Travel Medicine and Infectious Disease 63 (2025) 102785

Contents lists available at ScienceDirect

Travel Medicine and Infectious Disease

journal homepage: www.elsevier.com/locate/tmaid

Epidemiology and response to the COVID-19 pandemic in the Dadaab Refugee Camp Complex, Kenya, March 2020–December 2022

Maurice Ope [a,*], Raymond Musyoka [a], Abdihakim Kosar [b], Mohammed Osman [b], Abdijamal Hassan [c], Hussein Mohammed [d], Penina Munyua [e], Bonventure Juma [e], Elizabeth Hunsperger [e], Sofia Mohammed [f], John Burton [g], Rachel B. Eidex [a]

[a] Division of Global Migration Health, CDC, Nairobi, Kenya
[b] Kenya Red Cross Society, Dadaab, Kenya
[c] International Rescue Committee, Dadaab, Kenya
[d] Medecins Sans Frontières, Dadaab, Kenya
[e] Division of Global Health Protection, CDC, Nairobi, Kenya
[f] United Nations High Commissioner for Refugees, Dadaab, Kenya
[g] United Nations High Commissioner for Refugees, Nairobi, Kenya

ARTICLE INFO

Keywords:
Refugees
Epidemiology
SARS-CoV-2
COVID-19
Pandemic response

ABSTRACT

Introduction: Refugee settings may increase the risk of SARS-CoV-2 infection and death, yet data on the response to the pandemic in these populations is scarce.

Methods: We describe interventions to mitigate SARS-CoV-2 transmission in Dadaab Refugee Camp Complex, Kenya and performed descriptive analyses using March 2020 to December 2022 data from Kenya's national SARS-CoV-2 repository and line list of positive cases maintained by United Nations High Commissioner for Refugees (UNHCR). We calculated case fatality rates (CFR) and attack rates per 100,000 (AR) using the 2019 national census and population statistics from UNHCR and compared them to national figures.

Results: SARS-CoV-2 infection was first reported in April and May 2020, among host community members and refugees respectively. Of 964 laboratory-confirmed cases, 700 (72.6 %) were refugees. The AR was 82.7 (95 % CI 72.6–92.8) for host community members, 228.3 (95 % CI 211.3–245.4) for refugees and 721.1 (95 % CI 718.7–723.5) nationally. The CFR was 1.5 % (95 % CI 0.15–3.18) for host community members, 1.76 % (95 % CI 1.71–1.80) nationally and 7.4 % (95 % CI 5.4–9.4) for refugees.

Mitigation measures implemented by the Government of Kenya, UNHCR and partners during the pandemic included multisectoral coordination, movement restrictions, mass gathering bans, and health promotion. Social distancing, symptom screening and mandatory mask usage were enforced during mass gatherings. Testing capacity was bolstered, quarantine and isolation facilities established, and vaccination initiated.

Conclusions: Despite a low AR and UNHCR's swift and comprehensive response, refugees' CFR was high, underscoring their vulnerability and need for targeted interventions during epidemic responses.

1. Introduction

According to the United Nations High Commissioner for Refugees (UNHCR), as of December 2022, sub-Saharan Africa hosted nearly 7 million refugees, with the majority residing in camp settings [1]. This number continues to grow due to prolonged crises in many countries such as Somalia, the Democratic Republic of Congo, South Sudan, and the Central African Republic [2,3]. In the early phases of the COVID-19 pandemic, there was a concern about potential catastrophic effects of the virus on refugee populations living in resource limited settings, characterized by poor hygiene, inadequate access to clean water, and overcrowding [4]. As of October 18, 2023, there have been approximately 771 million reported cases of COVID-19 worldwide, resulting in an estimated 6.9 million deaths [5].

According to UNHCR, as of December 2022, Kenya hosted 573,708 refugees and asylum seekers, 84 % of whom were living in camps and 16

* Corresponding author. Division of Global Migration Health- Africa US-Centers for Disease Control and Prevention P.O. Box 606-00621, Village Market Nairobi, Kenya.
E-mail address: ybf8@cdc.gov (M. Ope).

https://doi.org/10.1016/j.tmaid.2024.102785
Received 13 May 2024; Received in revised form 18 October 2024; Accepted 18 November 2024
Available online 20 November 2024

% in urban settings [6]. Kenya has two major refugee camp complexes, namely Kakuma and Dadaab Refugee Camp Complexes. Dadaab Refugee Camp Complex is in Garissa County in northeastern Kenya approximately 500 km from Nairobi and 100 km from the Somali Border [7]. It was constructed in 1992 to host refugees fleeing conflict in Somalia [8]. The complex has now grown and consists of Hagadera, Ifo and Dagahaley camps with an estimated population between 217,197 and 233,661 during the period January 2020–December 2022 [6]. More than half of the population (57.4 %) are children less than 18 years, while only 3.4 % are elderly (≥60 years). Ongoing conflict and famine in Somalia have led to a continued influx of refugees into the complex, thus presenting numerous challenges, including overcrowding, limited access to clean water, and disease outbreaks, including COVID-19.

