Indian Journal of Economics and Business
Vol. 20 No. 4 (December, 2021)

http://www.ashwinanokha.com/IJEB.php

Effect of Crowding and Hygiene on COVID-19 Cases and Deaths in Punjab: Application of Negative Binomial Regression Model

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Received: September 10, 2021
Revised: October 12, 2021
Accepted: December 15, 2021

Abstract:

Objective: In current study objective is to investigate the effect of crowding and hygiene facility on COVID-19 cases and deaths in the Punjab, Pakistan.

Methods: Data on predictors has been taken from recent waves of Multiple Indicator Cluster Survey (MICS-2017-18), Punjab at district level. Data on response variable i.e. number of COVID-19 cases and deaths at district level has been accessed from websites of Punjab health care department (accessed on 29th April 2021). Study period is February, 2020 to May, 2021. Negative Binomial regression model is fitted to meet the objective.

Results: The value of IRR (IRR=1.000021, p-value=0.000) for crowding in the district is greater than 1 that shows effect of crowding is significantly positive on COVID-19 cases. Effect of crowding on the deaths due to COVID-19 in Punjab is also significantly positive (IRR=1.000021; p-value=0.015). The value of IRR (IRR=0.9999182; p-value=0.384) is less than 1 that shows effect of hygiene facility in the district has insignificantly inverse on COVID-19 cases. Insignificant negative effect (IRR=0.999828; p-value=0.221) of hygiene variable is also observed on COVID-19 deaths.

Conclusion: Crowding (population density and average number of persons sharing room in the districts) has been identified as significant risk factor of COVID-19 mortalities and morbidities in the Punjab. Hygiene facilities

(Handwashing and sanitation facility) has been identified as protective factor in Punjab but with insignificant effect.

Key Words: COVID-19, Handwashing, Sanitation, Crowding, Negative Binomial Regression

Introduction

Coronavirus, SARS-CoV-2, has caused a worldwide pandemic of respiratory illness, called COVID-19(WHO). COVID-19 is the disease caused by the new coronavirus that was first identified in 2019(WHO). The coronavirus can spread from person to person. COVID-19 appeared in Wuhan, a city in China, in December 2019.

Pakistan was placed at the second highest number of confirmed cases of COVID-19 in the list of South Asian countries after India in the second wave. In Asian countries, Pakistan stood on 9th highest number and 31st globally highest number regarding number of confirmed cases. Pakistan was reported at 29th number globally, regarding frequency of death due to COVID-19[(1)]. The spread of COVID-19 was not same in all areas of Pakistan. Four cities were identified as more exposed in the first two waves i.e. Karachi, Lahore, Islamabad and Peshawar[(1)]. These big cities bear a burden of approximately 55% of total confirmed cases of COVID-19 from Pakistan. These cities are congested and packed.

Since from the outbreak of COVID-19, World Health Organization is constantly emphasizing on hand washing and social distancing. Here question arises whether people living in low resource setting and in highly populated country like Pakistan, can practically implement social distancing and follow proper hygiene practices.

Only few researchers addressed the non-clinical factors that may be related to spread of COVID-19. Human interaction is major cause of corona virus transmission. Hence crowding help virus to spread. Population of Pakistan is 216.6 million in 2019[(2)]. It is densely populated country, where risk of extending the exposure of infection diseases become higher.

Risk of infection increases if an infected person is living in the place where social distancing is impossible. According to WHO, crowded homes are responsible for spreading the respiratory diseases[(3)]. World Health Organization defined that household is said to be crowded if more than three persons are sharing the room. Crowding means many people share small living space. In India, crowded households identified as potential risk factor of infectious disease[(4)]. In Pakistan, combine family system is popular. Multigenerational residents are expected in combine family system where both young and old persons live jointly in home[(5)]. In such situation standard quarantine measures (SOPs) are not easy to follow in case anyone got infected. Moreover, due to multigenerational residents, risk of death is expected to be higher if elderly people are living at home.

