Vaccines, Still a Contestable Subject in Medical Development

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Abstract

The advent of outbreaks runs in tandem with public health concern to study and to find therapies to cure or vaccines to prevent diseases. The reality of disease has since time immemorial triggered different medical interventions and protocols to manage them through scientific knowledge based on trial and error aimed at improving health and protecting people. In confronting public health crises, especially those predisposed by pandemics, epidemics and endemics, medical experts stress the fact that in the absence of therapies or cures, vaccines are the best and most effective medical interventions to eliminate wild-type pathogens globally. Epidemiologists also assert that to protect against diseases with far-reaching and expansive impacts vaccination is the best intervention, done over a lifespan and done routinely. But in times of outbreaks, such as the now infamous COVID-19, concern for vaccine development usually receives heightened attention often resulting in proponents and opponents being pitted against each other, therefore making the subject more contestable as it was aeons ago. This paper explores points of contestation to biomedical development through historical as well as current perspectives. The paper also gives a historical account of pandemics and their effect in terms of human cost and makes a point that in spite of controversies surrounding vaccines, they are still the best and most effective interventions to prevent disease and protect populations against outbreaks. The paper bases on secondary sources to present the case.

Keywords: vaccines, vaccination, infectious diseases, pathogens, pandemic, epidemic, endemic.

Introduction

As the fight against the novel coronavirus intensifies, especially amidst the lack of a cure, a cohort of scientists and non-scientists is working tirelessly to find a vaccine before the now infamous COVID-19 pandemic reaches its mortality peak.

Vaccine development characterises are a crucial part of public health, as outbreaks are known for catastrophic consequences, among them, death, post-pandemic trauma, psychosocial trauma, and shattered economies and to say the least, collapsing civilisations (Tulchinsky & Varavikova, 2014). Smallpox, for example, a disease whose origin is lost in prehistory was one of the deadlies outbreaks in history due to its debilitating effect across all continents. Besides causing death, the disease is considered to have been a major factor in the decline or collapse of civilisations. It is documented that smallpox was one of the factors that caused the decline of the Roman Empire (AD 108), Aztec and Incas civilisations among others (Riedel, 2005, January; History.com, 2015).

Before the arrival of the British colonisers, aboriginal Australians were one of the oldest civilisations occupying the mainland and the 274 islands between Australia and Papua New Guinea in the Torres Strait. Exposure to diseases such as influenza, venereal diseases, typhoid, tuberculosis, measles and whooping cough, brought by the new settlers, besides their murder, helped to decimate the indigenous people's civilisation (Hollingsworth, 2020).

Throughout the history of outbreaks, different diseases have manifested themselves differently but with one constant—posing danger to public health. Dr. Anthony Fauci, in his many stripes as a physician, immunologist and director of the National Institute of Allergy and Infectious Diseases in the US, cautions that one thing predictable about outbreaks is their unpredictability (WE HEARD THE BELLS: The Influenza of 1918 (DOCUMENTARY), April 12, 2015). Irrespective of what they were, health calamities classified as pandemics, epidemics or endemics, offer public health perspectives particularly in regard to causative factors, curative as well as preventive procedures (Tulchinsky & Varavikova, 2014).

This paper gives an account of some of the deadliest health pandemics, epidemics and endemics the world has experienced and the effort experts undertake to cure but most importantly prevent them. The paper explores reasons and factors for vaccine contestation and refusal. The paper bases on secondary sources.

Disease Outbreaks and Human Cost

A history of public health shows that a host of infectious diseases has ravaged the world in the past, with each outbreak presenting itself in a novel way. Although a paucity of knowledge exists in regard to the human cost, between the 17th and 19th centuries, the American, London, Marseille and Russian plagues, yellow fever and the influenza pandemics had their own onslaughts (Jarus, 2020).

In the 20th century, the Spanish flu of 1918/19 is estimated to have claimed between 20-40 million lives globally (Iwami *et al.*, 2009) and in the history of outbreaks is also considered one of the deadliest by its bounds and expanse (Barro, et al., 2020). Before it, polio, manifesting itself in 1916 in the US killed over 2,343, and to this day, with repeated rendition in some low-income countries continues to devastate (Keohane *et al.*, 2020).

In 1957/58, Avian or bird Flu killed between 1-3 million people (Bloom, et al., 2005), initially starting in China, and then spreading to Singapore, Hong Kong and the US (Jarus, 2020).

