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CORESMA - COVID-19-Outbreak Response combining E-health, Serolomics, Modelling, Artificial Intelligence and Implementation Research

WP 4	**Implementation Research Containment Measures**
Deliverable D4.3	**Report**
Title of Deliverable:	**In-depth analysis of containment measures and deployment of SORMAS (MS23)**
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16 November 2023

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Preamble

This deliverable (D4.3 and MS 23) within the European Commission funded project 'Outbreak Response combining E-health, Serolomics, Modelling, Artificial Intelligence and Implementation (CORESMA)' reviews two streams of research within work package 4:

1. In-depth analysis of containment measures in Côte d'Ivoire and Nepal
2. Deployment of SORMAS in Côte d'Ivoire and Nepal

The deliverable was proposed as a part of the project proposal in February 2020 at a time when it was not clear how the epidemic will evolve. As the two topics of this deliverable are not directly connected, we organise the document along two parts a first part focusing on the containment measures and a second part on SORMAS deployment.

Hereby, the she second part of this report overlaps in substantial proportions with a peer-reviewed publication entitled 'Introduction and acceptability of the Surveillance Outbreak Response Management and Analysis System (SORMAS) during the COVID-19 pandemic in Côte d'Ivoire' written by Tanja Barth-Jaeggi and further authors. The full article can be accessed at https://bmcpublichealth.biomedcentral.com/articles/10.1186/s12889-023-17026-3 or https://doi.org/10.1186/s12889-023-17026-3.

PART A: Containment measures

1. Background and objectives

On January 12 2020, the World Health Organization confirmed that a novel coronavirus was the cause of a respiratory illness in a cluster of people from Wuhan City in China. COVID-19 is a viral respiratory disease caused by infection with the SARS-CoV-2 virus. Symptoms occur 1-14 days following exposure, on average after 3-7 days. These symptoms include fever, fatigue, cough, difficulty breathing, sometimes worsening to pneumonia and kidney failure - especially in those with underlying medical conditions. On **March 11 2020, the WHO declared the ongoing COVID-19 outbreak as a pandemic. On May 5 2023, the pandemic was announced over by WHO.** COVID-19 as an established and ongoing health issue which no longer constitutes a public health emergency of international concern.

Along the emergence of the pandemic, the European Union’s Horizon 2020 research and innovation programme funds since April 2020 several research initiatives among else the project “COVID-19-Outbreak Response combining E-health, Serolomics, Modelling, Artificial Intelligence and Implementation Research (CORESMA)”.

The CORESMA project, among else, aims to immediately generate the most needed clinical and epidemiological data needed for defining targeted public health measures at national and global level, early enough to become effective during this COVID-19 outbreak, using the Surveillance Outbreak Response Management and Analysis System (SORMAS). Specifically, in the work package 1 (WP1) “Enhancing public health preparedness and availability of impactful real time data through digital health surveillance with SORMAS”. In this work package, the SORMAS software is being adapted to the countries in order to best serve the needs of the countries in surveillance of the pandemic, handling of cases, contact tracing and in the communication with the laboratories. It also enables the countries to analyse the current situation of the pandemic and react appropriately. Furthermore, the work package 4 (WP4) “Application of the epidemic surveillance and response analysis system (SORMAS) to improve preparedness and surveillance during the COVID-19 epidemic in Côte d'Ivoire: a study on the implementation of SORMAS” analyses the impact and acceptability of SORMAS on the preparedness and surveillance of the COVID pandemic in the countries.

This document guides us through the COVID-19 containment measures applied by the governments and the ministries of health in Côte d’Ivoire and Nepal during the pandemic (March 2020 until May 2023).

Consequently the **objective** of this section is

- **to review containment measures put in place in Côte d’Ivoire and Nepal in the course of the pandemic and at the time of the deployment of SORMAS.**

In **chapters 2** and **3**, we provide a chronogram of containment measures enforced in Côte d’Ivoire and Nepal during the COVID-19 pandemic. **Chapter 4** summarises and compares key measures in the two countries. This document enables to see the setting into which SORMAS was carried forward in Côte d’Ivoire and Nepal. SORMAS, supported the pilot areas in the registration and follow-up of COVID-19 cases and in the tracing of their contacts. It further facilitated the exchange between different actors in the health sector (doctors, contact tracers, nurses etc.). However, SORMAS was used as an additional system, as the official COVID-19 surveillance and management systems were always running simultaneously in both countries.

SORMAS, as a central platform connecting all actors, could shorten the time from diagnosis to the successful identification of contacts and their quarantine, and therefore reduce the risk for transmission in the wider population. **Chapter 5** looks retrospectively into the appropriateness of specific containment measures for SARS-CoV-2 control globally and in our pilot countries Côte d'Ivoire and Nepal. Finally, we give some concluding statements in **chapter 6**.

2. Côte d'Ivoire: COVID-19 situation and surveillance-response mechanism

March 11 2020, Côte d'Ivoire announces the first COVID-19 case, an Ivorian returning from Italy (1).

March 23 2020, the government of Côte d'Ivoire declares the **state of emergency** for the country and reports 73 COVID-19 cases, these increased to 916 cases and 13 deaths up to April 21 2020. The borders were closed and all **movement of people to and from Abidjan are banned**. A national **curfew (9pm - 5am)** was introduced and all **bars closed**. A national emergency plan is then being formulated (2).

May 8 2020 President Alassane Ouattara, begins to ease COVID-19 measures. **Measures were to be relaxed nationwide except for Abidjan and some surrounding suburbs, where a state of emergency is in place until at least Friday, May 15 2020.** However, the **curfew in Abidjan will be shortened** from 9pm to 5am to 11pm to 4am. The state of emergency means **restaurants, maquis, bars, nightclubs, cinemas and places of entertainment remain closed**, and **gatherings of more than 50 people are forbidden**. **Elsewhere, schools, restaurants, bars and concert venues have reopened, and gatherings of up to 200 people are allowed**. Areas impacted by the state of emergency include the District of Abidjan, Dabou, Azaguie, Bingerville, Grand-Bassam, Bonoua, Assinie and up to PK30 on the Abidjan-Yamoussoukro motorway. The use of protective **face masks** is mandatory in all public places nationwide, and those who do not comply are liable to be sanctioned by the authorities. The country's **borders remain closed** until further notice and international flights to and from Côte d'Ivoire were suspended indefinitely on March 22 2020, except for humanitarian and security purposes (3).

Côte d'Ivoire extends state of **emergency through July 30 2020**. **Land and sea borders will remain closed** during this period; however, **domestic flights resumed June 26 2020**. **International flights were allowed to restart July 1 2020**. Cargo and freight transport will likely continue through land and sea borders, with increased screening in place. The lockdown of the Grand Abidjan region (Abidjan, Dabou, Azaguie, Bingerville, Grand-Bassam, Bonoua, Assinie, and up to PK30 on the Abidjan-Yamoussoukro motorway) has been eased, and **unrestricted travel can resume July 15 2020**. Other measures that remain in place include: **A ban on large public gatherings, closure of bars, nightclubs, cinemas, and other places of entertainment**, monitoring and close screening of all passengers arriving in the country, mandatory wearing of **facemasks** in public (4).

16 September 2020, Abidjan ends isolation and schools reopen. All travellers to Côte d'Ivoire must carry a negative COVID-19 test certificate dating back no more than 72 hours. Bars, nightclubs, cinemas and entertainment venues reopened on 1 August 2020. The wearing of masks remains in force in public places. Continuing their support to the Government according to their comparative advantages, the various agencies of the United Nations Development System are contributing to the implementation of the national response plan for COVID-19, through multisectoral interventions aligned with the various strategic axes of this plan. These include interventions in: epidemic preparedness, health, risk communication, education and access to water, hygiene and sanitation (5).

December 17 2020, authorities maintain restrictive measures across the country as part of the nation's efforts to slow down the spread of COVID-19. **Land and sea borders are closed**; however, both **domestic and international flights have resumed**. Travellers arriving in Côte d'Ivoire will still need to present **negative COVID-19 test** results taken up to seven days before arrival. Travellers will also have to declare their trip on the official travel reporting portal and pay XOF 2,000 (USD 3.57). Travellers must present the declaration form at the port of entry. **Arriving travellers are encouraged to self-isolate for two weeks and monitor symptoms.** Travellers leaving Côte d'Ivoire also require a negative COVID-19 test and a declaration form. The test must be taken no more than seven days before departure. **Cargo and freight transport will likely continue through land and sea borders, with increased screening in place**. **Bars, nightclubs, cinemas, and other places of entertainment open with adequate hygiene and social distancing measures in place**. Large gatherings have resumed with the approval of local authorities. Protective **facemasks are mandatory** in public places, particularly in the greater Abidjan area. Authorities could reimpose, extend, further ease, or otherwise amend any restrictions with little-to-no notice depending on disease activity over the coming weeks (3).

March 2021, Côte d'Ivoire started to **vaccinate** the population (6). **Figure 1** shows the vaccine doses administered over the time of the pandemic. To set this data into context, the population census from 2021 estimated the population size of 29,389,150 people (7).

February 2023, Côte d'Ivoire has lifted its COVID-19 imposed land border closure and officially reopened its roads to neighbouring countries after almost 3 years (8).

April 2023 all containment measures are lifted (9).

Figure 1 COVID-19 vaccine doses administered over time in Côte d'Ivoire) (graph generated from (10)).

