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Identifying key indicators of job loss trends during COVID-19 and beyond

Satyaki Roy a,*, Ronojoy Dutta b, Preetam Ghosh c

a University of North Carolina, Chapel Hill, USA
b Deep Run High School, Glen Allen, VA, USA
c Virginia Commonwealth University, Richmond, USA

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ABSTRACT

COVID-19, declared by the World Health Organization as a Public Health Emergency of International Concern, has claimed over 2.7 million lives worldwide. In the absence of vaccinations, social distancing and lockdowns emerged as the means to curb infection spread, with the downside of bringing the world economy to a standstill. In this work, we explore the epidemiological, socioeconomic and demographic factors affecting the unemployment rates of United States that may contribute towards policymaking to contain contagion and mortality while balancing the economy in the future. We identify the ethnic groups and job sectors that are affected by the pandemic and demonstrate that Gross Domestic Product (GDP), race, age group, lockdown severity and infected count are the key indicators of post-COVID job loss trends.

1. Introduction

COVID-19 is the latest in the list of pandemics to reshape every facet of human existence. As of March 2021, over 2.7 million lives have been lost, and there is a possibility of a still higher fatality in Brazil, the UK, USA and parts of Asia (Coronavirus world map, 2020). Social distancing efforts, intended to curb the rapid spread of infection, has had an adverse effect on world economy. The decline in industrial output and stock exchange prices, increase in the price of goods (Khan et al., 2020) as well as a projected contraction in US GDP (Baker et al., 2020) are prompting the national leaderships to relax the lockdown rules in order to revive the global economy.

The world is beginning to recognize that there is a dearth of prior knowledge and coordinated mitigation strategies, making it necessary for the research community of epidemiologists, clinicians and computer scientists to identify the epidemiological or socioeconomic implications contributing to contagion as well as economic downturn (Adhikari et al., 2020). With regard to the United States, different states have experienced varied extents of infection spread and responded with commensurate levels of lockdown severity (Avila et al., 2020). It is evident that the robust predictions of social, cultural, demographic, health, and environmental factors affecting infection and death may contribute towards future government policymaking to contain contagion and mortality (Li et al., 2020; US Pharmacist, 2020). There have also been several efforts to study the long-term socio-psychological impact of the outbreak. For example, Sharma et al. discussed the role of misinformation causing cognitive dissonance, fear, indecision and xenophobia, etc. (Sharma et al., 2020). Verger et al. studied the psychological impact of COVID-19 on different age groups and the importance of “psychological competencies” such as creative and communication skills in alleviating the ill-effects on mental health (Verger et al., 2021). Chidue et al. discussed the differences in national preparedness and response in different parts of the world and the resultant public perception (Chidue et al., 2021). Monteblanco discussed the stress caused by the pandemic on the healthcare system, especially maternal facilities (Monteblanco, 2021). Kumar et al. highlighted the challenges and drawbacks in policies that exacerbated the suffering among Indian migrant workers during COVID-19 (Kumar & Choudhury, 2021)

Contributions. In this work, we compiled comprehensive datasets (see Sec.2.1) on the (1) businesses in US affected by COVID-19, ethnic groups employed by a sector and population data from the US Census Bureau Estimates and (2) diverse features from the 50 states of USA – this dataset includes features such as airport traffic, homeless numbers and variations in lockdown dates. We collate these datasets to identify the specific ethnic groups and job sectors that are worse affected by the pandemic. We utilize the GDP statistics to compare the impending economic crisis with that of the great depression of 2008-09. Following this, we apply multiple linear regression to show that race, age group, lockdown severity and infected count play a significant role in determining the job loss trends in each state.

* Corresponding author.
E-mail addresses: satyakir@unc.edu (S. Roy), bcps-duttar@henricostudents.org (R. Dutta), pghosh@vcu.edu (P. Ghosh).

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2. Materials and methods

Let us discuss the dataset and methods employed in this study.

2.1. Data

Our dataset has been carefully curated from several open sources to examine the possible factors that may affect the COVID-19 related infection and death numbers in the 50 states of USA (Roy et al., 2021; Roy & Ghosh, 2020). The integrated (curated) dataset has been shared on GitHub (Roy, 2020), and the summary of the original sources of the datasets is shown in Table A.3 of Appendix A.

2.1.1. Businesses closed due to COVID

The New York Times reported a state-wise list of businesses that are shut down (as per state laws) to prevent social contact and curb infection spread (Avila et al., 2020).

2.1.2. Ethnic groups employed by each sector

The US Bureau of Labor Statistics put out a summary of the number of individuals in different ethnic groups hired by each job sector in 2019 (US Bureau of Labor Statistics, 2020).