HIV/AIDS, believed to have started in the 1920s in what is now the Democratic Republic of Congo (DRC), embarked on its global wrath in the 1970s (McCoy *et al*., 2017). Since the 1980s, the world has been suffering in its throes with an estimated 35 million lives claimed so far (Jarus, 2020).

Other diseases of enormous magnitudes straddling centuries, particularly the 20th and 21st, continue to trigger problems. Measles, smallpox, whooping cough or pertussis, and mumps, tetanus and diphtheria, cause death worldwide every year, mainly to children and people in low income countries due to lack of effective vaccines or vaccination programmes (Jarus, 2020).

Even before the 21st century completes its first quarter, outbreaks have become persistent, manifesting themselves in several ways. In 2009/10, Swine Flu (H1N1), originating in Mexico, spread to other parts of the world infecting about 200 million people (Vogel, et al., 2018) and killing about 600,000 (Jarus, 2020). In 2014/15, Ebola lent a torrent in West Africa, especially in Guinea, Liberia, Sierra Leone, Nigeria and DRC, with intermittent episodes estimated to have killed 12,000 people so far (Calain, 2018).

The Zika virus is declared a public health emergency (Plourde & Bloch, 2016), with some reports indicating that the disease was endemic to the Americas. However, the virus was first isolated from a monkey in Entebbe, Uganda in Zika Forest in 1947 (Plourde & Bloch, 2016). Since 2007, Zika virus outbreaks have been intermittent elsewhere, especially in the Federated States of Micronesia, French Polynesia and Cook Islands; Easter Island and New Caledonia (Roth *et al.*, 2014).

Most recently in 2015, in the Americas, especially Brazil, infections were estimated to be 1,300,000 persons so far (Plourde & Bloch, 2016). Europe and the US suffered sporadic Zika Virus infections due to importations. The disease posed onerous threats, Guillain-Barre syndrome in adults and microcephaly in babies born to infected mothers (Plourde & Bloch, 2016). Microcephaly is a medical condition where infants suffer deformities in their heads even before they're born. Doctors say this condition indicates incomplete brain development in infants.

Coronaviruses have in the recent past produced similar but different virulent patterns capable of desolating public health tranquillity (Chen, et al., 2020). In 2002/3, the Severe Acute Respiratory Syndrome or SARS, believed to have originated in China killed about 812 people (Jarus, 2020). The Middle East Respiratory Syndrome or MERS, believed to have emanated from Saudi Arabia in 2012, claimed 866 (Jarus, 2020). Today, COVID-19, also a coronavirus is shaking the global edifice, as its variability becomes unprecedented, and causing immense concern how the disease should be stopped.

For every infectious disease that has happened, public health concern is always at the forefront of understanding its genomic or behavioural characteristics in order to control, cure or prevent it. With stewardship from the World Health Organisation (WHO), short- and long-term guidelines form part of the public health response to control disease. Vaccines, undoubtedly the most beneficial in terms of saving individual and community health, valuable time, money and resources, are part of the long-term public health response to outbreaks, but the subject of much discord (Lawrence, 2020).

Historical and Current Perspective of Vaccine Development

In confronting public health crises, especially those predisposed by pandemics such as COVID-19, medical experts agree that in absence of a cure, vaccines can be the best and most effective medical interventions to eliminate wild-type diseases globally (Liu, 2003). Vaccines are a key biomedical development because as begs emphasis, fit neatly in the old adage that purports that prevention from disease is better than cure. Since time immemorial, realities of disease and death have triggered different concepts and methods to manage them through scientific knowledge based on trial and error aimed at improving health and protecting people (Tulchinsky & Varavikova, 2014).

The advent of outbreaks runs in tandem with public health concern in respect to studying and finding therapies to cure or vaccines to prevent them. For example, Edward Jenner, an English physician, is widely acknowledged for preventive or prophylactic measures that helped eliminate smallpox in the 18th century (Zakir *et al.*, 2019). His work was very significant in addressing the first scientific attempt to control an infectious disease through vaccination (Riedel, 2005, January). Louis Pasteur, a 19th century French biologist, microbiologist and chemist, is also credited for the principles of vaccination, fermentation and pasteurisation (Ramirez *et al.*, 2017). His guiding principle of 'isolating, inactivating and injecting' causative microorganism, with developments recorded in trial and error efforts, otherwise known as clinical tests in medical lexicon, are still followed today (Ramirez *et al.*, 2017).