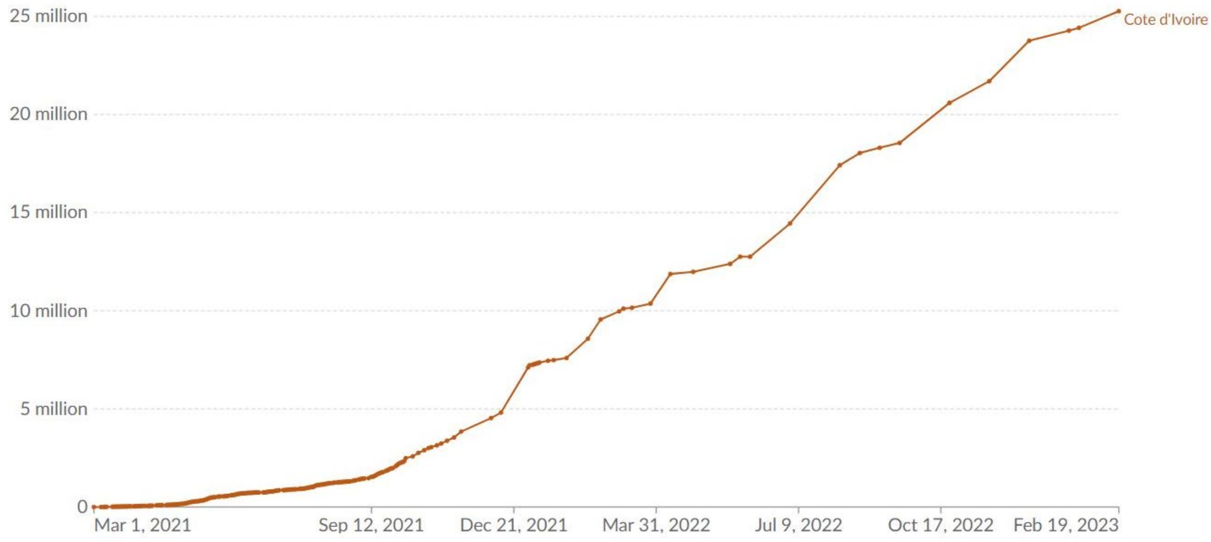


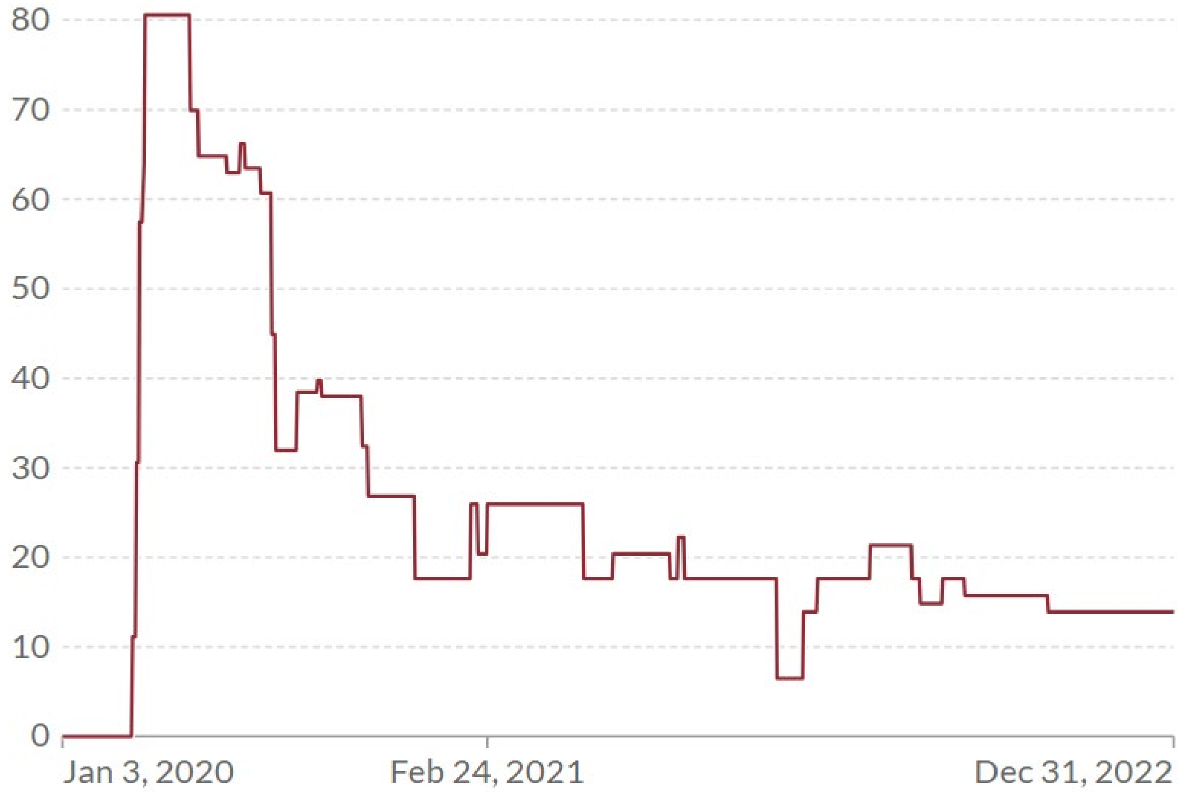
Table 1 Summary of containment measure for COVID-19 since the declaration of the state of emergency until the end of the pandemic, in Côte d'Ivoire.

Date	Event	Containment measures
2020		
March 23	Announcement of state of emergency	Nationwide curfew (9pm-5am), boarders, forbidden movement to and from Abidjan, restaurants, maquis, bars, nightclubs, cinema and other entertainment places are closed, gathering of more than 50 people forbidden
May 8	Measures relaxed (except Abidjan)	Schools, restaurants, bars and concert venues have reopened, and gatherings of up to 200 people are allowed. Use of face masks in public compulsory Abidjan curfew shortened (11pm-4am)
June 26	Opening of the boarders Lockdown of the Grand Abidjan region eased	International flights and airport entry allowed Unrestricted travel resume but ban on large public gatherings, closure of bars, nightclubs, cinemas, and other places of entertainment stays in place for Abidjan
August 1	Abidjan eases measures	Bars, nightclubs, cinemas and entertainment venues reopened
September 16	Abidjan ends isolation	Schools reopen Land and sea borders remain closed Face masks mandatory in public
2021		
March 1	Start of vaccination campaign	Awareness raising of vaccination for general population
2023		
February 16	Re-opening of land borders	Official re-opening of boarder entry by road (after nearly three years of closure)
April	Lifting all travel restrictions	no certification (vaccination or PCR test) need for entering or leaving the country

The **Oxford Stringency Index** is a composite measure based on nine response indicators: 1) school closures; 2) workplace closures; 3) cancellation of public events; 4) restrictions on public gatherings; 5) closures of public transport; 6) stay-at-home requirements; 7) public information campaigns; 8) restrictions on internal movements; and 9) international travel controls. The index on any given day is calculated as the mean score of the nine metrics, each taking a value between 0 and 100. A higher score indicates a stricter response (i.e. 100 = strictest response). The picture for Côte d'Ivoire shows a very steep increase in the index in

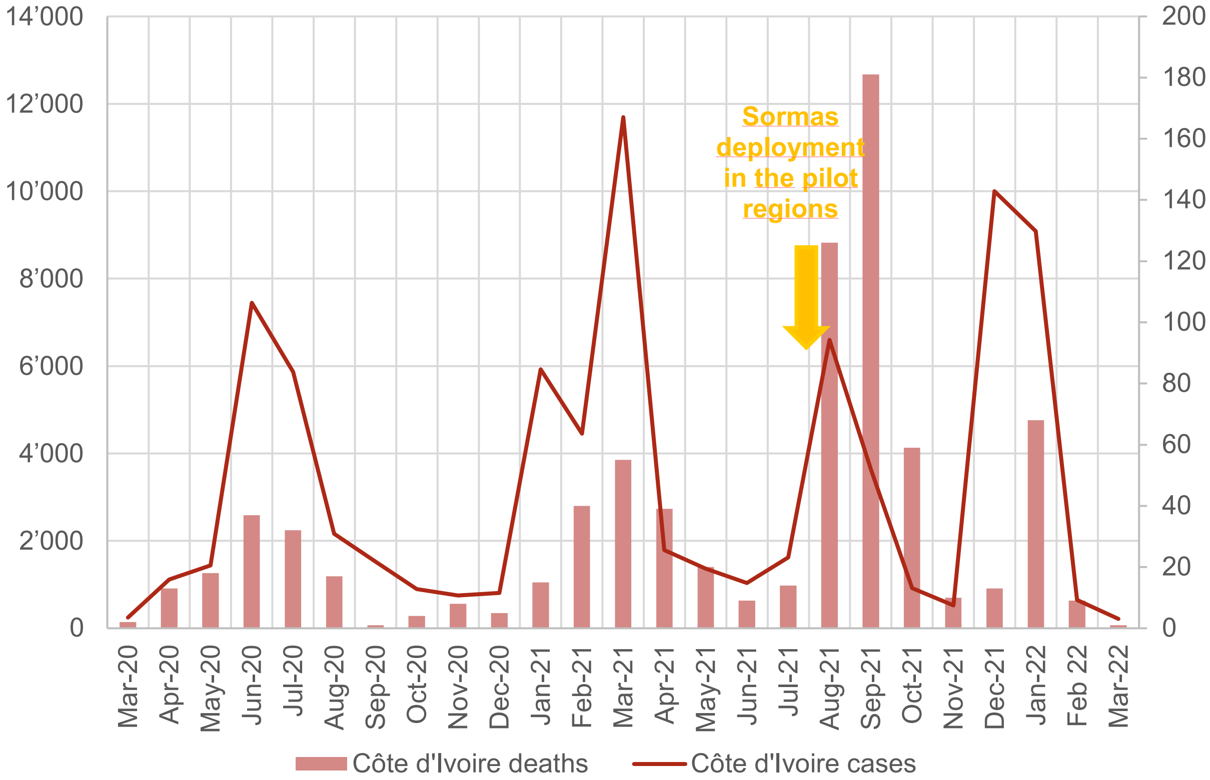
March 2020 to 80.6 until it started to decrease in May 2020 to 64.8 and August 2020 to 31.9 (***Figure 1***). From end of December 2020 (index 17.6) there is very little change in the Oxford Stringency Index until the end of the measurement in December 2022 (ranged from 25.9-6.5).

Figure 2 Stringency Index for Côte d'Ivoire (11, 12).



The COVID-19 cases and deaths in Côte d'Ivoire over the time of the pandemic are shown in **Figure 2**. There are four waves peaking in June 2020, March 2021, August/September 2021 and December/January 2022.

Figure 3 COVID-19 cases and deaths in Côte d'Ivoire during the pandemic (13). Left axis showing the monthly cases and right axis the deaths. The deployment of SORMAS in the two pilot regions is marked by the orange arrow in July and August 2021.



SORMAS was introduced in the two pilot (Abidjan 2 and Gbêkê) regions in July/August 2021. Acceptability of SORMAS among users and decision makers is high, but sustainable implementation needs close supervision, regular refresher training or other channels to ensure skilled users, and maintenance of infrastructure such as mobile devices and the host server. Potential of SORMAS for epidemic preparedness, surveillance and management with early case detection and evidence-based decision-making (containment measures, communication, management, and alerts) for infectious diseases has been shown to be substantial. By adding other endemic infectious diseases such as measles, yellow fever, meningitis, and cholera into SORMAS, a valuable tool is provided that ensures consistency between the different diseases and uses synergies to finally be a sustainable solution. SORMAS therefore provides a valid, country-adapted and highly acceptable surveillance, management, and analysis tool for Côte d'Ivoire that would ensure the country to be prepared for future outbreaks and epidemics.

3. Nepal: COVID-19 situation and surveillance-response mechanism

January 28 2020, the **first case was identified in Nepal**. Nepal started preparing for the epidemic, focusing mainly on the identification and management of cases. A High-Level Coordination Committee under the lead of the Prime Minister and Minister of Defense was formed for oversight of preparation and response activities. Five **hub hospitals** and **13 satellite hospitals** were designated COVID-19 hospitals, requiring dedicated space for the isolation of infected individuals. Expert teams were formed to formulate guidelines for the treatment, testing, and management of COVID-19 cases. Ongoing communication was established among the Central and Provincial Health Emergency Operation Centers and the

Ministry of Health. **Temperature monitoring was instituted at the Tribhuvan International Airport**, **the only international airport in Nepal** (14).

March 11 2020, **mandatory self-quarantine** of all individuals arriving from the eight nations (**China, Italy, Spain, Iran, South Korea, Germany, France, and Japan**) that had community spread, was initiated. **Health screening** consisting of a questionnaire for symptoms and a temperature check, was instituted at **43 Points of Entry from neighbouring nations, India and China** (14).

24 March 2020, the Government of Nepal issued a nationwide **lockdown from**, **prohibiting domestic and international travels, border closures and closure of non-essential services**. Only essential services, including pharmacies and grocery stores, remain open. Citizens could only leave their houses at designated time points. All domestic and international flights were halted. Maintaining **physical distancing, masks, hand washing**, **and hand sanitizers** were encouraged. End of March, there were five cases from China, Europe, and Dubai that tested positive and were placed in isolation in COVID-19-designated hospitals in Kathmandu. Trained personnel under the Epidemiology and Disease Control Division (EDCD) were mobilized to **conduct extensive contact tracing** based on their flight details and movement history to identify individuals with a potential infection. Lockdown/quarantine measures were strictly reinforced by the security sector (police, border management, corrections). Police presence was expansive and powerful, and non-adherence to quarantine measures were fined (14).

April 2020 the document **'COVID-19 NEPAL: PREPAREDNESS AND RESPONSE PLAN (NPRP)'** was published by UN Nepal (15). NPRP lays out the preparedness actions and key response activities to be undertaken in Nepal, based on the trends and developments of the global COVID-19 pandemic. The plan outlines two levels of interventions; one that is the preparedness that should take place at the earliest possible and that constitutes an investment in Nepal's health systems that will in any case benefit the people of Nepal, regardless of the extent of the COVID-19 pandemic in the territory. The second level is the effective response, across sectors, to an estimated caseload of 1500 infected people and 150,000 collaterally affected people (contacts). This can then be scaled up in case there is a vast increase in number of infected and affected people, beyond the original scenario of 1500 patients (15).

June 12 2020, government of Nepal has decided to **ease the lockdown adopting a phased approach**. In the first phase of 21 days, **shops were allowed to open** and **vehicles to operate under the odd-even** (alternate day) rule. **Public places, institutions and events with higher intensity of congregation (schools, colleges, shopping malls, pubs, conferences, sport activities etc.) remained close**d (16).

July 22 2020, with a few exceptions, most **lockdown restrictions have been lifted** (17).

October 17 2020, **Limited commercial flight service has resumed**, but, except for trekkers and mountaineers, foreign citizens are still prohibited entry into Nepal. Domestic flights have resumed, including full seating capacity. Flights will operate under strict COVID-19 mitigation measures. Depending upon the port of entry, newly arrived travellers must undergo a **mandatory quarantine** ranging from 2 to 14 days. Suspected COVID-19 cases already in country must also quarantine for 14 days. **Masks are required** when outdoors, including while on public transport and taxis (18).

