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Predictors of Chest CT Total Severity Score InCovid-19 Infected Patients In Rwanda

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Abstract
Background:
Over 5.54 million COVID-19 deaths occurred worldwide by the January 2021 and COVID-19 pneumonia remains the commonest cause of death. The current study was conducted to investigate predictors of total severity score in patients with COVID-19 pneumonia who underwent chest CT and in turn be used in setting with limited resource to predict TSS as well as prognosis
Materials and Methods:
The current study retrospectively evaluated the CT findings in COVID-19 patients with clinical severity using a 25-point visual quantitative assessment and total severity score predictors were determined. A sample of 384 COVID-19 patients was used and Statistical analysis was done using SPSS 25.0.
Results:
The findings of the current study indicate that age ($p < 0.001$), vaccination status ($p = 0.006$), and disease status ($p < 0.001$) are significant predictors of the total severity score on chest CT scans in patients with COVID-19 pneumonia. Specifically, as age increases, the odds of having a higher total severity score also increase. Conversely, individuals who are vaccinated tend to have lower severity scores, suggesting that COVID-19 vaccination is associated with a reduced likelihood of experiencing severe disease. Additionally, patients with severe COVID-19 pneumonia are more likely to exhibit higher severity scores on Chest CT.
Conclusion:
Chest CT scan total severity score can be predicted with age, immunization status and disease status classified as mild, moderate, severe and critical covid-19 pneumonia and this score can be used to predict clinical outcome.
Recommendation:
A large multicenter study can be used to validate current study findings and these clinical predictors can be used in resource limited settings where CT scan accessibility is not ensured.
Keyword: *Covid-19, pneumonia; CT scan; Total Severity Score; Rwanda*

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I. Introduction

Covid-19 was declared a pandemic in March 2020 by WHO and its clinical course changed dramatically after introducing vaccines against COVID-19[1]. To predict the extent covid-19 and its prognosis, one needs to use CT-scan total severity score which provides an insight on degree of lung injury from COVID-19 pneumonia[2]. CT Total severity score considers the percentage of lung involvement, patterns and laterality of involved lungs. CT scan Total severity score is semi-quantative clinical score tool that consider degree of lung involvement and its range varies from 0 to 25[3]. A TCSS above 18 was reported to be associated with mortality[2].

Computed tomography scan (CT) remains essential for the identification and treatment of individuals with Covid-19 -infected pneumonia[4]. CT is the imaging modality of choice in clinically suspected patients and helps track imaging changes as a patient receives treatment. Consequently, CT has been regarded as a proper diagnostic technique for suspicious COVID-19 patients[5]. It may identify individuals whose reverse transcription-polymerase chain reaction (RT-PCR) results are negative but still highly dubious of Covid-19 pneumonia considering their clinical features[6]. The results of a CT scan may also reveal information regarding the severity of the illness as well as its prognosis[7]. Additionally, given that most viral pneumonia has similar imaging patterns, the CT features identified in numerous recent studies may be useful for differentiating between viruses and other organisms that cause pneumonia and for triaging patients. Additionally, especially in the early stages of COVID-19, chest radiographs are less sensitive than chest CT meaning that even minimal changes can be easily identified by Chest CT scan rather chest x-ray [8]. According to recent findings, CT may identify the disease before its clinical manifestations [9]. Chest CT is therefore essential in preclinical screening and highly advised as a first-line procedure for examining potential COVID-19 cases [9].

From the Chinese retrospective study in Wuhan that involved 1014 patients during the height of the endemicity, Ai et al., reported that CT scan detected 88% of covid-19 patients during their initial infection while RT-PCR test detected only 59%[10]. Similar results were obtained by Fang et al., from their investigation of 51 high-risk patients who underwent serial RT-PCR and chest CT scans. From this study, 98% of patients were detected by CT scan while RT-PCR detected 71%[3]. Patients who have symptoms suggestive of COVID-19 pneumonia and whose initial RT-PCR results are initially negative but later turn positive on repeat testing frequently have more ground glass and less consolidation pattern on imaging, which is indicative of early illness and likely low viral load [11].In contrast, Kim et al., reported a higher diagnostic accuracy from RT-PCRthana chest CT scan[11]. All this studies with different results, none of them reported clinical parameters that may be used to predict total severity score and in turn be used in setting where CT scan is not available.Thus, current study was conducted to investigate predictors of total severity score in patients with Covid-19 pneumonia who underwent chest CT and in turn be used in setting with limited resource to predict TSS as well as prognosis.

II. Materials And Methods:

This study was conducted from Rwandan Tertiary hospitals namely King Faisal Hospital (KFH), Kigali University Teaching Hospital (KUTH), Butare University Teaching Hospital (BUTH) and Rwanda Military Hospital (RMH).A total of 384 patients were included in the study; who visited the radiology department for CT scan in the referral facilities in Rwanda.

Study design: Descriptive retrospective cross-sectional design using a quantitative approach.

Study location: This was a tertiary care teaching hospital-based study done in the departments of radiology at King Faisal Hospital (KFH), Kigali University Teaching Hospital (KUTH), Butare University Teaching Hospital (BUTH) and Rwanda Military Hospital (RMH).

Study duration: 1 year

Sample size: 384 patients

Sample size calculation: The sample size for this investigation was determined using the Fisher's formula as it has been used by Naing *et al.* (2016) stated as:

Given that COVID-19 is an infectious disease with an unknown prevalence in our population, the prevalence in our study is predicted to be 50%.

n =Sample size

Z: Standard normal variant at 5% type I error P<0.05, it is 1.96.

P: 50% (72)

d: absolute error or precision 5%

N: sample size

n = 384 patients

According to this formula and sample size estimation and sampling strategies for choosing a representative sample, our sample size was 384 patients.

Subject& selection method: The study targeted patients with COVID-19 who had a chest CT scan from one of the Selected hospitals in the period of March 2020 to December 2021.