As COVID-19 raises new concerns globally, vaccine development continues to receive heightened attention, although in the face of pandemics, as it were aeons ago, still remains a contestable subject. Epidemiologists say the danger posed by unknown pathogens such as COVID-19 and many others besides, and bioterrorism, where infectious agents are at the cusp of being misused as weapons of war, if they haven't been already, gives impetus to the development of vaccines (Liu, 2003).

However, circumventing the ambivalence surrounding vaccines is more elusive than it is to fuel it at the moment. The Centre for Disease Control (CDC) explains that vaccines contain the same germs that cause disease—weakened or altered to levels they can't cause harm—to boost immunity for production of antibodies to fight disease (CDC, 2012).

Louis Pasteur and Émile Roux also proved that weakened organisms provide protection—and as a result—in the 20th century, helped accelerate development of vaccines using new technologies (Doherty *et al.*, 2016). Today, genetic engineering advances embody improvements in the design of vaccine technology and diversification, hence helping expand on the spectrum of diseases that can be prevented (Ramirez *et al.*, 2017).

Vaccines are mainly developed for deadly diseases (CDC, 2012). They're preventive or prophylactic medical interventions that help the body to respond to wild pathogens or harmful organisms such as bacteria or viruses, rather than directly treating disease, as therapeutics such as antibiotics do (Liu, 2003). Vaccines are meant to mimic natural infections to elicit strong cellular and antibody responses for long-lived protective immunity (Ramirez *et al.*, 2017).

Several vaccine technologies exist today. The foregoing explanation presents traditional vaccine technologies—inactivated and live vaccines—with the former containing killed pathogens while the latter containing living pathogens but weakened or attenuated. Attenuated vaccines are highly effective but more prone to side effects than their inactivated counterparts (Gates, 2020).

The danger imposed by highly infectious diseases is prompting advances in technology to enable new vaccine platforms meant to address the time gap between pathogen emergency and vaccine licensure (Vogel *et al.*, 2018; Treanor, 2016). Unlike traditional vaccines that depend on introducing antigens in the body to induce immune response, Deoxyribonucleic Acid (DNA) or Ribonucleic Acid (RNA) based vaccines use computational prediction containing genetic information to produce antigens. DNA or RNA-based vaccines once introduced, instruct the production of antigens by the body itself (Hubaud, 2015). Protein ecoding by RNA especially, enables the body to develop preventive or therapeutic response to fight diseases (Schlake *et al.*, 2012). Of the two however, RNA-based vaccines have shown great potential to extent that they could be used to prevent a variety of diseases such as cancer, influenza, rabies, HIV and TB, just to mention but a few (Hubaud, 2015).

Even at their nascent stage, RNA-based vaccines are showing positive signs in triggering immune response in mice, ferrets and pigs against influenza (Vogel *et al.*, 2018). Other advantages already accruing from RNA-based vaccines before they can be scaled, is that they're less expensive to manufacture than traditional vaccines. Their production is more rapid, therefore offering quick response in case of pathogen emergencies (Petsch *et al*., 2012). RNA-based vaccines are also being developed to provide flexibility that will help prevent pathogens whose evolution is rapid (Kupferschmidt, 2012; Schlake *et al*., 2012). In a press release, The Bill and Melinda Gates Foundation, the organisation largely credited for the funding of RNA-based vaccine development, states that the new technology's thermostability helps eliminate demand for cold-chain storage and infrastructure, a factor which is very daunting for vaccine supply in most developing countries (Statement, 2015).

Irrespective of what they are—traditional or modern—vaccines are administered through injections; subcutaneous—under the skin or intramuscular—in the muscle or through oral means (Ramirez *et al.*, 2017). Vaccines differ from other medicines because they're administered to large and healthy populations to include infants and children (Di Pasquale *et al.*, 2016).

Historically, vaccines are proven to reduce disease burden among vaccinated individuals as well as surrounding communities medically referred to as herd protection (Ramirez *et al.*, 2017). Their safety and efficacy on high mortality and high morbidity diseases often leads to overwhelming support for immunisation programmes (Doherty *et al.*, 2016). Scientists state that vaccine efficacy is known for reducing associated disease mortality up to 97% and 100% (Ramirez *et al.*, 2017).

In circumstances where vaccines have helped eradicate, control or prevent diseases, in cases like; smallpox, polio, measles, whooping cough, tetanus, and mumps, they've been applauded. Praise for vaccines is in its ability to prevent condescending effects any outbreak may impose on health systems and economies, exemplified in treatment and equipment expenses, if vaccination were not done (Song, 2014).

