World Journal of Public Health
2024; 9(1): 34-42
http://www.sciencepublishinggroup.com/j/wjph
doi: 10.11648/j.wjph.20240901.15
ISSN: 2637-6040 (Print); ISSN: 2637-6059 (Online)

Analysis of Lethality Linked to the COVID-19 Epidemic in Senegal from March to August 2020

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To cite this article:
Alyette Carêne Bondha, Jean Augustin Diegane Tine. (2024). Analysis of Lethality Linked to the COVID-19 Epidemic in Senegal from March to August 2020. *World Journal of Public Health*, *9*(1), 34-42. https://doi.org/10.11648/j.wjph.20240901.15

Received: December 7, 2023; **Accepted**: January 2, 2024; **Published**: January 23, 2024

Abstract: *Objective*: Analyze the lethality linked to the COVID-19 epidemic in Senegal in 2020. *Methodology*: This was a time series analysis of COVID-19 during the period from March 02 to August 31, 2020. The study population was people tested by RT-PCR for COVID-19. The data was aggregated and published on the COVID-19 Senegal site. The data collected was analyzed using R software, for description and modeling with ARIMA and Prophet. *Results*: This study showed that the total number of COVID-19 cases recorded during the period studied was 13,611, a median of 3,740 was recorded on June 1, 2020; on average, 4810 cases were registered. New confirmed cases had a median of 79 and an average of 73.9 new cases recorded. 87.4 cases of death on average recorded with a median of 43. On average 19.3 serious cases were recorded with a median of 15. On average, 3940 cases were transmitted locally. March recorded the highest positivity rate at 13.56% with a sharp decline to 8.49% in August. A fatality rate of 5.71 per 1000 inhabitants in March and 20.87 in August 2020. The reproduction rate was 1.96 at the start of the state of emergency on March 23, 2020; this rate increased to 1.11 at the end of our study, on August 31, 2020. *Conclusion*: Predicted and actual data had shown a continuous record of new confirmed cases and deaths until the end of 2020. With no change, despite the measures put in place, the hope is that the vaccine can bring a solution.

Keywords: COVID-19, Confirmed Cases, Deaths, Transmission, Senegal

1. Introduction

The world is facing the coronavirus epidemic (COVID-19) which has various economic and social repercussions. The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2, 29), discovered in 2019 in the town of Wuhan (province of Hubei, in China), is a strain of the species SARSr-CoV of coronavirus source of an atypical pneumonia emergent, there coronavirus disease 2019, known as COVID-19 [1, 47]. There disease led the World Health Organization (WHO) to declare it a public health emergency of international concern THE30 January 2020 Thenpandemic March 11, 2020 [2, 4-6].

On January 20, 2020, human-to-human transmission was confirmed at Guangdong, in China, by a health commission team investigating the outbreak. The reproduction rate preliminary SARS-CoV-2, i.e. the average number of people infected by a patient, was estimated between 1.4 and 2.5 by the WHO on January 23, 2020. It would be comparable to that of SARS-CoV and the 1918 flu, between 1.4 and 3.8. Asymptomatic carriers of the SARS-CoV-2 virus can transmit it. The virus has a short incubation period and can be transmitted before the first symptoms appear [4, 13, 29]. Infected people did not transmit the virus, while others shed and/or transmitted it widely. Coronaviruses thrive in the respiratory tract, but are also commonly found in the blood and in the plasma where the serum sick people. This implies a risk of transmission via the transfusion of blood products.

Like other countries in the world, Senegal experienced the first imported case on March 2, 2020 [24].

The country has grown to 3,836 cases tested positive for COVID-19 and 43 deaths on June 2, 2020, and is currently one of the countries most affected by this pandemic in Africa

[6, 53].

In addition, for some time community transmission (case-contact) has become increasingly worrying within the population [4, 5, 7, 48]. To deal with this situation, the Government of the Republic of Senegal, with the support of partners, has worked to put in place strategies for the response to the COVID-19 epidemic [11, 22-24, 28, 33-34, 40-45]. These strategies aimed to ensure an operational and effective response in Dakar and in the provinces: banning of all public demonstrations throughout the national territory, closure of airports, suspension of lessons in schools and universities, systematic restriction and then banning of interurban travel, the declaration of a state of emergency and the establishment of a curfew from 8:00 p.m. to 6:00 a.m. throughout the national territory, thus putting the population in partial confinement [8-9, 11-12, 21, 28, 48]. Despite these measures, new confirmed cases and deaths continued to be recorded.