Hand washing is effective preventive measure to save from getting sick and avoid others to catch infections[(6)]. The coronavirus stays for a longer period on the surfaces[(6)]. During coughing or sneezing, there is accelerated risk that respiratory droplets stay at hands. People consciously or unconsciously touch mouth, eyes or nose off and on and it can become a source of infection. Frequent hand washing habit obstruct the virus to enter body through hands[(6)]. It is recommended by WHO to regularly wash hands prior to cooking, eating, after using toilet, touching animal, or changing baby diaper etc. Availability of handwashing amenities with water and soap should be within the five-meter access from lavatories[(7)].

People infected from COVID-19 should be provided improved and separate sanitation facility[7]. World Health Organization suggested standard, well maintained sanitation facilities to avoid infections. In 2003, in Hong Kong, spread of aerosolized SARS corona virus was observed due to defective sanitation system in multistory residential building[8]. It is also suspected that one of reason of wide spread of COVID-19 in multistory buildings might be faulty sanitation[9]. In case of less resources, pit latrine is recommended by WHO[7].

The hypothesis of association between population density and infection rate of disease is still under investigation since 1918 influenza pandemic due to varying results. Some studies negated relationship between 1918 influenza and population density[10]. A positive association has been reported in recent study based on COVID-19[11]. Another study based on urban areas reported earlier outbreak of COVID-19 in the dense regions. Although there was no association between population density and mortality rates[12]. This relationship needs to be further investigated in current pandemic to reach any conclusion[13]. In the first two waves of COVID-19 in Pakistan, it was observed that spread was observed more in big cities of urban areas as compared to rural areas[1].

The first case appears on 15 March 2020 in Punjab (14). Lahore, the country's second-largest city, has recorded (as of 5 September 2020) 49,000 cases of COVID-19, making up about 16% of the country's cases. In 3rd wave cases, recoveries and deaths were 267572, 216237 and 7430 respectively. In this wave the incidence rate is higher than other provinces[15].

Objective of current study is to investigate the effect of hygiene and crowding on COVID-19 cases and deaths in Punjab, Pakistan.

Material and methods

In current study, the effect of possible predictors such as mean number of persons sharing the room for sleeping in the household, percentage of households who had access to basic hand washing facilities (availability of soap and water facility in the household), percentage of households who had access to improved sanitation facility and population density (population/area per square kilometer) in districts on exposure and deaths due to COVID-19 in district is investigated. The data at individual household level is hard to collect on these indicators so all variables are taken at district level. Data has been taken from 36 districts of Punjab. The data related to independent variables has been collected from reports of MICS 2018 Punjab[16].

There are two dependent variables in current study. One is number of COVID-19 cases and other is number of deaths due to covid-19. Both variables are discrete in nature. Data on both dependent variables has been collected from websites of Primary & secondary health care department[17].

Statistical Technique

To study the impact of independent variables on COVID-19 cases and deaths in Punjab, appropriate model is Poisson regression model as both cases and deaths are count events. Poisson regression model is fitted as benchmark model and then Negative Binomial regression model is fitted due to over dispersion[18].

Results

This section comprised of descriptive and multivariate analysis in sequence using district level data of Punjab.

Table 1: Summary Statistics of Study Variables for Punjab

Variables	N	Min.	Max.	Median	Mode	Mean	SD
COVID-19 Cases	36	690	158090	2015	-	8300.50	26147.88
COVID-19 Deaths	36	0	3428	41	-	231.30	607.23
Hand Washing Facility (%)	36	71	98	-	-	91.05	5.38
Improved Sanitation Facility (%)	36	52	98	-	-	77.91	11.65
Household Crowding	36	3	5	-	4	3.94	0.41
Population Density	36	13.86	62768.9	524.36	-	2290.62	10531.88

Since there are outliers in the variables COVID-19 cases, deaths, population density so median is appropriate measure of average for these three variables. Median for case, deaths and population density is 2015, 41 and 524.36 respectively. Household crowding is discrete variable, so mode is appropriate average to report. In majority of districts in Punjab, on the average, 4 (Mode=4) persons shares room for sleeping. On the average, percentage of population in Punjab with handwashing facility with soap and water and improved sanitation facility is 91% and 78% respectively. There is more variation (11.65) across district in percentage of households with improved sanitation facility. For handwashing facility variation (5.38) is less as compared to improved sanitation facility among districts. High variability (26147.88) is found for cases. For choice of appropriate count regression model, assumptions of multicollinearity and equi dispersion are checked.

