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Early view of the potential impact of government policy responses on reproductive number of COVID-19 in African countries: Evidence from Cameroon

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Abstract

This brief paper analyses the potential impact of government policy responses on reproducible number of COVID-19 in African countries, using Cameroon as a case study. Based on public data from the Ministry of Public Health, results from susceptible-infected-recovered (SIR) model show that the first two sets of containment measures led to a decrease in the estimated reproduction number. However, the set of release measures taken to ease the impact of the COVID-19 on the Cameroon's economy first led to an increase in the reproduction number before a decrease. Therefore,a combination of containment measures followed by releases measures can be effective to prevent the spread of the pandemic.

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1 Introduction

The novel coronavirus disease 2019 (COVID-19), first reported in the city of Wuhan in China in December 2019 has now been recognized as a global health threat (Benvenuto et al. 2020; Ferguson et al. 2020; Li et al. 2020; Shereen et al. 2020; Velavan and Meyer 2020). Indeed, nowadays, the number of cases is exponentially rising. On the 17 July 2020, the world number of confirmed cases reached 13 616 593 and 585 727 confirmed deaths; Africa recorded 543 122 confirmed cases and the dead tolls reached 9 130 (WHO 2020). As usual in the case of such a new disease, it is crucial to understand, estimate and predict both its transmission patterns and the reproductive number over time (Kucharski et al. 2020). The reproductive number ($\mathbf{R}_t$) is a strategic parameter that can be used to follow-up the epidemics (Koo et al. 2020; Nishiura et al. 2016). $\mathbf{R}_t$ is different from the expected of basic reproductive number ($\mathbf{R}_0$) that is the expected number of additional cases that one case will generate (on average) during its infectious period in an otherwise uninfected population. $\mathbf{R}_t$ is a function of time and represents the actual average number of secondary cases per primary case (Wallinga and Teunis 2004). Therefore, information on the evolution of reproductive number are important to analyse whether the government policy measures taken so far can have significant impact and guide the design of alternative interventions.

Dynamics of transmission and projections of COVID-19 in African countries are particularly worrying since these countries have the weakest health system of the world and intense interactions with both China and Europe (Gilbert et al. 2020; Leach 2020; Velavan and Meyer 2020). Furthermore, in the context where strict measures of quarantine and social isolation are particularly difficult to implement since about 80% of the African population generally rely on informal activities; it is necessary to carry out modelling studies that can provide useful information in understanding epidemics and evaluating the potential impact of government policy measures in the early stages of pandemics.

While the literature on the potential transmission of the COVID-19 worldwide is abundant (Benvenuto et al. 2020; Ferguson et al. 2020; Kucharski et al. 2020; Li et al. 2020; Lin et al. 2020; Liu et al. 2020; Mission 2020; Mizumoto, Kagaya, and Chowell 2020; Shereen et al. 2020; Yuan et al. 2020), relatively few studies have focused on African countries (Nguimkeu, Dongo, and Assob 2020; Guiro, Kone, and Ouaro 2020). Besides, there are no studies to the best of our knowledge on the potential impact of government policy measures on reproductive number of COVID-19 in African countries.
Therefore, using Cameroon as a case study, this paper analyses the potential impact of government policy responses on the reproducible number of COVID-19. Indeed, in a response to COVID-19, the government has taken two important sets of containment measures on the 17th March and 13th April 2020, followed by release measures on the 30th April 2020 to lessen the impact of the COVID-19 outbreak on Cameroonian economy. The evolution of $\mathbf{R}_t$ over time can be a signal and an effective tool to assess the efficiency of the aforementioned policy responses taken to curb the spread of this deadly virus. Nowadays, the reproductive number has become a strategic indicator for the orientation and evaluation of public policies implemented during epidemics times. Its evolution guides governments in decision-making that has both

microeconomic and macroeconomic impacts such as business closures, budget adjustments, tax breaks, etc.
The rest of the paper is structured as follows. Section 2 summarizes the measures adopted by the government as a response to COVID-19 in Cameroon. Section 3 presents material and method used to achieve the main objective of this study. Section 4 provides empirical results and discussions, and Section 5 concludes the paper.