In Kenya, the first case of COVID-19, caused by infection with SARS-CoV-2, was reported on March 13, 2020, and by December 2022 a total of 342,499 cases had been reported across the country by the Kenya Ministry of Health [9]. Although the pandemic has been declared over, there is scarce literature on the epidemiology of COVID-19 and response to the pandemic among refugee populations from the onset to the end of the pandemic. We describe the epidemiology of COVID-19 in the Dadaab Refugee Camp Complex and the surrounding host community and response efforts within the camp complex.

2. Methods

2.1. Study setting

This study was conducted within the Dadaab Refugee Camp Complex, encompassing Hagadera, Ifo, Dagahaley camps and the surrounding host community. UNHCR provides overall operational oversight and coordination in the camp on behalf of the Government of Kenya. The healthcare implementing partners for these camps are the International Rescue Committee in Hagadera camp, the Kenya Red Cross Society (KRCS) in Ifo camp, and Médecins Sans Frontières in Dagahaley camp. Each of these camps is equipped with health posts that provide outpatient services exclusively, as well as a main hospital offering both inpatient and outpatient care, along with referral services for both refugees and members of the host community. The host community resides in areas around the three camps, spanning Fafi and Dadaab sub-counties, all of which are in Garissa County. The host community population in these two sub-counties is almost the same as the refugee population. The refugees can move freely between the camps and the host community, some host community members live within the refugee camp and even marry refugees and as a result there is no disparity in access to health care. In addition, the refugees sometimes travel back to their country of origin and return to the camp as re-entrants. Consequently, UNHCR and its partners conduct a household census every 6 months to determine the population in the camp that require services.

2.2. Study design

We calculated descriptive statistics, testing rates, attack rates (AR), and case fatality rates (CFR) using routinely collected data on COVID-19 in Dadaab Refugee Camp Complex from March 2020 to December 2022.

We also describe the interventions that were collaboratively implemented by UNHCR and the Government of Kenya. These interventions were aligned with national measures and aimed at delaying the introduction and mitigating the transmission of SARS-CoV-2 within the refugee camp. These interventions were periodically adjusted in response to evolving scientific knowledge about the virus and were strategically designed to minimize the adverse socioeconomic impact on the livelihoods of the refugee population.

2.3. Data sources and management

We used four distinct SARS-CoV-2 data sets (Table 1), which were systematically maintained by various entities: UNHCR, Kenya's National Public Health Emergency Operations Center (PHEOC), KRCS and the National Public Health Laboratories (NPHL). The criteria for eligibility for SARS-CoV-2 testing and type of test used is described elsewhere; notably testing was not available for everyone on a large scale [10].

Table 1
Characteristics of SARS-CoV-2 datasets, management and use in analysis.

Source	UNHCR refugee camp list of SARS-CoV-2 positives[a]	PHEOC list of SARS-CoV-2 positives[b]	NPHL national database of SARS-CoV-2 tests performed[b]	KRCS refugee camp database of SARS-CoV-2 tests performed[a]
Scope	Refugee camp	Nationwide	Nationwide	Refugee camp
Duration covered	May 2020 to December 31, 2022	March 2020 to December 2022	June 2020, to October 2021	July 2021 to December 2022
Laboratory test results (RT PCR or RDT)[c]	Only positive cases	Only positive cases	Both positive and negative cases	Both positive and negative cases
Used in analysis	Appended SARS-CoV-2 positive host community data obtained from the PHEOC to the UNHCR list of SARS-CoV-2 positive cases and calculated Case Fatality Rate (CFR) and AR among refugees and host community.		Merged SARS-CoV-2 testing data from NPHL and KRCS to obtain a complete testing data from June 14, 2020, to December 31, 2022, and calculated testing rates among refugees and host community.	

[a] Excluded host population but refugees and humanitarian workers were explicitly identified in the databases.
[b] Included refugees, humanitarian workers and host population but could only be identified using multiple variables. Refugee were defined as any a non-Kenyan living in the camp, humanitarian worker was anyone who worked for an NGO and was not a refugee while host community member was defined as anyone who was neither a refugee nor a humanitarian worker.
[c] Either real time reverse transcriptase polymerase chain reaction (RT-PCR) or Antigen rapid diagnostic test (Ag RDT) was used to determine SARS-CoV-2 test results.

