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Impact of COVID-19 on Biological Diagnosis of Malaria: Case of the Thierno Mouhamadoul Mansour Barro Hospital in Mbour, Senegal

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Abstract

Background: In Africa, malaria-endemic regions have not been spared from COVID-19 outbreak which emerged in the first quarter of 2020. This pandemic has shown clinical and therapeutic similarities with malaria. This following study sought to determine the impact of COVID-19 on the malaria diagnosis. **Method:** A review of laboratory registers and an exploitation of the District Health Information Software 2 (DHIS2) to collect information on the diagnosis of malaria by microscopy and by rapid diagnostic test (RDT), but also that of COVID-19 was done from 2017 to 2021 at the Thierno Mouhamadoul Mansour Hospital in Mbour, Senegal. **Results:** In 2017, 199 Thick drops (TDs) and 1852 RDTs were performed for malaria diagnosis. In 2018, it was 2352 malaria tests with 2138 RDTs and 214 TDs, before reaching a peak of 3943 tests in 2019 including 3742 RDTs and 201 TDs. By 2020, 2263 tests were performed with 2097 malaria RDTs, 158 TDs and 8 COVID RDTs. The latter increased significantly in 2021, reaching 444 COVID RDTs, while TDs and malaria RDT kept decreasing to 147 and 1036 respectively. Positive TDs were higher in 2020 (11.4%) compared to 2017 (3.5%), 2018 (1.4%), 2019 (6.5%) and 2021 (6.8%). For malaria RDTs, a decrease in the number of positive tests was noted between 2017 (4.5%) and 2021 (1.3%). The COVID RDTs were all negative in 2020, 29.5% were positive and 4.1% were undetermined in 2021. **Conclusion:** COVID-19 has led to changes in efforts to diagnose malaria as well as an increase in malaria prevalence directed towards children under 5 years of age.

Keywords

Impact, COVID-19, Biological Diagnosis, Malaria, Senegal

1. Background

In order to eradicate malaria, the World Health Organization (WHO) recommended several control strategies and programs including promoting the use of long-lasting insecticidal nets (LLINs), intermittent preventive treatment (IPT) for pregnant women and infants, and seasonal malaria chemoprevention (SPC) [1] [2] [3]. These different strategies have led to a considerable reduction in the global burden of malaria relative to the beginning of the century. Hence, the global incidence of malaria has fallen from 81 in 2000 to 56 in 2019. The same was true for malaria mortality, which fell in the same period from 896,000 to 558,000 [4]. However, in its latest annual report, the WHO highlights a break in the curve in 2020 with 14 million more cases and 69,000 more deaths recorded than in 2019, *i.e.*, an increase of 12% [4]. This might be explained by the fact that in the first quarter of 2020, a new pneumonia called coronavirus 2019 (COVID-19) emerged and spread rapidly across the world [5]. In less than three months, more than 125,000 people were infected and about 4600 deaths were reported. The pathogen of this disease is the severe acute respiratory syndrome coronavirus 2 (SARS-COV-2) [6]. The regions of Africa where malaria is endemic have not been spared by this pandemic. In Senegal, the first case was recorded on 2 March 2020 [7] [8]. In an attempt to contain the virus, several measures were adopted by Senegalese health authorities which included a state of emergency declared on 23 March 2020 throughout the country, the closure of public spaces, and the introduction of a curfew [9]. Globally, enormous resources have been deployed to contain the spread of the disease in affected countries, and every health community centers were mobilized [10] [11].

The occurrence of an infectious disease outbreak in malaria-endemic countries is a serious threat that could result in a devastating effect. This was the case during the previous Ebola outbreak in West Africa from 2014 to 2016. In Guinea, for example, 1067 deaths related to malaria were officially reported in 2014 compared to 108 in 2013. Factors like close resemblance of Ebola's early symptoms to malaria contributed in difficulties to diagnose the disease early which caused an increase of malaria cases [5].

COVID-19 and malaria also share similarities in their clinical presentation and empirical treatment. Furthermore, they share some pathophysiological features that support the overlap in clinical presentation [12]. These similarities and the previous experiences with Ebola have caused concern in malaria-endemic regions about this new infectious disease outbreak.

All of the above data suggest that this new pandemic could influence the diagnosis of malaria in endemic countries such as Senegal. Therefore, this research was carried out to determine the impact of COVID-19 on the biological diagnosis of malaria.

