Empirical Study of Effectiveness of Healthcare Instruments in Diagnosis and Treatment of COVID - 19 for Prevention of any Imminent Endemic Outbreak

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Abstract

Some things that happen once in a lifetime and Covid-19 is one such unwanted experience phenomenon. After effects of Covid-19 are still felt and seen in many parts of the world. It transformed the worldwide outlook towards healthcare and its precautionary measures to be taken have changed and given entirely new dimensions. Unfortunately, such scenarios may repeat themselves even though nobody wants it to happen again. Thus, it becomes imperative to study and analyze the measures adopted for containment of Covid -19 like pandemic for future readiness. Apart from the vaccines, diagnosis, instruments used for prevention and treatment of coronavirus patients were the major contributors in winning the war against the pandemic. But the success rate of these tests and instruments are still not conspicuous. In lieu of this, we conducted an exploratory study and surveyed doctors to know the success rate of various diagnosis tests and the effectiveness of instruments used in the treatment of Covid-19 viral infection. The survey has been statistically analyzed using the Kruskal-Wallis Test, to enhance the validity of our results.

Key words: Instrument Validity, Diagnostic Tests, Exploratory Survey, Kruskal-Wallis Test

1. Introduction

Nearly two and a half years ago the world saw a start of calamity big enough to be called one of the most depressing periods in the history of mankind 'Covid-19'. The Covid-19 pandemic that started from Wuhan, China took over the world and became a global phenomenon in no time. The first case was recorded in December 2019 but the high tide of coronavirus cases around the globe occurred at different times in the past three years. There was confusion, fear, uncertainty, depression, deaths, but there was something else which came into the picture, the world saw a revolutionary reform in our medical systems. Medical fraternity from all over the world united to fight this war against the deadly coronavirus pandemic. To fight the war, doctors were equipped with well-defined medical weaponry which either existed initially or was invented in tough times which made a giant difference. Instruments and measuring systems played a very important role in measurement and analysis of the vital units important for human health.The most important equipment which are used for treatment of the coronavirus infection included Digital Thermometer, Infrared Thermometer, Pulse Oximeter, Ventilator, CT-scan, Stethoscope, Portable Handheld Pulse Oximeter, Oxygen Regulator, Electrocardiograph, Patient Monitor Multiparametric, Basic non-invasive blood pressure [NIBP], oxygen saturation [SpO2] with accessories, Portable O2 Concentrator producing oxygen to be consumed by patients, Electronic Drop Counter, Infusion Pump, Ventilators CT Scanning System, Laryngoscope [1-5].

The major role in stopping the spread of the virus was played by diagnostic tests. The infection showed up with symptoms after many hours if not days, and by this time the subject had already transmitted the infection to a lot of people if he normally socialized. As the reports took days to come, and till that time the patient was left with a situation of uncertainty in quarantine. But by the time we reached a long way in the pandemic, we were also climbing the most quick and effective ways to diagnose the infection. The detection of infection in due time was a big milestone in winning the war against the pandemic. Some of the most effective tests for detection of Covid-19 are LFT (Lateral Flow Test), Serology/ Antibody Test and Real time reverse transcriptase-polymerase chain reaction (RT-PCR) test. There are many variations of the PCR tests but the one used to detect covid-19 is Reverse Transcription PCR or RT-PCR as SARS-Covid-19 virus only has RNA and is recognised by WHO [World Health Organisation] [6-7].

While assessing the effectiveness of a diagnostic test, two main factors are taken into account, namely the specificity and sensitivity. The term "specificity" refers to the ability of the test to eliminate "false positive" results—that is,identifying the infection caused by other viruses of the corona family (such as those causing common cold, SARS or MERS) as Covid-19 [8-10]. In this regard the RT -PCR test fits the bill perfectly. From this perspective, the efficiency of RT-PCR is almost 100 percent. If a person tests positive in RT-PCR, there is almost no chance for the result to be false positive. According to Prof. Harlan M Krumholz, director of the Yale New Haven Hospital Center for Outcomes Research and Evaluation "The good news is that the tests appear to be highly specific: If your test comes back positive, it is almost certain you have the infection," (*The New York Times*, April 1,2020).