2 Summary of Government Policy Responses to COVID-19 in Cameroon

In a response to COVID-19, the government has taken two major sets of containment measures on the 17th March and 13th April 2020, followed by release measures on the 30th April 2020 to ease the impact of the COVID-19 outbreak on Cameroonian economy. Ten days after the first confirmed case of COVID-19 in Cameroon, the government has taken a series of containment measures to stop the spread of the pandemic. At that time, 10 confirmed cases were so far reported. The Prime Minister Head of Government announced the following measures to be effective from March 18: *(i)* Cameroon's land, air and sea borders will be closed. Consequently, all passenger flights from abroad will be suspended with the exception of cargo flights and vessels transporting consumer and essential goods as well as materials whose stock over time will be limited and supervised; *(ii)* the issuance of entry visas to Cameroon at the airport shall be suspended; *(iii)* all public and private training educational establishments of various levels of education from nursery school to higher education, including vocational training centres and professional schools will be closed; *(iv)* gatherings of more than fifty persons are prohibited throughout the national territory; *(v)* school and university competitions like the university games which are supposed to be held in the days ahead are postponed; *(vi)* under the supervision of administrative authorities, bars, restaurants and entertainment spots will be systematically closed from 6pm; *(vii)* a system of regulation of consumer flows will be put in place in markets and shopping centres; *(viii)* urban and intercity travel should only be made in cases of extreme necessity; *(ix)* drivers of buses, taxis and motorbikes are urged to avoid overloading[1]; *(x)* private health facilities, hotels and other lodging facilities, vehicles and specific equipments necessary for the implementation of the COVID-19 pandemic response plan in Cameroon maybe repositioned as required by relevant authorities; *(xi)* public administration shall give preference to electronic communication and digital tools for meetings likely to bring together more than ten people; *(xii)* missions abroad of members of government and public and para public sectors, employees are hereby suspended; *(xiii)* the public is urged to respect and observe the hygiene measures recommended by the World Health Organization, including regular hand washing with soap, avoiding close contacts such as shaking hands or hugging and covering the mouth when sneezing with handkerchief.

These 13 measures were followed for a month but the number of new confirmed cases continued to rise exponentially. As these cases reached 856 on the 13th April 2020, the government

[1] Law enforcement officers will ensure that they comply.

announced seven additional measures to tighten the first ones. There are: *(i)* the general wearing of mask from Monday 13, April 2020 in all spaces open to the public[2]; *(ii)* the local production of medicines, protective masks and hand sanitizers by relevant national institutions under the supervision of the Minister of Scientific Research, in collaboration with the Ministry of Public Health; *(iii)* the establishment of specialized treatment centres for COVID-19 patients in all regional capital[3]; *(iv)* intensification of the COVID-19 screening campaign, with the collaboration of Centre Pasteur and its branches as well as other relevant health institutions[4]; *(v)* intensification of the awareness-raising campaign in urban and rural areas both in official and in local languages[5]; *(vi)* the continuation of activities essential to the economy[6]; *(vii)* the systematic sanctioning of any violation of the restrictions imposed on those at risk.

