



HEALTH POOLED FUND SOUTH SUDAN

Study report

A Spatial and Temporal Analysis of the Direct and Indirect Impact of COVID-19 on Healthcare Utilization in South Sudan

Authors: Nima Yaghmaei, Ente Rood, Eelco Jacobs

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Executive Summary

In late 2019 COVID-19, a contagious disease caused by the novel SARS-COV2 virus, began spreading throughout the world, leading to a global pandemic. Thus far, according to official reports, 116 million people have been infected worldwide, resulting in 2.5 million deaths. In the early stages of the pandemic there were serious concerns regarding the impact of the virus on countries in Sub-Saharan Africa (SSA) due to relatively weak health systems, poor health infrastructure, and limited resources related to pandemic management. However, despite having the first known case in SSA in late February 2020, the predictions of widespread infections and mortality never came to fruition. To date, SSA accounts for approximately 2.5% (2.9 million) of cases worldwide and 2.8% (73,381) of deaths. Furthermore, over 50% of these cases and deaths have occurred exclusively in South Africa. In the meantime, COVID-19 has ravaged throughout the world.

The limited recorded incidence and deaths thus far in SSA has been subject of much debate. A set of theories has emerged for the limited reported deaths and incidence, however many of these theories are only weakly supported by evidence, particularly due to a dearth of quality evidence to date. These theories include climate-related factors, demographic factors, context-specific factors, effective health measures, poor testing and reporting, and immune-related factors. Although these explanations for the relatively low-impact do provide some insight, particularly the demographic factors and poor testing and reporting, there still remains a significant gap in our understanding. The emergence of new variants and global inequity of vaccine distribution further emphasizes the importance of understanding the situation of COVID-19 in SSA.

In South Sudan health officials and the humanitarian community were gravely concerned about the eventual arrival of COVID-19, particularly due to the already challenged health system. With very limited resources and a challenging context for non-pharmaceutical interventions, the country's health system was not in the appropriate position to face a pandemic. As of March 2021, there have been approximately 8,677 cases and only 102 deaths, and therefore, similar to much of SSA, the pandemic has not manifested in the manner that was forecasted. It is critical to understand the progress of COVID-19 in South Sudan at this time. The country has severely limited resources and there is a threat of emerging new variants. Policy decisions should be based on the latest reliable evidence. Unfortunately, there is a significant knowledge gap pertaining to the spread of COVID-19 in the country.

This analysis used data sourced from routinely collected data of health facilities through the District Health Information Software 2 (DHIS2), supported under the Health Pooled Fund 3 (HPF3). The data included the number of monthly visits for various under-5 and over-5 health services from January 2018-September 2020.

As a result of the analysis, the following conclusions could be derived to further understand the spread of COVID-19 throughout South Sudan and its overall impact of healthcare utilization:

- The geographic patterns of healthcare utilization for respiratory illness vary considerably across states and counties;
- Counties in Western and Northern Bahr el Ghazal, Unity, and Warrap states had the highest levels of respiratory illness per health facility;
- There was significant temporal variation in respiratory illness across months of the pandemic, with the largest spikes occurring March to May 2020;
- Much of the temporal variation is accounted for by the counties with the highest levels of respiratory illness;
- Data indicates that there has not been an impact of reporting quality as a result of the pandemic;
- For non-respiratory illness related visits, such as antenatal care, measles vaccinations, skilled-birth deliveries, and malaria (under-5), there has not been a significant decline in health care utilization as a result of the pandemic;

Therefore, with these findings, it is concluded that the spatial and temporal variations may indicate locations and times when COVID-19 was responsible for spikes in health care utilization for respiratory illnesses. The following recommendations are made:

- **Continuously update relevant data** in order to develop a comprehensive historic dataset which can be used to observe trends for COVID-19 and other priorities;
- **Collect and report patient level data** to provide further insight into the manifestation of COVID-19 in the South Sudanese context;
- **Investigate respiratory illness classifications** to understand classification patterns across facilities in South Sudan;
- **Access non-HPF3 data** to fill the gap currently found in national data;
- **Use respiratory illness data to provide a systematic approach for surveillance and resource prioritization;**
- **Continue promoting health care utilization** throughout the country to minimize the impacts of COVID-19 on health system.

Introduction

Since its emergence as an unknown pneumonia outbreak in China in December 2019, SARS-COV2, the virus that caused COVID-19, has swept through the world, thus far infecting over 116 million people, resulting in over 2.5 million deaths (1). In addition to the direct impacts of the virus, the measures taken to reduce the spread of the virus, such as reduced travel, business closures, and stay-at-home orders, have resulted in widespread economic and social impacts.

In the early stages of the pandemic health experts were concerned about the impacts of the virus on countries in Sub-Saharan Africa (SSA). These concerns were due to the relatively weak health systems, poor health infrastructure, and limited resources related to pandemic management. On average, Sub-Saharan Africa has only 1 physician per 5000 inhabitants (compared to 1 per 270 in Europe), while some worse-off countries, such as Sierra Leone, have 1 physician per 33,000 inhabitants(2). In Kenya, almost 50% of counties do not have a single Intensive Care Unit (ICU) bed, and overall, many African health systems struggle to provide reliable and affordable oxygen supplies(3)(2). Additionally, much of the health resources in SSA are concentrated in the private sector and in a few middle-income countries, such as South Africa. At the beginning of the pandemic, the entire African continent had access to 1% of the ventilator capacity of the United States(4). Considering these challenges, there was significant concern due to the early projections for COVID-19 impacts. Forecast models early on estimated substantial impacts throughout the continent. One forecast estimated a mid-2020 peak in Kenya of 465,000 severely-ill individuals needing medical care, while another estimated 300,000 deaths in the Democratic Republic of the Congo (DRC)(5)(6). Nigeria was forecasted to experience exponential growth reaching 60,000 cases and 2,000 deaths by May 2020 (7). On May 7th 2020, the WHO announced less alarming, but still concerning, projections of between 29 million to 44 million cases across Sub-Saharan Africa in the first year, with an estimated 3.6 to 5.5 million requiring hospitalization and an overall infection fatality rate (IFR) of 0.66%(8).

The first reported case of COVID-19 in SSA was in Nigeria on February 27th 2020 from an Italian passenger arriving by plane(9). Swift action was taken by many countries across the continent by utilizing non-pharmaceutical practices, such as border closures, reduced economic activity, and the restriction of numerous civilian activities(10). Despite the concerning forecasts and the initial rising cases, the predictions never came to fruition, even one year on, as cases and deaths have been relatively limited according to formal reports (11) (10). Despite accounting for approximately 13% of the global population, as of March 2021, SSA accounts for 2.5% of reported cases (2.9 million) and 2.8% of deaths (73,381) worldwide(19) (1). However, the distribution of these impacts has not been homogenous as South Africa alone accounts for 53% of cases and 69% of deaths(1). In the meantime, COVID-19 has ravaged throughout the world, particularly in the Americas and Europe, which account for 48% and 34% of deaths worldwide respectively (12). This prompted the WHO to state that the pandemic “appears to be taking a different pathway in Africa”(10). However, in recent months, the emergence of new SARS-COV2 variants, particularly N501Y (referred to as the South African variant) has caused new concerns regarding vaccine efficacy and increased infectiousness, prompting fears of a resurgence of COVID-19 across the continent.

Understanding the limited spread in Sub-Saharan Africa

The limited recorded incidence and deaths thus far in Sub-Saharan Africa has been a subject of much debate, however, with limited evidence to date, the theories remain somewhat speculative. Theories for limited reported incidence and deaths include climate-related factors, demographic factors, context-specific factors, effective health measures, poor testing and reporting, and finally, immune-related factors(13)(14). Many of these arguments are only weakly supported by evidence, particularly due to a dearth of quality evidence available at the moment.

Climate-related factors

Early on evidence suggested that high temperatures and high humidity may reduce the spread of the virus, as both temperature and humidity were found to be inversely related to the spread of COVID-19(15). The latest evidence further supports these suggestions, however, the degree to which warmer and wetter climates can influence overall disease transmission remains unclear (16)(14). Additionally, it is important to note that Sub-Saharan Africa is a vast area covering approximately 25 million square kilometers (nearly 20% of the Earth's land surface) and is home to various geographies, such as deserts, rainforests, plateaus, coastal marshes, etc. Thus, if climate-related factors were highly influential in COVID-19 outcomes, higher levels of heterogeneity should be expected in COVID-19 transmission across the continent based on geographic and climate differences. Furthermore, relatively warm and humid locations in tropical regions of the world outside of SSA have experienced large-scale outbreaks and

some of the highest levels of recorded mortality in the world: these include Guayaquil (Ecuador), Manaus (Brazil), Rio De Janeiro (Brazil), and Mumbai (India).