Why Vaccines are a Subject of Discord and Contestation

Vaccines are plagued by sentiments encompassing resistance against biomedical development since time immemorial. Inconsistences in vaccines and immunisation programmes, nonetheless, have warranted a long history of hesitancy and refusal since the dawn of their introduction (Lawrence, 2020). The primary theme for opposition is the perception that individually or collectively, vaccines cause more harm than they're meant to prevent (Schwartz, 2012). The DPT vaccine in the 1960s and 1970s in the US, is a case in point. Doled out in a single combination to prevent Diphtheria-Pertussis-Tetanus, DPT was blamed for causing serious brain damage and autism and encephalopathy to children, hence throwing the efficacy and safety of vaccines in doubt (Di Pasquale *et al*., 2016).

Contemporary opposition to vaccine application resembles that of 200 years ago in spite of advances in the technology aimed at improving their success and practice. Vaccine science continues to be questioned in regard to risks versus benefits (Schwartz, 2012). Pandemrix, a vaccine manufactured by GlaxoSmithKline meant to protect against the swine flu (H1N1) outbreak in 2009/10, as a case in point, resulted in serious risks (Doshi, 2018). After its rollout, it soon became apparent that the vaccine caused narcolepsy as a side

effect, a neurological disorder that affected ability to wake and sleep in some of its recipients (Jacob *et al.*, 2015). What is intriguing is how fast the vaccine was authorised by responsible governments such as the Canadian, the US, the UK, the French and the German to protect it against lawsuits for any risks that might arise (Doshi, 2018).

A coalition of sceptics also alleges that vaccines are financial schemes by pharmaceutical companies and philanthropists to make money. This view seems to be holding much sway, especially on ambient media such as WhatsApp, Facebook and Youtube. As a new technology, the RNA-based vaccine made news when it was revealed that The Bill and Melinda Gates Foundation was to inject financial support into a biotech company, CureVac, towards its development (Hubaud, 2015). The new vaccine technology may sound terrifying but the most likely to save humanity from pestilence. Many sceptics allege that even the current COVID-19 crisis is delight for what they term as 'profit-obsessed' pharmaceutical manufacturers and donors to make money. Such views have also tended to whip up a storm of varied conspiracy theories, one of which purports that COVID-19 is lab-orchestrated rather than a natural cause. Most conspiracy theories tend to be self-serving distortions of the reality, often acquired from second-hand information or misinformation intended to perpetuate exaggeration (Lawrence, 2020).

Many online conversations on medical developments tend to be biased and sometimes misleading, hence resulting into activism against vaccination; particularly to policies and legislations, experts and donors behind them. Misinformation, as has always been known, contributes a lot to confidence in vaccines being undermined (Di Pasquale, *et al.*, 2016). Today, anti-vaccination coalitions are part of the national, as well as the international network buoyed by social media (Schwartz, 2012).

Vaccine controversy is also sustained by the association of its promotion with compulsory immunisation policies linked to school attendance (Schwartz, 2012). Enforcement to ensure immunisation compliance has often agitated more than it has appeased. In the US from the 1950s, vaccination became compulsory for schoolchildren, and to this day, the same model is replicated in many countries. Vaccination is a standard and a service integrated within health systems in many countries (Streefland *et al.*, 1999). It is mandated by law unlike other medicines that may impose risks on individuals (Lawrence, 2020).

In England in the 19th century, vaccination programmes sparked resistance when those in contravention received fines and jail terms (Porter & Porter, 1988). Consequences for vaccination refusal such as loss of access to doctors, loss of health benefits or loss of jobs where employers require vaccination has often sparked controversy (Lawrence, 2020). From this, anti-vaccination coalition usually emerges to include religious, ethnic and socioeconomic groups. And medical practitioners, as it is today, whose views are outside the mainstream medical profession only help to reinforce controversy (Schwartz, 2012). Notwithstanding, medical and health professionals describing themselves as pro-vaccine yet their support is metered by concerns of safety and efficacy only helps to raise ire (Lawrence, 2020).

A legion of the National Health Service (NHS) workforce in the UK to vaccinate with the much publicised Pandemrix vaccine for Swine Flu (H1N1) amidst instance from medical authorities like the Department of Health and the British Medical Association, is a case in point (Doshi, 2018). The NHS workforce was proved right when it was discovered that Pandemrix was the cause of narcolepsy among children and adolescents in Sweden and Finland due to the use of the ASO3 adjuvant in the vaccine. What becomes intriguing is the fact that the pharmaceutical manufacturer—GlaxoSmithKline— disguised other serious controversies surrounding the vaccine (Doshi, 2018). In Ireland, purchasing and rolling out the vaccine at the behest of government, even when it was apparent that Pandemrix had issues and that the swine flu pandemic wasn't as grave as it had been purported in the media, caused more controversy. The Scottish demonstrated against its continued application.

