CHI-SQUARE INDEPENDENCE TEST: TO STUDY THE EFFECT OF CHRONIC DISEASES AND RECOVERY FROM COVID 19

Case Study King Abdullah Hospital during the period December 2020-June 2021.

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ABSTRACT

The Chi-square statistic is a non-parametric tool designed to analyze group differences when the dependent variable is measured at the nominal level.

The aim of this research is to study two groups of people infected with COVID-19 who received the same medical care (one with chronic diseases who did not get the vaccine and the other group who did not have chronic diseases and did get the vaccine) and the extent of recovery from Covid 19.

A paper questionnaire was created for research purposes to follow up on cases received by King Abdullah Hospital during the period from December 2020 to June 2021. 316 valid questionnaires were retrieved with complete data and analyzed using SPSS software

The results showed that there is a statistically significant relationship between not having chronic diseases and getting the vaccine and recovery from Covid 19, and Cramer's V equals 0.75, and it is clear from the coefficient that there is a strong relationship between recovery from Covid 19 and being free from chronic diseases and getting the vaccine that confirms the hypothesis Research, and the study recommends the importance of getting the vaccine to increase immunity in individuals, whether they have chronic diseases or not.

Keywords: Chi-square, non-parametric, assumptions, categorical data, statistical analysis, COVID-19

الملخص:

إحصاء Chi-square عبارة عن أداة غير بارامترية مصممة لتحليل اختلافات المجموعة عندما يتم قياس المتغير التابع على المستوى الاسمي.

الهدف من هذا البحث هو دراسة مجموعتين من الأشخاص المصابين بفيروس كوفيد 19 الذين تلقوا نفس الرعاية الطبية (أحدهم مصاب بأمراض مزمنة ولم يحصل على اللقاح والمجموعة الأخرى لم تكن مصابة بأمراض مزمنة وحصلت على اللقاح) ومدى الشفاء من كوفيد 19.

تم إنشاء استبيان ورقي لتلبية أغراض البحث لمتابعة الحالات التي يتلقاها مستشفى الملك عبد الله خلال الفترة من ديسمبر 2020 إلى يونيو 2021. تم استرجاع 316 استبيانًا صالحًا مع بيانات كاملة وتحليلها باستخدام برنامج SPSS

أظهرت النتائج أن هناك علاقة ذات دلالة إحصائية بين عدم الإصابة بأمراض مزمنة والحصول على اللقاح والشفاء من كوفيد 19 ، و Cramer's V تساوي 0.75 ، ويتضح من المعامل أن هناك علاقة قوية بين الشفاء من كوفيد 19 و الخلو من الأمراض المزمنة والحصول على اللقاح الذي يؤكد فرضية البحث ، وتوصي الدراسة بأهمية الحصول على اللقاح لزيادة المناعة لدى الأفراد سواء كانوا مصابين بأمراض مزمنة أم لا.

الكلمات المفتاحية: مربع كاي ، غير معلمي ، فرضيات ، بيانات فئوية ، تحليل إحصائي ، COVID-19

1. INTRODUCTION

The Chi-square statistic is a non-parametric (distribution free) tool designed to analyze group diffe-rences when the dependent variable is measured at a nominal level. Like all non-parametric statistics, the Chi-square is robust with respect to the distribution of the data. Specifically, it does not require equality of variances among the study groups or homoscedasticity in the data. It permits evaluation of both dichotomous independent variables, and of multiple group studies. Unlike many other non-parametric and some parametric statistics, the calculations needed to compute the Chi-square provide considerable information about how each of the groups performed in the study. This richness of detail allows the researcher to understand the results and thus to derive more detailed information from this statistic than from many others.

The Chi-square is a significant statistic and should be followed with a strength statistic. Cramer's V is the most common strength test used to test the data when a significant Chi-square result has been obtained. Advantages of the Chi-square include its robustness to the distribution of the data, its ease of computation, the detailed information that can be derived from the test, its use in studies for which parametric assumptions cannot be met, and its flexibility in handling data from both two group and multiple group studies. Limitations include its sample size requirements, the difficulty of interpretation when there are large numbers of categories (20 or more) in the independent or dependent variables, and the tendency of the Cramer’s V to produce relatively low correlation measures, even for highly significant results.