2. Methodology

2.1. Type, Period and Study Site

This cross-sectional descriptive study covered the period from January 2017 to December 2021. It was conducted at the Thierno Mouhamadoul Mansour Barro Hospital, formerly the Grand Mbour Hospital (**Figure 1**) in the medical region of Thiès, Senegal. This hospital has several departments including a clinical biology laboratory where this study was carried out. The qualified staff is composed of a pharmacist-biologist, a biologist-engineer and three senior technicians in biology.

2.2. Study Population

The study population consisted of individuals for whom a biological test for the diagnosis of malaria by microscopy or SD Bioline PfHRP2 RDT, as well as COVID-19 by RDT, had been performed in the study site.

2.3. Study Design

Prior to the study, an approval was gained from the head of the laboratory to start data collection. Only thick drop and COVID tests performed were collected. Data relative to thick drop test was collected using a data entry mask created on RED-Cap 11.1.0—2022 Vanderbilt University (https://redcap.ucad.sn/index.php) (Annex 1). The thick drop data collected from the bench registers on this software included: register number, patient's initials, age and the result. Two others entry masks were created on Microsoft Excel 2019, 16.60 (22041000) (RRID: SCR_016137) (Annex 2). The first one was designed to collect COVID RDTs data and the information collected was, the date of the test and its result, the patient's identifier, age. The second one was for malarias RDTs recorded on the Senegal DHIS2 database because most of the malaria RDTs tests results from this period were missing in the registers from the laboratory. In this last Excel software, the period, the age groups, the number of RDTs performed and the number of positive RDTs were collected (Annex 3).

Figure 1. Photo of grand mbour hospital.

2.4. Data Management and Analysis

The data set was extracted into a Microsoft Excel 2007 file and analyzed using Epi Info 7.1.3.3 (RRID:SCR_021682) from CDC Atlanta. For better analysis, the population was subdivided into three age groups (<5 years; 5 years and older; ND subjects whose age was not provided).

Qualitative variables (sex, origin, diagnosis, etc.) were expressed as frequency or proportion with a confidence interval at 95%. Quantitative variables like age were expressed in terms of means with standard deviation.

2.5. Ethical Considerations

Approval from the head of the laboratory department was gained before the bench registers were used. The same applies to the Ministry of Health and Social Action for the use of data from the DHIS2. Patients were only identified by their initials to ensure anonymity.

3. Results

3.1. Evolution of the Number of Tests Performed over Time

A total of 12,236 biological tests were performed during the study period including 919 thick drops (TD) (7.51%; 95% CI = 7.05 - 8), 10,865 malaria RDTs (88.8%; 95% CI = 88.22 - 89.35) and 452 COVID RDTs (3.69%; 95% CI = 3.37 - 4.05). In 2017, 2051 tests were performed at the Mbour hospital laboratory, including 199 TD and 1852 malaria RDTs. In 2018, this total got to 2352 with 2138 malaria RDTs and 214 TDs, before reaching a peak of 3943 tests performed in 2019 including 3742 malaria RDTs and 201 GEs. By 2020, there was a decrease in malaria testing and COVID-19 diagnosis test started being performed. The overall number of tests carried out that year was 2263 with 2097 malaria RDTs, 158 TDs and 8 COVID RDTs, which showed an important increase in 2021, reaching 444 COVID RDTs, while the TDs and malaria RDTs continued to decline to 147 and 1036 respectively for a total of 1627 tests performed (**Figure 2**).

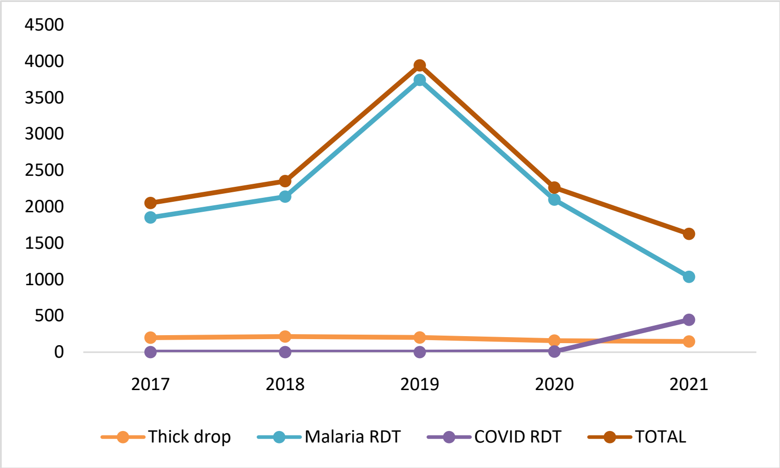

Figure 2. Number of malaria and COVID tests performed per year.