Age and Demographics

The demographic structure of Sub-Saharan Africa differs greatly from much of the world, particularly high-income countries with high recorded mortality rates. For example, in the DRC and Malawi, less than 3% of the population is older than 65 years, and most African countries have a median age below 20 years (17)(2). In comparison, the median age worldwide is over 30 years, and in some countries, such as Germany and Japan, the median age is above 47 years. Additionally, SSA countries have some of the lowest rates globally of non-communicable disease (NCDs), which have been identified as high-risk comorbidities for COVID-19. Given the age-specific fatality rates for COVID-19 and the association of increased severity of COVID-19 with NCDs, it is likely that Sub-Saharan Africa has the fortune of a lower IFR and lower rates of severe illness than the rest of the world (18)(19)(20)(14).

Thus, it is somewhat unsurprising that South Africa, Sub-Saharan Africa's oldest country (median age of 28 years), and the country with one of the highest levels of NCDs in the region, also has the highest mortality rate on the continent. Country specific evidence provides further insight into this matter. In Sudan, 35% of confirmed cases (likely those who sought health care due to severe illness) were over 45 years old, 2x older than the median age of the country(21). This age group also showed the highest mortality rate of confirmed cases (6%) (21). Preliminary aggregated data from multiple SSA countries also indicates the association between older cohorts and mortality rates in COVID-19(4) (22).

Although SSA countries have relatively low levels of NCDs compared to other regions of the world, the continent has high rates of other potential high-risk co-morbidities; such as tuberculosis (TB), HIV, malaria, malnutrition, and sickle-cell anaemia. Early evidence from South Africa suggests there may be an association, as TB and HIV were more common in younger individuals who died of COVID-19 and when adjusting for age and sex, individuals with HIV and/or TB were at higher risk of mortality (23). Unfortunately, to date there is still limited information on the interaction of these various co-morbidities and COVID-19 outcomes(24). However, evidence from other viral respiratory pathogens indicates that patients with co-morbidities and low immunity tend to have worse prognosis and increased risk of death(24). Thus, it is reasonable to anticipate co-morbidity with COVID-19 to result in some increased risks, although the degree to which remains unknown.

Therefore, based on the current available evidence, the younger age distribution and lower rates of common NCDs in Sub-Saharan Africa may partially explain the lower mortality rates of COVID-19 compared to other regions of the world. However, data from other regions cast doubts on the degree to which these factors influence the substantial difference seen between SSA and other regions of the world. For example, Bolivia (median age of 25 years) has a mortality rates of 1,010 per million inhabitants respectively, twice the mortality rate of Greece (median age of 45 years) and 15x the mortality rate of Japan (median age of 49 years)(1). Furthermore, largely age-related population-level reductions of IFR should be reflected in lower case fatality rates (CFR), as fewer cases develop severe illness, however, the data from SSA shows limited difference. With an CFR of 2.5%, the ratio of deaths from reported cases is somewhat similar to the global average of 2.2%.

Non-Pharmaceutical Interventions

Governments across SSA acted swiftly with non-pharmaceutical interventions which some argue is responsible for limited COVID-19 transmission(13). Additionally, the introduction of cases of COVID-19 in most SSA countries was somewhat delayed compared with the rest of the world, giving countries more time to prepare (13). Furthermore, lower levels of urbanization and poorer transport infrastructure may have reduced the velocity of the transmission between countries and across communities within SSA(5). Researchers in Nigeria and South Africa theorize that the measures have been effective in controlling the spread of the virus by reducing the reproductive rate $R(t)$ to approximately 1, thus preventing exponential growth(7)(25). Furthermore, it has been argued that South Africa's relatively developed transport networks and economy has contributed to the widespread impacts of COVID-19 compared other countries with rural hard to reach populations(26).

However, there remains little evidence that the non-pharmaceutical interventions in SSA have been enough to stifle the pandemic in comparison to other regions(27). The feasibility of various interventions in the SSA context is unknown considering the novelty of this virus (28)(27). Compliance to lockdown orders present significant challenges in countries with high levels of informal employment, limited internet accessibility, and rural populations (29)(28). Of the over 1 billion people living in SSA, 47% have no access to regular clean water supply, questioning the feasibility of regular handwashing, and approximately 200 million people live in informal housing with poor ventilation(19)(30). Additionally, in SSA, shielding high vulnerability individuals is difficult as most live amongst other family members in large households and are often unaware of their health status as a vulnerable

individuals (31). For example, in Accra, Ghana, 53% of households live in a single shared room, and a larger proportion of the population is reliant on shared public toilets (10). These settings are likely to facilitate transmissions, rendering home-based quarantines less effective. Additionally, strong measures were not feasible in certain settings due to social/culture contexts. An analysis of 4 West African countries found that places of prayer mostly remained open, as well as weddings, cultural ceremonies, and local markets, and by mid-2020, most restrictions had been fully lifted (28).

While there are some similarities in interventions across countries in Sub-Saharan Africa, there is much variation in the timing and types of measures implemented (10)(27). Surprisingly, this heterogeneity has not been reflected in COVID-19 transmission across the continent, and even the countries which have largely abandoned COVID-19 measures have not recorded large outbreaks of incidence and deaths(32). More importantly, the interventions which have been attributed to greatly controlling the pandemic in SSA have also been implemented in more stringent manners in conducive environments across the Americas and Europe, yet in those settings the virus has had great impacts (33). For example, Argentina (1170 deaths per million inhabitants) and Peru (1440 death per million inhabitants), two countries which adopted some of the earliest and strictest lockdown measures have mortality rates 18x and 22x the average mortality rate across SSA(1). Therefore, non-pharmaceutical interventions may have helped reduce transmission rates across SSA, but it remains unclear how effectiveness these interventions have been and whether they are responsible for limited transmission seen so far at a regional scale (10).

Immune-Related Factors

Cross-reactivity of T-cell immunity has been explored as a factor for limited transmission and severity of COVID-19 in SSA. The inclination is that individuals are protected from severe illness due cross reactivity of T-cells immunity derived from previous exposure to other circulating coronaviruses (such as the ones responsible for the common cold) (20)(33). Thus far six studies worldwide have found between 20% to 50% of people assessed have T-cell reactivity against the virus responsible for COVID-19, despite no known exposure to the virus(34). More evidence is needed to further investigate the potential role of cross-reactivity in reducing COVID-19 transmission and severe illness across various settings in SSA.

Testing and Reporting

Throughout the world there have been challenges with diagnostic capacity and reporting of incidence and deaths, particularly in the earlier months of the pandemic. The WHO estimated that fewer than 50% of symptomatic cases were being tested and reported worldwide(7). Thus, when also considering asymptomatic cases, it is likely that the vast majority of cases worldwide have gone undetected.

In the months of March and April 2020 most countries across SSA had limited testing capacity and many suspected cases were not being tested (35). In Chad there was a shortage of both tests and staff after many health workers became ill(32). The fraction estimated for reported symptomatic cases in Nigeria was between 10-50%, while in regions of Sudan 55% of tests conducted were positive, far exceeding the benchmark of adequate testing set by the WHO (3-12%) (7)(21). By May 2020, COVID-19 testing in Africa (685 tests per million) was a fraction of the tests conducted in other regions, such as Europe, which had conducted 23,000 tests per million (32). Of the tests being conducted 80% were concentrated in just 10 African countries, with South Africa having the most tests overall and tests per capita (36)(10). Overall across the SSA, the number of reported cases from a country has been correlated with the number of tests conducted, with great heterogeneity in testing across countries(10).

In addition to resource shortages impacting testing, other factors have created challenges in understanding the full scope of the pandemic across SSA. In Nigeria, contact tracing has often been ineffective as 70% of confirmed cases are unaware of the source of their infection(36). While in other countries public reluctance to report symptoms, attitudes of denial, and stigma to disclose names of close contacts have impacted surveillance(11)(21)(37). Additionally, syndromic surveillance is difficult for COVID-19 as the typical symptoms, such as a cough or fever, are similar to other common respiratory illness and endemic disease (such as malaria)(20)(38). Furthermore, the age structure of the population may present a challenge since children and young adults are more likely to be asymptomatic or not show signs of severe disease (20).

There is increasing evidence that large numbers of cases and deaths are going unreported across SSA. A study (pre-print) which aggregated data from across the region found that 78% of COVID-19 deaths were individuals 50 years or older, and that majority of deaths were individuals who self-presented or were tested post-mortem(4). Death rates were higher in these individuals as compared to those captured through active surveillance, which accounts for the majority of identified cases(4). This likely means that many of the deceased individuals were only recorded due to severe disease outcomes and that likely their contacts and source of infections were unreported. Data from Burkina Faso support this as over 50% of deaths reported occurred in patients hospitalized for 2 days or less, indicating significant delays in seeking care at health facilities(4). While in Liberia, of the 18 recorded deaths by May 10th 2020, 11 occurred in the community and only one was in a facility designated for COVID-19 treatment(4). In

Zambia, a post-mortem study found that 73% of deaths of people with COVID-19 occurred in the community; none had been tested for COVID-19(39). Furthermore, over 80% of those with COVID-19 related symptoms did not receive a COVID-19 test prior to death, further exacerbating challenges in identifying COVID-19 mortality considering the high rates of tuberculosis and HIV/AIDS in the study population (39). In Sudan, a number of regions reported over 50% case fatality rates, despite these rural provinces having very young populations and limited confirmed cases (40). These findings suggest significant community spread and that official reports may only show the tip of the iceberg(40). This is even the case in South Africa, where although the IFR is estimated to be between 0.04% and 0.22%, the national CFR is between 2.45% - 6.01%, suggesting the majority of cases remain undiagnosed(25). By mid-2020, the South African Medical Research Council reported excess mortality rates four times greater than the number of reported COVID-19 deaths with suggestions that there significant unreported COVID-19 deaths in the figures(27).