The "Sensitivity" of a test is the ability to detect the virus and minimise "false negative" result—that is, failing to detect the virus when it is actually present in a patient's sample. The performance of RT-PCR is not that good in this respect. There are reports of 15-30 percent "false negative" results, as the sources vary. This was a scary situation that could lead to catastrophic consequences. On the one hand, the infected individual may be deprived of necessary care; on the other hand, he/she may socialize with others considering themselves "not infected", keeping on transmitting the disease to others[10].

It was thus seen that the tests contained their own set of complications and hence the accuracy of detection of infection and damage done by the infection was still a topic of doubt [11]. These errors were too not in the same trend but were varying with different patients. This prompted us to dig a bit more in this regard and carry out an exploratory study so as to clarify the effectiveness of these diagnostic tests. Also, the medical instruments that were used in the treatment of patients by the doctors were also reviewed to know their success rate in treatment of the patients for future readiness of similar disease/pandemic outbreak.

In the present work, in order to achieve a conclusion we decided to have a questionnaire containing a set of questions which was to be answered by a sample of 49 doctors. Questions were asked to know the effectiveness of the diagnostic instrument, success rate of various tests for detection of covid 19. Response was taken from doctors from all over India and abroad as well, both genders, having practice experience from 0 to above 10 years to find out a common trend. Paper presents the analysis of the survey filled by doctors.

2. Instruments used for diagnosis and treatment of Covid-19

The recent Covid-19 pandemic has brought attention to the quality and quantity of life saving instruments in labs and hospitals all around the world. The instruments can be classified as testing and diagnosing instruments as shown in figure 1.Instruments are used for examining symptoms and for the detection of bacteria or viruses that come under testing includes test such as RT-PCR (Reverse Transcription Polymerase chain reaction (PCR) testing machine, LFT (Lateral Flow Test) and Serology/ Antibody Test. These tests are performed to identify whether the virus is present or not. Thermometers and pulse oximeters are used to identify temperature and oxygen level of the patient. CT-scan (Computed Tomography Scan) is performed in critical cases. There are various instruments used by doctors and nurses for the treatment of covid-19 along with medicines. The instruments discussed in this section are: Nebulizer, Ventilator, Infusion and Suction pumps.

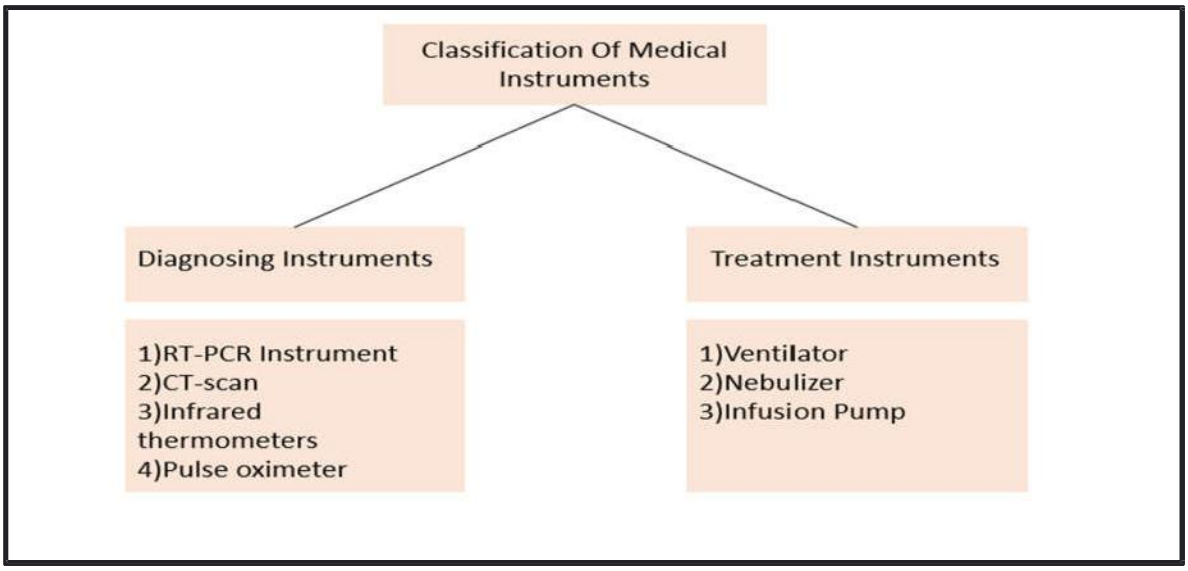

Figure 1: Classification of Medical Instruments in terms of Diagnosis and treatment