Several studies have been carried out on COVID-19 but few are carried out in this context of the epidemiological evolution of the disease with chronological analysis.

The general objective of this study is to analyze the lethality linked to the COVID-19 epidemic in Senegal [19, 20, 23, 31, 32, 39, 43-45, 53].

2. Methodology

This is a descriptive and analytical study of time series (time) from March 02 to August 31, 2020 [35].

Our study population concerned people tested for COVID-19 regardless of the results (Positive or negative) [30]. Our study included individuals screened, with validated data, available on websites and in certified documents from the Ministry of Health and WHO. The main judgment criterion is represented by the use of official documents to measure new cases of death during the study period.

It was a documentary collection of information from:

1) COVID-19 epidemiological bulletins published on the official website of the Ministry of Health;
2) Press releases made by the Ministry of Health;
3) Data published on the WHO COVID-19 websites;
4) Data published on the website www.sante.gouv.sn

Data entry was performed with Epi Info software version 7.2.2.6.

After cleaning the database, the data was analyzed using R software version 4.0.2.

3. Analysis Plan

Our study will not be able to answer all the questions about COVID-19, but it will contribute to obtaining essential data for the first interventions (early stages) against epidemic, and which can serve as a basis for evaluating public health interventions over time. Other survey protocols adapted for COVID-19 can help obtain additional data, which will facilitate the calculation of the main epidemiological parameters.

The description of the variables is made during the univariate analysis. All variables are quantitative, measures of indicators of central tendency (mean and median) and dispersion (standard deviation and range) were calculated.

Then the measurement of monitoring indicators and We are interested in the evolution over time of a phenomenon, with the aim of describing, explaining and then predicting this phenomenon in the future using ARIMA modeling[1] and Prophet[2] with R software.

During the bivariate analysis, crosses between the occurrence of new cases of death and certain variables were carried out to determine the existence or otherwise of a correlation based on statistical tests between the quantitative variables. The test is considered statistically significant for a p-value below the significance level at 0.05.

4. Results

Table 1. *Description of variables according to position and dispersion parameters from March to August 2020.*

Variables	Mean (Standard Deviation)	Median [Min, Max]
Total confirmed cases	4810 (4450)	3740 [1, 13611]
Total new confirmed cases	73.9 (51.5)	79 [0.207]
Total deaths	87.4 (94.9)	43 [0.284]
Total new death cases	1.56 (1.58)	1 [0, 6]
Number of active cases	1670 (1370)	1680 [1, 4308]
Number of cured cases	3050 (3020)	1860 [0.9439]
Number of local transmission cases	3940 (3540)	3300 [0, 10200]
Number of imported cases	115 (57.7)	93 [1,200]
Number of community transmission cases	757 (902)	351 [0, 3200]
Number of severe cases	19.3 (18.3)	15 [0.57]
Total number of tests performed	830 (532)	930 [0, 1960]
Number of positive tests	74.3 (51.4)	81 [0.207]

N=185 days

Table 2. *Monthly COVID-19 test positivity rate (%) from March to August 2020 in Senegal.*

Year 2020	Total COVID-19 tests performed or suspected cases	Positive COVID-19 tests or confirmed cases	Positivity rate (%)
March	1291	175	13.56
April	10013	750	7.49

Year 2020	Total COVID-19 tests performed or suspected cases	Positive COVID-19 tests or confirmed cases	Positivity rate (%)
May	31261	2712	8.68
June	36578	3148	8.61
July	31439	3313	10.54
August	41273	3505	8.49

The month of March with 175 recorded cases is the one where the positivity rate was the highest with 13.56% followed by the month of July with a positivity rate of 10.54%.

4.1. During the State of Emergency (from March 23 to June 29, 2020)

The positivity rate was initially high in March (13.56%) then a decrease was observed in the period from the end of April to June 2020 (8.61%).

