Categorization of Vaccine in Adolescent Implementing by the Chi − Square (χ^2) Test

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Abstract

When the dependent variable is recorded at a specific level, the χ^2 a statistical is essentially a non-parametric technique used to explore group differences. The χ^2 is powerful in regard to the distribution associated with information like all data being non-parametric. Particularly, it does not need equivalence of variances a few of the analyze this is research classes or homoscedasticity with the particular information. It allows analysis of both dichotomous variables is split along with numerous group studies. The computations required to determine the χ^2 provide a lot of information about how all of the teams fared in the research, as well as a variety of non-parametric and parametric statistics. This vast amount of information helps the researcher to acquire the result and so gain more specific info about this statistic than from other kinds. The χ^2 is an important statistic, and may get used by way of the power statistic. When a significant $\chi^2$the final result has been received, the Cramer's V is the ultimate greatest power that is commonly used to examine the information. Benefits of the χ^2 consist of value to circulation to its robustness associated at that the data, their simplicity of calculation, the step-by-step content which may become based on the test, it is used in studies which is why parametric assumptions can't be fulfilled, and its freedom in dealing with information at every two classes and several classes' studies. Limits contain their sample or test dimensions needs, the problem of explanation if there will be more and more categories into the separate aspects, and inclination of this Cramer's V to make general the correlation in which is reduced, also for very significant or considerable results.

Keywords. Categorical information; Chi-square formula; Assumptions; Non-parametric; Analytical analysis.

1. INTRODUCTION

The test this is certainly χ^2 (chi-square) of very important helpful statistics for examining hypotheses as soon as the variables are moderate, normally occurs in medical research. The Chi-square χ^2can provide information not merely from the importance about any noticed variations, however, usually gives step-by-step info on exactly which groups take into account any variations found, unlike most statistics. Therefore, the extent and information of data this statistic can offer render it probably one of the most of good use resources into the variety that is researchers of evaluation resources. As with every statistic, you can find

demands because of its usage that proper tends to be known as “assumptions” from the statistic. Furthermore, the χ^2is a value test, and may forever be paired at the test this is certainly appropriate of power. The χ^2 (Chi-square) test is the non-parametric statistic, also named a distribution test this is certainly no-cost. Non-parametric examinations should always be utilized when anybody is associated with the problems that are after towards the information:

1. The measuring quantity of the facets is nominal.

2. But some parametric tests need equal categories, the sample sizes from the identified categories are uncompilable; for the χ^2 (Chi-square), the categories are of the equal attribute or dissimilar dimensions, although other parametric tests require equal categories.

3.The initial data are assessed at a proportion level, however violate one of the after presumptions to the test this is certainly parametric.

i) The distribution regarding the information was seriously skewed or kurtotic and therefore the specialist should use a distribution for free statistic instead of a statistic that is parametric.

ii)The data change the assumptions of alike homoscedasticity or variance.

iii) For some of several aspects (1), the continuous facts were flattened as a quantity this is certainly tiny of, and therefore the info is not any more interval or proportion

2. PRESUMPTION ASSOCIATED WITH χ^2 TEST

The non-parametric examinations, like the χ^2assume the data had been gotten through random selection as with parametric tests. However, it is not uncommon to locate data that are inferential whenever information comes from convenience examples in the place of random examples. (to possess self-confidence within the outcomes as soon as the sampling this is certainly random is violated, a few duplication tests should be pre-created at basically the same outcome received). All test that is non-parametric its particular inference too. The presumptions for χ^2 test offer:

1) instead of percentage or a few other information transformations, the information within the cells must be frequencies or problems of cases.

2) The understood levels of these variables are collectively special. That is, a subject this is certainly certain into only one amount of each of the factors.

3) Each topic might add information to one and just one cellular in the χ^2.Then $\chi^2$is almost certainly not utilized if, for instance, the same topics are tested over moment in a way that the evaluations are of the same subjects at moment 1, moment 2, moment 3, etc.

4) Separate groups for academic analysis should be formed. If two teams are relevant, this suggests that a separate test should be used. For example, if the professor's data consists of independent variables and dependent variables, such as in investigations involving a mother or father and their kid, a different test should be used.