Inclusion Criteria

This study included COVID-19 patients with CT chest done during active disease (positiveCOVID-19 result by PCR/Rapid test)

Exclusion Criteria
It excluded all patients with negative COVID-19 test result

Procedure methodology

Before data collection, ethical clearance was sought and approved by the Rwanda national ethics committee (RNEC)-approval number N0.525/RNEC/2002. Data were collected from imaging registry, request forms and CT report forms. A sample size of 384 patients were selected and only patients who underwent chest CT scan in their active phase of covid-19 infections defined by positive RT-PCR test were included in the current study. Demographic, vaccination status and clinical presentations data were mainly collected from imaging registry and request forms while CT scan finding patterns and total severity score were extracted from CT scan reports. No consent form was sought because it was a retrospective study. After data collection, data were entered in computerized Excel form and encoded, verified for omission and errors. Then data were imported to SPSS version 25 and verified again for omissions and errors, then analyzed. Descriptive and Bivariate analysis were performed to describe demographic features of our patients and sort out significant variables to be used to Multivariate logistic regression, which generated the total severity score predicting model and the statistical significance cut off was 5%.

Statistical analysis

Entry of data was dome on an MS excel sheet for cleaning and transferred and analyzed with SPSS V 25.0 for the different specific objectives.

III. Results

In this study, a total of 384 patients was included who visited the radiology department for CT scan in the referral facilities in Rwanda.

The research subjects were split into three age groups which are: 35 and below, 36-50 years, and 51 and above.

The results from our study show that a majority of participants (82.3%) were aged 36 years and above with a mean of 48.4±14 years and 47 years as median. The youngest participant was 16 years old, while the oldest was 107 years old. There were 226 males and 158 females representing 58.9% and 41.1% respectively. The results also showed that City of Kigali had 320 patients (83.3%), 12 patients were from the Eastern Province (3.1%), 23 patients were from Southern Province (6.0%), 13 patients were from the Western Province (3.4%), and 16 patients were from the Northern Province (4.2%).

Regarding their marital status, 312 patients were married (82.0%), 50 patients were single (13.0%)13 patients were widows (3.4%), while 6 patients were widowers (1.6%)

Table 1 shows sociodemographic features and total severity score of covid-19 infected patients underwent chest CT

Variable		TSS Cat			
		Mild		Moderate	
		Count	Percentage	Count	Percentage
Age	35 and below	11	78.6%	3	27.2%
	36 to 50	21	58.3%	15	41.6%
	51 and above	12	33.3%	**24**	**66.6%**
Gender	Male	25	46.2%	**29**	**53.7%**
	Female	19	59.4%	13	40.6%
Province	Kigali	42	59.1%	29	40.8%
	East	0	0.0%	2	100%
	South	0	0.0%	5	100%
	West	2	50%	2	50%
	North	0	0.0%	4	100%
Marital	Married	38	86.4%	**33**	**78.6%**
	Single	6	13.6%	6	14.3%
	Widow	0	0.0%	2	4.8%
	Widower	0	0.0%	1	2.4%

As shown in table 1, the total severity score increases with age and the moderate total severity score was found in majority of people aged 51 and above (66.6%) and the higher total severity score was more common in male (53%). Majority of patients with higher score came from Kigali(82%) due to that fact that 3 out 4 tertiary hospitals are located in the city of Kigali (CoK) but patients who came outside of Kigali tends to have higher total severity score and they were married (78.6%).

Symptoms distribution among patients with proven Covid infection.

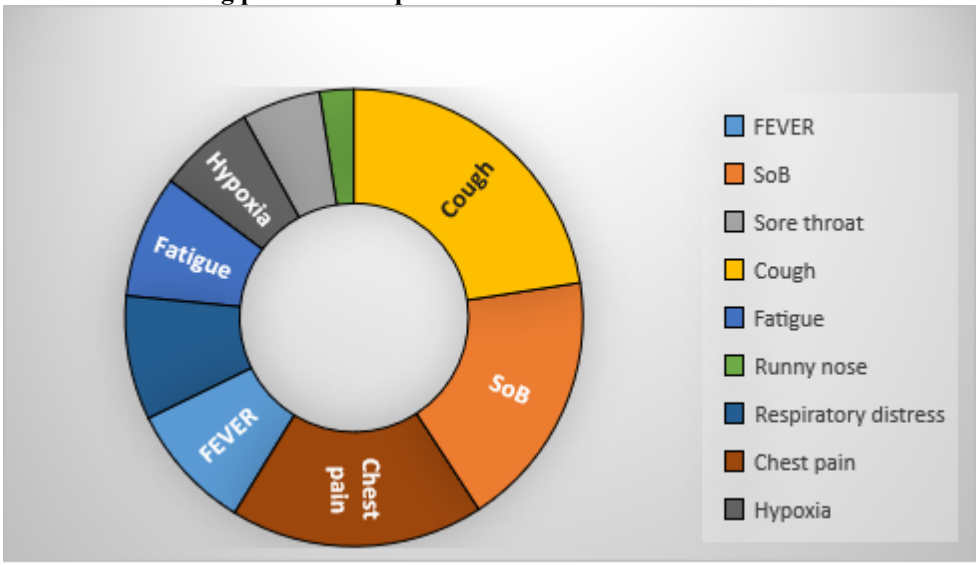

Figure 1 Common clinical findings among COVID-19 patients who underwent CT scan

The patients in this study demonstrated different clinical presentations. The patient clinical presentations shown in our study were cough (50.8%), shortness of breath (41.1%), chest pain (40.4%), fever (20.3%), respiratory distress (19.8%), fatigue (19.5%), sore throat (12.5%), and runny nose (5.5%).