In recent months antibody testing is being used across the world to understand the true scope of the incidence in various settings. In a August 2020 study from Kenya, 3000 blood donors were tested and the findings suggested that 5% of Kenyans 15-64 years old had developed antibodies as a result of past infection(41). These figures are similar to those reported from Spain, a country that experienced one of the world's worst outbreaks (41). Similar levels of antibodies were detected in tests conducted in Malawi and Mozambique, much higher than expected (41). By the end of the first wave in 2020, the WHO reported seroprevalence estimates that one in ten Kenyans had COVID-19 antibodies, again similar to European countries, despite less than one in five hundred Kenyans having confirmed cases(1). These findings are striking considering the noticeably different impacts seen in these countries compared European countries with similar levels of antibodies in the population (41).

Conclusion

Overall, numerous factors have been suggested for the limited number of reported cases and deaths across Sub-Saharan Africa, however, at this time, there is limited evidence to draw strong conclusions. Further investigations are needed into the aforementioned factors and primary data is critical to provide answers to the questions that remain. The emergence of new variants and the global inequity in vaccine distribution emphasize the importance of understanding the condition of the pandemic across SSA. If in fact interventions have been effective, there is a risk for a major resurgence of COVID-19(13). However, if epidemiological factors specific to the region (such as age structure, cross reactivity of T-cells, etc) are the primary reason, there may be strong justifications for safe reopening to limit the secondary effects of COVID-19 measures in an already vulnerable region(13).

COVID-19 in South Sudan

Prior to the pandemic South Sudan already had a health system facing protracted crisis due to years of civil war and economic stagnation(42). According to the Office for the Coordination of Humanitarian Affairs (OCHA), 6.5 million people in South Sudan (over 50% of the population) face severe food insecurity and over 7.5 million people are in need of humanitarian assistance(43). Therefore, health officials and the humanitarian community were gravely concerned about the eventual arrival of COVID-19 to the country.

Non-pharmaceutical interventions, such as physical distancing, are hardly feasible as over 1.7 million people are displaced nationwide and over 160,000 live in cramped settlements (44). For most the population, basic services, such as access to clean water and hygienic facilities is limited(44). Additionally, the threat of ongoing violence in the civil war jeopardizes COVID-19 prevention measures. In the initial months there were only 3 ventilators available nationwide, all of which were concentrated in a single COVID-care centre located in the capital city of Juba(45). Additionally, most of the other resources allocated to the pandemic, such as health equipment and testing facilities, were initially in Juba, where only 10% of the population is based (45). There was also an acute shortage of personal protective equipment (PPE) for health workers, including basics such as gloves (45)(42). Following the initial stages of the pandemic, hospitals have been prepared in 10 states across the country through the support of the international community (46). However, there are still severe shortages in equipment and expertise(46).

As of March 2021, South Sudan has experienced approximately 8,677 cases and only 102 deaths despite the initial confirmed case arriving in early 2020(1). Therefore, similar to most SSA countries, the pandemic has not manifested in the manner that was forecasted. Initial data also suggests that severe disease outcomes are concentrated in older individuals as the average age for COVID-19 deaths has been 62 years, significantly older than the national median of 18 years(47). However, since Feb 2021, there has been an uptick of confirmed cases, indicating that the threat of the pandemic has not yet subsided for the country. Additionally, neighbouring countries of Kenya and Sudan are reporting more substantial cases and death tolls, allowing for cross-border transmissions (40).

Although there has been a limited number of reported incidence and deaths, the management and reporting has remained challenging for health officials. Relatively narrow case definitions and non-specific symptoms means that there is likely cases going

untested (45). Additionally, many people, including those who are aware of the health risks, are hesitant of being tested due to fear of ostracization by their community (48). This level of stigma is one the barriers to reducing transmission since it motivates people to hide illness, avoid seeking health services, and negatively impacts the process of contact tracing (48). Furthermore, home isolation is difficult in the South Sudanese context due to the local housing infrastructure where individuals need to isolate within cramped conditions, putting other members of the household at risk(45). As well, delays in test results have created resentment towards health officials and contact tracers, while delays in response times from Rapid Response Teams (RRT) has resulted in patients seeking services elsewhere or dying prior to treatment(49).

Moving Forward

At this time, it is critical to further understand the progress of the COVID-19 pandemic in South Sudan, particularly considering the emerging 2nd wave (50). The country has severely limited resources and thus policy decisions should be based on the latest reliable evidence. Unfortunately, as highlighted by the current on-the-ground challenges, and as discussed in section pertaining to the spread of COVID-19 across SSA, there is much left unknown. Therefore, further analysis of South Sudanese data on COVID-19 cases and deaths would provide policy makers critical information(50).

However, there are likely blind spots in the COVID-19 specific data, and thus utilizing overall health system data can also provide valuable insight. This approach has been used in Sierra Leone where patient records and health system data has allowed for detection of an overall reduction of health care utilization(2). While in South Africa, all-cause mortality data derived from historical average has allowed health officials to investigate fluctuations in deaths due to other diseases, and further understand the impacts of COVID-19 that were missed due to testing and surveillance challenges(26). These approaches can be brought to use in South Sudan. Therefore, in this study, the objectives are to further understand the direct impact of COVID-19 in South Sudan and its secondary impact on health care utilization through time-series analyses using data from health facilities across the country.

Methodology

Data Source

The data for this analysis was sourced from routinely collected Health Management Information System data of health facilities through the District Health Information Software 2 (DHIS2), supported under the Health Pooled Fund 3 (HPF3). Monthly reported data from the DHIS2 database representing clients seeking specific primary care services at health facilities was extracted for subsequent analysis. For this analysis, only the number of clients seeking various types of services was used, and no personal data was provided. The data included the number of monthly visits for various under-5 and over-5 health services from January 2018 to September 2020 (not all indicators were available for the entire period). There are no major changes to be reported to the initial dataset sources from HPF3.

Data Processing

All data management, analysis, and output were conducted using STATA and QGIS.

Proxy Indicator:

In the initial part of the analysis, a proxy indicator was developed to measure the reporting quality of selected variables across different counties. An indicator measuring reporting quality is critical to understand the impacts of changes to reporting, and the absence of such indicator would not allow the analysis to separate changes in disease patterns from potential artefacts of reporting changes. A proxy indicator was developed using the percentage of health facilities reporting cases as a measure of reporting quality. Then the sensitivity of this proxy indicator to reporting changes was tested using a time-series for case reporting of under-5 pneumonia (Figure 1).

The approach to testing the proxy indicator was selected due to a specific event between January and February 2020, when the South Sudanese health system underwent a methodological change in reporting of respiratory illness, including under-5 pneumonia cases. Qualitative data reported from HPF3's monitoring, evaluation, and learning unit (pers comm) suggests reporting quality noticeably diminished during this transition. Therefore, in order to test the sensitivity of the newly developed proxy indicator, its sensitivity to identifying this known drop in reporting quality was determined through the time-series analysis.

County Classifications:

To evaluate the impact of COVID-19 across counties with varying levels of respiratory healthcare utilization, counties were classified by their level of overall respiratory illnesses related health visits was developed. This classification would allow for disaggregation of various indicators across counties experiencing different levels of respiratory illness impacts. All counties were classified as either Low, Middle, or High respiratory illness counties based on the mean number of respiratory illness related health visits per health facility (excluding facilities without reporting) throughout the course of the pandemic (February 2020 – September 2020). Counties classified as “Low” reported mean respiratory illness related visits per health facility lower than 20% below the national mean, while “Middle” counties reported between 20% below and 40% above the national mean. Finally, counties classified as “High” counties reported 40% or more above the national mean.

Data Analysis

To assess the impact of COVID-19 on public health, as well as health care utilization, both respiratory illness and non-respiratory illness related visits were considered in this analysis. Respiratory illness data was used to understand the potential impacts of COVID-19 across the country, while non-respiratory health visits were used to understand health care utilization during the COVID-19 pandemic. The respiratory illnesses of interest were Severe Acute Respiratory Illness (SARI), over-5 Pneumonia, and Upper Respiratory Tract Infections (URTI). As COVID-19 has a wide range of symptoms, it was not appropriate to select one respiratory illness exclusively as it would reduce the sensitivity of the analysis. URTI and over-5 Pneumonia were given particular attention, while SARI was given less due to limited cases/poor reporting. To analyze respiratory illness as a whole, a single indicator “all respiratory illness” was developed by combining SARI, over-5 Pneumonia, and URTI visits at each facility (excluding facilities without reporting). The non-respiratory illness related health visits of interest were measles vaccinations (under-1 fixed dose), antenatal care visits (ANC; 1st visit for antenatal care), skilled birth deliveries (SBD in facility), and malaria cases (uncomplicated clinically diagnosed). For each of these indicators there were two variables of primary interest: the reporting quality (measured by the proxy indicator previously discussed) and the total number of visits at each facility (excluding facilities without reporting). Time-series analysis for both reporting quality and reported visits were conducted for all indicators of interest using all available months of data. Due to an absence of data prior to February 2020 for over-5 respiratory illnesses, spatial counterfactuals were used to by examining differences across states and county classifications of respiratory illness, while for health care utilization, non-respiratory illness related visits were examined using spatial counterfactuals across county classifications of respiratory illness and by comparing pre-pandemic figures to pandemic figures.

