

# A Multi-modal Infection Prevention and Control Approach to Combat COVID-19 in Overcrowded Settings Such as Prisons and Boarding Schools: The Experience from Rwanda

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## Abstract

**Background:** Coronavirus disease 2019 (COVID-19) is a respiratory tract infection caused by a new strain of coronavirus that was first recognized in Wuhan, China, in December 2019. COVID-19 spreads via droplets, aerosols, fomites and faeces and it spreads more quickly in overcrowded settings. The aim of the study was to establish a multi-modal approach which is a set of interventions to be implemented together in overcrowded settings to enable effective COVID-19 response by flattening the epi-curve and control the transmission of the disease.

**Methods:** This was an intervention study. A comprehensive multi-modal approach developed and implemented in 2 prisons and 15 boarding schools in Eastern Province of Rwanda. It started from November 2020 to the end of May 2021. The overall objective of the study was to evaluate the impact of the tailored infection prevention and control interventions on the COVID-19 infection prevention and response in overcrowding settings. The taskforce for COVID-19 prevention and response was established in each institution, members of taskforce trained and community members (students, teachers, inmates, and correctional facility staff) capacitated and assigned roles and responsibilities. Monitoring of the effectiveness of the interventions was pre-determined and regularly conducted. Data was analysed using MS Excel.

**Results:** The implementation of the project was sanctioned by a significant decrease of COVID-19 infection in both boarding schools and prisons. The incidence rate decreased from 48.82% to 7.69% at day 10 and to 0.38% at day 14 in boarding schools. The same decrease was observed in Ngoma women prison from 95% to 1.72% at day 10 and to 0.00% at day 14. >98% cases recovered in ≤ 10 days in boarding schools while in prisons 85% recovered in ≤ 10 days. It took on average of 21 days for boarding schools and 37 days for prisons to eliminate COVID-19 outbreak.

**Conclusion:** The implementation of the multi-modal infection prevention and control approach in 15 boarding schools and 2 prisons in Rwanda came up with the very impactful findings. COVID-19 was eliminated in those settings within a short period of time. The recovery rate increased and the deaths minimized.

**Keywords:** Multi-modal infection prevention and control approach • COVID-19 • Overcrowded setting • Boarding school • Prison • Correctional facility • Infection rate • Recovery period

## Introduction

The global outbreak of the COVID-19 pandemic was identified in December 2019 in Wuhan, China and has spread to all countries in the world. It is caused by Severe Acute Respiratory Syndrome Coronavirus type 2 (SARS-CoV-2) [1]. SARS-CoV-2 is a new coronavirus closely related to SARS-CoV and genetically clusters within *Betacoronavirus* subgenus *Sarbecovirus*. SARS-CoV-2 is a positive-stranded RNA virus of approximately 29,000 base pairs from lineage B of the genus *Betacoronavirus* covered with distinctive spikes about 9-12 nm in size that facilitate viral entry [2]. COVID-19 spreads via droplets, aerosols, fomites and faeces [3]. COVID-19 spreads more quickly

in overcrowded settings [4]. The basic reproductive number ( $R_0$ ), defined as average number of secondary infections produced by a case of an infection in a fully susceptible population, and determines the epidemic potential.  $R_0$  above 1 will lead to further spread.  $R_0$  for COVID-19 varied initially between countries, from just above 1 to 5 or higher [5].

Physical distancing and other non-pharmaceutical interventions decreased the transmission of COVID-19 in many countries [6]. Data from 11 European countries suggested an initial reproduction number  $R_0$  estimate of 3.87 [95% CI 3.01-4.66] and a noticeable decrease in an effective reproduction number  $R_e$  below 1 following the combined non-pharmaceutical interventions in several European countries [7]. In China, strict community quarantine and mobility restrictions combined with isolation of cases, and contact tracing enhanced by big data and led to the complete reported control of the COVID-19 outbreak [8].

Evidence has shown that overcrowding is a risk factor for respiratory diseases such as COVID-19 [9]. The overcrowding has been highlighted to be linked to high spread of infection during influenza pandemic of 1918 ( $P < .001$ ) [10].