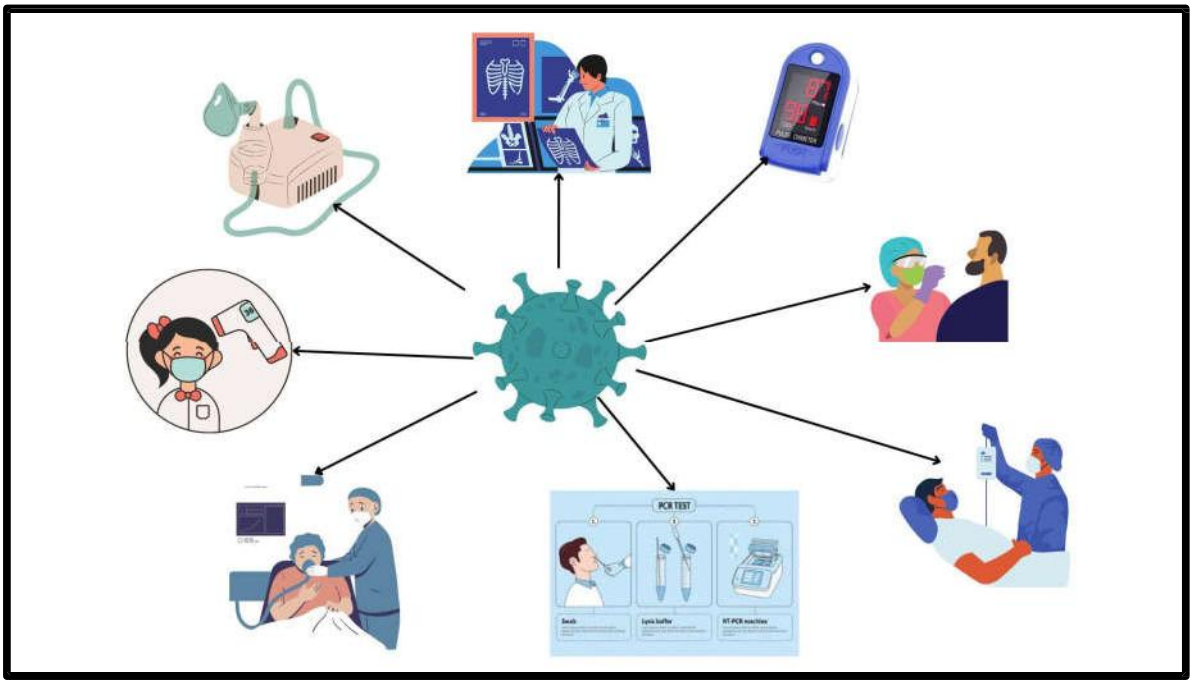

Figure 2: Instruments used in diagnosis and treatment of Covid-19

3. Hypothesis

In the initial stage, we assumed that the following scenario-

(1) The RT-PCR test is the most effective of all and was a boon in the chronic stage.

(2) The accuracy ratings of the LFT test, Serology/ Antibody test and the RT-PCR test effectiveness in diagnosing the infection are similar by all doctors.

(3) The accuracy ratings of the treatment instruments effectiveness in treating the infection is similar by all doctors.

4. Method

4.1 Study Design:

This was an Indian Questionnaire-based internet survey distributed by the google form platform. This survey is conducted by the students and faculty of Department of Instrumentation, Bhaskaracharya college of Applied Science, University of Delhi. In order to know the success rate of various tests and the effectiveness of instruments used in the treatment of Covid-19 infection, this survey was designed and responses from 49 doctors were recorded.

4.2 Study Participants:

The questionnaire was designed by the group of students and faculty under the supervision of doctors. It contained 10 questions in total including name, gender, institution for which they are working, years of practicing, state and city in which they are based. The details of which are shown in pie charts depicted in figures 4-9.