Results

Data quality

To assess the consistency and completeness of data, the percentage of health facilities reporting visits in a given area or time was used as a proxy indicator. Under-5 pneumonia was used to test the sensitivity of this proxy indicator based on the methodology change in reporting that occurred at the beginning of February 2020. As evident from Figure 1, the proxy indicator was able to detect the impact of reporting quality (seen as the significant drop in reporting in February 2020) as a result of the methodology change, and thus demonstrated its sensitivity. Based on this finding, it is understood that percentage of health facilities reporting visits is an appropriate methods of deriving reporting quality for various indicators.

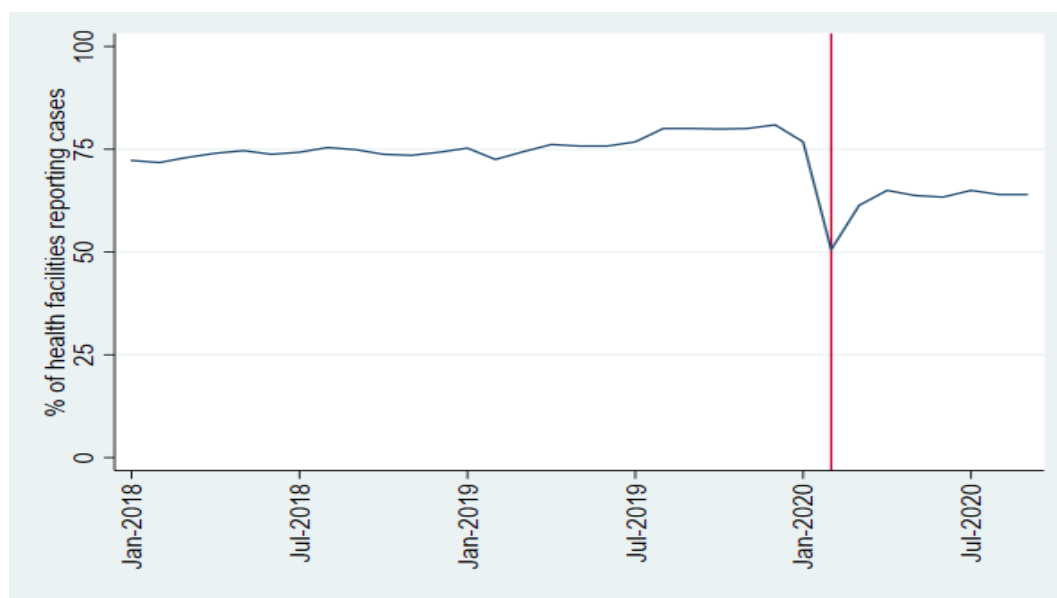
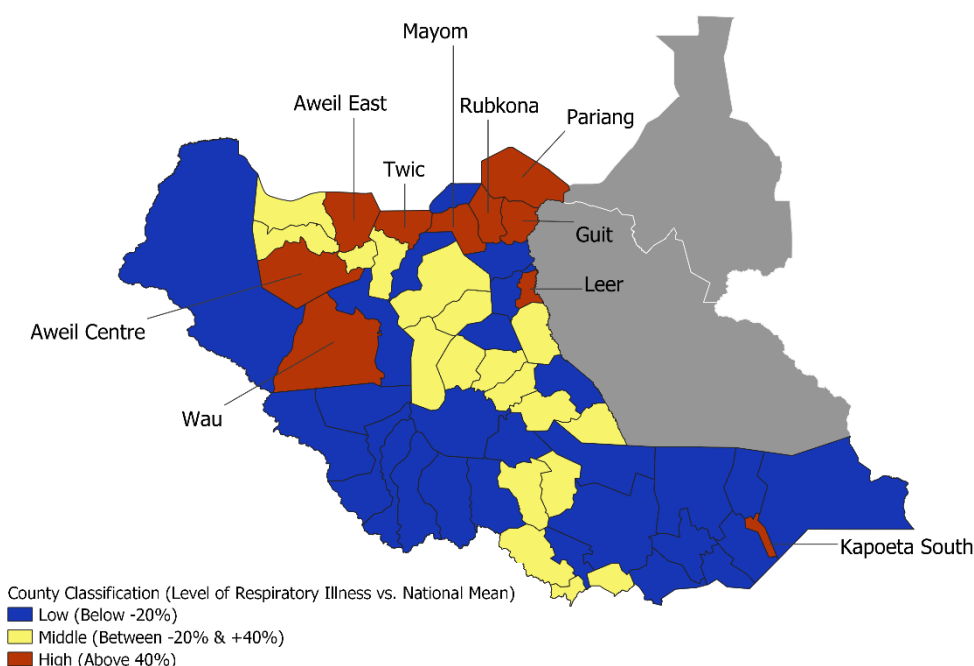


Figure 1: Under-5 Pneumonia (% of health facilities reporting visits per month)

Map 1 shows the distribution of respiratory illness visits at county levels compared to the national mean. The map does not provide temporal variation as it is a measure throughout the period of the pandemic. However, by categorizing counties by level of total respiratory illness visits it becomes possible to compare other indicators across these categories. From Map 1 it is evident that the northern areas, particularly those in Northern Bahr el Ghazal, Warrap, and Unity states, appear to have had relatively higher levels of respiratory illness visits.



Map 1: County Classification by Level of Respiratory Illness Visits (Feb. 2020 – Sep. 2020)

Respiratory Illnesses

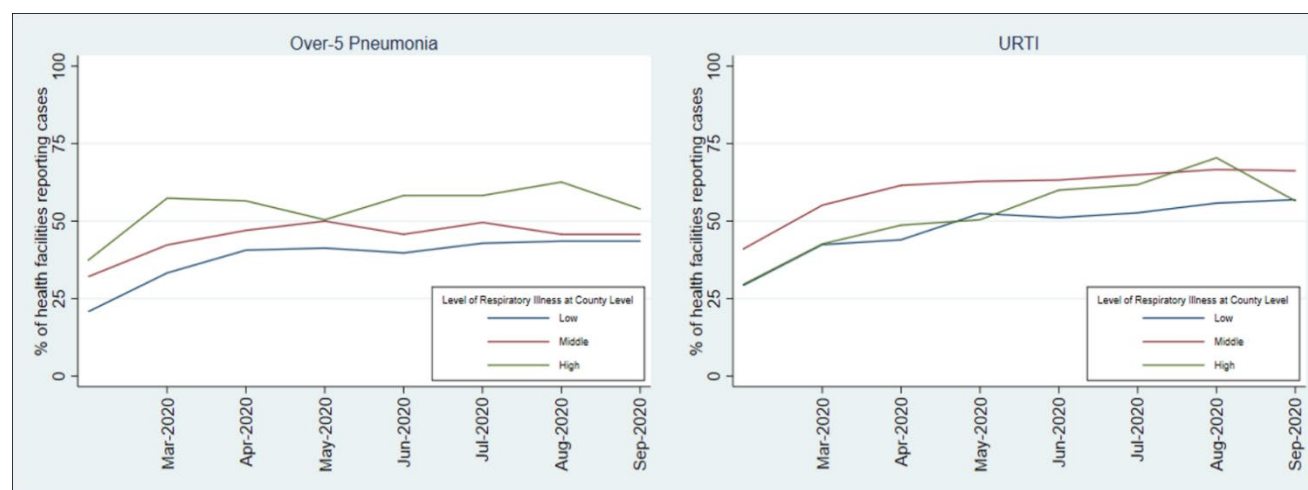


Figure 2: Over-5 Pneumonia and URTI (% of health facilities reporting visits per month)