A line list of SARS-CoV-2 positive cases reported from the refugee camp and nationwide was obtained from UNHCR and PHEOC respectively. All SARS-CoV-2 positive cases, compiled for each camp, was aggregated, and maintained by UNHCR, through the period May 2020 to December 31, 2022. This dataset captured cases reported among refugees and humanitarian workers but excluded members of the host community. Simultaneously, the PHEOC maintained a line list of all SARS-CoV-2 positive cases reported nationally, which included host community members though they were not categorized as such in the database. To estimate positive cases among the host community, we used PHEOC data to identify Kenyan citizens residing in Dadaab or Fafi sub-county who were not classified as a humanitarian worker. We combined the host data from the PHEOC to the UNHCR line list to obtain a complete set of SARS-CoV-2 positive refugees and host community members.

The NPHL maintained records of all SARS-CoV-2 testing (both positive and negative results) in Kenya from June 14, 2020, through October 24, 2021. Similarly, refugees, humanitarian workers and host community members were defined using multiple variables, as described above, since they were not explicitly identified in the national NPHL dataset. When testing capacity became available within the camp, from July 2021 through to December 2022, the test results for refugees and humanitarian workers from Dadaab Refugee Camp Complex were no longer submitted to the NPHL but were instead managed by the KRCS on behalf of all health care implementing partners across the camp complex. KRCS however couldn't access the secure weblink for submitting SARS-CoV-2 testing data to NPHL because of a communication breakdown between the two organizations. We merged the two datasets

to obtain complete testing data from June 14, 2020, through to December 31, 2022.

2.4. Statistical analysis

Statistical analysis was performed using R version 4.1.1. We used population data for the two sub-counties from the 2019 census and biannual camp population census data from UNHCR as a denominator to estimate the AR for the host community and Dadaab Refugee Camp Complex, respectively. These populations were extrapolated for each month and monthly ARs were computed. We compared ARs, CFRs, and testing rates between the refugees, the host community, and national rates. To compare rates among these three groups, we tested the null hypothesis that the proportions were the same using the Pearson's chi-squared test statistic. Confidence intervals for the underlying proportions were computed with confidence level of 95 percent.

We employed locally weighted scatterplot smoothing (LOWESS), which involves localized weighted regression with a span of 20 % of the nearest points. Additionally, we applied weights to points closer to it to effectively capture the prediction of the AR and testing rate trends. To avoid negative ARs because of smoothing caused by values closer to zero, we fitted them on a log-scale and then applied exponentiation to get results on the original scale.

This project was reviewed by the Kenya Ministry of Health and determined to be a non-research programmatic activity to inform public health prevention strategies and did not require local Institutional Review Board approval. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.

3. Results

3.1. Epidemiology of COVID-19 in Dadaab Refugee Camp Complex

Two months after the initial introduction of SARS-CoV-2 in Kenya, on May 16, 2020, two distinct first-cases among refugees were simultaneously reported in Dadaab Refugee Camp Complex. One case was reported from Ifo camp, who was a re-entrant to the camp, and the other case was reported from Dagahaley camp, without a history of travel in the previous 14 days. The first case of SARS-CoV-2 infection was reported in the host population on April 29, 2020. By December 31, 2022, a total of 964 laboratory confirmed SARS-CoV-2 infections were reported from Dadaab Refugee Camp Complex and the surrounding host community. Among these cases, 700 (72.6 %) were among refugees while 264 (27.4 %) were reported among the host population. Of the 700 SARS-CoV-2 infections reported among refugees, 64 (9.4 %) cases had travelled in the last 14 days. Similarly, among the host population there were no imported cases, while at least 256 (97.0 %) were likely infected locally since they did not report travelling in the previous 14 days and 8 (3.0 %) had an unknown recent travel status.

Notably, 57.4 % of the refugee population were aged less than 18 years old but only 16.3 % of SARS-CoV-2 infections among refugees occurred in this age group (Table 2). In contrast, 51.6 % of the total host community population were aged less than 18 years old yet only 4.9 % of SARS-CoV-2 infections in host community members were reported in this age group. Nationally 46.1 % were under 18 years old with just 7.3 % reporting SARS-CoV-2 infections. Most SARS-CoV-2 infections among refugees (64.1 %) occurred in the age group 18–59 years, despite this group making only 38.7 % of the refugee population. SARS-CoV-2 infections were reported in 17.7 % of elderly (≥60 years) refugees, but elderly refugees represented only 3.9 % of the total refugee population.

From June 14, 2020, to December 31, 2022, a total of 6480 tests were performed among refugees and host community members. There was weekly variation in testing rates during the pandemic partly because of challenges in access to specimen collection and testing commodities. The average weekly testing rate for SARS-CoV-2 among host community members was 0.02/1000 population, among refugees it

Table 2
Attack rates and case fatality rates of SARS-CoV-2 among refugees and host community in Dadaab Refugee Camp Complex, Kenya.

Age group in years	Refugees				Host community				National			
	Population[a] (%)	Cases (%)	Death (CFR)	AR/100,000 population (95 % CI)	Population[b] (%)	Cases	Death (CFR)	AR/100,000 population (95 % CI)	Population[b] (%)	Cases (%)	Death (CFR)	AR/100,000 population (95 % CI)
0–4	40416 (17.1)	28 (4.0)	0	69.3 (42.4–96.2)	41385 (13.0)	2 (0.8)	0	4.8 (0.0–12.7)	5993267 (12.6)	4387 (1.3)	26 (0.59)	73.2 (71.0–75.4)
5–11	54534 (23.1)	47 (6.7)	0	86.2 (60.6–111.7)	68968 (21.6)	5 (1.9)	0	7.2 (0.2–14.3)	8747107 (18.4)	8098 (2.4)	26 (0.32)	92.6 (90.6–94.6)
12–17	40683 (17.2)	39 (5.6)	1 (2.6)	95.9 (64.6–127.2)	54476 (17.1)	6 (2.3)	0	11 (1.3–20.7)	7182813 (15.1)	12392 (3.6)	33 (0.27)	172.5 (169.5–175.6)
18–59	91444 (38.7)	449 (64.1)	21 (4.7)	491 (445.2–536.9)	145154 (45.5)	219 (83.0)	3 (1.3)	150.9 (130.6–171.2)	22899907 (48.1)	266598 (77.7)	2327 (0.87)	1164.2 (1159.8–1168.6)
60+	9177 (3.9)	124 (17.7)	30 (24.2)	1351.2 (1109.5–1592.9)	9291 (2.9)	28 (10.6)	1 (5.6)	301 (184.5–418.2)	2740515 (5.8)	46825 (13.7)	3208 (6.85)	1708.6 (1693.3–1724)
Unknown	–	13 (1.9)				4 (1.5)			687 (0.0)	4678 (1.4)		
Total	**236254 (100.0)**	**700 (100.0)**	**52 (7.4 %)**	**228.3 (211.3–245.4)**	**319274 (100.0)**	**264 (100.0)**	**4 (1.8 %)**	**82.7 (72.6–92.8)**	**47564296 (100.0)**	**342978 (100.0)**	**5688 (1.76)**	**721.1 (718.7–723.5)**

[a] Population statistics from biannual census performed by UNHCR and partners during the period 2020–2023.
[b] Population projections from 2019 national housing population census.

was slightly higher at 0.04/1000 population, and nationally it was 0.8/1000 population.

Overall, refugees and the host community had lower ARs compared to the overall national SARS-CoV- 2 infection AR of 721.1 (95 % CI 718.7–723.5) per 100,000 population (Table 2). This trend was observed even when SARS-CoV-2 infection ARs by age group and by week were compared (Table 2 and Fig. 1). However, refugees had a SARS-CoV-2 infection AR of 228.3 per 100,000 population (95 % CI 211.3–245.4; p-value <0.001)) which was significantly higher than host community members with a rate of 82.7 (95 % CI 72.6–92.8). Of all age groups those aged ≥60 years had the highest AR among refugees, host community members, and nationally (Table 2). Refugees, in Ifo (AR 253.3: 95 % CI 219.4–287.1: P value < 0.001) and Dagahaley camps (AR 253.4; 95 % CI 220.1–286.6: p value < 0.001) had higher AR than those in Hagadera (AR 169.9; 95 % CI 146.9–192.8) camps.

There were 52 deaths reported among refugees with a CFR of 7.4 % (95 % CI 5.4–9.4) while the host community had 4 deaths with a CFR of 1.5 % (95 % CI 0.15–3.18). Refugees had a significantly higher case fatality rate (p-value < 0.001) compared to Kenyans which had a rate of 1.76 % (95 % CI 1.71–1.80). There was however no significant difference in the CFR reported between the camps, despite the difference in AR. The CFR in Dagahaley, Hagadera and Ifo camps were 9.5 % (95 % CI 5.5–13.5), 8.3 % (95 % CI 4.4–12.2) and 5.4 % (95 % CI 2.2–8.6) respectively.

3.2. Public health response to COVID-19 in Dadaab Refugee Camp Complex

Following reports of the first case of COVID-19 in Kenya on March 13, 2020, to ensure preparedness and delay introduction of the virus in the refugee camp, the Government of Kenya placed a gazette notice in April 2020 limiting movement between specific areas throughout the country, which included suspension of movement into the camps [11]. However, the limitation of movement into the camps presented challenges in service provision to the refugees and needed to be addressed. Due to the close interaction between refugees and host communities, strictly enforcing movement restriction between them was difficult. During the restricted movement period, to ensure a unified effort in preventing and controlling the spread of SARS-CoV-2, the Government of Kenya, UNHCR, and partners established a multisectoral coordination mechanism to address management of the camps during the pandemic. Below, we provide a timeline of the measures taken to mitigate the impact of the pandemic on refugees in Dadaab Refugee Camp Complex. These measures were consistent with those implemented at the national level as was officially communicated by the Government of Kenya and official notifications published on the Kenya Ministry of Health website [11].

