The correlation of population, population density, age, and sex to the number of confirmed cases of COVID-19 among local government units in the National Capital Region

Ron Carlo C. Vedan; Alixson M. Velasquez, RPm; Nina Patricia S. Ventura; Estrella Natalia O. Vigo, RMT; Cristina P. Villanueva, RMT; Crizelle Keith G. Villanueva; Geneve S. Villareal; Kimberly Anne D. Wee; Victor Antonio F. Yañga, PTRP; Krista Mari P. Yap, RPh; Ally Norr G. Yee; Dan H. Zambrano III; Rik James S. Zantua and Leopoldo P. Sison, Jr., MD, MPH

Abstract

Introduction The NCR had amassed 752,668 cases of COVID-19 as of September 2021, the highest among the regions in the Philippines. This study aimed to determine the correlation between population, population density, age, and sex with the number of cases among local government units (LGU) in the National Capital Region (NCR).

Methods The data for population, population density, age, and sex distribution of the LGUs of NCR were retrieved from the 2015 Philippine census while the data for cases were from DOH's COVID-19 Tracker. Pearson correlation coefficient was computed to determine the correlation between population, population density and cases. Phi and Cramer's V statistic were computed to determine associations between sex, age groups, and cases.

Results There was little or no correlation between population density and number of cases ($r = 0.236$) but was good ($r = 0.905$) when Quezon City was excluded for being an outlier. There was good correlation between population and number of cases ($r = 964$, $p < 0.001$). There was very weak to no association between sex and number of COVID-19 cases. There was a statistically significant moderate association between age and COVID-19 cases ($\phi = 0.145$, $p < 0.001$).

Conclusion The study has shown that population density and population have a good correlation with the number of COVID-19 after Quezon City was removed as a data point. There is a moderate association between age and number of COVID-19 cases. There is a very weak to no association between sex and COVID-19 cases.

Key words: COVID-19, population density, correlational study

Epidemics and pandemics have brought about changes not only in the healthcare system, but also in man's social life, economy, and travel. The latest pandemic that has been wrecking havoc across the world is COVID-19, which came to the attention of the World Health Organization (WHO) on December 31, 2019 when their China office was informed of a group of patients with pneumonia of unknown origin in Wuhan City.[1] At the time of this writing, despite

Correspondence:
Victor Antonio F. Yanga, PTRP, Department of Preventive and Community Medicine, College of Medicine, University of the East Ramon Magsaysay Memorial Medical Center, Inc., 64 Aurora Boulevard, Barangay Doña Imelda, Quezon City, PH 1113; E-mail: yangav3369@uerm.edu.ph; Telephone: +63917 521 7550

Department of Preventive and Community Medicine, College of Medicine, University of the East Ramon Magsaysay Memorial Medical Center, Inc., Quezon City, PH

combined efforts of WHO and involved countries, the virus has spread to 222 countries and territories.[2] In the Philippines alone, 2,385,616 confirmed cases and 36,934 deaths have been recorded.[3] The country was only second to Indonesia with the greatest number of confirmed cases in Southeast Asia. This is despite the Philippines recording 23,210 cases per million, which is close to double compared to Indonesia.[4] The National Capital Region (NCR) had the highest number of cases among the regions, with 752,668 confirmed cases, equivalent to 31.55% of the country's total. This was followed by Region IV-A, found in close proximity to NCR, with 450,008 confirmed cases.[3] In spite of efforts to contain the spread of the virus through lockdowns, cases in NCR showed a slow decline in the number of new cases since mid-August of 2020, followed by a rapid rise in mid-April 2021 and mid-September 2021.[3] As of September 20, 2021, the confirmed cases in the Philippines were 2,385,616 of whom 51.1% were male, the most affected age groups were 25-29 years (15.5%) and 30-34 years (13.3%). As shown in Table 1, Quezon City (QC) had the bulk of the cases in NCR with 151,856 (20.2%) and held the largest increase in new cases from NCR, followed by the City of Manila with 94,032 cases (12.5%), and Caloocan City with 57,833 cases (7.7%). Pateros had the lowest number of cases (1%).[3] Tables 2 and 3 show the sex and age distribution of the cases, respectively.