Table 2: Testing of Assumptions

Detection of Multicollinearity (Punjab)			
	Eigenvalue	**Condition Index**	
1	4.0320	1.0000	
2	0.9411	2.0699	
3	0.0225	13.3881	
4	0.0032	35.2749	
5	0.0011	59.2312	
Equi-Dispersion Assumption			
Variables	**Mean**	**Variance**	**Alpha**
Cases	8300.5	68377711628.5	.745377*
Deaths	231.30	3688731.06	1.85749*

*significant at 5% level of significance

From Table 2, it can be seen that the eigenvalues are close to zero and also the condition index is greater than 30, this indicates the multicollinearity. To handle multicollinearity two new variable are computed using interaction of existing variables. Variable improved hygiene facility is computed by the interaction of two variables i.e., handwashing facility and improved sanitation facility. Second variable named as crowding is generated by using interaction of household size and population density.

Improved Hygiene Facility =Handwashing Facility (%) *Improved Sanitation Facility (%)

Crowding = Household Crowding*Population Density

One of the features of Poisson distribution is that the average of occurrences of a rare event is equals to the variation in the occurrences of that event (18) i.e. $E(x) = \mathrm{Var}(y)$. Since$\mathrm{Var}(y_i) > E(y_i)$, for both outcome variables (cases and deaths), hence it is concluded that data shows the over-dispersion (Table 2). Dispersion parameter alpha is also used to test the assumption. Alpha>0 and also it is statistically significant for both response variables[18]. In case of over-dispersion recommended model is Negative Binomial regression model.

The value of IRR (IRR=1.000021, p-value=0.000) for crowding in the district is greater than 1 that shows effect of crowding is positive on COVID-19 cases (Table 3). It can be concluded that increase in the crowding in the district has resulted in the significantly higher risk of increase in the cases of COVID-19 in the district. Effect of crowding on the deaths due to COVID-19 in Punjab is also significantly positive (IRR=1.000021; p-value=0.015). It is found that crowded districts have higher chances of increased death poll due to COVID-19.

Table 3: Incidence Rate Ratio of Negative Binomial Regression Model (Punjab)

	Cases of COVID-19			Deaths by COVID-19		
	IRR	**p-value**	**95% C.I. (LL-UL)**	**IRR**	**p-value**	**95% C.I. (LL-UL)**
Crowding	1.000021	0.000	.9997338-1.000103	1.000021	0.015	0.999553-1.000103
Improved Hygiene	0.999918	0.384	1.000011- 1.000032	0.999828	0.220	1.000004-1.000037
Constant	.999918	-	-	1.857490	-	-

IRR =Incidence Rate Ratio, LL=Lower limit, UL=Upper limit, C.I.=Confidence Interval

The value of IRR (IRR=0.9999182; p-value=0.384) is less than 1 that shows effect of hygiene facility in the district is inverse on COVID-19 cases. It can be concluded that increase in the percentage of household with proper hygiene facilities has resulted decline in COVID-19 cases in the districts of Punjab. Negative effect (IRR=0.999828; p-value=0.221) of hygiene variable is observed on COVID-19 deaths. Risk of mortality is decreased if percentage of household in the districts with improved hygiene facilities is increased. This factor has insignificant effect.