3.2. Distribution of Tests Performed According to Age

For TDs, the age was recorded for 894 individuals and ranged from 29 days to 89 years with an average of 28.68 (±19.84) years. For the COVID RDTs, the age was recorded for only 423 individuals. It ranged from 7 days to 101 years with an average of 45.59 (±20.16) years. Concerning the malaria RDTs, individuals were classified by age groups.

TDs tests were the most requested in the over 5 age group in 2017, 2018, 2019 and 2021. They represented 84.9% (CI 95 = 80 - 89.8), 88.3% (CI 95 = 84 - 92.6), 84.1% (CI 95 = 79.1 - 89.1) and 83% (CI 95 = 77 - 89) respectively of all tests performed. In 2020, most tests were performed within the under-5 age group (91.7%, CI 95 = 87.4 - 96). For malaria RDTs, over-5 group were mostly concerned by the tests, except in 2020 where they represented only 26.2% (CI 95 = 24.4 - 28). For COVID RDTs, the majority (91.6%, CI 95 = 89.1 - 94.1) of tests were performed in the over-5 in 2021 (**Table 1**).

3.3. Test Results by Year

The number of positive TDs was higher in 2020 (11.4%) compared to 2017 (3.5%), 2018 (1.4%), 2019 (6.5%) and 2021 (6.8%). For malaria RDTs, a decrease in positive tests was noted between 2017 (4.5%) and 2021 (1.3%). The COVID RDTs were all negative in 2020. In contrast, in 2021, 29.5% were positive and 4.1% remain undetermined (**Table 2**).

3.4. Overall Distribution of Test Results by Age

Positive tests were much higher in subjects over 5 years of age, regardless the test type. In fact, they represented 5% (CI 95 = 3.6 - 6.4) for TDs, 3.6% (CI 95 = 3.3 - 3.9) for malaria RDTs and 27% (CI 95 = 23 - 31) for COVID tests. For people below-5 age group, 0.4% (CI 95 = 0 - 0.8) tests were positive for TDs, 0.2% (CI 95 = 0.12 - 0.28) for malaria RDT and 0.4% (CI 95 = 0 - 0.9) for COVID. Finally, in subjects with unknown age, only 0.1% (CI 95 = 0 - 0.3) of the tests were positive for TDs and 1.5% (CI 95 = 0.4 - 2.6) for COVID (**Table 3**).

4. Discussion

This study conducted at the laboratory of the Thierno Mouhamadoul Mansour BARRO hospital in Mbour, aimed to evaluate the impact of the COVID-19 pandemic on the biological diagnosis of malaria. During data collection, we came across the fact that most of the clinical indications requested were not recorded. For some tests, the mention "not determined" was listed as results. Also, the age of some patients was not indicated. Similarly, on the DHIS2 database, the distribution of data according to sex was not mentioned in the reports. The presentation of the results of this study could then only be done according to age and therefore prevented us from better appreciating the impact of COVID on malaria diagnosis. These shortcomings led to a descriptive analysis of the data. In total, 12236 data were recorded including 919 TDs, 10865 malaria RDTs and 452

Table 1. Number of malaria and COVID tests performed per year according to age groups.