There have been several studies correlating the spread of COVID-19 and population density, which is a measure of the number of people living per square kilometer in an area. One such study found that countries with greater population density had higher rates of transmission that may be due to increased contact rates.[5] Furthermore, studies in Algeria and Japan have shown similar results, with increasing population density being implicated in a higher number of confirmed cases of COVID-19.[6] However, this, may not be the case in countries with strict lockdown rules.[7] This is in consideration that population density and COVID-19 case estimates are influenced by factors such as socioeconomic indicators, adherence to social distancing policies, and infrastructures catering to health care services.[8] According to the largest publicly available database on sex-disaggregated data on COVID-19, worldwide, there is no clear trend whether either sex is more likely to be infected with the virus. However, many of the countries report that when it comes to mortality, men are more likely than women to die from COVID-19.[9] A study on the epidemiologic profile of COVID-19 in the Philippines found that slightly over half of

Table 1. Population, population density, and cases of the different LGUs in NCR.

District	City	Population	Population Density (pax/km^2)	Cases	Cases per 1000
1	Manila	1,780,148	71,263	94,032	52.82
2	Mandaluyong	386,276	41,580	29,563	76.53
	San Juan	122,180	20,534	14,569	119.24
	Pasig	755,300	15,586	55,020	72.85
	Quezon City	2,936,116	17,099	151,856	51.72
	Marikina	450,741	20,945	23,977	53.19
3	Caloocan	1,583,978	23,387	57,833	36.51
	Malabon	365,525	23,267	21,773	59.57
	Navotas	249,463	27,904	17,209	68.98
	Valenzuela	620,422	13,195	34,313	55.31
4	Las Pinas	588,894	18,014	31,408	53.33
	Muntinlupa	504,509	12,692	26,760	53.04
	Paranaque	665,822	14,297	43,556	65.42
	Pasay	416,522	29,815	35,174	84.45
	Makati	582,602	27,010	53,097	91.14
	Taguig	804,915	17,804	55,165	68.54
	Pateros	63,840	17,804	7,363	115.34
NCR		12,877,253	20,784	752,668	58.48

Table 2. Population, cases, cases per 1000 in females and males per age group in NCR.

Age Groups	Female			Male		
	Population	Cases	Cases/ 1000	Population	Cases	Cases/ 1000
0 to 4	578,262	6,614	11.44	622,181	7,570	12.17
5 to 9	562,817	7,803	13.86	600,902	8,506	14.16
10 to 14	552,556	10,215	18.49	583,036	10,911	18.71
15 to 19	635,585	15,479	24.35	618,218	14,771	23.89
20 to 24	687,833	42,064	61.15	661,172	39,501	59.74
25 to 29	638,532	56,958	89.20	626,570	60,030	95.81
30 to 34	548,788	46,138	84.07	555,830	53,644	96.51
35 to 39	483,275	34,535	71.46	480,592	40,484	84.24
40 to 44	409,369	28,666	70.02	408,420	34,276	83.92
45 to 49	364,570	23,919	65.61	347,683	27,593	79.36
50 to 54	309,071	23,185	75.02	282,371	24,547	86.93
55 to 59	247,539	20,824	84.12	220,867	20,147	91.22
60 to 64	186,953	17,127	91.61	158,211	15,211	96.14
65 to 69	124,534	12,429	99.80	98,704	11,283	114.31
70 to 74	73,271	8,991	122.71	49,693	8,121	163.42
75 to 79	53,010	5,258	99.19	30,692	4,104	133.72
80+	52,923	7,497	141.66	23,223	4,267	183.74

Table 3. Population, cases, cases per 1000 per age group in NCR.