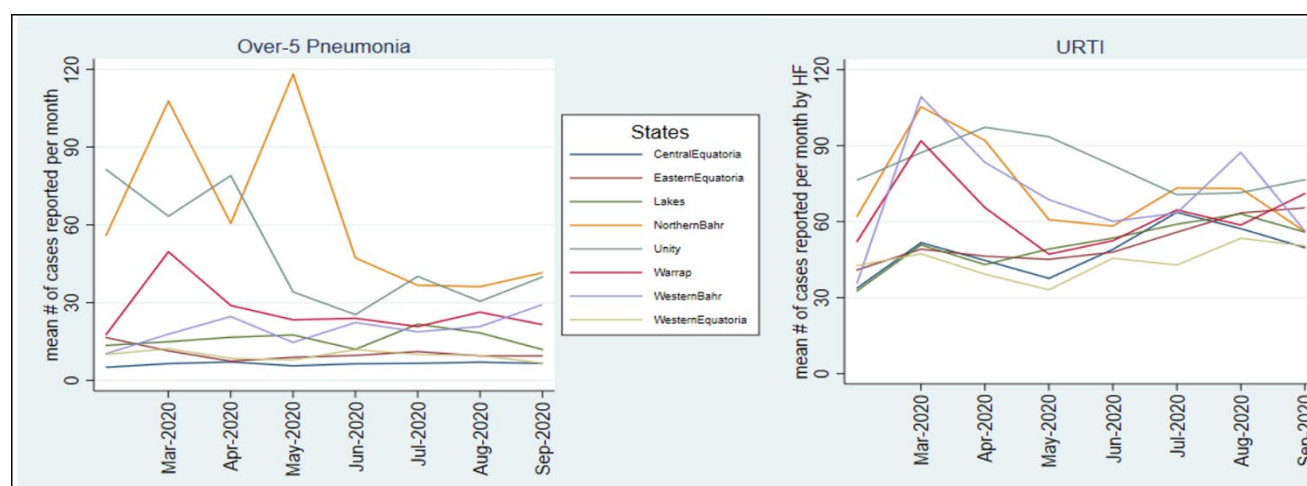


Figure 3: Over-5 Pneumonia and URTI (mean # of cases per facility per month by state)

Figure 2 indicates that there were relatively moderate levels of reporting quality for over-5 pneumonia and URTI across South Sudan (in all three county classification categories), although there have been improvements in reporting for both conditions since February 2020. Additionally, it is evident that reporting quality levels appear to be somewhat similar across counties with different levels of respiratory illness, although for over-5 pneumonia “High” respiratory illness counties tend to have slightly better reporting, while for URTIs “Middle” respiratory illness counties tend to have slightly better reporting. The better reporting of over-5 pneumonia in “High” respiratory illness counties may indicate that the higher levels of respiratory illness recorded in those counties is actually an artefact of better reporting. However, the figures for URTI directly contradict this hypothesis.

For over-5 pneumonia visits disaggregated by state (Figure 3), there is clear geographic variation. Throughout the early months of the pandemic (Feb. 2020 – May. 2020), Northern Bahr el Ghazal and Unity reported substantially higher levels of over-5 pneumonia, with over 60 visits per health facility per month, while most states had levels below 20 visits per facility. Additionally, temporal variation is also evident as the numbers of visits has fluctuated across months. Similar patterns were observed for URTI visits (Figure 3), however unlike over-5 pneumonia, there were more states represented in the initial spike of cases in the early months of the pandemic. Additionally, URTI cases began to rise across most states starting in June 2020. Unity state had the highest sustained levels of URTI throughout the middle months, but as this corresponds with a reduction in over-5 pneumonia during the same months, it may be a result of changes in clinical classification.

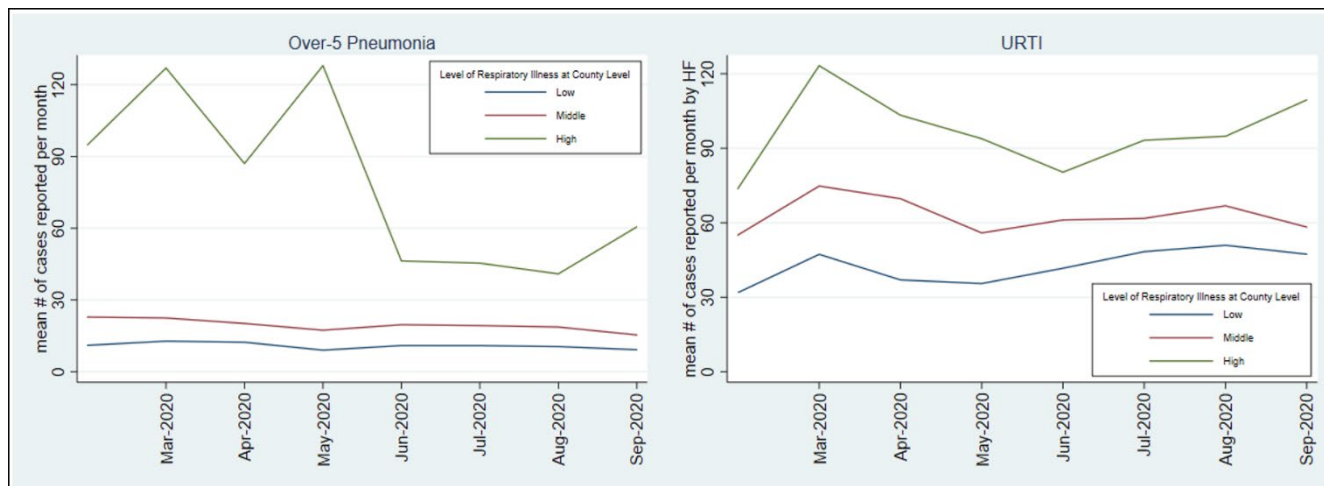
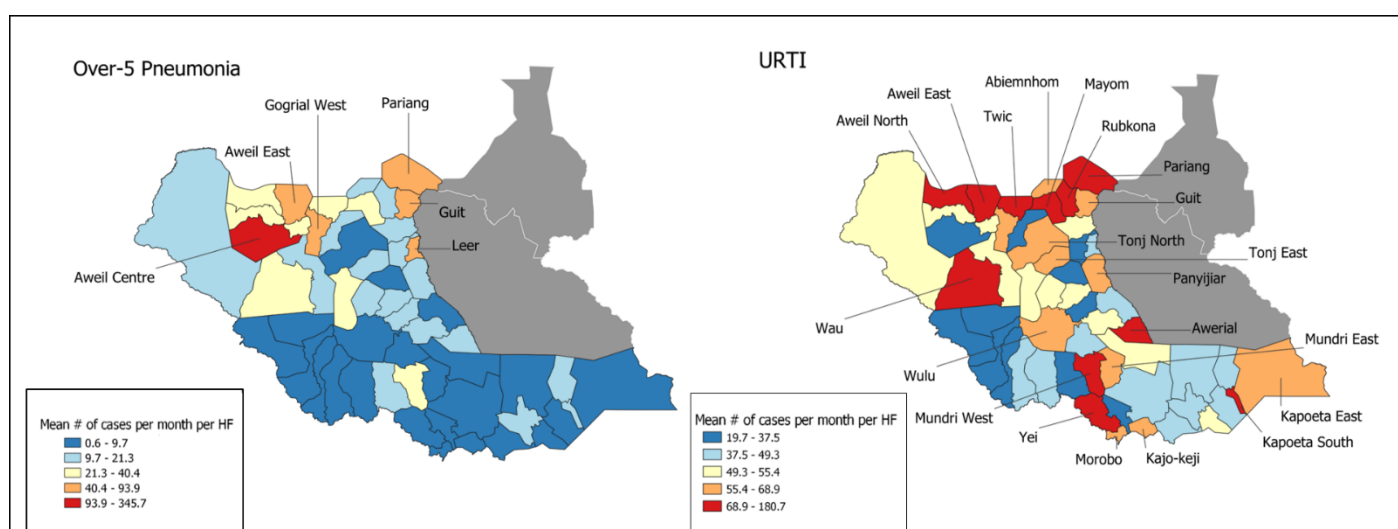


Figure 4: Over-5 Pneumonia and URTI (# of cases per month by health facility) by County Classification of Respiratory Illness

Over-5 pneumonia visits disaggregated by county classification of respiratory illness (Figure 4), indicate that “High” respiratory illness counties had significantly higher levels of over-5 pneumonia visits than “Middle” and “Low areas”. During the first four months of the pandemic (Feb. 2020 – May. 2020) “High” respiratory illness counties had an average of 5.3 times more over-5 pneumonia visits than “Middle” respiratory illness counties, and 9.9 times more than “Low” respiratory illness counties. Additionally, it is evident that temporal fluctuations observed at the state level (Figure 3), were predominantly a result of the fluctuations in the “High” respiratory illness areas (Figure 4). The same trends, for both temporal fluctuations and influence of “High” counties, were observed for URTI visits in Figure 4, although to a lesser degree.

Map 2 presents the mean number of visits per month per health facility at county level for both over-5 pneumonia and URTIs. For over-5 pneumonia it is evident that the majority of counties with high levels of over-5 pneumonia are in the northern areas of the county, with the highest by far in Aweil Centre (346 visits per month per health facility). This finding corresponds with the role of a particular hospital in Aweil Centre that acts as large referral hospital for those from the local and neighbouring counties.

For URTI visits there is a more evenly distribution across the country. The states of Western and Northern Bahr el Ghazal, Warrap, and Unity had the highest levels of URTIs, along with Central Equatoria. It is important to note that the county of Aweil Centre which had by far the highest levels of over-5 pneumonia contrastingly had amongst the lowest levels of URTI. It is reasonable to suggest that this is likely an artefact of classification, with many of the potential URTI cases in the county being recorded as over-5 pneumonia. These findings justify the use of all respiratory illness to understand the potential spread of COVID-19 instead of single indicators.