As shown in figure1, cough (50.7%), shortness of breath (41.1) and chest pain (40.4) were the most common clinical findings among COVID-19 patients who underwent CT scan**.**

Radiological and Imaging findings of patients with Covid Pneumonia in Rwanda

Of the 384 scans, 81 of them were normal. The identified CT scan patterns in the current study were Ground glass opacities (GGO), followed by consolidation changes and features of septal thickening (crazy paving) with predominant bilateral distribution at a percentage of 70.3%, 37.2% and 40.4% respectively for each of the patterns mentioned.

The results of the CT scans performed on the study's COVID-19 subjects are shown in the table below.

Table 2 CT findings in COVID-19 patients who underwent CT scan

Variables	group	Count	percentage
Ground grass opacity	Yes	270	**70.3%**
	No	114	29.7%
Consolidation	Yes	143	**37.2%**
	No	241	62.8%
Septal thick	Yes	155	**40.4%**
	No	229	59.6%
Pleural effusion	Yes	29	7.6%
	No	355	92.4%
Lymphadenopathy	Yes	16	4.2%
	No	368	95.8%
Vascular _thickening	Yes	19	4.9%
	No	365	95.1%
Lobe	Both	190	**49.5%**
	Lower	76	19.8%
	Upper	18	4.7%
	None	100	26.0%

As shown in table 2, Ground glass opacity was the commonest CT findings (70.3%) followed by septal thickening (40.4%) and consolidation (37.2%) with involvement of both upper and lower lobe (49.5%), the rest were less common in patients with COVID-19 who underwent CT scan.

The cases below are examples of CT results from COVID-19 patients in Rwanda.

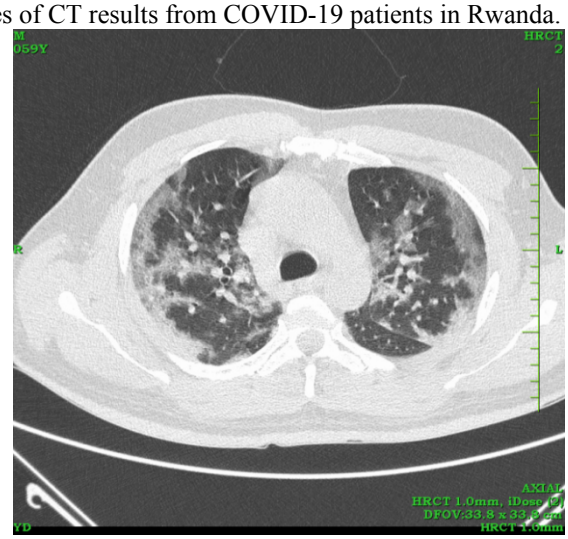

Figure 2. Axial non-enhanced HRCT with GGO.

The CT scan of a 59-year-old male showing intermediate density with the lung parenchyma also known as ground glass infiltrates seen predominantly with peripheral distribution.

Courtesy of King Faisal Hospital, Rwanda- Radiology department.

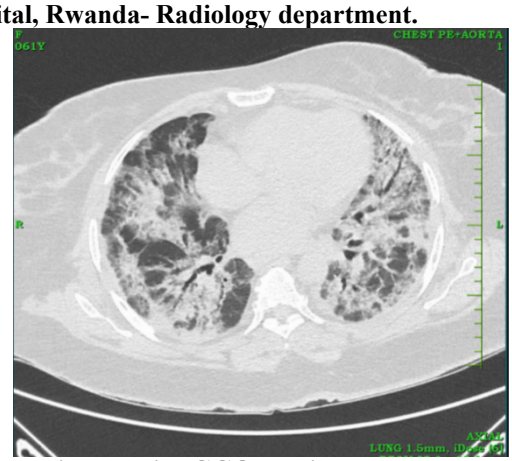

Figure3. Axial CT scan, lung window with GGO and interlobular septal thickening/ crazy paving.

The CT scan of a 61-year-old female showing diffuse bilateral GGO's with accompanying interlobular septal thickening creating a pattern of crazy paving.

Courtesy of King Faisal Hospital, Rwanda- Radiology department.

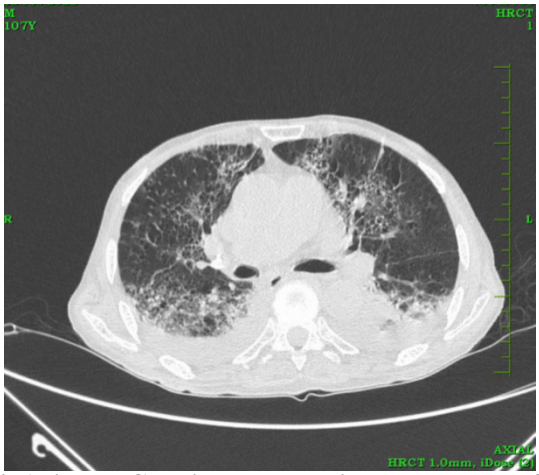

Figure 4. Axial HRCT with crazy paving and pleural effusions.

HRCT of a 107-year-old male patient showing GGO superimposed with intralobular septal thickening giving a crazy paving appearance. There are also bilateral pleural effusions.

Courtesy of King Faisal Hospital, Rwanda- Radiology department.

Driving factors for Covid pneumonia severity score in Rwanda

This section illustrates different clinical risk factors and their association to the severity of COVID-19. This was done using logistic regression between risk factors with total severity score out of 25.

The risk factors included age, vaccination status, and patient underlying comorbidities (hypertension, diabetes, chronic kidney disease, obesity, asthma and HIV).

The results from the table below indicate that age (Beta=0.277; P<0.001) is a statistically significant positive predictor of CT severity score. Therefore, there is an increase of 0.277 in TSS for one unit (year) increase in age. Since the P-value is less than 0.001, once can say that it is statistically significant at 0.1%.

There is a statistically negative relationship between being female and CT severity score (Beta=-0.098; P=0.032). This means that being a female decreased the probability of scoring a high CT severity index.