Practice physical distancing in overcrowded settings such as prisons and boarding schools has become a big challenge and impossible since people stay closely together in dormitories, in dining rooms and shared sanitary facilities are not enough. The aim of this study was to establish a multi-modal approach which is a set of interventions to be implemented together in overcrowded settings to enable effective COVID-19 response by flattening the epi-curve and control the transmission of the disease.

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## Methodology

This was an intervention study whereby a comprehensive multi-modal approach has been developed and implemented in 2 prisons and 15 boarding schools in Eastern Province in Rwanda. The study started from November 2020 to the end of May 2021. The overall objective of the study was to evaluate the impact of the tailored infection prevention and control interventions on the COVID-19 infection prevention and response in overcrowding settings. The specific objectives were to:

1. Introduce a well-designed and coordinated multimodal infection prevention and control approach in overcrowding setting including schools and prison where at least one positive case of COVID-19 was found;
2. Monitoring the COVID-19 infection rate among students and inmates over time (looking for new cases);
3. Monitoring the recovery period in terms of days for the positive cases under clinical case management (control test for COVID-19 cases undergone case management);
4. Monitoring the duration of COVID-19 infection in overcrowding institutions.

The fifteen (15) boarding schools and two (2) prisons served to measure the COVID-19 infection rate overtime and the duration of COVID-19 infection in overcrowding settings because it was easy to ensure fully compliance to the IPC intervention as the movements to and from outside the institutions were restricted. The recovery period was evaluated to each of the 15 boarding schools and the 2 prisons and it was pre-determined as follows: between five and seven days, between eight and ten days, between eleven and fourteen days and beyond fourteen days. The COVID-19 infection rate (incidence rate) was monitored at day 0 (when the first positive case confirmed in the institution), at day seven, at day ten, at day fourteen and beyond day fourteen. The control tests among the cases of COVID-19 undergone case management were organised and performed at day seven, day ten, day fourteen and every seventy-two (72) hours after day fourteen for the cases which were not able to recover from COVID-19 within the fourteen days of case management. The duration of COVID-19 infection in each institution was calculated in terms of number of days from the day 0 (when the first case was tested positive) to the day when the institution was cleared free from COVID-19 infection, it means when the control test of the last case of COVID-19 became negative. The average and median number of days spent to breakdown all the chains of COVID-19 infection were calculated to know the number of days required to eliminate COVID-19 in correctional facilities (prison) and in boarding schools respectively.

### The incidence rate called Positivity Rate (PR) of COVID-19 in different institutions was interpreted as follows

Institutions with PR below 5% were classified as Green. The institutions with between 5 and 10% were classified as Yellow, while those with PR equal and above 10% were classified as Red.

An infection prevention and control multi-modal approach defined as a set of interventions to be implemented together in overcrowded settings was determined by the researcher and implemented in each institution among the 15 boarding schools and 2 prisons. The implementation of the multi modal infection prevention and control interventions was triggered once a positive case of COVID-19 was found at the facility level (boarding school or prison).

### Description of the multi-modal infection prevention and control approach

#### 1. System change:

**A. Make accessible basic IPPC PPE and supplies:** Delivery of Infection Prevention and Control kit composed of PPE, supplies and materials (surgical face masks, clinical examination gloves, chlorine, HTH 65%, alcohol-based handrub, coveralls, isolation gowns, heavy-duty gloves, rubber boots, face

shields, plastic basins, plastic buckets, sprayer chemical-resistant, hand washing stations known as Kandagirukarabe, liquid soap, environmental cleaning detergent known as OMO, VIM for cleaning and disinfection of flush toilets, sinks and running water handwashing basins.

Distribution of 3- layers surgical face masks to all covid-19 cases, staff and all students or inmates at daily basis.