Map 2: Over-5 Pneumonia and URTI (mean # of cases per facility by county) (Feb. 2020 – Sep. 2020)

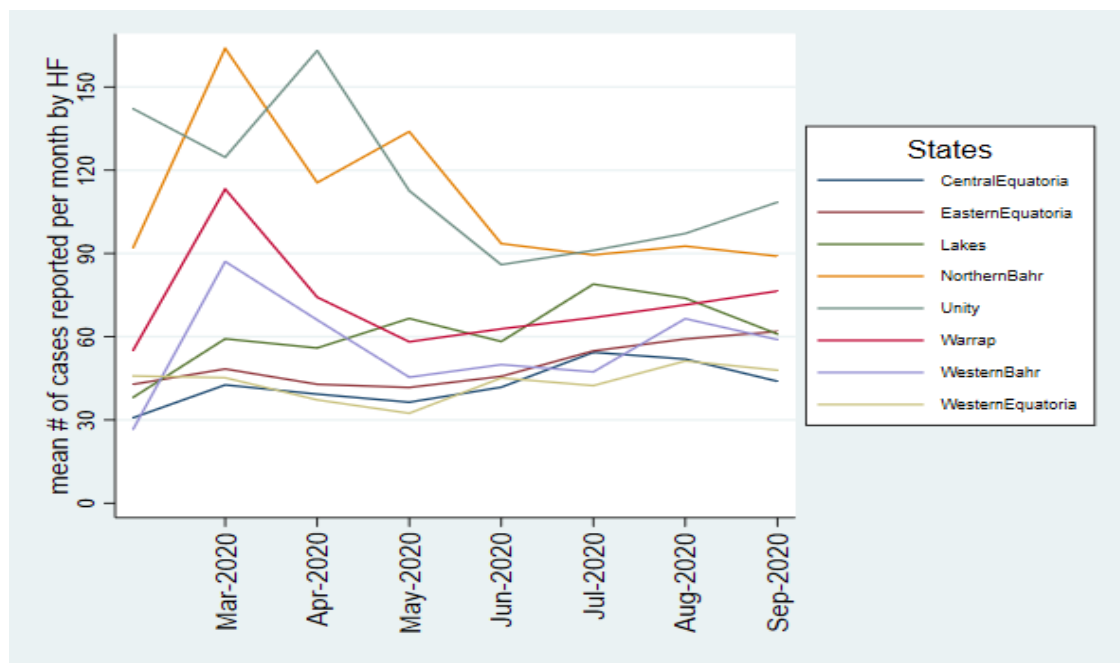


Figure 5: All over-5 Respiratory Illness (# of cases per month per health facility) by State

The trends observed for the distribution of all over-5 respiratory illnesses (the combination of SARI, URTI, and over-5 pneumonia) across the pandemic months by state (Figure 5) are similar to those independently observed for over-5 pneumonia and URTIs (Figure 3). The trends indicate temporal fluctuations in respiratory illnesses concentrated in a few particular states, with an initial spike in the early months of 2020. The disaggregation of all over-5 respiratory illnesses by county classification of respiratory illnesses (Figure 6) demonstrates that “High” respiratory illness counties had substantially higher levels of all over-5 respiratory illness compared to “Middle” counties (2.3 times higher) and “Low” counties (4.7 times higher), and that these “High” respiratory illness counties account for the temporal fluctuations observed at national level.

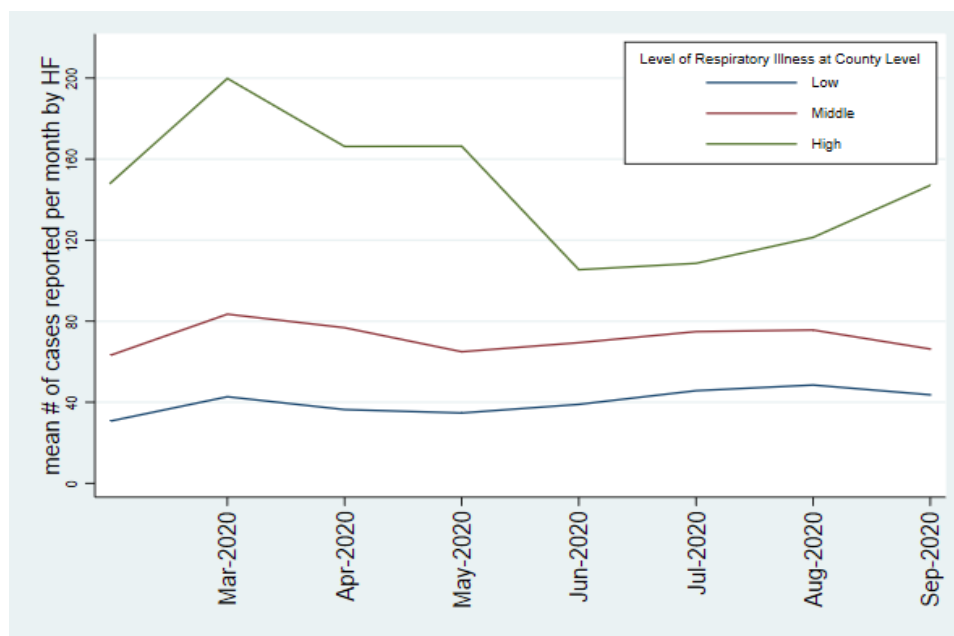
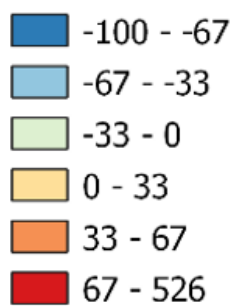


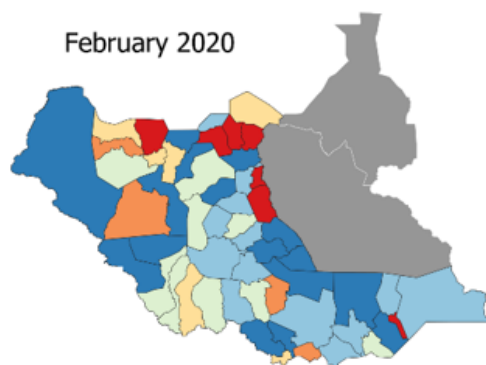
Figure 6: Over-5 Respiratory Illness (# of cases per month by health facility) by County Classification of Respiratory Illness

Map 3 presents a set of maps of mean cases of all over-5 respiratory illnesses per health facility by county for each month of the pandemic. The set of maps indicates that respiratory illnesses cases were not consistently distributed spatially nor temporally, although there were a set of counties that regularly experienced high numbers of cases.

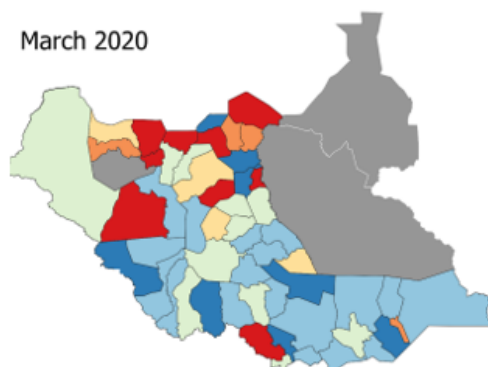
% difference from national mean # of cases