5) We may discover two factors, which are both calculated as classes, and which are frequently used throughout the minimal degree. Data, on the other hand, might be quantitative information. Additionally, percentage data that has been crumpled into ordinal types can be used. Although chi2 does not have a law limiting the number of cells, an actual

number this large (over 10) makes it difficult to satisfy the presumption not equal to 6 below, as well as to comprehend the significance of the results.

6) In a minimum of 80% of cells, the appropriateness for the cell expected is five or higher, with no cell having an expected of less than one (3). This assumption is almost definitely fulfilled if the sample size is at least the number of cells multiplied by five. This assumption, in essence, determines the number of instances necessary to utilize the $\chi^2$for any other number of cells since χ^2. This need will be easily specified in the example of statistic calculation when you look at the entire example instance.

3. ILLUSTRATION

In [1] authors created a number of versions to predict the cases' security and opportunities of recuperation in MERS-COV contaminated situations. The files on COVID-19 suggested that it is actually a pneumonia like SARS, in which 26 to 33 per cent of individuals called for extensive treatment and the mortality rate 4 to 15 % [2], [3] China [4], [5], Lombardy, Italy [6] as well as New York City, USA [7] has described clinical discussion and early outcomes on the attributes of COVID-19 clients. On 11th March, the infection outbreak was proclaimed a widespread due to the Planet Health Association [8] Far, it has actually been actually stated that 13.8-- 19.1% of COVID-19-infected clients in Wuhan, China, became drastically sick [9], [10] The first case of Coronavirus CoVID-19 illness in India was announced on 30th January 2020 [11] India is actually thought about as the largest country having affirmed situations in Asia. Since 11th June 2020, the Department of Health and also Family Well Being [12] have affirmed an overall of 286,579 scenarios, 141,029 rehabilitations and also 8,102 deaths in India [Thirteen], while the worldwide lot of afflicted instances is 7255960 as well as variety of confirmed deaths is 412583, describing Globe Wellness Company (WHO) [14] In India, 1024 validated cases as well as 27 varieties of confirmed deaths were stated by 29th March, 2020. Due to the opportunity, the amount of confirmed afflicted cases has been actually rapidly boosted in India. The growth rate of verified cases was actually rapid till 29th May, 2020, while India's casualty cost is actually relatively lower at 2.80%, against the global 6.13% as of 3rd June 2020 [15]. India is looked at as the biggest country having confirmed situations in Asia. In India, 1024 confirmed scenarios and 27 amounts of verified fatalities were mentioned through 29th March, 2020. Through the time, the amount of confirmed afflicted instances has actually been rapidly boosted in India [15].

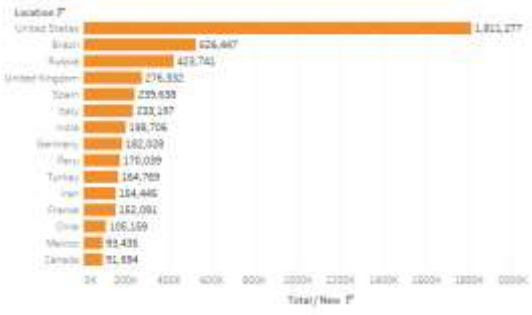

Figure 1. Top 15 Countries with COVID Cases [16,17]

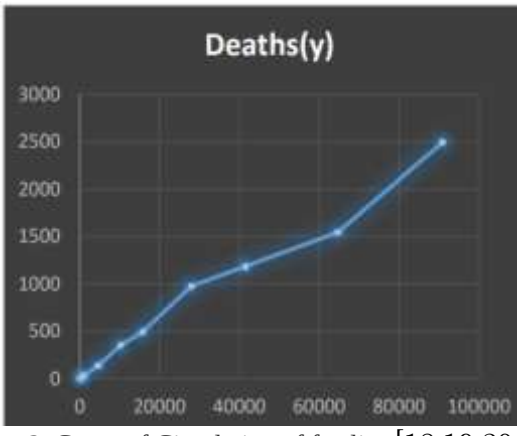

Figure 2. Curve of Circulation of fatality [18,19,20,21]