Age Group	Population	Cases	Cases per 1000
0 to 4	14,184	1,200,443	11.82
5 to 9	16,309	1,163,719	14.01
10 to 14	21,126	1,135,592	18.60
15 to 19	30,250	1,253,803	24.13
20 to 24	81,565	1,349,005	60.46
25 to 29	116,988	1,265,102	92.47
30 to 34	99,782	1,104,618	90.33
35 to 39	75,019	963,867	77.83
40 to 44	62,942	817,789	76.97
45 to 49	51,512	712,253	72.32
50 to 54	47,732	591,442	80.70
55 to 59	40,971	468,406	87.47
60 to 64	32,338	345,164	93.69
65 to 69	23,712	223,238	106.22
70 to 74	17,112	122,964	139.16
75 to 79	9,362	83,702	111.85
80+	11,764	76,146	154.49

the cases were men.[10] In the United States, where testing was prioritized for symptomatic individuals, diagnosis rates were similar for men and women although in South Korea, where community testing was mainly practiced, more women tested positive. In both countries, however, men had higher mortality rates.[11] A study linked the higher rates of COVID-19-associated morbidity and mortality of men to a range of biological, psychological, and behavioral factors.[12]

This research aimed to determine the correlation of population, population density, age, and sex with the number of confirmed cases of COVID-19 among the Local Government Units (LGUs) in NCR from January 30, 2020, to September 20, 2021. The study specifically aimed to determine 1) the correlation of population and the number of confirmed cases of COVID-19, 2) the correlation of population density and the number of confirmed cases of COVID-19, and 3) the relationship of age, sex, and the number of confirmed cases of COVID-19.

Methods

This study employed a correlational design as its objectives were to identify the relationship between COVID-19 cases per age range and sex, population, and population density among LGUs in NCR. The age-sex structure, population, and population density of the 16 cities and 1 municipality in NCR were retrieved from the 2015 census of the Philippines from the Philippine Statistics Authority website. The data for the confirmed cases of COVID-19 per age and sex were retrieved from the DOH COVID-19 Tracker. Population density was computed as the number of individuals or inhabitants occupying an area of 1 km^2 (inhabitants/km^2) per LGU.

Pearson correlation coefficient (r), with the following cut-off values: 0.00-0.25 for little to no correlation, 0.26-0.50 for fair, 0.51-0.75 for moderate to good, and > 0.75 for good to excellent correlation, was used to determine the strength and the nature of relationship between population and population density and the number of COVID-19 cases in each LGU.[13] A Pearson correlation was done to assess the strength and nature of relationship between population density and the number of COVID-19 cases per sex. Using the population and population density data, different statistical analyses were used to determine the correlation of sex and age with number of COVD-19 cases. Phi and Cramer's V were used to test for association between age and COVID-19 cases, and for association between sex and COVID-19 cases with the following cut-off values: > 0.25 for very strong association, > 0.15 for strong, > 0.10 for moderate, > 0.05 for weak, and > 0 for very weak to no association. Additional statistical analysis, specifically Pearson correlation coefficient was used to assess the correlation of population density with sex. A subset analysis was carried out excluding the data from an outlier LGU.

Results

Population density, population and COVID-19 cases

The Pearson correlation for population density was r = 0.236, indicating little or no correlation, however this was not statistically significant (p = 0.362). The Pearson correlation for population was r = 0.964, indicating a good correlation that was statistically significant (p < 0.001). Figures 1 and 2 showed that Quezon City was an outlier in terms of population density but not in population. Excluding Quezon City and recomputing the Pearson correlation for population density resulted in r = 0.905, indicating a good correlation which was statistically significant (p < 0.001). Excluding Quezon City in the recomputation of Pearson's correlation for population showed a moderate to good correlation (r = 0.569, p = 0.021).

Sex and COVID-19 Cases

Using a phi and Cramer's V statistic, there was a very weak to no association between sex and COVID-19 ($\phi = 0.008$, $p < 0.001$).