October and November, high caseload and deaths observed in Nepal, especially in

Kathmandu district, home isolation and quarantine as well as contact tracing seem to pose problems. New testing sites were established by the Ministry of Health and Population (19).

December 15 2020, Nepal is generally relaxing international and domestic **air travel allowed**, although some controls continue. On-arrival and electronic visa issuance remains suspended, except for foreigners officially affiliated with international development organizations and diplomatic missions. **Foreign nationals must present evidence of a negative COVID-19 test result** issued no more than 72 hours prior to departure for Nepa**l. Land border crossing points remain closed to foreign nationals**. Arrivals, regardless of nationality, must **quarantine for at least 2 and up to 14 days**. Most nationwide gathering restrictions have been lifted, though some limitations remain. Most **schools, religious institutions, and nonessential businesses have been allowed to reopen**. Residents are still required to wear **protective face masks** and adhere to **social distancing** guidelines while in public. Several areas are enacting localized curbs on top of nationwide protocols. **Travel to the Kathmandu Valley from other areas remains limited**, with visitors required to have proof of having tested negative for COVID-19. Nonessential activity remains limited in some high-risk zones. Residents must stay home to the extent possible in these locations. Essential and permitted businesses must enforce social distancing standards and may be subject to closures. Access to such areas is limited. Officials continue to advise Nepali citizens against nonessential international travel. **Health checks are mandatory at all entry points** (20).

January 2021, Nepal rolled out the **vaccine** within first priority groups, which are health and social sector frontline personnel followed by people over 65 years throughout the country and those over 55 years in all high mountainous terrain districts (21). **Figure 4** shows the COVID-19 vaccine doses administered over time. To set the data into context, the population census from 2021 estimates the population size of 29,164,578 (22).

April 2021, **second lockdown** after increase in cases due to **Delta variant**. The lockdown **ended in September 2021**(21).

Figure 4 COVID-19 vaccine doses administered (graph generated from (10)).

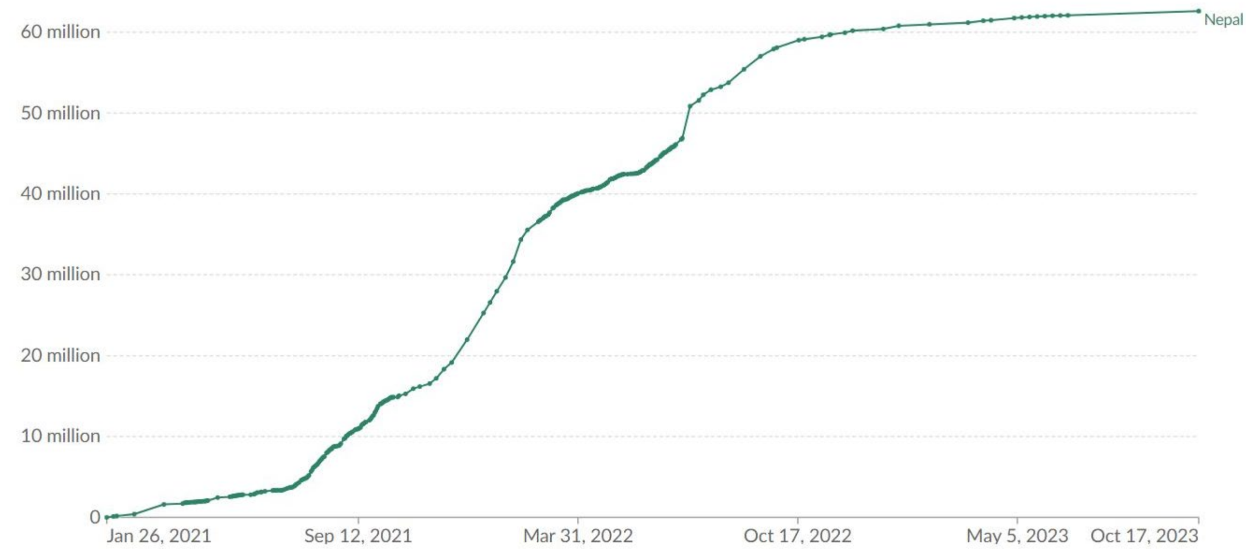


Table 2 Summary of containment measures for COVID-19 in Nepal.

Date	Event	Containment measures
2020		
March 11	Control of immigration	Mandatory self-quarantine for people arriving from China, Italy, Spain, Iran, South Korea, Germany, France, and Japan Health screening at Indian and Chinese boarders
March 24	Nationwide lockdown	Borders closed and non-essential services (NOT contribute to preserving life, health, public safety and basic societal functioning) forbidden Physical distancing, face masks and handwashing encouraged
June 12	Phased ease of lockdown	Shops reopen, vehicles allowed on even-odd number system (alternating days) Public places, institutions and events with higher intensity of congregation (schools, colleges, shopping malls, pubs, conferences, sport activities etc.) remained closed
July 22	Most lockdown restrictions lifted	
October 17	Commercial flights allowed with restrictions	Mandatory quarantine Face masks in public places mandatory
December 15		Most schools, religious institutions, and nonessential businesses have been allowed to reopen Travels to Kathmandu restricted land borders closed for foreign nationals, all arrivals need to quarantine Gathering restrictions mostly lifted
2021		
January	Start of national vaccination campaign	First priority groups: Health and social sector and front-liners, following people over 65 years old throughout the country and those over 55 years old in all high mountainous terrain districts.
April	Second national lockdown	
September	Lockdown ended	

In addition, the Stringency Index shows the very strict regulations of containment measures in Nepal mid-March 2020 to 96.3 (**Figure 3**). That comes steadily down to 29.6 one year later in March 2021 and increased a second time to 97.2 in May 2021.

The COVID-19 cases and deaths over the time of the pandemic are shown in **Figure 4**. There were three major waves with peaks in October 2020, May 2021 and January 2022. The third wave was mainly showing high prevalence of Omicron cases but not in deaths.

Figure 5 Stringency Index for Nepal (11, 12).

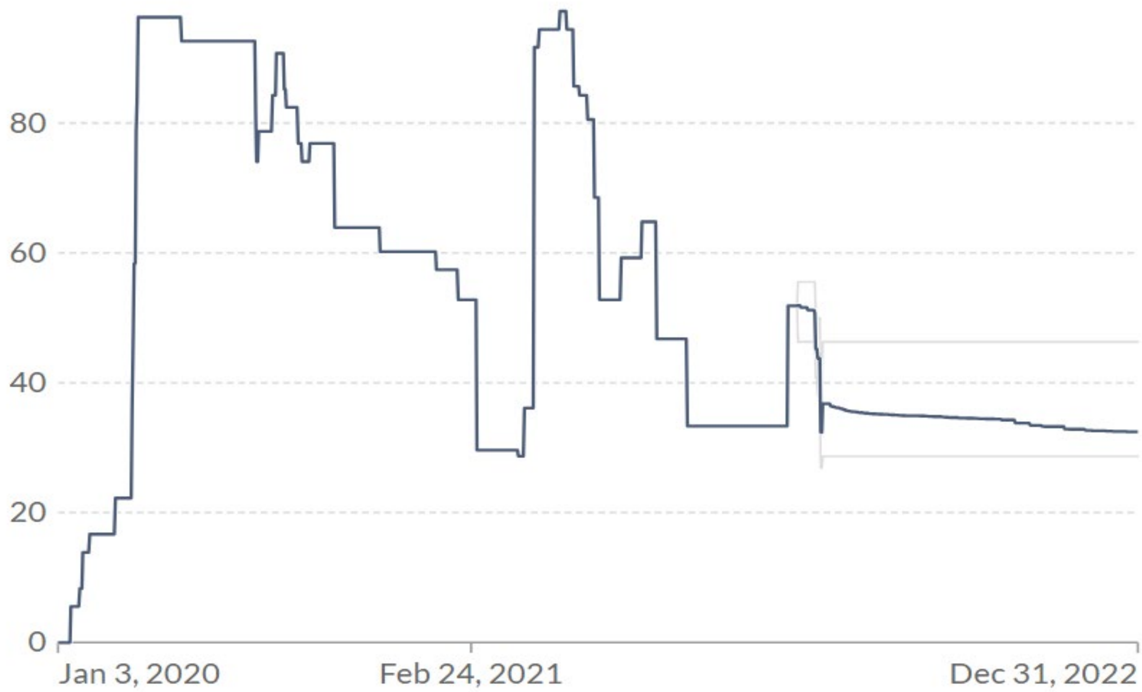
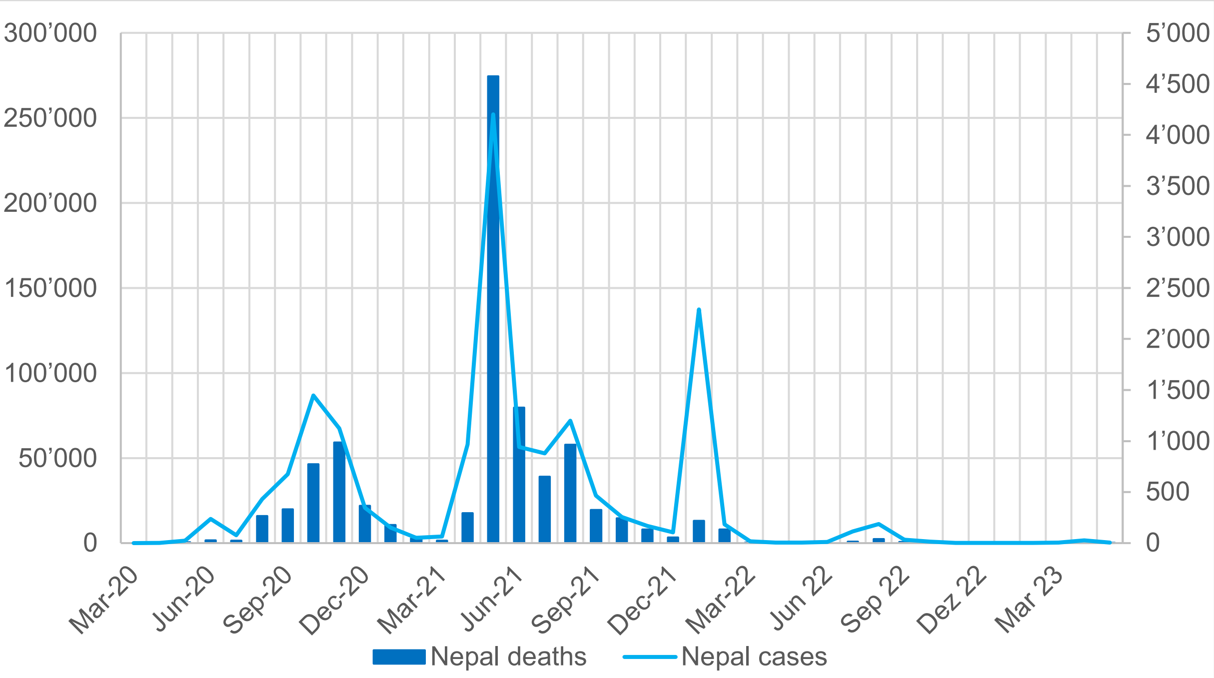


Figure 6 Cases and deaths due to COVID-19 in Nepal from January 2020 to the end of the pandemic April 2023. Left axis showing the monthly cases and right axis the deaths (23).



Unfortunately, the deployment of SORMAS in the pilot provinces (Gandaki and Sudur-paschim) could not be done over the course of the pandemic due to multiple reasons (impact of the pandemic on travel and administration, delayed training, other outbreaks).

4. Containment measures in Côte d'Ivoire and Nepal

Table 3 below summarizes the various containment measures and their intended impact on the COVID-19 situation in the countries, as well as their application in Côte d'Ivoire and Nepal.

Table 3 Containment measures and their duration of application in the countries (Côte d'Ivoire and Nepal).