- Survey was shared with doctors of both genders. 42.3% of female doctors have filled the response whereas response from 57.7% doctors was obtained from male doctors.
- Response from doctors of nine different states was received. In addition to this, response from doctors outside India is also received as shown in figure. Maximum respondents were from Delhi NCR region of north India

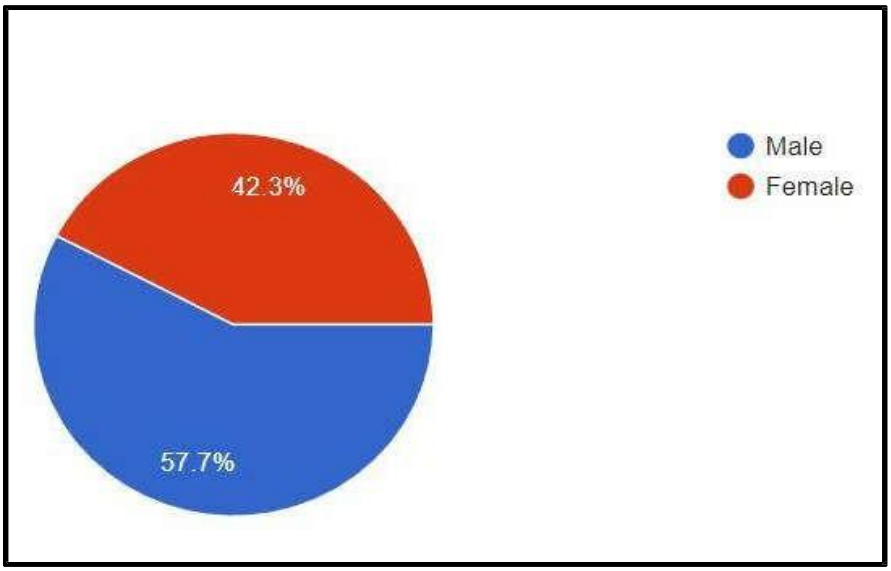

Figure 3: Percentage of Male and Female Doctors Respondents

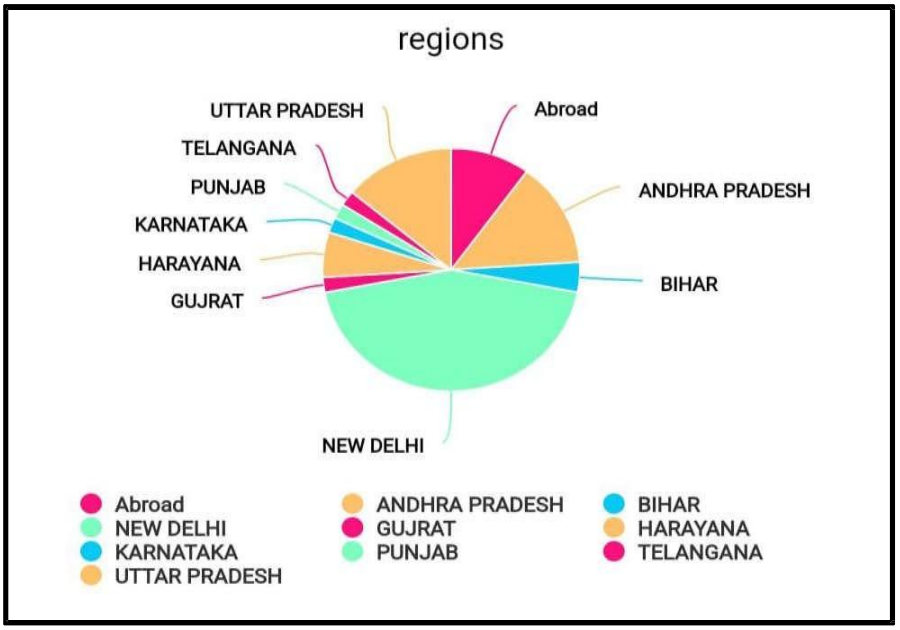

Figure 4: City of Doctors

- With respect to doctor's specialty, most of the patients were consulting general physicians in the early stage of the virus and critical patients were consulting ENT and pulmonologist. The responses from all the specialists were recorded. Apart from the responses from cardiologists and other doctors, patients also consulted locally available pharmacists and lab technicians due to ease of access, which forms the "others" category, as shown in figure 5.

- Survey was filled by doctors of varied experience to have a well distributed response for our hypothesis. As shown in figure 6 , 34.6 % of doctors filling the responses had more than 10 years of experience. Around 31% doctors had 5-10 years of experience and approximately 35 % of doctors with 2-5 years of experience filled the survey. The myriad distribution added more insight to our study.

