

ISSN 2472-3878

Openventio
PUBLISHERS

PUBLIC HEALTH

Open Journal 

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December 2021 | Volume 6 | Issue 2 |

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Short Communication

Helping Public Health Decision-Makers Refine Community Coronavirus Disease-2019 Vaccination Efforts--Association between Confirmed Coronavirus Disease-2019 Cases and Vaccinations

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Article information

Received: August 9th, 2021; **Revised:** September 6th, 2021; **Accepted:** September 7th, 2021; **Published:** September 13th, 2021

Cite this article

Fant GV, Jones T. Helping public health decision-makers refine community coronavirus disease-2019 vaccination efforts--Association between confirmed coronavirus disease-2019 cases and vaccinations. *Public Health Open J.* 2021; 6(2): 37-42. doi: [10.17140/PHOJ-6-157](https://doi.org/10.17140/PHOJ-6-157)

ABSTRACT

Introduction

The response to the coronavirus disease-2019 (COVID-19) epidemic included biomedical and vaccine research as well as identification of COVID-19 cases, contact tracing, community health promotion and disease prevention and community vaccination. The COVID-19 vaccinations remind public health professionals and non-professionals alike of this essential public health intervention for controlling infectious diseases. Actions that seek to improve existing vaccination efforts are equally important for effective public health programming.

Methods

Secondary data analysis uses an ecological study design to examine any possible associations between the number of COVID-19 cases identified at medical facilities (facility names not identified) within a healthcare system and the number of COVID-19 vaccinations administered within the system and reflect upon the findings for public health action. A loess curve was plotted to help to identify if a curvature pattern was present in a scatter plot.

Results

The statistical algorithm for the loess curve identified a curvature pattern. All plots showed that values became more separated in moving from left to right.

Discussion

This aggregate pattern in number of COVID-19 cases and number of vaccinations administered might be present in other public health settings or healthcare systems. Four refinements were proposed to help public health decision-makers to improve vaccination efforts: explore the reasons for differences in COVID vaccination given the number of confirmed COVID cases between facilities; provide vaccination outside traditional settings; facilitate public health and primary care partnerships for community vaccination; and address vaccine knowledge-gaps in the community and other barriers to vaccination.

Keywords

COVID-19 vaccination; Refining vaccination efforts; Public health decision-makers; Public health and primary care partnerships; Ecological study; Loess curve.

INTRODUCTION

Globally and in the United States, public health officials continue to monitor the prevalence of coronavirus disease-2019 (COVID-19) cases along with incidence, mortality, and the population vaccinated.^{1,2} The U.S. Department of Veterans Affairs (VA)

also publishes similar COVID-19 data from the population that utilized VA medical facilities.³ Elected leaders, public health professionals, and clinicians remain concerned about the number of new COVID-19 cases and individuals who have received COVID-19 vaccinations. The COVID-19 delta variant and its possible impact on the population is a concern to elected leaders, public

health officials, and clinicians.⁴ This variant is one of four “variants of concern” for public health and medical professionals (Table 1). Throughout the COVID-19 pandemic, genetic variants of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) have been circulating around the world.

Table 1. Classification-SARS-CoV-2 Variants of Concern, as of June 29, 2021

Pango Line-age	WHO Label	First Identified	Attributes
B.1.1.7	Alpha	United Kingdom	<ul style="list-style-type: none"> • ~50% increased transmission • Potential increased severity based on hospitalizations and case fatality rates • No impact on susceptibility to EUA monoclonal antibody treatments • Minimal impact on neutralization by convalescent and post-vaccination sera
B.1.351	Beta	South Africa	<ul style="list-style-type: none"> • ~50% increased transmission • Significantly reduced susceptibility to the combination of bamlanivimab and etesevimab monoclonal antibody treatment, but other EUA monoclonal antibody treatments are available • Reduced neutralization by convalescent and post-vaccination sera
B.1.617.2	Delta	India	<ul style="list-style-type: none"> • Increased transmissibility • Potential reduction in neutralization by some EUA monoclonal antibody treatments • Potential reduction in neutralization by post-vaccination sera
P.1	Gamma	Japan/Brazil	<ul style="list-style-type: none"> • Significantly reduced susceptibility to the combination of bamlanivimab and etesevimab monoclonal antibody treatment, but other EUA monoclonal antibody treatments are available • Reduced neutralization by convalescent and post-vaccination sera

Source: Centers for Disease Control and Prevention (CDC)⁴

The history of public health is marked by several areas of success. Vaccine-preventable diseases are of public health significance.⁵ For example, vaccines, like immunizations, are important public health interventions. The history of public health in the United States is filled with many successes. In the 20th century, the greatest public health achievements in the United States included the following^{6,7}:

- Vaccination
- Motor-vehicle safety
- Safer workplaces
- Control of infectious diseases
- Decline in deaths due to coronary heart disease and stroke
- Safer and healthier foods
- Healthier mothers and babies
- Family planning
- Fluoridation of drinking water
- Recognition to tobacco use as a health hazard

The response to the COVID-19 epidemic included biomedical and vaccine research, identification of COVID-19 cases, contact tracing, community health promotion and disease prevention, and community vaccination. COVID-19 vaccinations re-

mind public health professionals and non-professionals alike of this essential public health intervention for controlling infectious diseases. Actions that seek to improve existing vaccination efforts are equally important for effective public health programming and should be driven by evidence and considerations of professional practice. As we consider sustained public health action to protect populations from COVID-19 in the foreseeable future, it might be useful to explore the relationship between the number of COVID-19 cases and vaccination at a systems-level and discuss our point of view on the possible implications of the data for public health programming.

METHODS

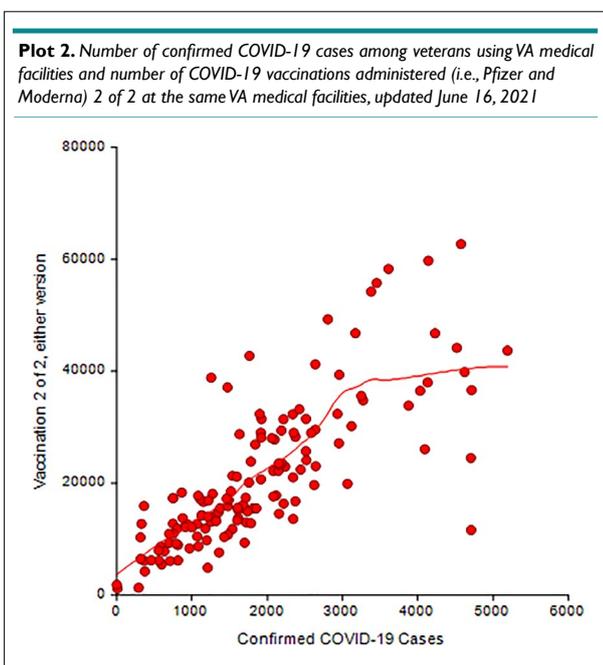
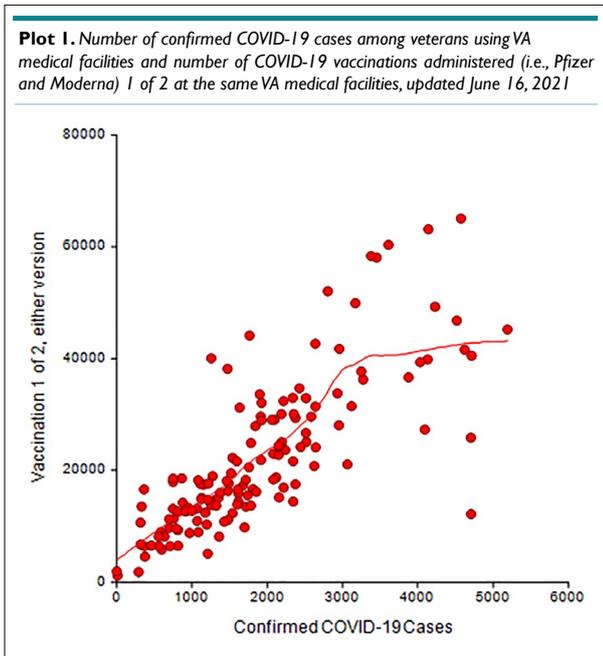
This project explored the association between the aggregate number of COVID-19 cases identified within a healthcare system and the aggregate number of COVID-19 vaccinations administered within the same system as well as the implications of the findings for public health action. Secondary data analysis techniques were combined with an ecological study design to examine any possible associations between the number of COVID-19 cases identified at medical facilities (facility names not identified) within the VA healthcare system and the number of COVID-19 vaccinations administered within the system. The public data (n=141 medical facilities) were accessed using the VA ‘Open Data’ portal: VA COVID-19 National Summary (updated: June 16, 2021). The data presented aggregated counts on the number of COVID-19 veteran patients who had been tested or vaccinated at VA facilities throughout the United States and Puerto Rico. The data fields found in the dataset used in this project included each facility name along with counts for VA Total Confirmed COVID Cases, Convalescent Cases, Dose 1 of 2 for Pfizer or Moderna Vaccine, Dose 2 of 2 for Pfizer or Moderna Vaccine, and Dose 1 of 1 for Janssen Vaccine. An assumption made in reviewing the data was that the type of vaccination recorded is mutually exclusive: That is, data were recorded in situations where individuals who received the two-dose vaccine could also not receive the single-dose vaccine, and vice-versa, during the period of COVID vaccination administration. The number of Convalescent Cases and other aggregate data fields were not used.