(C 2007),(McHugh 2013)

The chi-square test for independence also called Pearson's chi-square test or the chi-square test of association. It is used to discover if there is a relationship between two categorical variables. (Boduszek 2016)

Chi-square (x^2) test is a nonparametric statistical analyzing method often used in experimental work where the data consist in frequencies or 'counts' for example the number of boys and girls in a class having their tonsils out as distinct from quantitative data obtained from measurement of continuous variables such as temperature, height, and so on. The most common use of the test is to assess the probability of association or independence of facts.(Zibran 2007)

2. COVID-19

There has beena new globalhealth crisisthatthreatens the entire world due tothe adventand spreadingof the newcorona-virus 2019 (2019-n-CoV) or severe acute respiratory syndrome corona-virus 2 (SARS-CoV2). Thisvirus has first originated in the bats and has beentransmitted tothehumanbeings by theyet unknown intermediary animalsin Wuhan, China in Dec.2019. the period of incubation ranges between 2 and14 days.

The signs of this illnessare oftencough, fever, shortness of breath, sore throat, malaise,fatigue,etc.Severalpeople do not have anyasymptoms.

SARS- CoV2 infectspeople of any age, the elderly and the eople who already havemedical conditions (like thediabetesand heart diseases) are at highrisksto get severeillnessby thisvirus. The world is facing an unprecedented challenge with communities and economies everywhere affected by the growing COVID-19 pandemic.

The world is coming together to combat the COVID-19 pandemic bringing governments, organizations from across industries and sectors, and individuals together to help respond to this global outbreak. The outpouring of global solidarity and support sparked by this shared challenge has been phenomenal the world is facing an unprecedented challenge with communities and economies everywhere affected by the growing COVID-19 pandemic. (Weiss and Leibowitz 2011)

COVID-19 is one of the advanced viruses of the coronavirus, which was previously occurring in the form of the acute respiratory syndrome known as SARS, and Middle East Respiratory Syndrome (MERS), the previous type of coronavirus, and on December 31, 2019, a new virus appeared from this family, and this type was known New in the name of the new coronavirus (SARS-CoV2) or the new coronavirus 2019 (COVID-19). The outbreak has started in Wuhan, China, and China has completely isolated the city to avoid spreading infection.

People with COVID-19 suffer from symptoms - from mild symptoms to severe illness. Symptoms may appear two to 14 days after exposure to the virus such as (Trouble breathing, Persistent pain or pressure in the chest, New confusion Inability to wake or stay awake, Bluish lips or face), There were many warnings and instructions from health organizations that they should look for warning signs in an emergency for COVID-19. If someone shows any of these signs, urgent medical care should be sought immediately, as this list is not all possible symptoms. Medical follow up, other symptoms appear, It is possible to test positive for influenza (in addition to other respiratory infections) and COVID-19 at the same time. (WHO reports, Dec.2020)

The main variables that could be considered to understand the COVID19. The main variables that are considered in this study are sex, region, infection reasons, birth date, confirmed deceased date, and confirmed the recovered data. After discussing the obtained results, it is found that to mitigate the coronavirus disease in South Korea, several procedures should be followed. These procedures are related to prevent any direct contact with patients, especially those inside isolated hospitals and prevent any kind of community events (ie, visiting patients, going to restaurants, shopping at groups and big stores, etc). Besides, the processes of testing people against coronavirus should be faster. Keeping South Koreasafe from coronavirus would affect all nearby countries. (Al-Rousan and Al-Najjar 2020)

Due to the lack of preliminary studies on the risks of people with chronic diseases infection with the Covid-19 virus, due to the large number of infections since the spread of the virus, the paper aims to determine the impact of chronic diseases and obtaining the vaccine on the recovery of the virus carrier.

3. COVID-19 AND CHRONIC DISEASES

According to World Health Organization (WHO) reports, cardiovascular disease, diabetes and hypertension are the most frequent of these diseases associated with COVID-19.

Seven coronaviruses which are responsible for someserious respiratory diseases wereidentified in humans during the past 20 years. Many of them, like Covid-19(beta coronavirus lineage b / sarbecovirus), may result inlung damage to patients and often multi-organ dysfunction with adversarialmyocardial re-modeling, cardiomyopathy and myocardial stress.