In developed countries in the 1960s and 1970s, perception which persists to this day, is that vaccination programmes also intruded on religious beliefs as well as personal liberties (Schwartz, 2012). In the context of strong religious inclinations, vaccination as well as contraception is viewed negatively. In the Philippines, strong Roman Catholic belief imbibes society and as a result, vaccination programmes are

always resisted. In the 1990s for example, based on allegations that toxoid, the tetanus vaccine, was associated with abortifacients or substances that induce abortion, resulted in a court injunction to halt the programme (Streefland *et al.*, 1999). In West Bengal, India, the oral polio vaccine (OPV) administered in 1996 was associated with the death and illness of children. This provoked resistance to the second phase of the Pulse Polio Immunisation campaign even when there was no proof that vaccination was the cause of the sad events (Coutinho & Banerjea, 2000). Adverse events and reactions subsequent to vaccination programmes are observed to be one of the significant causes of negative perception to vaccines even when their correlation to side effects is unfounded (Rogers & Pilgrim, 1995).

Clinical trial mistrust likewise bears evidence in historical circumstances, particularly in the brutal and unethical treatment of Africans in medical experiments and practices. Medical research in the US and elsewhere, is abound with accounts of unethical standards bereft of compassion applied to people of native ancestry and low-income statuses (Harris *et al.*, 1996). African-Americans and people of low economic statuses were often abused as specimen for dissection, testing new technologies and remedies on account of ascertaining medical progress (Savitt, 1982).

For 40 years since 1932 in the US, the Tuskegee Syphilis study is the longest nontherapeutic experiment on humans, and also known for its human rights notoriety. The experiment continues to fortify mistrust to this day, after media leaks in 1972 found that its participants, African-American sharecroppers, were abused as observation groups to investigate the natural history of untreated syphilis. Even after the discovery of penicillin in the 1940s, participants continued to be denied the antibiotic treatment for syphilis even when many of them started dying, suffered mental derangement and other health problems (Nix, 2017).

Peter Buxton's whistleblowing effort in this covert study is important for two reasons. It helped facilitate review of regulation regarding protection of participants in medical trials as we have it today, some to mention, participant informed consent, diagnosis communication and accurate reporting on test results (Childress, 1998).

Buxton's discovery also helps explain lingering mistrust of medical developments, and without doubt, justifiably so. The current COVID-19 conundrum proves the point that Africans are still viewed in the light of 'guinea pigs'. For example, two French doctors recently appearing on TV sparked outrage when they suggested that since Africa lacked requisite medical standards, such as masks, treatment and resuscitation, clinical trials for the COVID-19 vaccine should be conducted on the continent. In response, Dr. Tedros Adhanom Ghebreyesus, Director-General WHO, termed the suggestion 'colonial mentality' hangover, as he also retorted that "Africa cannot and will not be a testing ground for any vaccine." (BBC, 2020).

Complementary and Alternative Medicine (CAM) practitioners, also referred to as Complimentary and Integrative Health (CIH), equally harbour strong sentiments against vaccination. CAM practices are espoused by homeopathy, chiropractic, reflexology and naturopathy. CAMs are nonconventional therapies widely applied for treatment of diseases ranging from influenza, inflammatory diseases, breast cancer, etc. (Maurya *et al.*, 2020). Homeopathy, a form of alternative medicine developed by a German physician, Samuel Hahnemann (1755-1843), advocates for extremely diluted amounts of natural substance to treat varied ailments (Wanjek, 2013). The practice relies on high dilution of infectious agents administered orally (Ernst, 2001). Homeopathy's efficacy is globally acknowledged although scientific validation is yet to be established (Maurya *et al.*, 2020).

Chiropractic is also a very popular form of CAM developed by a Canadian physiotherapist, Daniel David Palmer (1845-1913). Chiropractors believe that the body has enormous supply of natural healing power administered through the nervous system, therefore requiring no vaccination. Chiropractors believe that misalignment of the vertebra is the main cause of most diseases—and argues that its realignment to correct defects is treatment (Ernst, 2001).