April 2020.

- Movement in and out of camps was officially suspended but this excluded movement within Dadaab Refugee Camp Complex because it was considered the same geographical area.
- Quarantine and isolation centers established for refugee settings.
- Training for healthcare workers on case definitions, sample collection and transportation, contact tracing.
- Protocols developed for management of suspected cases, sample collection and transport, quarantine of new arrivals, use of personal protective equipment, continuation of essential services.
- Systems for contact tracing for all confirmed cases established.
- Health promotion activities through local radio stations was implemented.

June 2020.

- The national gazette notice expired.
- UNHCR and the Government of Kenya, continued the suspension of movement into the camps.
- Food and commodity distribution frequency reduced to every other month, and required symptom screening, mandatory use of masks and regular handwashing, and SARS-CoV −2 testing of humanitarian staff. While food and commodity were distributed less often during the pandemic, the amount given stayed the same.
- Community health promoters and emergency committees composed of trusted refugee leaders representing various segments (e.g., religious, women group leaders, youth group leader etc.) were trained to support surveillance, contact tracing, identify new arrivals, and share information on risks and ways to stay safe.

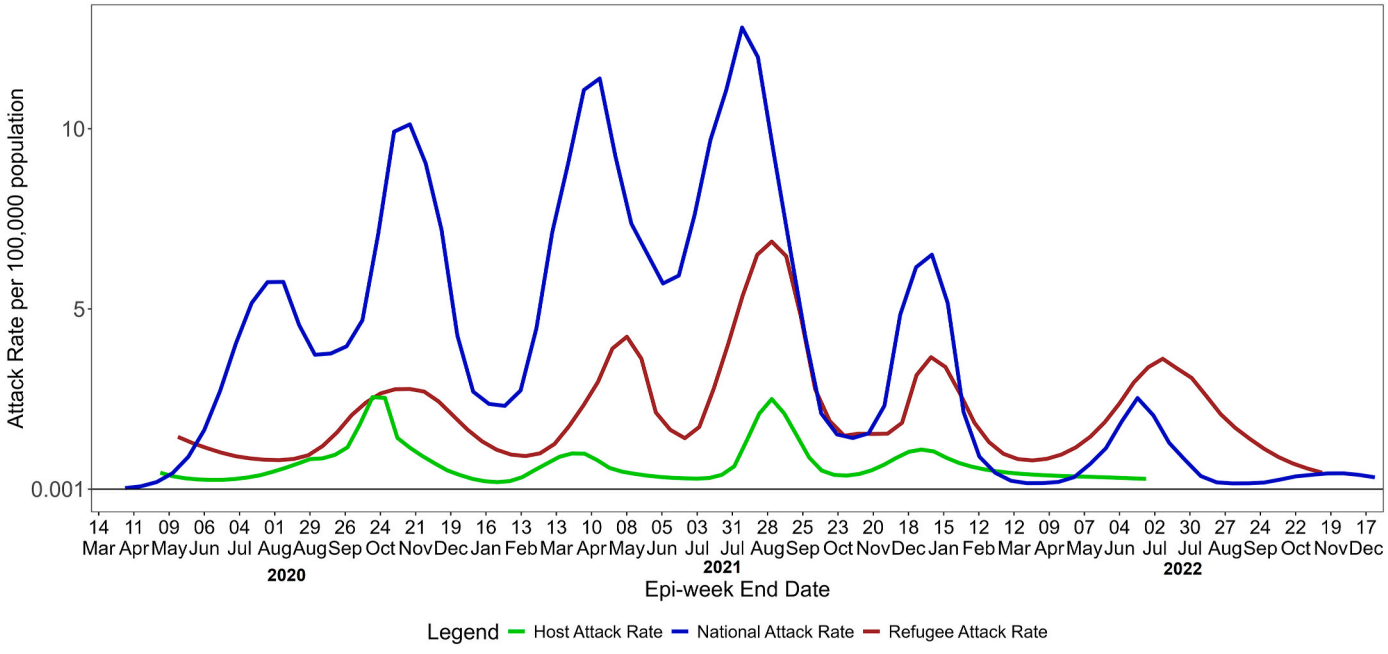

Fig. 1. Weekly SARS-CoV-2 infection attack rates for Kenya, refugees and host population, March 12, 2020, to December 31, 2022.

- A toll-free number was provided for refugees to call and get answers to their questions, thus helping to address rumors.
- Weekly interactive radio talk shows were organized for refugees to participate in discussions about COVID-19.
- A joint MOH-UNHCR case management facility was established at a previously decommissioned hospital at Ifo 2 camp for both refugees and host community members. Staffs were recruited, an intensive care unit bed, ventilator, oxygen, pharmaceutical and non-pharmaceutical supplies procured for the hospital. A dedicated ambulance was also made available to facilitate patient referrals.
- All symptomatic SARS-CoV-2 positive cases were referred to Ifo 2 hospital for case management.

September 2020.

- Protocols established for entrance of essential mission personnel, including providing a negative SARS-CoV-2 test result within 96 hours prior to travel; and completion of a 5-day quarantine upon arrival in the camp in line with MOH guidelines.
- Authorized travel into and out of camps as per established protocols.
- Initially, contact tracing was systematically conducted for all confirmed cases and was discontinued when there were reports of widespread asymptomatic cases.
- Voluntary repatriation recommenced following strict protocols.

February 2021.

- PCR testing capacity was established in the camp.

March 2021.

- COVID-19 vaccination introduced in the camp.

April 2021.

- Non-hospital isolation facilities established in the camp, per national guidelines requiring symptomatic and asymptomatic cases, who did not need hospitalization, be isolated in non-hospital facilities.
- All SARS-CoV-2 positive cases were hospitalized, and their contacts isolated in non-hospital facilities.

May 2021.

- SARS-CoV-2 using rapid antigen tests was introduced in the camp, following joint accreditation of the testing laboratory by both the national public health laboratory and the Kenya Medical Laboratory Technicians and Technologists board, molecular and rapid tests were centralized in one laboratory run by the KRCS within Ifo camp. An external quality assurance program was established for the tests performed and some positive specimens were sent to the Kenya Medical Research Institute (KEMRI) in Kilifi for genomic sequencing.

Throughout the pandemic, in addition to following national guidelines, continual measures were taken to protect the health of refugees at increased risk of infection and death due to COVID-19. These included prioritization for mask distribution, telemedicine to facilitate consultation, home visits to ensure refill of medications and established protocols to ensure continuation of essential services at health facilities. Health education was provided throughout the pandemic and refugees were involved in creation and reviewing informational materials that were developed in local languages understood by refugees.

4. Discussion

Refugee camps are prone to disease outbreaks and their impact can frequently be exacerbated by harsh, crowded, and resource poor conditions [12]. For these reasons, at the beginning of the COVID-19 pandemic, there was concern of potential catastrophic effects of the SARS-CoV-2 virus on refugee populations [13,14]. As such, when the spread of COVID-19 was declared a global pandemic, UNHCR and the Government of Kenya swiftly implemented several interventions to prevent importation of the virus into the refugee camps in Kenya. It is challenging to thoroughly evaluate these interventions; however, it is noteworthy that SARS-CoV-2 infection was initially reported among the host population before affecting refugees. In addition, the first SARS-CoV-2 infection identified among refugees was a re-entrant, detected during the period when movement in and out of the camp had been suspended. The lifting of this suspension coincided with the first wave of infections among both refugees and the host population. This sequence may indicate that the measures, including the suspension of movement, may have been effective in delaying the introduction and spread of the virus within the refugee camp. This underscores the pivotal role of timely interventions in mitigating the impact of the virus and highlights the need for continued vigilance in such settings.

This analysis also found that refugees had a higher SARS-CoV-2 infection AR and CFR compared to the host community; which is similar to findings in Kakuma Refugee Camp Complex, Kenya [10]. This disparity may be partly attributed to inadequate resources for testing SARS-CoV-2, stigma associated with SARS-CoV-2 positive individuals, and identification of COVID-19 related deaths in the host community. Moreover, during the COVID-19 pandemic, there was a well-established process to check if COVID-19 caused refugee deaths. It included collecting samples from deceased refugees and testing them for the presence of SARS-CoV-2. This process was not consistently applied among host community members. Additionally, there were anecdotal reports by partners of hesitancy for SARS-CoV-2 testing among host community members for fear of testing positive and being isolated. Other studies showed that during the COVID-19 pandemic, there was hesitancy in visiting health facilities for fear of contracting SARS-CoV-2 infection, leading to lower reported AR [15]. In addition, differences in living conditions, particularly higher population density and poor sanitation and hygiene among refugees, compared to within the host community may have contributed to higher AR among refugees. However, there is need to explore further the disparities to understand the higher AR and CFR among refugees.

The elderly ($\geq$60 years) were more vulnerable to severe illness and death both among refugees and the host community. This is consistent with what was observed globally during the pandemic [16,17] and may be due to pre-existing diagnosed and undiagnosed medical conditions, delays in accessing health care during the pandemic, and age-related co-morbidities [17]. The vulnerability of elderly refugees underscores the importance of tailored programs to safeguard this group.