There are many scientific studies that aimed to study the effect of infection with Covid 19 on people who have chronic diseases. These studies found that patients with chronic diseases are more likely to be infected with Covid 19, and their recovery rate is lower than people who do not have chronic diseases.(Bavishi, Maddox, and Messerli 2020)

Although abnormalities of liver function indicators are common in patients with COVID-19, impaired liver function is not a prominent feature of COVID-19, and may not have serious clinical consequences. (Zhang et al. 2020)

The current study has identified a strong inverse association between COVID-19–related anosmia and a critical branch
a point in the management of COVID-19: the decision to com-mit to hospital admission. Patients admitted for COVID-19
were 10 times less likely to report anosmia. These find-ings have important immediate practical applications to the lay public as well as healthcare workers and health-care systems looking to efficiently risk-stratify patients to efficiently provide appropriate medical and nonmedical in-interventions.
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Elevated age and NLR can be considered independent biomarkers for indicating poor clinical outcomes. (Yan et al. 2020)

Clinical features of 95 sequential hospitalized patients with novel coronavirus 2019 disease (COVID-19), the first UK cohort by(Tomlins et al. 2020).

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4. **COVID-19 VACCINATION.**

COVID-19 Vaccination is a safer way to Build Protection, Getting a COVID-19 vaccination is a safer way to build protection than getting sick with COVID-19, COVID-19 vaccination help protect by creating an antibody response without you having to experience sickness.

Getting sick with COVID-19 can cause severe illness or death, even in children, and we can't reliably predict who will have mild or severe illness, there may be long-term health issues after a COVID-19 infection. Even people who don't show symptoms when this happens, People who are sick with COVID-19 may spread COVID-19 to others including friends and family who are not eligible for vaccination and people at increased risk for severe illness from COVID-19, COVID 19-vaccines are effective and can lower your risk of getting and spreading the virus that causes COVID-19. COVID-19 vaccines also help prevent serious illness and death in children and adults even if they do get COVID-19.(Oliver 2021)

Aims of this study were to analyze the clinical data, discharge rate, and fatality rate of COVID-19 patients for clinical help. The clinical data of COVID-19 patients from December 2019 to February 2020 were retrieved from four databases. We statistically analyzed the clinical symptoms and laboratory results of COVID-19 patients and explained the discharge rate and fatality rate with a Single-Arm Meta-Analysis.

The available data of 1994 patients in 10 literatures were included in our study. The main clinical symptoms of COVID-19 patients were fever (88.5%), cough (68.6%), myalgia or fatigue (35.8%), expectoration (28.2%), and dyspnea (21.9%). Minor symptoms include headache or dizziness (12.1%), diarrhea (4.8%), nausea and vomiting (3.9%).

The results of the laboratory showed that the lymphocytopenia (64.5%), increase of Creactive protein (44.3%), increase of lactic dehydrogenase (28.3%), and leukocytopenia (29.4%) were more common.

The results of Single-Arm Meta-Analysis showed that the male took a larger percentage in the gender distribution of COVID-19 patients 60% (95% CI [0.54, 0.65]), the discharge rate of COVID-19 patients was 52% (95% CI [0.34,0.70]), and the fatality rate was he aim of this study was to analyze the clinical data, discharge rate, and fatality rate of COVID-19 patients for clinical help.

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5. HYPOTHESES:

The research hypothesis states that the two variables are dependent or related.

This will be true if the observed counts for the categories of the variables in the sample are different from the expected counts.

