voce once you have completed and handed in your EE. This document acts as a record in supporting the authenticity of your work. The three reflections combined must amount to no more than 500 words.*

The completion of this form is a mandatory requirement of the EE for first assessment May 2018. It must be submitted together with the completed EE for assessment under Criterion E.

Supervisor: *You must have three reflection sessions with each candidate, one early on in the process, an interim meeting and then the final viva voce. Other check-in sessions are permitted but do not need to be recorded on this sheet. After each reflection session candidates must record their reflections and as the supervisor you must sign and date this form.*

First reflection session

Candidate comments:

My World Studies EE is related to the theme of health and development, and the two subjects I have decided to focus on are History and Biology. The title of the EE is 'To what extent has the development of biotechnology affected the combat of disease in sub-Saharan Africa?'
I was intrigued by the idea of the World Studies EE, as it could allow me to explore global perspectives and at the same time submit a piece of academia which I had personal interest. I aspire to work in the fields of health and medicine, and thus I chose biotechnology as a potential topic for study as it represents a growing field of biology aided by continual developments in technology. I had some difficulties in choosing this topic, as it was hard to reconcile the two subjects. Ultimately, I decided on a history-essay based approach with biological elements as complement.

Date: 23/04/2018

Supervisor initials:

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Interim reflection

Candidate comments:

As of now, I have finished my first draft of the Extended Essay. Throughout the writing process, there were several challenges: I realized that my research question was too narrow in scope, as I had focused on contrasting the development of biotechnology along with other factors, such as education and infrastructure, therefore the research question should be changed to reflect this. In addition, some of the historical sections were a bit too repetitive, thus analysis and critical thinking in the historical should become more concise, in addition to adding the definition of 'biotechnology' for conciseness. Currently, I argue in my essay that biotechnology was not the defining factor in repressing Ebola Virus Disease outbreaks, and that other factors, such as the location of outbreaks, local education and relations with the population, and medical and highway infrastructure that were more crucial in combating Ebola Virus disease outbreaks.

Date: 26/09/2018

Supervisor initials:

Final reflection - Viva voce

Candidate comments:

Over the course of the EE, I have gained an understanding of public health policy and biotechnological developments through investigating the effects of biotechnology, international response and local relationships on the treatment of Ebola Virus Disease in Sub-Saharan Africa. This EE allowed me to truly realize the importance of interdisciplinary study and research in its application to real-life issues around the globe.

Looking back at the writing process, there were many challenges, including the need to integrate in the essay methodologies used in biology with methodologies used in historical investigation, whilst maintaining a balance between the two; the difficulty in locating a variety of secondary sources on currently ongoing outbreaks, and a need for constant refinement of language to ensure its conciseness and accuracy. However, these challenges were overcome by support from my supervisor and good time-management and organizational skills with regards to interim deadlines and extensive research. The EE unexpectedly revealed that improvements in biotechnology as a whole was not a major factor in the suppression of the studied EVD outbreaks; instead, local relationships and a fast international response were more important. Overall, I believe that I was able answer the research question sufficiently while displaying critical thinking.

Date: 04/12/2018

Supervisor initials: