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COVID-19 in North Africa: An Epidemiological Analysis of Cases, Deaths, and Vaccination Efforts (2020-2023)

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ABSTRACT

Background: SARS-CoV-2, the virus responsible for the COVID-19 pandemic, has caused a worldwide health crisis, impacting millions of individuals across the globe. The aim of this study was to conduct an epidemiological investigation into the progression of COVID-19 in the North African region, encompassing Morocco, Algeria, Tunisia, Libya, and Egypt, from January 2020 to May 2023, with a primary focus on analyzing and understanding the COVID-19 data in these five North African countries.
Materials & Methods: This research aimed to observe and analyze an international database from our World in Data, using SPSS and Excel, considering the number of COVID-19 cases, fatalities, and vaccination rates in the five specified North African countries.
Findings: Over the course of three years, a total of 3,722,560 new COVID-19 cases and 83,860 deaths were documented in North African countries, and the year 2021 emerged as the most devastating period with the highest number of COVID-19 cases (1,767,410) and fatalities (50,341) across the region. Among the countries studied, Morocco (34.23%) and Tunisia (31%) of cases, reported the highest infection rates. Similarly, the highest death tolls were recorded in Tunisia (35%) and Egypt (30%). Additionally, Morocco led the vaccination efforts in the region, administering 47% of the total of 384,851,069 vaccine doses.
Conclusion: The COVID-19 pandemic has posed a significant global health challenge, affecting each North African country differently, depending on various factors such as their population, control measures, and vaccination campaigns. This study emphasizes the importance of continued efforts and tailored strategies for each country in the region to combat the pandemic and effectively address the ongoing crisis.

Keywords: SARS-CoV-2, COVID-19, North Africa, Cases, Deaths, Vaccination

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Introduction

COVID-19, a viral disease caused by SARS-CoV-2, first emerged in Wuhan, China in December 2019 and rapidly spread across the globe, leading to a pandemic. This infectious disease has profoundly disrupted daily routines and social structures, resulting in financial insecurity, increased caregiving responsibilities, and elevated stress levels due to physical distancing measures [1, 2]. Its impact has been far-reaching, causing significant changes and disturbances in the lives of people worldwide. The pandemic has affected various communities indiscriminately, manifesting in some cases as mild flu-like symptoms and in others as severe pneumonia [3]. Since no effective antiviral therapies were available at the beginning of the pandemic, the urgent development of a safe and efficient vaccine became the primary hope to control the pandemic and restore normalcy [4].

How do the numbers of new COVID-19 cases, deaths, and vaccination rates in North African countries between January 2020 and May 2023 compare? Utilizing an international database for reliable regional COVID-19 data, this study sought to analyze these key indicators to provide insights into the progression of the disease and the effectiveness of vaccination efforts in the North African context.

Objectives: The findings are expected to contribute to our understanding of the pandemic's impact in this geographical area and inform potential strategies to manage and mitigate its effects in the future.

Materials and Methods

A comparative statistical epidemiological study conducted on the evolution of the COVID-19 pandemic in North African countries (Morocco, Algeria, Tunisia, Libya, and Egypt) from January 2020 to May 2023. The required data were obtained from an international database called our World in Data [https://github.com/owid/covid-19-data/tree/master/public/data] that had updated COVID-19 deaths, cases and vaccination rates since the start of the pandemic.

Data collection: The comprehensive data collection process involved literature search, observation, and analysis of data retrieved from the "Our World in Data" database. This database contains essential variables and daily records representing confirmed cases, deaths, and vaccination data. In this database, information is continuously updated from reliable sources, including the WHO COVID-19 data, the Oxford COVID-19 Government Response Tracker, and Johns Hopkins University.

Data analysis: The gathered data underwent statistical analysis using SPSS software (statistical package for social science) Version 25 and Excel Version 2019. Through these tools, tables and graphs were generated to analyze and present the findings.

Findings

This study results regarding COVID-19 cases, deaths, and vaccination rates in North Africa are presented in Table 1 that provides a comprehensive overview of the number of cases, deaths, and vaccination rates in each country in the region each year, and Table 2 which presents the comparison of these parameters, shedding light on the pandemic's impact in North African countries.

Distribution of new COVID-19 cases in North African countries: Figure 1 illustrates the new COVID-19 cases over the years 2020 to 2023, reaching a total of 3,722,560 cases during this period.

Notably, Morocco and Tunisia reported the highest number of cases with 1,274,180 (34.23%) and 1,153,261 (approximately 31%) cases, respectively, while Algeria was the least affected country with only 271,835

Table 1) COVID-19 cases/deaths and vaccination rates in North African countries

Country	Date	Cases	Cases (%)	Deaths	Deaths (%)	Vaccinations	Vaccinations (%)
Algeria	2020	99,311	2.67%	2,751	2.77%	/	0.00%
Algeria	2021	118,726	3.19%	3,520	3.53%	170,786	0.44%
Algeria	2022	53,180	1.43%	610	0.61%	/	0.00%
Algeria	2023	618	0.02%	/	0.00%	/	0.00%
Egypt	2020	136,643	3.67%	7,576	7.64%	/	0.00%
Egypt	2021	248,084	6.66%	14,151	14.27%	2,078,777	5.40%
Egypt	2022	130,805	3.51%	3,075	3.10%	78,722	0.20%
Egypt	2023	490	0.01%	28	0.03%	/	0.00%
Libya	2020	99,935	2.68%	1,459	1.47%	/	0.00%
Libya	2021	288,248	7.74%	4,237	4.27%	81,613	0.21%
Libya	2022	118,959	3.20%	741	0.75%	119,042	0.30%
Libya	2023	120	0.003%	/	0.00%	/	0.00%
Morocco	2020	437,332	11.75%	7,355	7.39%	/	0.00%
Morocco	2021	523,726	14.07%	7,489	7.53%	27,354,182	71.08%
Morocco	2022	310,490	8.34%	1,450	1.46%	53,973	0.14%
Morocco	2023	2,632	0.07%	3	0.00%	1,204	0.00%
Tunisia	2020	137,216	3.70%	4,620	4.65%	/	0.00%
Tunisia	2021	588,626	15.81%	20,944	21.07%	7,864,021	20.43%
Tunisia	2022	421,729	11.33%	3,720	3.75%	682,211	1.77%
Tunisia	2023	5,690	0.15%	131	0.13%	638	0.00%
Total	----	3,722,560	100.00%	83,860	100.00%	38,485,169	100.00%

Table 2) Comparison of deaths, cases and vaccinations among the studied countries

	Country				
	Algeria	Egypt	Libya	Morocco	Tunisia
	Mean	Mean	Mean	Mean	Mean
Cases	67,959	129,006	126,816	318,545	288,315
Deaths	1,720	6,208	1,609	4,074	7,354
Vaccinations	42,697	539,375	50,164	6,852,340	2,136,718

cases (7.30%).

Distribution of COVID-19 death cases in North African countries: Figure 2 illustrates COVID-19-related death rates in North African countries from 2020 to 2023, totaling 83,860 recorded fatalities. Notably, Tunisia with 29,415 (35.08%) deaths and Egypt with 24,830 (almost 30%) deaths reported

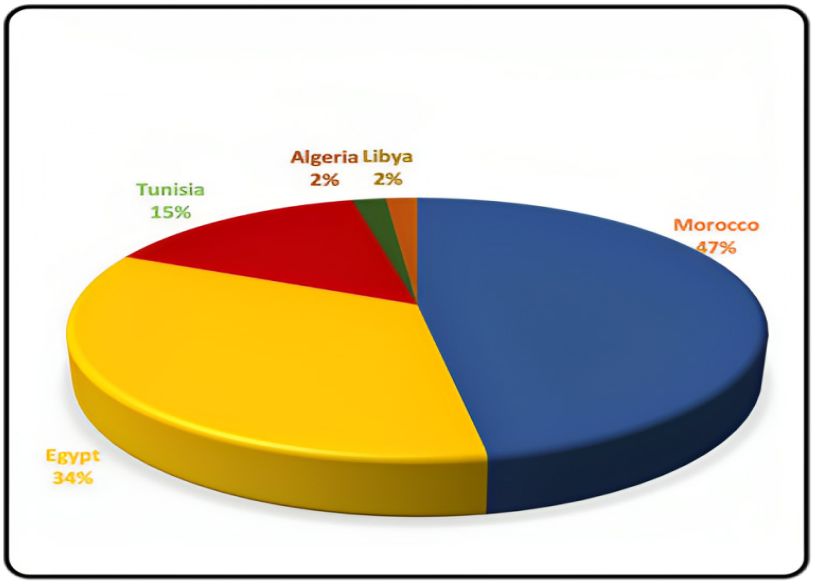

Figure 1) Distribution of cases in North African countries

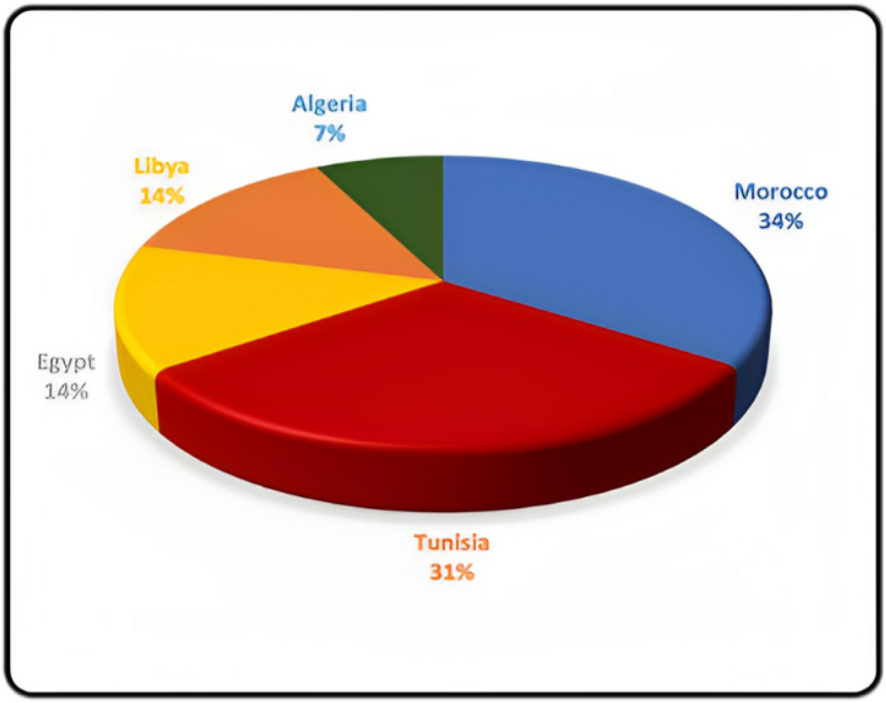

Figure 2) Distribution of COVID-19 death cases in North African countries

the highest death tolls from the virus, respectively. Conversely, Libya and Algeria recorded the lowest death rates with 6,437 and 6,881 deaths, respectively, each accounting for 8% of the total deaths.

Distribution of vaccination rates against COVID-19 in North African countries: Figure 3 displays cumulative vaccination rates from January 2020 to May 2023, totaling 384,851,690 recorded injections across North African countries. Remarkably, Morocco had the highest vaccination rate among its African counterparts, with 71.22% (27,490,359 individuals) of its population being vaccinated. In contrast, Libya and Algeria had the lowest vaccination rates,

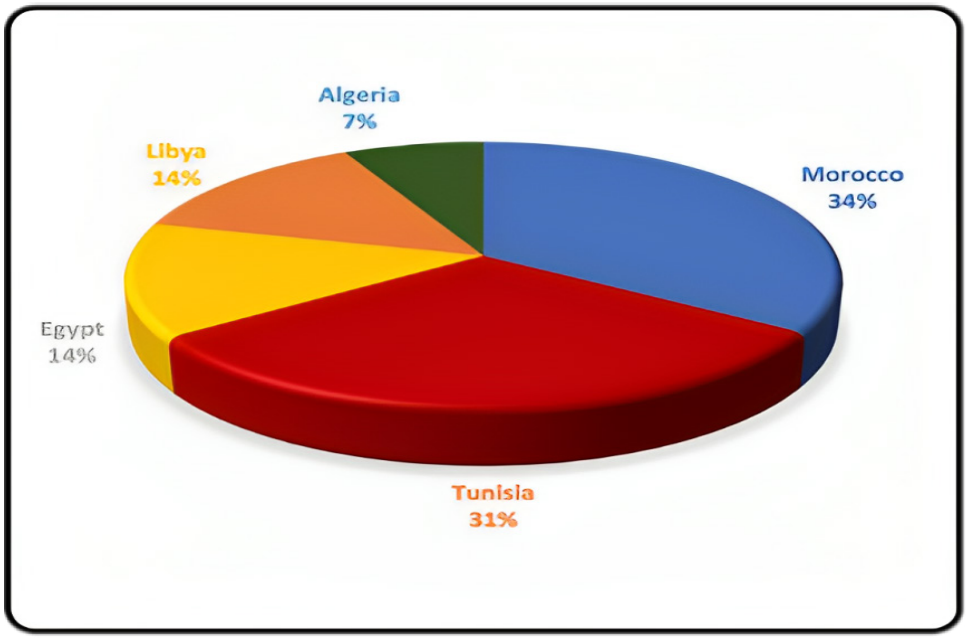

Figure 3) COVID-19 vaccination rates in North Africa

Table 3) Kruskal Wallis test results

	Kruskal Wallis Test by country		
	Cases	**Deaths**	**Vaccinations**
Kruskal-Wallis H	4.257	2.524	.925
df	3	3	3
Asymp. Sig.	.235	.471	.819

both vaccinating around 0.5% of their respective populations (200,655 and 170,786 doses administered, respectively).

Cases: The Kruskal-Wallis H statistic is 4.257 with 3 degrees of freedom, and the associated p-value is 0.235. The *p*-value suggests that there is no significant difference in the distributions of Cases among the countries.

Deaths: The Kruskal-Wallis H statistic is 2.524 with 3 degrees of freedom, and the associated *p*-value is 0.471. The p-value indicates that there is no significant difference in the distributions of Deaths among the countries.

Vaccinations: The Kruskal-Wallis H statistic is 0.925 with 3 degrees of freedom, and the associated *p*-value is 0.819. The *p*-value suggests that there is no significant difference in the distributions of Vaccinations among the countries.

Evolution of COVID-19 cases/deaths and vaccination rates in North African countries: Figure 4 and Tables 1-3 present the progression of key parameters in North African countries, highlighting notable trends over the years.

Discussion

The disparities in COVID-19 outcomes among North African countries can be attributed to distinct government measures implemented in response to the pandemic. Measures such as the closure of schools, educational institutions, and mosques as well as the suspension of air and maritime connections played crucial roles in mitigating the spread of the virus. Additionally, the adoption of total containment in the wilaya of Blida and partial containment in Algiers at

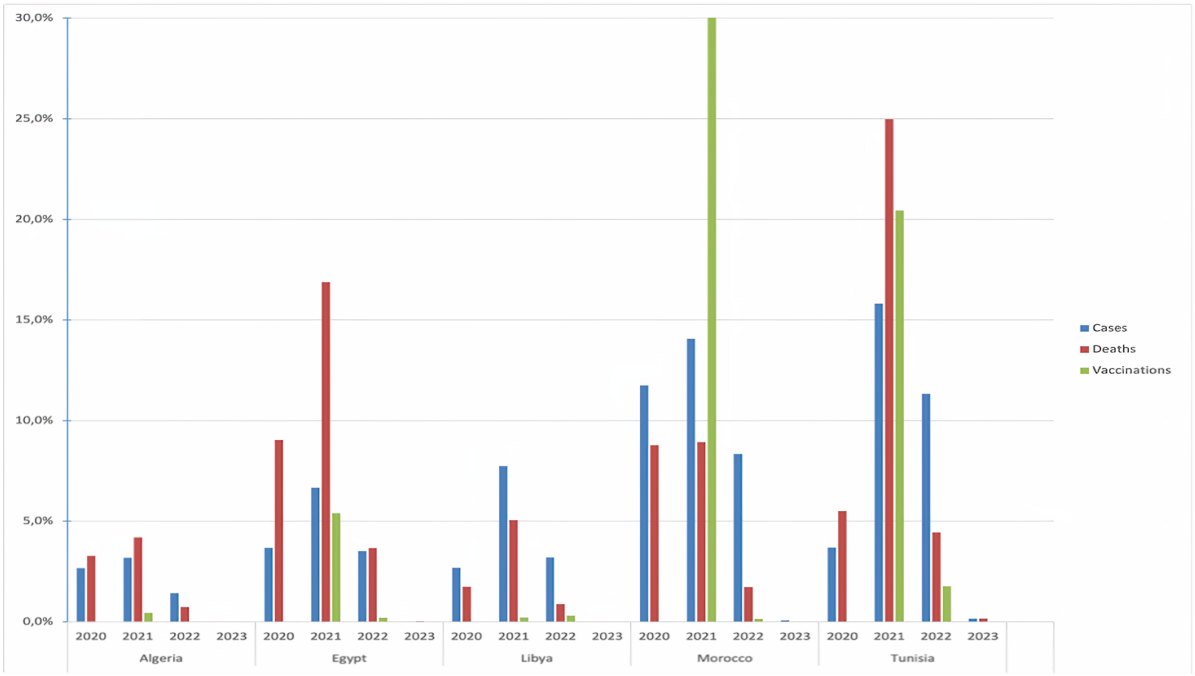

Figure 4) Evolution of COVID-19 cases/deaths and vaccination rates in North African countries

the initial stages of the epidemic [5] likely contributed to the variation in case numbers among these North African countries.

An interesting finding was that despite experiencing a large number of infected cases (1,274,180 cases), Morocco exhibited a comparatively lower mortality rate of 19.43% (16,297 deaths) compared to Tunisia and Egypt. This outcome suggests that Morocco's proactive approach, including the availability of virological reagents and laboratory tests to facilitate rapid isolation and protection of infected individuals [6], might have contributed to mitigating the impact of the virus. Additionally, strict quarantine measures and the implementation of compulsory vaccination campaigns in this country [7] might have played a crucial role in containing the spread of the virus and reducing the overall mortality rate.

Our analysis highlights the significance of implementing effective public health measures to combat the COVID-19 pandemic and provide valuable insights into the management of this disease for other nations facing similar challenges.

The vaccination rates findings underscore Morocco's notable achievement in implementing an effective awareness campaign and encouraging widespread vaccination uptake. According to a study, the country's success could be attributed to targeted email appeals, particularly focusing on students responding to public health initiatives [8].

Moreover, it is essential to highlight that despite a substantial number of vaccinations in Morocco, the overall infection rate remained high. However, the encouraging aspect is that the number of deaths decreased significantly. These observations reaffirm the effectiveness of vaccines in protecting against severe forms of the disease while not necessarily preventing infection altogether.

These data emphasize the importance of ongoing vaccination efforts and public health campaigns to curb the impact of COVID-19 in the region. As the number of people

receiving vaccines increases, the severe outcomes of the disease are expected to be further reduced, ultimately leading to better control and management of the pandemic.

Tracking the progression of COVID-19 across the years unveils distinct patterns and evolving dynamics in North African countries. Let's delve into the annual analysis to understand the shifting landscape of infections, mortality, and vaccination rates. In 2020, Morocco stood out with a relatively high infection rate of 11.75%, registering 437,332 COVID-19 cases, whereas Algeria, Egypt, Tunisia, and Libya reported infection rates between 2 and 4% with 99,311, 136,643, 137,216, and 99,935 infected cases, respectively. The highest mortality rate was recorded in Egypt with 7,576 (9.03%) deaths, followed by Morocco with 7,355 (8.77%) deaths. Libya reported the lowest mortality rate at 1.74% (1,459 deaths). It is important to note that the absence of vaccination data could be attributed to the unavailability of vaccines at the pandemic's outset [9]. However, the infection rate obtained in this study for Morocco (8.77%) differs from that reported in a previous study [10].

Moving to 2021, Tunisia experienced a significant surge in infection rate, reaching 588,626 infected cases (15.81%), closely followed by Morocco with 523,726 infected cases (14.07%). In contrast, the infection rate in Algeria was lower, reaching 3.19% (118,726 cases). The mortality rate in Tunisia reached ≈ 25% (20,944 deaths), while Algeria reported a lower mortality rate of 4.20% (3,520 deaths). These findings mark high infection and mortality rates in Tunisia in 2021, with Algeria experiencing the lowest rates of the studied parameters. Notably, another study reported lower percentages of new cases and deaths [6], contradicting our findings showing significantly higher infection and mortality rates in Tunisia. Regarding vaccination, Morocco led the vaccination efforts in the region with a vaccination rate of 71.08% (27,354,182 doses administered), while Libya had the lowest vaccination rate of just 0.21% (81,613 doses administered) [11]. These results are consistent with other studies findings underscoring Morocco's leading vaccination efforts compared to its North African counterparts [11, 13].

Moving to 2022, the infection rate in Tunisia remained high at 11.33%, whereas Egypt and Algeria recorded lower infection rates of 3.51 and 1.43%, respectively. The highest mortality rate was recorded in Tunisia at 4.44% and Egypt at 3.67%, while Algeria reported the lowest mortality rate of 0.73%. These findings align with the results of another study, corroborating high infection and mortality rates in Tunisia and Morocco and lower rates in Libya and Algeria [12]. Vaccination data revealed that Tunisia had the highest vaccination rate at 1.77%, while Algeria had no records of vaccine administration [13, 14].

In 2023, infection and mortality rates were almost negligible, ranging between 0.01 and 0.16%. Among the countries that carried out vaccination, Morocco and Egypt recorded vaccination rates between 0.002 and 0.003%, while other countries showed nearly zero vaccination rates, particularly Algeria.

In summary, the analysis results indicated that 2021 was the most challenging year for North African countries, characterized by high infection and mortality rates and variation in vaccination rates. In contrast, 2023 emerged as the least challenging year with significantly lower infection and mortality rates and minimal vaccination coverage. These findings provide valuable insights into the pandemic's fluctuating trends in the region and highlight the importance of sustained vaccination efforts to better manage the disease. Several

constraints and challenges were encountered during the course of this study, like variations in data reporting practices among different countries, variations in testing capacities and reporting practices, and the absence or incomplete availability of vaccination data for certain periods. Also, the study focuses primarily on government measures and vaccination efforts, possibly overlooking other factors that could influence COVID-19 outcomes, such as climate, population density, and international travel patterns.

Conclusion

The recent COVID-19 pandemic has emerged as a critical global health challenge, considering our analysis results revealing significant trends in North African countries. Specifically, the year 2021 stood out as the most challenging year, characterized by a surge in COVID-19 cases and deaths in the region and subsequently the highest vaccination rates. In contrast, the year 2023 marked significant declines in new cases, deaths, and vaccination rates, representing a relatively quiet period in comparison to the other years.

Among the North African countries, Morocco and Tunisia bore the brunt of new COVID-19 cases, thereby experiencing higher infection rates. Conversely, Libya and Algeria reported fewer cases during this period. In terms of COVID-19 deaths, Tunisia and Egypt recorded the highest figures, while Libya and Algeria had comparatively lower death tolls.

It is noteworthy that Morocco recorded the highest vaccination rate among North African countries. This successful vaccination campaign contributed to controlling the mortality rate, despite the significant number of reported cases. Algeria and Libya also showed commendable efforts in controlling the spread of the epidemic, resulting in the lowest infection and death rates compared to the other countries in the region.

Overall, the findings indicate that vaccination efforts play a crucial role in mitigating the impact of the pandemic, considering Morocco's success in effectively controlling mortality rates. As the region continues to combat the COVID-19 pandemic, the results of this analysis offer valuable insights for policymakers and healthcare authorities in implementing targeted strategies and vaccination campaigns to manage and mitigate the effects of the disease.

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Authors' contributions: Ilyes Zatla: literature search, data collection, data analysis, manuscript writing, manuscript editing, and manuscript review; Lamia Boublenza: conceptualization, manuscript editing, manuscript review, and supervision of the project; Amira Sebiane: manuscript writing and manuscript editing; Ikram Salah: manuscript writing and manuscript editing.

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