4.2. After the State of Emergency (After June 29, 2020)

The positivity rate increased to 10.54% in July 2020 to decrease towards the end of August 2020 to 8.49.

Table 3. *COVID-19 fatality rate per 1000 inhabitants from March to August 2020 in Senegal.*

Year 2020	Total number of confirmed cases	Case of death	Case fatality rate per 1000
March	175	1	5.71
April	933	11	11.79
May	3645	42	11.52
June	6793	116	17.08
July	10106	209	20.68
August	13611	284	20.87

The lowest fatality rate was in March 2020 with 5.71 per 1000 inhabitants. Death cases were only increasing and in August 2020 the case fatality rate was 20.87 per 1000 population.

4.3. During the State of Emergency

The case fatality rate per 1000 inhabitants was 5.71 in March 2020, this rate doubled in April 2020 (11.79 per 1000) and this growth continued until June 2020 (17.08 per 1000).

4.4. After the State of Emergency

The case fatality rate continued to increase, 20.68 per 1000 in July and remained stable until August 2020 at 20.87 per 1000.

Reproduction rate R0 (Average number of people an infected person can infect)

1) The date of March 23, 2020, represented the start of the state of emergency.
   As of March 23, 2020, there were 75 active confirmed positive cases and from March 23 to April 06, 2020, 147 confirmed positive contacts were recorded.
   A confirmed positive case contaminated an average of 1.96 or two (02) other people.
2) S27[3], June 29 (lifting of the curfew) to July 05, 2020.
   As of June 29, 2020, there were 6698 active confirmed positive cases and from June 29 to July 13, 2020, 8198 confirmed positive contacts were recorded.
   A confirmed positive case infected an average of 1.22 other people.
3) S31, July 27 to August 02, 2020, Tabaski, July 31, 2020.
   As of July 31, 2020, there were 10,232 active confirmed positive cases and from July 31 to August 14, 2020, 11,872 confirmed positive contacts were recorded.
   A confirmed positive case infected an average of 1.16 other people.
4) S35, August 24 to 30, 2020, end of our study.
   As of August 17, 2020, there were 12,237 active confirmed positive cases and from August 17 to August 31, 2020, 13,611 confirmed positive contacts were recorded.
   A confirmed positive case infected an average of 1.11 other people.
5) S52, December 21 to 27, 2020, Christmas on December 25, at the end of the year 2020.
   As of December 11, 2020, there were 16,893 active confirmed positive cases and from December 11 to 25, 2020, 18,369 confirmed positive contacts were recorded.
   A confirmed positive case infected an average of 1.08 other people.

Table 4. *Proportion of serious cases compared to new confirmed cases of COVID-19 from March to August 2020 in Senegal.*

Year 2020	Number of severe cases	Number of new confirmed cases	Proportion (%)
March	0	174	0
April	2	758	0.26
May	12	2712	0.44
June	18	3148	0.57
July	20	3313	0.60
August	5	3505	0.14

No serious cases recorded in March. The proportion of serious cases compared to new confirmed cases reached 0.60% in July to decrease in August to 0.14%.

4.5. During the State of Emergency, the Proportion of Severe Cases to New Confirmed Cases Reached 0.57% in June 2020

After the state of emergency, in July, this proportion was 0.60% and dropped considerably at the end of our study, in August, to 0.14%.

The trend shows that the number of death cases was increasing every month.

