1   INTRODUCTION

Healthy citizens are real assets to any nation. Developed and developing countries are investing huge amount on reinforcement of "Healthcare systems" and obligatory "Health Infrastructure". Few nations are proactive in their health care approach across the globe. The recent ongoing pandemic taught tough lessons to nations about the significance of developing robust healthcare systems.

Studies on Public Health surveillance (PHS) and their subsequent inferences are crucial in the framing efficient health policies and strategies. The advent of newer technologies and computing techniques has made this task more lucid. Technology when rightly used has always been the savior for humans. This study is carried out in this context; most promising deep learning approaches are used. Section 1.1 presents the origin of such diseases, those shackled the health infrastructure and emphasized upon the necessity of PHS and usage of technology in prediction, prevention and protection in conjunction with these diseases.

1.1   ORIGIN AND IMPACT OF PANDEMIC

"Health is Wealth" perhaps the best old lesson re-learned in the new normal created by pandemic since 2019. Any study in handling such unprecedented health situation is significant to researchers and crucial to the human race welfare. This work carried out in this specific context, even though the initial idea is to focus on contagious diseases in generic sense. Therefore, in the introductory chapter also the onus is mostly on "Pandemic disease" rather than conferring to only contagious diseases.

Infectious and contagious disease is highly alarming for the citizens' in a society, thereby to a region or nation. Pandemic is much worse scenario, where most of the countries are in risk of getting effected. Pandemic diseases are intensely contagious and infectious. Transmission, re-transmission of infection is mostly disruptive and disturbs common

life. This transmission shall be from individual to individual or individual to a cohort or cluster (Morens et al., 2009).

Influenza A virus subtype H7N9 is a bird flu strain. H7N9 was spread by means of contact with living poultry (Su and He, 2015), whereas SARS transmission is direct i.e. person to person. Mutation of this influenza strain poses challenges in containing or handling this virus induced pandemic scenario.

Historical evidences suggest the occurrence of this pandemic to an average of once in hundred years. Everytime the impact of pandemic on the evolution and growth story of human race is unimaginable. To summarize, pandemic is a harpoon of humans' growth mission.

This new virus is found to be Ribonucleic acid (RNA) based and is different from known coronavirus family. The virus presence was observed in lungs, throat swab and blood of infected patients. Electron microscopic investigations revealed this virus presence in about 15 patients. As per the scientists and researchers of virology opinion "a fast paced research is needed to understand the bio mechanism, this would help to develop antiviral agents and also the vaccines in future".

1.1.1   Contagious Diseases: Pandemic – Nature and Features

The nature of a typical Pandemic is Contagious, Uncontrollable and tumbles health and economic foundations of nations across the globe. The principal feature of a pandemic is the range. Wide geographic impact is observed, when pandemic erupts. The term pandemic relates to the expansion of a disease over large geographical areas. Plague in 14th century, cholera and influenza are specimens of this case.

Mobility, novelty, severity, explosivity and population immunity are other features of a pandemic. One or more aforementioned features are common in other general contagious diseases like dengue and malaria.

Mobility: Unforeseen disease movement from one region to another region is another feature of a pandemic. Disease spread is unimaginable and sometimes exponential growth can be seen in a region. This can be a localized cluster or across the regions. The spread is very fast and clueless sometimes. If the disease is not localized by all the available resources, the spread becomes inevitable.

Person to person transmission, person to cohort, cluster to cluster transmission are most prominent. A single infected person shall transmit to hundreds directly and indirectly. The respiratory viruses such as SARS, influenza belong to this category. Sometimes enteric

organisms like cholera or vectors such as dengue also exhibit great degree of mobility.

The mobility is in such a way that it doesn't resemble seasonal transmission. It is the out of the season transmission. For example, H1N1 – the pandemic influenza-A spread was found in both hemispheres.

Novelty: Variants add the novelty to the progress of a pandemic. Antigenic shifts occur in influenza RNA viruses. Novel variants pose unexpected challenges in handling this pandemic. Few variants are less impactful, whereas some of the variants cause severe damage. This trend of novel variants was seen in the history of SARS family, plague and also to some extent in HIV/AIDS (Morens et al., 2009). Avian is also a novel infection that can be considered as a pandemic with Asian origin.

Severity: Pandemic sounds synonymous to severity. Mild infections generally are not termed as pandemic. They are mostly contagious alone, pandemic only has such severity, where greater impact in shorter time. This resembles an avalanche effect. "Pandemics with extraordinary mortality and morbidity occur, when a contagious viral strain transpires, against which the humans have no immunity" (Rewar et al., 2015). Severity is assessed by the mortality ratio (Donaldson et al., 2009).

Explosivity: History provides apt examples such as Ebola exhibiting the feature of explosivity. But in recent past, COVID-19 is a best example for the explosive nature in some countries. In general Pandemic is characterized by its rate or frequency of attacks or waves. Explosiveness is one of the key features of pandemic, even if a disease is widespread but not explosive; it may not come under the category of pandemic. West Nile is an example of this category, this virus spread was observed in Russia, Western hemisphere and some parts of Middle East in 1999. But the transmission lacks explosive nature and rate of attack was too low, therefore this is not classified as a pandemic. Diseases spread over wide range also sometimes are not declared as Pandemic because of low attack rate.