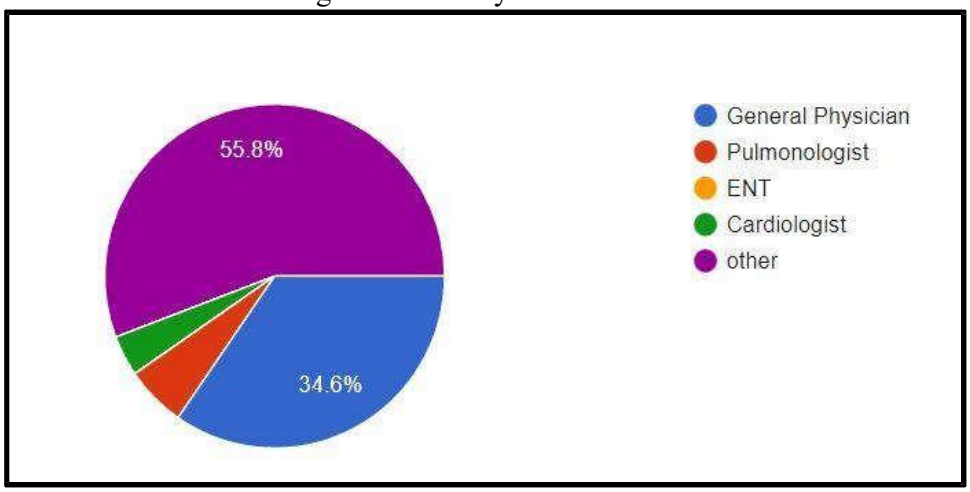

Figure 5: Percentage of different type of Doctors

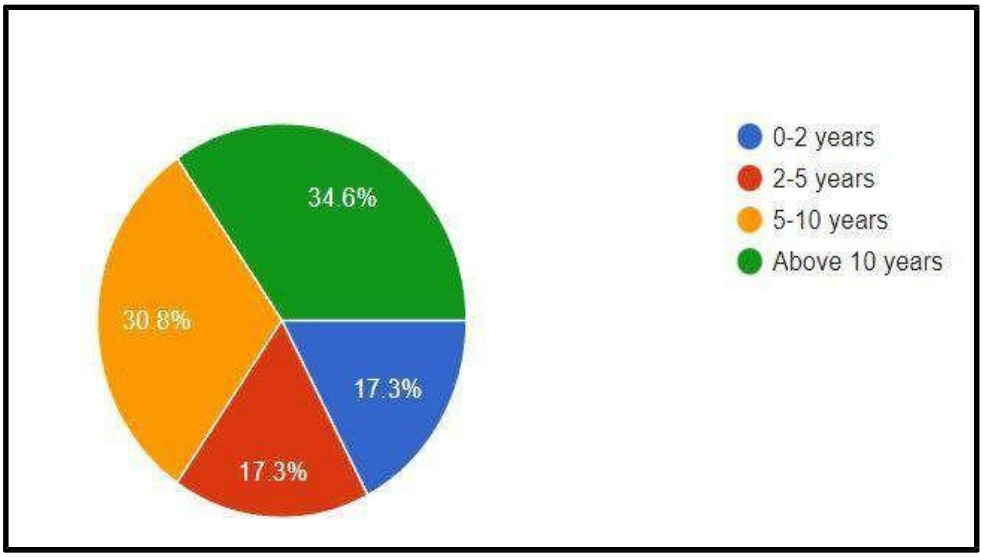

Figure 6: Year of practicing of Doctors

4.3 Survey Questionnaire

The following questions were asked from the doctors via google forms on effectiveness of various covid detection tests, their success rate and instruments used in their diagnosis and treatment.

Q: Rate the effectiveness of each test to check whether a patient has covid-19 or not?				
Test Name/Rating	**least effective**			**Most effective**
RT-PCR test	1	2	3	4
Rapid Antigen Test	1	2	3	4
Serology/Antibody Test	1	2	3	4
LFT test(Lateral Flow test)	1	2	3	4