Statistical scatter plots were constructed using NCSS 11 Statistical Software.⁸ A loess curve was plotted to help to identify if a curvature pattern was present. The loess method (or the locally weighted regression scatter plot smoothing method) was used to obtain a smooth curve representing the relationship between the values (x, y). Unlike linear regression, the loess method does not have a simple mathematical model. It is an algorithm that, given a value of x, computes an appropriate value of y. The algorithm was designed so that the loess curve travels through the middle of the data, summarizing the relationship between x and y.^{8,9} An increasing pattern (indicated by an increasing curvature pattern of the loess curve) in the number of confirmed COVID cases to the number of COVID vaccination might have public health implications.

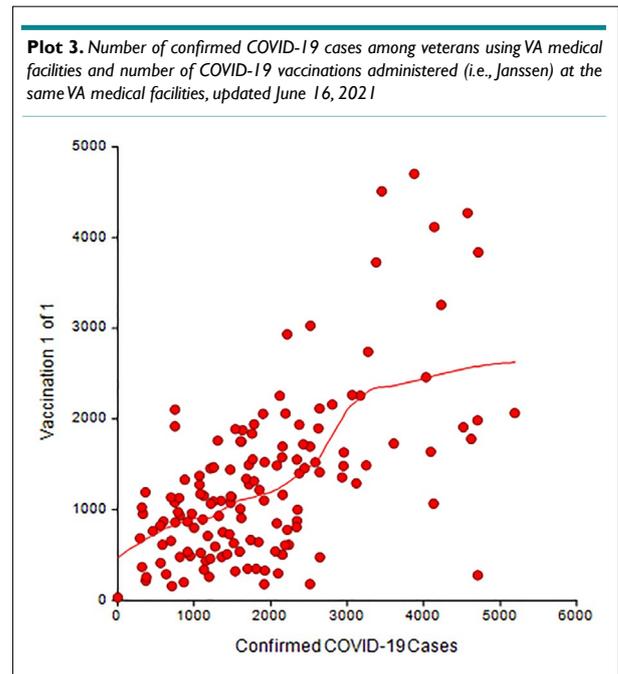
RESULTS

In each plot (Plot 1, 2 and 3), the number of vaccinations adminis-

tered for each type of vaccine by the number of confirmed COVID-19 cases at each of the 141 medical centers is graphed (x, y). The two-dose Pfizer and Moderna COVID-19 vaccines along with the Janssen single-dose vaccines are reported. A loess curve was included with each plot. It is very unlikely that during the current COVID-19 pandemic that individuals in the population received both types of vaccines.



The red symbols in each plot represent the number of vaccinations administered and the number of confirmed cases of COVID-19 at each medical facility. The statistical algorithm for the loess curve identified an increasing curvature pattern. All plots showed that the red symbols became more separated in moving from left to right.



DISCUSSION

We found that within this healthcare system, the loess curve showed a gentle, upward association between the number of confirmed cases of COVID-19 at medical facilities and the increasing number of COVID-19 vaccinations (Plot 1, 2, and 3). Many facilities performed near the loess curve while others did not. For example, consider facilities with approximately 1,000 confirmed COVID-19 cases and the curve in Plot 1: Some facilities reported a high number of vaccinations for the number of confirmed COVID-19 cases compared to other facilities. For some reason, facilities in the lower right portion of each plot did not report vaccination administration at a level near or above the loess curve although the number of confirmed cases was high. By contrast, this was not the case in the upper right portion of each plot.

Refinement 1

Explore the reasons for differences between facilities: It might be useful to further explore the efforts at the facilities that are well-above and well-below the loess curve to understand the differences. These differences might yield a collection of “best practices” in community vaccination to share among medical facilities. For example, the differences found in the prior plots could be related to a number of characteristics pertaining to individuals who chose to receive a COVID-19 vaccination, including the decision to receive it, perhaps, outside of the healthcare system and that information not being part of the data collection and reporting efforts of the system.

Refinement 2

Provide vaccination outside traditional settings: The COVID-19 pandemic has been addressed by a combination of biomedical-re-

search related to vaccine development, clinical treatment, vaccine administration and public health interventions in developed countries. In middle income and developing countries, the pandemic has been addressed by clinical treatment, vaccine administration (where available), and public health measures. Efforts to identify cases of COVID-19 along with community vaccination activities could illustrate the importance of making available prevention services outside of the traditional clinical setting in order to achieve better community-wide, public health prevention outcomes.¹⁰

Refinement 3

Public health and primary care partnerships for community

vaccination: The Association of State and Territorial Health Officers (ASTHO) has posited that public health and primary care partnerships in the U.S. and, perhaps, other countries, might be useful in advancing immunization efforts for the population. ASTHO considered the partnership using a graphical representation (Figure 1)¹⁰:

It might be that some of the ideas from ASTHO regarding immunization at the community-level could be applied to future COVID-19 vaccination efforts. It is important to note that public health work could not be accomplished without health administrators and health managers.¹¹ Furthermore, community engagement and collaboration are commonly used techniques of public health

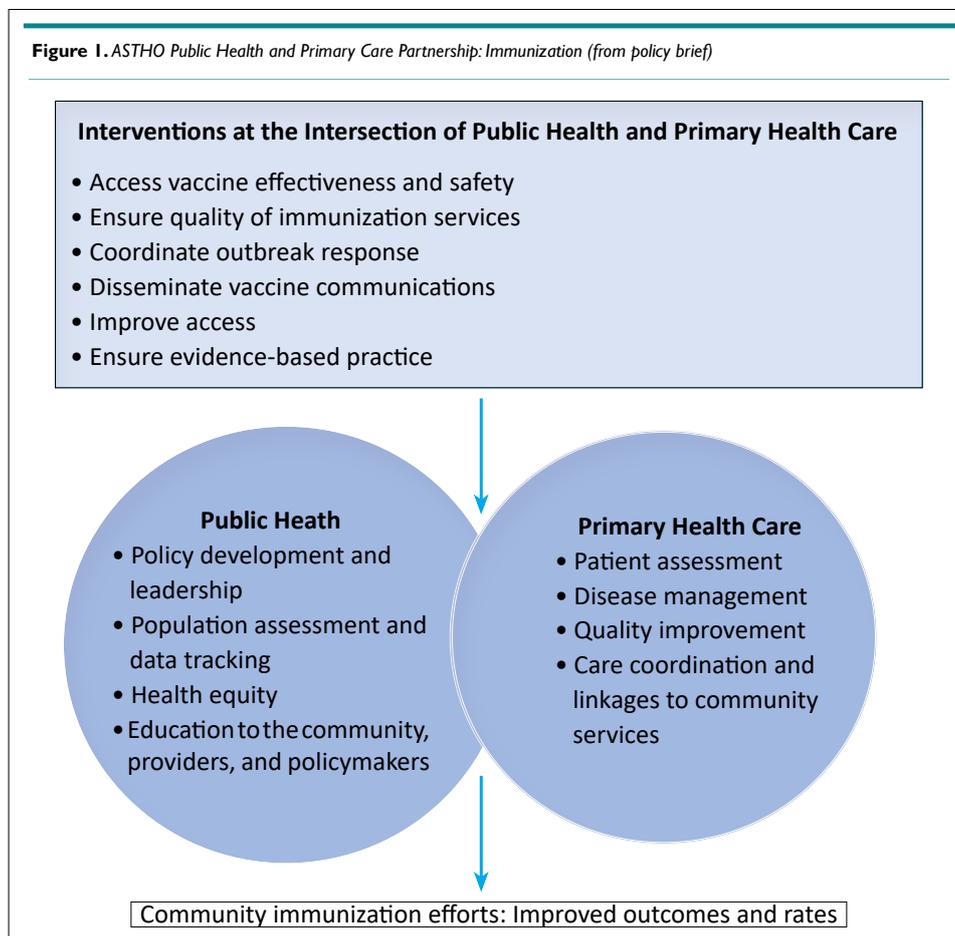
practice. Public health administrators and managers might consider using these techniques with the community and among primary health care professionals in efforts designed to produce increased COVID-19 vaccination rates in the population.

