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Assessing the Effectiveness of Temperature Screening in COVID-19 Detection: A Statistical Study of Socio-Demographic Variables in Lagos, Nigeria

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Abstract

Introduction: Since the emergence of coronavirus disease in December 2019, Global health has been a major concern. COVID-19 symptoms include an elevated body temperature above the normal range, and preventive measures against the causative agent involve social distancing, the use of face masks, and frequent hand washing. This study evaluates participants' temperature and COVID-19 status to reduce the risk of SARS-CoV-2 infection. **Aim of the Study**: This study aims to estimate the risk of SARS-CoV-2 infection using a logistic regression model. Specific objectives include evaluating the relationship between participants' temperature, COVID-19 status, gender, age, and mode of transportation to understand their impact on infection risk. **Method**: Data for this study were collected through a cross-sectional survey conducted from March 31, 2020 through April 30, 2020, at the Nigerian Institute of Medical Research in Lagos, Nigeria. The study included 2160 participants, (53.1% women) and (46.9% men) and 69 (3.2%) tested positive for SARS-CoV-2. The logistic regression model was used for inferential analysis to estimate the risk of infection based on various factors. **Results**: This study found that 5(7.2%) participants who tested positive for SARS-CoV-2 exhibited elevated body temperature, while 64 (92.8%) had normal body temperature. Although gender was not significantly associated with body temperature ($p > 0.05$), female participants showed higher odds (OR = 1.5) of having a normal body temperature compared with male participants. Age and mode of transportation significantly affected participants' temperature ($p < 0.05$), with the odds of having a normal body temperature being 0.34 times lower for participants aged ≤ 49 years and those who walked to the testing center being 2.26 times more likely to have a normal body temperature. Participants who tested negative for SARS-CoV-2 were 3.33 times more likely to have a normal body temperature. **Conclusion and Recommendation**: The study concludes that temperature alone is not sufficient as an indicator of COVID-19 infection, and asymptomatic transmission is a critical factor in the overall incidence of COVID-19. These findings support sustainable public health strategies, such as targeted resource allocation, holistic approaches to disease management, and effective communication. To mitigate the spread of COVID-19 and support community well-being, it is essential to continue to prioritize preventive measures and account for the impact of asymptomatic transmission in public health planning. These findings are in line with findings in other studies during COVID-19 outbreak in Nigeria.

Keywords

COVID-19, Infrared Digital Thermometer, Inferential Analysis, Odds Ratio, Sustainability

1. Introduction

In recent years, sustainability has emerged as a critical framework for addressing global challenges, including public health crises. Sustainability integrates social, economic, and environmental factors to ensure the well-being of current and future generations. In public health, this framework helps evaluate and mitigate the risks of infectious diseases like COVID-19, while optimizing the use of resources. Specifically, this study evaluates whether relying on temperature as the primary indicator for COVID-19 detection results in resource inefficiencies or missed cases, thereby impacting the effectiveness of public health interventions. Additionally, we explore how incorporating additional symptoms and risk factors into screening protocols can lead to more sustainable public health practices, improving accuracy in case detection and reducing unnecessary resource usage. The goal is to provide insights into optimizing public health strategies for immediate pandemic response and long-term health system resilience.

The COVID-19 pandemic, caused by the SARS-CoV-2 virus, first emerged in Wuhan, China, in December 2019 and rapidly spread worldwide [1] [2]. The World Health Organization (WHO) declared it a global pandemic on March 11, 2020, urging nations to implement critical measures to contain the virus [3]-[6]. In Nigeria, the first case was recorded on February 27, 2020, and since then, the country has reported over 266,000 confirmed cases and more than 3000 deaths as of July 19, 2023 [7]. The pandemic has caused significant social and economic disruptions globally, including in Nigeria. These impacts have been felt across various sectors, leading to job losses, disruption of education, and increased mental health challenges. In response, public health measures, such as social distancing, face masks, hand hygiene, and temperature screening, were widely implemented [8]. Temperature screening, using non-contact infrared thermometers, became a key method for detecting individuals with elevated body temperature which is a primary symptom of COVID-19, thereby helping to control the spread of the virus. However, the effectiveness of temperature screening alone as an infection control measure is questioned, especially given the presence of asymptomatic carriers and the similarity of COVID-19 symptoms to those of other diseases such as malaria [9]-[11].

The Ebola Virus Disease (EVD) outbreak in Sierra Leone during 2014 revealed that women who exhibited fever and self-reported symptoms, along with complications, displayed a higher likelihood of testing positive for EVD infection, as indicated by previous research conducted [12]. In contrast to EVD, the symptoms of COVID-19 resemble those of malaria and several other infectious diseases. The aim of this study is to evaluate participants' temperature, COVID-19 status and some selected demographic variables as a means of controlling the risk of SARS-Cov-2 infection. Given Lagos' dynamic urban environment and socioeconomic diversity, it presents a unique context to study the relationship between temperature, COVID-19 status, and socio-demographic variables.

2. Methodology

The research methodology employed in the present study aimed to rigorously examine the interplay between participants' temperature, COVID-19 status, and selected socio-demographic variables in Lagos, Nigeria. This involved a systematic approach to data collection, analysis, and interpretation, ultimately providing knowledge into the relationships and influences shaping the dynamics of the studied variables. The study adhered to established ethical guidelines and sought to ensure the validity and reliability of the findings.

2.1. Study Design and Methods

This was a retrospective cohort study designed to evaluate the relationships between temperature measurements, COVID-19 status, and selected sociodemographic variables among participants, as part of COVID-19 infection control efforts [13]. The research was conducted at the Nigerian Institute of Medical Research (NIMR), Yaba, Lagos State, Nigeria, between March 31, 2020, and April 30, 2020. The institute houses various departments, both research and non-research oriented. Within its premises, clinics provide clinical services while laboratories are dedicated to the research and diagnosis of infectious diseases such as tuberculosis and HIV/AIDS. The data collection period was between March and April 2020. Standardized questionnaires were administered to capture socio-demographic information, including age, gender, and mode of transportation to the testing center.

2.2. Human Ethics and Consent to Participate Declarations

Ethical approval for the study was obtained from the Institutional Review Board (IRB) of the Nigerian Institute of Medical Research, Yaba, Lagos State, Nigeria, to ensure compliance with ethical standards. This study also ensured that informed verbal consent was secured from each participant before data collection and same was also obtained from the parent/guardian of each participant under 18 years of age.

2.3. Population and Sample Size for the Study

The study population consisted of participants who visited NIMR during the pandemic. Two thousand, one hundred and sixty (2160) participants who consented to take part in the study were originally assessed among visitors that visited the institute during the COVID-19 pandemic. The sample size used was calculated using the sample size estimation method for prevalence studies [14] based on the sample size estimated for the main study.

2.4. Sampling Strategy

Participants were selected using a convenience sampling method, focusing on individuals who presented themselves for COVID-19 testing during the study period. The sample size of 2160 participants used ensured broad representation of the population in terms of age, gender, and mode of transportation.

2.5. Study Procedure and Statistical Method

The data generated through the questionnaire developed for the main study were entered into the excel spreadsheet [15]. The data were exported into STATA 16.0 software for further analysis. The guidelines in the thermometer's user manual [15] were taken into consideration while using a non-contact infrared digital thermometer (Imose, modelTM IM-201IT accuracy ±0.3) for temperature measurement. During the process of data collection, a distance of 3 - 5 cm was consistently maintained, and the temperature measurements were taken by directly pointing the detector head of the thermometer at the participants' foreheads [16]. Normal body temperature limit was set between 36.1˚C to 37.9˚C [17] while temperature greater than normal was set to be elevated [15]. The measuring point was the area of the forehead not covered by hair. In addition to taking participants' temperature measurements, information on age, gender, and mode of transportation was collected using a validated questionnaire. Age is a fundamental demographic variable that indicates the number of years an individual has lived since birth. In this study, participants' ages range from younger individuals to older adults. The breakdown of participants into different age groups helps analyze how different age segments were affected by COVID-19 and related factors. Mode of transportation which indicates choice of transportation is a demographic variable related to how participants travelled to the COVID-19 testing center. The two options were walking and arriving by car. This information provides an understanding of participants' mobility patterns, which may be associated with socioeconomic factors, physical activity levels, and environmental considerations. Outcomes of COVID-19 testing reflects the results of participants' COVID-19 tests. The outcomes include "negative" (indicating no SARS-CoV-2 infection) and "positive" (indicating a confirmed SARS-CoV-2 infection). These data are crucial for understanding the prevalence of COVID-19 within the studied population and for examining the relationship between testing outcomes and other variables, such as body temperature and socio-demographic characteristics. Temperature status refers to participants' body temperatures as measured during COVID-19 testing. The two categories are "normal temperature" and "elevated temperature".

Elevated temperature might indicate a potential fever, which could be a symptom of various illnesses, including COVID-19. This study employs logistic regression and its associated odds ratio [18] to assess the relationship between participants' temperature status and COVID-19 test outcomes as part of infection risk control.

2.6. Statistical Data Analysis

The data were analysed using STATA Software version 16.0, which was acquired by the Nigerian Institute of Medical Research (NIMR). Descriptive statistics such as frequency counts, means, and percentages were used to summarize the overall data collected. The temperature measurements were categorized as either elevated or normal, which served as the response variable, while other factors such as gender, age, mode of transportation, and COVID-19 laboratory results of the participants were used as explanatory variables. Age was grouped into six categories. The proportion of participants with elevated and normal temperature was calculated. Inferential statistics were used to identify factors predicting normal body temperature, employing a logistic regression model. The logistic regression model was used because the response variable (temperature status) was binary, consisting of two possible outcomes: elevated and normal body temperature. The resulting odds ratios were interpreted with a 95% Confidence Interval, and their significance was established at a threshold of $p < 0.05$. The odds ratios and corresponding confidence intervals were used to evaluate the strength and significance of the observed associations. The primary focus of the study is on participants' temperature measurements, aiming to identify which explanatory variables significantly predict whether a participant has a normal or elevated temperature in relation to COVID-19 status. When dealing with a binary response variable with values of 0 and 1 (representing elevated and normal participants' body temperature, respectively), the anticipated value translates directly to the probability "θ" of the variable taking the value 1, or in other words, the probability of having a normal body temperature. This "θ" is subsequently modelled indirectly through a logit transformation, namely $\ln[\theta/(1-\theta)]$. This transformation underpins the logistic regression model applied in the current study.

The estimated regression coefficients derived from this model signify the anticipated change in the log-odds pertaining to a one-unit alteration in the corresponding explanatory variable, while the other explanatory variables remain constant. This approach facilitates the exploration of relationships between these explanatory variables and the likelihood of a normal body temperature measurement, providing an understanding into the predictive factors as a means of infection control for COVID-19.

3. Results and Discussion of Findings

3.1. Results

A total of 2160 participants participated in the study, of which majority 1147 (53.1%) were females and the remaining 1013 (46.9%) were males. The mean age of the participants stood at (39.43 ± 11.47 SD) years. Among the age groups, participants between 29 to 41 years exhibited the highest frequency 854 (39.5%), whereas those between 68 to 80 years exhibited the lowest, accounting for merely 14 (0.6%) of the participants. Regarding the mode of transportation to the testing centre, 1469 (68.0%) participants walked to the testing center and 691 (32.0%) participants went by car. The COVID-19 testing outcomes were meticulously recorded, revealing that 2091 participants (96.8%) yielded negative results for SARS-CoV-2, while a minority of 69 participants (3.2%) were confirmed positive for SARS-CoV-2 infection (as shown in Table 1).

Table 1. Socio-demographic and COVID status of the participants.

Characteristic	Frequency (N)	Percent (%)
Gender		
Female	1147	53.1
Male	1013	46.9
Age		
3 - 15	54	2.5
16 - 28	326	15.1
29 - 41	854	39.5
42 - 54	726	33.6
55 - 67	186	8.6
68 - 80	14	0.6
Mode of Transportation		
Walk	1469	68.0
Car	691	32.0
COVID Result		
Negative	2091	96.8
Positive	69	3.2