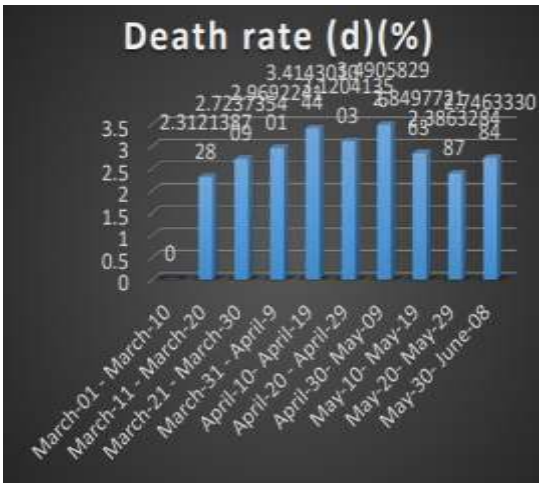

Figure 3. Mortality rate in India for various scenarios [23,24, 25]

The following case example can be used to explain how to calculate and explain the χ^2statistic. The Chairman of an Institute would like to hold keep this is certainly sick reasonable that you can by continuing to keep students healthier through illness avoidance programs. Many students have developed diseases ultimately causing output problems due to go out of that is ill the illness. Generally, there is a vaccine for bacterial disease, while the Chairman feels it is usually crucial to obtaining as numerous students vaccinated as you can Because of to difficulty with offline classes at the institute that makes the vaccine, there was only one vaccination that was sufficient for half of the students. Essentially, there are two groups of students: those who received the vaccine and those who did not receive the vaccine. Each student who hired illness received a questionnaire helper from the institute, and they were also required to accept a sputum test for culture to find the causative representative. They kept track of the true number of students who contracted sickness and what sort of ailment each of them had. The following is how the data was organized:

Category 1: The vaccination may not be provided with this class. (N=52)

Category 2: provided in conjunction with the vaccination. (N=52)

In conditions like these, the vaccination status is a distinct variable. The variable that is reliant Three degrees of overall health outcome:

- established a bacterial disease
- established non-bacterial disease and
- did not establish disease.

The organization needs to recognize whether or not providing the vaccination made much difference. To resolve this, they must each select a fact that will be utilized to test for differences when all of the variables are moderate. To evaluate the relevant question, the χ^2 statistical was utilized. "Was there a difference in the occurrence of disease between the two classes?" Table 1 was created over the summer months to represent the incident of disease in one of the students**.**

Table 1. The outcome of the vaccination model.

Overall health Impact	Non vaccinated	Vaccinated
Unwell with bacterial disease	21	12
Unwell with non-bacterial disease	8	10
No disease	23	30

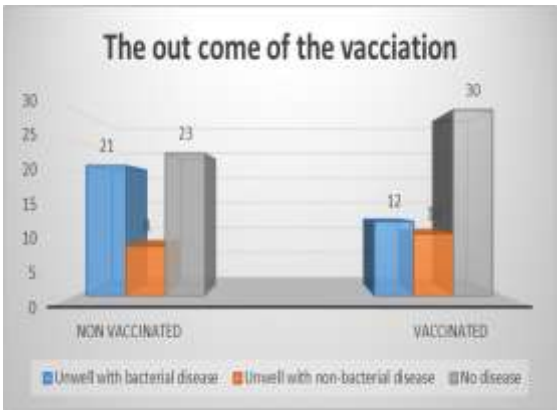

Figure 4. The outcome of the Vaccination

4. COMPUTING χ^2 TEST

To extend the problem posed by [1],[2],[3],[4], [5] the researcher can use the χ^2analysis to see if the vaccination program had any effect on the students' health and well-being. The following is the formula for obtaining a χ^2 is:

$$\sum \chi^2_{i-k} = \frac{(Fo - Fe)^2}{Fe} \qquad (1.1)$$

Therefore:

F_0 = Observed value

F_e = Expected value

χ^2 = Calculate chi-square value
$\sum\chi^2$ =Technique studies to add up each cell's χ^2values

$\chi^2_{i-k} = i - k$ is the correct notation to represent all the cells

Adding the sums of all the rows and columns is the first step in computing χ^2 . These sums are referred to as the "borderline," and we may also discover row borderline values $B_R$and column borderline values B_C, which are borderline calculations. Table 2 usually contains values that are on the edge of the case study data. Second is the method for computing the expected values (F_e) for each cell. The "expected" values (F_e) represent a calculation of how the conditions would be distributed if the Chi-square statistic did not include a vaccination impact. Expected values(F_e) must represent both the incidence of cases in each group as well as the circulation when there is no vaccination effect. Because the total N is not equal to the expected number in each cell, the expected number (F_e) in each cell cannot be divided by 6. That will not explain the well-known fact that more people remained healthy whether or not they were vaccinated. (see Table 2, 3,4).