#### Procedure:

- Each student/inmate remove old surgical face mask and threw it away into a biohazard bag;
- He/she performs hand hygiene (hand washing or use hand sanitizer);
- A new piece of surgical face mask given to him/her;
- Wears a piece of surgical face mask and ensures it covers both mouth and nose correctly;
- Changing of surgical face masks is organised at daily basis, basically each morning after bathroom and morning physical exercises.

#### B. COVID-19 testing accessibility:

- Initial testing of people that presenting signs and symptoms for COVID-19
- Control testing after seven (7) of interventions from the initial testing.
- Control testing after three (3) days of interventions from the first control test

#### 2. Isolation of covid-19 positive cases:

Establish an isolation facility within the prison or the school to hold asymptomatic and mild symptomatic COVID-19 cases.

Moderate symptomatic cases were transferred to a hospital for management.

Severe symptomatic cases were transferred to a COVID-19 treatment centre for management.

Establishment of COVID-19 Emergency Task force to coordinate covid-19 response.

#### 3. Briefing and training in terms of COVID-19 preventive and control measures:

- Briefing of admin senior staff on COVID-19 preventive and control measures (individual and collective safety measures) and on the comprehensive multimodal approach to be implemented to effectively respond to COVID-19 outbreak.
- Training of all people (admin staff, students, inmates and support staff/cleaners) on covid-19 preventive and control measures (individual and collective safety measures), environmental cleaning and decontamination, clothes and linen management, waste management. The emphasis was on hand hygiene, wearing of face masks, social distancing, avoid sharing of items such as phones, chargers, and avoiding paying stuff using cash. We encouraged them to always use Mobile Money when buying or paying whatever they want to buy.
- Training of environmental decontamination team including students/inmates, cleaners, teachers, kitchen staff and volunteers on environmental cleaning and decontamination, donning and doffing of PPE, preparation of chlorine solutions (0.5% and 0.05%) and waste management. Both theoretical and practical sessions were conducted today.
- Briefing of students, staff, inmates on covid-19 preventive/safety measures (individual and collective) insisting on wearing of face masks properly, hand hygiene and avoiding sharing of items with others such as chargers, telephones, and practising physical exercises.

- Briefing of active covid-19 cases in isolation by encouraging them to double efforts (exercises), motivating them to boost their immune system to chase away the virus as soon as possible.

#### 4. Environmental cleaning and disinfection:

- Environmental cleaning and decontamination of all isolation facilities, workshops, classrooms, dormitories, refectories, toilets and bathrooms, mattresses, bags.
- Laundry of all students' clothes, bed sheets, bed covers and curtains every seventy-two (72) hours for 2 to 3 weeks.

#### 5. Improving food of students or inmates:

- Increasing food in quantity and quality (proteins, carbohydrates, vitamins/vegetables and fruits)
- Adding fruits and vegetables
- Adding drinking water (mineral or cooked water) of at least 2 litres a day.

#### 6. Physical exercises to all isolated covid-19 cases, all students or inmates:

- At least 30 minutes of physical exercises were organised twice a day morning and evening to all COVID-19 cases in isolation for the period of two weeks.
- A session of 1 hour of physical exercises was organised once a day in the afternoon for the period of one to two weeks.

#### 7. Monitoring and evaluation:

- Supervision of students or inmates adherence to covid-19 preventive measures such as wearing of face mask, hand washing and social distancing in different dormitories and classrooms or in different blocks for inmates.
- Enforcement of hand washing practices in prison/school with focus on two key moments for hand washing which are: before eating and after attending the toilets.
- Daily briefing and monitoring of students/inmates to avoid sharing items such as phones, chargers, plates, spoons, forks, basins, buckets and ensure each one use his/her own items and those items are kept clean and dry.

#### The fifteen boarding schools included in the study were

**Four boarding schools from Rwamagana district:** GS St Aloys, Agahozo Shalom Youth Village, APPEGA Gahengeri, and GS HVP Gatagara Rwamagana (blind students).

**Six boarding schools from Kayonza district:** Fawe Girls School Gahini, University of Rwanda College of Education Rukara Campus, Institut Don Bosco Kabarondo TVET, APPEKA-Kabarondo TVET, Kabarondo TVET School and GS Gahini.

**Four boarding schools from Ngoma district:** GS Kabare, IPRC Ngoma, Lycee de Zaza and Gahima AGAPE Secondary School.

**One boarding school from Bugesera district:** Montfort Secondary School.

**The two correctional facilities are:** Rwamagana men prison from Rwamagana district and Ngoma women prison from Ngoma district.

## Results

The total population in the 15 boarding schools was 14723 while it was 15804 in the two (2) prisons. The overall proportion of the population tested for COVID-19 (those presented clinical signs and symptoms for COVID-19) was 30.40% in schools and 12.03% in prisons (Table 1). The findings from

overall COVID-19 testing in 15 boarding schools and 2 prisons showed that the positivity rate was 29.27% (ranged from 8.48% to 65.05%) in schools and 25.24% (ranging from 23.40% to 26.04%) (Table 1). The initial testing of students and inmates that presented clinical signs and symptoms for COVID-19 showed that the COVID-19 infection was very high in all the 15 boarding schools and in the 2 prisons. The average PR in 15 schools was 48.82% and ranged from 23.75% to 84.62% (Table 2). The average PR in 2 prisons was 38.57% and ranged from 16% to 95.00% (Table 2). The epidemic curve descended from 48.82% (Day 0) up to 0.38% (Day 14) in boarding schools and similarly, it decreased from 38.57% (Day 0) up to 1.19% (Day 14) in the 2 prisons. At Day 7, in 15 boarding schools, the COVID-19 infection decreased from 48.82% to 28.18% (ranging from 0.00% to 59.50%) (Table 2). In Rwamagana men prison, the COVID-19 infection increased from 16.00% (Day 0) to 46.67% at Day 7, and then it decreased to 26.21% at Day 10 and to 1.28% at Day 14 (Table 2). In Ngoma women prison, the COVID-19 infection decreased significantly from 95% (Day 0) to 17.81% at Day 7 and to 1.72% at Day 10 and it was 0.00% at Day 14 (Table 2).

The recovery period measured over time demonstrated that 88.09% (ranged between 27.66% and 100%) of COVID-19 cases among students in the fifteen (15) boarding schools recovered from COVID-19 between day five and day seven. 10.15% (ranged between 2.68% and 38.30%) recovered between day eight and day ten. 1.45% (ranged between 1.19% and 25.53%) recovered between day eleven and day fourteen, while few cases (0.23%) remained positive after day fourteen. In Prisons, the recovery period was at 68.96% (ranged between 67.25% and 73.33%) between day five and day seven. It was at 16.04% (ranged between 13.33% and 22.96%) recovered between day eight and day ten. It was at 8.75% (ranged between 3.70% and 10.72%) recovered between day eleven and day fourteen. The recovery period was at 3.54% (0% at Ngoma prison and 4.93% at Rwamagana prison) after day fourteen (Table 3). The average time required to fully breakdown the chains of COVID-19 infection was 21 days (ranged between 9 days and 33 days) in boarding school while it was 37 days (ranged between 23 days and 51 days) (Table 4).

## Discussion

The results of the study demonstrated the importance of a multi-modal infection prevention and control approach in improving the response of COVID-19 in overcrowded settings especially in prisons and boarding schools. The results from the study supported in decision making whereby before the study the first control test was conducted at day fourteen counting from the day the sample tested positive [11-14]. Since then, Rwanda changed the clinical guidelines for COVID-19 and admitted the control tests at day ten, then at day seven and lastly at day five. The multi-modal infection prevention and control approach was adopted by the country and recommended to be implemented in all schools, prisons, police stations and in other overcrowding settings in Rwanda [11-14]. The study was very impactful since it helped in capacity building of local human resources and the facility was able to coordinate, manage and evaluate their performance.

The capacity building was made by establishing a taskforce for COVID-19 response at each overcrowded institution, trained members of the taskforce as well as the students and inmates on the activities such as environmental cleaning and disinfection, soap preparation, chlorine preparation, personal protective equipment, hand hygiene, respiratory hygiene, linen management, waste management, safe and dignified burial, monitoring and supervision competencies as well as summarizing of data and reporting. The study supported in reducing the costs of the response since local human resources were capacitate and implemented COVID-19 response activities, which is very different of the previous situations where the Ministry of Health in collaboration with Rwanda Biomedical Centre deployed rapid response team from central level to provide primary response and extend the team with other human resources to ensure COVID-19 response activities are well managed. The government of Rwanda covered all the expenses of the deployed team members including wages, accommodation, communication fees and transport.

**Table 1.** The overall picture of COVID-19 Testing in the overcrowded settings in Rwanda, November 2020 to May 2021.

S/N	District	School	Type of School	Boarding/Day	Total Population	Total Tested	Total Positive	Positivity Rate	Total Recovered	Total Deaths	Cfr (%)
1	Rwamagana	Gs St Aloys	General	Boarding	1000	505	47	9.306931	47	1	2.12765957
2	Rwamagana	Agahozo Shalom Youth Vilage	General	Boarding	1000	224	19	8.482143	19	0	0
3	Rwamagana	Appega Gahengeri	TVET	Boarding	492	415	149	35.90361	149	0	0
4	Rwamagana	G.S. Hvp Gatagara Rwamagana	HVP	Boarding	229	229	99	43.23144	99	0	0
5	Kayonza	Fawe Girls' School Gahini	General	Boarding	700	42	29	69.04762	29	0	0
6	Kayonza	Ur-Ce/Rukara Campus	University	Boarding/External	6000	868	335	38.59447	335	0	0
7	Kayonza	Idbk/Kabarondo Tvet	TVET	Boarding	500	161	53	32.91925	53	0	0
8	Kayonza	Appeka-Kabarondo Tvet	TVET	Boarding/External	250	137	54	39.41606	54	0	0
9	Kayonza	Kabarondo Tvet School	TVET	Boarding/External	100	56	15	26.78571	15	0	0
10	Kayonza	G.S. Gahini	General	Boarding	864	245	50	20.40816	50	0	0
11	Ngoma	G.S. Kabare	General	Boarding	928	377	75	19.8939	75	0	0
12	Ngoma	Iprc Ngoma	PR/TVET	Boarding/External	1342	343	148	43.14869	148	0	0
13	Ngoma	Lycee De Zaza	General	Boarding	633	371	112	30.18868	112	0	0
14	Ngoma	Gahima Agape Secondary School	General	Boarding/External	235	372	83	22.31183	83	0	0
15	Bugesera	Montfort Secondary School	O-Level	Boarding	450	131	42	32.06107	42	0	0
Overall					14723	4476	1310	29.2672	1310	1	0.07633588
<b>Proportion of Tested Students</b>						30.4014					
No	District	li. Prisons	Type of Facility	Population	Total Population	Total Tested	Total Positive	Positivity Rate	Total Recovered	Total Deaths	Cfr (%)
1	Ngoma	Rwamagana Prison	Correctional	Inmates	14404	1325	345	26.03774	332	13	3.76811594
2	Rwamagana	Ngoma Prison	Correctional	Inmates	1400	577	135	23.39688	135	0	0
Overall/Prisons					15804	1902	480	25.23659	467	13	2.70833333
<b>Proportion of Tested Inmates</b>						12.0349					

**Table 2.** The COVID-19 infection rate over time in the 15 boarding schools and 2 prisons in Rwanda from November 2020 to May 2021.

No	District	Institution	Infection Rate Over Time											
			Initial Positivity Rate			Positivity Rate At Day 7			Positivity Rate At Day 10			Positivity Rate At Day 14		
			Total Tested	Nbr Positive Cases	Positivity Rate (%)	Total Tested	Nbr Positive Cases	Positivity Rate (%)	Total Tested	Nbr Positive Cases	Positivity Rate (%)	Total Tested	Nbr Positive Cases	Positivity Rate (%)
1	Rwamagana	G.S. Saint Aloys	100	31	31.00	205	11	5.37	100	5	5	100	0	0
2	Rwamagana	Agahozo Shalom Youth Vilage	50	19	38.00	111	1	0.90	63	0	0	0	0	-
3	Rwamagana	Appega Gahengeri	100	74	74.00	100	56	56.00	100	18	18	115	0	0
4	Rwamagana	G.S. Hvp Gatagara Rwamagana	224	98	43.75	5	1	20.00	0	0	-	0	0	-
5	Kayonza	Fawe Girls' School Gahini	42	29	69.05	0	0	-	0	0	-	100	0	0
6	Kayonza	Ur-Ce/Rukara Campus	182	154	84.62	286	123	43.01	200	53	26.5	200	5	2.5
7	Kayonza	Idbk/Kabarondo Tvet	87	34	39.08	70	16	22.86	100	3	3	100	0	0
8	Kayonza	Appeka-Kabarondo Tvet	98	47	47.96	39	6	15.38	65	1	1.54	50	0	0
9	Kayonza	Kabarondo Tvet School	54	15	27.78	46	0	0.00	100	0	0.00	0	0	-

10	Kayonza	G.S. Gahini	58	48	82.76	100	2	2.00	161	0	0.00	100	0	0
11	Ngoma	G.S. Kabare	191	73	38.22	26	2	7.69	160	0	0.00	100	0	0
12	Ngoma	Iprc Ngoma	50	35	70.00	121	72	59.50	70	3	4.29	100	0	0
13	Ngoma	Lycee De Zaza	208	110	52.88	63	2	3.17	100	0	0.00	100	0	0
14	Ngoma	Gahima Agape Secondary School	160	38	23.75	76	27	35.53	79	18	22.78	235	0	0
15	Bugesera	Montfort Secondary School	131	42	32.06	50	0	0.00	50	0	0.00	100	0	0
<b>Overall/Schools</b>			1735	847	48.82	1093	308	28.18	1248	96	7.69	1300	5	0.38
<b>No</b>	<b>District</b>	<b>Ii. Prisons</b>	<b>Total Tested</b>	<b>Nbr Positive Cases</b>	<b>Positivity Rate (%)</b>	<b>Total Tested</b>	<b>Nbr Positive Cases</b>	<b>Positivity Rate (%)</b>	<b>Total Tested</b>	<b>Nbr Positive Cases</b>	<b>Positivity Rate (%)</b>	<b>Total Tested</b>	<b>Nbr Positive Cases</b>	<b>Positivity Rate (%)</b>
1	Rwamagana	Rwamagana Prison	50	8	16.00	375	175	46.67	515	135	26.21	2109	27	1.28
2	Ngoma	Ngoma Prison	20	19	95.00	146	26	17.81	116	2	1.72	166	0	0
<b>Overall/Prisons</b>			70	27	38.57	521	201	38.58	631	137	21.71	2275	27	1.19

**Table 3.** The recovery period from COVID-19 in overcrowded setting in Rwanda included in the study in Rwanda: November 2020 to May 2021.

No	District	Institution	Nbr COVID-19 Positive Cases	Recovery Period									
				5-7 Days		8-10 Days		11-14 Days		Beyond 14 Days			
		I. Schools	Total Positive Cases	Nbr Cases	Rate (%)	Nbr Cases	Rate (%)	Nbr Cases	Rate (%)	Nbr Cases	Rate (%)	Nbr Cases	Rate (%)
1	Rwamagana	G.S. Saint Aloys	47	13	27.66	18	38.3	12	25.53	3	6.38		
2	Rwamagana	Agahozo Shalom Youth Village	19	19	100	0	0	0	0	0	0		
3	Rwamagana	Appega Gahengeri	149	144	96.64	4	2.68	1	0.67	0	0		
4	Rwamagana	G.S. Hvp Gatagara Rwamagana	99	75	75.76	24	24.24	0	0	0	0		
5	Kayonza	Fawe Girls' School Gahini	29	29	100	0	0	0	0	0	0		
6	Kayonza	Ur/Rukara Campus	335	287	85.67	44	13.13	4	1.19	0	0		
7	Kayonza	Idbk/Kabarondo Tvet	53	49	92.45	3	5.66	1	1.89	0	0		
8	Kayonza	Appeka-Kabarondo Tvet	54	47	87.04	7	12.96	0	0	0	0		
9	Kayonza	Kabarondo Tvet School	15	12	80	2	13.33	1	6.67	0	0		
10	Kayonza	G.S. Gahini	50	50	100	0	0	0	0	0	0		
11	Ngoma	G.S. Kabare	75	72	96	3	4	0	0	0	0		
12	Ngoma	Iprc Ngoma	148	135	91.22	13	8.78	0	0	0	0		
13	Ngoma	Lycee De Zaza	112	103	91.96	9	8.04	0	0	0	0		
14	Ngoma	Gahima Agape Secondary School	83	80	96.39	3	3.61	0	0	0	0		
15	Bugesera	Montfort Secondary School	42	39	92.86	3	7.14	0	0	0	0		
<b>Overall/Schools</b>			1310	1154	88.09	133	10.15	19	1.45	3	0.23		
No	District	Ii. Prisons	Total Positive Cases	Nbr Cases	Rate (%)	Nbr Cases	Rate (%)	Nbr Cases	Rate (%)	Nbr Cases	Rate (%)	Nbr Cases	Rate (%)
1	Rwamagana	Rwamagana Prison	345	232	67.25	46	13.33	37	10.72	17	4.93		
2	Ngoma	Ngoma Prison	135	99	73.33	31	22.96	5	3.7	0	0		
<b>Overall/Prisons</b>			480	331	68.96	77	16.04	42	8.75	17	3.54		

The study demonstrated the importance of coupling infection prevention and control measures and other non-pharmaceutical interventions such as monitored daily physical exercises, nutrition, psychosocial support, communication and awareness sessions, etc effectively control and breakdown all the chains of infections, therefore eliminate the infection as faster as possible in the overcrowded settings. It clearly demonstrated that physical distancing which was recommended since the early phase of COVID-19 as critical component of COVID-19 preparedness and response plan was not something to be scared for in overcrowded settings since the multi-modal infection prevention and control approach fully implemented. A multi-modal infection prevention and control approach contributed significantly to the

clinical case management of COVID-19 cases in isolation sites by shortening the number of days spent in the treatment centre or isolation site from fourteen days and above to ten days and less, whereby more than 98% in boarding schools and 95% in prisons were recovered at less than ten days (Table 3). It improved the recovery rate up to 99.92% in boarding schools and up to 97.29% in prisons (Table 1).

The multi-modal infection prevention and control approach contributed significantly in breaking chains of transmission, therefore combating community transmission of the virus within the boarding schools and prisons whereby infection rate decreased from 48.42% to 7.69% at day ten, and then at 0.38% at day fourteen in fifteen boarding schools (Table 2). The same

**Table 4.** The time taken to eliminate COVID-19 in overcrowded settings included in the study, Rwanda from November 2020 to May 2021.