Refinement 4

Addressing vaccine knowledge-gaps in the community and other barriers to vaccination:

While vaccinations are effective for preventing vaccine-preventable diseases in a population, some members in a population refuse to receive vaccination.¹² The control of communicable diseases relies on the application of public health sciences, and study of how members of a population understand a communicable disease and disease prevention efforts in a cultural context. Small-area questionnaires might be useful for examining how populations understand a communicable disease and related prevention activities.¹³ The topics of vaccine misinformation and refusal may have a cultural dimension and was found in a systematic review exploring disparities in H1N1 vaccination rates and synthesis of insights to inform COVID-19 vaccination efforts. Some recommendations for improved COVID-19 vaccination equity resulting from the systematic review included¹⁴:

- Vaccines should be offered at no-cost.
- Target vaccination outreach to communities with large ethnic populations or lower-income populations, especially in areas with



fewer healthcare resources.

- Make use of non-traditional settings for vaccine administration.
- Provide vaccination in or near workplaces.
- Engage with trusted, community messengers.
- Address issues of vaccine safety.

These recommendations might be applicable to various populations around the globe.

CONCLUSION

This aggregate pattern in number of COVID-19 cases and number of vaccinations administered might be present in other public health settings or healthcare systems. Four refinements were proposed. A discussion of vaccination “best practices” is always useful for public health decision-makers, health system managers, and clinicians. In some public health settings or healthcare systems, there might be a role for a group practice manager to facilitate the adoption of some vaccination best practices, along with collaboration of effort, to effectively administer vaccinations to a population outside traditional settings. This might lead to public health and primary health care collaboration on issues of vaccination and other related prevention services.

Conducting small-area questionnaire among the unvaccinated population in selected, geographic areas might produce useful results. A better understanding of vaccination refusal might permit local public health leaders and the community to address issues in the local population that could facilitate vaccination acceptance. Collectively, vaccination “best practices” and findings from small-area questionnaires, and the involvement of various agents in collaborative efforts might help public health decision-makers and health system managers to better understand the system-level resource needs and issues of vaccine acceptance. Refinements could lead to higher COVID-19 vaccination rates in a public health setting or within a healthcare system.

ACKNOWLEDGEMENTS

None.

DISCLOSURES

No financial investments—stock, stock options—connected with this work. Public/Open Data available from the US Department of Veterans Affairs “Open Data” Portal.

DISCLAIMER

The views in this paper are those of the authors and do not represent any official position of the US Government.

SOURCE OF FUNDING

None.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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Original Research

A Study on the Role of Public Health in Reducing the Abuse of Ambulance Services

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Article information

Received: May 29th, 2021; **Revised:** November 2nd, 2021; **Accepted:** November 2nd, 2021; **Published:** November 10th, 2021

Cite this article

Tanveer YAMDI. A study on the role of public health in reducing the abuse of ambulance services. *Public Health Open J.* 2021; 6(2): 43-53. doi: [10.17140/PHOJ-6-158](https://doi.org/10.17140/PHOJ-6-158)

ABSTRACT

Background

Demand for emergency medical services or ambulance response is situated within the context of other healthcare and social welfare services. Worldwide ambulance providers have a wide variety of services available, but many services are struggling to meet service demand. Inappropriate use of ambulance services is one of the biggest concerns globally. The burden of using the ambulance services includes transporting non-critical patients to the hospital. Misuse of the ambulance services is a serious problem that must be addressed and solved.

Objective

The purpose of this study is to evaluate the public perception of appropriate usage of ambulance services and determine the applicable role of public health to reduce the inappropriate use of an ambulance.

Methodology

A cross-sectional study was conducted to collect data from the general public using an online survey. The survey contains 9 questions that evaluate the public awareness of appropriate ambulance use. Participants are people from the public within the age of 18 and above.

Sample Size

A total of N=97 of participants' responses were used to analyze the data.

Inclusion Criteria

Complete surveys and answer data using the English language.

Exclusion Criteria

Uncompleted surveys, and answered with other languages.

Results

During the online survey, a total of n=97 participants enrolled voluntarily. The majority of the residents are aware of when to and whom to call in case of a medical emergency. N=35 (36%) of the participants believe that ambulance services are misused.

Conclusion

The conducted study demonstrated that almost 36% of participants believed abuse of ambulance services, though there might be numerous reasons for calling ambulance unnecessary. Public health plays a vital role to reduce inappropriate ambulance calls when both ambulance services and public health are integrated into one system of care.

Keywords

Public health; Ambulance services; Emergency medical services (EMS); Emergency care pathway; Misuse of ambulance services; Paramedic; Scope of public health in EMS.

What is known about the topic?

Global perceptive ambulance utilization is increasing annually, with previous research suggesting numerous underlying factors.

What does this study add?

This study will be emphasized on the role of public health with the support of primary research (Cross-sectional study) and

secondary research (literature review). These factors have not been previously synthesized in the international literature. This narrative review clearly articulates the underlying problems.

What are the implications for practitioners (Both ambulance services and public health)?

This study outlines the need for further research of the causes of increased emergency ambulance utilization, to enable the development of appropriate strategies to manage misuse of ambulance services in the future.

INTRODUCTION

Overview

The primary role of all ambulance services is emergency pre-hospital medical care, although they generally provide both emergency response and patient transfer on behalf of the health sector. They provide easy access to health services, particularly out of hours, and contribute significantly to telephone triage and telephone health services through sophisticated communications infrastructure. In recent times it has become apparent that increasing health system pressures cannot be resolved only by adding resources but must also be addressed with new methods of service delivery.

The ambulance service is ideally placed to be part of the first line in the continuum of healthcare, and can significantly contribute to 'treat and transfer' or 'treat and leave' programs. If ambulance services can develop towards an out-of-hospital, clinical care service rather than merely pre-hospital clinical care, they could substantially add to the functionality of the health system. This could be through more efficient transfer of patient information; more efficient movement of patients; an ambulance service with public service – rather than profit-driven – philosophy; and patient treatment regimens consistent with the broader health system.

By integrating ambulance services into the health system generally, their respective strategic agenda is aligned, increasing efficiency, and providing an opportunity for an ambulance service, with its relevant expertise, to influence the outcome of 'health' initiatives.

The Problem Statement

Demand is growing throughout healthcare services, but for ambulance services, the increase is faster, in some countries close to twice the rate of other healthcare services and often without a commensurate increase in resources. Life expectancies are increasing, as is the frequency of serious adverse health events, multi-morbidity, and chronic diseases.¹

Aging is not the only causal factor for increased emergency medical service (EMS).¹ It has also been argued that, among all the conveniences of modern society delivering instant gratification to the door at the push of a button, there may be an increased

expectation for an in-house health service in public perception. Such expectations, combined with the belief in quicker care when arriving at a hospital *via* ambulance services, could contribute to the growing volume of non-emergency ambulance calls, placing an increasing strain on ambulance services.

This kind of societal change and increased patient volume, combined with exacting government targets, requires ambulance services to achieve more, for more people (and, frequently, with the same or even fewer resources, as in the case of e.g. the National Health Services (NHS) in the United Kingdom (UK). In addition, the increased load exacerbates problems further down the treatment pathway, such as hospital overcrowding and Emergency Department waiting times. This in turn can cause increased ambulance handover times and further decrease the available ambulance cover, leading to states of severe under-resourcing, excessive workload, and dangerously high response times.

Given this state of increasingly stretched resources, limiting systematic over-triage leading to immediate ambulance response in low-acuity cases (were dispatching an ambulance car provides little or no patient benefit compared to viable alternatives) is vitally important, as over-triage potentially leads to shortages in high-acuity emergencies, increased response times, and other aspects of suboptimal EMS resource utilization. However, avoiding under-triage, i.e. inappropriately low response in high-acuity emergency cases, is even more important if medical ethics is to be respected.

Description of the Emergency Care Pathway

For our case study, the emergency care pathway consists of the Ambulance Service bringing a patient to the hospital (typically two paramedics in an ambulance), the emergency department (ED), and hospital departments that receive patients from the ED. Figure 1 shows the resulting process emergency care pathway suggested by World Health Organization (WHO).²

It is internationally recognized that there are 10 steps required for an emergency medical service to receive a call, respond, treat, transport the patient, and be ready and available for the next call. This requires all aspects of the service to work together in performing their roles in a manner that will ensure the total management of the call is done effectively and efficiently. The success of a call for assistance is the united effort of all staff.

This policy and procedure will detail all the roles and responsibilities required to complete all Steps in EMS call management. Specific ambulance policy, policy statements and procedures may be issued in support of specific actions within this management process.

What is the Public Health Connection to Ambulance Services?

