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Assessment of COVID-19 vaccination performance in Tlemcen: Insights into vaccine inventory management

Ilyes Zatla^{1,*}, Lamia Boublenza¹, Wafaa Lemerini², Dalale Behar¹, Bouchra Dahmani¹, Abia Khouani¹, Nabahate Selka³

1- Laboratory of Microbiology applied to the Food industry, Biomedical and the Environment, Faculty of Natural and Life Sciences, Earth and Universe Sciences. Department of Biology. University of Tlemcen, 13000, Algeria.

2 - Laboratory of Organic Chemistry, Natural Substances, and Analysis, Faculty of Natural and Life Sciences, Earth and Universe Sciences. Department of Biology. University of Tlemcen, 13000, Algeria.

3- MD in Epidemiology, Public Health Establishment Near Tlemcen (EPSP), 1300, Algeria.

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ABSTRACT

Background: The global response to the COVID-19 pandemic has been characterized by unprecedented vaccination efforts aimed at mitigating the spread of the virus and curbing its impact on public health. **Methods:** This study presents a comprehensive analysis of the vaccination campaign in Tlemcen, Algeria, focusing on vaccine distribution, utilization, and demographic trends. Data from the Public Health Establishment near Tlemcen were analyzed using Excel and SPSS to assess the distribution and management of five distinct vaccine brands: Sputnik, AstraZeneca, Sinopharm, Sinovac, and Janssen. Statistical analysis included the calculation of means, standard deviations, and percentages to evaluate vaccine distribution, uptake, and wastage. **Results:** The findings revealed varying levels of efficiency and challenges in vaccine management across different brands. Specifically, Sinovac had the highest administered doses at 93,908, representing 91.94% of its total imported vaccines. Sputnik had the lowest wastage rate, with no expired vaccines and only 10.35% lost doses. Age-specific trends in vaccine uptake highlighted Sinovac's prominence among the 50-64 and 65+ age groups, while Janssen was more popular in the 30-49 age group. Additionally, individuals with comorbidities showed a higher vaccine response to Sinovac, suggesting the need for tailored vaccination strategies for this subgroup. **Conclusion:** These findings provide valuable insights into the dynamics of the vaccination campaign in Tlemcen and contribute to ongoing efforts to optimize vaccination strategies and mitigate the impact of COVID-19.

Introduction

The COVID-19 pandemic has prompted an unparalleled global vaccination campaign, marking a pivotal moment in contemporary history. As the world grappled with the unanticipated onslaught of the pandemic, its toll surpassed what many had deemed conceivable (1, 2). With the identification of the causative agent and the decoding of its genetic

blueprint, efforts to develop a vaccine against SARS-CoV-2 commenced as early as January 2020. Multiple entities embarked on simultaneous vaccine development endeavors, employing a diverse array of vaccine platforms (3). Notable vaccines developed during this period include Sinovac and Sinopharm from China, Sputnik V from Russia, Janssen (Johnson & Johnson) from the United

States, and AstraZeneca from the United Kingdom. These vaccines utilized various technological approaches, such as inactivated viruses, adenovirus vectors, and recombinant protein platforms, reflecting the rapid and collaborative response to the pandemic.

While the precise magnitude of infections and fatalities remains elusive, COVID-19 has exacted a staggering toll, claiming at least seven million lives by May 5, 2023, prompting the World Health Organization (WHO) to rescind its declaration of a global health emergency (4). Vaccination emerged as a pivotal milestone in the pandemic narrative, with a staggering 13.3 billion doses administered worldwide. Presently, WHO reports that 89% of healthcare workers and 82% of individuals over 60 years have completed their primary course of COVID-19 vaccination, though coverage within these priority groups varies significantly across regions (5). Despite the WHO's proclamation of the pandemic's conclusion, vaccination efforts persist as new cases or reinfections continue to be reported, albeit at reduced rates (6).

At the outset of the COVID-19 crisis, Algeria found itself ill-equipped to confront the escalating threat, lacking both a coherent containment strategy and adequate medical infrastructure to manage the surge in cases (7, 8). Notably, Tlemcen, a province within Algeria, has actively engaged in vaccination campaigns, targeting individuals across diverse age groups and health conditions. This study endeavors to provide a comprehensive analysis of vaccination data in Tlemcen, from the start of the outbreak till the end of the year 2022, encompassing the distribution of five distinct vaccines and their administration for three doses.

Materials and Methods

This study is a descriptive, retrospective analysis of the vaccination campaign management at the University Hospital of Tlemcen during the COVID-19 pandemic.

Data collection

The data for this study were obtained from the Public Health Establishment near Tlemcen (EPSP) and encompassed records from the onset of the COVID-19 vaccination campaign in University Hospital of Tlemcen through December 2022. Data sources included vaccination logs, inventory records, and demographic information of vaccine

recipients. The primary variables collected comprised:

1. Vaccine Administration Data
 - Total doses administered for each vaccine type.
 - Distribution of first, second, and third doses across different age groups.
2. Demographic Data
 - Age and gender of vaccine recipients.
 - Presence or absence of comorbidities.
3. Vaccine Inventory and Utilization
 - Quantities of each vaccine type received, administered, or wasted.
 - Expired doses and wastage rates for each vaccine.

Data were collated by healthcare professionals at the EPSP and ethical approval for the use of anonymized data was obtained from relevant authorities. All records were anonymized prior to analysis to ensure privacy and confidentiality.

Data Analysis

The collected data underwent rigorous statistical analysis using SPSS software to unveil key insights and trends. Descriptive statistics, including mean, median, standard deviation, and frequency distributions, were computed to characterize the distribution of vaccinated individuals with either Sinovac, Sinopharm, Sputnik V, Janssen, or AstraZeneca across age groups and to quantify the prevalence of underlying morbidities within each cohort.

To ensure the robustness of findings, subgroup analyses have been conducted to investigate the consistency of results across different demographic strata or vaccination scenarios. The significance level was set at $p < 0.05$ to determine statistical significance in all analyses.

Results

Vaccine Distribution and Management

Table 1 provides a comprehensive overview of vaccine distribution, utilization, and management across five distinct vaccine brands deployed in Tlemcen's vaccination campaign, namely Sputnik, AstraZeneca, Sinopharm, Sinovac, and Janssen. This table encapsulates mean values for

imported, administered, lost, expired, and remaining vaccine doses, offering valuable insights into the efficiency and challenges of vaccine management.

Table 2 provides an overview of the vaccine doses administered at the University Hospital of Tlemcen. It includes the total number of first, second, and third doses administered to individuals, reflecting the hospital's vaccination efforts

Health personnel and patients

The group statistics in Table 3 compares mean values, standard deviations, and standard error means for health and vaccinated personnel across different iterations of Sputnik, AstraZeneca, Sinopharm, Sinovac, and Janssen vaccines.

Age-Based Vaccine Distribution

The bar chart (Figure 1) depicting mean values of different vaccines across various age groups elucidates intriguing trends in vaccine uptake. Sinovac stands out prominently, exhibiting significantly higher mean values in the 50-64 and 64 or more age brackets, suggesting either enhanced

efficacy or greater utilization in these age cohorts. Conversely, other vaccines display relatively consistent mean values across age groups, with minor fluctuations. Notably, Janssen displays a marginally higher mean value in the 30-49 age group compared to others.

Impact of Comorbidities on Vaccine Response

The bar chart (Figure 2) comparing mean values of a specific metric among individuals with and without comorbidities unveils intriguing insights into vaccine response dynamics. Sinovac emerges as a standout performer, registering significantly higher mean values among individuals with comorbidities, indicative of a pronounced effect or correlation with this subgroup. In contrast, mean values for individuals without comorbidities remain relatively consistent across all vaccines, underscoring the potential interaction between comorbidities and vaccine response, particularly in the context of Sinovac.

Table 1. Vaccine inventory at the University Hospital of Tlemcen.

Vaccines					
Vaccine Name	Imported vaccines	Administered vaccines	Lost vaccines	Expired vaccines	Remaining vaccines
Sputnik	7910	4352	819	2739	0
AstraZeneca	26100	9918	8576	7606	0
Sinopharm	5200	5192	8	0	0
Sinovac	102140	93908	3767	0	4465
Janssen	18605	5511	2534	9035	1525

Table 2. Administered vaccine doses at the University Hospital of Tlemcen

Total administered 1 st dose	66841
Total administered 2 nd dose	46736
Total administered 3 rd dose	5304
Total doses	118,881

Table 3. Vaccinated groups statistics at the University Hospital of Tlemcen.

Group Statistics					
Vaccines	Doses	group	Mean	Std. Deviation	Std. Error Mean
Sputnik	1	Health personnel	17.6250	27.28651	9.64724
		Vaccinated individuals	260.6250	174.43455	61.67193
	2	Health personnel	17.6250	27.28651	9.64724
		Vaccinated individuals	236.7500	140.55375	49.69326
	3	Health personnel	00	00	00
		Vaccinated individuals	11.3750	5.97465	2.11236
AstraZeneca	1	Health personnel	0.7500	2.12132	0.75000
		Vaccinated individuals	597.2500	626.42654	221.47523
	2	Health personnel	0.7500	2.12132	0.75000
		Vaccinated individuals	561.5000	585.00183	206.82938
	3	Health personnel	00	00	00
		Vaccinated individuals	79.5000	85.03109	30.06303
Sinopharm	1	Health personnel	16.1250	22.66802	8.01436
		Vaccinated individuals	308.8750	148.64765	52.55488
	2	Health personnel	16.0000	22.39260	7.91698
		Vaccinated individuals	306.7500	148.23509	52.40902
	3	Health personnel	00	00	00
		Vaccinated individuals	1.2500	1.90863	.67480
Sinovac	1	Health personnel	197.7500	191.29390	67.63261
		Vaccinated individuals	6472.5000	3078.98425	1088.58532
	2	Health personnel	155.6250	147.66655	52.20801
		Vaccinated individuals	4345.2500	2677.60153	946.67510
	3	Health personnel	8.3750	17.10420	6.04725
		Vaccinated individuals	357.2500	129.12757	45.65349
Janssen	1	Health personnel	9.6250	9.51596	3.36440
		Vaccinated individuals	474.0000	264.30394	93.44555
	2	Health personnel	00	00	00
		Vaccinated individuals	00	00	00
	3	Health personnel	13.1250	23.01203	8.13598
		Vaccinated individuals	192.1250	52.91621	18.70870

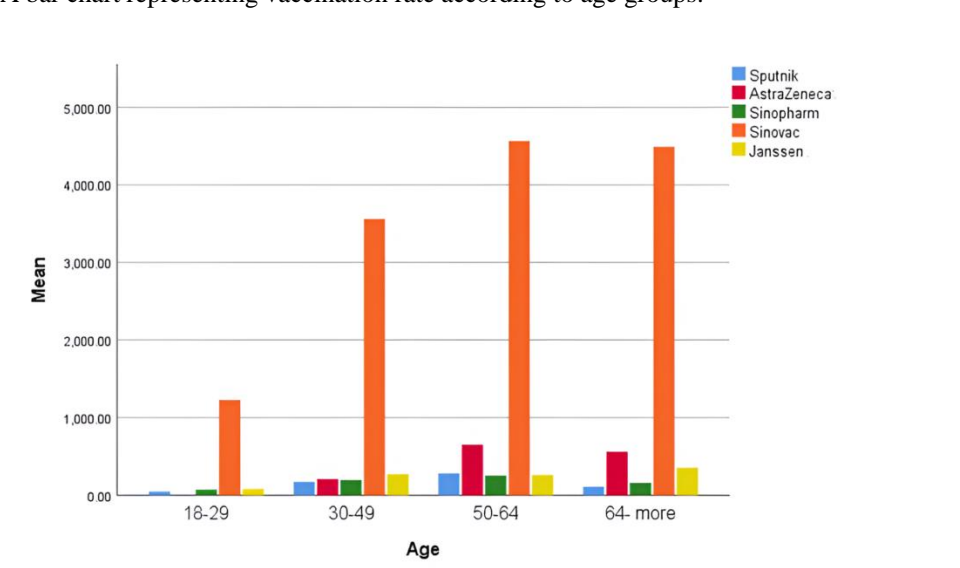
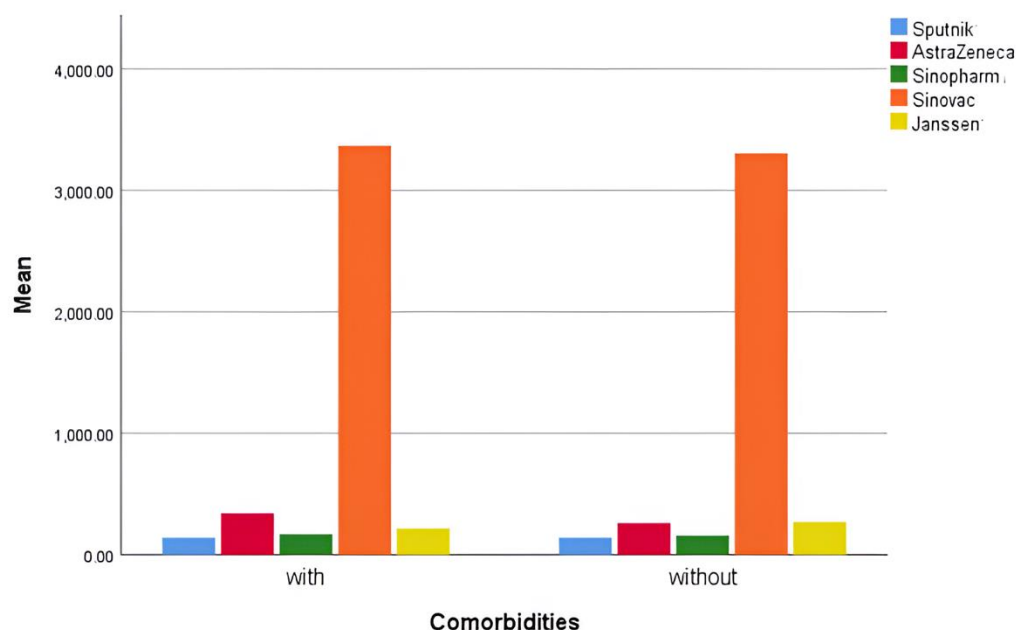
Figure 1. A bar chart representing vaccination rate according to age groups.