Similar to findings in Kakuma Refugee Camp Complex. refugees in Dadaab had a higher CFR but lower AR than Kenya as a whole [10]. In contrast, the host community had a lower AR but a CFR similar to the national CFR of Kenya. It is noteworthy that a survey done among community health workers and traditional birth attendants and their family members during the pandemic (in May 2021) in Dagahaley refugee camp of Dadaab Refugee Camp Complex in Kenya, revealed that the seroprevalence of SARS-CoV-2 was 5.8 % (95 % CI 1.6–8.4) [18]. This seroprevalence is markedly lower than the seroprevalence reported in Nairobi County (32.7 %) and an urban informal settlement (43.3 %) within the country [19,20]. Applying the 5.8 % seroprevalence reported in Dagahaley camp to the refugee population of 236,254 yields 13,702 (95 % CI 3780–19,845) infections which is 19 times greater than the 700 SARS-CoV-2 infections reported among refugees. Therefore, the AR we report among refugees in Dadaab may be an underestimate.

The higher CFR among refugees may be due to suboptimal healthcare quality or readiness to manage severe illness in refugee settings for example few ventilators were available in the camp late in the pandemic but even then, staff were not trained on how to use them. It could also be because of a higher prevalence of diagnosed or undiagnosed chronic

conditions among refugees. On the other hand, the lower CFR among host communities could have been due to underreporting of COVID-19 deaths unlike refugees where there was a stronger system for confirming causes of death. Despite the increased risk in refugee camps, it remains unclear why SARS-CoV-2 infection AR among refugees was lower than the national average. To inform effective public health interventions, it is important to understand these differences. It is noteworthy that previous studies in urban setting in Kenya indicated that there was underreporting of both SARS-CoV-2 infections and deaths [19]. Therefore, the low CFR reported among the host community and nationally ought to be interpreted with caution since the magnitude of underreporting of COVID-19 related deaths has not been determined.

This analysis had some limitations, firstly, the SARS-CoV-2 cases reported may be an underestimate because of under reporting, particularly among the host community. Secondly, the testing rate was not estimated from the beginning of the pandemic due to lack of data. Thirdly, the effectiveness of each of the mitigation measures of the COVID-19 response was challenging to ascertain due to the descriptive nature of the analysis.

5. Conclusion

UNHCR and the Government of Kenya responded swiftly to prevent introduction of COVID-19 into Kenya's refugee camps at the start of the pandemic, however, ultimately, the CFR of COVID-19 among refugees was four times higher than the national CFR underscoring that this population is exceptionally vulnerable. To assure reliability of the data collected in this population, it is essential to include migrant populations into the national data systems to thoroughly understand the differences in transmission. Our findings suggests that there is need to ramp up interventions aimed at improving access to health care, COVID-19 vaccination, and hygiene not only in the camps but also among host population. For the success of these efforts, it is critical to ensure collaboration with host communities, humanitarian agencies, county, and national governments.

CRediT authorship contribution statement

Maurice Ope: Writing – review & editing, Writing – original draft, Methodology, Conceptualization. **Raymond Musyoka:** Writing – original draft, Methodology, Formal analysis. **Abdihakim Kosar:** Writing – review & editing. **Mohammed Osman:** Writing – review & editing. **Abdijamal Hassan:** Writing – review & editing. **Hussein Mohammed:** Writing – review & editing. **Penina Munyua:** Writing – review & editing. **Bonventure Juma:** Writing – review & editing. **Elizabeth Hunsperger:** Writing – review & editing. **Sofia Mohammed:** Writing – review & editing. **John Burton:** Writing – review & editing. **Rachel B. Eidex:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization.

Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the U.S. Centers for Disease Control and Prevention.

Funding

This work did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We are grateful to UNHCR and the Kenya Government for the leadership they provided in ensuring that the refugees are cushioned from the effects of the pandemic. We also appreciate the laboratory technicians who performed the laboratory tests, and all the health implementing partners in the refugee camps who provided care to the refugees.