It was also noted that there is a negative relationship between taking the vaccine and CT severity score (Beta=-0.268; P<0.001). This means that taking a vaccine reduces the total severity score by 0.268.

Diabetes mellitus was a statistically significant positive predictor of CT severity score (Beta=0.150; P=0.004). This means that Diabetes mellitus increases the total severity score by 0.150.

Chronic Kidney Disease was proved to be a statistically significant positive predictor of CT severity score (Beta=0.102; P=0.031). This means that chronic kidney disease increases the total severity score by 0.102.

Table 2. Predictors of total severity score in covid-19 patients underwent chest CT

Model		Unstandardized Coefficients		Standardized Coefficients	p-value
		B	Std. Error	Beta	
	(Constant)	-2.442	1.130		**.031**
	Age	**.055**	**.015**	**.115**	**<.001**
	Gender	-.250	.421	-.018	.552
	Province	.181	.212	.027	.393
	Vaccine	**-1.215**	**.439**	**-.087**	**.006**
	Marital	.223	.358	.019	.533
	Fever	.342	.598	.020	.568
	SoB	.772	.518	.055	.137
	Sore throat	1.124	.772	.054	.146
	Cough	.277	.517	.020	.591
	Fatigue	-.850	.667	-.049	.204
	Runny noise	-.784	1.104	-.026	.478
	Respiratory distress	.552	.625	.032	.378
	Chest pain	-1.004	.524	-.072	.056
	Hypoxia	-.431	.708	-.023	.543
	DM	1.225	.748	.057	.102
	HTN	.154	.836	.006	.854
	Asthma	.519	1.450	.011	.721
	Disease status	**4.588**	**.241**	**.757**	**<.001**
	HIV	.324	2.045	.005	.874
	OBESE	1.104	2.305	.014	.632
	CKD	-.978	1.643	-.019	.552

As shown in table 4, age (p-value<0.001), vaccine (p-value=0.006) and disease status (p-value<0.001). as people get older, the odd of having higher total severity score increases while vaccinated people tend to have lower score in other words, covid vaccination reduce the odd of having a severe severity score. Covid vaccination reduces disease severity while as people get older, they are prone to a severe covid-19 infection. People with severe disease have increased odd to have higher severity score.

Total severity score can be predicted using the following equation(model): TSS= 0.055*age - 1.215*Vaccination status + 4.588* disease status-2.442.

TSS=0.055X-1.215Y+4.588Z-2.442 where X=patient's age, Y=Vaccination status (Yes=1, No=0), Z=disease status (mild=1, moderate=2, severe=3, critical=4)

IV. Discussion

Demographics:

The current study involved 384 patients who underwent CT scan during the active phase of COVID-19 disease. Majority of patients (82.3%) were aged 36 years and above with a mean age of 48.4 years. The participants from the current study had an almost similar mean age group to those in Abu Dhabi in a study by Saeed et al., in 2021 where the reported population mean age was 44.2 years [12]. Both studies had similar methodologies and one of the reasons for the younger mean age group in Abu Dhabi was the prevalence of younger workers, which can also be explained for our population. An almost similar mean age range was also observed in a study in India by Gupta et al., in 2020, where the mean age was 40.3 years [13]. Their study however only involved one tertiary hospital and had a smaller sample size compared to our study.

About 41.7% of the patients were between ages of 36-50 years, while about 40.6% were older than 50 years and only 17.7% aged 35 years and below. In a study to find the age demographics contributing to the highest transmission of disease in the USA by Monod et al., in 2021, adults between the ages of 35 and 49 were found to have the largest number of infections [14]. Their findings are almost closely related to the current study; however, they reported using age specific cumulative death counts to obtain their data.

Another study in Hunan, China by Zhao et al., showed that 70.2% of the population age distribution was between 21-50 years old[15]. Their study had a slightly younger population group compared to this study. In comparison, their study and the current study were retrospectives involving four institutions; however, they had a smaller sample size of 101 patients.

The majority of affected people in this study were older than 35 years old. During the pandemic, Rwanda passed through a series of lockdown measures as a preventive and control measure throughout 2020 and 2021. This meant that all schools were closed limiting the number of contact and spread of disease in the younger population. The essential services did however continue and the majority of the work force fell in the age category of 35 and above, hence making them vulnerable to disease exposure.

Our population groups also highlight the projections from the Rwandan 4th Population and Housing Census done in 2012, whereby it was predicted that in the following two decades the Rwanda population would be less young with a larger percentage of the adult and the elderly aged 60 and above in the population expanding with time[16]. This means that the life expectancy is expected to increase and it also explains the higher number of elderly patients who also made up of 40.6% of our study population

Further, the current study demonstrates a male predominance of about 58.9%, with females constituting about 41.1%. A study from Abu Dhabi by Saeed et al., in 2021 shares similar findings evidenced by a male predilection of the disease, and proposed that this distribution may be attributed to different factors such as the possible protective effect of estrogen as well as disparity in behavior [12].

A male predominance of 82% was observed in a study from Italy by Grasselli et al., on patients admitted in ICU with COVID-19[17], as well as in cross sectional study from Bangladesh by Hasan et al., in 2021, where by the study had a male predominance of 64%[18]. The latter study was done in a single in a tertiary hospital, however both these studies reflect the same findings as those from our study.

To explain the reason for a male predominance in COVID-19 patients, a study by Beyerstedt et al., in 2021 reported that men compared to women had more elevated concentrations of angiotensin-converting enzyme 2 (ACE2) in their bloodstream. This ACE2 factor permits and facilitates infection of normal cells by the COVID virus [19]. This could explain the reason men tend to be more susceptible to COVID-19 than women, hence explaining our numbers.

During lock down, only essential services were allowed. According to the National institute of statistics of Rwanda, statistics released in February 2022 demonstrated that the rate of unemployment was somewhat high among females (18.2%) in comparison to males (15.0%). From these statistics one can deduce that the majority of the workers in the essential services were male [20]. The essential workers had a higher probability of acquiring COVID-19 in comparison to those who worked from home.