Population density and COVID-19 cases per sex

A Pearson correlation showed a weak to low correlation between population density and cases per sex that was not statistically significant (r = 0.264, p = 0.306). However, like population density and COVID-19 cases, removing Quezon City as a data point yielded a statistically significant, moderate to good correlation between population density and both sexes (r = 0.588, p = 0.017).

Age and COVID-19 cases

As shown in Table 3, there were more cases in the 20-24 years age group with a peak in the 25-29 and 30-34 years age groups (92.47 and 90.33 cases per 1000 population) and a higher incidence in the 65 years and older age groups. Phi and Cramer's V statistic showed a statistically significant moderate association between age and COVID-19 ($\phi = 0.145$, $p < 0.001$).

Discussion

In this study, the researchers analyzed the relationship of population, population density, age, and sex, with the number of COVID-19 cases. The results show that in NCR, an increase in population may lead to an increase in the number of COVID-19 cases. This is similarly supported by previous research in Japan, New York, Madrid, and London.[14,15]

The continued movement and traffic of people engaged in face-to-face activities like social gathering events and industrial activity may also have a bigger effect on the rise of cases.[16] Conversely, access to private transportation may help stem the infection with COVID-19 by minimizing contact with infectious and susceptible individuals. In a study from Ethiopia, probable factors contributing to the fast spread of coronavirus include poverty, which leads to a poor way of life and an increased vulnerability to infectious diseases.[17] Poor access to personal protective equipment as well as the health care itself, large family size with poor housing, and citizens who engaged in risky working conditions in order to support their daily lives were some of the contributing factors on how poverty affects increasing COVID-19 cases, thus strong and continuous intervention is needed to support the poor during the pandemic.[17] In the Philippines, with a fairly high incidence of poverty and where more than 16% of the population are living below the poverty line, this may also be one of the reasons why cases are still increasing.[18]

A study showed that a reason why densely populated areas may have lower infection and mortality rates could be the presence of superior healthcare systems in these areas.[19] Sociodemographic characteristics and social inequities were noted as factors which can also affect the spread of infectious diseases, as well as prevent access to health care. This consequently led to higher rates of mortality. The study also recognized the nationwide shortage in testing capacity as one of the limitations related to data and methodology.[19] Since statewide testing rate was considered the most significant predictor of county virus infection rate in this study, testing capacity should also be considered as a factor in obtaining the accurate depiction of the COVID-19 cases in the study population.

Another possible explanation for the results could be the differing protocols per LGU and a very erratic and unpredictable national policy. The said differing protocols are due to the mandate for each LGU to adopt, coordinate, and implement guidelines in accordance to the given local protocols that should be implemented as set by the national government.[20] This is also supported by a study showing an increase in the Government Stringency Index, along with an increase in the number of beds per 1,000 people and number of physicians per 10,000 people, decreased the number of confirmed COVID-19 cases.[21] The study further posits that an increase in proportion of people with pre-existing health conditions, population density and high median age of the population would increase the number of confirmed COVID-19 cases.[21] This shows that there is a huge interplay between the different factors that may decrease or increase the number of COVID-19 cases in an area, with population density being just one of them.

It should be noted though that once Quezon City was eliminated as one of the variables, results showed a significant correlation and aligned with the literature.[14,15] This would suggest that there may be something unique to Quezon City for it to cause a drastic shift in results once it is removed. As cited earlier, in cities with higher socio-economic status and superior healthcare systems, the effect of population density on the number of COVID-19 cases may be lesser.[19] Given Quezon City's status as the country's wealthiest city until 2017, it may be suggested that their pool of resources may have been integral to their low prevalence rate, being second only to Caloocan.[22] Though they may have the most cases in NCR, this is but a small fraction of their population. Moreover, Quezon City is home to most of the hospitals in NCR, a possible indication of better healthcare systems available to its people.[23] The Cities and Municipalities Competitiveness Index (CMCI), an annual ranking anchored on the pillars of economic dynamism, government efficiency, infrastructure and resiliency has also been topped by Quezon City for the past four years, with capacity of health services being one of the key indicators.[24] It should also be noted that Quezon City has the highest employment rate among the different cities in NCR, which may have affected the results.[25]