2.1.3. 2019 U.S. Census Bureau Estimates

The US Census Bureau reports a yearly breakdown of the population on the basis of age, sex, race, family arrangement, income and poverty, etc. (United States Census. Pop, 2020).

2.1.4. Data from US states

We discuss the state-level socioeconomic, demographic and epide-miological features and output labels covered in the integrated dataset (Roy, 2020).

- Gross Domestic Product (in terms of million US dollars) for US states (World Population Review., 2020) (filename: source/GDP.xlsx, feature name: GDP).
- Ethnicity feature(s) are the fraction of total population representing white, black, Hispanic and Asian individuals (we leave out other smaller ethnic groups) (population distrib, 2018) (filename: source/Data ethnic.csv, feature name: White, Black, Hispanic and Asian).
- Healthcare index is measured by Agency for Healthcare Research and Quality (AHRQ) on the basis of (1) type of care (like preventive, chronic), (2) setting of care (like nursing homes, hospitals), and (3) clinical areas (like care for patients with cancer, diabetes) (Agency for Healthcare Res, 2018) (filename: source/Data health.xlsx, feature name: Health).
- Homeless feature is the number of homeless individuals in a state (Hud Exchange. 2013 aahr, 2013) (filename: source/Data homeless.xlsx, feature name: Homeless). The normalized homeless population of each state is the ratio between its homeless and total population.
- Total cases (and deaths) of COVID-19 are the number of individuals tested positive and dead (United States Laboratory, 2020) (filename: source/Data covid total.xlsx, feature name: Total Cases and Total Death). The normalized infected/death is the ratio between the infected/death count to total population of the given state.
- Infected score and death score is obtained by rounding the normalized total cases and deaths to a discrete value between 0 and 6 (feature name: Infected Score, Death Score).
- Lockdown type is a feature capturing the type of lockdown (shelter in place: 1 and stay at home: 2) in a given state (United States Laboratory, 2020; Worldometer. Covid-19 cas, 2020) (filename: source/Data lockdown.csv, feature name: Lockdown).
- Day of lockdown captures the difference in days between 1st January 2020 to the date of imposition of lockdown in a region (Kimball et al., 2020) (filename: source/Data lockdown.csv, feature name: Day Lockdown).
- Population density is the ratio between the population and area of a region (United States Census. Pop, 2020) (filename: source/Data population.csv, feature name: Population, Area, Population Density).
- Traffic/activity of airport measures the passenger traffic (also normalized by the total traffic across all the states of USA (Kirk, 2009; Wikipedia. List of the bu, 2019) (filename: source/Data airport.xlsx, feature name: Busy airport score, Normalized busy airport).
- Age groups (0–80+) in brackets of 4 years (also normalized by total population) (United States Census. Pop, 2020) (filename: source/Data age.xlsx, feature name: age_to_norm, e.g., age4to8).

2.2. Pearson correlation coefficient

Pearson correlation coefficient (PCC) between any given random variables X and Y measures the strength of linear association between them. PCC value close to 1 and −1 reflect near perfect positive and negative correlations, respectively, while 0 indicates no correlation (i.e., uncorrelated)

2.3. Pearson correlation coefficient

Multiple regression (MR) captures the linear relationship between the independent and the dependent variables X and Y of a function \( Y = g(X) \). MR generates a linear relationship \( Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \epsilon \), where \( \beta_0 \) is the coefficient that captures the contribution of feature \( X_i \) towards the dependent variable Y, while \( \beta_0 \) and \( \epsilon \) are the intercept and error terms.

Summary of the methods. In Sec. 3, we estimate the Pearson Correlation Coefficient to estimate the relationship between GDP and job loss trends. We also perform frequency analysis to connect the reports of the specific employment sectors in the COVID era with those from prior recession trends. We utilize regression analysis to identify the various socioeconomic and demographic factors contributing towards the unemployment in the US states measured in terms of the job loss frequencies across each US state.

3. Results

Results are classified into two subsections: (a) relationship between unemployment rate and GDP (b) sectors and ethnic groups affected by job losses. The statistical summary of the features of the US states (discussed in Sec. 2.1.4) are shown in Table 1.

3.1. Relationship between unemployment rate and GDP

We plot the mean percentage unemployment rate and mean GDP across the 50 states in USA from January 2010 - present (Fig. 1a). Their inverse relationship is corroborated by Fig. 1b, which shows that GDP and unemployment rates have high negative correlation (approximately 0.8) for a majority of the US states. This statistic alludes to the fact that GDP itself is an immediate and effective indicator for the recent job loss trends.

