Association Learning Between the COVID-19 Infections and Global Demographic Characteristics Using the Class Rule Mining and Pattern Matching

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ABSTRACT Over 26 million cases have been confirmed worldwide (by 20 August 2020) since the Coronavirus disease (COVID-19) outbreak in December 2019. Research studies have been addressing diverse aspects in relation to COVID-19 including potential symptoms, predictive tools and specifically, correlations with various demographic attributes. However, very limited work is performed towards the modelling of complex associations between the combined demographic attributes and varying nature of the COVID-19 infections across the globe. Investigating the underlying disease associations with the combined demographical characteristics might help in comprehensive analysis this devastating disease as well as contribute to its effective management. In this study, we present an intelligent model to investigate the multi-dimensional associations between the potentially relevant demographic attributes and the COVID-19 severity levels across the globe. We gather multiple demographic attributes and COVID-19 infection data (by 20 August 2020) from various reliable sources, which is then fed into pattern matching algorithms that include self-organizing maps, class association rules and statistical approaches, to identify the significant associations within the processed dataset. Statistical results and the experts’ report indicate strong associations between the COVID-19 severity levels and measures of certain demographic attributes such as female smokers, when combined together with other attributes. These results strongly suggest that the mechanism underlying COVID-19 infection severity is associated to distribution of the certain demographic attributes within different regions of the world. The outcomes will aid the understanding of the dynamics of disease spread and its progression that might in turn help the policy makers, medical specialists and the society, in better understanding and effective management of the disease.

INDEX TERMS COVID-19 Demographics Impacts, COVID-19 Symptoms, COVID-19 Causes, Association Rules in COVID-19, Global Deaths in COVID-19
I. INTRODUCTION

Respiratory viral illnesses are allied with the continuing and serious psychopathological concerns among survivors [1]. Coronaviruses are RNA (Ribonucleic acid) viruses that can trigger contamination illnesses including standard colds or even serious concerns such as severe acute respiratory conditions [2]. Research studies indicated that the exposure to coronavirus has shown to be associated with neuropsychiatric diseases including Middle East Respiratory Syndrome (MERS), Severe Acute Respiratory Syndrome (SARS) and other outbreaks [3]. Coronavirus disease (COVID-19) which initially appeared in Wuhan, China in December 2019, is triggered by acute respiratory syndrome and is referred to as coronavirus-2 (SARS-CoV-2).

In March, the classification of COVID-19 was altered from a “public health emergency” to a pandemic by WHO. COVID-19 pandemic is crucial global health disaster of modern history and the greatest trial human confronted since the World War II which has span every continent apart from Antarctica. There are more than 25 million cases and more than 850000 deaths to date (August 2020). COVID-19 affects people who have weak immune system, such as elderly and vulnerable people who have medical conditions including diabetes and cardiovascular diseases. The effects of the virus on children and young adducts is not known, since the number infections or/and death rate is very low [4]. This disease can be transmitted through droplets produced when an infected person sneezes, coughs, or exhales.

Various research studies has been addressing medical symptoms, personal attributes and demographic characteristics being highly correlated with the COVID-19 infection. For instance, centre of disease control and prevention (CDC) indicated that there are 52,166 deaths from 47 US jurisdictions [5] between February 12 to May 18, 2020. Amongst the 52,166 decedents, 79.6% were found to be aged 65, 55.4% were males, 40.3% contained white ethnicity, 21.0% were black, 13.8% were Hispanic/Latino, 3.9% were listed with Asian ethnic background. Median decedent age was found to be 78 years. Statistics also indicated that 0.3% were American Alaska Native/Indian, 0.1% were other Pacific Islander or Native Hawaiian, 2.6% were listed as multiracial or other ethnicity while 18% were identified with unknown ethnic background. Among 10,647 individuals who have died after testing positive for COVID-19 in 16 different public health jurisdictions in USA, the majority were aged 65 years while most of them had underlying medical ailments. Authors reported that 34.9% of Hispanic and 29.5% of non-white decedents were aged <65, compared to 13.2% of white, non-Hispanic decedents. Within decedents aged <65, 7.8% died in emergency units or at home.

Studies have also indicated other clinical attributes specifically, obesity [6, 7], cardiovascular diseases, and hypertension [6, 8] as important factors affecting the COVID-19 infection rate. On the other hand, studies address the demographic attributes such as GDP ratio of a country, smoking prevalence, and average annual temperature of a country [5, 6, 9, 10] etc., being highly correlated with the COVID-19 infection around the world.

Whilst the aforementioned studies have identified some clinical and economic demographic parameters to predict the disease spread and its associations, most of the works are either carried-out at early stages with insufficient amount of data, or using conventional statistical approaches, which are limited to investigate the individual attributes’ associations with the COVID-19 infections. An intelligent algorithm is needed to model the complex and multidimensional attributes in relation to investigate the combined impact of various demographic characteristics over the COVID-19 severity particularly, at the current stage where sufficient dataset is available. This could be helpful for understanding the in-depth demographic aspects of this disease that can significantly contribute towards the effective policy-making and disease management.

In order to explore COVID-19 severity and its associations to multiple demographical characteristics across the globe, this study investigate whether the diversity in the COVID-19 infection severity (e.g. variations in death rate) across the globe, is significantly associated with an individual or combination of demographic attributes?

To answer the underlying research question, authors have undertaken this study to model the associations between multiple demographic attributes including economic, socio-economic, environmental, and health related attributes. The varying nature of COVID_19 infections in global geographic regions is far from clear and therefore, adopting an open-minded approach is useful in unravelling such a complex problem. Deploying machine intelligence might have an advantage over the conventional statistical methods to analyze the complex patterns and potential associations between multiple predefined demographic facts and the COVID-19 spread in the world. The major contribution of this study include:

- Using Class association rules (CARs) to investigate the combined demographic attributes that are significantly associated to the COVID-19 infections severity across the globe.
- Using the Self-organizing maps (SOM) for the pattern identification within the multi-dimensional demographic and COVID-19 related datasets as well as detailed country-level information in the form of two-dimensional visualizations of COVID-19 spread across the globe, which is easily understandable and interpretable by humans.
- Gathering COVID-19 data as well as various demographic characteristics from different reliable public data sources and transformation into required form using statistical approaches and medical experts’ recommendations where appropriate.