Containment measure	**Côte d'Ivoire**	**Nepal**
Reduction of the risk of transmission		
Confinement (curfew)	March to May 2020 - longer for Abidjan and some peri-urban areas of Abidjan • National curfew 9pm-5am • Bars, restaurants, cinemas and entertainment closed • Large gatherings forbidden State of emergency extended through July 2020	March to July 2020 – first Nationwide lockdown Shops closed until June 2020 Restricted circulation through cars operating on odd even rule from June 2020 Second lockdown April to September 2021
Face masks in public places	March to May 2020 nationally for Abidjan and some peri-urban areas of Abidjan up to December Face mask wearing at airports in place up to April 2023	July 2020 to June 2023
Contact tracing	March 2020 - contacts of travellers from affected countries are followed via sms and phone calls Isolation of contacts in the dedicated centre for follow-up	For travellers based on flight details (passenger lists to track contacts)
Disinfection measures	March 2020 onwards - disinfection of facilities frequently visited by positive cases	March 2020 onwards
Hand-washing	March 2020 onwards - promotion of handwashing with water and	

	soap and hydro-alcoholic solutions	
Disinfection of potentially contaminated surfaces	March 2020 onwards - disinfecting places at risk (home, office), of confirmed cases	
Increase social distance		
Self-confinement of persons	March to May 2020 Self-confinement of asymptomatic or mild cases in dedicated places	March to July 2020 Citizens could only leave their resident place at designated time periods
Closure of schools	March to May 2020 nationally March to September 2020 in Abidjan and suburbs	March to July 2020
Population-wide measures to reduce mixing of adults	Forbidden of large gatherings Bars, restaurants and cinemas and entertainment institutions closed	
Decrease interval between symptom onset and start of isolation		
Promotion of testing	April 2020, 13 new testing sites were established	October 2020 new testing sites were established
Mass testing	Never	never
Thermal scanning	At Félix Houphouët-Boigny airport with thermal cameras	End January 2020 onwards At Tibhuvan International Airport
Contact tracing	March 2020, Identification and follow-up of contacts	March 2020 Especially for travellers on the same flight
Travel restrictions		
Recommended deferral of non-essential travel	March to June 2020	
Travel ban and closure of boarders	March to July 2020	March 2020 to July 2020 17 October 2020 limited commercial flights for tourists, namely trekkers, resumed

Thermal screening at entry/exit	March 2020 to April 2023	March 2020 to ongoing Health screening (questionnaire and temperature check) at 43 entry points from India and China
Mandatory COVID testing when travelling	July 2020 to April 2023, negative PCR test not older than 5 days required	March 2020 June 2023
Quarantine after travel	Encouraged non-mandatory self-isolation for two weeks	March 2020 to May 2023 Mandatory self-quarantine for China, Italy, Spain, Iran, South Korea, Germany, France, and Japan. Later for all travellers suggested self-quarantine
COVID-19 vaccination certificate needed for flights	Never (if vaccination certificate available PCR test certificate not needed)	Never (if vaccination certificate available PCR test certificate not needed)
Increase immunity through vaccination		
Vaccination campaigns	March 2021, start of vaccination and awareness raising campaign	January 2021, start of vaccination in first priority groups (health and social front-liners and elderly)

5. Appropriateness of specific containment measures for SARS-CoV-2

To flatten the epidemic curve, it has proved necessary to adopt early measures such as case finding, contact tracing, isolation of suspected and confirmed cases, social distancing, and national lockdowns (24). Later in the COVID-19 pandemic, large-scale vaccination campaigns were complementing these non-pharmaceutical interventions. This chapter refers to essential evidence on various non-pharmaceutical containment measures and their appropriateness regarding practicality and effectiveness.

Flaxman and colleagues assessed the impact of different non-pharmaceutical interventions in 11 European countries. They show that major containment measures, lockdowns in particular, have a large effect on reduction of transmission (25). Cascini *et al*. report another more detailed cross-country comparison of COVID-19 containment measures in five European countries (France, Germany, Italy, Spain, and the UK) and their effects on the epidemic curves (26). The authors looked at containment measures, their timing and duration, and their impact on the countries incidence rates. They conclude that there are three main factors affecting the SARS-CoV-2 pandemic in these five countries: 1) timing of adoption of containment measure (the earlier the better), 2) duration of containment measure adoption (early restrictive measures prior the lockdown gave better results than no restrictive measures prior lockdown),

3) prevalence in COVID-19 cases before easing the containment measures (the lower the better) (26).

Talic *et al*. conducted a meta-analysis to assess the effect of handwashing, mask wearing, and physical distancing measures on the incidence of COVID-19. They conclude that these personal and social protective measures are associated with decrease in virus circulation (27).

The World Health Organization released a brief on syndromic screening (fever and respiratory or other symptoms) for COVID-19 in travellers crossing land borders and international rivers (28). WHO states that there is lack of evidence to support syndromic screening for COVID-19 at land or international river boarders to reduce transmission and that there is a need for additional research on the effectiveness or success of syndromic screening versus testing, quarantine and other public health and social measures or syndromic screening coupled with other health measures (28).

Alecta *et al*. modelled the SARS-CoV-2 transmission dynamic in the Boston metropolitan area using mobility, census and demographic data (29). They conclude that a response system based on enhanced testing, contact tracing, and isolation of cases plays a major role in relaxing social distancing interventions without exceeding the capacity of the health care system in the absence of herd immunity against SARS-CoV-2 (29).

A study by Leung *et al.* revealed that early in into the pandemic, conventional control strategies such as lockdowns, stay at home requests, and school closures, could not completely stop the transmission of SARS CoV-2 in many countries (30). By contrast, centralized digital contact tracing (i.e. via an app tracking movement of infected and exposed individuals) was associated with a decline in number of new cases (30). However, digital contact tracing bears the issues of right to privacy and placing public interests above individual rights (31, 32).

Zhong et al. developed a country distance approach to capture the pandemic's propagation backbone tree from airline mobility networks and evolving outbreak locations (33).Through this they evaluate the effectiveness of travel restriction (i.e. entry ban, global travel ban, lockdown) on delaying infections and therefore reducing the pandemic burden. All travel restrictions at that time (June 2020), reduced 36.3% of passenger influx from the global mobility network, therefore delaying the disease in the world by 15.6 days on average and reduce cases by over 13 million (33). Especially travel restrictions at the very early stage of the pandemic proved to be effective (33). However, they further conclude that the majority (63.2%) of travel restrictions were ineffective (33). Their country distancing approach captures the global diffusion pattern, despite the heterogeneous response of governments to the pandemic and varying outbreak locations, and therefore enables to design optimized and coordinated travel restrictions (33). Full early travel bans for travellers from China on the other hand, was considered highly effective in Australia (34).

An extensive analysis using data from 68 countries revealed that mainly social distancing measures such as school closures, shut-downs of non-essential business, mass gathering bans, travel restrictions in and out of risk areas, national border closures and/or complete entry bans, and nationwide curfews decrease the growth rate of the coronavirus (35). Another very comprehensive modelling analysis by Haug *et al*. indicates that a suitable combination and timing of non-pharmaceutical interventions is necessary to reduce the spread of SARS-CoV-2 (36). Less disruptive and costly containment measures can be as effective as more intrusive and drastic ones (i.e. national lockdowns). The research team therefore used country-specific “what-if” scenarios to assess the effectiveness of interventions and their combinations, offering country-specific simulations that can improve the planning of future outbreaks (36).

It is difficult to globally rank containment measures according to their appropriateness or effectiveness; as, for any given situation, there are many influencing factors (eg. mobility, economy, social factors, and culture) and the epidemic profile of each setting is different. Setting-specific scenario modelling can therefore help to plan the best-fitted control strategy for a country (35, 36).

6. Conclusions on containment measures

Effective containment measures were crucial in managing and mitigating the impact of the COVID-19 pandemic. Best practices encompass a multifaceted approach that included: vaccination campaigns, testing strategies, public health guidelines (e.g. mask wearing, social distancing), and community engagement.

In Côte d'Ivoire, a comprehensive approach to COVID-19 containment measures has been used. The government has prioritized vaccination campaigns to achieve widespread immunity. Efforts were made to ensure equitable vaccine distribution, focusing on vulnerable population groups. Testing strategies emphasised an early detection through widespread and regular testing. Public health guidelines, including mask-wearing and social distancing, were emphasized, with clear and consistent communication to enhance public understanding and compliance. The success of public health guidelines showed to be subject to effective communication and widespread compliance, which may be influenced by factors such as socio-economic disparities, cultural practices, and misinformation. Community engagement was part of Côte d'Ivoire's strategy. Local leaders were involved in disseminating information and addressing community-specific concerns, fostering trust and cooperation. The government adapted guidelines based on scientific evidence and communicated transparently, encouraging individuals to take personal responsibility.

Similarly, in Nepal, COVID-19 containment measures were characterized by a multifaceted approach. Vaccination campaigns prioritize vulnerable populations, and testing strategies focus on early detection through widespread testing. Robust testing strategies focusing on early detection were crucial components, but the effectiveness may be contingent upon the accessibility of testing facilities, particularly in remote areas. Public health guidelines, such as mask-wearing and social distancing, were enforced, with transparent communication to ensure public compliance. These public health guidelines were challenged by ensuring widespread compliance, influenced by factors such as cultural practices and socio-economic disparities. Community engagement has also been emphasized, with local leaders playing an essential role in disseminating information and addressing specific concerns. International collaboration were sought to enhance preparedness and response efforts.

Thus, both Côte d'Ivoire and Nepal showcase good practices in COVID-19 containment, emphasizing vaccination, testing, clear communication, community engagement, and international cooperation. Looking back, most containment measures implemented by Côte d’Ivoire and Nepal during the COVID-19 pandemic were well-grounded and appropriate. However, even retrospectively, it is difficult to judge on the specific combination and timings of measures set in place in these countries. Nepal started very early and long travel restrictions, with the exception of trekkers and mountaineers tourism, which is of course a major business for the country. Whereas Côte d'Ivoire focused its movement restrictions on the capital city and point of entry for international air and sea travel. Overall, Côte d'Ivoire put in place many containment measures early in the pandemic, and then constantly reduced them over the time of the pandemic. Nepal on the other hand, also started with a high stringency index at the beginning of the pandemic and started to ease the measures. However, Nepal reacted with a second national lockdown to the second wave dominated by the Delta variant of COVID-19 (with a steep increase in deaths) in May 2021. The effective detection and management of cases on one hand and the tracing of contacts on the other hand bring challenges for many reasons (e.g. logistically, privacy reason, data collection and management etc.).

Nevertheless, we know that for countries it is most important in an ongoing epidemic or pandemic to have good surveillance and management system in place in order to be able to efficiently detect, isolate, and manage cases, trace contacts, share data and see infection patterns to guide the optimal and fast decisions making. Further, vaccination stands out as a cornerstone in the battle against COVID-19. Governments and health organizations worldwide emphasize the importance of widespread vaccination to achieve herd immunity and reduce the severity of illness. Prioritizing vulnerable populations and promoting equitable vaccine distribution were important components of successful vaccination campaigns. Robust testing strategies played a pivotal role in identifying and isolating cases promptly. Public health guidelines, including mask-wearing, social distancing, and hand hygiene, were also fundamental. Clear and consistent communication about these measures, along with the rationale behind them, fostered public understanding and compliance.

In summary, an effective COVID-19 containment strategy integrates vaccination, widespread testing, clear public health guidelines, community engagement, and international collaboration. Flexibility and adaptability in response to the evolving situation contribute to successful containment and management of the pandemic.