Given the results shown in both scenarios, with and without Quezon City, it may be seen that population density, though an important factor, can be heavily affected by its interplay with other factors with regards to the effect on the rising number of COVID-19 cases. A deeper look into the effect of Quezon City's huge land area and population is recommended to see what effects they may have on the transmission of COVID-19. Moreover, implemented COVID-19 mitigation measures the city may be employing can be further studied and possibly be emulated by other cities. Future studies may investigate whether Quezon City's situation is just incidental to its vast area or if there are certain things the city is doing more efficiently that may explain these surprising results.

Another factor the study sought to investigate was sex and its relation to the rising number of COVID-19 cases in NCR. The study's results demonstrated an association between sex and COVID-19 cases, albeit weak and non-directional. As shown in Table 2, males in NCR across all age groups, except 15-19 and 20-24, were found to have higher prevalence per 1,000 cases. This is supported by the data from a study on clinical and demographic risk factors and COVID-19, wherein there were more cases of males than females in Pakistan.[26] Likewise, data in Germany and Switzerland showed that there was an increased incidence of COVID-19 infection specifically in males above 60 years old.[27] However, this is in contrast to a study stating that females of working age are more likely to be diagnosed with COVID-19, attributing this to the greater number of females in the healthcare profession.[28] Moreover, in an ecological study of incidence of COVID-19 and gender in 177 countries, the ratio of people above 60 years was positively associated with the incidence, noting a higher correlation in females than in males.[29] Yet, in a meta-analysis of 90 reports involving 46 countries, the results showed that the proportion of male cases was exactly half at 50%, indicating that males and females have similar numbers of infections.[30]

Nonetheless, though the effect size was small, the association prompted the researchers to further thresh out the relationship of sex and COVID-19 cases by comparing it to population density. Similar to this study's previously elaborated results, when NCR was evaluated as a whole, there was no significant correlation between the population density and sex of those who tested positive for COVID-19. When Quezon City was removed as a data point, the Pearson correlation between population density and both male and female cases proved significant. This suggests that an increase in the population density of a place would lead to higher cases in both genders. In both cases, with and without Quezon City, it was noted that males show a higher correlation with population density compared to females ($r = 0.264 > 0.206$; $r = 0.588 > 0.543$).

Given this, it would be helpful to understand what factors may lead to sex being a possible factor in the rise of COVID-19 cases in NCR. Aside from biological and genetic factors, differences in attitude may play a role in the difference in susceptibility among the two sexes. Rather than simply looking at sex as a risk factor for COVID-19, other factors may be investigated to increase knowledge and understanding on the spread of the virus. These may include the percentage of female health professionals, adherence to preventive measures, and adaptive behaviors. In a meta-analysis, gender demographics was cited as having association with adaptive behaviors during a pandemic.[31] These include health-protective factors such as being female, older, more educated, and non-white. Furthermore, in another study, females showed greater adherence to preventive measures than males, making the latter more vulnerable to infection.[32] Despite the fact that some actions such as making a livelihood and purchasing supplies could be possible reasons in increasing COVID-19 cases among males in NCR, this has to be studied further by future researchers. Future studies may give a look into the qualitative aspect of male and female behaviors during the pandemic as well as comparing other predisposing risk factors such as occupation, nature of occupation, and dynamics in the family to get a more coherent understanding of the apparent risk factor of sex.