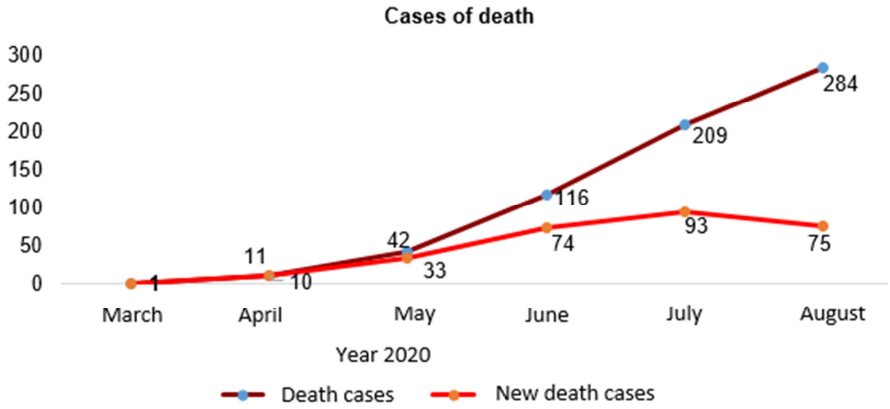

Figure 1. *Trend of cumulative cases of death from March to August 2020.*

The average of death cases was 87.4 cases, and a median of 43 [0.284].

The curve of new death cases began to decline in late August 2020.

In addition, the transmission commonly called "Local transmission/contact case" was the most represented during the first six (06) months of the epidemic.

Table 5. *Summary table of intersections between the main variables.*

crosses	Kendall's test		Correlation
	P-value	tau	
New confirmed cases and new death cases	< 2.2e-16	0.4867537	Yes
Serious case and new death cases	< 2.2e-16	0.5620654	Yes
Positive tests and new cases of death	< 2.2e-16	0.4979563	Yes
Severe case and cured case	< 2.2e-16	0.8417209	Yes
New confirmed cases and serious cases	< 2.2e-16	0.5528386	Yes

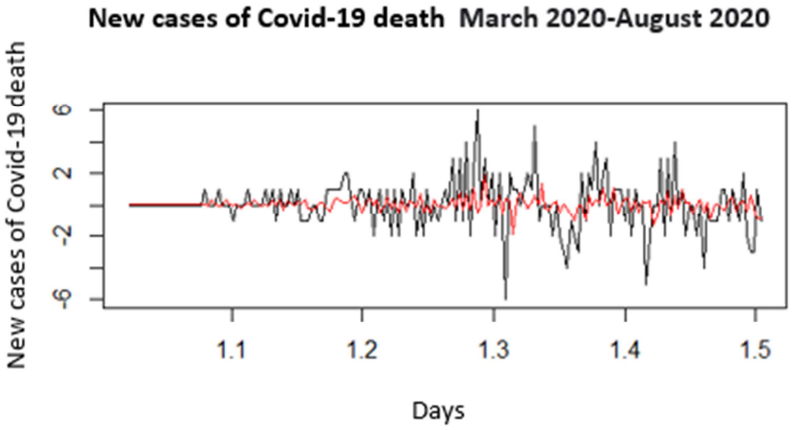

Figure 2. *Plot model 2 with linear adjustment.*

The mean of the residuals is zero: p =0.9973> 0.05 not significant

The residuals are not auto correlated: p = 0.8658> 0.05 not significant

The distribution of residuals follows the normal law

Model 2 is created from the differential base with a hindsight of eight (08) days. AIC^4=567.27.

This model has been validated. In conclusion, deaths related to COVID-19 occurred in the majority of cases in people whose symptoms of the disease persisted or worsened beyond eight (08) days despite medical follow-up.

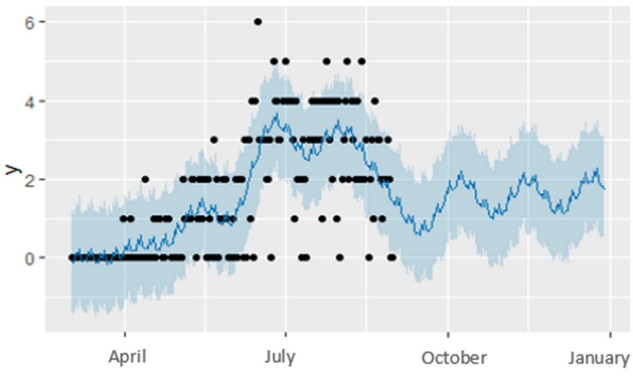

Figure 3. *Prediction plot of new COVID-19 death cases over 120 days.*

The number of new death cases, which fell from August to early September 2020, would increase around mid-September with multiple variations until December.