Public health is an amazingly broad discipline that includes injury prevention, disease surveillance, meeting the needs of underserved populations, and much more. The American Public Health Associ-

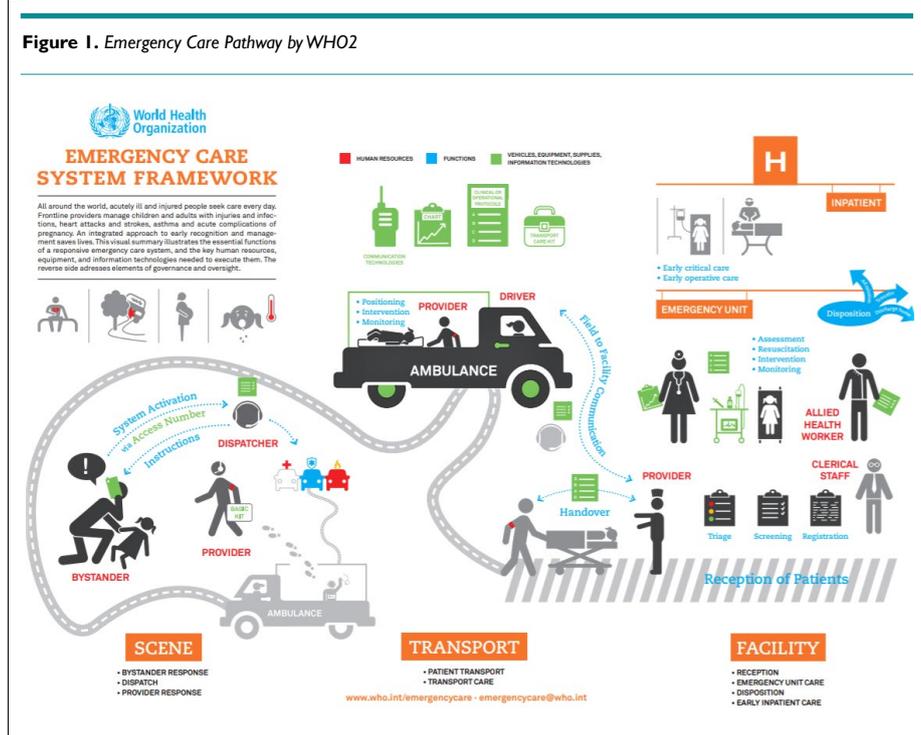


Figure 2. The Public Health System Integrated with Ambulance Services

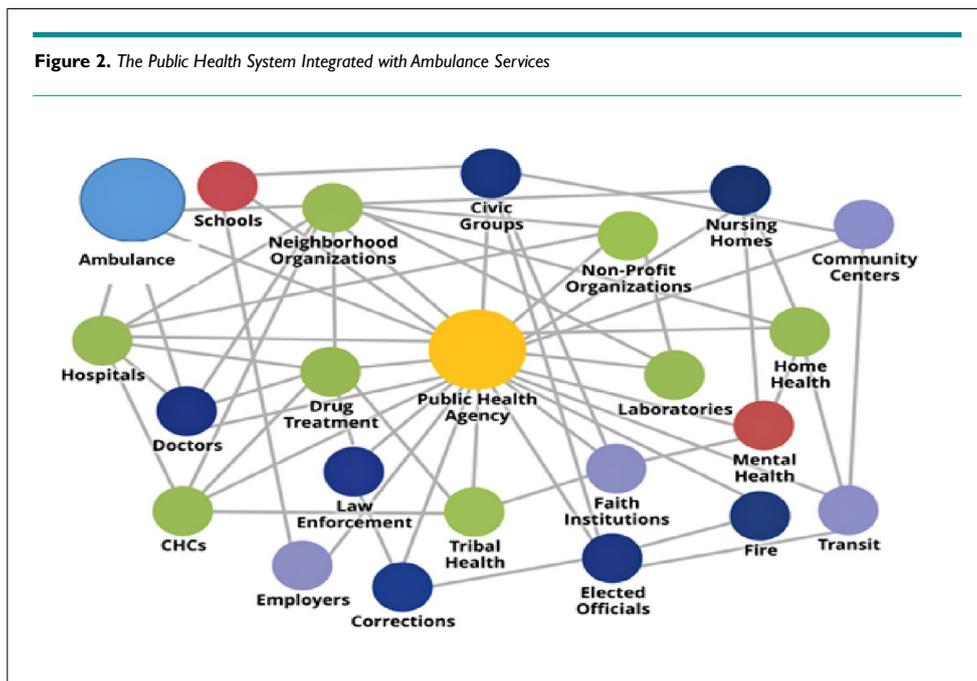


Table 1. Common Purpose of Public Health and Ambulance Services

	Purpose of Public Health	Purpose of Ambulance Services
Prevention	Prevent epidemics and spread of disease	Play vital role in communicable and non-communicable diseases especially in secondary and tertiary prevention of Public Health
Protect	Protect against environmental hazards	Support the purpose of Public Health
Prevent	Prevent injuries	Injury surveillance system
Promote	Promote and encourage healthy behaviors	Promote community care services, when to call the ambulance and what to do in case of a medical emergency
Response	Respond to disasters and assist communities in recovery	Play a major role in all phases of Disaster
Assure	Assure the quality and accessibility of services	Assure the quality and accessibility of emergency medical services

ation (APHA) has no less than 31 interest areas and or sections for its members, spanning from human immunodeficiency virus infection and acquired immune deficiency syndromes (HIV/AIDs) to school-based health to health information systems to behavioral health. There is even an emergency health services section concerned with ambulance services and emergency care systems. Table 1 has eventually prepared to demonstrate the common purpose where public health and ambulance services can work together for the development of the healthcare system not just in emergency care but also in preventive measures for preparation, prediction, and promotion.

As a general rule, public health is a catch-all discipline that is concerned with the health of communities in general. As a result, it is essentially anything health-related that is not an individual healthcare service. Despite its broad mission, public health (Figure 2) is only a fraction of the healthcare system, especially in the United States (U. S.) where we have a substantial focus on acute care services.

The history of public health is extensive and includes many great successes regarding environmental health, the control of infectious diseases, occupational health, and reductions in smoking amongst the general public. Public health is often a governmental responsibility and is accomplished to varying degrees at all levels of local, state, and federal government. At the federal level, multiple agencies, including the U.S. Public Health Service and the Centers for Disease Control and Prevention (CDC), have public health responsibilities. Every state has a health department, as do almost all counties and many larger municipalities.³

Research Questions

The research questions for this study were:

1. Does the public perception affect the inappropriate use of ambulance services?
2. Assess the knowledge among the community awareness of when to call an ambulance, know the role of ambulance services in society?
3. Does the community aware of the misuse or inappropriate use of ambulance services and how does affect the ambulance services?
4. Can public health play a vital role to reduce the inappropriate use of ambulance services?

Objective

The purpose of this study is to evaluate the public perception of appropriate usage of ambulance services and determine the applicable role of public health to reduce the inappropriate use of an ambulance.

METHODOLOGY

Study Design

A cross-sectional study was conducted to collect data from the

general public using an online survey. The survey contains 9 questions that evaluate the public awareness of appropriate ambulance use. Participants are residents from United Arab Emirates (UAE) public within the age of 18 and above.

Sample Size

Used the *t*-tests for sample size selection. The minimum sample size required is 54 as below stated. However, a total of N=97 of participants' responses were used to analyze the data as Figure 3.

Inclusion Criteria

Complete surveys and answer data using the English language.

Exclusion Criteria

Uncompleted surveys, and answered with other languages.

Study Period

The study has conducted within 5-months of duration (1 February 2018 till 30 June 2019).

Data Collection Tools

Data was collected through an online survey from the residents of the UAE.

Ethical Consideration

All the data collected online as well all the participants informed that anonymity and confidentiality of responses are guaranteed. The purpose of the study has been mentioned to participants as well the Institutional Review Board (IRB) approval is not needed.

Pilot Study

A pilot study has been conducted on a small scale to evaluate feasibility, time, cost, and improve upon the study design before a performance of a full-scale research project.

Data Entry

All data entered online by the general public voluntarily, a total of 97 responses received with 100% completion of the survey, and the average time has taken 2 minutes 27 seconds to complete the survey.

Data Analysis

Statistical Package for the Social Sciences (SPSS) and Microsoft Excel are used for statistical data analysis.

Figure 3. Two Tails by Using t-test

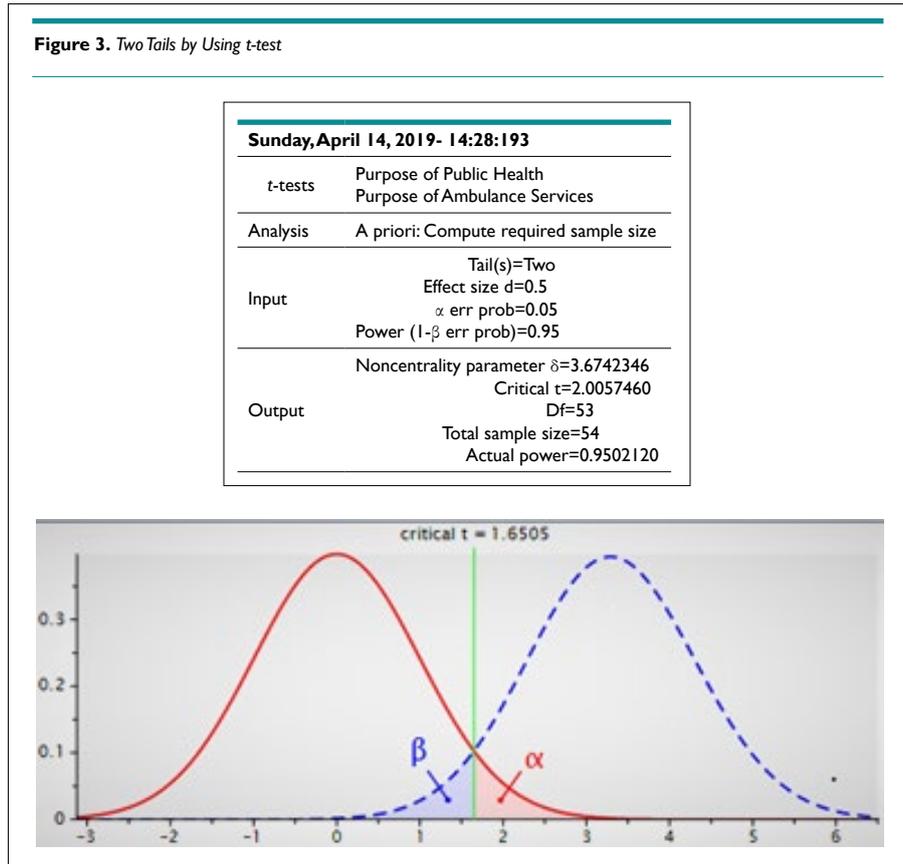
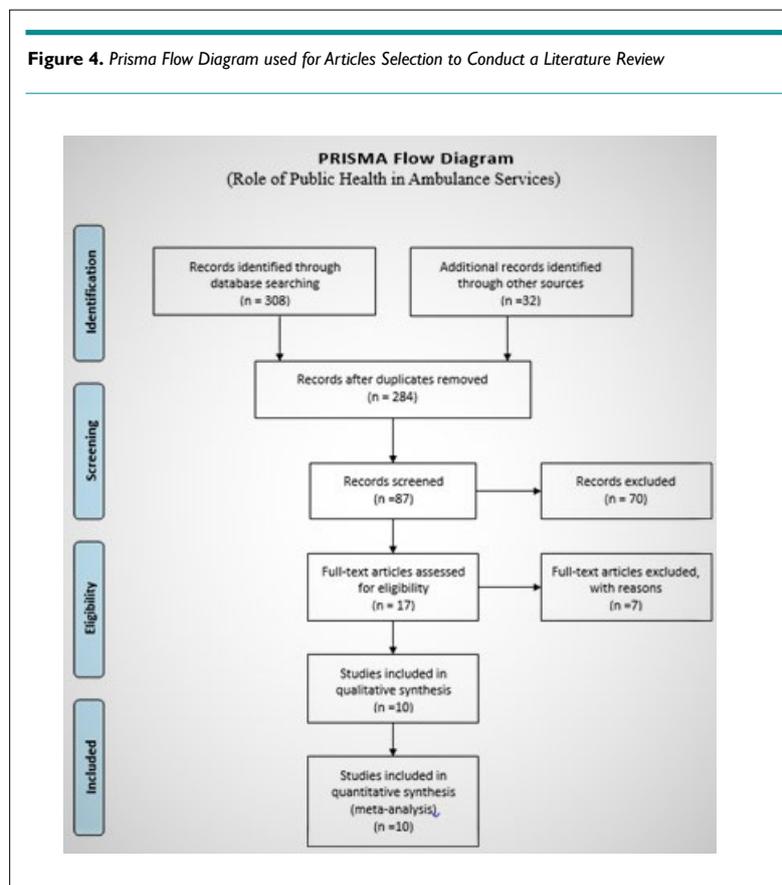


Figure 4. Prisma Flow Diagram used for Articles Selection to Conduct a Literature Review



Methodology-Secondary Research

Literature review: The following Databases that were searched were MEDLINE, Literature (CINAHL), Cochrane library, Google Scholar, and PubMed. The search strategy was perused with key terms such as “ambulance Services and public health”, “misuse of ambulance services”, “public health role in ambulance services”, “demand of emergency medical services” and “scope of public health in EMS”. Additional articles were found from the reference list of these studies.

E.g. of PubMed Search Results (“ambulances” [MeSH Terms] OR “ambulances” [All Fields] OR “ambulance” [All Fields]) AND services [All Fields] AND (“public health” [MeSH Terms] OR (“public” [All Fields] AND “health” [All Fields]) OR “public health” [All Fields]).

Inclusion criteria consisted of full-text articles, studies conducted on ambulance services and public health relations, articles published in the english language from the period of 2002-2019. Peer-reviewed articles were preferred.

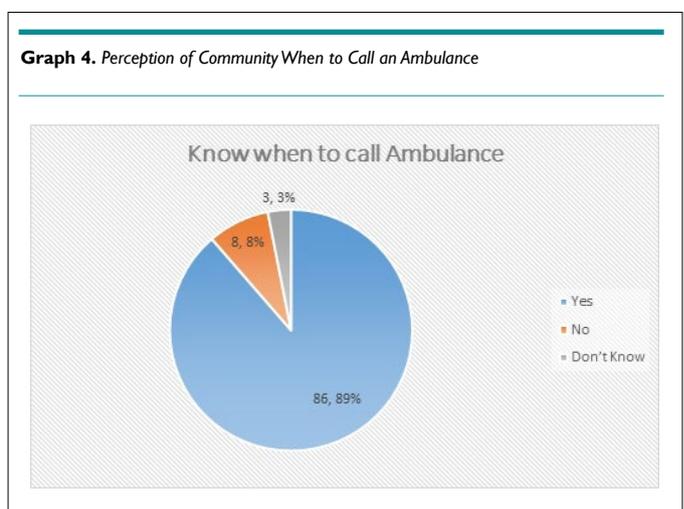
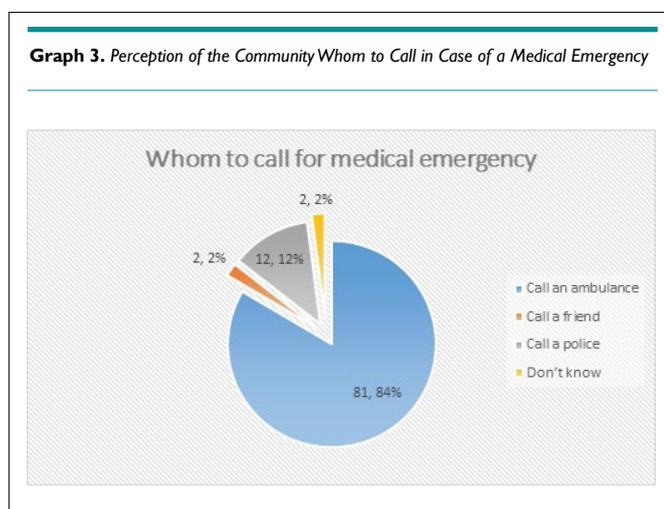
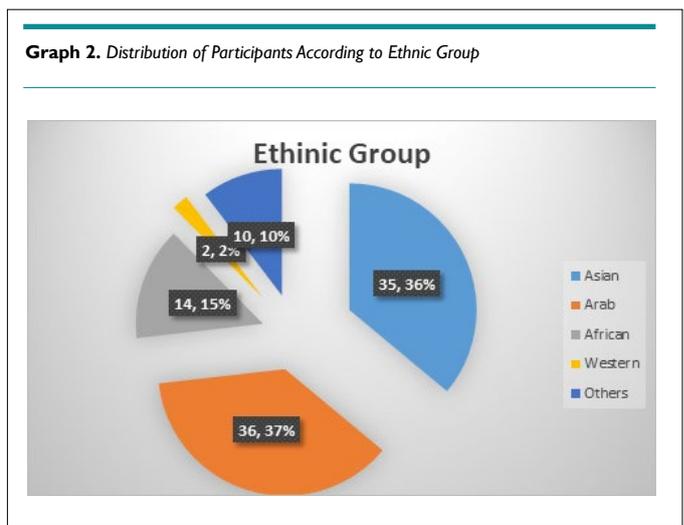
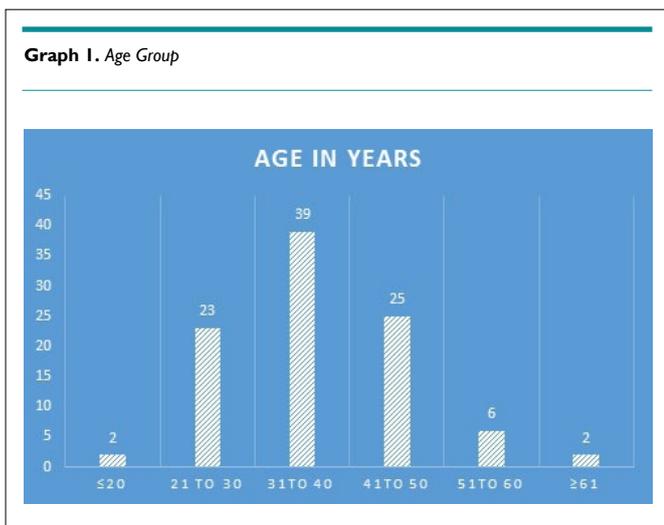
The search was broadened to in healthcare settings due