Figure 2. A bar chart representing vaccination rate among individuals with or without comorbidities

Discussion

The ongoing COVID-19 pandemic has necessitated robust vaccination campaigns worldwide to curtail the spread of the virus and mitigate its public health impact. Our study provides a descriptive analysis of the vaccination campaign in Tlemcen, Algeria, shedding light on local vaccination trends and contributing to understanding broader global vaccination efforts. The analysis of vaccine distribution, utilization, and demographic trends in Tlemcen reveals insights that resonate with broader global vaccination challenges and strategies.

As of December 31, 2023, the World Health Organization (WHO) reported that 67% of the global population had completed the primary series of a COVID-19 vaccine. Sinovac and Sinopharm, developed in China, have been particularly prominent in low- and middle-income countries due to their easier storage requirements, with significant use in places like Algeria. Sputnik V, from Russia, has also been deployed in various countries, including Algeria. The Janssen vaccine, a single-dose option from the U.S., has been used worldwide, particularly in Africa, to increase vaccination coverage. Meanwhile, the AstraZeneca vaccine, developed in partnership between the U.K. and Sweden, has been a cornerstone of the global vaccination effort, especially through the COVAX initiative, and has been distributed across many African nations. These vaccines have been integral

to the global response to COVID-19, with the WHO closely monitoring their distribution to ensure broad and equitable access (9).

Sinovac emerges as the frontrunner in both imported and administered vaccine doses, boasting a substantial surplus of remaining vaccines (4,465), indicative of efficient utilization with minimal wastage. Conversely, AstraZeneca exhibits significant losses, with notable numbers of both lost (8,576) and expired (7,606) vaccine doses, hinting at potential issues in distribution or storage protocols. Sinopharm demonstrates commendable efficiency, with nearly all imported doses administered and minimal losses recorded. However, both Sputnik and Janssen register noteworthy numbers of expired vaccine doses, hinting at potential overestimation of demand or logistical inefficiencies. Comparable findings in other regions of Algeria suggest that vaccine booster acceptance remains moderate, highlighting the critical role of targeted communication to address public concerns and ensure continued booster uptake (10, 11).

The age-specific and comorbidity-based variations in vaccine uptake and response observed in this study reflect the universal need for tailored vaccination approaches. These results highlight the critical importance of optimizing vaccine distribution and administration strategies to enhance vaccine accessibility and efficacy, particularly for vulnerable populations with underlying health

conditions. Studies conducted in Algeria reinforce the importance of vaccine equity and engagement strategies to overcome hesitancy and ensure widespread uptake. For instance, determinants of vaccine acceptance have been analyzed in population-based studies, revealing challenges such as hesitancy, resource limitations, and misconceptions about vaccine safety and efficacy (12).

There has been a notable rise in the acceptance of COVID-19 vaccines, particularly among healthcare workers, compared to earlier studies. However, the overall acceptance rate among the general population remains low (13). The adoption of pandemic-related vaccinations is a positive step towards restoring the global economy to its previous state. Evidence of stock market recovery post-COVID-19 vaccination implementation indicates the effectiveness of government interventions in controlling the virus's spread and severity (14). Our findings underscore the multifaceted nature of vaccine distribution and storage, with each vaccine brand presenting unique challenges and opportunities for optimization. Addressing these discrepancies is crucial for enhancing vaccine accessibility and efficacy.

