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The Possibility of Using Modern Methods to Control Bubonic Plague Infection, A Highly Infectious Zoonotic Disease, Mongolia

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Mongolia is a natural habitat to numerous zoonotic diseases including bubonic plague, anthrax, rabies and others. Lack of CDC-like structure, limited government capabilities and nomadic pastoral farming reflect high risk of future emerging and re-emerging outbreaks. Rapid risk assessment of outbreaks is conducted by the National Center for Zoonotic Diseases, meanwhile local and central governmental capacity of disease control remain unsatisfactory. With an AI-based disease control platform and instant mapping of hotspot locations should enable the rapid control and containment strategies. Furthermore, these dashboards and platforms will enable advanced level cooperation and management of emerging and re-emerging infections occurring within the intersection of nature, domesticated animals, wildlife and people in Mongolia and beyond. Ultimately, we aim to incorporate One Health approach and other International Health Regulations under the project outcomes. Mobile phone uses are above 90 per cent among Mongolian adults. In addition, connectivity is essentially well connected across the country.

Keywords: Bubonic plague, re-emerging infection, machine learning, artificial intelligence, Mongolia

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Introduction

Bubonic plague

The plague, sometimes referred to as the Black Death, was a zoonotic illness caused by Yersinia pestis that spread over the world.[1] Due to its high mortality rate and strong infectivity, it presents a serious risk to both people and animals. Bubonic, pneumonic, septicemic, meningeal, and pharyngeal plague are the five main types of the illness. It can cause skin ulceration, carbuncles, and ulcers, along with pustules, spots, petechiae, bruises, and gangrene. It can also be spread through flea bites, respiratory droplets, eating raw, tainted meat, and handling infected animals. Patients risk dying from shock and heart failure if treatment is delayed.[2]

Epidemiology

Mongolia is a nation in central Asia that is bordered by China to the east and south and by Russia to the north and northwest. With a population of over 3.4 million, Mongolia is the 19th-largest and fewest densely populated independent nation in the world. Its total area is 1,564,116 km^2. 30% of the population live a nomadic or semi-nomadic lifestyle. With the Gobi Desert to the south and chilly mountainous areas to the north and west, Mongolia's landscape is diverse. Steppes make up the majority of the remaining land in Mongolia. Echinococcosis, plague, tularemia, anthrax, foot-and-mouth disease, and rabies are a few important emerging infectious diseases in Mongolia.[3] In 28.3% of Mongolia's total area, there are natural plague foci, and 47.1% of them are highly active. More than 3000 plague cultures have been identified from host animals and their ectoparasites, and highly active foci of the plague are mostly found in western Mongolia. Between 640 to 3500 meters altitude level, plague foci can be found between latitudes 88°00 and 120°00 and longitudes 50°00 to 43°00.[4] Because there are so few confirmed instances, it appears that human-to-human transmission of the disease is just a small factor.[3] In 1980, the World Health Organization received the first reports of human cases in Mongolia.[5] Each year, particularly in rural Mongolia, 40 people have been diagnosed with plague cases caused by Yersinia pestis infection. Hunting marmots (Marmota sibirica), huge rodents that are particularly common over the vast steppes of Central Asia, appears to be the primary source of transmission.[3] One probable way for Mongolians to contract the plague is through the practice of consuming diseased raw marmot flesh. As Y. pestis is effectively inactivated by cooking, eating raw meat is the cause of illnesses in Mongolia, not eating boodog that has been cooked. In Mongolia, close contact with infected marmots is the main route of Y. pestis infection. As rodents play a significant role in the spread of the plague, Mongolia is the perfect place to conduct in-depth research on their function as Y. pestis epizootic and enzootic reservoirs.[6]