Naturopathic medicine, also a CAM, draws its practices from a long and rich history extending thousands of years. Naturopathic practitioners rely on natural resources for health and healing purposes, particularly

presented by plants as therapeutic agents. Plants offer nutraceutical—nutrition and medicinal—value (Hechtman, 2020). The practice promotes herbal remedies, nutritional therapies, hydrotherapies and manipulative techniques therapeutic practices believed to strengthen the body's own defences (Ernst, 2001).

Alternative medicine practitioners view vaccines as dangerous with simmering contestation to their application. Their practitioners strongly believe that the body only requires natural remedy to facilitate or to trigger immunity or immune response.

Conclusion

The trajectory of medical developments, particularly in regard to vaccines and therapies continues to be a controversial one, even when many developments are important in preventing and controlling disease. Persistent indignation to vaccines stems from the safety and efficacy debate encouraged by risk and benefit concerns. Although effort is always made to ensure that a vaccine's benefits outweigh its risks, it needs to be understood that no drug or medical procedure can be ascribed to be totally risk free (Di Pasquale *et al.*, 2016).

The unethical standards and biases applied in clinical trials such as using people of different ethnic groups and low economic statuses as guinea pigs, like in the covert Tuskegee Syphilis study and the recent suggestion by the two French doctors, is compelling, and justifiable reason for mistrust in biomedical developments.

Scientist disclose that vaccine development should be a process requiring rigorous procedure. Before licensure, vaccine manufacturers take extensive safety evaluations, starting with individual vaccine components, and testing the final formulation before it is administered widely (Gates, 2020) . Raw materials require high purity and high-quality standards. Notwithstanding, components must be tested for purity, sterility, potency, consistency, activity and stability, all of which are lab procedures. Efficacy, toxicity, safety and effects is always done in animal models (Di Pasquale *et al.*, 2016).

From historical accounts, resistance to medical interventions bears credence in the manner in which such developments have been rolled out. Enforcement in many immunisation programmes and associated penalties for those found in contravention has often been a subject of consternation. Enforcement of lockdowns and mask wearing in the containment of COVID-19 may seem farfetched, but serves as a lurid example to how well-intentioned interventions can go wrong if people for whom they're intended are tortured for compliance. Treatment by health workers, usually leading to bad experiences on account of vaccination programmes always engender resistance, refusal and controversy; and in the context of coercion, vaccination programmes may receive low or no response at all (Streefland *et al*., 1999). Doherty *et al.* (2016) enjoin that continued success in any medical intervention hinges on combined consensus of individuals, healthcare professionals and governments. Streefland *et al.* (1999:1707) also add that 'understanding people's vaccination behaviour should be guided by a sensitivity to differences in local experiences and vaccination settings'.

Although ambient media such as WhatsApp, Facebook and Youtube etc., is responsible for the persistent indignation, medical developments propelled by pharmaceutical manufacturers may not have always fallen short of their intentions and purposes but their objectives. With regard to this view, dissenters believe that pharmaceutical manufacturers are more 'profit-obsessed' than interested in eliminating pathogens that cause disease. The Pandemrix Swine Flu in 2009/10 vaccine as seen in the article, bears all the semblance of GlaxoSmithKline's intention to make money more than stemming the outbreak. The pharmaceutical manufacturer and some health authorities were aware of some other adverse effects long before narcolepsy disorders emerged, but continued to administer the vaccine while wallowing in a transparency vacuum. The intentional lack of transparency of such odds seems to prove the controversy of 'profit-obsession' more than anything else (Doshi, 2018).

This view is also widely covered in the chronicles of the Ebola Virus Disease in West Africa in 2014. WHO termed the epidemic an 'exceptional circumstance' based on its lethality, contagiousness and the burden it

was imposing on fragile health systems in the region, but unproven clinical trials for both the vaccine and curative therapies caused controversy that resulted into community resistance. 'Exceptional circumstance' was also challenged because it lacked merit in application to other biomedical developments (Calain, 2018).

From the foregoing, vaccines as medical developments and interventions are effective but can also be risky. Medical experts contend that in some cases, vaccines, especially those developed from attenuated or weakened virus strains can revert to a wild type. The risk they pose can be in form of inflammation, uncontrolled replication and disease (Ramirez *et al.*, 2017). With advances in technology, risks can be minimised to protect and keep people healthy. In spite of the controversies surrounding them, vaccines remain the best and most effective medical interventions in disease outbreaks. From the host of many outbreaks confronted globally, many diseases are at the cusp of being eliminated completely, such as smallpox, polio and measles among others. While new technologies such as the RNA-based vaccines sound terrifying, but the most likely to protect humanity from pandemics and bioterrorism.