PART B: Deployment and acceptability of SORMAS in Côte d'Ivoire and Nepal

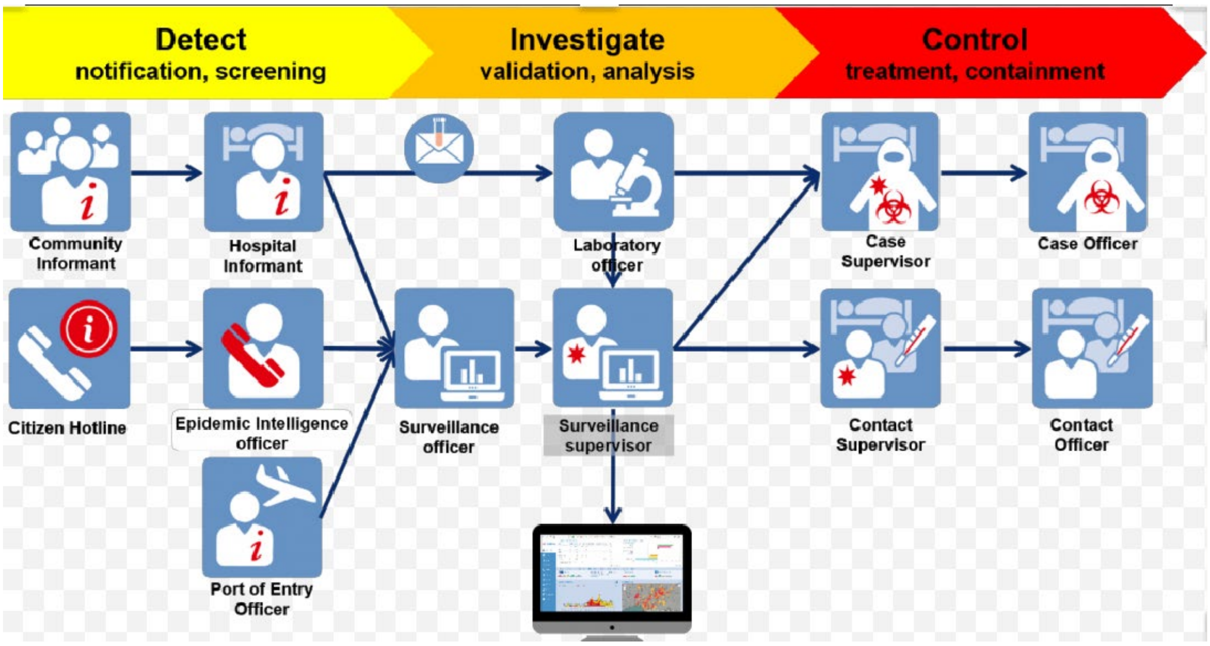
This section presents the deployment and acceptability of SORMAS in the pilot areas of Côte d'Ivoire and Nepal. Results for the acceptability of SORMAS in Côte d'Ivoire are published in a manuscript in BMC Public Health entitled: '*Introduction and Acceptability of the Surveillance Outbreak Response Management and Analysis System (SORMAS) during the COVID-19 pandemic in Côte d'Ivoire*' (37).

The analyses for Côte d'Ivoire compare the data collected at baseline, prior to the implementation of SORMAS and after its regular use. Unfortunately in Nepal, the implementation of SORMAS has not yet been fully complete, we therefore can present data from Nepal of the baseline interviews only.

1. Background

The software SORMAS (Surveillance Outbreak Response Management and Analysis System) was developed by Nigerian and German partners as part of their experience during the Ebola virus outbreak in West Africa in 2014-2015. SORMAS is an open source mobile and web application that enables health care workers and surveillance officers to notify health services or politicians and decision makers of new cases of infectious diseases, and to manage the response to such outbreaks or epidemics. SORMAS covers 43 diseases and provides disease-specific process models (with algorithms for case definitions and classifications, implemented in line with WHO standard guidelines) for 16 of them. Furthermore, it offers specific interfaces for 12 different types of users, such as clinicians, epidemiologists and laboratory workers (see **Figure 5**). SORMAS is free of cost and respects the highest data protection standards, good scientific practice and the open access policy. SORMAS' vision is to improve the prevention and control of communicable diseases, especially in low-resource settings, and should be customized in collaboration with those involved in public health surveillance and monitoring disease control.

Figure 7 SORMAS software allows simultaneous workflow and interlinkages. Illustration by the Helmholtz Center for Infection Research



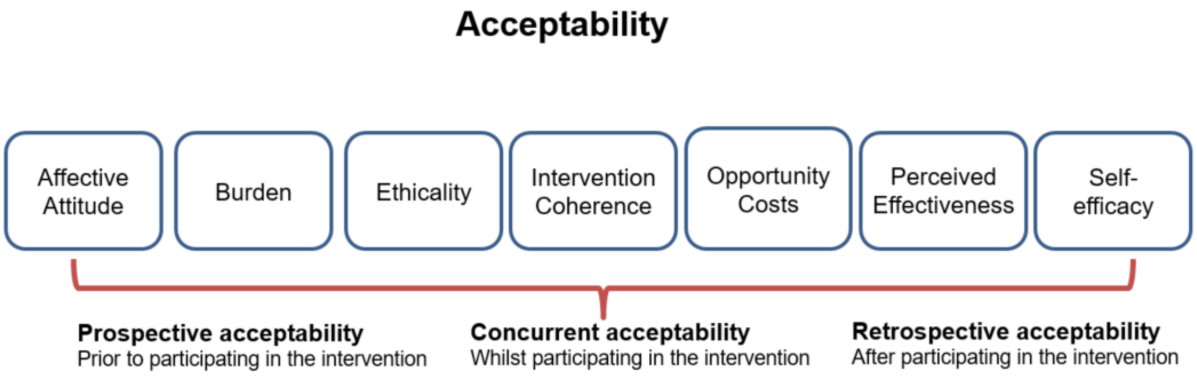
In 2017, soon after its deployment in Nigeria, SORMAS successfully contributed to the response to three simultaneous large outbreaks caused by monkey pox, Lassa fever and bacterial meningitis. Publications in high impact peer-reviewed journals highlight the usefulness of SORMAS for preparedness and response in Nigeria (38-40). Since then, the number of clinicians, nurses, laboratory technicians, public health workers, and epidemiologists using SORMAS on mobile tablets or desktop computers has continued to grow. Currently, SORMAS is used by healthcare professionals on a routine national or subnational level in Germany, Ghana, and Nigeria. In Luxemburg, SORMAS is currently being implementing at national level for all notifiable diseases. On a subnational level, it was used during the COVID-19 pandemic in Cameroon, Central African Republic, France, Fiji, Gabon, the Republic of the Congo, the Republic of Chad, and Switzerland. Additionally, it is in pilot phase in Côte d'Ivoire, Nepal, Tanzania, and Tunisia.

A study by Tom-Aba and colleagues published in 2018 compared SORMAS to other similar tools in terms of functionality and technical characteristics, and assessed user perception, acceptance and use during the Ebola disease outbreak in West Africa 2014-2015 (41-43). Healthcare professionals have found SORMAS to be very useful, acceptable and have reported improvements over time.

On 11 March 2020, the World Health Organization declared the COVID-19 outbreak a pandemic. One important containment measure in Côte d'Ivoire as well as Nepal consisted in strengthening the surveillance by screening for SARS-CoV-2 by rt-PCR (real-time polymerase chain reaction); testing of symptomatic persons, contacts of confirmed cases, persons with comorbidities and travelers. In addition, rapid antigenic tests have been made available to hospitals to enable timely management of patients. For the surveillance and management of the COVID-10 pandemic, different surveillance software was deployed in Côte d'Ivoire the software of the company MAGPI or District Health Information System 2 (DHIS2). AS the surveillance systems in Côte d'Ivoire and Nepal do have their limitations, for example in data analysis and scope of services included, the potential of SORMAS was tested.

While WP1 conceived and deployed a strategy for implementing SORMAS in Nepal and Côte d'Ivoire, WP4 has been focusing on implementation challenges at health service going along this deployment of SORMAS. Particular emphasis has been placed on two aspects; namely (i) acceptability of SORMAS and (ii) process and outcome of complex interventions such as SORMAS.

Figure 8 The theoretical framework of acceptability comprising seven component constructs (Note: According to Sekhon *et al*. The seven component constructs are presented alphabetically with their anticipated definitions. However, the extent to which they may cluster or influence each of the assessments of acceptability remains an empirical question).



The concept of acceptability of new intervention or surveillance system has several definitions. In general, it refers to the degree to which the intended programme beneficiaries, as well as those involved in implementing a given intervention, consider it to be congruent with cultural beliefs and values. The framework of Sekhon *et al*., highlights seven dimensions of acceptability: (i) perceived effectiveness; (ii) affective attitude; (iii) intervention coherence; (iv) ethicality; (v) self-efficacy; (vi) opportunity costs; and (vii) experienced intervention burden.

The UK Medical Research Council (MRC) issued a framework in 2000 and updated it in 2006, providing guidance for researchers and research funders in the development and evaluation of complex interventions such as SORMAS. Despite widespread use, conceptual, methodological, and theoretical advancements have occurred since. Recognizing these developments, a new framework was established in 2021 (44, 45). This updated framework incorporates these advancements and is designed to assist researchers in collaboration with various stakeholders. The previous framework and guidance were grounded with a prime interest to determine the effectiveness of an intervention. However, focusing solely on this question in complex intervention research might result in interventions that lack practicality, cost-effectiveness, transferability, and scalability in real-world scenarios. To address this limitation and provide solutions applicable to real-world practice, it is crucial for complex intervention research to engage early and robustly with different stakeholder groups such as patients, health workers, and policy makers. This shift redirects the focus from a simplistic 'binary question of effectiveness' to an exploration of whether and how interventions can be acceptable, implementable, cost-effective, scalable, and transferable across various contexts. Consequently in the frame of piloting SORMAS in Côte d'Ivoire and Nepal a key question is about practical effectiveness – whether the intervention works in everyday practice – in which case it is important to understand the whole range of effects, how they vary among recipients of the intervention, between sites, over time and the causes of that variation. Within the deployment of SORMAS, it consequently will be of interest to study and analyse the process as well as the outcome of the deployment of SORMAS and its effects.

In the frame of the European Union funded CORESMA project (COVID-19 Outbreak Response combining E-health, Serolomics, Modelling, Artificial Intelligence and Implementation Research), we investigated if the use of SORMAS improves the process and outcomes of COVID-19 preparedness and surveillance measures with the main objective to study the acceptability of SORMAS for district and local users, as well as regional and national decision-makers.

To be noted that SORMAS was implemented in the frame of WP1 for COVID-19 surveillance in two pilot areas in Côte d'Ivoire. Further implementation was planned for two pilot regions in Nepal in the frame of the WP1. At the time of this report, SORMAS was not in regular use in the pilot areas of Nepal and therefore only baseline results can be shown for Nepal. The objective of the **Part B** of this report is the assessment of the acceptability and usability of SORMAS by users and COVID-19 decision makers in the pilot areas of Côte d'Ivoire and Nepal.

2. Methods

Study area and participants

For the pilot implementation of SORMAS in Côte d'Ivoire, two health regions were selected: urban Abidjan 2 in the South with five health districts, and rural Gbêkê in the Center with six health districts. This selection of the regions was done by the National Public Health Institute (INHP) overseeing epidemic/pandemic surveillance in Côte d'Ivoire. Similar in Nepal, two pilot provinces were identified: Gandaki and Sudurpaschim. In these two provinces, we included a total of six districts.The acceptability of SORMAS and its potential as an epidemiological surveillance tool was captured through semi-structured interviews with COVID-19 decision makers (district and regional directors) and SORMAS users (district surveillance officers and their deputy, health care providers from referral hospitals, surveillance officers of the two regions and the officers of the national reference laboratory). We included health personnel and decision makers involved in COVID-19 surveillance and management in the pilot areas.

At baseline, participants were defined based on their position as future SORMAS users (surveillance officers, health care providers, laboratory personnel) or decision makers (district and regional directors). However, according to the function in a given institution, a participant could simultaneously act as a SORMAS user and a decision maker. Hence, at follow-up, we asked for their involvement in decision making and active use of SORMAS. Therefore, some participants answered questions on both the use of the software and decision making at both time points.

Data collection

The questionnaire covered personal information, general knowledge on COVID-19, information on conventional surveillance systems for disease monitoring (including COVID-19), acceptability of SORMAS, and impact of SORMAS on epidemic preparedness and surveillance. We considered the guidance document by MRC for evaluating complex interventions so understand the practicability, transferability and scalability of SORMAS (44, 45).

The framework of Sekhon *et al*. with its seven dimensions of acceptability was used as a basis for our questionnaire: (i) affective attitude; (ii) experienced intervention burden; (iii) ethicality; (iv) intervention coherence; (v) opportunity costs; (vi) perceived effectiveness; and (vii) self-efficacy (46). We covered these seven components in a semi-structured questionnaire, tailored to the country with the input of Ivorian stakeholders involved in the health system and disease surveillance. The adaptations and additions made to the framework of Sekhon were mainly related to the knowledge on COVID-19 and conventional surveillance systems, such as the COVID-19 definition and case management, as well as the country-specific control measures and conventional surveillance. For most questions on acceptability we used a five-point Likert scale, with scores of one being the least acceptable and five the most acceptable (e.g. 1 – '*not at all*', 2 – '*rather not'*, 3 – '*neutral'*, 4 – '*rather yes*', 5 – '*yes, clearly*'). The questionnaires in French and Nepali were uploaded into the electronic data collection tool ODK (Open Data Kit).