Table 2. Evaluation of Borderlines

Overall health Impact	**Non vaccinated**	**Vaccinated**	**Row borderlines (Row Sum)**
Unwell with bacterial disease	21	12	33
Unwell with non-bacterial disease	8	10	18
No disease	23	30	53
Column borderlines (Column Sum)	52	52	(N) = 104

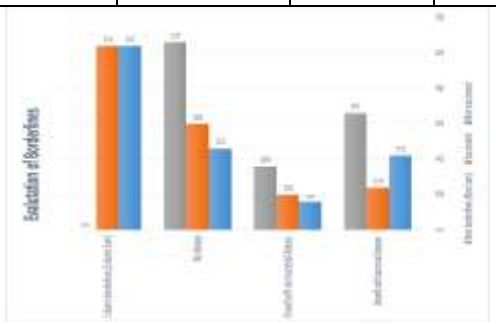

Figure 5. Evaluation of Borderlines

$$F_e = \frac{B_R \times B_C}{N}$$

Where:

$F_e =$ Denotes the expected value of something like the cell

$B_R =$ The rows borderlines for such a cell are represented by this symbol.

$B_C =$ The column borderlines for that cell are represented by this symbol.

$N =$ The total sample size is

Table 3. Compute Expected values F_e

Overall health Impact	Non vaccinated	Vaccinated
Unwell/Suffering with bacterial disease	21(16.5)	12(17.01)
Unwell/Suffering with non-bacterial disease	8(8.95)	10(9.05)
No disease	23(26.5)	30(27)

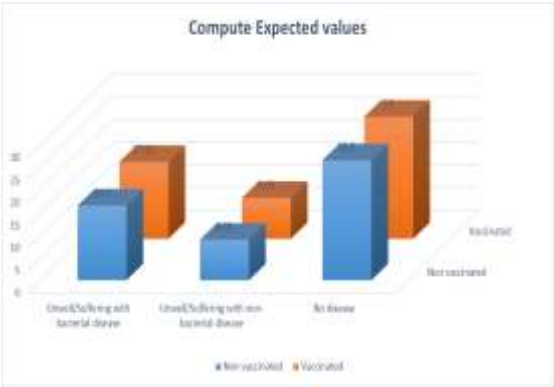

Figure 6. Compute Expected values

The following formula is used to determine the cell χ^2 values:

$$\chi^2 = \frac{(F_o - F_e)^2}{F_e}$$

The cellχ^2 value by each cell the value using parentheses for each cell. (see Table 4)

Table 4: Compute Cell Chi-Square Values $\chi^2 = \frac{(F_o - F_e)^2}{F_e}$

Overall health Impact	Non vaccinated	Vaccinated
Unwell with bacterial disease	21(1.227)	12(1.475)
Unwell with non-bacterial disease	8(.1008)	10(.099)
No disease	23(.4622)	30(.3333)

Following that, the cell chi2 values are computed and then totaled to produce the table's χ^2 statistic. In this condition, χ^2 is 3.697. The χ^2 the table uses the degrees of freedom of

the table to determine the significant level of the fact. The df for a $\chi^2 the$ table is determined with all the formulas: (R_s-1) x (C_s-1). Where R_s is several rows and C_s is the number of columns.

If the calculated value of χ^2 (3.679) differs for each of these df (1, 4, and 12), the significance level from the tabulated of χ^2 values tends to be: df = 1, P > 0.10(α), df = 4, P 0.025(α), and df = 12, P > 0.10(α), Observe that as df rises, the P-level becomes less significant; for example, at the.05 (α) degree, the computed value χ^2 (3.679) is no longer statistically significant because P was larger than 0.10. df =2, when working with a sample table with three rows and two columns. Many important statistics literature, as well as different web resources, provide a chi-square χ^2 of table. The significance of the value is chi-square χ^2 of with 2 df P < 0.005using a tabular value of χ^2. This number might be rounded to P < 0.01. for simplicity. When the Chi-square χ^2 is computed using the mathematical system, the significance is determined to be P = 0.0011.