Women have been found to have a higher likelihood of practicing health protective behaviors compared to men. This finding has been highlighted in a number of studies whereby it was noted that gender

influenced health behaviors, where by women showed a high chance to adjust to new health protective behaviors, such as wearing protective gear and practicing social distancing compared to men [21,22].

A majority of the participants in our study 82.0% were married, 13.0% were single, 3.4 % were widows while 1.6% were widowers. In an observational study in Michigan, USA by Harvey et al., in 2021 on hospitalized patients with COVID-19,45.99% of patients were married, while 26.25% were single, constituting half and quarter of the population studied respectively[23]. Their study involved a larger sample size; however, their findings are similar to ours and demonstrate a higher number of participants as being married.

A reason for the high rate of infection among adults, especially those who are married might be that spouses are more prone to increased risk of disease transmission than any other household members due to the fact that they spend more time in close proximity to each other. Similar findings were also highlighted in a study done in 2021 by Semakula et al., from Rwanda where it reported the relationship to the index case, as an important factor for spread of infection [24]. This may indicate the possibility of a familial or cluster outbreak in a household.

Regarding provincial distribution, 83.3% patients were from the City of Kigali, 6.0% were from Southern Province, 4.2% were from Northern Province, 3.4% were from Western Province, and 3.1% were from Eastern Province.

In a previous study done in Rwanda by Semakula et al., similar findings to this study were noted by their study and showed that the highest spread of COVID-19 infection was centered in Kigali city [24]. Another study from Algeria in 2020 by Kadi et al., demonstrated the spread of COVID-19 increased with an increased population density which was noted in the bigger cities of Algeria namely as Algiers, Blida, Oran, and Setif[25]. Those were the biggest cities and found to have the highest population. Therefore, we can conclude that the increase in population density is directly proportional to increase in spread of COVID-19 infection in the area.

Among the earliest numbers of COVID-19 cases in Rwanda, it was found that all confirmed cases were brought in and the majority of patients had a recent travel history which initiated the tracing of contacts in Kigali city [24]. Kigali City is the capital city, the most visited and busiest area in Rwanda. It is densely populated and is rapidly growing with an urbanization annual growth rate of 4%, according to the National institute of statistics of Rwanda 2012[16]. In a survey conducted in Rwanda it was found that urban districts had the highest population densities, markedly in the districts of Nyarugenge, Kicukiro and Gasabo which constitute of the three districts of Kigali City[16]. Given the concentration of people and the economic activities in these areas, they are often hotspots of COVID-19 infections which would explain the high number in Rwanda.

The Rwandan Medical referral board guidelines of 2019, stated that there were four referral hospitals, namely the University Teaching Hospitals of Butare and Kigali, the King Faisal Hospital, Kigali and the Rwanda Military Hospital[26]. Among those hospitals, three are in Kigali which made it easier for patients in that region to acquire CT scans without transportation difficulties. This can also explain why with our study the majority of patients were from Kigali City followed by those from the Southern province.

Clinical presentation

Development of some of these symptoms may represent pulmonary involvement especially features such as cough, shortness of breath and respiratory distress. It may also indicate the presence of severe COVID-19 pneumonia. The variation in symptoms may also be described by disease severity at presentation[27].

Clinical symptoms may range from asymptomatic, mild, moderate, severe to critical presentations[28,29]. Complaints of fever, coughing, and shortness of breath usually indicate pulmonary involvement[30].

The findings from our study demonstrate that the most prevalent symptoms in the patients were cough (50.8%) followed by shortness of breath (41.1%), and chest pain (40.4%). Other clinical presentations demonstrated were fever (20.3%), respiratory distress (19.8%), fatigue (19.5%), sore throat (12.5%), and runny nose (5.5%).

The findings by Tabatabaei, Seyed Mohammad Hossein, et al., in Iran showed that most common clinical presentation was cough (80%) seconded by fever (76.5%) and third common symptoms being shortness of breath (46%), these findings reflect those found in our study[31]. In their study, fever was a more common finding compared to our study, however their study only comprised patients who were hospitalized whereas our study involved both hospitalized and non-hospitalized patients.

A study from China by Guan et al., reported fever in only 44% of admitted patients but eventually 89% presenting with fever during their hospital stay[32]. In another study done by Richardson et al., in New York, only 31% of patients had a fever at hospital presentation[33]. Fever has been reported as a common finding, however it isn't universal on clinical presentation.

Risk factors contributing to CT severity score

This study revealed a number of risk factors that contributed to a higher CT severity score. Advanced age, comorbidities like diabetes as well as chronic kidney disease contributed to a more severe disease. This

study also highlighted that female gender and COVID-19 vaccination may be a protective factor and decrease the risk of severe forms of infection.

Most literature consider advanced age as the strongest risk factor for an outcome of severe COVID-19 with the severity of disease increasing exponentially with increase in age[25]. This may be due to several additional confounding factors such as age-related risk factors such as hypertension, diabetes, chronic kidney disease which are more likely to affect the elderly population[34].

It was noted in our study that the age was statistically significant at 0.1% and a positive predictor of a higher CT severity score, which means that the older population had more severe CT features, the patients involved were above 50 years old. Findings from our study showed that those aged 51 and above were more likely to develop severe COVID-19 pneumonia.

In a study from Sudan by Hasabo et al., it was observed that old age and diabetes were found significantly associated with patient mortality [27]. They reported elderly patients above 60 years were more vulnerable as a result of weakened immunity; they had a greater likelihood of a more severe outcome compared to the younger population.

A study conducted in China in 2020 by Liu et al., also revealed that patients over 60 years old had more severe clinical manifestations with longer duration of the disease course compared to those under 60 years of age [35].