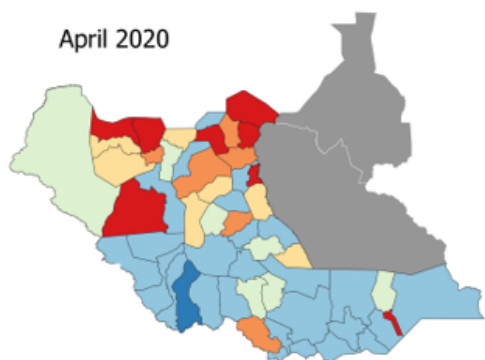
February 2020



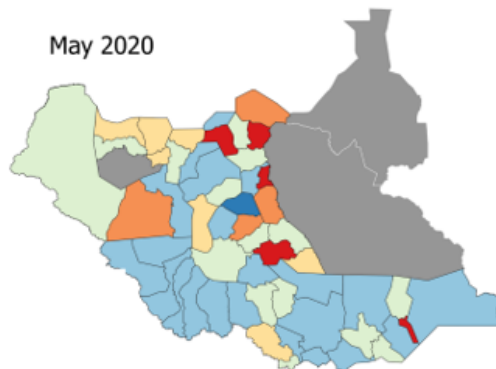
March 2020



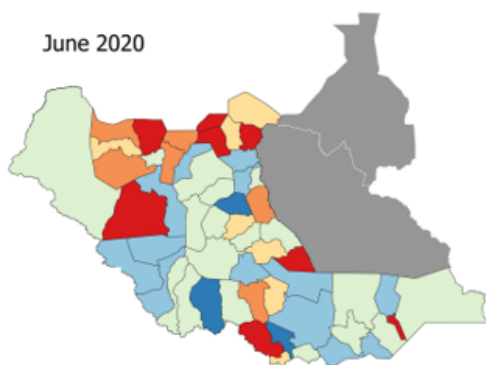
April 2020



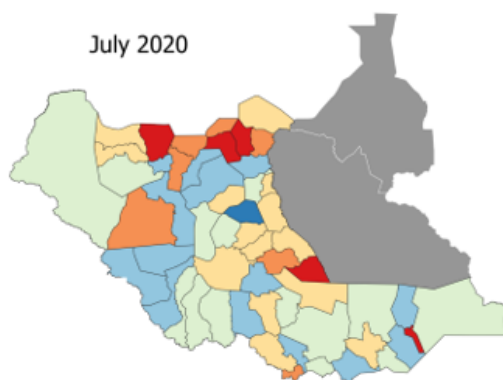
May 2020



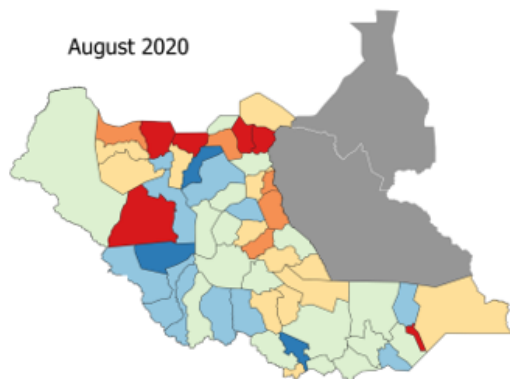
June 2020



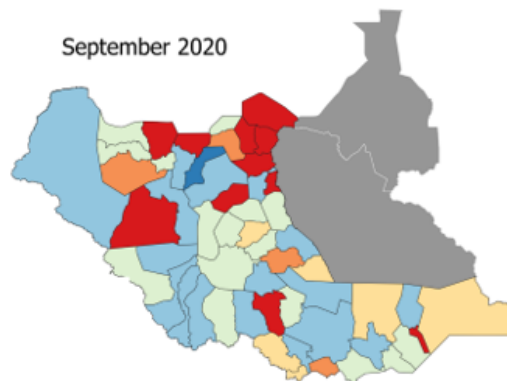
July 2020



August 2020



September 2020



Map 3 – All Respiratory Illnesses by Month (Feb. 2020 – Sep. 2020)

Non-Respiratory health care utilization

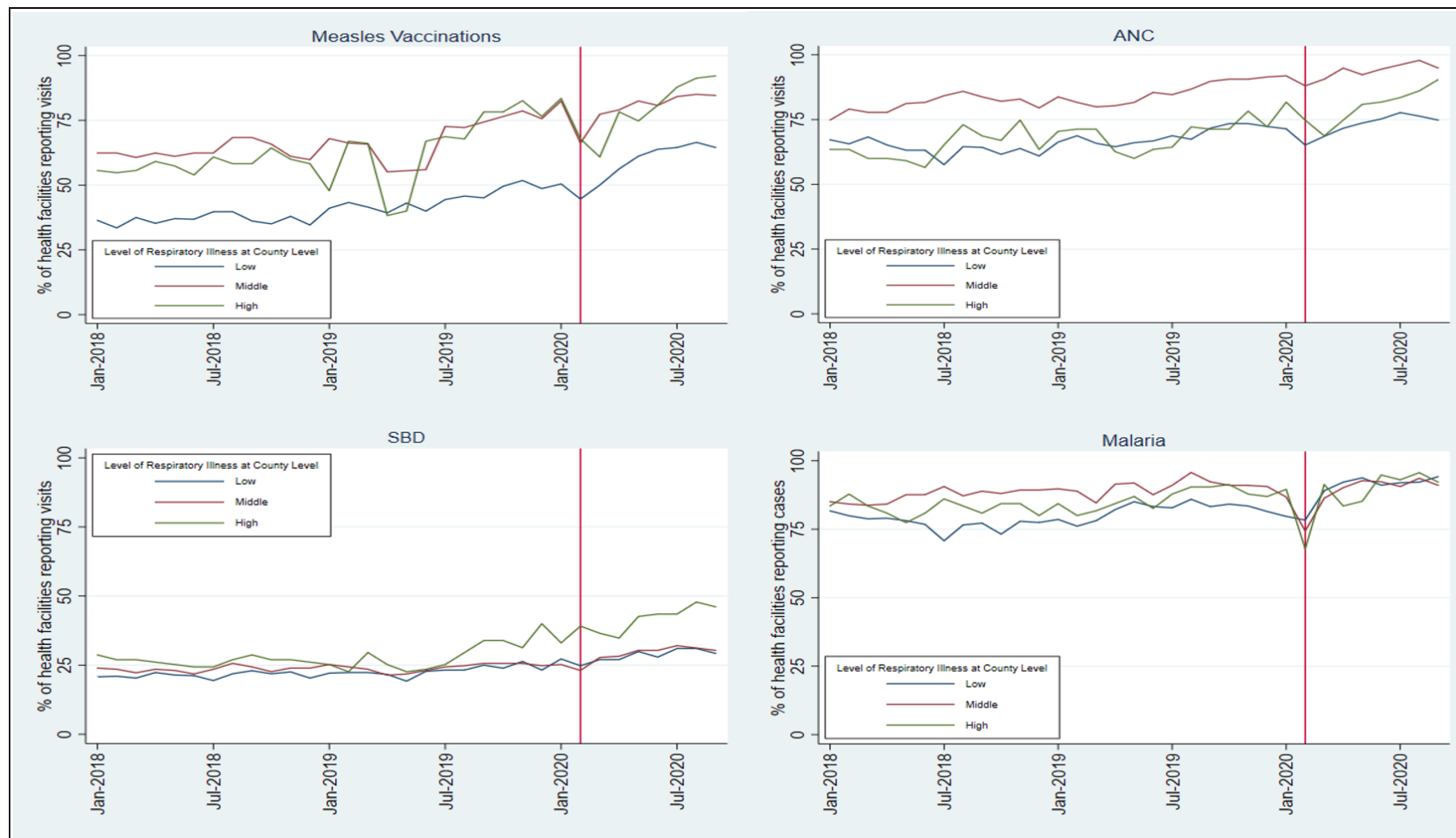


Figure 7: Non-Respiratory Illness Visits (% of health facilities reporting visits per month by county classification of respiratory illness)



Figure 8: Non-Respiratory Illness Visits (mean # of cases per facility per month by county classification of respiratory illness)

The reporting quality for non-respiratory visits (measles vaccinations, ANC, SBD, and childhood malaria) is presented on Figure 7. These figures are disaggregated by the county classifications of respiratory illness according to Map 1. The reporting of measles vaccinations improved throughout all areas of the country, however, counties with “Low” respiratory illness also had worse reporting of measles vaccinations, potentially indicative of poor reporting overall in these counties. For ANC, reporting quality has remained consistent since 2018. Countries with “High” respiratory illness reports did not have better reporting for ANC. The same observations are made for reporting of malaria cases, although there was a sudden drop in reporting of malaria cases in February 2020 (indicated by the red line). SBD indicated higher reporting quality in areas of “High” respiratory illness, however, overall SBD reporting in general was low across the country. Overall, reporting quality has not diminished since the start of the COVID-19 pandemic for the non-respiratory visits observed. Furthermore, there was not a significant difference in reporting quality for “High” respiratory illness counties, indicating that the significantly higher levels of respiratory illness (Figure 6) reported in those counties may represent actual differences in respiratory morbidities.

The mean number of non-respiratory illness related visits per health facility is presented in Figure 8. Unlike Figure 7, Figure 8 provides insight into the healthcare utilization across different county classifications. Overall, for all four indicators observed “High” respiratory illness counties reported higher levels of respective visits compared to “Middle” and “Low” counties. This is evidence that these “High” counties likely have higher levels of healthcare utilization even in non-respiratory illnesses, and therefore the higher levels of respiratory illnesses reported in these counties may also be attributable to this higher level of overall healthcare utilization. For the scope of this study it is not possible to explain the reason for higher healthcare utilization in these counties, however, potential reasons could be infrastructure, higher population, better outreach, etc. Furthermore, as evident in Figure 8, there is no clear indication that healthcare utilization levels have dropped nationwide as a result of the COVID-19 pandemic. For all four indicators presented in Figure 8, healthcare utilization levels have remained consistent before and after the start of the pandemic (distinguished by the red line in the figure). However, for SBD, ANC, and measles vaccinations a minor drop in healthcare utilization was observed for “High” respiratory illness counties. This may indicate some impact on healthcare utilization for non-respiratory illness related issues in areas of significant respiratory illness spikes. In addition, it is evident that malaria cases follow a seasonal pattern, as seen in Figure 8. This pattern continued into the 2020 pandemic with a significant surge in malaria cases starting in the middle months of 2020.