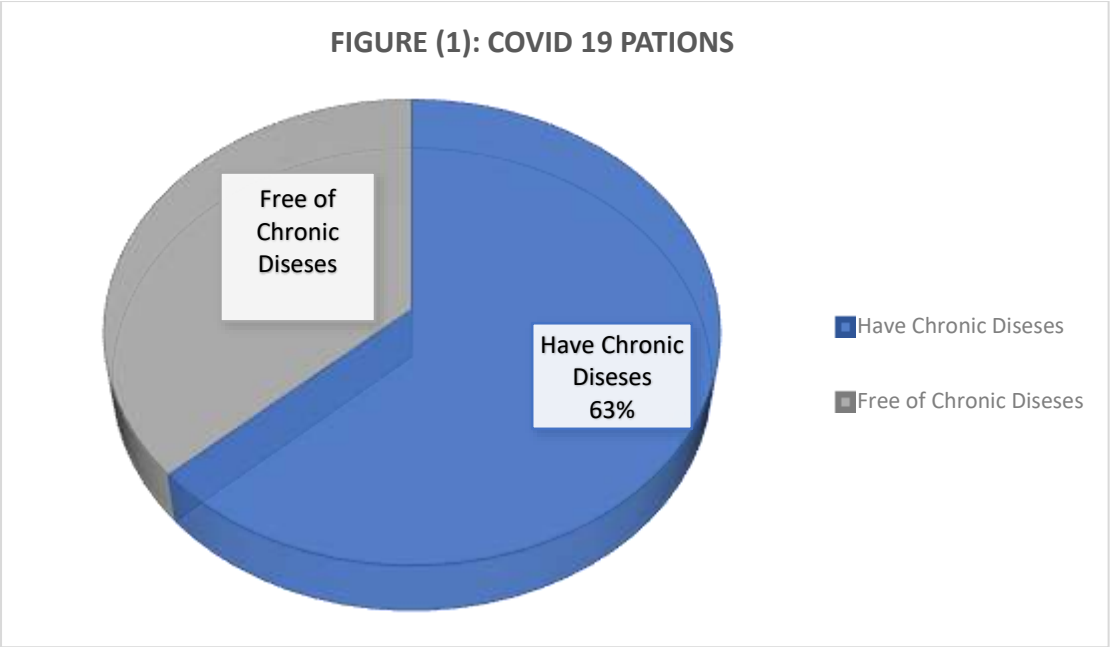
The null hypothesis: there is no relationship between chronic disease,(don't got vaccen) and healing from COVID19 without getting the vaccine.

6. CASE STUDY FOR SOME OF COVID-19 PATIENTS AT KING ABDULLAH UNIVERSITY HOSPITAL.

To study the impact of chronic diseases on recovery from COVID19 whether or not he gets the vaccine a case study was made for 316 patients who were infected with a COVID19 during the period Dec. 2020 -Jon.2021 and who received the same level of medical care in King Abdullah Hospital and getting the vaccine.

6.1. DESCRIPTIVE STATISTICS:

Through the follow-up records of the Department of Critical Cases, it was found that 316 patients with COVID19, 200 of them have chronic diseases (suffer from one or more of these diseases and don't got the vaccine: difficulty breathing, persistent pain or chest pressure, New confusion, the inability to wake up or remain awake, or bluish lips or face), 32 of them were in contact with the affected cases and 116 free of chronic diseases and got the vaccine but 42 of them were in contact with the affected cases, by inquiring about the cause of injury to the contestants who had mixed with them, it was found that they were suffering from one or more of the above mentioned chronic diseases, 19 cases, was due to the nature of the work (doctors, nurses, ..., etc.).



figure(1) shows that the percentage of people with chronic diseases who were infected with COVID19 and not got the vaccine is 63%, while the percentage of people without chronic diseases who are infected with COVID19 and got the vaccine is 37% of the study's observations.