Another study done in Abu Dhabi by Saeed et al., in 2021 demonstrated a higher mortality rate in patients above 50 years. These could be explained by an increase in patient comorbidities associated with increased age as well as their weakened immune status [12].

Our study also demonstrated that there is a significant association between being female and a lower CT severity score meaning that our findings indicate that being a female decreases the probability of a higher CT severity score. Furthermore, it was revealed that the odds of having more severe COVID pneumonia was increased in male population

In a study from China by Jin et al., in 2020, to analyze the relationship between COVID-19 disease severity and gender distinction, it was found that men had more severe COVID pneumonia with higher CT scoring and mortality rate compared to females [36]. Their study constituted of case series; however, they had similar findings to the ones of the current study

A meta-analysis on outcomes of COVID-19 by Fabiao et al., in 2022, had similar findings, whereby an increase in disease severity was noted in male population compared to the female population irrespective of their difference in age[37].Another meta-analysis by Peckham et al., involving 90 studies, found that male patients had more severe of COVID-19 pneumonia compared to females with an even higher likelihood of poor outcome [38]. These findings are similar to the findings in our study and one can therefore conclude that being male increased the likelihood of a higher CT severity score.

Females with COVID-19 infection have been found to have lower mortality rates as well as lower rates of hospitalization[39].A study by A. Dangis, N. De Brucker, A. Heremans et al., in 2020 suggested that a reason for a lower mortality and CT severity rate in female populations may be due to factors such as the possibility of the estrogen factor providing an effect of protection as well as a better health behavioral approach[40]. This means that they are likely to have milder forms of infection, with less severe COVID-19 manifestation due to their intrinsic or innate immunity.

Both innate and humoral immunity against the COVID-19 infection play a great role in the infected individual. Findings from our study noted that vaccination against COVID-19 reduced the total severity score. It was noted that those who did not take the vaccine against COVID-19 were three times more likely to have severe COVID-19 pneumonia. This means that patients who received vaccination prior to COVID-19 infection had milder symptoms and suffered less severe COVID-19 pneumonia compared to those who were not vaccinated. This is in line with the study from Italy by Russo et al., in 2022, which discovered that the mean CT severity score was lower in fully vaccinated patients compared to the partially vaccinated or unvaccinated patients[41]. It was highlighted in their study that receiving the 3 vaccine doses was a protective factor and decreased the overall CT severity score.

In addition, in a meta-analysis by Ssentongo et al., which examined the effectiveness of vaccines against COVID-19, it was noted that the vaccination effectiveness against severe COVID-19 in all ages was generally high with a longer duration effectiveness on full vaccination[42].

A study done in Pakistan by Aslam et al., in 2022, on the patient outcome and vaccination status of COVID-19 patients, it was found that regardless of the type of vaccination, the vaccinated patients had less severe disease. The patients in their study who were vaccinated had an overall better prognosis [43]. These findings reflect well with the current study.

Irrespective of vaccination, the presence of comorbidities may still influence the patient outcome[44].The patients from this study who had diabetes and those with chronic kidney disease presented with a worse clinical picture compared to other risk factors. It was observed that having Diabetes mellitus increased the total severity

score. The odds of having more a severe case of COVID-19 pneumonia were higher for patients with diabetes mellitus

Chronic kidney disease also proved to be a statistically significant positive predictor of high CT severity score. The odds of having more severe COVID pneumonia was increased in patients with CKD. These findings could be explained by the immunosuppression caused by these diseases weakening the patients and leaving them more exposed to infections.

There are existing studies that show that having comorbidities, particularly diabetes, hypertension, cardiac diseases carry a poor prognosis, with a worse scenario when co-morbidities are combined [45,46].

In a meta-analysis involving 42 studies by Dessie et al., in 2021, it was found that having diabetes, cardiovascular diseases, and renal disease carried were the significant risk for severe disease. In their study, it was revealed that patient death in COVID-19 patients with diabetes was relatively higher compared to those without that risk factor. Diabetic patients presented with more severe COVID symptoms with ventilation requirements and a higher CT severity compared to those without diabetes[47]. Similarly, research done by Rangankar et al., in India revealed that the CT severity was higher with increased involvement of lungs among COVID-19 patients with diabetes compared to those without diabetes [48]. From these findings one can deduce that having diabetes as a risk factor was associated with an increase in CT severity score.

The current study demonstrated similar findings to a study done in 2022 by Jdiaa et al., where findings from their analysis revealed that in patients who have COVID-19 infection risk of hospitalization, severe disease as well as the mortality rate was higher in patients with CKD to those without it. The severity of disease was directly proportional to the higher stages of CKD [49].

CT findings

In this study, the most common CT scan patterns were consolidation (37.2%), septal thickening/crazy paving (40.4%), and ground glass opacity (70.3%), with a predominately bilateral distribution in roughly 49.5% of patients.

Similar results were found in a study by Chekki, Sonia Toujani, and colleagues, who found that the dominant CT characteristics included GGO (72.6%), crazy paving (66.7%), and consolidations (68.1%), with a lobar predominance that was bilateral in 96.9% of patients and peripheral in 72%[31].

Results of the meta analysis by Zhu Jieyun et al., in 2020 showed similar findings to our study. In their study it was noted that most of the patients (73.8%). had both lungs affected. GGO (68.1%) was the lesion density change that occurred most frequently, followed by air bronchograms (44.7%), crazy paving pattern (35.6%), and lung consolidations (32.0%)[40].

V. Conclusions And Recommendations

Overall, the current study highlighted that age, vaccination status and disease status may be used to predict Chest CT scan total severity score in settings where CT scan availability and accessibility are limited especially in low resource setting and may be used to redirect available resources as well as predict prognosis for a patient combining both total severity score and clinical features.

Further studies are encouraged to confirm the current findings and as retrospective study which considered patients who had CT scan from tertiary settings which usually admit patients with severe form of covid-19 and transferred from district hospitals, the current study is prone to biases.