3.2. Sectors and ethnic groups affected by job losses

When compared to the great recession of 2008-09 that marked a great slump in world economy, the projected recession in 2020 and beyond due to COVID-19 exhibits interesting trends. Fig. 2a shows that the goods manufacture, wholesale and finance sectors are amongst the worst affected sectors during both recessions (Bureau of Labor Statis, 2020; Goodman & Mance, 2011). In case of COVID-19, government regulations for restricted mobility as well as panic has caused an...
### Table 1

Summary of features and statistics (i.e., mean, standard deviation (dev.), maximum (max.) and minimum (min.)). Features in the order shown under ‘Feature name’ are GDP, ethnicity, quality of health care facility, number of homeless people, total infected and death, population density, airport passenger traffic, age groups in a state.

| Feature name                  | Abbreviation | Mean      | Dev.     | Max        | Min        |
|-------------------------------|--------------|-----------|----------|------------|------------|
| Gross Domestic Product        | GDP          | 412286:6  | 527087:5 | 3018337    | 34154      |
| Ethnicity                     | Wht, Blk, His, Asn | 0:24      | 0:28     | 0:93       | 0:0        |
| Healthcare index              | health       | 25:8      | 14:8     | 51:0       | 1:0        |
| Homeless                      | Home         | 11963:48  | 21859:53 | 136826:0   | 946:0      |
| Total Cases                   | Inf          | 32155:46  | 39521:26 | 168663:0   | 487:0      |
| Total Death                   | Dth          | 1677:86   | 2428:85  | 11770:0    | 10:0       |
| Population Density            | PD           | 173:39    | 210:6    | 103564:0   | 1:12       |
| Busy Airport Score            | Air          | 375630:44 | 249207:97| 1019704:0  | 100000:0   |
| Age group                     | age          | 362738:87 | 439896:78| 3125816:0  | 6853:0     |

**Fig. 1.** Relationship between GDP and unemployment rate. (a) Time varying evolution of unemployment rate and GDP between 2010 to present, (b) Pearson correlation coefficient between unemployment rate and GDP for all states of USA.

**Fig. 2.** Sectors and Ethnic Groups Affected by Job Losses. (a) Job sectors affected during recession of 2008-09 and COVID, (b) GDP during 2008 and 2020 recession.
additional decline in the leisure, recreation and education sectors (Franck, 2020). Consequently, COVID-19 has triggered a greater decline in GDP compared to the 2008 recession (Fig. 2b). We take a closer look at the job sectors that as well as the job losses suffered by ethnic groups (G), i.e., white, black, Asian and others (native Hawaiian, Pacific Islander, Hispanic or Latino, etc.), affected by COVID-19. We enlist the job sectors closed as per state regulation (refer Sec. 2.1.1) to curb infection spread, and categorize them into a set (S) of the following groups:

- bartenders (BR)
- dining room and cafeteria attendants (DN)
- entertainers, performers and sports workers (ENT)
- hotel, motel, and resort desk clerks (HOTL)
- lifeguards and other recreational, protective service workers (LIFE)
- miscellaneous entertainment attendants (MIS)
- recreation and fitness workers (REC)

We enumerate the frequency of these sectors in the list of closed businesses across all the states. Fig. 3a shows that the bars and diners feature as the most frequently closed businesses in order to curb social contact. This explains why leisure and recreation are the worst affected by the pandemic. We combine the state-wise list of closed businesses (Sec. 2.1.1) with the labor statistics data reporting the breakdown of the individuals in each ethnic group $g \in G$ (Sec. 2.1.2) to analyze how the pandemic has economically affected ethnic groups. On the basis of labor statistics data, we define job loss index as the expected number of people working in sector $s$ by the fraction of the total population belonging to group $g$ (obtained from the US census records discussed in Sec. 2.1.3). The red bars show which of the socioeconomic, demographic and epidemiological factors (discussed in Sec. 2.1.4) influence the increase in state-level unemployment rates. We select dependent variable ($Y$) as the increase in unemployment rates and independent variables ($X$) as all 4-combinations from the following set of features (all enumerated in Sec. 2.1.4): race (white, black, Hispanic, Asian), health index, homeless, confirmed COVID cases, lockdown severity, lockdown date, population density, airport traffic and age groups in intervals of 4. We rank our parameters of regression in the decreasing order of the $R^2$ values (which signifies how effectively $Y$ captures the variance in $X$). The top results are summarized in Table 2, along with the $p$ values.

- High age groups (80+) emerge as a key factor with high positive coefficient across most of the top results, suggesting that states with a smaller younger population have higher job loss trends.
- The fraction of white population has negative coefficient indicating that states with a lower proportion of whites experienced a higher job loss.
- States with high number of confirmed cases lose fewer number of jobs. This is because such states either relaxed lockdown severity or people living in the states have flouted state regulations and ventured out.
- Lockdown severity also exhibits a positive correlation with job loss trends, showing that states observing stricter social distancing measures to restrict infection spread lost more jobs in the bargain.