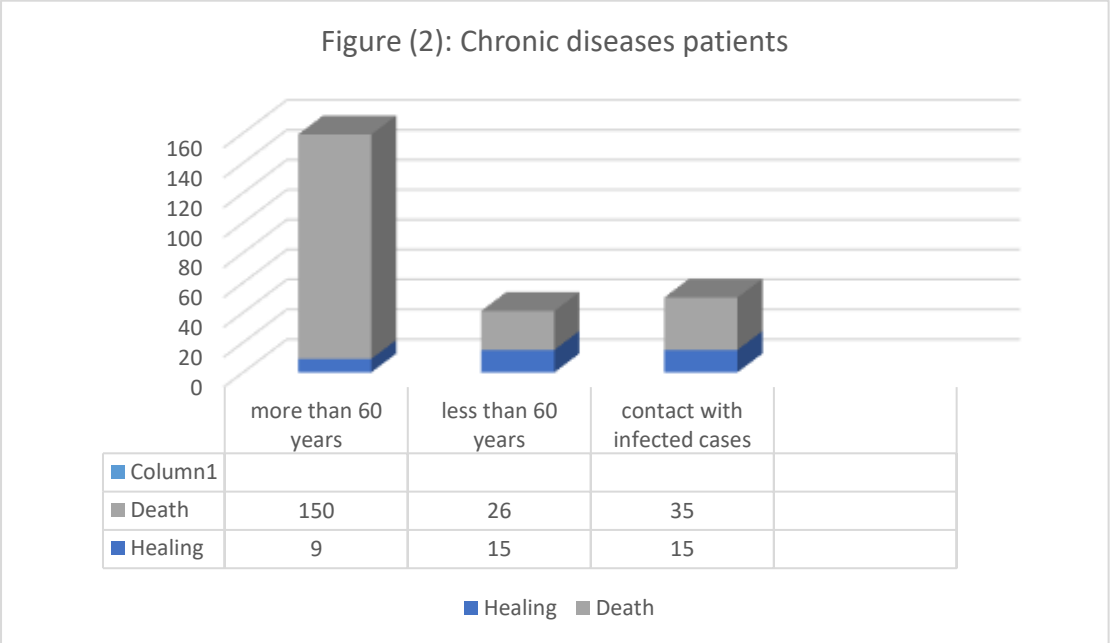
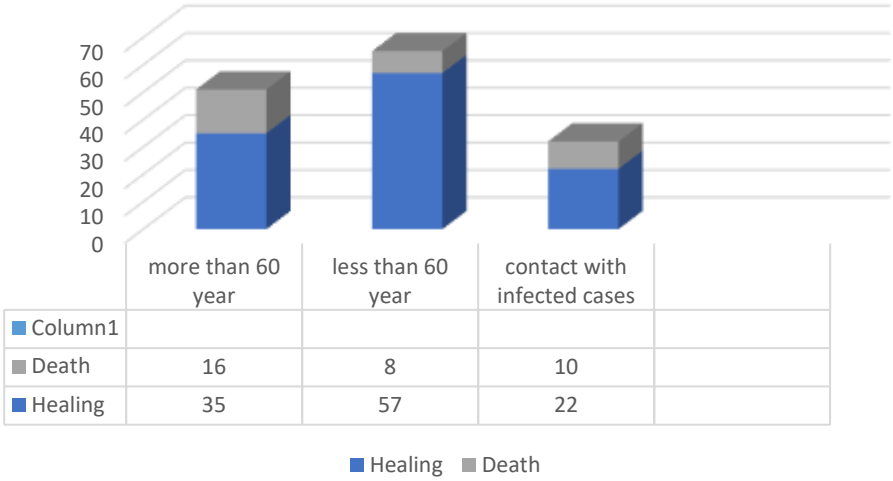


Figure 2 shows the healing rate for patients with chronic diseases, don't got the vaccine and their ages over 60 years 6% and 94% death, while the healing

rate for patients suffering from chronic diseases and their ages less than 60 years 27%

Figure (3): Free of Chronic diseases patients



and 63% death ,the number of those injured due to contacting infected cases is 42.

Figure 2 shows the healing rate for patients with chronic diseases, got the vaccine and their ages over 60 years 69% and 31% death, while the healing rate for patients suffering from chronic diseases and their ages less than 60 years 88% and 12% death, The number of those injured due to contacting infected cases is 32.

6.2 CHI-SQUARE ASSUMPTIONS:

As with parametric tests, non-parametric tests, including $\chi 2$, assume that data obtained by random selection. However, it is not uncommon to use second inferential statistics when data are from appropriate samples instead of random samples. As is the case with our current research.

The assumptions of the Chi-square as followig:

1. Data in cells represent the number of patient cases.
2. Levels (or categories) of variables are mutually exclusive.
3. The two groups were tested for the same period.
4. The study groups are independent.

In our current study, two groups of patients who received the same level of medical care were used, the first group (have chronic diseases), dont got the vaccine, the second group (who free of chronic diseases), got the vaccine and whether this affects the patient's healing or not (death).

From the study data, we have two groups:

The first group: those with COVID19 and have one or more chronic diseases and don't got the vaccine.

The second group: those with COVID19 and free of chronic diseases and got the vaccine.

In this case, the dependent variable will result in the two groups receiving the same level of medical care, which is one of two results:

1- healing

2- death

The study aimed to find out whether the incidence of chronic diseases, don't got the vaccine had an impact on the extent of recovery or not.

To answer this question, we must use an appropriate statistical test that can test for differences in the outcome of medical care in both cases. So the $\chi 2$ statistic was used to test the question, "Was there a difference in the incidence of recovery between the two groups?".

Table (1) clarifies infection with Coronavirus (COVID19).

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Row Labels	**Death**	**Healing**
Free of chronic diseases and got the vaccine	14	102
chronic disease and don't got the vaccine	176	24

6.3 CALCULATING CHI-SQUARE:

With the data in the table (1), the researcher can proceed with calculating the $\chi 2$ statistic to find out if the incidence of chronic diseases,don't got the vaccine, affects healing from non- healing (death).