Lastly, the study investigated how age and COVID-19 cases were related. The results showed a moderate association between age and COVID-19 cases. It must be noted that the age distribution was obtained from the 2015 census. This was non-directional and could not explain whether the association was linked to an increase or decrease in the age. This is partially supported by an ecological study of incidence of COVID-19 and age in 177 countries wherein age was found to be a significant determinant of COVID-19 infections. The study also found that the median age of 25 to 64 years old was strongly associated with the incidence rate of COVID-19.[29] Zoning in on the results of the study as shown in Table 3, a drastic increase from age group 15-19 and 20-24 and another spike from 20-24 and 25-29 is observed. A plateau in prevalence can then be observed from age groups 25-29 to 60-64 ranging from 72.32 and 93.69 prevalence per 1000. This is further supported by a study on COVID-19 infection rates across European countries which reported that individuals under the age of 19 are the least infected, while the population with the age over 20 have the most cases with a rising infection rate seen in the working group.[28] The working population are more likely to be mobile compared to other age groups, and thus more likely to encounter infectious individuals. On the other hand, another study suggested that children may be less likely to be infected due to their stronger, more active immune response, less comorbid conditions, and clearer respiratory tracts because of lesser exposure to smoke, pollution, and other airway irritants.[32] This is in line with the safety protocols enacted by the Philippines wherein individuals below 18 and above 65 are generally not allowed to go out. Another factor that may be looked into is that age groups 0-4 until 15-19 are engaging in online classes rather than in-person classes, thus limiting their need to go out and get exposed. This may also indicate the effectiveness of the imposed quarantine restrictions banning those aged below 18 and those over 65 from going outside their residences.

There is also an observable disparity in the result of the above studies and the prevalence of COVID-19 among the groups from 65-69 until 80+ in NCR, wherein the prevalence remained high or even increased in some age groups. This may be due to their willingness to be tested secondary to symptomatic or even severe COVID-19. As aging is associated with increasing numbers of comorbidities such as cardiovascular diseases, hypertension, diabetes, congestive heart failure, cerebrovascular disease, chronic kidney disease, chronic liver disease, cancer, chronic obstructive pulmonary disease and asthma, these predispose older adults to more severe COVID-19 symptoms.[33] A study on age distribution and COVID-19 found that older adults are more likely to be tested since they more often present with symptomatic COVID-19.[34] Additionally, according to a systematic review and meta-analysis on the prevalence of comorbidities and COVID-19, hypertension and diabetes mellitus are the two most prevalent diseases in patients with COVID-19. The study then stated that it is intuitive that younger age groups are not showing too severe symptoms to make them refer to the hospitals and get tested and thus they remain undiagnosed.[35]

It is recommended that future studies investigate the willingness of each age group to get tested for COVID-19, which may be affecting the distribution of the number of cases across these age groups. The severity of symptoms and the presence of comorbidities in each age group can also be studied, all of which give a picture on understanding as to how age, and other factors linked to it, are related to COVID-19. Future studies may investigate the differences of testing rates between the LGUs. Further analyses per city and barangays within those cities may also be investigated as there may be differences in the possible results when the LGUs and their components are split into smaller sets of data.

The study has shown that population density and population have a good correlation with the number of COVID-19 after Quezon City was removed as a data point. There is a moderate association between age and number of COVID-19 cases. There is a very weak to no association between sex and COVID-19 cases.