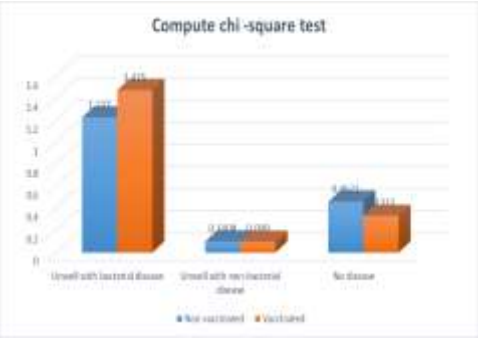

Figure 7. Compute chi square test

The null hypothesis (H_0) is rejected, whereas the alternative hypothesis (H_1) is accepted: when the table's P-value is considerably lower than P < 0.05. "There is indeed a difference in the number of bacterial disease incidents between the vaccinated and non-vaccinated groups." This overall conclusion, however, does not describe the difference could be. Examine the cell Chi-square χ^2 values to fully comprehend the overall result.

5. INTERPRETATION OF CHI-SQUARE X^2 VALUES

Table 4 may contain the fact that the cell with the largest value of 1.227is Cell 1. Here is the complete result of the value, which is observed 21 whereas only 16.5 was expected. As a result, these cells contain much more observed instances than may be expected with a chance. Cell 1 represents the number of non-vaccinated students who contracted the disease. Bacterial disease infection is most likely. This implies exactly how many not people that are vaccinated contracted disease that is bacterial disease significantly greater than anticipated. Cell 2 has the second cell with the highest χ2value of 1.475. However, we find that the number of observed instances in this cell is much lower than predicted (Observed =12, Expected =47.01). If the vaccination had no effect, there would be a significantly smaller number of vaccinated patients who had a bacterial disease. A cell with a χ2value larger than 99% is rare in any other cell.

Table 5. Compute Cell Expected value F_e and Chi-Square Values $\chi^2 = \frac{(F_o - F_e)^2}{F_e}$

Overall health Impact	Non vaccinated	Vaccinated
Unwell with bacterial disease	16.5(1.227)	17.01(1.475)
Unwell/Suffering with non-bacterial disease	8.95(.1008)	9.05(.099)
No disease	26.5(.4622)	27(.3333)

A cell χ^2 with a value less than 1.0 should be regarded as an exact number of observed cases roughly equaling the number of expected circumstances, implying that the vaccination has no impact on a few other cells. In the case study example, all of the cells had cell χ^2 values less than 1.0. As a result of the ongoing lessons, it can be concluded that there was no difference in the occurrence of non-bacterial sickness between the two teams. It was clear that virtually all workers stayed healthy in both merged groups. It's worth noting that vaccinated staff had far fewer occurrences of bacterial disease than non-vaccinated students. As a consequence, the institution should be able to establish if the vaccination program has consistently reduced the incidence of bacterial disease. Several statistical applications generate cell expected and cell χ^2 value tables as part of the basic processing. The cell χ^2 values must be checked using choice since certain applications build those tables as a choice. The method of this χ^2 price gives data if the indicates that having you print just the cell χ^2 value (or whichever cell they choose). A positive cell value denotes that the observed value surpasses the expected value, whereas a negative cell value denotes that the observed cases are less than the expected number. For convenience, researchers may choose to manually calculate the cell expected and cell 2 values. Whenever the application does not present either option, most experts can determine what it is: the general table shows that the two groups are either separate. The majority of studies examine the dinner table to see whether cells are overrepresented with a large number of scenarios against those with only a few. Nonetheless, the interpretation of the path for team variations is less accurate without the inclusion of cell expected or cell $\chi 2$ values. Researchers may wish to manually determine the cell expected and cell $\chi 2$ values to better interpretation due to the convenience of finding such values.

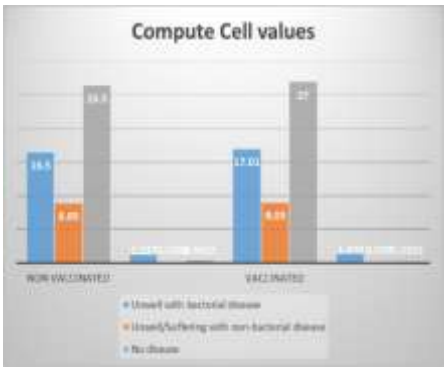

Figure 8. Compute cell values

6. CHI-SQUARE AND MANY OTHER TESTS THAT SEEM TO BE CLOSELY CONNECTED

One could ask if the Chi-square was the best or only test available to the researcher in this case. For nominal variables, non-parametric tests are necessary, and there are three commonly used significance tests for this type of nominal data. The Chi-square is the simplest basic and commonly used. Fisher's exact test is the second test, which is more precise than the Chi-square but only works with 2 x 2 tables (6).