References

[1] UNHCR. Global Trends: Forced Displacement in 2022. Secondary Global Trends: Forced Displacement in 2022. p. 16. https://www.unhcr.org/global-trends-report-2022 (Accessed on October 24, 2023).
[2] Ibrahim AD, Akpus AI, Aborode AT, Babatunde AO. Will refugees also get vaccinated against COVID-19 in Africa? Public Health Pract (Oxf) 2021;2:100118. https://doi.org/10.1016/j.puhip.2021.100118 [published Online First: 20210406].
[3] Truelove S, Abrahim O, Altare C, et al. The potential impact of COVID-19 in refugee camps in Bangladesh and beyond: a modeling study. PLoS Med 2020;17(6): e1003144. https://doi.org/10.1371/journal.pmed.1003144 [published Online First: 20200616].
[4] Arafa A. The forgotten people: impacts of COVID-19 on refugees. Publ Health 2022; 205:e25. https://doi.org/10.1016/j.puhe.2022.01.032 [published Online First: 20220202].
[5] World Health Organization. WHO coronavirus (COVID-19) dashboard. Secondary WHO coronavirus (COVID-19) dashboard. 2023. https://covid19.who.int/. [Accessed 24 October 2023].
[6] UNHCR Kenya. Kenya Operation Statistics. Secondary Kenya operation statistics. https://www.unhcr.org/ke/857-statistics.html. [Accessed 22 March 2022].
[7] Ope M, Nyoka R, Unshur A, et al. Evaluation of the field performance of ImmunoCard STAT!((R)) rapid diagnostic test for rotavirus in Dadaab refugee camp and at the Kenya-Somalia border. Am J Trop Med Hyg 2017;96(6):1302–6. https://doi.org/10.4269/ajtmh.16-0885.
[8] Burkardt AD, Krause N, Rivas Velarde MC. Critical success factors for the implementation and adoption of e-learning for junior health care workers in Dadaab refugee camp Kenya. Hum Resour Health 2019;17(1):98. https://doi.org/10.1186/s12960-019-0435-8 [published Online First: 20191209].
[9] Ministry of Health. Guidelines on case management of COVID-19 in Kenya. In: Directorate of public health; 2021. p. 3–4.
[10] Ope M, Musyoka R, Kiogora J, et al. Epidemiology of SARS-CoV-2 in Kakuma refugee camp complex, Kenya, 2020–2021. Emerging Infectious Diseases Journal 2024;30(5).
[11] Government of Kenya. The public health act (CAP 242). The public health (COVID-19 restriction of movement of persons and related measures) rules 2020. Legal notice number 50. In: Kenya gazette. Nairobi: Government Printer; 2020.
[12] The L. COVID-19 will not leave behind refugees and migrants. Lancet 2020;395 (10230):1090. https://doi.org/10.1016/S0140-6736(20)30758-3.
[13] Ismail MB, Osman M, Rafei R, Dabboussi F, Hamze M. COVID-19 and refugee camps. Trav Med Infect Dis 2021;42:102083. https://doi.org/10.1016/j.tmaid.2021.102083 [published Online First: 20210512].
[14] Vonen HD, Olsen ML, Eriksen SS, Jervelund SS, Eikemo TA. Refugee camps and COVID-19: can we prevent a humanitarian crisis? Scand J Publ Health 2021;49(1): 27–8. https://doi.org/10.1177/1403494820934952 [published Online First: 20200610].
[15] Meyer K, Abimpaye M, Harerimana JD, Williams C, Gallagher MC. Understanding the sexual and reproductive health experiences of refugee and host community adolescents and youth in Rwanda during COVID-19: needs, barriers, and opportunities. Front Reprod Health 2022;4:799699. https://doi.org/10.3389/frph.2022.799699 [published Online First: 20220328].
[16] O'Driscoll M, Ribeiro Dos Santos G, Wang L, et al. Age-specific mortality and immunity patterns of SARS-CoV-2. Nature 2021;590(7844):140–5. https://doi.org/10.1038/s41586-020-2918-0 [published Online First: 20201102].
[17] Pastor-Barriuso R, Perez-Gomez B, Hernan MA, et al. Infection fatality risk for SARS-CoV-2 in community dwelling population of Spain: nationwide seroepidemiological study. BMJ 2020;371:m4509. https://doi.org/10.1136/bmj.m4509 [published Online First: 20201127].
[18] Gignoux E, Athanassiadis F, Garat Yarrow A, et al. Seroprevalence of SARS-CoV-2 antibodies and retrospective mortality in a refugee camp, Dagahaley, Kenya. PLoS One 2021;16(12):e0260989. https://doi.org/10.1371/journal.pone.0260989 [published Online First: 20211217].
[19] Ngere I, Dawa J, Hunsperger E, et al. High seroprevalence of SARS-CoV-2 but low infection fatality ratio eight months after introduction in Nairobi, Kenya. Int J Infect Dis 2021;112:25–34. https://doi.org/10.1016/j.ijid.2021.08.062 [published Online First: 20210902].
[20] Munywoki PK, Nasimiyu C, Alando MD, et al. Seroprevalence and risk factors of SARS-CoV-2 infection in an urban informal settlement in Nairobi, Kenya, December 2020. F1000Res 2021;10:853. https://doi.org/10.12688/f1000research.72914.2 [published Online First: 20210826].