	2017			2018			2019			2020			2021		
	TD (N = 199)	Malaria RDT (N = 1852)	COVID RDT (N = 0)	TD (N = 214)	Malaria RDT (N = 2138)	COVID RDT (N = 0)	TD (N = 201)	Malaria RDT (N = 3742)	COVID RDT (N = 0)	TD (N = 158)	Malaria RDT (N = 2097)	COVID RDT (N = 8)	TD (N = 147)	Malaria RDT (N = 1036)	COVID RDT (N = 444)
<5 years	28 (14.7%; CI 95 = 5.1 - 24.3)	270 (14.6%; CI 95 = 13.1 - 16.3)	0	18 (8.4%; CI 95 = 4.7 - 12.1)	287 (13.4%; CI 95 = 12 - 14.8)	0	31 (15.4%; CI 95 = 10.5 - 20.3)	775 (20.7%; CI 95 = 19.5 - 21.9)	0	145 (91.7%; CI 95 = 87.4 - 96)	1549 (73.8%; CI 95 = 72 - 75.6)	0	15 (10.2%; CI 95 = 5.4 - 15)	338 (32.6%; CI 95 = 29.8 - 35.4)	16 (3.6%; CI 95 = 1.9 - 5.3)
>5 years	169 (84.9%; CI 95 = 80 - 89.8)	1582 (85.4%; CI 95 = 83.8 - 87)	0	189 (88.3%; CI 95 = 84 - 92.6)	1851 (86.6%; CI 95 = 85.2 - 88)	0	169 (84.1%; CI 95 = 79.1 - 89.1)	2967 (79.3%; CI 95 = 78.1 - 80.5)	0	9 (5.6%; CI 95 = 2.1 - 9.1)	548 (26.2%; CI 95 = 24.4 - 28)	0	122 (83%; CI 95 = 77 - 89)	698 (67.4%; CI 95 = 64.6 - 70.2)	407 (91.6%; CI 95 = 89.1 - 94.1)
ND*	2 (0.4%; CI 95 = 0 - 1.2)	0	0	7 (3.3%; CI 95 = 1 - 5.6)	0	0	1 (0.5%; CI 95 = 0 - 1.4)	0	0	4 (2.7%; CI 95 = 0.2 - 5.2)	0	8 (100%)	10 (6.8%; CI 95 = 2.8 - 10.8)	0	21 (4.8%; CI 95 = 2.9 - 6.7)

ND*: Not determined.

Table 2. Results of malaria and COVID tests per year.

	2017			2018			2019			2020			2021		
	TD (N = 199)	Malaria RDT (N = 1852)	COVID RDT (N = 0)	TD (N = 214)	Malaria RDT (N = 2138)	COVID RDT (N = 0)	TD (N = 201)	Malaria RDT (N = 3742)	COVID RDT (N = 0)	TD (N = 158)	Malaria RDT (N = 2097)	COVID RDT (N = 8)	TD (N = 147)	Malaria RDT (N = 1036)	COVID RDT (N = 444)
Positive	7 (3.5%; CI 95 = 1 - 6)	84 (4.5%; CI 95 = 3.6 - 5.4)	0	3 (1.4%; CI 95 = 0 - 2.9)	105 (5%; CI 95 = 4.1 - 5.9)	0	13 (6.5%; CI 95 = 3.1 - 9.9)	130 (3.5%; CI 95 = 3 - 4)	0	18 (11.4%; CI 95 = 6.5 - 16.3)	74 (3.5%; CI 95 = 2.8 - 4.2)	0	10 (6.8%; CI 95 = 2.8 - 10.8)	13 (1.3%; CI 95 = 0.7 - 1.9)	131 (29.5%; CI 95 = 25.3 - 33.7)
Negative	185 (93%; CI 95 = 89.5 - 96.5)	1768 (95.5%; CI 95 = 94.6 - 96.4)	0	207 (96.7%; CI 95 = 94.4 - 99)	2033 (95%; CI 95 = 94.1 - 95.9)	0	146 (72.6%; CI 95 = 66.6 - 78.6)	3612 (96.5%; CI 95 = 96 - 97)	0	128 (81%; CI 95 = 74.9 - 87.1)	2023 (96.5%; CI 95 = 95.8 - 97.2)	8 (100%)	118 (80.3%; CI 95 = 74.3 - 86.3)	1023 (98.7%; CI 95 = 98.1 - 99.3)	295 (66.4%; CI 95 = 62 - 70.8)
ND*	7 (3.5%; CI 95 = 1 - 6)	0	0	4 (1.9%; CI 95 = 0.1 - 3.7)	0	0	42 (20.9%; CI 95 = 15.3 - 26.5)	0	0	12 (7.6%; CI 95 = 3.5 - 11.7)	0	0	19 (12.9%; CI 95 = 7.9 - 14.9)	0	18 (4.1%; CI 95 = 2.3 - 5.9)

ND*: Not determined.

Table 3. Malaria and COVID test results by age groups.