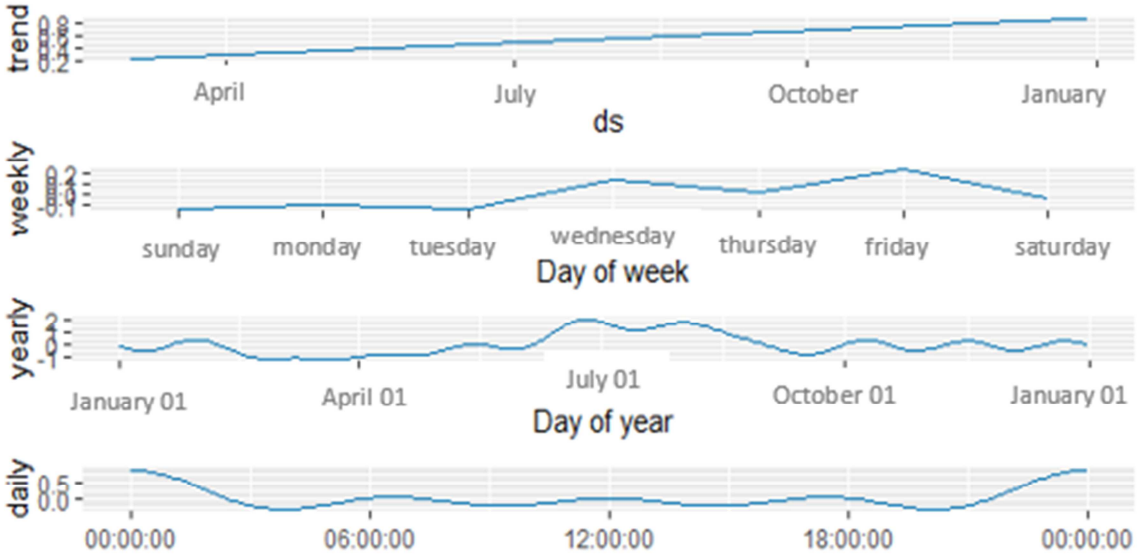

Figure 3. *Plot of daily, weekly and annual trends in new COVID-19 death cases.*

The overall trend with the prediction showed that new cases of COVID-19 deaths would continue to be recorded.

Weekly, more new death cases would be recorded from Tuesday to Friday. The number of new death cases would drop over the weekend into the start of the week.

There were more new death cases in June and July then a drop in August and this drop would continue until September 2020.

From October, new cases of death would be recorded with multiple variations.

New death cases would be recorded more in the middle of the night.