Experienced enumerators were selected and trained for two days on the specific data collection and ODK use. The testing, piloting and finalizing of the questionnaire was conducted during this training.

In Côte d'Ivoire, in July and August 2021, the Institut National d'Hygiène Publique (INHP) and the Helmholz Centre for Infection Research (HZI) conducted introduction and training events on SORMAS to future SORMAS users and COVID-19 decision makers in each pilot region . On the last day of these activities, we conducted the baseline questionnaires of this implementation study. In March 2022, the same enumerators received a refresher training on how to conduct the survey and were given an introduction to the adapted follow-up questionnaire. The questionnaire was again tested prior to the second data collection. All respondents from the first round or their successor were contacted and an individual date for an interview was arranged, when possible. The second round of the survey took place in March 2022, around 6-8 months after the implementation of SORMAS and its regular use by the health care personnel and decision makers.

In Nepal, trainings of SORMAS users and COVID-19 decision makers were given by the Epidemiology and Disease Control Division (EDCD) and HZI in April 2022 on province and district level and in August 2023 on municipality level. Also in Nepal, the baseline data collection on the acceptability of SORMAS was conducted after the training.

Statistical analysis

All questionnaire data were imported for analysis in STATA v16.1 (Stata Corp. LLC, College Station, USA). We checked the data for plausibility and if needed contacted the participants for clarifications. Especially some categorization of functions (active user and decision maker) needed double-check in order to be in line with our definitions. Answers to open questions were translated from French and Nepali to English for analysis. Descriptive data analysis of the scores was conducted and boxplot graphs were created to visualize the various aspects of acceptability and usability of SORMAS at baseline, before the implementation of the software, and for Côte d'Ivoire at follow-up, after its regular use.

3. Results

In Côte d'Ivoire, 136 questionnaires were applied, 70 at baseline (July and August 2021) and 66 at follow-up (March 2022). The majority were male (61.6%), and aged 35-44 years (35.6%). Active users were on average younger and more often female (majority 35-44 years, 43.1%

women) compared to decision makers (majority 45-54 years, 32.8% women). Further information on their function, SORMAS training, and tablet possession is presented in **Table 4**. At follow-up, 88.6% of SORMAS users and 89.7% of participants involved in decision making reported to be trained by INHP and therefore also participated in the baseline survey. Out of the 66 follow-up respondents, 44 (66.7%) reported to actively use SORMAS for data entry, and 39 (59.0%) participants reported to use SORMAS in any way for decision making. These decisions could be of various types, such as case management (following up on positive cases, isolating positive cases, and confining potential contacts), surveillance and awareness raising (increasing surveillance, public awareness to control the spread of COVID-19, putting in place awareness-raising strategies and intensifying awareness in alert areas), vaccination (sensitizing the population to get vaccinated, increasing vaccination coverage, and testing more people), screening and testing (increasing the number of screenings in the area, routine sampling, and raising awareness in alert areas), and case management and contact tracing (following up on the patient and their contacts, and identifying at-risk contacts). Among all respondents, 42.4% (n=28) received regular reports containing data from SORMAS. Of these, 35.7% (10) received quarter-yearly reports, 35.7% (10) received it monthly, 7.1% (2) weekly, and 21.4% (6) received them several times per week. It is important to note that pre-defined and automated reports were not implemented during this pilot.

Table 4 General characteristics of study participants in Côte d'Ivoire (37)

		Baseline (July/August 2021)		Follow-up (March 2022)	
		SORMAS users	Involved in decision making	SORMAS users	Involved in decision making
Participants (n)		58	19	44	39
Age group (n (%))					
25-34		14 (24.1)	1 (5.3)	5 (11.4)	5 (12.8)
35-44		21 (36.2)	4 (21.1)	18 (40.9)	14 (35.9)
45-54		17 (29.3)	8 (42.1)	13 (29.6)	11 (28.2)
55-62		6 (10.3)	6 (31.6)	8 (18.2)	9 (23.1)
Sex, female (n (%))		27 (46.6)	8 (42.1)	17 (38.6)	11 (28.2)
Function					
Health facility level	**Epidemiological surveillance focal point**	5 (8.6)	1 (5.3)	1 (2.3)	1(2.6)
	Healthcare provider	21 (36.2)	1 (5.3)	25 (58.8)	15 (38.5)
District level	**Epidemiologic surveillance officer**	10 (17.2)	--	8 (18.2)	7 (18.0)
	Deputy epidemiologic surveillance officer	6 (10.3)	--	7 (15.9)	4 (10.3)
	Director	1 (1.7)	9 (47.4)	1 (2.3)	7 (18.0)
Regional level	**Epidemiologic surveillance officer**	1 (1.7)	--	--	1 (2.6)
	Deputy epidemiologic surveillance officer	3 (5.2)	--	--	--
National level	**Lab data manager (Pasteur Institute)**	3 (5.2)	--	--	1 (2.6)
Others*		8 (13.8)	8 (42.1)	2 (4.6)	3 (7.7)
Trained at baseline by INHP (%)		58 (100)	19 (100)	39 (88.6)	35 (89.7)
Received a tablet from INHP (%)		47 (81.6)	5 (26.7)	42 (95.5)	28 (71.8)

*deputy head of health department; head of the monitoring, evaluation and health information management department; deputy director of department; sanitary engineer; health action officer; data manager; deputy head of the health department; head of monitoring and evaluation; care unit supervisor

In Nepal, 55 questionnaires were applied for the baseline acceptability assessment. The majority of interviewees were aged between 23 and 36 years, the most of them (81.8%) being male (**Table 5**). There were more users being interviewed (43) compared to decision-makers (12). The participant profile and titles can be found in **Table 5**.

Table 5 General characteristics of study participants in Nepal

Characteristic	
Age group (n (%))	
23-35	21 (38.2%)
36-45	15 (27.3%)
46-55	16 (29.1%)
56-65	3 (5.5%)
Sex (n (%))	
Female	10 (18.2%)
Male	45 (81.8%)
Participant profile (n (%))	
Decision-maker	12 (21.8%)
User	43 (78.2%)
Participant title (n (%))	
Central decision-maker	2 (3.6%)
Provincial decision-maker	2 (3.6%)
Local decision-maker	4 (7.3%)
District focal person	20 (36.4%)
Reference hospital care provider	2 (3.6%)
Director or lab personnel of Province Public Health Laboratory (PPHL)	2 (3.6%)
Lab data manager	7 (12.7%)
Trainers	3 (5.5%)
Health post and point of entry staff)	13 (23.6%)

Knowledge on COVID-19 management

In Côte d'Ivoire, at baseline 69.0% (40) of active users and 73.7% (14) of decision makers knew the definition of a confirmed and a suspected COVID-19 case (positive PCR test), respectively. At follow-up, 65.9% (29) of active users and 59.0% (23) of decision makers knew the current definition of a case. There was a better knowledge of, both active users and decision makers, on the duration of the quarantine period (91.3% of all study participants knew the correct duration) as compared to the isolation period of a case (76.9 %). Additionally, we found that overall, the knowledge concerning the quarantine period of a contact slightly decreased between baseline and follow-up (96.1% vs. 88.0%), whereas the knowledge concerning the isolation period of a case slightly increased (75.3% vs. 78.3%).

In Nepal, at baseline 27.2% (15) of participants knew the correct definition of a confirmed and suspected case (a positive PCR) and 5.4% (3) the duration of the quarantine period. We would like to note here, that most participants answered a positive PCR for the definition for confirmed case, but also added either symptoms or rapid tests in addition to this.

Conventional system

In Côte d'Ivoire, when asked about the channels used to communicate COVID-19 results to district surveillance officers or the person responsible for surveillance, respondents often mentioned more than one (**Table 6**). The most common form of communication was via email, both at baseline (41.4%) and at follow-up (53.0%). The least common communication method was paper at both time points. Between baseline and follow-up, there was an increase in persons reporting the use of an electronic platform and email as a means to communicate COVID-19 results. As shown in **Table 6**, concerning the recording tool used for COVID-19 surveillance and management, at baseline most respondents used the data collection software by the company MAGPI, followed by Excel, notification forms, and DHIS2. Several months later, the use of these tools considerably decreased and seems to have been replaced by the use of SORMAS, which was by far the most commonly used tool at follow-up.

Table 6 Tools for COVID-19 communication, surveillance and management activities in Côte d'Ivoire (several answers possible) (37)

	Baseline (n=70)	Follow-up (n=66)
Method of communicating results		
SMS	8 (11.4%)	9 (13.6%)
Phone	23 (32.9%)	25 (37.8%)
Email	29 (41.4%)	35 (53.0%)
Electronic platform	16 (22.9%)	23 (34.8%)
Paper	5 (7.1%)	7 (10.6%)
Others	3 (4.3%)	2 (3.0%)
Does not know	10 (14.3%)	4 (6.1%)
Tools used for COVID-19 surveillance and management		
DHIS2	8 (11.3%)	3 (4.6%)
MAGPI	28 (40.0%)	21 (31.8%)
SORMAS	na	47 (71.2%)
Excel	18 (25.7%)	11 (16.7%)
Notification forms	9 (12.9%)	2 (3.0%)
Book	3 (4.5%)	5 (7.6%)
Others	4 (6.1%)	6 (9.1%)
Does not know	11 (16.7%)	3 (4.5%)

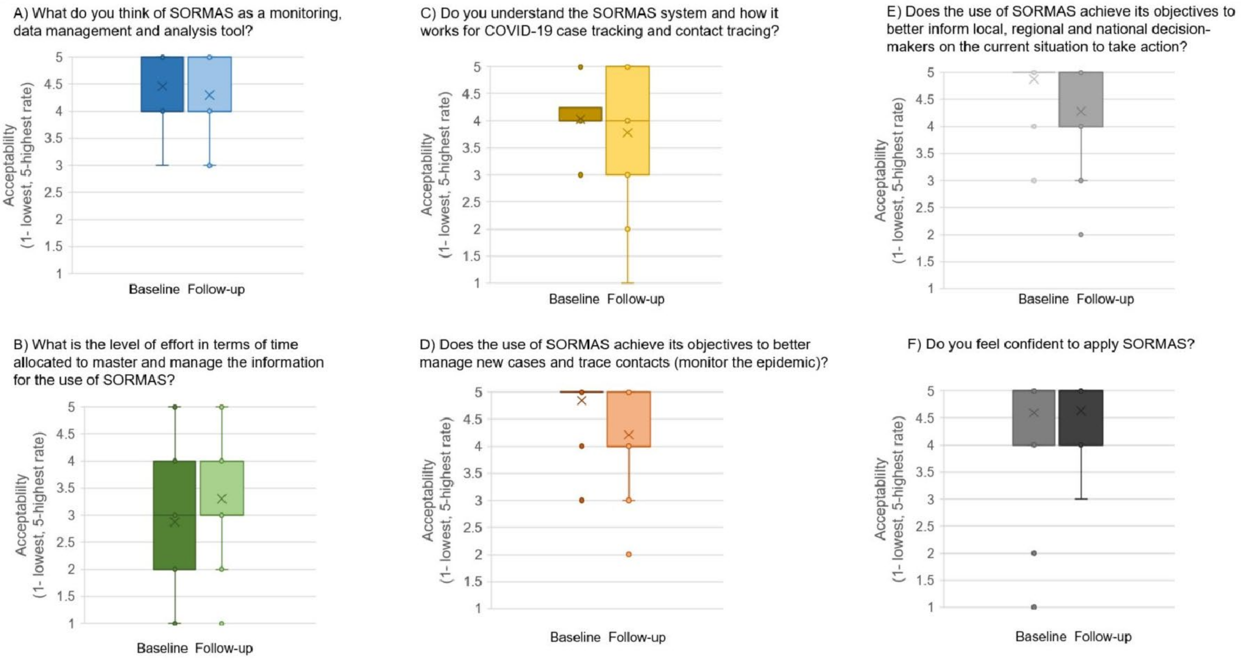
In Nepal, Respondents mostly reported that more than one method of tracking COVID-19 cases is being used. The most used was the electronic platform (67.3%), followed by email (36.4%) and phone/SMS (20.0%). There was also more than one surveillance system used; the most used was the Information Management Unit (IMU, 61.8%), followed by DHIS"

(40.0%), the Early Warning And Reporting System EWARS (27.3%), and excel (20.0%).