References

[1] World Health Organisation. Who Director-General ' S Opening Remarks At The Media Briefing On. World Heal. Organ. 2021 (2021).
[2] Szabó, M. Et Al. The Importance Of Chest Ct Severity Score And Lung Ct Patterns In Risk Assessment In Covid-19-Associated Pneumonia: A Comparative Study. Front. Med.10, 1–9 (2023).
[3] Fang. Sensitivity Of Chest Ct For Covid-19: Comparison To Rt-Pcr. Lancet395, A1–A2 (2020).
[4] Azadbakht, J., Haghi-Aminjan, H. & Farhood, B. Chest Ct Findings Of Covid-19-Infected Patients, Are There Differences Between Pediatric And Adult Patients? A Systematic Review. Egypt. J. Radiol. Nucl. Med.51, (2020).
[5] Zhao, W., Zhong, Z., Xie, X., Yu, Q. & Liu, J. Relation Between Chest Ct Findings And Clinical Conditions Of Coronavirus Disease (Covid-19) Pneumonia: A Multicenter Study. Am. J. Roentgenol.214, 1072–1077 (2020).
[6] Wu, J. Et Al. Chest Ct Findings In Patients With Coronavirus Disease 2019 And Its Relationship With Clinical Features. Invest. Radiol.55, 257–261 (2020).
[7] Ramanathan, K. Et Al. Clinical Features Of Patients Infected With 2019 Novel Coronavirus In Wuhan, China. Lancet395, 497–506 (2020).
[8] Wong, C. Et Al. Frequency And Distribution Of Chest Radiographic Findings In Covid-19 Positive Patients. Radiology Xxx (2020).
[9] Pan, Y. Et Al. Initial Ct Findings And Temporal Changes In Patients With The Novel Coronavirus Pneumonia (2019-Ncov): A Study Of 63 Patients In Wuhan, China. Eur. Radiol.30, 3306–3309 (2020).
[10] Strunk, J. L., Temesgen, H., Andersen, H. & Packalen, P. Correlation Of Chest Ct And Rt-Pcr Testing In Coronavirus Disease 2019 (Covid-19) In China: A Report Of 1014 Cases. 80, 1–8 (2014).
[11] Hao, W. & Li, M. Clinical Diagnostic Value Of Ct Imaging In Covid-19 With Multiple Negative Rt-Pcr Testing. Travel Med.