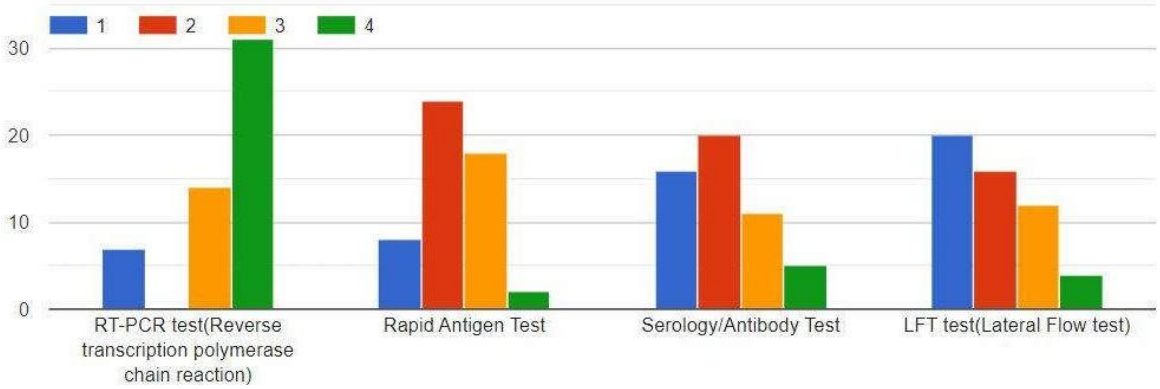

Figure 7: Rating of different COVID-19 detection test

The bar graph illustrates that the doctors consider RT-PCR as the most effective test for detection of SARS 2 COVID virus. This can be attributed to its high efficiency in correctly detecting the virus as depicted in the response to the next question. The rapid antigen test is also widely popular owing to its simplicity and speedy outcome. The antibody and LFT test are less popular being more elaborate, expensive and time consuming though they become essential in critical cases.

As the RT-PCR test was established to be most effective in determining whether a person has COVID or not, so it is essential to know about its success rate, hence our next question was framed as below.

Q. What is the success rate of the RT-PCR test in detecting sars-cov2 in the patient?
70%
75%
80%
80%
95%

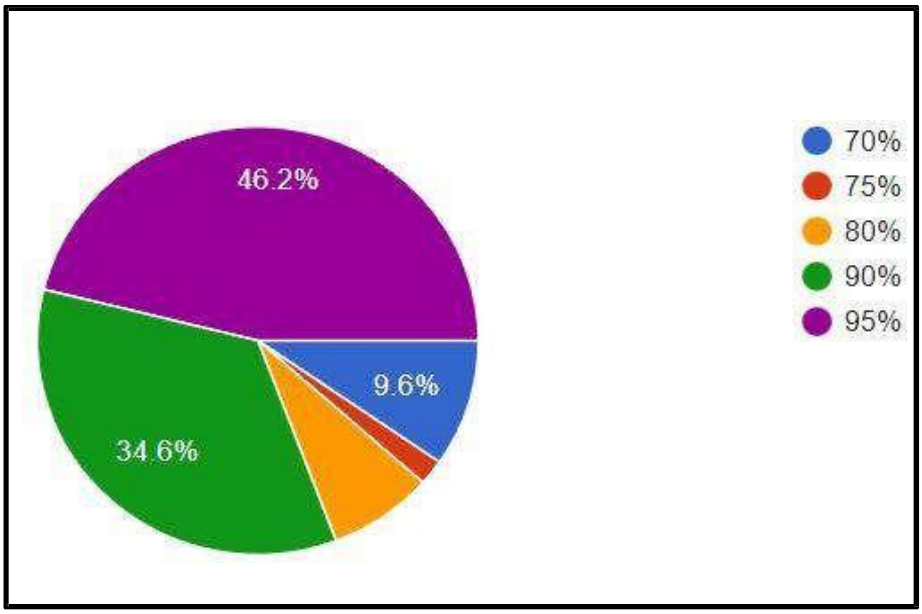

Figure 8: Success rate of the RT-PCR test in detecting sars-cov2 in the patient

As depicted, responses received from the doctors indicate that 80.8% doctors find RT-PCR to be highly successful (>90%) in detecting coronavirus in patients. This may be attributed to the fact that the test analyzes the genetic sequences of the virus and then determines the results. Most of the doctors relied on the high specificity of the RT-PCR test. The term "specificity" refers to the process of identifying the infection caused by other viruses of the corona family (such as those causing common colds, SARS or MERS) as Covid-19. Thus if a person tests positive in RT-PCR, there is almost no chance for the result to be a false positive.

The treatment of Covid-19, various instruments are used. Therefore, the next question prodded the instruments most commonly used for treating Covid-19 patients.