to the lack of evidence found on ambulance services and public health. The articles were then reviewed by title and abstract. Irrelevant articles were excluded. The method sections of the articles were reviewed and study design literature reviews were preferred. The initial search resulted in 308 hits (Figure 4). Two hundred and twenty-one (221) were excluded due to unobtainable full-text articles and some were irrelevant based on title and abstract. Some were repeated articles. Eighty-seven (87) were then selected for further review. Upon inspection and thorough reading of the papers, 70 more were excluded. Finally, only 10 articles remained which matched the search strategy and inclusion criteria.

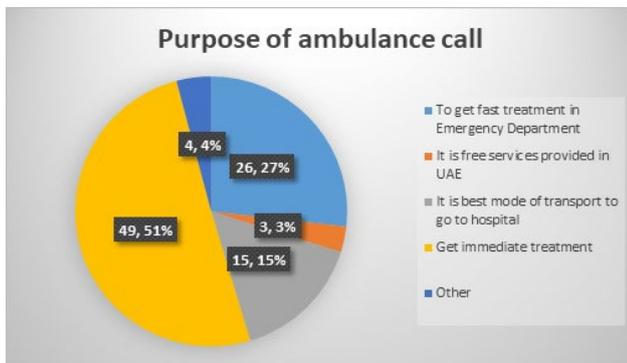
RESULTS

Results for Primary Research

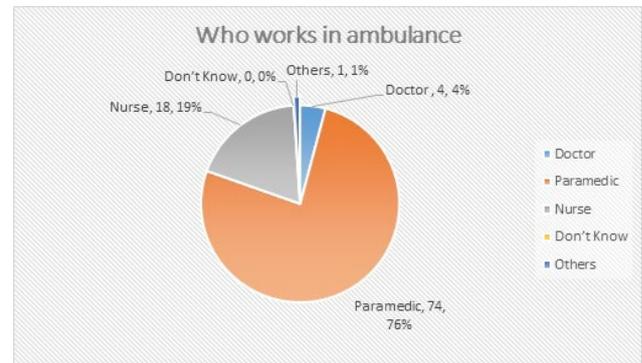
During the online survey, a total of n=97 (100%) participants enrolled voluntarily. The mean age of the participant reported was 41.5-years and further age distribution is mentioned in Graph 1. Among this survey almost n=39 nationalities participated those are residents of the UAE, thus they further cluster as a group in Graph 2 based on race. The majority of the residents are aware of when to and whom to call in case of a medical emergency in UAE



Graph 5. Perception of the Community Why Need to Call an Ambulance



Graph 6. Perception of the Community Who Works in an Ambulance



Graph 7. Acceptance of Abuse of Ambulance Among the Community

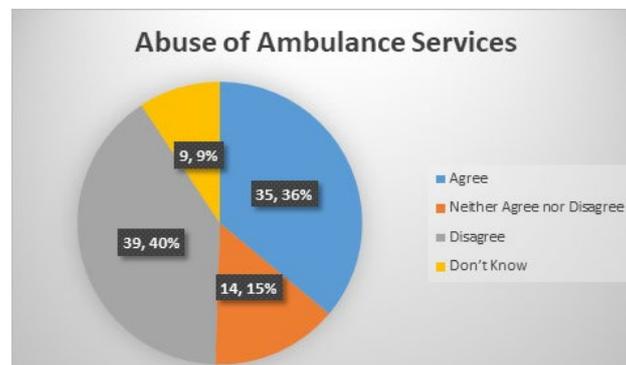


Table 2. Results for Secondary Research

Authors	Year of Publication	Study Design	Study Participants	Study Settings	Major Findings
Sultan et al ⁴	2018	Cross-sectional retrospective	N=801	Out of hospital	A common reason for the utilization of ambulance services
Phung et al ⁵	2018	Semi-structured interview	N=16	Out of hospital	Community first responders role in supporting ambulance services
Phung et al ⁶	2017	Systematic scope review	More than n=2000 articles	Out of hospital setting	Community responders scheme in the United Kingdom in collaboration with ambulance services.
Victor et al ⁷	1999	census	N=623000	Out of hospital setting	60% of patients needed to call an ambulance while remaining of the 40% should use other healthcare services rather than using ambulance services.
Gray et al ⁸	2007	retrospective review	N=354	Out of hospital setting	
Stirling et al ⁹	2007	Qualitative data were collected from semi-structured interviews	NA	Out of hospital setting	Increased interactions between ambulance services and rural communities with an overall benefit to health care
Toledo et al ¹⁰	2013	A cross-sectional survey	N=911	Emergency Department	Community call ambulance for getting higher priority at the ED (34%), not having a car (34%), and financial concerns (17%).
Roberts et al ¹¹	2014	two mixed-methods studies	NA	Out of hospital setting	Findings that explore the liminal and complex role of the first responder as both 'practitioner' and community member.
Palazzo et al ¹²	1998	retrospective review	N=300	Accident and emergency department	15.7% were inappropriate ambulance calls.
Møller et al ¹³	2015	Descriptive analysis	N=211,193	Emergency medical dispatch center	"Unclear problem" was the most frequent category (19 %).

(Graphs 3 and 4). The purpose of calling an ambulance is classified in Graph 5. The understanding about ambulance professionals is distributed in Graph 6 as per community perception. N=35 (36%) of the participants believe that ambulance services are misused referred to Graph 7 (Table 2).

DISCUSSION

Most of the ambulance services concerned a large increase in calls, and especially treating on the scene or treat and refer another healthcare facility rather than transferred by ambulance. Most of the ambulance services have given response time as key performance indicators, hence the emphasis on response times and transportation to an end destination, there may be a major underestimation of the value and cost-effectiveness of activities at the scene. This emphasis was reinforced by the performance measurement regime being concentrated on response times. However, the majority of the developed countries do not just emphasize response time only as key indicators they are promoting the clinical outcome indicators, as well-focusing on prevention of medical emergency and involvement of community volunteers. Moreover, we would argue that the process of developing new indicators should be deliberative and involve wide a range of stakeholder's e.g. healthcare organizations, law enforcement. The major concern here is the knowledge gap between healthcare professionals and their patients which means that the concept of the perfectly informed customer central to classical economics is absent. It may well-be that the problem of information identified is the key obstacle to the closer involvement of the public in this process.

Our findings about public perceptions of ambulance services when to call for an ambulance in case of emergency is the biggest challenge. Patients describe their experience of the situation as "intolerable" and cite feelings of anxiety before calling.¹⁴ Booker et al¹⁴ study of patients who called an ambulance for primary care problems revealed a misunderstanding of options in the healthcare system or previous negative experiences seeking care as factors influencing the decision to call, which is consistent with the cues we found that paramedics use to identify a patient's inability to cope.

This study also builds on previous studies that have examined the perceived prevalence of inappropriate use by community. These empirical studies of inappropriate ambulance use have focused primarily and often solely on clinical criteria. Our examination of how paramedics view and judge appropriate *versus* inappropriate ambulance use found that paramedics also tend to characterize the appropriateness of ambulance use according to contextual information gathered on scene.

Ultimately, addressing the problem of ambulance misuse requires asking fundamental questions about what the role of paramedics and ambulances should be in the healthcare system. In the UAE the context, the patient initiates ambulance use, and paramedics are unable to refuse transportation or to transport patients to alternative care settings. In addition to the patient attributes noted in this study, more research is needed about the effect of organ-

izational and systemic factors on ambulance use and perceptions of appropriateness.