Acceptability of SORMAS

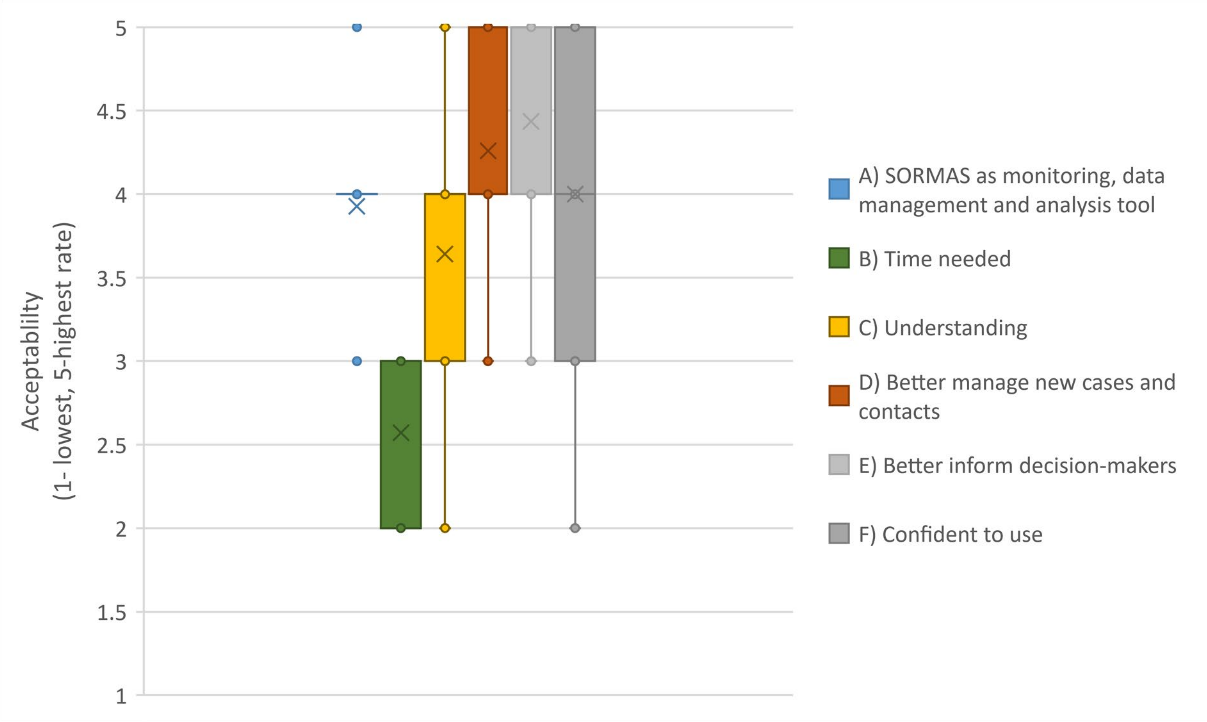
In Côte d'Ivoire, the overall acceptability of SORMAS as a monitoring, data management and analysis tool was "positive" to "very positive" (mean 4.5 out of 5) right after the user training at baseline, and stayed on a very similar level at follow-up (mean 4.3, **Figure 6**). At baseline, participants anticipated a "medium" amount of time to manage SORMAS (mean 2.9), this shifted more towards "little" (mean 3.4) at follow-up. Interestingly, the answers on the understanding of SORMAS right after the training were quite uniform at good (mean 4.0, minimum 3), but after several months of using the software more or less routinely the understanding dropped slightly and was overall more diversely perceived (mean 3.7, minimum 1). Responses concerning the objectives of SORMAS 'to better manage new cases and trace contacts and, therefore, monitor the epidemic and to better inform local, regional and national decision makers on the current situation to take action' very uniform and positive (**Figure 6**). At baseline, respondents were clearly agreeing that SORMAS achieves its objective to better manage the epidemic (mean 4.8, 4 meaning "rather yes" and 5 "yes, clearly"). Similar results were found concerning the use of SORMAS to better inform decision makers' action (mean 4.9). Several months after implementation, at follow-up, these two indicators decreased both to a mean of 4.2. Right after the baseline training, 94.8% (55/58) of future active users were confident ("rather yes" or "clearly yes") to use SORMAS (mean 4.6), whereas at follow-up this decreased to 84.1% (37/58; mean 4.7). In contrast, prior to its implementation, around 14.3% (10) of interviewees expected that there would be advantages and benefits that users would have to give up the engagement of SORMAS, but at follow-up only 4.5% (3) of the participants raised this issue. The main concern brought up by participants was the additional time needed to enter the data in SORMAS, in addition to entering it the conventional system, MAGPI. The systematic real-time notification of COVID-19 cases meant surveillance officers had to work during additional weekends and, therefore, negatively impacted their work-life balance.

Figure 9 Acceptability of SORMAS at baseline and follow-up in Côte d'Ivoire (graph taken from Barth-Jaeggi *et al.* (37))



In Nepal, as shown in **Figure 7**, the overall acceptability of SORMAS as a monitoring, data management and analysis tool was "positive" (mean 3.9 out of 5) right after the user training at baseline. The participants anticipated a "medium" to "fairly important" amount of time to manage SORMAS (mean 2.6), showing the lowest level of acceptability among all indicators. The answers on the understanding of SORMAS right after the training were at "medium" to "good" (mean 3.6). Most respondents were agreeing that SORMAS achieves its objective to better manage the epidemic (mean 4.3, 4 meaning "rather yes" and 5 "yes, clearly"). Similar results were found concerning the use of SORMAS to better inform decision makers' action (mean 4.4). After the baseline training, 72.7% (32/44) of future active users were confident ("rather yes" or "clearly yes") to use SORMAS (mean 4.0).

Figure 10 Acceptability of SORMAS at baseline in Nepal



Ability to improve COVID-19 preparedness and surveillance

In Côte d'Ivoire, at baseline, active users of SORMAS were very positive that it would increase epidemic preparedness (mean 4.8, 4 meaning '*yes, most cases*' and 5 '*yes, always*') and help early detection (mean 4.7). At follow-up these ratings decreased marginally (4.6 and 4.5, respectively; **Figure 7**). The implementation of SORMAS was reported to be smooth by most participants. Some mentioned that due to the fact that the COVID-19 case load decreased a lot during the pilot period in their health centers there was no regular use of the surveillance and management tools, which was an issue. Others experienced problems with their tablets or difficulties in synchronizing the data due to poor internet connection. Overall, many participants wished to receive a refresher training as well as to have more tablets to have the possibility to decentralize the work. The local, regional, and national decision makers answered various questions on the ability of SORMAS to facilitate the surveillance and management of the COVID-19 pandemic (**Figure 8**). At baseline, prior to the implementation of SORMAS, the expectations of decision makers were all very high. On a scale from one to five, the mean level of expectation that the use of SORMAS by surveillance officers, healthcare providers and laboratories would allow for better decision-making on risk assessment and containment measures (reports received in time with up-to-date data) was 4.8. The prospect of SORMAS to facilitate the development and communication of prevention recommendations to the population were as high as 4.9 (mean). Further, the expectation of SORMAS to facilitate the management of the COVID-19 pandemic (isolation, case management, preparation of equipment and infrastructure, etc.) reached a mean level of 4.8. The outlook on the facilitation on the establishment of alerts (proactive messages) and regular communication to the population ranked a mean of 4.8. After several months of implementation, these aspects dropped slightly but were still all between high to very high (**Figure 8**). Also, at follow-up, most respondents who used SORMAS for decision-making reported that the data produced by

SORMAS met their expectations to support decision-making. Their overall mean score of satisfaction was 4.5 (4 meaning '*rather yes*' and 5 '*yes clearly*'). The four people who mentioned that the data produced by SORMAS did not meet their expectations ('*rather not*' (2) and '*clearly not'* (1)) specified further that either they never received any results emerging from SORMAS, or that it provided them with incomplete data from which they could not take decisions, or that SORMAS did not show them the total number of confirmed cases, or that they did not have the necessary tools or access to SORMAS. During this pilot, 1585 COVID-19 cases were entered: 759 in Abidjan 2 (39 in Adjamé-Plateau-Attécoubé, 342 in Cocody Bingerville, 88 in Treichville-Marcory,70 in Koumassi,220 in Port Bouet-Vridi), and 826 in Gbêkê (19 in Bouaké Nord-Est, 111 in Bouaké Sud, 517 in Bouaké Nord-Ouest, 104 in Sakassou, 64 in Béoumi, 11 in Botro). After several months of more or less routine use, the main issues reported by SORMAS users were the connection that was missing between the laboratory data and the SORMAS platform, an existing feature of the software that could not be established in these two pilot areas of Côte d'Ivoire. Furthermore, SORMAS users suggested to open the use of this software for other endemic diseases that are already available in SORMAS, ensuring its synergistic and consistent routine use.

Figure 11 Impact of SORMAS on the level of preparedness and surveillance according to the active users in Côte d'Ivoire at baseline and at follow-up (graph from Barth-Jaeggi *et al.* (37))

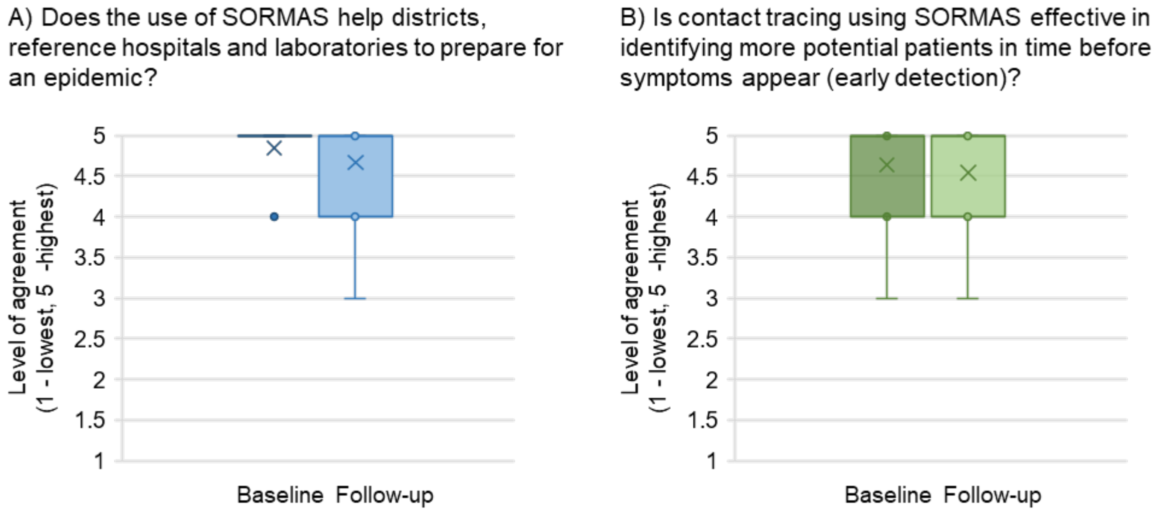
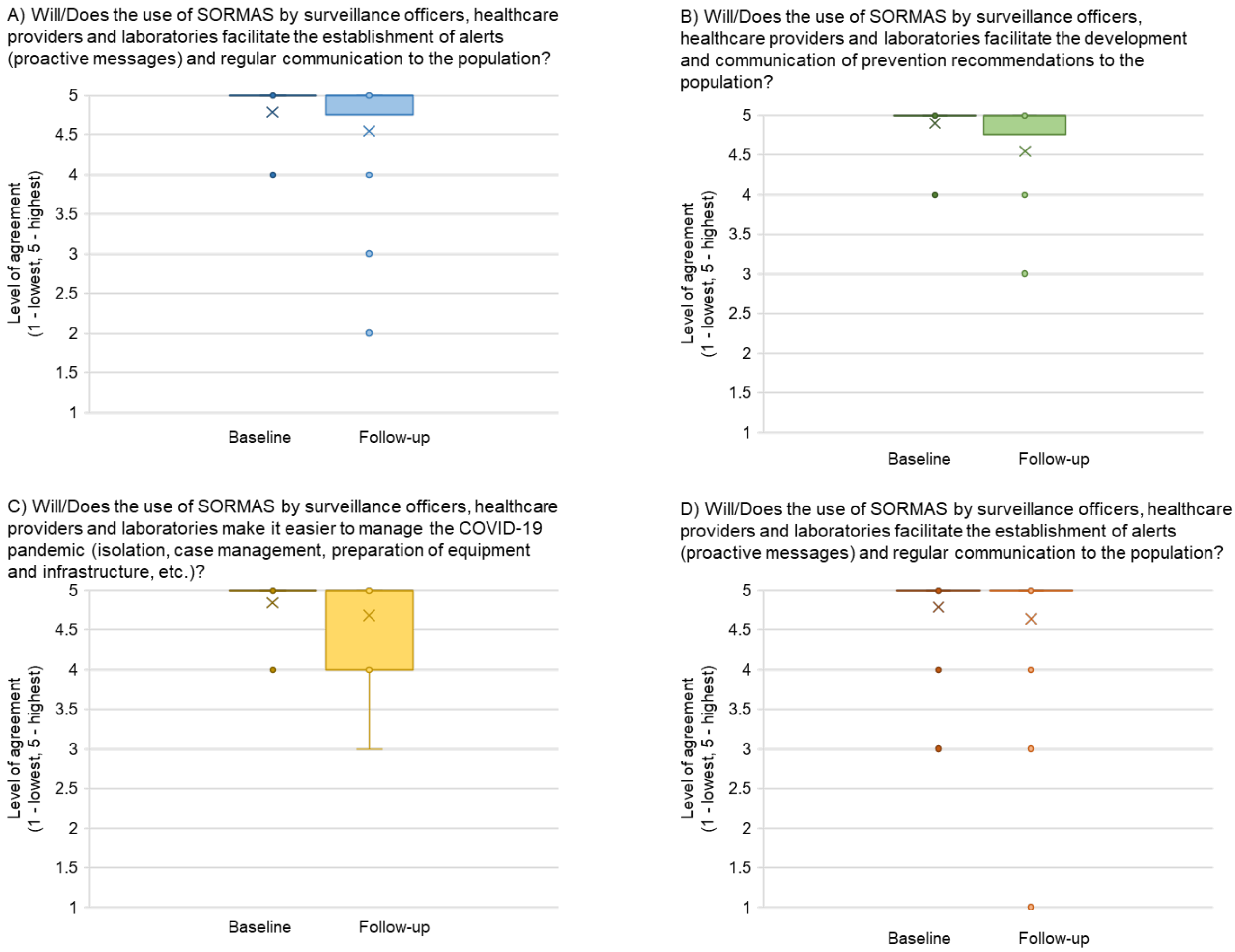