A total of 12 endemic mammal species and 1 species of bird had ectoparasites that included 27% of all plague cultures. Fleas' ectoparasites were the source of the majority of isolates of plague cultures (91.5%). Sixty-four percent of the flea cultures that were isolated were from marmot fleas. The Oropsylla silantiewi marmot flea is thought to be the main plague carrier. The primary disease hosts in Mongolia are Siberian marmots. Mountain steppe and steppe zones are home to marmots. On marmots, 71 flea species and subspecies (5 families, 19 genera), 10 tick species, and 1 species of louse were discovered. On marmots, O. silantiewi fleas were nearly constantly present (95.8–100%). Ctenophyllus hirticrus, Citellophilus tesquorum, Oropsylla alaskensis, Neopsylla mana, Neopsylla pleskeiFrontopsylla, luculenta, Amphalius runatus, Frontopsylla hetera and Rhadinopsylla li transbaikalica, were also commonly found on marmots.[4] Six Yersinia pestis subspecies have been shown to be present in Mongolian among populations of voles and picas, according to recent investigations. It was important to detect the Analytical Profile Index 20E (API20E) test agent using classic biochemical methods in previous studies that clarified the phenotypic heterogeneity of Y. pestis strains in Mongolia. The isolation of multiple resistant strains in addition to those known from Madagascar is alarming and highlights the importance of bacterial cultivation and susceptibility testing.[7]

AI-based solution

AI refers to a set of modern technologies that enable computers to accomplish very complicated jobs that would need intelligence if performed by a human. Moreover, the distinction between AI and other methodologies, such as big data analytics, can be hazy.[8] Intelligence is defined as a "agent's capacity to attain goals in a variety of environments", and AI is defined as any created agent (i.e. software or robot) that demonstrates intelligence. In the public sphere, AI is sometimes characterized as sentient computers with human-like capabilities, but the state-of-theart falls short of this ideal. Existing AI is 'narrow,' with computers learning to do just certain functions and not being able to apply their intelligence more broadly. Improved georeferenced datasets would be beneficial for quantitative analysis, such as the reconstruction of regional transmission networks or maybe the identification of probable historical plague reservoirs.[9] Integrating plague data from various sources to address regional and temporal gaps may help to lessen the problem of spatial and/or temporal representativeness and increase our understanding of the spatio-temporal spread. Integrating plague data from various sources to address regional and temporal gaps may help to lessen the problem of spatial and/or temporal representativeness and increase our understanding of the spatio-temporal spread. Consistency in data definition and collection, on the other hand, is critical. Understanding the spatiotemporal dynamics of the past and current plague pandemics is a large task that is best approached collaboratively and transdisciplinary, and in the spirit of open data. Researchers see the opportunity that AI provides for advancement and, as a result, for saving lives. Stopping and thinking about the datasets utilizing, as well as the ramifications of apparently innocuous decisions, will allow us to get the most out of this bright, new technology.[10]

Method

Theory of the change

Detecting and tracing the spread of the disease is crucial for preventing outbreaks and controlling the spread of the disease. Artificial intelligence (AI) technology has the potential to revolutionize bubonic plague contact tracing and detection by analyzing large datasets and identifying patterns that might otherwise be missed. This theory of change outlines the steps necessary to develop and implement AI technology for bubonic plague contact tracing and detection.

Step one - Identify the Problem and Need

The first step in developing AI technology for bubonic plague contact tracing and detection is to identify the problem and the need. The bubonic plague is a highly infectious disease that can spread rapidly, making it difficult to control. Traditional methods of contact tracing and detection rely heavily on human labor, which can be time-consuming and slow. Additionally, the disease is often misdiagnosed, which can further delay treatment and contribute to the spread of the disease. Mongolia has unique problems where it is illegal to hunt marmots, while it is consumed widely in the countryside. People often neglect and hide exposure that has life threatening hazards (**Figure 1**).

Step two – Develop the AI Technology

The second step in implementing AI technology for bubonic plague contact tracing and detection is to develop the technology. This involves building AI algorithms that can analyze data from a variety of sources, including medical records, social media, and public health surveillance systems. The AI algorithms must be trained on data specific to the bubonic plague and must be capable of identifying key indicators of the disease, such as symptoms and geographic locations. This approach will highly concentrate on mobile phone data based on proximity of cellular phones and chances of marmot exposure.

The development of AI technology for bubonic plague contact tracing and detection requires collaboration between public health officials, data scientists, and software developers. Data scientists must work closely with public health officials to identify the key data sources that are most relevant to the bubonic plague. Software developers must then build the necessary infrastructure to collect, store, and analyze the data. Public health officials must also ensure that the technology complies with ethical and privacy standards.