Approximately two-thirds of Algerians are unlikely to engage in COVID-19 vaccine uptake, positioning them as one of the least receptive populations to voluntary vaccination in the MENA (Middle East North Africa) region. This lack of engagement likely contributes to the slow increase in the vaccination rate, posing significant public health concerns (15). Despite Algeria boasting one of Africa's top healthcare systems, it falls short of the standards set by wealthier countries. The country received the first 50,000 doses of the Russian vaccine Sputnik V on January 29, 2021, prioritizing distribution to healthcare workers, vulnerable individuals, and police officers, and with a population of approximately 44 million, this initial distribution marks the beginning of a massive vaccination campaign requiring substantial resources (16). Our observations underscore the potential influence of age on vaccine preferences and efficacy, with Sinovac demonstrating heightened effectiveness among older populations. Further research is warranted to elucidate the underlying mechanisms driving these age-specific trends and optimize vaccine distribution strategies accordingly.

For all vaccines listed in our study indicate that there are no statistically significant differences between group means for any of the vaccines. This suggests that, within each vaccine iteration, the different conditions or treatments being compared do not lead to different outcomes. Also, the mean values for vaccinated personnel are significantly higher than for health personnel in nearly all categories, which indicates a substantial difference in the sample measurements between health and vaccinated personnel. Overall, the data reflects substantial differences in the responses of health versus vaccinated personnel to various vaccine iterations, with considerable variability in some groups. Furthermore, the mean differences are negative across all groups, indicating that the mean value for the first group is lower than for the second group in all cases.

For most vaccines, the mean values for those with comorbidities are slightly higher than for those without, suggesting that comorbidities may have a mild effect on the outcomes measured. However, for Sinovac, the mean value is exceptionally high for both groups, indicating a significant outcome associated with this vaccine regardless of comorbidities. These results underscore the importance of considering comorbidities when evaluating vaccine effects but also highlights that the magnitude of the effect varies significantly depending on the vaccine type.

This study also provides the first insights into the attitudes of the Algerian public of Tlemcen towards COVID-19 vaccine boosters. The acceptance rate of boosters remains moderate, lower than those reported in developed countries. Specific groups with the highest acceptance rates include males, individuals over 60 years old, and those with chronic diseases, while healthcare professionals and postgraduate students exhibit higher hesitancy. Psychological factors related to vaccine effectiveness and safety play a significant role in booster acceptance (17). Additionally, this study confirms the short-term safety of adenoviral-based and inactivated-virus booster doses used in Algeria. Side effects following such boosters, including injection site pains and mild systemic reactions like fever and fatigue, were generally brief and less severe compared to those following initial doses. Notably, individuals who received inactivated-virus or adenoviral-based vaccines for their primer-booster doses experienced more severe side effects (18).

To date, monitoring of the effects of COVID-19 has rested on several epidemiologic and clinical measures, which have shaped the recommended or mandated protective actions. Most commonly, these measures have included estimated rates of COVID-19 cases, hospitalizations, and deaths; monitoring has also been conducted of circulating SARS-CoV-2 variants and their susceptibility to available vaccines and treatments (19). Vaccine hesitancy is an increasingly pervasive challenge across the world and the saving of more than 19 million lives by the unprecedented rapidity of development and roll-out of COVID-19 vaccines is an extraordinary global health feat. Nonetheless, millions of additional lives could have been saved by more equitable distribution of vaccines (20). The discussion extends beyond the local context to highlight broader implications and challenges related to COVID-19 vaccine acceptance and coverage. Despite limitations, the study confirms the short-term safety of booster doses used in Algeria, emphasizing the need for targeted communication and engagement efforts to address psychological factors and ensure vaccine safety. Furthermore, these observations align with national findings on vaccine hesitancy and resource allocation, highlighting the need for innovative strategies to improve public trust and ensure equitable vaccine distribution (21).

Conclusion

This study highlights the dynamic interplay between vaccine distribution, age demographics, and comorbidity status in shaping vaccination outcomes in Tlemcen. Addressing the observed discrepancies in vaccine utilization and response is paramount for optimizing vaccination campaigns and mitigating the impact of COVID-19. Future research endeavors should focus on elucidating the underlying mechanisms driving age-comorbidity-specific vaccine responses to inform targeted vaccination strategies and enhance public health outcomes.

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Authors' contributions

All authors contributed equally to the work.

Consent for publication

Not applicable.

Competing interests

The authors declare no conflict of interest.

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Ethics approval and consent to participate

Not applicable.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon request.

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