Among the total participant for the study, 2107 individuals (97.5%) exhibited normal body temperatures, while 53 participants (2.5%) displayed elevated temperatures beyond the defined threshold of normalcy. Among the subset of 53 participants with elevated temperatures, 23 (43.4%) were identified as females, while 30 (56.6%) were males. Notably, participants aged 49 years or younger constituted the highest count within the group displaying elevated temperatures. Furthermore, transportation mode emerged as a discerning factor, with 27 participants (50.9%) opting for car travel to the testing center, slightly surpassing those who chose to walk. Regarding gender's influence on temperature status for SARS-CoV-2 detection, female participants exhibited 1.5 times higher odds of having a normal body temperature for SARS-CoV-2 detection. However, the odds range of 0.86 to 2.59 indicated that gender did not exert a statistically significant impact on participants' body temperature status ($p > 0.05$). Conversely, participant's age exhibited a noteworthy effect on temperature status, signified by an odds ratio of 0.34 and a confidence interval spanning from 0.12 to 0.95 ($p < 0.05$). This implied that participants aged 49 years or less were associated with 0.34 times lower odds of displaying a normal body temperature for SARS-CoV-2 detection. Moreover, the mode of transportation significantly influenced temperature status, as indicated by an odds ratio of 2.26 and a confidence interval ranging from 1.31 to 3.40 ($p < 0.05$). Participants who walked to the COVID-19 testing center had 2.26 times higher odds of demonstrating a normal body temperature for effective SARS-CoV-2 detection, compared to their counterparts who arrived by car. Finally, the study underscored a noteworthy relationship or association between participants' body temperature and COVID-19 status, as evident from the findings presented in Table 2.

Table 2. Logistic regression analysis of temperature measurements.

Variable	Temperature Measurements		Coefficient	Odds ratio	(95% CI)	p-value
	elevated	Normal				
Gender						
Female	23	1124	0.40	1.49	0.86 - 2.59	0.16
Male	30	983		1		
Age group (years)						
≤49	49	1700	−1.07	0.34	0.12 - 0.95	0.04
≥50	4	407		1		
Mode of transportation						
Walk	26	1443	0.81	2.26	1.31 - 3.40	0.003
Car	27	664		1		
COVID Result						
Negative	48	2043	1.20	3.33	1.28 - 8.63	0.01
Positive	5	64		1		

3.2. Discussion of Findings

These findings provide a comprehensive understanding of the relationships between temperature, COVID-19 status, and various socio-demographic factors. One noteworthy finding is the absence of a statistically significant association between gender and participants' body temperature status. Although female participants had 1.5 times higher odds of having a normal temperature for SARS-CoV-2 screening, the wide confidence interval (0.86 - 2.59) indicates that gender alone may not be a reliable predictor of temperature status. Several factors may account for this finding. First, fever is a non-specific symptom influenced by factors beyond gender, including individual baseline temperature variations, hormonal fluctuations, and underlying health conditions. Second, social and cultural factors may affect healthcare-seeking behaviour, potentially introducing gender-related differences in testing practices and temperature measurement. Despite the lack of statistical significance, it remains important to monitor gender-related patterns in COVID-19 cases and temperature status. The study identified age as a significant factor affecting temperature status. Participants aged 49 years or younger were associated with 0.34 times lower odds of having a normal body temperature for SARS-CoV-2 detection. This finding implies that older individuals may be more likely to exhibit elevated temperatures, which could serve as an early indicator of COVID-19 infection. Several explanations may account for this age-related difference. First, older individuals are more likely to have weakened immune responses or underlying health conditions, increasing their susceptibility to infections such as COVID-19, which may present with fever. Second, age-related changes in thermoregulation and baseline body temperature may influence observed temperature measurements. However, further research is needed to investigate the specific mechanisms underlying this age-temperature relationship. The implications of this finding are substantial, suggesting that temperature screening, particularly among older age groups, may serve as a useful tool for early identification of potential COVID-19 cases and for facilitating timely testing and isolation. Additionally, the mode of transportation emerged as a significant factor influencing temperature status. Participants who walked to the COVID-19 testing center had 2.26 times higher odds of exhibiting a normal body temperature for effective SARS-CoV-2 detection compared with those who arrived by car. This observation raises important questions regarding the influence of physical activity and environmental exposure on body temperature measurements. In this study, mode of transportation was considered an indirect proxy for recent physical activity, as participants who walked to the testing center were likely to experience increased physical activity and exposure to outdoor conditions, which could result in temporary elevations in body temperature. Conversely, participants who arrived by car may have exhibited more stable body temperatures due to reduced physical exertion and limited environmental exposure. However, physical activity was not directly measured in this study, and therefore the observed association should be interpreted with caution, as residual confounding related to recent exertion cannot be completely excluded. The practical implication is that healthcare facilities should consider these factors when interpreting temperature measurements. It may be necessary to establish specific temperature thresholds based on transportation mode to reduce the likelihood of false positives.