Q. Please rate the following instruments on the basis of maximum usage in your practice , while treating covid-19 patients.				
Instruments/Rating	**least used**			**Most used**
Ventilator	1	2	3	4
Nebulizer	1	2	3	4
Infusion Pump	1	2	3	4
Oxygen concentrator	1	2	3	4

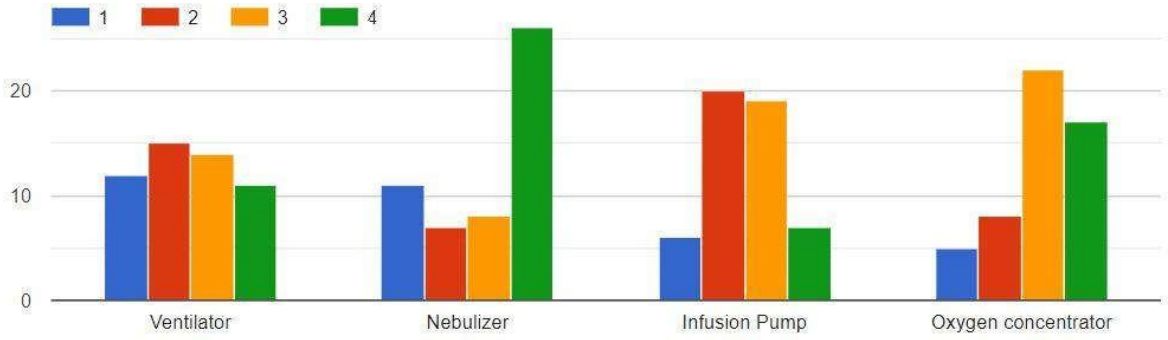

Figure 9: Rating given by the doctor's instruments on the basis of maximum usage while treating covid-19 patients.

The bar graph conspicuously establishes nebulizer to be the most effective instrument for alleviating Covid-19 related symptoms. The doctors found it highly effective in treating early stage symptoms. It acted as a precautionary measure to prevent the infection from advancing to lethal stages. Also it was readily available and cost effective as well. But for severe symptoms like reduced oxygen levels and incapacitated lungs oxygen concentrator and infusion pumps became a necessity. Ventilator was used in extremely critical cases only.

5. Statistical analysis:

Quantitative analysis has been done by circulating a survey on rating and ranking various tests and instruments to doctors of different expertise with international and national responses. This is an exploratory research with a sample size of 49 doctors. Primary data was in the form of survey responses recorded in excel through google forms and was analyzed on different parameters on the IBM software SPSS (Statistical Package for the Social Sciences).

We have used the responses of various doctors as primary data for the analysis. The data was nominal: name, type of doctor and ordinal: ratings and ranking answers. The data analyzed is non-parametric as it is in a rating\ranking format. The Kruskal-Wallis test is a rank-based nonparametric test that can be used to determine if there are statistically significant differences between two or more groups of an independent variable on a continuous or ordinal dependent variable. As our data is ordinal, non-parametric and rank based we have used Kruskal-Wallis [12].We have used the range 0.01-0.05, anything beyond this threshold will relay the original\\Null hypothesis to be wrong.

We have also used the chi-square test, which is a statistical technique used to compare the observed results with the expected results. The goal of this test is to see if there is a difference between observed and expected data due to chance, or due to an actual relationship between the variables being studied. The Asymptotic Significance, or p- value, of the chi-square run in SPSS aids in determination of the statistical significance of the relationship that was tested. If p/asym fig. $<$ 0.05, it is derived that there is a statistically significant relationship between the two categorical variables [10].

Analysis is done on mainly two aspects, first is the success rate of four tests for detecting Covid-19 and second on the usage of different instruments in treatment of Covid-19 patients.

For the first one, the data was grouped according to the type and gender of doctors and Kruskal-Wallis test was performed to check the opinion on the effectiveness of different diagnosing tests. The descriptive statistics values obtained are tabulated in Table 1.

Descriptive Statistics					
Effectiveness of :	**N**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
RT-PCR	49	3.29	1.041	1	4
Rapid Antigen Test	49	2.22	0.771	1	4
Serology	49	2.12	0.949	1	4
LFT	49	1.94	0.944	1	4
Type of Doctor	49	2.80	1.414	1	4
Gender of Doctor	49	1.54	0.5	1	2

Table 1: Descriptive statistics on the effectiveness of different diagnosing tests for different type and gender of doctors

The results obtained on performing the test for different types of doctors and different gender are tabulated in Table 2 and 3 respectively.