Following these series of containment measures, 19 release measures (also called accompanying measures) were taken to help businesses to overcome the difficulties arising from the pandemic, on the 30th April 2020. The aim of these measures was at all to reduce the impact of the COVID-19 outbreak on Cameroonian economy. Measures introduced are as follows: *(i)* the opening after 6pm of pubs, restaurants and leisure facilities, with the obligations for customers and users to respect barrier measures; *(ii)* the lifting of the measures reducing the mandatory number of passengers in all public transport[7]; *(iii)* the suspensions for the second quarter of general accounting audits, except in cases of suspected tax evasion; *(iv)* the postponement of the deadline for filing statistical and tax declarations, without penalties in case of payment of the corresponding balance; *(v)* the granting moratoriums and deferrals of payment to companies directly affected by the crisis; *(vi)* supporting the finances of companies through the allocation of a special envelope of FCFA 25 billion for the clearance of stocks of VAT credit awaiting reimbursement; *(vii)* the postponement of the deadline to pay land taxes for the financial year to 30 September 2020; *(viii)* full deductibility to determine the corporate income tax of denotations and gifts made by the companies in their fight against the COVID-19 pandemic; *(ix)* the exemptions from the tourist tax in the hotel and catering sectors for the rest of the 2020 financial years as from March; *(x)* exemption from the withholding tax and from parking fees for taxis and motorbikes as well as from the axle tax for the 2nd quarter; *(xi)* exemption for the second quarter from the withholding tax and council taxes (market duty, etc.) for petty traders; *(xii)* the temporary suspension for a period of three months of the payment of parking and demurrage fees in the Douala and Kribi ports for essential goods; *(xiii)* the establishment of a Ministry of Finance-Ministry of Economy, Planning and Regional Development consultation framework, with the main economic actors, in order to mitigate the effects of the crisis and

[2]The Minister of Industry has been instructed to publish the technical standard for the mass production of these masks locally.

[3]Those centres were meant to receive patients in case of a peak of the pandemic and to allow hospital to operate normally

[4]Emphasis will be laid on already identified affected areas.

[5]This was done through complementary channels of communication to be defined by the Minister of communication with the support of administrative, municipal, traditional and religious authorities.

[6]In strict compliance with the 17th March guidelines and the measures recommended by the World Health Organization to prevent the spread of the disease.

[7]The wearing of masks remains compulsory and overloading is prohibited.

promote a rapid resumption of activities; *(xiv)* the suspension for a period of three inspections by the National Social Insurance Fund (NSIF); *(xv)* the cancellation of penalties for the late payment of social security contributions due to the NSIF; *(xvi)* spreading the payment of the social security contribution for the months of April, May and June 2020 over three instalments; *(xvii)* the maintenance, for the next three months, that is from May to July, of the payment of family allowances to staff of companies which are unable to pay social contributions or have placed their staff on technical leave because of the economic downturn; *(xviii)* an increase of family allowances from FCFA 2800 to FCFA 4500; *(xix)* a 20% increase of old pension that were not atomically reassessed after the 2016 reform.

The next section presents the model and the data used in such pandemic situation in order to assess the impact of the aforementioned measures.

3 Material and Method

One of the most basic procedures in modelling a disease is to use a compartmental model, in which the population is divided into different groups: Susceptible, Infected and Recovered group. The Susceptible-Infected-Recovered (SIR) model is used in epidemiology to estimate the amount of susceptible, infected, and recovered people in a population. It is also used to explain the change in the number of people in need of medical attention during an epidemic. It is important to note that this model does not work with all diseases and not appropriate if a person has been infected but is not infectious. In addition, once a person has recovered from the disease, they would receive lifelong immunity.

3.1 The susceptible-infected-recovered (SIR) model assumptions

The SIR model is an appropriate one to use under the following assumptions:

Assumption 1. *The population is fixed.*
Assumption 2. *(a) The only way a person can leave the susceptible group is to become infected. (b) The only way a person can leave the infected group is to recover from the disease. Once a person has recovered, the person received immunity.*
Assumption 3. *Age, sex, social status, and race do not affect the probability of being infected.*
Assumption 4. *There is no inherited immunity.*
Assumption 5. *The members of the population mix homogeneously (have the same interactions with one another to the same degree)*

3.2 The susceptible-infected-recovered (SIR) model

Throughout the paper, we adopt the following notations. For $t \in [1 : T]$, let $\mathbf{S}_t$ be the number of individuals not yet infected with the disease at time t or those susceptible to the disease, $\mathbf{I}_t$ be the number of individuals who have been infected with the disease at time t and are able to spread it to those in the susceptible category and $\mathbf{R}_t$ be the compartment used for those individuals who were infected and then recovered from the disease at time t. Those in this category cannot be infected again or transmit the disease to others.