**Observations.** Our analysis demonstrates that the declining GDP captures the job loss trends in the COVID-19 period fairly accurately. The sudden surge in the COVID numbers made contagion containment an absolute imperative and greatly hurt the revenue derived from the leisure, education, construction and government sectors. This finding is corroborated by the high job loss trends in the bars and diners (Roy et al., 2021). We know that the CDC continues to impose strong guidelines for recreational activities (Center for Disease Control, 2020), although social isolation has fostered indoor activities and family time (Guzel et al., 2020). Interestingly, unlike the general perceptions, the white population have high job loss rates. This supports recent trends of premature job loss among non-Hispanic whites particularly in rural areas due to socioeconomic factors (Stein et al., 2017). Through regression studies, we observe that states that relaxed lockdown regulations tend to exhibit lower job losses, albeit at a higher contagion rate.

**4. Conclusions**

In this work we analyze the demographic, socioeconomic and epidemiological data of the different states in USA to understand their impact on the unemployment rates and job loss trends in the post-COVID period. We look at the ethnic groups and job sectors affected by the pandemic in light of the GDP of recession of 2008-09 and utilize multiple linear regression (refer Sec. 2.3) to understand which of the socioeconomic, demographic and epidemiological factors (discussed in Sec. 2.1.4) influence the increase in state-level unemployment rates. We select dependent variable ($Y$) as the increase in unemployment rates and independent variables ($X$) as all 4-combinations from the following set of features (all enumerated in Sec. 2.1.4): race (white, black, Hispanic, Asian), health index, homeless, confirmed COVID cases, lockdown severity, lockdown date, population density, airport traffic and age groups in intervals of 4. We rank our parameters of regression in the decreasing order of the $R^2$ values (which signifies how effectively $Y$ captures the variance in $X$). The top results are summarized in Table 2, along with the $p$ values.

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linear regression to show that race, age group, lockdown severity and infected count play a vital role in determining the job loss trends in each state. We infer that it is imperative to incorporate these heterogeneous factors while carrying out government policymaking with respect to the duration, timing and extent of lockdown.

**CRediT authorship contribution statement**

Satyaki Roy and Preetam Ghosh conceived the study and conceptualized the methods. Ronojoy Dutta performed the experiments. All authors contributed towards writing the manuscript.

**Declaration of competing interest**

We have no conflict of interest.

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**Appendix A. Data references**

| Table A.3 | Summary of original sources for the socioeconomic and epidemiological data; the compiled dataset is available at (Roy, 2020) |
|-----------|----------------------------------------------------------------------------------|

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**Fig. 4.** Difference between predicted and actual unemployment rate in each state in the first two quarters of 2020 showing an overall nationwide increase in job losses.
In Table A.3 we summarize the tables utilized in the study.

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Dr. Satyaki Roy is a postdoctoral research associate in the Department of Genetics, University of North Carolina Chapel Hill, USA. He has completed his Ph.D. from the Department of Computer Science, Missouri University of Science and Technology, USA in 2019. His research interest lies in computational biology, epidemiology, network science, wireless networks and parallel computing.

Ronojoy Dutta is a rising senior at Deep Run High School and a visiting research scholar at the Biological Networks Research Lab, Department of Computer Science, Virginia Commonwealth University. His research interests include simulation and optimization techniques in biological systems and applied machine learning.

Dr. Preetam Ghosh is a Professor in the Department of Computer Science and Affiliate Professor in the Department of Radiation Oncology at Virginia Commonwealth University. He currently serves as the Secretary/Treasurer of ACM-SIGBIO, served on the technical program and executive committees of various international conferences including ACM BCB and on the Editorial Board of journals like Frontiers in Systems Biology. He obtained his Ph.D in Computer Science from UT-Arlington, completed postdoctoral training in Biomedical Informatics at UT-Southwestern Medical Center and also held summer appointments with the wireless gaming division at Nokia Research, Systems engineering division at Nortel Research, and the Exploratory medicinal services division at Pfizer Global Research. His research interests include simulation and modeling methodologies applied to Bioinformatics, Computational and Systems Biology domains that have resulted in several federally funded research projects from NSF, NIH, DoD and US-VHA.

Table A.3 (continued)

| Dataset               | References for original data sources                                                                 |
|-----------------------|--------------------------------------------------------------------------------------------------------|
| Homeless              | HUD exchange (Hud Exchange. 2013 aahr.; 2013)                                                          |
| Total COVID cases and deaths | COVID data tracker (United States Laboratory, 2020)                                                      |
| Lockdown              | Worldometer (Worldometer. Covid-19 cas, 2020)                                                           |
| Population density and age group | US Census Records (United States Census. Pop, 2020)                                                  |
| Airport               | Airport Improvement Program (Kirk, 2005; Wikipedia. List of the bus, 2019)                            |