	TD (N = 919)			Malaria RDT (N = 10865)			COVID RDT (N = 452)		
	Positive	Negative	ND*	Positive	Negative	ND*	Positive	Negative	ND*
<5 years	4 (0.4%; CI 95 = 0 - 0.8)	79 (8.6%; CI 95 = 6.8 - 10.4)	18 (1.9%; CI 95 = 1.1 - 2.7)	24 (0.2%; CI 95 = 0.12 - 0.28)	2194 (20.2%; CI 95 = 19.5 - 20.9)	0	2 (0.4%; CI 95 = 0 - 0.9)	14 (3.1%; CI 95 = 1.6 - 4.6)	0
>5 years	46 (5%; CI 95 = 3.6 - 6.4)	687 (74.7%; CI 95 = 71.9 - 77.5)	63 (6.8%; CI 95 = 6.6 - 8.4)	382 (3.6%; CI 95 = 3.3 - 3.9)	8265 (76%; CI 95 = 75.2 - 76.8)	0	122 (27%; CI 95 = 23 - 31)	267 (59.1%; CI 95 = 54.6 - 63.6)	18 (4%; CI 95 = 2.2 - 5.8)
ND*	1 (0.1%; CI 95 = 0 - 0.3)	20 (2.2%; CI 95 = 1.8 - 2.6)	3 (0.3%; CI 95 = 0 - 0.6)	0	0	0	7 (1.5%; CI 95 = 0.4 - 2.6)	22 (4.9%; CI 95 = 3.5 - 6.3)	0

ND*: Not determined.

COVID RDTs. Our results concluded in the increase of malaria RDTs and TDs tests between 2017 and 2019. However, from 2019 to 2021, these dropped in favor of COVID RDTs. This decline coincides with the onset of the COVID-19 pandemic. Containment and other restrictive measures introduced to slow down the virus transmission caused a lack of transportation which interrupted access to health care services and reduced people attendance to hospitals. Thus, the stigmatization of COVID-19 infected patients led the population to desert health facilities by fear of being infected or declared positive. This was noted by Diongue *et al.* [13] who stated that Senegalese avoided going to places where any test that might suggest COVID-19 was carried out. The "stay at home" policy put in place during the fight against COVID-19 could have influenced the population's reduced use of health services. A study conducted in Senegal by Ndiaye *et al.*

observed an average reduction in hospital visits of 19% during the first quarter of 2020, with a significant decrease of 33% in March [14]. This decline in facility attendance for the above reasons could explain the decrease in malaria diagnostic tests performed between 2019 and 2021. Furthermore, during the first wave of the pandemic, some global RDTs suppliers stated their intention to reallocate malaria RDT production capacity to COVID due to high demand [15]. These disruptions may have caused a shortage of input for malaria biology diagnostics, which could explain the decline in malaria tests performed in favor of COVID. According to the WHO report, 15 high malaria burden countries reported reductions of more than 20% in malaria testing in April-June 2020 compared to the same period in 2019 [4]. A study conducted in Uganda found similar results revealing a drop in the average number of patients who had a malaria RDT from the second half of the year after COVID [16]. It is important to mention that at the beginning of the pandemic, resources allocated to COVID-19 prevention were not sufficient for every health staff member. In a series of Global Fund spot checks in health facilities noted that 55% of facilities in Africa did not have sufficient basic PPE available for their workers [17] [18]. These highly exposed workers were particularly affected by COVID-19, with varying numbers of cases reported. For example, in the Sangalkam health district in Senegal, a quarter of the medical staff tested positive for COVID-19 between April 2020-2021 with an average absence of 13 days [19]. The Health care staff vulnerability and absenteeism have led to a decline in hospital services delivery with a reduction in capacity and limited consultations, which could also explain the decrease in tests performance.

The TD positivity rate increased from 6.5% in 2019 to 11.4% in 2020 before getting to 6.8% in 2021, highlighting a peak in positivity in the first-year post COVID. The interruption of certain malaria prevention strategies such as LLIN and IRS distribution campaigns could be implicated. WHO has reported a moderate disruption in the deployment of malaria services leading to a disruption in provision of malaria diagnostics and prevention tools in some African countries [4]. Health supply chain systems have experienced disruptions in transport from the manufacturing site to countries and within countries. Manufacturers delivered about 229 million LLINs to malaria-endemic countries in 2020, 24 million fewer than in 2019 [15]. Of the 31 countries that planned to distribute LLINs in 2020, 18 completed their campaigns by the end of the year and 6 had distributed less than 50% of the allocated nets by the end of 2020 [4]. This decline in preventive measures is likely to increase the population's exposure to malaria infection which increase malaria incidence. A study in Zimbabwe found a peak in malaria diagnostic test positivity during COVID-19 outbreak [20]. In Rwanda, on the other hand, there was no significant change in the overall hospital test positivity rate in the first few months after COVID, but a monthly increase of 3.05% was subsequently reported [21]. This increase was more noticeable in community settings than in hospitals [22].