The formula for calculating a Chi-Square is:

$$x^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

Where:

O_i : Observed (the actual count of cases in each cell of the table).

E_i: Expected value (calculated below).

x^2 : The cell Chi-square value.

x_{ij}^2: ij is the correct notation to represent all the cells, from the first cell (i) to the last cell (j); in this case Cell 1 (i) through Cell 4 (j).

The first step in calculating a $\chi 2$ is to calculate the sum of each row, and the sum of each column. These sums are called the "marginals" and there are row marginal values and column marginal values.

The marginal values for the case study data are presented in Table 2.

Table (2) Calculation of marginals.			
Row Labels	**Death**	**healing**	**Row marginals (Row sum)**
Free of chronic diseases, got the vaccine	14	102	116
chronic disease, don't got the vaccine	176	24	200
Column marginals (Sum of the column)	**190**	**126**	**N = 316**

The second step is to calculate the expected values for each cell. In the Chi-square count, the "expected" values represent an estimate of how the cases are distributed if there is no effect of one or more chronic diseases.

The expected values should reflect the occurrence of each case in each category and the unbiased distribution of cases if there was no effect of one or more of the chronic diseases. This means that the statistic cannot just calculate the sum of N and divide 4 by the expected number in each cell, this will not take into account the fact that more have been cured regardless of whether they have chronic diseases or not. The expected Chi-Square for each cell is calculated as follows:

$$E = \frac{(M_R * M_C)}{n}$$

Where:

E : represents the cell expected value.

M_R : represents the row marginal for that cell.

M_C : represents the column marginal for that cell.

n : represents the total sample size.

Specifically, for each cell, its row marginal is multiplied by its column marginal, and that product is divided by the sample size. For Cell 1, the math is as follows: (116 * 190)/316 = 69.74683544. Table 3 provides the results of this calculation for each cell.

Table 3. Cell expected values			
Expected (fe)	**Death**	**healing**	**Total**
Free of chronic diseases, got the vaccine	69.74683544	46.25316456	116
chronic disease, don't got the vaccine	120.2531646	79.74683544	200
Total	190	126	316

Table 3 provides the results of this calculation for each cell. Once the expected values have been calculated, the cell $\chi 2$ values are calculated with the following formula:

$$E = \frac{(O - E)^2}{E}$$

Cell $\chi 2$ is calculated for the first cell in the case study data as follows:

$$\frac{(14 - 69.746840)^2}{69.746840} = 44.556998$$

Cell value χ2 Table 4 shows the value χ2 for each cell.

Table 4. cell Chi-square values			
Chi -Square	**Death**	**healing**	**Total**
Free of chronic diseases, got the vaccine	44.55699878	67.18912515	111.7461239
chronic disease, don't got the vaccine	25.84305929	38.96969259	64.81275188
Total			176.5588758

Once the cell χ2 values have been calculated, they are summed to obtain the χ2 statistic for the table. In this case, the χ2 is 176.56 (rounded) as shown in Table 4. The Chisquare table requires the table's degrees of freedom (df) to determine the significance level of the statistic. The degrees of freedom for a χ2 table is calculated with the formula:

(Number of rows -1) x (Number of columns -1).

For a sample table that has two rows and two columns, df =(2-1)(2-1)=1*1=1

is a square significance table in many stats text stats and on many websites. Using a χ2 table, the significance of a Chi-square value of 3.841 with 1 df, α=0.05.

The value of $P < 0.05$ for convenience. The exact significance when the Chi-square is calculated through a statistical program is found to be P = 0.00000011.

Since the value of P for the table is less than $P < 0.05$, the null hypothesis is rejected and the alternative hypothesis is accepted: "There is an effect of chronic diseases on the healing from the Coronavirus (COVID19)"

However, this result does not specify what that difference might be. To fully interpret the result, it is useful to look at the cell $\chi 2$ values.

Table 5. Cell expected values and (cell Chi-square values).		
Expected (fe)	**Death**	**Healing**
Free of chronic diseases, got the vaccine	69.75 (44.6)	46.3(67.2)
chronic disease, don't got the vaccine	120.3 (25.84)	79.75 (38.96)

It can be seen in Table 5 that the largest cell $\chi 2$ value of 67.2 occurs in Cell 2. This is a result of the observed value being 102 while only 46.3 were expected. Therefore, this cell has a much larger number of observed cases than would be expect ed by chance.