The relationship between participants' body temperature and COVID-19 status was also explored. Although elevated body temperatures were present among individuals who tested positive for SARS-CoV-2, majority of these individuals exhibited normal body temperatures. Specifically, 5 of the 69 participants with elevated temperatures tested positive for COVID-19 while 64 positive cases were recorded among participants with normal temperatures. This highlights the limited utility of elevated body temperature as a sole indicator for COVID-19 detection. While fever remains a recognized symptom of COVID-19, the findings emphasize that most COVID-19-positive cases in this study were not associated with elevated body temperatures. This aligns with the broader observation that asymptomatic cases and cases without fever are common, particularly in settings with robust surveillance.

4. Conclusion

This study demonstrates that temperature screening alone is insufficient for the detection of COVID-19 cases, as the majority of participants who tested positive for SARS-CoV-2 had normal body temperatures. Sole reliance on elevated temperature as an indicator of COVID-19 may therefore lead to missed or undetected cases, particularly among asymptomatic individuals. Therefore, comprehensive screening approaches that integrate temperature assessment with symptom-based screening, evaluation of epidemiological risk factors (such as recent exposure and travel history), and confirmatory diagnostic testing including rapid antigen tests and RT-PCR are necessary for more accurate identification and control of the virus. In addition, routine use of face masks, enforcement of physical distancing in public spaces, improved hand hygiene practices, and targeted testing of high-risk populations should be incorporated into screening protocols. These results underscore the importance of sustainable public health strategies that prioritize effective resource utilization and address both symptomatic and asymptomatic transmission in Nigeria [10] [12] [13].

5. Recommendation

Based on the findings of this study, several recommendations are proposed to guide future research and public health initiatives. While temperature screening has notable limitations, it remains a useful component of routine health assessments, particularly when integrated with other screening and diagnostic measures. Elevated body temperature, when present, can still serve as an indicator of potential COVID-19 cases and support early detection and isolation. Public health interventions should consider age-specific strategies, especially for individuals aged 49 years or younger, who were found to have lower odds of normal temperature. This could include targeted testing and vaccination efforts. Encouraging individuals to walk or engage in physical activity before COVID-19 testing may help improve temperature status. Further research into the relationship between physical activity and body temperature is imperative. This study should be seen as a starting point, and continuous data collection and analysis should be conducted to monitor changing trends in temperature and COVID-19 status.

6. Limitations of the Study

The study was conducted in Lagos, Nigeria, and may not be representative of other regions or countries with different demographics and healthcare systems. In addition, the study adopted a convenience sampling technique, which is a non-probability sampling method and this may limit the generalizability of the findings to the broader population. The study included 2160 participants, which, while substantial, may not capture the full diversity of the population. This study adopted a cross-sectional design which provides only a snapshot at one point in time. Longitudinal studies could provide a more in-depth understanding of the relationships over time. The accuracy of temperature measurements and the methods used for data collection could impact the results. Variability in measurement devices and techniques should be considered. The study did not account for external factors such as environmental conditions, underlying health conditions, or recent physical activity, which could affect body temperature. This study sheds light on the complex interplay between temperature, COVID-19 status, age, gender, and transportation mode. While it provides important insights, further research and a broader perspective are needed to develop comprehensive public health strategies in the fight against COVID-19.

Ethics Approval

Ethics approval with protocol number IRB/20/023 for this study was obtained from the NIMR (Nigerian Institute of Medical Research, Yaba, Lagos State, Nigeria) IRB (Institution Review Board).

Availability of Data and Material

Data for this research is available anytime needed. you can get it through.
https://drive.google.com/file/d/1MGWekRS4aSWsrLDiu_NV1vUVjL-syNh8L/view?usp=sharing

Consent for Publication

All authors have reviewed and approved the final manuscript and have provided their consent for its publication.

Authors' Contributions

Kazeem Osuolale and Dayo Lawal worked on the writing of the manuscript, data analysis and interpretation. Babatunde Adewale and Toyosi Raheem provided guidance and supervised the writing of the manuscript. Oluwaseun Otekunrin and Dolapo Shobanke participated in the analysis of data. Folahanmi Akinsolu and Hakeem Osho participated in the interpretation of the result

Conflicts of Interest

The authors declare no conflicts of interest.

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