The table would have two rows and two columns, and Fisher's exact test would be used if the case study's only options were Bacterial illness or Non-Bacterial disease. Because the case study example requires a 2 x 3 table, the data is insufficient. If the case study's sole alternatives were Bacterial illness or Non-Bacterial disease, for example, the table would have two rows and two columns, and Fisher's exact test would be employed. The data are unsuitable for Fisher's exact test since the case study example suggests a 2 x 3 table. Assume the sample size was significantly less. If the sample size was lower and the results presented In table 6 were in the table.

Table 6. A table that violates the expected cell values is shown below.

Impact on overall health	**Un-vaccinated**	**Not Vaccinated**
Bacterial disease	4(2.226)/1.42	0(1.75)/1.78
Non-bacterial disease	2(1.67)/.07	1(1.33)/.08
Stayed healthy	14(16.11)/.028	15(12.89)/.35

7. CONCLUSION

The Chi-square is a useful test that provides a lot of information on the type of study results. That's a helpful statistic for researchers to utilize when they want to test hypotheses about nominally measured variables. As with any inferential data, the best results are produced when information is gathered from arbitrarily selected topics, and when test sizes are large enough, they attain excellent analytical power. The Chi-square is a useful tool to use when the assumptions of equal variances and homoscedasticity are broken, and parametric data (Figure 2.3.1 Compute cell values, Table 5) such as the t-test [6] and ANOVA cannot provide trustworthy findings. Hence there is indeed a difference in the number of bacterial disease incidence between the vaccinated and non-vaccinated groups.

REFERENCES

[1] E. Mahdi, V. Maryam, A. Ali, A. Afsoon, O. Sepideh, J. Katayoun, S. Jila, F. Faranak, M. Farzaneh, M. Ali. Prevalence of tobacco consumption: Iranian health perception survey. Payesh (Health Monitor), 2011, 10(3):365-372. Available from: https://www.sid.ir/en/journal/ViewPaper.aspx?id=200649

[2] I. Turaiki, M. Alshahrani, T. Almutairi, “Building predictive models for Mers-CoV infections using data mining techniques”. Journal of Infection and Public Health 2016: 9,744-748.

[3] P. Tungjiratthitikan, “Accidents in Thai Industry between 2001 and 2017”, Evergreen Joint Journal of Novel Carbon Resource Sciences & Green Asia Strategy, Vol. 05, Issue 02, pp.86-92, June 2018.

[4] M. Rahman, A. Pal, K. Uddin, T. Kyaw, B.B. Saha, “Statistical Analysis of Optimized Isotherm Model for Maxsorb III/Ethanol and Silica Gel/Water Pairs”, Evergreen Joint Journal of Novel Carbon Resource Sciences & Green Asia Strategy, Vol. 05, Issue 04, pp.1-12, December 2018.

[5] S. Kitjanukit, “Attitude toward Bio remediation Related Technology and Relation with Company Social Responsibility”, Evergreen Joint Journal of Novel Carbon Resource Sciences & Green Asia Strategy, Vol. 06, Issue 03, pp240-245, September, 2019.

[6] F. Zhou, T. Yu, R. Du, G. Fan, Y. Liu, Z. Liu, J. Xiang, Y. Wang, B. Song, X. Gu, et al. Clinical course and risk factors for mortality of adult inpatients with covid-19 in Wuhan, China: a retrospective cohort study. The Lancet, 395(10229): 1054–1062, 2020.

[7] J. Zhang, X. Dong, Y. Cao, Y. Yuan, Y. Yang, Y. Yan, C.A. Akdis, and Y. Gao. Clinical characteristics of 140 patients infected with sars-Nov-2 in Wuhan, China. Allergy, 75(7):1730–1741, 2020.