1.1.2   Impact of Pandemic – Economical and Psychological

Pandemic has great impact on regular lifestyle of people. All economic activity slows down and sometimes come to a pause during these times. Global and National economy goes to a Limbo state. Uncertainty is the only normalcy that one can experience during Pandemic. Psychological complications, domestic violence, hunger deaths, economic paralyses are most common and notable deviations that Pandemic brings to normal life.

Health and Economic emergencies occur simultaneously. Millions of people get infected and fall sick, sometimes leading to terminal illness. Health of the society will be in unforeseen danger. Mental and Physical health becomes questionable for a long period.

Social distancing enforcement, closing academic, religious, political and mass gathering activities to be carried out in the first hand. Promoting safety norms implementation such as washing hands, keeping hydrated and reducing mobility, if not necessary. Economic relief, liberal economic policies, measures to safeguard purchasing capacity of the citizens is a herculean task for governments.

Acting swiftly and as early as possible is so crucial in Pandemic management. The negative consequences are sometimes unmanageable, early reaction to the Pandemic situation is very important for people and for the governments across the globe. Millions of people get affected in short time, large number of people fell sick and exponential rise in cases makes the situation bad to worst. This Pandemic is not only a health hazard but also the serious threat to the global economy.

Economy instability should be addressed. Direct, indirect costs increases contributing to increased cost of living. Social, health and economic impact is almost challenging to handle. Travel is restricted, market is closed suddenly, which may leads to unforeseen unrest in lives, social trauma, which has to be collectively handled. High morbidity, mortality is a most generic scenario; this has to be handled carefully. Security of course at global, national and region level is another threat inherent in the time of a Pandemic.

1.1.3   Early Warning Systems

Early warning systems are designed and developed using deep learning methods in the recent past. To accomplish the task of predicting a Pandemic, in this work deep learning algorithms are used. Deep learning is neural network based method and it belongs to the sect of Machine learning.

These neural networks otherwise known as Artificial Neural Networks are of two categories a) Discriminative and b) Generative. Discriminative models are of bottom-to-top approach, whereas Generative are top-to-bottom approach. In discriminative data flow is from input to output through hidden layers. This is applicable in supervised learning. Regression analysis, classification comes under this category of applications. In Generative model; data flows in the reverse direction. This is used in unsupervised learning, ambiguity, uncertainty

and probabilistic models come under this category. Detailed information pertinent to deep learning models is provided in the Chapter 3.

1.2   MOTIVATION

The works on epidemic and pandemic, contagious nature of these diseases and means of prediction gave enough thirst and enthusiasm to work in this area. The impact of these diseases on normal life is huge. Effective estimation mechanisms and prediction models using the advanced outcomes of technology shall be made use to counter the challenges emerge out of these diseases. This research was started with this context, and the needed investigations have been carried out to reach out for an optimal and feasible solution with deep learning and machine learning approaches.

Early Pandemic Response and its economic impacts, Social impacts and Security impacts has to be measured, studies pertinent to this contagious and pandemic diseases is vital for human health and world economy. This work also focused upon providing early warning to the regions of interest, in this work the context of South India, especially Chennai is taken as the region of interest.

1.3   METHODOLOGY – A SCIENTIFIC APPROACH

The methodology used in this work is based on facts and scientific data. The experimental data analysis, interpretations are carried out using most promising and proven scientific procedures/algorithms. Exhaustive literature survey has been carried out to understand the nature and features of contagious diseases such as dengue, pandemic such as SARS virus. The necessary models to mitigate the challenges of these diseases were studied and the better models are chosen based on available scientific data.

The initial phase of this research work focused on understanding the efficacy of the machine learning approach in analyzing/predicting random data such as weather in a region and infectious diseases such as dengue. The results of these investigations have encouraged in using the ARIMA model in estimating the impact in the case of pandemic, namely, COVID-19.

The second phase of this work concentrated upon the application of deep learning algorithms on the prediction of spread of pandemic. This work has various dimensions those include, Environment Changes, Seasonal Changes, and Communicable Diseases.

1.4   ORGANISATION OF THESIS

This thesis is organized into four chapters to present the approach followed in realizing the research objectives.

Chapter 1 deals with the introductory concepts of contagious diseases and pandemic. The context in which this work is carried out and the methodology are explained.

Chapter 2 presents a report on the extensive literature study completed to arrive at the research objectives and the problem formulation has been stated.

Chapter 3 elaborates on the prediction mechanisms and effectiveness in health care. A case study approach has been presented in the case of dengue w.r.t to the variables influencing the spread of the disease. Similar study has been carried out for the efficacy using machine learning approach for COVID-19 also presented in this chapter.

Chapter 4 does the analysis and interpretation of the outcomes of deep learning based studies upon the impact of pandemic on normal life and presents about the conclusion and future scope.