The assumptions lead us to the basic deterministic skeleton (see Kermack and McKendrick 1927, for more details) of the SIR model which is given by the following system of differential equations,

$$\frac{d\mathbf{S}_t}{dt} = -\beta \frac{\mathbf{S}_t \mathbf{I}_t}{N} \tag{1a}$$

$$\frac{d\mathbf{I}_t}{dt} = \beta \frac{\mathbf{S}_t \mathbf{I}_t}{N} - \gamma \mathbf{I}_t \tag{1b}$$

$$\frac{d\mathbf{R}_t}{dt} = \gamma \mathbf{I}_t \tag{1c}$$

To see why equation (1a) holds, note that an infected individual can transmit to β people per unit of time if all of them are susceptible, but the probability of meeting a susceptible individual is only $\frac{\mathbf{S}}{N}$. Thus, $\mathbf{I}$ infected individuals can transmit to $\beta \times \mathbf{I} \times \mathbf{S}/N$ individuals per unit of time. Equation (1b) holds because the change in the number of infected individuals equals the newly infected minus closed cases (either due to recovery).

The basic reproduction number is given by $\mathbf{R}_0 = \frac{\beta}{\gamma} s_0$ (where s_0 is the proportion of susceptible when the disease starts), and represents the expected number of additional cases that one case will generate (on average) over the course of its infectious period.

3.3 Data

The number of cases of COVID-19 in Cameroon is provided by the *Cameroon Ministry of Health*. Figure 1 shows the evolution of the number of confirmed active cases over the period of studies accounting for the two sets of containment measures (the 17th March and 13th April) and release measures of the 30th April 2020. We have to note that since the 24th June the Ministry of Health totally changed the frequency of data publication, then from this date, daily data on the evolution of COVID-19 were not available[8].
The first case of COVID-19 was identified on March 06th 2020 and the number of cases rapidly increased, resulting to 2 179 confirmed active cases on June 24th. The number of confirmed active cases were 10 on the 17th March, 721 on 13 April and 1 070 on 30 April, meaning that the spread of the COVID-19 is worrying. The highest number of confirmed active cases was 4 323 around the 15th June.

The epicentre of the COVID-19 outbreak in Cameroon has been identified in Yaoundé, the capital of country and the second largest city after Douala with a population of more than 3 millions. Douala, the economic capital of the country records the second highest number of confirmed cases. Both Yaoundé and Douala account for about one third of the total population

[8]Only weekly aggregate data are published.

of the country and have recorded more than 90% of the total confirmed cases.