The biggest challenge is to "educate the public" in terms of recognizing a real medical emergency and to make aware of "when to call an ambulance". The 'public' served by the emergency services is varied as is the range of activities; the public's perceptions of the role of the service may be inherently simple and conservative; and the culture of the service itself may also be conservative and at times defensive in its approach to the users and conflictual in its relationship with other healthcare professionals with their aims, objectives and performance measures to fulfill.

This present situation of increased workload of ambulance services and misuse of ambulance services can be tackled with "public health initiatives". Thus public health policies, the modern health system, and community awareness are vital to consider for a successful integrated healthcare system.

LIMITATIONS

The major limitation of our study is the small sample size (99 participants only) so the results cannot be generalized.

STRENGTHS

- Overall study has shown positive results that majority of the participants are aware of when to call and whom to call in case of medical emergency.
- The study had provided more detailed information to explain complex issues related to misuse of the ambulance services.
- Data collection is usually cost efficient for this study.
- The study as well as suggests exploring the individual items to understand public perception for utilization of ambulance in more depth.

CONCLUSION

In case of medical emergency the ambulance services is the first choice for the global community, however calling an ambulance still a huge dilemma. This study emphasizes almost 35% of participants believed abuse of ambulance services, though there might be numerous reasons for calling ambulances unnecessary. We can change this perception of the public by completing the healthcare system approach and adopting the public health strategies. The basic steps can be adopted by "public health education initiatives" in collaboration with ambulance services and public health together to reduce the workload of ambulance services, train the community for recognizing the medical emergency, promote the culture of health prevention and share the knowledge when to call an ambulance.

We as a global community need to acknowledge that there is a need for further research in the development of policies, procedures, and collaboration for the enhancement of ambulance services.

RECOMMENDATIONS

Given that, many strategies could help reduce the number of inappropriate calls including:

- Public Awareness: Raising awareness of the public about “when to call an ambulance initiative” can make a huge difference and public health can play a vital role through the journey of the patient in case of a medical emergency.
- Collaboration between Public Health Organization and Ambulance Services: From prevention, protection, promotion till post-treatment and rehabilitation both public health and ambulance services can work together.
- Education Institutes: Education institutes need to consider teaching curriculum in medical schools, paramedic schools, or other allied healthcare colleges to consider the importance of the role of public health and ambulance services in our community.
- Global healthcare organization: WHO and Ministry of Health of respective countries can develop the “Global Public Health Strategy” to reduce the inappropriate calls of ambulance services.

ACKNOWLEDGEMENTS

I wish to thank all the participants who gave their time to participate in the study and the reviewers for their time and constructive feedback.

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APPENDIX

Example of Search Strategy		
Database	Description of Database	The Rationale for Using this Database
Google Scholar	It offers a wide range of scholarly articles on one platform.	Widely popular and reliable
PubMed	It belongs to the service provided by the National Library of Medicine, thus rendering access to MEDLINE citations dating back to the mid-1960s until the present date.	Public Health-related information may be easily obtained

QUESTIONNAIRE

Utilization of Ambulance Services Perception Among the Public

Please answer the questions below by placing a tick in the appropriate box. Please note that your personal opinions will be kept confidential and that no information, which could identify you, will be released. Information obtained from you will be combined with the other responses and used for Ph.D. in Public Health graduation purposes only.

NAME (Optional): _____

Age: _____

Nationality: _____

1. What would you do next if a person is lying unconscious by the side of the road with the scene being safe?

- Call an ambulance
- Call a friend
- Call the police
- If Other -----

2. Are you aware of the number to call an ambulance in case of an emergency?

- Yes
- No
- If yes what is the number -----

3. Are you aware of when to call an ambulance in case of an emergency?

- Yes
- No
- Don't Know

4. Do you know who works in an ambulance to treat the patient?

- Paramedic
- Doctors
- Nurse
- Don't Know

5. Which is the most important purpose do you think to call an ambulance?

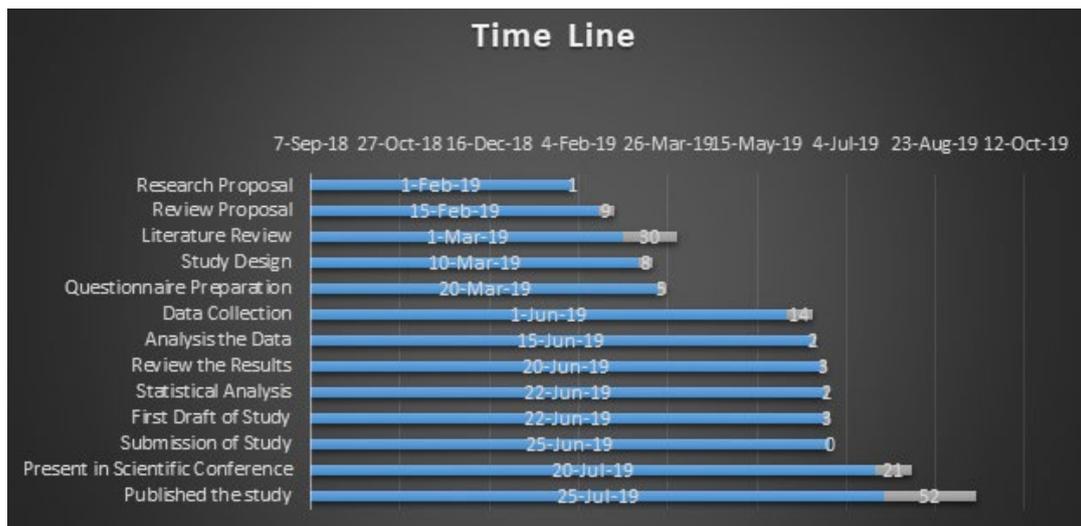
- To get fast treatment in Emergency Department
- It is a free service provided in UAE.
- It is the best mode of transport to go to the hospital
- Get immediate treatment
- If Other -----

6. Do you agree or disagree with the abuse or misuse of ambulance services in the UAE?

- Agree
- Disagree
- Neither agree or disagree
- Don't Know

Thank you.....

Timeline



Original Research

Assessing the Private Sector and Civil Society Engagement in Poliomyelitis Myelitis Vaccination among Internally Displaced People in Khartoum State, 2019

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Article information

Received: October 23rd, 2021; Revised: December 11th, 2021; Accepted: December 18th, 2021; Published: December 22nd, 2021

Cite this article

Salih AAM, Abdeen LSE, Salih ASM, Malik EM. Assessing the private sector and civil society engagement in poliomyelitis myelitis vaccination among internally displaced people in Khartoum State, 2019. *Public Health Open J.* 2021; 6(2): 54-61. doi: [10.17140/PHOJ-6-159](https://doi.org/10.17140/PHOJ-6-159)

ABSTRACT

Background

Poliomyelitis is an oro-fecal vaccine preventable disease affecting mainly children under five-years-old and is prevalent in poor sanitation and hygiene environment. The World Health Organization (WHO) stressed the need for coordination between the public and the non-governmental (particularly private) sectors to increase the coverage with immunization. This study aims to assess the private sector and civil society engagement in the implementation of poliomyelitis vaccination among internally displaced people and irregular settlement in Khartoum. Specifically, the study aimed to identify the major gaps in immunization program among internally displaced people (IDP), and to determine the enablers and barriers for the private sector and civil society active engagement in the immunization program.

Methods

This cross-sectional study used both quantitative and qualitative methods. Data was collected from the health facilities managers and the expanded program of immunization (EPI) service providers at private and civil society's facilities in the targeted areas using a semi-structured interview guideline and a self-administered questionnaire respectively. The obtained quantitative data was coded and then analyzed using the statistical package for social science (SPSS version 21) and presented using tables. For qualitative part, all data were transcribed verbatim and analyzed using a thematic analysis, paying particular attention to axes of difference, including gender, private center and non-governmental organization.

Results

The major gaps were the insufficient number of health facilities together with uneven distribution of the available ones, and unclear mandate of non-governmental organizations (NGOs) and private sector in EPI programme. Most of the managers complained from the lack of human resources for vaccination but stressed on the fact that training of the existing staff made the availability of the service easier. Twelve (12) out of 23 health facilities visited by the field team where in areas that do not have electricity or water supply which imposed more efforts to preserve the vaccines.

Conclusion

Private and civil societies were not well utilized by EPI program in Khartoum, Sudan. A clear mandate for engagement and periodic training for the service providers is highly needed.

Keywords

Private sector; Civil societies; Poliomyelitis vaccination; Internally displaced people (IDP).