Most malaria diagnostic tests were performed in the over-5 age group from

2017 to 2019, but in 2020 the trend was reversed with the under-5 age group receiving the most tests. As malaria prevention strategies are more focused on children and pregnant women, the disruption caused by this epidemic may increase the vulnerability of this age group.

Finally, among the results, we found that 91.6% of COVID-19 tests were performed in the over-5 age group at our study site. In this age group, the age ranged from 7 days to 101 years with an average of 45.59 years. These figures are close to those observed by Bousso *et al.* where the average was 41 years with extremes of 7 months and 101 years [23]. This age group was also the most affected by COVID-19 with 27% of positive cases in 2021. This could be explained by the structure of the Senegalese population. The 2019 population statistics indicate that 83.61% of this population is over 5 years of age with an average of 19 years. This age group therefore becomes the most exposed during infectious epidemics [24].

5. Conclusion

Malaria is an infectious disease caused by *Plasmodium* parasites, which are spread to people through the bites of infected female *Anopheles* mosquitoes. Over the past decade, the WHO recommendations have made it possible to note remarkable progress in malaria control. In 2019, a new infectious disease with high severity was declared worldwide. The occurrence of an infectious epidemic in malaria-endemic zone can induce major consequences, as demonstrated by the previous Ebola virus outbreak. This survey conducted in Senegal aimed to determine the impact of COVID-19 on the biological diagnosis of malaria. It was found that COVID-19 resulted in a decrease in the number of malaria diagnostic tests performed. Thus, there was an increase of malaria cases diagnosed after TDs and RTDs tests, especially in the beginning stage of the pandemic. Children below 5 years of age were the most affected group by malaria whereas children over 5 years suffered more from COVID-19. The limitations of this study included the lack of clinical data. Future research may determine the overall impact of COVID-19 on malaria incidence and mortality rate.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Tairou, F., Diallo, A., Sy, O., *et al.* (2022) Malaria-Associated Risk Factors among Adolescents Living in Areas with Persistent Transmission in Senegal: A Case-Control Study. *Malaria Journal*, **21**, 193. https://doi.org/10.1186/s12936-022-04212-8

[2] Mwesigwa, J., Achan, J., Tanna, G.L.D., *et al.* (2017) Residual Malaria Transmission Dynamics Varies across the Gambia despite High Coverage of Control Interventions. *PLOS ONE*, **12**, e0187059. https://doi.org/10.1371/journal.pone.0187059

[3] Organisation mondiale de la santé (2013) Chimioprévention du paludisme saison-

nier par administration de sulfadoxine-pyriméthamine et d'amodiaquine aux enfants. Guide de terrain.

[4] World Health Organization. World Malaria Report 2021. https://apps.who.int/iris/handle/10665/350147

[5] Wang, J., Xu, C., Wong, Y.K., *et al.* (2020) Preparedness Is Essential for Malaria-Endemic Regions during the COVID-19 Pandemic. *The Lancet*, **395**, 1094-1096. https://doi.org/10.1016/S0140-6736(20)30561-4

[6] Institut Pasteur. Maladie Covid-19 (nouveau coronavirus). https://www.pasteur.fr/fr/centre-medical/fiches-maladies/maladie-covid-19-nouveau-coronavirus

[7] Les Nations Unies au Sénégal. L'ONU confirme un premier cas de coronavirus parmi son personnel au Sénégal. https://senegal.un.org/fr/44373-lonu-confirme-un-premier-cas-de-coronavirus-parmi-son-personnel-au-senegal

[8] Dia, N., Lakh, N.A., Diagne, M.M., *et al.* (2020) COVID-19 Outbreak, Senegal, 2020. *Emerging Infectious Diseases*, **26**, 2771-2773. https://doi.org/10.3201/eid2611.202615

[9] Radio France international (2020) Coronavirus au Sénégal: Les mesures du gouvernement font l'unanimité. RFI. https://www.rfi.fr/fr/afrique/20200315-senegal-coronavirus-mesures-prises-largement-saluees-macky-sall