References

Barro, R., Ursúa, J. & Weng, J., 2020. The coronavirus and the great influenza pandemic: Lessons from the "spanish flu" for the coronavirus's potential effects on mortality and economic activity (No. w26866). *National Bureau of Economic Research.*

BBC, 2020. *Coronavirus: Africa will not be testing ground for vaccine, says WHO.* [Online]Available at: https://www.bbc.com/news/world-africa-52192184 [Accessed 27 May 2020].

Bloom, E., De Wit, V. & Carangal-San Jose, M., 2005. Potential economic impact of an avian flu pandemic on Asia.

Calain, P., 2018. The Ebola clinical trials: a precedent for research ethics in disasters. *Journal of medical ethics,* Volume 44(1), pp. 3-8.

CDC, 2012. *Centre for Disease Control and Prevention, 2012. CDC.* [Online] Available at: https://www.cdc.gov/vaccines/vpd/vpd-vac-basics.html [Accessed 14 May 2020].

Chen, Y., Liu, Q. & Guo, D., 2020. Emerging coronaviruses: genome structure, replication, and pathogenesis. *Journal of medical virology,* Volume 92(4), pp. 418-423.

Childress, J., 1998. The National Bioethics Advisory Commission: bridging the gaps in human subjects research protection. *J. Health Care L. & Pol'y,* Volume 1, p. 105.

Coutinho, L. & Banerjea, N., 2000. Social production of blame: Case study of OPV-related deaths in West Bengal. *Economic and political weekly,* pp. 709-717.

Di Pasquale, A. et al., 2016. Vaccine safety evaluation: Practical aspects in assessing benefits and risks. *Vaccine,* Volume 34(52), pp. 6672-6680.

Doherty, M. et al., 2016. Vaccine impact: benefits for human health. *Vaccine, 34(52),* pp. 6707-6714.

Doshi, P., 2018. Pandemrix vaccine: why was the public not told of early warning signs? *Bmj,* Volume 362, p.k3948.

Ernst, E., 2001. Rise in popularity of complementary and alternative medicine: reasons and consequences for vaccination. *Vaccine,* Volume 20, pp. S90-S93.

Gates, B., 2020. *World Economic Forum.* [Online] Available at: https://www.weforum.org/agenda/2020/05/what-you-need-to-know-about-the-covid-19-vaccine [Accessed 7 June 2020. 'Bill Gates: Here's what you need to know about the COVID-19 vaccine'. World Economic Forum. 04 May. (Accessed: 07 June 2020)].

Harris, Y., Gorelick, P., Samuels, P. & Bempong, I., 1996. Why African Americans may not be participating in clinical trials. *Journal of the National Medical Association,* Volume 88(10), p. 630.

Hechtman, L., 2020. *Advanced Clinical Naturopathic Medicine.* s.l.:Elsevier Health Sciences..

History.com, E., 2015. *HISTORY.* [Online] Available at: https://www.history.com/topics/south-america/inca [Accessed 3 June 2020].

Hollingsworth, J., 2020. *Why US protests have prompted a conversation about race in Australia.* [Online] Available at: https://edition.cnn.com/2020/06/10/australia/protests-indigenous-australians-bias-intl-hnk/index.html [Accessed 12 June 2020].

Hubaud, A., 2015. *RNA vaccines: a novel technology to prevent and treat disease.* [Online] Available at: http://sitn.hms.harvard.edu/flash/2015/rna-vaccines-a-novel-technology-to-prevent-and-treat-disease/ [Accessed 8 June 2020].

Iwami, S., Takeuchi, Y. & Liu, X., 2009. Avian flu pandemic: Can we prevent it? *Journal of theoretical biology,* Volume 257(1), pp. 181-190.

Jacob, L. et al., 2015. Comparison of Pandemrix and Arepanrix, two pH1N1 AS03-adjuvanted vaccines differentially associated with narcolepsy development. *Brain, behavior, and immunity,* Volume 47, pp. 44-57.

Jarus, O., 2020. *Live Science.* [Online] Available at: https://www.livescience.com/worst-epidemics-and-pandemics-in-history.html [Accessed 25 May 2020].

Keohane, C., Chimelli, L. & Ryan, A., 2020. Poliovirus Infection and Postpolio Syndrome. *Infections of the Central Nervous System: Pathology and Genetics,* pp. 95-204.