Duration Of COVID-19 Infection In Overcrowding Institutions							
No	District	I. Schools	Started Date	Cleared Date	Duration (Nbr Days)	Average	Median
1	Rwamagana	G.S. Saint Aloys	21-Nov-20	24-Dec-20	33	-	-
2	Rwamagana	Agahozo Shalom Youth Vilage	11-Jan-21	24-Jan-21	13	-	-
3	Rwamagana	Appega Gahengeri	22-Feb-21	16-Mar-21	22	-	-
4	Rwamagana	G.S. Hvp Gatagara Rwamagana	05-May-21	21-May-21	16	-	-
5	Kayonza	Fawe Girls' School Gahini	16-Jan-21	04-Feb-21	19	-	-
6	Kayonza	Ur-Ce/Rukara Campus	17-Dec-20	12-Jan-21	26	-	-
7	Kayonza	Idbk/Kabarondo Tvet	20-Jan-21	11-Feb-21	22	-	-
8	Kayonza	Appeka-Kabarondo Tvet	24-Jan-21	15-Feb-21	22	-	-
9	Kayonza	Kabarondo Tvet School	28-Jan-21	06-Feb-21	9	-	-
10	Kayonza	G.S. Gahini	07-Feb-21	23-Feb-21	16	-	-
11	Ngoma	G.S. Kabare	07-Feb-21	04-Mar-21	25	-	-
12	Ngoma	Iprc Ngoma	05-Jan-21	06-Feb-21	32	-	-
13	Ngoma	Lycee De Zaza	03-May-21	18-May-21	15	-	-
14	Ngoma	Gahima Agape Secondary School	07-May-21	27-May-21	20	-	-
15	Bugesera	Montfort Secondary School	07-Mar-21	24-Mar-21	17	-	-
<b>Overall/Schools</b>						20.5	20
No	District	ii. Prisons	Started Date	Cleared Date	Duration (Nbr Days)	Average	Median
1	Rwamagana	Rwamagana Men's Prison	05-Nov-20	26-Dec-20	51	-	-
2	Ngoma	Ngoma Women's Prison	28-Dec-20	20-Jan-21	23	-	-
<b>Overall/Prisons</b>						37	37

decrease was observed at Ngoma women prison, it was 95.00% initially and decrease to 17.81% at day 7, and at 1.72% at day ten, and finally at 0.00% at day fourteen (Table 2). At Rwamagana prison, the situation was different from in the first week of intervention, whereby all interventions were concentrated at the treatment centre and isolation sites. The rest of the prison was not taken in consideration. The implementation of the approach in a selected area not widely implemented in the correction facility came up with an increase of cases from the different dormitories of inmates and the incidence rate/positivity rate increased from 16.00% to 46.67% in the first week of intervention. The decision was made to extend the intervention to all inmates and to all areas of the correction facility. Since then, there was a significant decrease of infection to 25.21% at day ten, and to 1.28% at day fourteen (Table 2).

## Conclusion

The multi-modal infection prevention and control approach was the most effective way to combat COVID-19 in overcrowded setting such as boarding schools and prisons. The implementation of the multi-modal infection prevention and control approach in fifteen boarding schools and two prisons from the Eastern Province, in Rwanda came up with the very impactful findings. It was able to eliminate COVID-19 in the boarding schools and prisons within the short period of time. The median time in terms of days from the study was 21 days (ranged between 9 days and 33 days) in boarding school while it was 37 days (ranged between 23 days and 51 days) (Table 4). There was a remarkable decrease of infection rate among students and inmates in their respective communities (dormitories, classes, etc). Within the first ten days of implementation of the multi-modal infection prevention and control approach, the incidence rate/positivity rate decreased by six times in fifteen boarding schools, and it decreased fifty-five times in Ngoma women prison. The recovery rate among COVID-19 cases in treatment centres and isolation sites increased significantly and the time spent in treatment centres and isolation sites was significantly shortened. More than 98% from the fifteen boarding schools and 85% from the two prisons were recovered and discharged at day ten and less. The nutritional component as part of the intervention package improved the recovery rate up to 99.92% in the fifteen boarding schools and up to 97.29% in the two prisons. It also contributed in the decrease of Case Fatality Rate (CFR) (Table 1).

The study demonstrated a very good example of community engagement

programme whereby most of activities were carried by students and teachers and support staff in the fifteen boarding schools and by inmates and the correctional facility staff at the two correctional facilities. For sure, this ensured the sustainability of the project once they demonstrated full ownership and determination from the leadership to the single individual member of the institution. The project left with them the required knowledge, skills and experience to tackle COVID-19 and not only COVID-19 but for a wide range of health emergencies.

The Implementing the multi-modal infection prevention and control approach in the overcrowded settings should be recognised and adopted by countries and considered during emergency preparedness and response plans.

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## Conflict of Interest

The authors declare no conflicts of interest.

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