[10] Organisation des nations unies (2020) Cinq raisons qui expliquent le rôle essentiel de l'OMS pour lutter contre le Covid-19. ONU Info. https://news.un.org/fr/story/2020/04/1066332

[11] United Nations. Face à la pandémie, l'OMS multiplie recommandations et initiatives. https://www.un.org/fr/coronavirus-covid-19/face-%C3%A0-la-pand%C3%A9mie-l%E2%80%99oms-multiplie-recommandations-et-initiatives

[12] Gutman, J.R., Lucchi, N.W., Cantey, P.T., *et al.* (2020) Malaria and Parasitic Neglected Tropical Diseases: Potential Syndemics with COVID-19? *American Journal of Tropical Medicine and Hygiene*, **103**, 572-577.

[13] Diongue, K. and Diallo, M.A. (2020) COVID-19 during Malaria Transmission Season in Africa and Why We Should Be Prepared: An Example from Senegal. *African Journal of Laboratory Medicine*, **9**, 1332. https://doi.org/10.4102/ajlm.v9i1.1332

[14] Ndiaye, O., Fall, F.T., Faye, P.M., *et al.* (2020) Impact de la pandémie à COVID-19 sur les activités du Service de Pédiatrie du Centre Hospitalier National d'Enfants Albert Royer: Étude préliminaire comparant les premiers trimestres des années 2019 et 2020. *The Pan African Medical Journal*, **36**, Article No. 162. https://www.panafrican-med-journal.com/content/article/36/162/full

[15] World Health Organization. World Malaria Report 2020. https://www.who.int/teams/global-malaria-programme/reports/world-malaria-report-2020

[16] Namuganga, J.F., Briggs, J., Roh, M.E., *et al.* (2021) Impact of COVID-19 on Routine Malaria Indicators in Uganda: An Interrupted Time Series Analysis. *Malaria Journal*, **20**, 475. https://doi.org/10.1186/s12936-021-04018-0

[17] World Health Organization. In Fighting COVID-19, We Can't Neglect Malaria. https://www.theglobalfund.org/en/blog/2021-04-25-in-fighting-covid-19-we-cant-neglect-malaria

[18] Noel, L., Marion, E., Boufercha, R., *et al.* (2021) Dépistage du personnel de santé

exposé au SARS-CoV-2 dans un hôpital universitaire. *Infectious Diseases Now*, **51**, S64-S65. https://doi.org/10.1016/j.idnow.2021.06.138

[19] Diedhiou, B.B., Tine, J.A.D., Diabate, M., Seck, I. and Ndiaye, M. (2021) Profile of Workers Tested Positive for Sars-CoV-2 in Sangalkam Health District (Senegal). *Health* (*N Y*), **13**, 1278-1284. https://doi.org/10.4236/health.2021.1311093

[20] Zawawi, A., Alghanmi, M., Alsaady, I., *et al*. (2020) The Impact of COVID-19 Pandemic on Malaria Elimination. *Parasite Epidemiology and Control*, **11**, e00187. https://doi.org/10.4236/health.2021.1311093

[21] Hakizimana, D., Ntizimira, C., Mbituyumuremyi, A., *et al*. (2022) The Impact of Covid-19 on Malaria Services in Three High Endemic Districts in Rwanda: A Mixed-Method Study. *Malaria Journal*, **21**, 48. https://doi.org/10.1186/s12936-022-04071-3

[22] Afai, G., Banze, A.R., Candrinho, B., *et al*. (2021) Challenges for Malaria Surveillance during the COVID-19 Emergency Response in Nampula, Mozambique, January-May 2020. *The Pan African Medical Journal*, **38**, 254. https://doi.org/10.11604/pamj.2021.38.254.27481

[23] Abdoulaye, B., Badara, L.A., Ibrahima, S., *et al*. (2022) The Initial Management of the Covid-19 Outbreak in Senegal. https://www.semanticscholar.org/paper/The-Initial-Management-of-the-Covid-19-Outbreak-in-Abdoulaye-Badara/5d11430a258ffdb885e73416b974e1597680506b

[24] Agence Nationale de la Statistique et de la Démographie. Situation économique et sociale du Sénégal 2019, Janvier 2022. 42 p. https://www.ansd.sn/index.php?option=com_sess&view=sess&Itemid=398