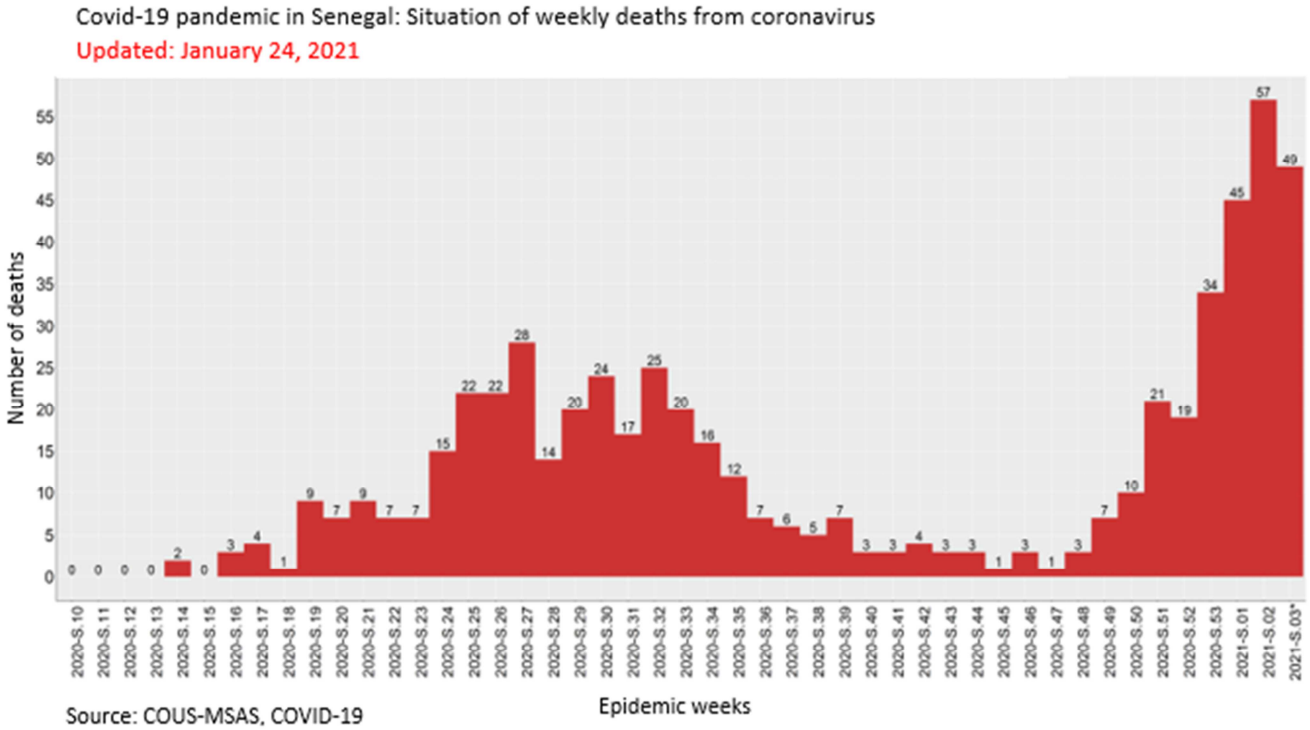

Figure 4. *COVID-19 pandemic in Senegal: Situation of weekly deaths from coronavirus.*

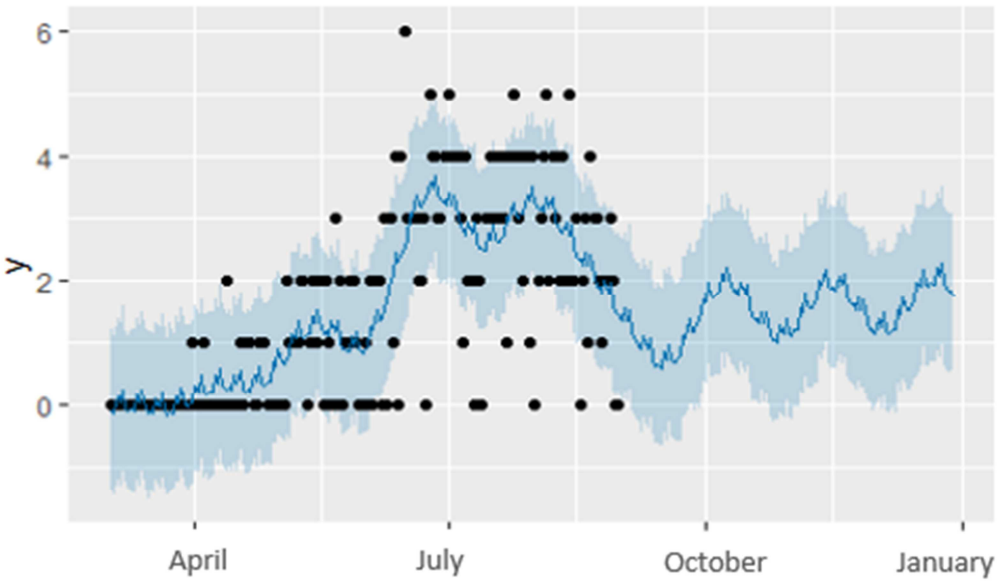

Figure 6. *Forecast graph of new cases of deaths due to COVID-19 over 120 days.*

Above: Comparative evolution of COVID-19 death cases in Senegal, prediction data and actual data (Ref: Figure 5, 6).

In September, the prediction showed a number of new death cases that would continue to decline.

From September to November, the observation was the same, the trend differed comparatively on the two figures.

In October, the prediction showed that new death cases would rise first, then fall and then rise again in November. The recording of new death cases would continue until December.

The actual data showed that the number of new death cases continued to decrease from September to October; but from November to December, there was an increase in the number of new death cases.