Cell 2 reflects the second group: those with COVID19 and free of chronic diseases, They have the same medical care and have been cured of Covid 19 (healing).

This means that the number of the second group was significantly greater than expected.

The second largest cell $\chi 2$ value of 4.56 is locateed in Cell 1. However, in this cell we discover that the number of observed cases was much lower than expected (Observed = 44.6, Expected = 69.75). We note from the values of the table that the significantly relationship between the healing of Covid 19 and chronic diseases.

6.4 STRENGTH TEST FOR THE CHI-SQUARE

Statistical strength tests are correlation measures. For the Chi-square, the most commonly used strength test is the Cramer's V test. It is easily calculated with the following formula.

$$\sqrt{\frac{x^2/n}{(k-1)}} = \sqrt{\frac{x^2}{n(k-1)}}$$

$$\sqrt{\frac{176.56}{316(2-1)}} = \sqrt{0.559} = 0.7476$$

The Cramer's V is a form of a correlation and is interpreted exactly the same. For any correlation, a value of 0.75 is a strong correlation.

It is clear from the coefficient that there is a strong relationship between the healing of Covid 19 and Free of chronic diseases and got the vaccine which confirms the hypothesis of the research.

7.LIMITATIONS OF CHI-SQUARE TEST

As mentioned before, chi-square test cannot be applied on continuous data. It can only be applied to qualitative data classified into categories, or labeled using nominally scaled variables, the Chi-square was the best or only test the researcher could have used. Nominal variables require the use of non-parametric tests, and there are three commonly used significance tests that can be used for this type of nominal data.(Pope, Ziebland, and Mays 2000)

The first and most commonly used is the Chi-square.

The second is the Fisher's exact test, which is a bit more precise than the Chi-square, but it is used only for 2 x 2 and one or more of the cell counts in a 2×2 table is less than 5. The case study example requires a 2 x 2 table but the cell counts mor than 5 thus the data are not suitable for the Fisher's exact test.(Cochran 1954)

The third test is the maximum likelihood ratio Chi- square test which is most often used when the data set is too small to meet the sample size assumption of the Chi-square test, As exhibited by the table of expected values are more than 5 for the our case study, so the cell expected requirements of the Chi-square and there is no need to use the maximum likelihood ratio chi-square.

When researchers use the Chi-square test in viola- tion of one or more assumptions, the result may or may not be reliable. In this author's experience of having output from both the appropriate and inappropriate tests on the same data, one of three outcomes are possible:

First, the appropriate and the inappropriate test may give the same results.

Second, the appropriate test may produce a significant result while the inappropriate test provides a result that is not statistically significant, which is a Type II error.

Third, the appropriate test may provide a nonsignificant result while the inappropriate test may provide a significant result, which is a Type I error.

8.SUMMARY AND CONCLUSIONS

The Chi-square is a valuable analysis tool that provides considerable information about the nature of research data. It is a powerful statistic that enables researchers to test hypotheses about variables measured at the nominal level.

As with all inferential statistics, the results are most reliable when the data are collected from randomly selected subjects, and when sample sizes are sufficiently large that they produce appropriate statistical power.

The Chi-square is also an excellent tool to use when violations of assumptions of equal variances and homoscedascity are violated and parametric statistics such as the t-test and ANOVA cannot provide reliable results. As the Chi-Square and its strength test, the Cramer's V are both simple to compute, it is an especially convenient tool for researchers in the field where statistical programs may not be easily accessed. However, most statistical programs provide not only the Chi-square and Cramer's V, but also a variety of other non-parametric tools for both significance and strength testing.

9.CONCLUDING REMARKS

Chi-square test tells us whether the classifications on a given population are dependent on each other or not. However, it is important to stress that the establishment of statistical association by means of chi-square does not necessarily imply any causal relationship between the attributes being compared, but it does indicate that the reason for the association is worth investigating.(Pope et al. 2000)

For example, if further investigations are carried out in the event of the death of people From Covid 19, we may have discovered that the cause of death of men from Covid 19 who have respiratory injury is higher than women may be due to the fact that there are more smokers in men than women.

More on chi-square test may be found in the references given below. Maxwell in his book "Analysing Qualitative Data".(Pope et al. 2000) elaborately describes the chi-square test and related topics. (Koschmann 2012)

covers necessary preliminary knowledge on statistics and illustrates the chi-square test with descriptive examples.

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