Discussion

After the outbreak of COVID-19, World Health Organization disseminated certain precautionary measures, top of these are social distancing and hand washing. It is called foremost line of protection. Inequalities in access to improved handwashing amenities and the number of people sharing living space is observed not only across countries but across communities within same country or at subnational level. At district level population density is used as proxy measure for crowding. Physical distancing at crowded places is not easy to follow, whether crowding is at household level or at district level. In three of South Asian countries Pakistan, India and Afghanistan have almost on average three persons sharing a room for sleeping. In Pakistan, among South Asian countries has highest mean number of persons sharing a room for sleeping. In Pakistan, around two quarter (65%) households have at least three members sharing a room. At least 5 people shares room in 27% of households in Pakistan[19].

Hand washing is another highly recommended activity during COVID-19 pandemic. It requires facility of improved hand washing facility in the household with availability of soap at hand washing place. Improved sanitation is also needed to ensure hygiene and consequently reduce disease burden. In many developing countries like Pakistan many households have not access to simple hand washing facility with detergent and water. In current study it is investigated to find the effect of crowding and hygiene facility on COVID-19 cases and deaths in the Punjab. Exploring risk factors help to manage medical

resources during pandemic. It provides data driven evidence to WHO guidelines. Study is also important as Pakistan suffered less severely from pandemic as compared to many other countries to explore reasons. Due to unavailability of household level data, district is taken as unit of analysis. Current study assessed effect of non-clinical factors using immediate available data.

For Punjab crowding in the districts has been identified as significant risk factor for both spread and deaths due to COVID-19 in the districts of Punjab, Pakistan. It was found that crowded districts had higher chances of increased exposure and death poll due to COVID-19. It was found that population density used as an indicator of social distancing had a significant effect on COVID-19 mortality and morbidity rate[20]. Population density also played an important role in the outbreak of COVID-19 for country Iran[21]. Population density was also observed highly correlated with spread of COVID-19 in England, Germany and Japan except China[22]. Trend was reverse in China and reason may be strict lockdown so in spite of that China is densely populated, effect of population density was not present. In India, housing and hygiene characteristics (persons sharing room in household, unavailability of handwashing facility and sanitation facility) were used to compute the vulnerability index for COVID-19. These three indicators are very useful to access susceptibility and vulnerability. Elderly people residents of dense urban areas are more susceptible and vulnerable to both mortality and morbidity[23].Intra household crowding is vital risk factor in case of Pandemics[4]. It increases respiratory contagion[3]. Household crowding become more threat if residents sharing rooms are multigenerational like in India and Pakistan[24]. Population density is significant factor irrespective whether country is highly populated or not[25].

Regular and appropriate hand washing exercise not only depends on personal hygiene attitude but also depends on availability of essential infrastructure at home and outside home[5]. Increase in the percentage of household with proper hygiene facilities had resulted decline in COVID-19 cases and deaths in the districts of Punjab, Pakistan. Appropriate hygiene facilities in the household are thus identified as protective factor for both exposure and deaths due to COVID-19 in Punjab though its effect is insignificant.

Conclusion and Recommendation

Crowding (population density and average number of person sharing room in households) has been identified as significant risk factor of COVID-19 mortalities and morbidities in the Punjab, Pakistan. Hygiene facilities (Handwashing and sanitation facility) has been identified as insignificant protective factor in Punjab. Insignificant impact of hygiene reflect that behaviors matters more as compared to availability of infrastructure for handwashing and sanitation facilities. Significant impact of population density recommends Government to follow strict lock down during waves of COVID-19. In spite of Government hand washing campaigns in the pandemic period its effect remains insignificant. Government should use holistic approach on social or digital media in Punjab to change behaviors of people about personal hygiene so that its effect be converted into significant protective factor. Analysis can also be extended by taking country as unit of analysis.

Strengths and Limitations

Impact of two foremost line of action on COVID-19 exposure and mortalities advised by WHO are investigated for Punjab, Pakistan. Since impact varies country wise so it is essential to identify the role of both precautionary measures in our country on the basis of data driven evidence.

Sample (Districts) taken is pretty small due to data availability constraint at lower level of communities. Analysis is restricted to macro level due to unavailability of COVID-19 cases and deaths data at household level.

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