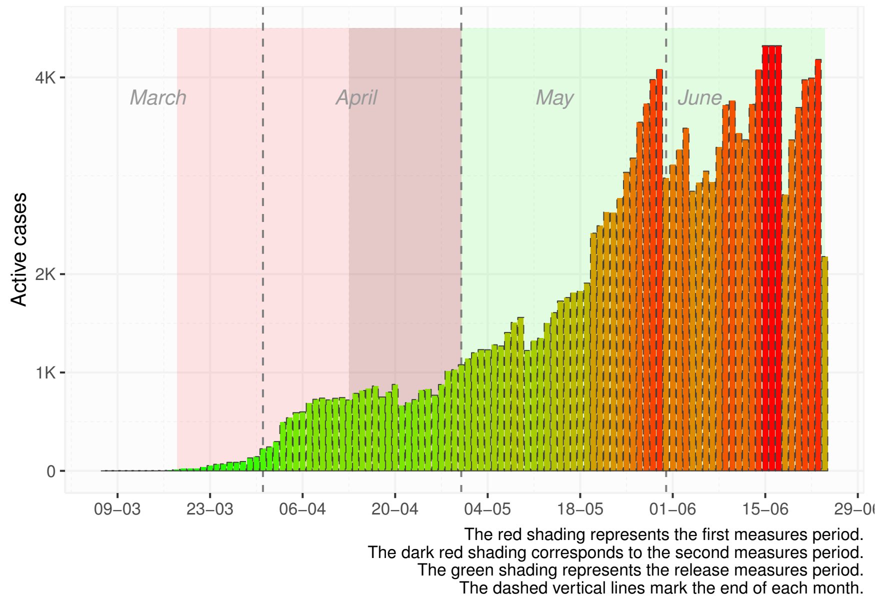

Figure 1: COVID-19 confirmed actives cases in Cameroon.

4 Results and Discussions

Estimation of the model poses significant challenges because the situation of COVID-19 is rapidly evolving. We estimate the parameters of the model by nonlinear least squares, minimizing the distance between model outputs and data.

Table 1 presents the estimated parameters. The basic reproduction number $\mathbf{R}_0$ that is the average number of secondary infections arising from a typical single infection in a completely susceptible population based on the optimal values for $\beta = 0.168$ and $\gamma = 0.075$ is estimated at 2.247 [95% CI: 2.209-2.287]. This indicates that an individual could generate approximately 2 new cases on average throughout his infectious period. This is consistent with estimates obtained in other studies. For instance, Ferguson et al. (2020) found an $\mathbf{R}_0$ of 2.4 in the case of US and UK; Rai, Shukla, and Dwivedi (2020), 2.56 in the case of India; and Liu et al. (2020) a value between 2 and 3 in China before interventions. This value of basic reproductive number above 1 is an indicator of the fact that the spread of COVID-19 is still problematic. Indeed, as mentioned by Favero (2020), a value of $\mathbf{R}_0$ close to one is an indicator of success in the fight against any pandemic by releasing the strain in healthcare capacity.

Table 1: Estimated parameters.

	β	γ	$\mathbf{R}_0$
Estimated	0.168	0.075	2.247
lower CI	0.166	0.072	2.209
upper CI	0.170	0.077	2.287

Figure 2 displays the evolution as well as the spread projection of the disease in Cameroon by using the SIR model and accounting for both containment and release measures taken so far by the government. The red shading shows the period of the first set of containment measures, when the dark red shading corresponds to the second set of containment measures; the green shading shows the release measures period. According to the prediction based on available data, the peak of the infection was attained on June 15 with a number of confirmed active cases around 4 323.

