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Artificial Intelligence in the Control of Food Borne Diseases: A Review

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Abstract: ***Artificial intelligence over time has become a primary resource for predicting the spread of infectious diseases. Its ability to organize information from multiple cases enables ineffective epidemic control. The study of pathogens that cause food borne diseases at a genomic level helps in elucidating the nature and course of infection. The primary area of application lies in the determination of the origin of the disease-causing pathogen in food material. Tracking the sale of the food supply is performed using a spatial network model based upon the gravity model that determines the route of transfer in the form of a tree. On the other hand, a machine learning based classifier enables in the prediction of the pathogen's host. This is performed by studying the whole genome sequence of the pathogen extracted from infected patients which aids in the determination of the infected food source. Both of these techniques will help to curb its spread. This operating procedure can be standardized and used as a template for other infectious diseases that don't spread through food. This review details the application of artificial intelligence in food borne diseases and how this practice can be extended to other epidemics too.***

Keywords: Artificial intelligence, Machine learning, Random Forest Classifier, Food-borne diseases, Gravity model, Convolutional neural network

1. Introduction

Infectious diseases caused by various pathogens have been a major concern to public health worldwide in this decade. They not only pose risk to health but also threaten the financial, social and emotional status of people. The recent incidences of outbreak of pandemics and epidemics like covid 19, Ebola, Nipah, Zika virus, MERS, swine flu etc have been an evidence of how a tiny organism can cause destruction on a large scale. Infectious diseases can be air borne, food borne or can spread through contact.

Food safety and security is one of the necessary public health requirements. Breaches in safety of food is due to contamination by infectious agents. Food can get contaminated anytime from its production to consumption [7]. Food borne outbreaks constitute one quarter of deaths worldwide. The most susceptible population are children under the age of 5 and elders [8]. Although according to CDC most of the cases are sporadic, food borne infections gain attention due to its outbreak in particular region [8].

Containing the spread of infection by identifying the source and tracing the infected is critical in preventing and managing outbreaks. The only way to contain food borne infections is to quickly identify the food product causing it. Normally food borne outbreaks are determined by using public surveillance system which involves long, complex procedures [4]. The cumbersome procedure involves clustering people with symptoms into groups followed by analysing the eating pattern of each cluster by using univariate and multivariate models stepwise [4].

In an era of digitization, a technology that has revolutionised the field of healthcare is Artificial Intelligence. Artificial Intelligence involves use of mathematical tools namely machine learning to learn patterns from a train data and applying the same to make decisions on actual data [3]. AI based tools used in healthcare are primarily machine learning and deep learning. Deep learning is used to increase the accuracy by using new learning methods on very large and complex datasets.[1]. AI has plethora of potential in healthcare field as national and public surveillance system generate huge datasets. Applications of AI in healthcare involve disease diagnosis using images obtained in MRI, CT SCAN, infection prevention and control, epidemic management, management of clinical trial data etc. In Infection prevention AI can be used in epidemiology monitoring, analysing symptoms of a disease, disease tracking, finding the source of outbreak and design new drugs (Ex: COVID19) [4, 5]. With respect to managing food borne diseases various mathematical models can be developed using AI tools to identify the source.

In this review we will be discussing about the advantages of artificial intelligence and machine learning in the development of models to identify the source of an outbreak and methods to mitigate the risks with a special emphasis on food borne infections.

Gravity Model and its Use in Tracking the Spread of the Food- Borne Disease

The application of artificial intelligence and machine learning has far reaching impact on control of diseases. Its use can be extended to all the phases of treatment. The use of current technology can be a boon in providing efficient, comprehensive and compelling diagnosis. Use of neural networks to create a contingency plan to combat infectious disease spread can be time saving. The use of effective distance and gravity model to retrace the path of food distribution. They are used to conclude the shortest distance for the spread of the diseases. The density of population in the affected areas is an important parameter to access the damage and in track the epidemic.[4]

Random Forest Classifier

Random forest classifier is core part of machine learning. It creates a decision tree from randomly sampling the dataset. The votes are tallied to find the right answer, then same objective can be accomplished by assigning weights to decision tree. The one with the highest error rate can have highest impact on the model. This concept is used to classify pathogens. The use of genomic information and a phylogenetic analysis helps in the identification of the disease-causing agent. [9] This concept can be extended to other diseases, if we have adequate information for the creation of a classifier then the pathogen causing the symptoms can be easily identified without any ambiguity.

AI and Pathogen Identification

The use of artificial intelligence to enhance microscopy to improve the accuracy with which the pathogens are identified. The use of convolutional neural network can act as an impetus to FastTrack the treatment of the patient.[1] Artificial intelligence mediated microscopy can be used in remote areas where technical support is staggered and unreliable. The process of training, testing and validation is the common methodology used in Artificial intelligence driven tools but the circumstances that surround the spread of epidemics is erratic and the tedious task of having the machine learn is impractical.

Active Learning with Real Timedata

We need the system to use real time data and self-learn to solve the problem.[3] The use of AI tools and block chain to collect the test results of the patients and provide this information to local authorities can be pragmatic as in the case of the Covid-19. [6]

Multiple Parameters Helps in Improved Modelling

This can be used in other epidemic control containment and treatment models. AI tools can also be used the classify the vulnerable population using multiple parameters to obtain the list of those that are the most susceptible to the infection.[2] in the case of Covid-19 the use of parameter like age, weak immune system, diabetes , hypertension and respiratory disorders are important markers. The same can be done in the case of food borne disease. The identification of the liable source like poultry, cattle etc can help to ensure that those sources are avoided. Pathogens can have affinity for a particular host. Having a robust dataset and a network that has weight assigned to multiple factors can help in the containment of the spread.

Extending the Model of One Geographical Location to Other Hotspots

The model created for a geographic location can be used as a template to deal with outbreaks in other areas. The model can be adjusted to accommodate the change in data of the current location. This process is time saving and helps the learning process as the system is not starting from scratch as groundwork has already been done. [3]

2. Conclusion

Effective epidemic control involves concluding upon the source food of infection, the pathogen responsible for the diseased state, the nature of infection, vulnerable populations, hotspots all enabling in the construction of a contingency plan. These steps become paramount in ensuring that the state and health care professionals carry out necessary precautions and treatment plans. Due to the time sensitivity of these cases researchers must ensure that these conclusions are drawn upon in a reliable fashion for which the use of artificial intelligence to process large quantities of information becomes necessary. The performance of the machine can suffer due to overfitting or underfitting. When the machine is able to model the training dataset too well or unable to model the training dataset it has far reaching repercussions. The quality of data provided to the system can also have an impact and introduce bias, thus polarising the results.

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