References

1. World Health Organization [Internet]. World Health Organization; c2020 [cited 2020 Nov 10]. Archived: WHO Timeline - COVID-19; [about 2 screens]. Available from: https://www.who.int/news/item/08-04-2020-who-timeline---covid-19
2. World Health Organization [Internet]. World Health Organization; c2020 [cited 2020 Dec 10]. Coronavirus disease (COVID-19) pandemic; [about 3 screens]. Available from: https://www.who.int/emergencies/diseases/novel-coronavirus-2019
3. Department of Health [Internet]. COVID-19 Tracker. c2000 - [cited 2021 Sep 20]. Available from: https://www.doh.gov.ph/covid19tracker
4. Center for Strategic & International Studies [Internet]. Center for Strategic & International Studies; c2020 [cited 2020 Dec 10]. Southeast Asia COVID-19 Tracker; [about 2 screens]. Available from: https://www.csis.org/programs/southeast-asia-program/southeast-asia-covid-19-tracker-0
5. Sy KTL, White LF, Nichols BE. Population density and basic reproductive number of COVID-19 across United States counties. medRxiv. 2020 Jun 13. doi: 10.1101/2020.06.12.20130021
6. Kadi N, Khelfaoui M. Population density, a factor in the spread of COVID-19 in Algeria: Statistic study. Bulletin of the National Research Centre 2020 Aug 20; 44(1): 138. doi: 10.1186/s42269-020-00393-x
7. Kodera S, Rashed EA, Hirata A. Correlation between COVID-19 morbidity and mortality rates in Japan and local population density, temperature, and absolute humidity. Int J Environ Res Public Health [Internet]. 2020 Jul 29; 17(15): 5477. doi: 10.3390/ijerph17155477
8. Martins-Filho PR. Relationship between population density and COVID-19 incidence and mortality estimates: A county-level analysis. J Infect Public Health 2021 Aug; 14(8): 1087-8. doi: 10.1016/j.jiph.2021.06.018
9. The Sex, Gender and COVID-19 Project [Internet]. Global Health 5050. c2000 [cited 2020 Nov 10]. Available from: https://globalhealth5050.org/the-sex-gender-and-covid-19-project/
10. Haw NJL, Uy J, Sy KTL, Abrigo MRM. Epidemiological profile and transmission dynamics of COVID-19 in the Philippines. Epidemiol Infect [Internet]. 2020 Sep 15; 148: e204. doi: 10.1017/S0950268820002137