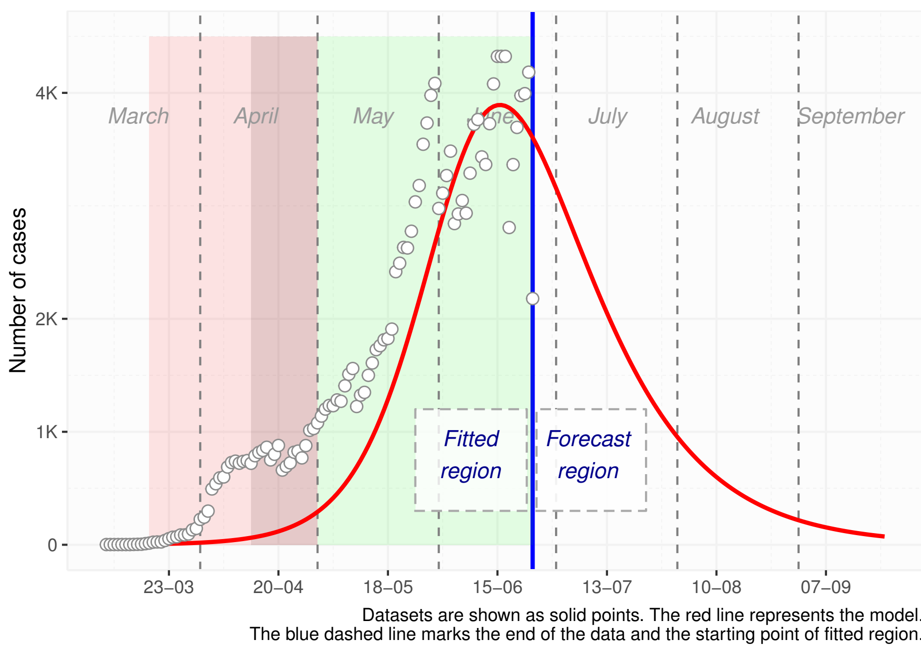

Figure 2: Dynamics of COVID-19 SIR in Cameroon, Fitted up to September.

Figure 3 provides the estimated reproduction number of cases for COVID-19 epidemic in Cameroon. $\mathbf{R}_t$ is a meaningful tool that helps to capture the transmission dynamics of epidemics (Chintalapudi et al. 2020; Inglesby 2020; Pan et al. 2020). From March 15 to 19, $\mathbf{R}_t$ moved from its initial median value of 3.04 [95% CI: 2.07- 4.00] to 2.78 [95% CI: 2.12 - 3.56]. This slight decrease can be due, in part, to the first set of containment measures (see the first block in Table 2) taken to control the spread of the disease. In addition, we observe a stringent decrease in $\mathbf{R}_t$ from the last two weeks of March to the first week of April. Then, from March 24 to the beginning of April estimated values of $\mathbf{R}_t$ are located between 2.09 [95% CI: 1.54 - 2.65] and

1.28 [95% CI: 0.75 - 1.93]. These findings can be attributed to the implementation of the second set of containment measures initiated since March 17, as specified in the section 2. Similar estimated median $\mathbf{R}_t$ values during exponential growth of the pandemic were established between 2.2 and 2.7 in Wuhan (Kucharski et al. 2020), 2.2 in the diamond princess ship (Mizumoto and Chowell 2020) and 1.5 in South Korea that was the lowest possible value that appeared in north Asia (Shim et al. 2020).
Besides, it appears that the second set of containment measures has stabilized $\mathbf{R}_t$ around 1.37 over the period April 13 to 16 (see the second block in Table 2). Similar significant decreases in $\mathbf{R}_t$ were found in most location in China after the adoption of containment measures such as travel restrictions, home quarantine and social distancing (Kraemer et al. 2020; Yuan et al. 2020).

Table 2: $\mathbf{R}_t$ evolution and government policy measures.

Date	$\mathbf{R}_t$	$\mathbf{R}_t^{low}$	$\mathbf{R}_t^{up}$
First set of containment measures			
2020-03-15	3.0411809	2.0750000	4.0000000
2020-03-19	2.7844512	2.1234375	3.5625000
2020-03-24	2.0994457	1.5476084	2.6501856
2020-04-03	1.2808308	0.7502963	1.9382654
Second set of containment measures			
2020-04-13	1.3621596	1.1407798	1.6366072
2020-04-14	1.3613455	1.0762481	1.6442679
2020-04-15	1.4107707	0.9677623	1.7780006
2020-04-16	1.3726479	1.1724279	1.6203486
Release measures			
2020-05-08	1.6628371	1.2889747	2.1232148
2020-05-23	1.1196621	0.9918921	1.2543136
2020-06-12	0.8293170	0.6669685	0.9953938
2020-06-14	0.9559726	0.5243135	1.3822809