[8] W. Guan, Z. Ni, Y. Hu, W. Liang, C Ou, J. He, L. Liu, H. Shan, C. Lei, D. Hui, et al. Clinical characteristics of coronavirus disease 2019 in china. New England journal of medicine, 382(18):1708–1720, 2020

[9] P. Bhatnagar, S. Kaura, S. Rajan, Predictive Models and Analysis of Peak and Flatten Curve Values of CoVID-19 Cases in India: vol.07.issue 04, pp458-467 November 2020.

[10] G.D. Nugraha, B. Sudiarto, R. Kalamullah, “Machine Learning-based Energy Management System for Prosumer”, Evergreen Joint Journal of Novel Carbon Resource Sciences & Green Asia Strategy, Vol. 07, Issue 02, pp309-313, June, 2020.

[11] N. Zhu, D. Zhang, W. Wang, X. Li, B. Yang, J. Song, “China novel coronavirus investigating and research team”. A novel coronavirus from patients with pneumonia in China, 2019. N Engl J Med 382: 727-33 2020.

[12] D. Wang, B. Hu, C. Hu, F. Zhu, X. Liu X, J. Zhang, “Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan”, China. JAMA, 323: 1061-9 2020.

[13] Z. Wu, J.M. McGoogan, “Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: Summary of a report of 72314 cases from the Chinese center for Disease Control and Prevention”. JAMA, 323: 1239-42 ,2020.

[14] W.J. Guan, Z.Y. Ni, Y. Hu, W.H. Liang, “Clinical characteristics of coronavirus disease 2019 in China”. N Engl J Med ,382: 1708-20, 2020.

[15] G. Grassell, A. Zangrillo, M. Antonelli, L. Cabrini, A. Castelli, “Baseline characteristics and outcomes of 1591 patients infected with SARS-CoV-2 admitted to ICUs of the Lombardy region, Italy”. JAMA ,323: 1574-81, 2020.

[16] S. Richardson, J.S. Hirsch, M. Narasimhan, J.M. Crawford, T. McGinn, K.W. Davidson, “Presenting characteristics, co-morbidities and outcomes among 5700 patients hospitalized with COVID-19 in the New York city area”. JAMA ,323: 2052-9, 2020.

[17] World Health Organization. Coronavirus Disease 2019 (COVID-19) Situation Report 68,28thMarch-2020. [Online], Available: https://www.who.int/docs/default-source/coronavirus/situation-reports/20200328-sitrep-68-covid-19.pdf
[18] C. Huang, “Clinical features of patients infected with 2019 novel coronavirus in Wuhan”, China. Lancet ,395, 497–506, 2020.
[19] L. Zhonghua, B. Xing, Z. Xue. “Novel Coronavirus Pneumonia Emergency Response Epidemiolog Team The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19) in China,: 41, 145–151, 2020.
[20] M.A. Andrews, B. Areekal, K.R. Rajesh, J. Krishnan, R. Suryakala, B. Krishnan, “First confirmed case of COVID-19 infection in India”: A case report. Indian J Med Res ,151: 490-2, 2020.
[21] "India most infected by Covid-19 among Asian countries, leaves Turkey behind". Hindustan Times. 29th May 2020. Retrieved 30th May 2020.
[23] "Home | Ministry of Health and Family Welfare | GOI". [Online], Available: mohfw.gov.in. Retrieved 30 May 2020.
[24] World Health Organization (WHO) Coronavirus Disease (COVID-19) Dashboard Data [Online], Available: https://covid19.who.int., last updated: 2020/5/29, 7:02pm
[25] "Coronavirus pandemic (COVID-19) in India". Our World in Data. [Online], Available: https://ourworldindata.org/coronavirus/country/india, Retrieved 20th May 2020.
[26] J.H. Yoo, S.T. Hong, “The outbreak cases with the novel coronavirus suggest upgraded quarantine and isolation in Korea”. Journal of Korean Medical Science, 35(5) 2020.
[27] Korea Centers for Disease Control and Prevention 2020, [Online], Available: http://ghdx.healthdata.org/organizations/korea-cnters-disease-control-and-prevention-kcdc
[28] S. Bagheri Nezhad, N. Mozayani, Elham Abdi, and Setareh Rostami. Smoking data of hospitalized covid-19 patients, Jun -2021.
[29] New COVID-19 cases in India by state and union territory, [Online], Available: https://en.wikipedia.org/wiki/COVID-19_pandemic_in_India#Escaping_of_suspected_people

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