11. Scully EP, Haverfield J, Ursin RL, Tannenbaum C, Klein SL. Considering how biological sex impacts immune responses and COVID-19 outcomes. Nat Rev Immunol [Internet]. 2020 Jun 11; 20(7):442–7. doi: 10.1038/s41577-020-0348-8
12. Griffith DM, Sharma G, Holliday CS, et al. Men and COVID-19: A biopsychosocial approach to understanding sex differences in mortality and recommendations for practice and policy interventions. Prev Chronic Dis [Internet]. 2020 Jul 16; 17: E63. doi: 10.5888/pcd17.200247
13. Schneider A, Hommel G, Blettner M. Linear regression analysis. Dtsch Arztebl Int 2010 Nov 5; 107(44): 776–82. Doi: 10.3238/arztebl.2010.0776
14. Rashed EA, Kodera S, Gomez-Tames J, Hirata A. Influence of absolutehumidity, temperature and population density on COVID-19 spread and decay durations: Multi-prefecture study in Japan. Int J Environ Res Public Health [Internet]. 2020 Jul 24 [cited 2020 Nov 15]; 17(15): 5354. Available from: https://www.mdpi.com/1660-4601/17/15/5354
15. Carozzi F. Urban density and COVID-19 [Internet]. Ssrn.com. 2020 [cited 2020 Nov 15]. Available from: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3643204
16. Saidan MN, Shbool MA, Arabeyyat OS, et al. Estimation of the probable outbreak size of novel coronavirus (COVID-19) in social gathering events and industrial activities. Int J Infect Dis [Internet]. 2020 Sep; 98: 321-7. doi: 10.1016/j.ijid.2020.06.105
17. Tekalign K. Probable factors contributing to the fast spread of the novel coronavirus (COVID-19) in Ethiopia. J Infect Dis Epidemiol [Internt]. 2020 Oct 17; 6(169). Available from: https://doi.org/10.23937/2474-3658/1510169
18. Poverty: Philippines [Internet]. Asian Development Bank. Asian Development Bank. 2021 [cited 2021 Oct 6]. Available from: https://www.adb.org/countries/philippines/poverty
19. Hamidi S, Sabouri S, Ewing R. Does density aggravate the COVID-19 pandemic? J Am Planning Assoc [Internet]. 2020 Jun 18; 86(4):495–509. Available from: https://www.tandfonline.com/doi/full/10.1080/01944363.2020.1777891
20. S Talabis DA, Babierra AL, H Buhat CA, Lutero DS, Quindala KM III, Rabajante JF. Local government responses for COVID-19 management in the Philippines. BMC Public Health [Internet]. 2021 Sep 21; 21(1): 1711. doi: 10.1186/s12889-021-11746-0
21. Haldar A, Sethi N. The effect of country-level factors and government intervention on the incidence of COVID-19. Asian Economics Letters 2020 Oct 27; Available from: https://doi.org/10.46557/001c.17804
22. Commission on Audit. Commission on Audit - Annual Audit Reports. 2017 Annual Financial Report for the Local Government (Volume II). 2017. Available from: coa.gov.ph/index.php/reports/annual-audit-report
23. Department of Health. National Health Facility Registry v2.0 NHFR, 2013. Available from: https://nhfr.doh.gov.ph/rfacilities2list.php
24. Department of Trade and Industry. Cities and Municipalities Competitiveness Index. CMCI, 2020, cmci.dti.gov.ph/about-indicators.php.
25. Quezon City Government. Economic profile and development. 2020 Ecologic profile [Internet]. 2020. Available from: https://quezoncity.gov.ph/wp-content/uploads/2020/12/QC-Ecological-Profile-2015.pdf
26. Ishtiaq N, Shoaib N, Noureen N, et al. COVID-19 severity: Studying the clinical and demographic risk factors for adverse outcomes. PLOS ONE [Internet]. 2021; 16(8): e0255999. Available from: https://doi.org/10.1371/journal.pone.0255999
27. Gebhard C, Regitz-Zagrosek V, Neuhauser HK, Morgan R, Klein SL. Impact of sex and gender on COVID-19 outcomes in Europe. Biol Sex Differ [Internet]. 2020 May 25; 11(1): 29. doi: 10.1186/s13293-020-00304-9.
28. Sobotka T, Brzozowska Z, Muttarak R, Zeman K, Lego VD. Age, gender and COVID-19 infections. Wittgenstein Centre for Demography and Global Human Capital [Internet]. 2020 May 26; Available from: https://www.medrxiv.org/content/10.1101/2020.05.24.20111765v1.article-info
29. Hu D, Lou X, Meng N. et al. Influence of age and gender on the epidemic of COVID-19. Wien Klin Wochenschr [Internet]. 2021; 133: 321–30. Available from: https://doi.org/10.1007/s00508-021-01816-z
30. Peckham H, De Gruijter NM, Raine C, et al. Male sex identified by global COVID-19 meta-analysis as a risk factor for death and ITU admission. Nat Commun [Internet]. 2020 Dec 9; 11(1): 6317. doi:10.1038/s41467-020-19741-6
31. Moran KR, Valle SYD. A meta-analysis of the association between gender and protective behaviors in response to respiratory epidemics and pandemics. PLOS ONE [Internet]. 2016 Oct 21; 11(10). Available from: https://doi.org/10.1371/journal.pone.0164541
32. Vega RDL, Ruíz-Barquín R, Boros S, Szabo A. Could attitudes toward COVID-19 in Spain render men more vulnerable than women? Global Public Health [Internet]. 2020 Jun 4; 15(9): 1278–91. https://doi.org/10.1080/17441692.2020.1791212
33. Ssentongo P, Ssentongo AE, Heilbrunn ES, Ba DM, Chinchilli VM. Association of cardiovascular disease and 10 other pre-existing comorbidities with COVID-19 mortality: A systematic review and meta-analysis. PLOS ONE 2020 Aug 26; 15(8): e0238215. doi: 10.1371/journal.pone.0238215
34. Fisman DN, Greer AL, Brankston G, et al. COVID-19 case age distribution: Correction for differential testing by age. Ann Int Med [Internet]. 2021 Oct; 174(10): 1430-8. Available from: https://doi.org/10.7326/M20-7003
35. Baradaran A, Ebrahimzadeh MH, Baradaran A, Kachooei AR. Prevalence of comorbidities in COVID-19 patients: A systematic review and meta-analysis. Arch Bone Jt Surg [Internet]. 2020 Apr; 8(Suppl 1): 247-55. doi: 10.22038/abjs.2020.47754.2346