Step three – Implement the Technology

The third step in implementing AI technology for bubonic plague contact tracing and detection is to deploy the technology to public health agencies and healthcare providers. The AI algorithms must be integrated into existing public health surveillance systems and healthcare provider workflows to ensure that they are used effectively. Implementation also requires addressing potential ethical and privacy concerns. AI technology for bubonic plague contact tracing and detection must be developed in a way that protects patient privacy and confidentiality. Additionally, public health officials must ensure that the use of AI technology does not result in discriminatory practices or exacerbate existing health disparities.

Provincial health departments and Local zoonotic disease centers will be directly invited to selected local areas. Four provinces of Mongolia will be selected for geographical coverage.

Step four – Monitor and Evaluate the Technology

The fourth step in implementing AI technology for bubonic plague contact tracing and detection is to monitor and evaluate the technology. This involves tracking the performance of the AI algorithms and identifying areas for improvement. Public health officials must establish key performance indicators (KPIs) to track the effectiveness of the technology, such as the number of cases identified and the timeliness of response.

Evaluation should also include stakeholder feedback, including feedback from healthcare providers and patients. This can help identify any challenges or limitations associated with the use of AI technology for bubonic plague contact tracing and detection. Public health officials must also continually assess the ethical and privacy implications of the technology.

Step five – Articulate Assumptions

The fifth or final step will focus on policy development and formal introduction to the health system in Mongolia. In order to be institutionalized and integrated into the health system, the AI product must be registered and documented by the Ministry of Health Mongolia by order of the Minister or licenses. However the final product will be public good for non-commercial uses.

The Ministry of Health will finalize the receipt of products for implementation and utilization at nationwide level. Maintenance and further responsibilities will be led by the Ministry of Health, Mongolia.

Conclusion

AI technology has the potential to address these challenges by providing real-time disease surveillance and contact tracing. AI algorithms can analyze large datasets and identify patterns that might be missed by human analysts. This can help to identify potential outbreaks before they become widespread and allow for more targeted responses. By implementing AI technology for bubonic plague contact tracing and detection, public health officials can better control the spread of the disease and early detection.

References

1. Demeure CE, Dussurget O, Mas Fiol G, Le Guern AS, Savin C, Pizarro-Cerdá J. Yersinia pestis and plague: an updated view on evolution, virulence determinants, immune subversion, vaccination, and diagnostics. Genes Immun. 2019 May;20(5):357–70.
2. Rachel C. A, Tonie E. R. Plague. National Wildlife Health Center; 2012. (Circular).
3. Ebright JR, Altantsetseg T, Oyungerel R. Emerging infectious diseases in Mongolia. Emerg Infect Dis. 2003 Dec;9(12):1509–15.
4. Galdan B, Baatar U, Molotov B, Dashdavaa O. Plague in Mongolia. Vector Borne Zoonotic Dis Larchmt N. 2010;10(1):69–75.
5. World Health Organization. Plague manual: epidemiology, distribution, surveillance and control. Geneva: The Organization; 1999.
6. Riehm J. Yersinia pestis in Small Rodents, Mongolia. Emerg Infect Dis [Internet]. 2011 Jul [cited 2023 Feb 18];17(7):1320–1. Available from: http://wwwnc.cdc.gov/eid/article/17/7/10-0740_article.htm
7. Kukleva LM, Shavina NYu, Odinokov GN, Oglodin EG, Nosov NYu, Vinogradova NA, et al. Analysis of diversity and identification of the genovariants of plague agent strains from Mongolian foci. Russ J Genet [Internet]. 2015 Mar [cited 2023 Feb 18];51(3):238–44. Available from: http://link.springer.com/10.1134/S1022795415010068
8. Growing the artificial intelligence industry in the UK. Gov.uk. 2017. https://www.gov.uk/government/publications/growing-the-artificial-intelligence-industry-in-the-uk.
9. Carmichael, A.G. (2015). Plague Persistence in Western Europe: A Hypothesis. The Medieval Globe 1(1), 157-191. https://www.muse.jhu.edu/article/758488.
10. Parfett A, Townley S, Allerfeldt K. AI-based healthcare: a new dawn or apartheid revisited? AI Soc [Internet]. 2021 Sep [cited 2023 Feb 18];36(3):983–99. Available from: https://link.springer.com/10.1007/s00146-020-01120-w

Supplementary Files

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Appendix 1

Figure 1. Zoonotic Diseases Outbreak Monitoring and Control Platform Through AI -Based Notification and Contact Tracing in Mongolia, and Beyond