Overall

From the evidence presented thus far, it is evident that there was a spatial relationship to the distribution of respiratory illnesses during the pandemic months as some counties in the country experienced higher levels of cases than others. Additionally, it is also evident that there have been temporal fluctuations to the respiratory illness cases as peaks and troughs have been observed through the months. These temporal fluctuations appear to be largely attributed to the areas with the highest levels of respiratory illnesses. Furthermore, the evidence suggests that for non-respiratory related health facility visits, reporting quality has not diminished throughout the pandemic months, and nor has health care utilization. Health care utilization for these types of visits appear to be consistent with the historic data, although there also appears to be a slightly lower level of utilization corresponding to areas of “High” respiratory illness for services such as measles vaccinations.

Evidence also indicates that the higher levels of respiratory illness in “High” respiratory illness counties may be partially or fully explaining by higher levels of health care utilization, as even non-respiratory illness related visits were also higher in “High” respiratory illness counties. To untangle the combined effects of varying health care utilization and respiratory health care needs, the utilization patterns of respiratory health care and non-respiratory health care were compared. Figure 9 presents the comparison between “Medium” and “High” respiratory illness counties for both respiratory illness visits and non-respiratory illness visits. The findings indicate that the difference in case-load between “Middle” and “High” counties was substantially larger for respiratory illnesses than for non-respiratory illnesses, particularly between Feb. 2020 – May. 2020 when the difference in case-load was more than two times higher for respiratory illnesses. These substantially higher levels for respiratory illness are not sufficiently explained by health care utilization. Furthermore, these higher levels have temporal fluctuations similar to the patterns observed in the COVID-19 pandemic throughout much of the world.

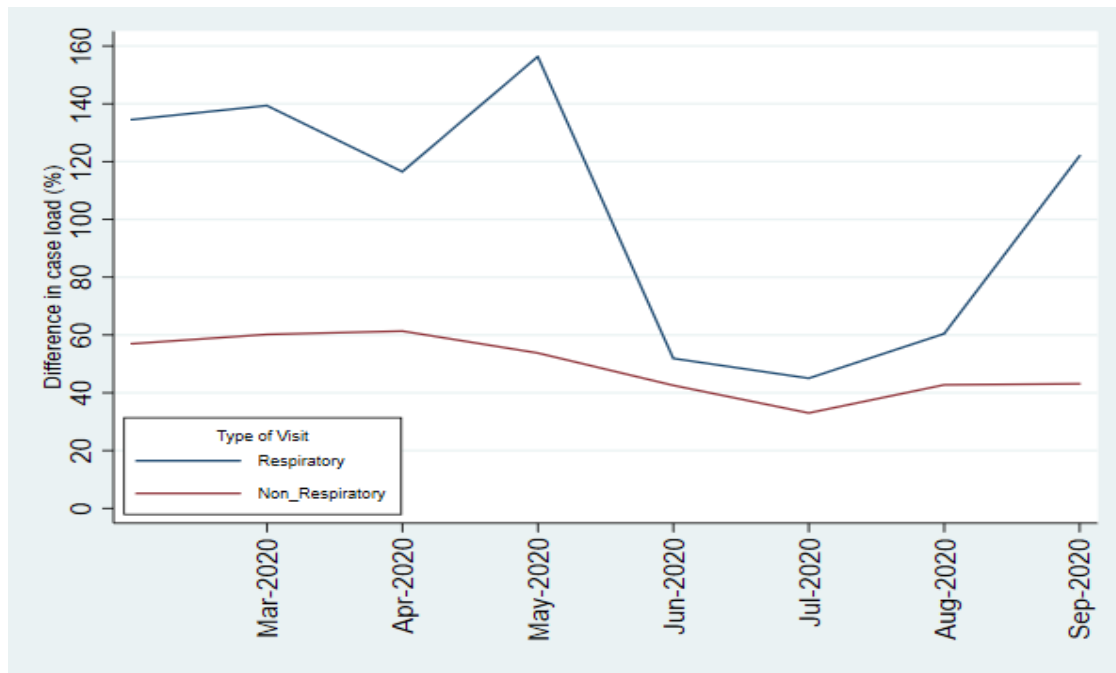


Figure 9: Difference in Case Load (%) of Respiratory and Non-Respiratory related visits for High vs. Middle counties by respiratory illness classification

Conclusions

As a result of the analysis there are a number of conclusions that could be derived to further understand the potential spread of COVID-19 throughout South Sudan and its overall impact on healthcare utilization for other public health care concerns.

The data indicates that the geographic pattern of healthcare utilization for respiratory illnesses varies considerably across states and counties in South Sudan. Counties in Western and Northern Bahr el Ghazal, Unity, and Warrap states had the highest levels of respiratory illness per health facility. The data also indicates that there was temporal variation in respiratory illness across months of the pandemic, with the largest spikes occurring in the months of March to May 2020, however, cases have been rising since August 2020 as well. Additionally, much of the temporal variation is accounted for by the spatial variation as large temporal variation in counties with the highest levels of respiratory was responsible for the fluctuations observed in the national level data. Therefore, with these findings, it is concluded that the spatial and temporal variations may indicate locations and times when COVID-19 was responsible for spikes in health care utilization for respiratory illnesses.

Furthermore, the data demonstrates relatively stable reporting quality before and after the start of the pandemic, suggesting that there has not been an impact on reporting quality as a result of the pandemic. Additionally, some indicators, such as ANC and measles vaccination have improved in reporting. In regard to health care utilization for non-respiratory illness visits, the data indicated relatively stable levels of health care utilization for various illnesses and critical programs. Therefore, a reduction in health care utilization as a result of the pandemic is not immediately clear in the data. Two findings that warrant further inquiry are the slight drop in measles vaccinations reported in “High” respiratory illness counties and the recent surge in malaria cases nationwide exceeding the historic seasonal levels.

Overall, counties classified as “High” respiratory illness tended to have higher levels of health care utilization for various non-respiratory illness related visits. These findings may have indicated that areas reporting higher levels of respiratory illness were artefacts of better reporting and higher levels of overall healthcare utilization. However, when adjusting for higher levels of reporting quality and higher levels of health care utilization, there are still significantly higher levels of respiratory illnesses in “High” respiratory illness counties compared to “Middle” respiratory illness counties. This may provide an indication that these areas are experiencing COVID-19 outbreaks. Given the data limitations it is not possible to confirm that the trends observed were in fact COVID-19 outbreaks, however, there is enough confidence in the methodology and findings to suggest that if there was significant community spread of COVID-19 throughout South Sudan, the counties identified in this analysis are the most likely to have experienced these impacts.

Limitations

There are a number of limitations found in this analysis, some of which are related to the data, while others are related to the context found in South Sudan. The recommendations section of this report contains a number of suggestions to address some of these limitations. Firstly, there was no historic data in the dataset on over-5 respiratory illness prior to the start of pandemic. This limitation prevents us from understanding the context of over-5 respiratory illness in a non-COVID-19 scenario. Additionally, there is limited information on population and demographic factors on a community-level and a patient-level to further examine the distribution and manifestation of the reported respiratory illness cases. This information would have allowed for data adjusting. Furthermore, for the classification of respiratory illnesses, there is a limited understanding on the validity and reliability of these classifications. The lack of insight into non-HPF3 facilities also presents a limitation as it represents a blind spot in the national data. Finally, the lack of COVID-19 diagnostic information for respiratory illnesses at facilities does not allow for cross-checking of the findings of the analysis. Therefore, the limitations of this analysis were a barrier to providing more concrete and conclusive results.

Recommendations

The following recommendations were developed with a priority for feasibility, applicability, and usefulness.

Continuously update relevant data;

The data utilized for this analysis, as well as other relevant data, should be continuously updated in order to develop a comprehensive historic dataset which can be used to observe trends for COVID-19 and other priorities.

Collect and report patient level data;

Data regarding basic demographic and epidemiological information should be collected and reported at patient levels. This data would provide further insight into the manifestation of COVID-19 in the South Sudanese context and would allow for disaggregated analysis.

Investigate respiratory illness classifications;

The main classifications for respiratory illnesses (ie: URTI, SARI, and over-5 pneumonia) should be investigated to understand the classification patterns across facilities in South Sudan. This investigation can be conducted by testing recently classified respiratory illness cases for COVID-19 and analyzing the classification differences between COVID-19 positive and negative patients.

Access non-HPF3 data;

Accessing relevant data from non-HPF3 states would fill the gap currently found in national data helping further understand respiratory illness patterns across the country.

Use respiratory illness data for testing and resource priorities;

The levels of respiratory illness at county and facility level should be used as an indication of priority locations for COVID-19 testing. These priority locations should use a systematic approach to testing in order to establish counties and facilities with comparatively higher test positivity rates. Thus, the locations with higher respiratory illness cases and test positivity rates will be an indication of areas with higher COVID-19 impacts. With this information, COVID-19 related resources can be allocated appropriately.

Continue promoting health care utilization;

The findings of this analysis suggest that health care utilization throughout South Sudan has not been significantly impacted by COVID-19. It is critical that it remains this way as South Sudan is a country with a high burden of health needs and a fragile health system. Therefore, it is strongly recommended to continue promoting non-COVID-19 health priorities and minimizing the impacts of COVID-19 on other health conditions in the country.

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