Another noteworthy result is that the estimated $\mathbf{R}_t$ fall close to the threshold value of 1 at the third week of May, after an increase in early May. This may be related to the release measures undertaken in May (see the second block in Table 2). The effects of these measures led to a decrease of $\mathbf{R}_t$ below the threshold value of 1, although there was a slight rebound of 0.95 [95% CI: 0.52 - 1.38] on June 14. Overall, our results indicated a rigorous decline of the dynamic of transmission of the epidemic based on the reproduction number $\mathbf{R}_t$ estimated in real time. More specifically, during the period including extensive restrictive measures (i.e. March to end of April), there appears to be signs of a sharp decrease in $\mathbf{R}_t$ from 3.04 to 1.66. This could reflect the effectiveness of restrictions. At all, government policy responses that can be classified as non-pharmaceutical interventions (NPI) have brought the reproduction number close to one as expected (Favero 2020). However these important results have to be constant over time, since the value of $\mathbf{R}_t$ close to one is of great interest for both the public health bodies and the government to test the effectiveness of measures adopted (Chintalapudi et al. 2020; McBryde et al. 2020).

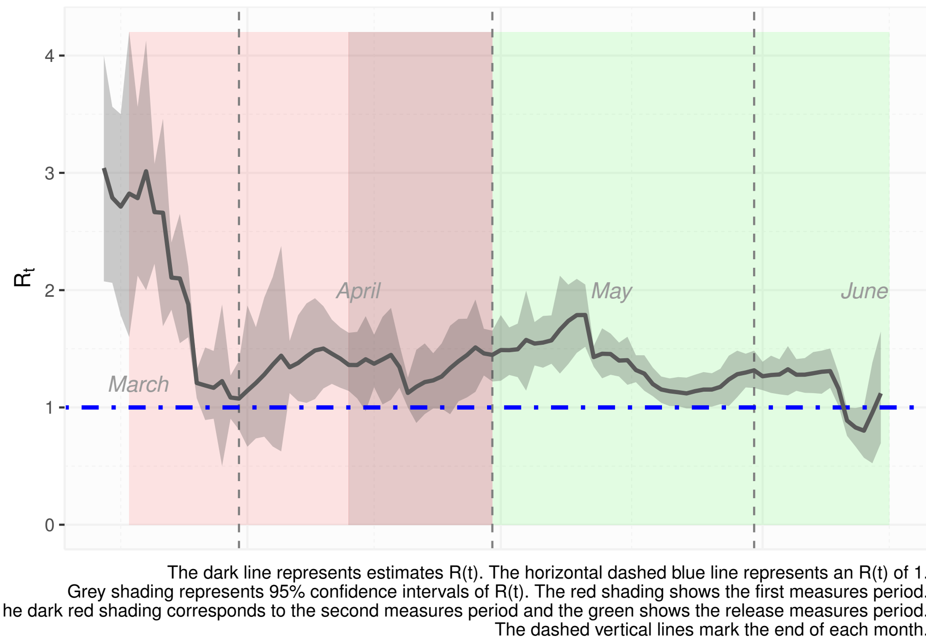

Figure 3: Time reproduction number in Cameroon.

5 Conclusion

The COVID-19 situation is progressing quickly and the quantification of transmission during the epidemic phase is crucial for addressing public health policies. This paper examines the relationship between government response measures and the reproduction number of COVID-19 in Cameroon. We apply the SIR model to estimate the reproduction number ($\mathbf{R}_t$) over the period of the study. Our main results suggest that there is a decline in reproduction number of cases of COVID-19 just after the implementation of containment measures undertaken to stop the spread of the disease. Even if the release measures taken to lessen the impact of the COVID-19 outbreak on Cameroonian economy after containment measures first led to an increase in $\mathbf{R}_t$, decrease in $\mathbf{R}_t$ was globally observed over time. As recommendation, government policy measures taken so far by Cameroonian authorities must be reinforced and maintained for a while. A combination of containment measures followed by release measures can be effective to prevent the spread of the pandemic. However, results from this paper should be understood with caution as the estimates strongly depend on available data. If for instance there is a huge amount of unreported or misreported cases, both predictions and dynamics could differ significantly. It may be interesting for future research to investigate the optimal changing point between containment measures and release measures in order to deal simultaneously with both health and economic constraints for developing countries with high proportion of informality as African countries.

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