Figure 12 Decision makers' expectations (baseline) and perceived experience (follow-up) on SORMAS ability to facilitate COVID-19 management and surveillance in Côte d'Ivoire (graph from Barth-Jaeggi *et al.* (37))



In Nepal, as we do only have baseline data, we can only see the expectation on SORMAS on the impact on COVID-19 preparedness and surveillance right after the training and no insights

after a period of use. Overall, in Nepal future active users reported that SORMAS will help districts, reference hospitals and laboratories to prepare for an epidemic: 22.7% answered with '*yes, always* (5)'; 72.7% with '*yes, most cases* (4)' and one person answers 'moderately (3)', no answers were below the five-point Likert scale level of agreement below 3. This was similar for the Côte d'Ivoire baseline (**Figure 8 A**). However, the agreement was a lot lower on the statement for early detection: '*Will contact tracing using SORMAS be effective in identifying more potential patients in time before symptoms appear?*' Here in Nepal, 4.5% answered '*yes, always* (5)'; 54.5% with '*yes, most cases* (4)' 20.5 answered 'moderately (3)', 9.1% '*no, rather not*' and 11.4% did not know.
The expectations of decision makers for SORMAS' ability to facilitate COVID-19 management and surveillance in Nepal are shown in **Table 8**. Overall, the expectations on the impact of SOMRAS among the decision makers were all very high.

Table 7 Decision makers' responses to questions concerning the impacts of the use of SORMAS by surveillance officers, healthcare providers and laboratories

	SORMAS will allow to make better decisions on risk assessment and containment measures	SORMAS will facilitate the development and communication of prevention recommendations to the population	SORMAS will make it easier to manage the COVID-19 pandemic	SORMAS will facilitate the establishment of alerts and regular communication to the population
Not at all	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Rather not	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Moderately	1 (9.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Good	5 (45.5%)	5 (45.5%)	3 (27.3%)	3 (27.3%)
Very good	5 (45.5%)	6 (54.5%)	8 (72.7%)	8 (72.7%)
Don't know	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)

4. Discussion

Côte d'Ivoire has successfully introduced SORMAS in two pilot regions (Abidjan 2 and Gbêkê) and is operating the system to surveil and manage the COVID-19 pandemic since July and August 2021. Each study region has specific characteristics; Abidjan 2 is a densely populated area and an entry point for international air and sea travel with potentially high transmission rates, whereas Gbêkê is a more rural setting with lower transmission rates. National Public Health Institute (INHP), selected these two regions for piloting SORMAS given their different characteristics and so to get an understanding how effectively and efficiently the surveillance system operates in different settings. The capital city of Abidjan also experienced much more stringent containment measures compared to the rest of the country, such as movement restrictions (6). Overall, Côte d'Ivoire put in place a range of containment measures early in the pandemic, and then progressively reduced them over the course of the pandemic (11).

In Nepal, SORMAS was introduced to the two pilot provinces (Gandaki and Sudurpaschim) with a long series of advocacy meetings and trainings in 2022 and 2023, but until today we are not aware of its routine use. Therefore data from Nepal could only show expectations of decision makers and future users but could not be verified after regular use.

The sample size was determined by the number of health staff and decision makers trained on SORMAS and involved in the surveillance, management and analysis of the COVID-19 pandemic. A limitation of the study is that a comparatively low number of health personnel and decision makers has been involved in surveillance monitoring within SORMAS, this together with the nature of the questions, did lead to descriptive analyses rather than statistical analyses.

As this was a pilot study conducted during a pandemic, the pilot areas were simultaneously managing other surveillance and management tools. Therefore, this pilot implementation of SORMAS in Côte d'Ivoire and the need to enter all data on the official surveillance tools in addition to entering it in SORMAS, increased the work load of the public health staff during this exceptional time. On the other hand, it was certainly a unique opportunity to test and compare SORMAS under such conditions as the COVID-19 pandemic.

As seen in the piloting of SORMAS in Nigeria, the importance of early involvement of authorities and other stakeholders and the need for in-depth on-site training and supervision, as well as adequate technical capacity to adapt the tool to local needs are crucial (47). This pilot profited from previous experiences of the software under non-pandemic conditions, along with SORMAS experts from HZI providing continuous technical support. On the other hand, this pilot had to work under the conditions of an ongoing pandemic which brought the health staff and infrastructure to its limits (6).

The self-perceived understanding of SORMAS right after the training was very high in the Côte d'Ivoire (95%) and somewhat lower but still reasonable for Nepal, where 73% were confident to use the software. Overall this shows the usefulness and importance of the well-prepared user trainings. After several months of more or less regular use in Côte d'Ivoire, the self-perceived understanding of the software somewhat decreased (84%) and was considerably more diverse across all participants. This may be due to mobility of health workers and fluctuations in positions. For example as people who did not attend the original training, took over the task of managing SORMAS from their predecessor. Furthermore, real understanding and correct appraisal of knowledge gaps, can only be identified after regular use of a tool. Both points indicate the need for regular refresher trainings or other channels to allow the users to confidently use the software at all times. This desire for refresher trainings or other means of exchange was also directly stated by the SORMAS users in this survey. In this context, the SORMAS Foundation is developing a community platform to foster exchange through forums, groups, gamification, and file sharing (personal communication, platform: www.sormas.org).

An online surveillance system, despite being free of cost, requires equipment and its maintenance and comes with running costs for its routine operation. Therefore, the regular maintenance and exchange of tablets, as well as the host server need to be budgeted by the user country for successful and sustainable implementation of the tool. In this pilot we could see the need for additional tablets designated for SORMAS to ensure regular and decentralized data collection and entry.

SORMAS is able to connect all actors from health care personnel to laboratories to data managers. Unfortunately, during the implementation in the pilot regions of Côte d'Ivoire the connection to the national reference laboratories was not feasible. There was already an established national notification system from the central laboratories for PCR results (trace tube). Over time, many cases were then confirmed via rapid tests, directly in the health facilities, reducing the samples being tested in laboratories. Our pilot showed that users would have liked to have the connection between the laboratories and the SORMAS database. Another process that the software would allow but was not established in Côte d'Ivoire is the delivery of regular pre-defined and automated reports. During this study, the data from SORMAS used for decision-making was depending on the individual retrieving of the data from the system. This led to some concerns of missing data or entire reports.

At baseline the largest negative impact on acceptability of SORMAS in Côte d'Ivoire and Nepal was the fear of the additional workload and time needed to handle the software. This was somehow less distinct after several months of regular use in Côte d'Ivoire. However, there were still concerns about the additional efforts on health personnel that were already challenged during the pandemic. All districts used the national software MAGPI and to some extend DHIS2, therefore, the use of SORMAS in this pilot created not only additional work but a double entry effort. A study in Nigeria confirms that vertical programs lead to duplication of efforts, inequitable funding, and inefficiencies in surveillance (48). The ability of SORMAS to improve COVID-19 preparedness and surveillance was rated very highly by decision makers at both time points, meaning this software would be suitable to react faster and more appropriately to a disease outbreak. Similar findings were reported in a study by Leung and colleagues that conducted an analysis of various containment strategies and found that centralized digital contact tracing tools were associated with a decline in numbers of new cases (30). However, the national surveillance and management system MAGPI is currently not suitable for contact tracing. Opening SORMAS to other diseases was an important aspect of this pilot and was implemented during the further continuation of the pandemic. Currently, in Côte d'Ivoire, SORMAS is being used for measles, yellow fever, meningitis, cholera and COVID-19 in the two pilot regions. This ensures consistency and through the use of synergies also sustainability even after the COVID-19 pandemic has ended.

5. Conclusions on acceptability and deployment of SORMAS

Côte d'Ivoire

The surveillance and monitoring tool, SORMAS, was successfully implemented for COVID-19, in the two pilot regions of urban Abidjan 2 and rural Gbêkê, Côte d'Ivoire. The acceptability of SORMAS was high, but its sustainable implementation needs close supervision, regular refresher trainings and/or other channels to ensure skilled users, and maintenance of infrastructure, such as mobile devices and the host server. The potential of SORMAS for epidemic preparedness, surveillance and management with early case detection and evidence-based decision-making (containment measures, communication, management, and alerts) for infectious disease outbreaks has been shown to be substantial. By adding other endemic infectious diseases such as measles, yellow fever, meningitis, and cholera in SORMAS, it becomes a valuable tool that ensures consistency and transferability between the different diseases and uses synergies to achieve a sustainable solution. SORMAS, therefore, provides a valid, country-adapted and well acceptable surveillance, management, and analysis tool for Côte d'Ivoire that would ensure the country to be prepared for future outbreaks and epidemics.

Our findings are concentrated on the acceptability, practicability and transferability aspects of the surveillance tool during its pilot implementation. The scale-up of the tool was on one side promoted through adaptation to the setting and inclusion of additional diseases to surveil, but in the end proved to be not enough to overcome the challenges of the running costs, continuous training and maintenance efforts. Therefore SORMAS is presently not any longer in use in Côte d'Ivoire. There are however discussions under way as per 2023 to redeploy, further test and validate the use of SORMAS by National Institute of Public Health with the support of the West African Health Organisation (WAHO) and the German International Technical Cooperation (GiZ).

Nepal

SORMAS could not be fully implemented in Nepal during the time of this study. Therefore we are only able to present the perceptions and expectations of the future users and decision makers right after their training by EDCD and HZI. Similarly we are not able to judge on the practicability, transferability and scalability of SORMAS in Nepal. Self-rated understanding of SORMAS in Nepal was a bit lower, compared to the Côte d'Ivoire, but still 3 out of 4 were confident to use it. The overall acceptability of SORMAS was high. Somewhat reluctance to the effectiveness of SORMAS for early detection.

Plans to use SORMAS for several diseases in Nepal are established and the software is well adapted to the country needs. As there is a long gap between trainings and the full implementation of the software, refresher trainings will be needed in Nepal. If this is given, SORMAS, could provide a valid, country-adapted and acceptable surveillance, management, and analysis tool for Nepal that would ensure the country to be prepared for future outbreaks and epidemics.

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