Test Statistics[a,b]				
	Effectiveness of RT-PCR	Effectiveness of Rapid Antigen Test	Effectiveness of Serology	Effectiveness of LFT
Chi-Square	2.880	3.128	2.356	10.827
df	3	3	3	3
Asymp. Sig.	.410	.372	.502	.013
a. Kruskal Wallis Test				
b. Grouping Variable: Type of Doctor				

Table 2: Results of the Kruskal Wallis Test,on grouping by type of doctor

Test Statistics[a,b]				
	Effectiveness of RT-PCR	Effectiveness of Rapid Antigen Test	Effectiveness of Serology	Effectiveness of LFT
Chi-Square	.057	.212	.782	.110
df	1	1	1	1
Asymp. Sig.	.811	.645	.377	.740
a. Kruskal Wallis Test				
b. Grouping Variable: Gender				

Table 3: Results of the Kruskal Wallis Test,on grouping by gender of doctor

As demonstrated from the table, the asymptotic significance value is more than 0.05 for all the four types of tests. Thus, it indicates that doctors of different specializations have different opinions on the efficiency of these tests. It can be attributed to the general fact that different doctors

would have different diaspora of patients experiencing diverse symptoms, hence leading to different diagnostic tests being employed. General physicians find RT-PCR as the most effective diagnostic test but for severe cases reaching the hospitals more elaborate tests are required to decide an appropriate treatment plan.

For the second analysis, the data has been again grouped according to the type of doctor and gender of doctors to implement the Kruskal-Wallis test to check the opinion on the effectiveness of different treatment instruments. The descriptive statistics values obtained are shown in Table 4.

Descriptive statistics					
Success of :	**N**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Ventilator	49	2.39	1.057	1	4
Nebulizer	49	2.96	1.241	1	4
Infusion Pump	49	2.55	0.867	1	4
Oxygen Concentrator	49	2.94	0.944	1	4
Type of Doctor	49	2.80	1.414	1	4
Gender of Doctor	49	1.54	0.5	1	2

Table 4. Descriptive statistics on the effectiveness of instruments used for treatment of Covid-19 for different type and gender of doctors

Results of the analysis obtained on applying the Kruskal-Wallis test are depicted in Table 5 and 6.

Test Statistics[a,b]				
	Success rate of VENTILATOR	Success rate of NEBULIZER	Sucess rate of Infusion Pump	Success rate of Oxygen Concentrator
Chi-Square	6.965	2.992	1.986	4.175
df	3	3	3	3
Asymp. Sig.	.073	.393	.575	.243
a. Kruskal Wallis Test				
b. Grouping Variable: Type of Doctor				

Table 5. Results of the Kruskal Wallis Test

Test Statistics[a,b]				
	Success rate of VENTILATOR	Success rate of NEBULIZER	Sucess rate of Infusion Pump	Success rate of Oxygen Concentrator
Chi-Square	.567	1.128	.441	.890
df	1	1	1	1
Asymp. Sig.	.451	.288	.506	.345
a. Kruskal Wallis Test				
b. Grouping Variable: Gender				

Table 6. Results of the Kruskal Wallis Test on grouping by gender of doctor

As we can see from the table, the asymptotic significance value is more than 0.05 for all the four tests, indicating a difference in opinion on the efficiency of these instruments by the doctors of different specializations and gender. As stated earlier, doctors with different specializations attend to patients having different variants of coronavirus strain and hence they adopt unique treatment

plans for each of them. Consequently, the instruments used to implement the treatment also vary from case to case leading to the obtained Kruskal- Wallis outcome.

6. Conclusion

An exploratory study of management of healthcare during Covid -19 pandemic was successfully conducted. The study was based on a survey conducted on the success of diagnostic tests used for detection of COVID -19 virus and effectiveness of instruments used for the treatment of this virus. 49 doctors with different specializations and regions participated in the survey conducted via Google Forms. Analysis of the survey responses specified that to detect SARS Covid-19 virus, RT-PCR test is the most effective diagnostic tool as 80% of the doctors rated it to be 90-95% accurate. Majority of the doctors also stated that nebulizer is found to be the most effective instrument for alleviating Covid-19 related symptoms especially during the early stages. The hypothesis was further corroborated by Kruskal - Wallis Test conducted on the questionnaire. The results of this statistical analysis indicated that doctors of different specializations and gender have different opinions on the success of diagnosing tests and effectiveness of treatment instruments. This variance is attributed to the diversity in symptoms of this virus amongst the patients which resulted in different treatment plans and hence difference in doctors' approach towards the tests as well as instruments.

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