Kupferschmidt, K., 2012. *Making a flu vaccine without the virus.* [Online] Available at: https://www.sciencemag.org/news/2012/11/making-flu-vaccine-without-virus [Accessed 8 June 2020].

Lawrence, H., 2020. *Vaccine Rhetoric.* Columbus: The Ohio State University Press.

Liu, M., 2003. DNA vaccines: a review. *Journal of internal medicine, 253(4),* pp. 402-410.

Maurya, V., Kumar, S., Haikerwal, A. & Saxena, S., 2020. Complementary and Alternative Medicine Treatments of WaterAssociated Infectious Diseases in Alliance with Conventional Medicine Treatments. *In Water-Associated Infectious Diseases,* pp. 119-13.

McCoy, C. et al., 2017. Multidisciplinary Approach to HIV/AIDS: Historical Perspective (pp. *In Global Virology II-HIV and NeuroAIDS,* pp. 1-20.

Nix, E., 2017. Tuskegee Experiment: The infamous syphilis study. *History stories.*

Petsch, B. et al., 2012. Protective efficacy of in vitro synthesized, specific mRNA vaccines against influenza A virus infection. Nature b. *Nature biotechnology,* Volume 30(12), p. 1210.

Plourde, A. & Bloch, E., 2016. A literature review of Zika virus. *Emerging infectious diseases,* Volume 22(7), p. 1185.

Porter, D. & Porter, R., 1988. The politics of prevention: anti-vaccinationism and public health in nineteenth-century England. *Medical history,* Volume 32(3), pp. 231-252.

Ramirez, J., Sharpe, L. & Peppas, N., 2017. Current state and challenges in developing oral vaccines. *Advanced drug delivery reviews,* Volume 114, pp. 116-131.

Riedel, S., 2005, January. Edward Jenner and the history of smallpox and vaccination. . *In Baylor University Medical Center Proceedings,* Volume 18 (1), pp. 21-25.

Rogers, A. & Pilgrim, D., 1995. The risk of resistance: perspectives on the mass childhood immunisation programme. *Sociology of health & illness monograph series,* pp. 73-90.

Roth, A. M. A. L. C. et al., 2014. Concurrent outbreaks of dengue, chikungunya and Zika virus infections–an unprecedented epidemic wave of mosquito-borne viruses in the Pacific 2012–2014. *Eurosurveillance,* Volume 19(41), p. 20929.

Savitt, T., 1982. The use of blacks for medical experimentation and demonstration in the Old South. *The Journal of southern history,* Volume 48(3), pp. 331-348.

Schlake, T., Thess, A., Fotin-Mleczek, M. & Kallen, K., 2012. Developing mRNA-vaccine technologies. *RNA biology,* Volume 9(11), pp. 1319-1330.

Schwartz, J., 2012. New media, old messages: themes in the history of vaccine hesitancy and refusal. *AMA Journal of Ethics, 14(1),* pp. 50-55.

Song, G., 2014. Understanding public perceptions of benefits and risks of childhood vaccinations in the United States. *Risk Analysis,* Volume 34(3), pp. 541-555.

Statement, P. R. a., 2015. *The Bill & Melinda Gates Foundation and CureVac Collaborate to Accelerate the Development of Transformative Vaccine Technology,* SEATTLE, WA, USA and TÜBINGEN, GERMANY: The Bill & Melinda Gates Foundation and CureVac.

Streefland, P., Chowdhury, A. & Ramos-Jimenez, P., 1999. Patterns of vaccination acceptance. Social science & medicine. Volume 49(12), pp. 1705-1716.

Treanor, J., 2016. Influenza vaccination. *New England Journal of Medicine,* Volume 375(13), pp. 1261-1268.

Tulchinsky, T. & Varavikova, E., 2014. The new public health. *Academic Press.*

Vogel, A. et al., 2018. Self-amplifying RNA vaccines give equivalent protection against influenza to mRNA vaccines but at much lower doses. *Molecular Therapy*, Volume 26(2), pp. 446-455.

Wanjek, C., 2013. *What's Homeopathy.* [Online] Available at: https://www.livescience.com/31977-homeopathy.html [Accessed 9 June 2020].

WE HEARD THE BELLS: The Influenza of 1918 (DOCUMENTARY). April 12, 2015. [Film] Directed by James Randolph Farris. USA: Lisa Laden for the US Department of Health and Human Services.

Zakir, F., Islam, F., Jabeen, A. & Moni, S., 2019. Vaccine development: A historical perspective.