5. Main Results and Discussion

The average death rate was 87.4; the median was 43 with extremes of 0 to 284. The number of death cases was 11 from March 2 to early April; this number was multiplied by 4 at the end of May 2020 with a total of 42 cases of death.

At the end of June, 116 cases of death were recorded and this number was multiplied by 1.8 at the end of July, with a total of 209. This number was multiplied by 1.35 with at the end of August a total of 284 cases of death. The number of death cases was higher at the beginning of the epidemic, in the first quarter.

Other studies have confirmed this [8, 26-27, 52, 54].

New death cases had an average of 1.56, a median of 1 with extremes of 0 to 6.

With regard to confirmed cases, the average was 4810, the median was 3740 with extremes of 1 to 13611. We went from one confirmed case on March 2 to 175 cases at the end of March.

The number of community transmission cases had an average of 757. The median was 351 with extremes of 0 to 3200 cases. In March, this number was 10 and increased to 109 in April, 341 in May to 817 in June, 1608 in July to 3201 in August. Some authors have demonstrated this [5-6, 9, 22, 36, 38].

The average number of serious cases was 19.3, the median was 15 with extremes of 0 to 57 serious cases. Serious cases were managed in resuscitation and intensive care units [8, 40, 49-50, 55].

In March, 175 positive COVID-19 tests out of 1,291 tests carried out; in April, 750 positive tests out of 10,013 tests carried out; in May 2712 out of 31261; in June 3148 out of 36578; in July 3439 out of 31439; in August 3379 out of 41273.

The positivity rate was 13.56 in March, we observed a decrease in rate to 7.49 in April, 8.68 in May and 8.61 in June. This rate increased further in July to 10.94 and fell to 8.19 in August. These results confirm the reality with the level of the state of health emergency and the curfew in June 2020 and the reopening of the airport in July 2020; This has been demonstrated in several studies [15, 17-18, 21-22, 29, 40].

The fatality rate was 5.71 in March, this rate in April was multiplied by 2 giving 11.79; 11.52 in May; 17.08 in June; 20.68 in July and 20.87 in August. Some studies have shown this [15-16, 25, 27, 50, 52, 55].

The cases of death linked to COVID-19 occurred in the majority of cases in people whose symptoms of the disease persisted or worsened beyond eight (08) days despite medical follow-up. This is the case in some studies [2, 14, 16, 26, 46, 50].

New cases of death were also recorded among new confirmed cases, among serious cases and among people who took COVID19 tests and declared positive. It was also observed that among the serious cases, there were many cases of recovery. Studies have also shown [26, 27, 50-51].

The prediction showed that new confirmed cases would continue to be recorded with multiple periodic variations.

The comparison of the actual data and those of the

prediction has elucidated the fact that the epidemic is not over; new confirmed cases would continue to be recorded with an increase towards the end of 2020 (in November and December 2020).

6. Conclusion

The COVID-19 epidemic is distinguished by its great variability over time; thus we note a continuous presence of the epidemic in all the monitoring indicators calculated between March 02 and August 31, 2020. COVID-19 has become a high risk for the general population [37, 38].

The 120-day prediction (September to December 2020) shows that the epidemic would evolve with epidemic growth towards the end of 2020. The hope is that the vaccine can provide a solution [3, 10].

What Is Known About This Subject

Lethality linked to the COVID-19 epidemic in Senegal from March to August 2020.

What New Does This Study Bring

The comparison of actual data and those of the prediction elucidated the fact that the epidemic is not over; new confirmed cases would continue to be recorded with an increase towards the end of 2020 (in November and December 2020).

Contribution of the Authors

The authors of this research carried out a chronological analysis in order to study and analyze the lethality linked to the COVID-19 epidemic in Senegal and predict the near future of the evolution of the epidemic.

Conflicts of Interest

The authors declare no conflict of interest.

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1 ARIMA: Autoregressive integrated moving average, a statistical model for prediction.

2 Prophet: open source library (R and Python) for forecasting time series data based on an additive model.

3 Week 27.

4 AIC= Akaike information criterion allowing to measure the quality of a model (parsimony).