Infect. Dis.34, (2020).
[12] Saeed, G. A. Et Al. Interrelationship Between Chest Ct Severity Scores And The Clinical Parameters Of Adult Patients With Covid-19 Pneumonia. Curr. Innov. Med. Med. Sci. Vol. 62021, 55–70 (2022).
[13] Gupta, N. Et Al. Clinical And Epidemiologic Profile Of The Initial Covid-19 Patients At A Tertiary Care Centre In India. Monaldi Arch. Chest Dis.90, 193–196 (2020).
[14] Monod, M. Et Al. Age Groups That Sustain Resurging Covid-19 Epidemics In The United States. Science (80-.).371, (2021).
[15] Zhao, W., Zhong, Z., Xie, X., Yu, Q. & Liu, J. Relation Between Chest Ct Findings And Clinical Conditions Of Coronavirus Disease (Covid-19) Pneumonia: A Multicenter Study. Am. J. Roentgenol.214, 1072–1077 (2020).
[16] National Institute Of Statistics Rwanda. National Institute Of Statistics Of Rwanda(Nisr) Fifth Rwanda Population And Housing Census, Thematic Report Population Size, Structure, And Spatial Distribution,July 2023. Nisr7, 1–101 (2023).
[17] Grasselli, G. Et Al. Baseline Characteristics And Outcomes Of 1591 Patients Infected With Sars-Cov-2 Admitted To Icus Of The Lombardy Region, Italy. Jama - J. Am. Med. Assoc.323, 1574–1581 (2020).
[18] Hasan, M. Z. Et Al. Clinical Profile And Short-Term Outcomes Of Rt-Pcr- Positive Patients With Covid-19: A Cross-Sectional Study In A Tertiary Care Hospital In Dhaka, Bangladesh. Bmj Open11, 1–13 (2021).
[19] Beyerstedt, S., Casaro, E. B. & Rangel, É. B. Covid-19: Angiotensin-Converting Enzyme 2 (Ace2) Expression And Tissue Susceptibility To Sars-Cov-2 Infection. Eur. J. Clin. Microbiol. Infect. Dis.40, 905–919 (2021).
[20] Statistics South Africa. Labour Force Survey: Historical Revision September Series 2000 To 2007. Stat. Release Labour Force Surv.P0210, 1–52 (2009).
[21] Bish, A. & Michie, S. Demographic And Attitudinal Determinants Of Protective Behaviours During A Pandemic: A Review. Br. J. Health Psychol.15, 797–824 (2010).
[22] Suen, L. K. P., So, Z. Y. Y., Yeung, S. K. W., Lo, K. Y. K. & Lam, S. C. Epidemiological Investigation On Hand Hygiene Knowledge And Behaviour: A Cross-Sectional Study On Gender Disparity. Bmc Public Health19, 1–14 (2019).
[23] Harvey, R. Et Al. Healthcare Disparities Correlated With In-Hospital Mortality In Covid-19 Patients. Int. J. Gen. Med.14, 5593–5596 (2021).
[24] Semakula, M. Et Al. The Secondary Transmission Pattern Of Covid-19 Based On Contact Tracing In Rwanda. Bmj Glob. Heal.6, 1–11 (2021).
[25] Kadi, N. & Khelfaoui, M. Population Density, A Factor In The Spread Of Covid-19 In Algeria: Statistic Study. Bull. Natl. Res. Cent.44, (2020).
[26] Ministry Of Health. Medical Referral Board Guidelines. 1–8 At Https://Www.Moh.Gov.Rw/Index.Php?Eid=Dumpfile&T=F&F=11708&Token=E5b735aa351fea454bb9998a956b13b2edcb34e5 (2019).
[27] Hasabo, E. A. Et Al. Clinical Manifestations, Complications, And Outcomes Of Patients With Covid-19 In Sudan: A Multicenter Observational Study. Trop. Med. Health49, (2021).
[28] Cascella, M., Rajnik, M. & Aleem, A. Features, Evaluation, And Treatment Of Coronavirus (Covid-19). Natl. Libr. Med.2019, 30 (2022).
[29] Cdc, C. For D. C. And P. Coronavirus Disease 2019 (Covid-19) Treatment Guidelines - Nitazoxanide. 2019, 172–173 (2021).
[30] Chen, N. Et Al. Epidemiological And Clinical Characteristics Of 99 Cases Of 2019 Novel Coronavirus Pneumonia In Wuhan, China: A Descriptive Study. Lancet395, 507–513 (2020).
[31] Beauchene, R. C. De Et Al. Plos One Sars-Cov2 Pneumonia Patients Admitted To The Icu : Analysis According To Clinical And Biological Parameters And The Extent Of Lung Parenchymal Lesions On Chest Ct Scan , A Monocentric Observational Study. 1–16 (2024) Doi:10.1371/Journal.Pone.0308014.
[32] Guan, W. Et Al. Clinical Characteristics Of Coronavirus Disease 2019 In China. N. Engl. J. Med.382, 1708–1720 (2020).
[33] Richardson, S. Et Al. Presenting Characteristics, Comorbidities, And Outcomes Among 5700 Patients Hospitalized With Covid-19 In The New York City Area. Jama - J. Am. Med. Assoc.323, 2052–2059 (2020).
[34] Starke, K. R. Et Al. The Age-Related Risk Of Severe Outcomes Due To Covid-19 Infection: A Rapid Review, Meta-Analysis, And Meta-Regression. Int. J. Environ. Res. Public Health17, 1–24 (2020).
[35] Liu, Y. Et Al. Association Between Age And Clinical Characteristics And Outcomes Of Covid-19. Eur. Respir. J.318, (2020).
[36] Jin, J. M. Et Al. Gender Differences In Patients With Covid-19: Focus On Severity And Mortality. Front. Public Heal.8, 1–6 (2020).
[37] Fabião, J. Et Al. Why Do Men Have Worse Covid-19-Related Outcomes? A Systematic Review And Meta-Analysis With Sex Adjusted For Age. Brazilian J. Med. Biol. Res.55, 1–8 (2022).
[38] Peckham, H. Et Al. Male Sex Identified By Global Covid-19 Meta-Analysis As A Risk Factor For Death And Itu Admission. Nat. Commun.11, 1–10 (2020).
[39] Scully, E. P., Haverfield, J., Ursin, R. L., Tannenbaum, C. & Klein, S. L. Considering How Biological Sex Impacts Immune Responses And Covid-19 Outcomes. Nat. Rev. Immunol.20, 442–447 (2020).
[40] Allegranzi, B., Tartari, E. & Pittet, D. "Seconds Save Lives – Clean Your Hands": The 5 May 2021 World Health Organization Save Lives: Clean Your Hands Campaign. J. Hosp. Infect.111, 1–3 (2021).
[41] Russo, G. M. Et Al. Total Severity Score (Tss) Comparison In Vaccinated And Unvaccinated Patients During The Fourth Wave (December 2021 - January 2022) Of Covid-19 In Italy. Eur. Rev. Med. Pharmacol. Sci.26, 5971–5977 (2022).
[42] Ssentongo, P. Et Al. Sars-Cov-2 Vaccine Effectiveness Against Infection, Symptomatic And Severe Covid-19: A Systematic Review And Meta-Analysis. Bmc Infect. Dis.22, 1–12 (2022).
[43] Aslam, J. Et Al. Association Of Disease Severity And Death Outcome With Vaccination Status Of Admitted Covid-19 Patients In Delta Period Of Sars-Cov-2 In Mixed Variety Of Vaccine Background. Saudi J. Biol. Sci.29, 103329 (2022).
[44] Callender, L. A. Et Al. The Impact Of Pre-Existing Comorbidities And Therapeutic Interventions On Covid-19. Front. Immunol.11, 1–16 (2020).
[45] Klein, F. Risikofaktor Komorbiditäten Bei Covid-19- Erkrankung. Pneumologie74, 640 (2020).
[46] Chamorro, E. M., Tascón, A. D. & Ibá, L. Since January 2020 Elsevier Has Created A Covid-19 Resource Centre With Free Information In English And Mandarin On The Novel Coronavirus Covid- 19 . The Covid-19 Resource Centre Is Hosted On Elsevier Connect , The Company ' S Public News And Information Website . Elsevier Hereby Grants Permission To Make All Its Covid-19-Related Research That Is Available On The Covid-19 Resource Centre - Including This Research Content - Immediately Available In Pubmed Central And Other Publicly Funded Repositories , Such As The Who Covid Database With Rights For Unrestricted Research Re-Use And Analyses In Any Form Or By Any Means With Acknowledgement Of The Original Source . These Permissions Are Granted For Free By Elsevier For As Long As The Covid-19 Resource Centre Remains Active . (2020).

[47] Dessie, Z. G. & Zewotir, T. Mortality-Related Risk Factors Of Covid-19: A Systematic Review And Meta-Analysis Of 42 Studies And 423,117 Patients. Bmc Infect. Dis.21, (2021).
[48] Rangankar, V. Et Al. Correlation Between Ct Severity Scoring And Diabetes Mellitus In Patients With Covid-19 Infection. Cureus13, 8–14 (2021).
[49] Jdiaa, S. S. Et Al. Covid–19 And Chronic Kidney Disease: An Updated Overview Of Reviews. J. Nephrol.35, 69–85 (2022).