INTRODUCTION

Poliomyelitis is an oro-fecal disease that is easily transmitted in poor sanitation and hygiene environment. The disease mainly affects children under five-years-old. The disease is one of the vaccine preventable diseases. Globally, cases due to wild poliomyelitis virus have decreased by over 99% since 1988, from an estimated 350,000 cases to 33 reported cases in 2018.¹ In 2012, the World Health Assembly adopted the Global Vaccine Action Plan with the goal of providing equitable access to vaccines by 2020.² In April 2016, the World Health Organization (WHO) strategic advisory group of experts (SAGE) on immunization stressed that the implementation of immunization in the context of health system strengthening and Universal Health Coverage (UHC) requires increased coordination between the public and the non-governmental (including private) sectors.³ Non-governmental organizations (NGOs) role in the health sector has also changed in recent years, and significant emphasis has been placed on NGOs contracts for service delivery.⁴ In low and middle income countries (LMICs), NGOs play a significant role in financing and providing health care services, and the use of NGOs in advancing public health goals is increasingly common.⁵ In some areas, NGOs seem to be the best tool for developing essential health services and are part of the strategy to achieve UHC.⁶ NGOs are uniquely committed to providing health services in sparsely populated areas globally, mainly through their active participation in providing health services directly through the ancillary factors of supply.⁷ Many governments partnered with NGOs, recognizing their significant and often dominant role in providing health services in LMICs.⁶ Proponents of formal government interaction with NGOs argue that they operate extensively, even in remote and rural areas, and are more accountable than their public-sector counterparts.⁵ Despite injecting financial resources into health systems, many countries still face difficulties in progress towards sustainable UHC and did not provide preventive and curative health care services.⁸ In many LMICs, the challenge of adequate provision of quality care to all who needs it becomes even more apparent, as all available human resources for health (both public and private) are required to achieve this goal. However, it is time to change how we look and think about health issues and health services provision if we want to achieve health attainment and well-being for all.⁹

The Horn of Africa has a long history of outbreaks of poliomyelitis due to large pockets of children remaining unimmunized, weak surveillance systems in some areas that fail to recognize importations before they take hold, mobile populations that are hard to access, and conflict and insecurity that create inaccessible zones. To ensure that the country stays free from poliomyelitis, it is essential to maintain the momentum to reach every child with poliomyelitis vaccines and to strengthen poliomyelitis surveillance.¹⁰ Cases of inequity in access to immunization service continue to exist in the region; it remains for the national governments, communities, civil societies and immunization partners to engage into the drive of universal access to immunization as a cornerstone for health and development in Africa.

In Sudan, the national expanded program of immunization (EPI) services are integrated in primary health care services

at facility and community levels. Care providers (medical doctors, medical assistant, health visitors and nutritionists), at facility and community levels represent a backbone for these services as they report vaccine preventable diseases (VPDs), identify and direct non-immunize children to vaccinators and deliver education messages to care-givers.¹¹

Although Sudan has been free from poliomyelitis since 2009,¹² Sudan is classified as high-risk country for poliomyelitis as there is difficult to reach many areas in the country because of unrest and conflicts. The influx of refugees from nearby countries is another factor. Low coverage with poliomyelitis vaccine plays also a major role. According to the Sudan multiple indicator cluster survey (MICS) that was carried out in 2014,¹³ Percentage of children age 12-23-months who received the third dose of oral poliomyelitis vaccine 3 (OPV 3) by their first birthday was 65.3%.

In research done to study private sector engagement and its contribution to immunization service delivery and coverage in Sudan, the health system has learned the importance of regulating and licensing private facilities and incorporating them into the immunization program's decision-making, planning, regular evaluation and supervision system to ensure their compliance with immunization guidelines and the overall quality of services. In moving forward, strategic engagement with the private sector will become more prominent as Sudan transitions out of donors' financial assistance with its projected income growth.¹⁴

Following civil wars in Blue Nile, South Kordofan and Darfur, protracted displacement is widespread in Sudan. Ongoing violence, particularly in Darfur, and disasters, predominantly flooding, also trigger significant new displacement every year. In the first half of 2019, about 29,000 new displacements were recorded, 21,000 by conflict and 8,000 by disasters making the internally displaced people (IDPs) to be 2,072,000.¹⁵ A study done in Nayala (South Darfur) to assess the vaccination coverage concluded that "*the vaccination coverage in the studied area was low compared to the national coverage*". Efforts to increase vaccination converge and completion of the scheduled plan should focus on addressing concerns of caregivers particularly side effects and strengthening the EPI services in rural areas.¹⁶ Moreover, there are 1.2 million refugees and asylum seekers. This indicates a dynamic population that needs to be covered and monitored¹⁷ as refugees and IDPs are one of the most vulnerable groups for communicable diseases due to low socio-economic status, poor sanitation and hygiene, and low access to services.

Fifty-five percent (55%) of private health facilities in Sudan (411 out of 752) provide immunization services, with 75% (307 out of 411) are based in Khartoum state and the Darfur region. In 2017, private providers administered about 16% of all third doses of pentavalent (diphtheria, pertussis, tetanus, hepatitis B and Haemophilus influenzae type (B) vaccines to children. Private health providers contribution in immunization services have especially been critical in filling the gaps in government services in hard-to-reach or conflict-affected areas, among marginalized populations, and thus in reducing inequalities and access to services.¹⁴

Thus, assessing the private sector and civil society engagement in delivering poliomyelitis vaccination is a step forward to improve the accessibility of health services among IDPs and irregular settlement in the periphery of urban areas such Khartoum. It is important also to determine the enablers and barriers for the private sector and civil society active engagement in the immunization program.

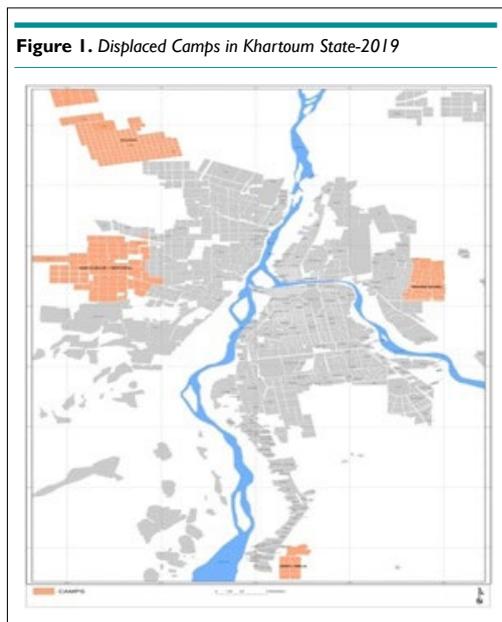
METHODS

Study Design

In this cross-sectional study we used both quantitative and qualitative methods to identify gaps and to assess the private sector and civil society engagement in the implementation of immunization program especially poliomyelitis vaccination among IDPs and irregular settlement in Khartoum State.

Study Area

The study area is located in the outskirts of Khartoum. They are distributed over 4 localities out of the 7 localities in Khartoum State (Figure 1). The study covered all the 8 camps and settlements in Khartoum. The study settings included the private and civil society facilities in the camps.



Study Population and Sampling

The study population planned to include one senior facility manger and one EPI service provider at private and civil society's facilities in the targeted areas. A sample of 30 facilities (15 private clinics/centers and 15 civil society facilities) had been planned for data collection but we reached 23 of them. The reasons for not including the remaining facilities were: 3 facilities refused to be studied, 2 were closed for maintenance and 2 facilities were visited more than two times and were found closed. In these 23 facilities, 16 managers (3 refused to participate, and 4 were absent during visit time)

and 21 EPI service providers (one has no vaccination services and the other the provider was absent) had been interviewed.

Data Collection

For primary data, trained data collectors used a semi-structured interview guideline to interview the managers of private and civil society health facilities at IDPs camps and irregular settlement in Khartoum State. A self-administered questionnaire and review form was used to collect data from the EPI service providers. Data collectors contacted listed participants for permissions and agreement on date and place for interviewing.

Data Analysis

For quantitative variables, the obtained data were coded and then analyzed using the statistical package for social science (SPSS) version 21 and presented in tables. For qualitative part, all data were transcribed verbatim and subsequently translated into english and sent to the qualitative coordinator for initial coding. Data were analyzed using a thematic analysis, paying particular attention to axes of difference, including gender, private center and non-governmental organization. This allowed for an exploration of how and why experiences differ across those axes. The analysis process included coding, sorting and explanation of data, during which links between themes and codes are explored and situated within wider discourses of knowledge about health policies and definition of IDPs. The data coding and emerging themes were discussed regularly.

Ethical Considerations

Ethical clearance: Ethical clearance has been obtained from the national ethical committee at the Federal Ministry of Health on the third of November 2019 and permission from the Khartoum Ministry of Health was also obtained.

Written informed consent: Written informed consent obtained from each participant separately. Consent was documented as a tick on each questionnaire together with signature.

RESULTS

Data obtained through an in-depth interview with 16 managers and self-explanatory questionnaire with 21 EPI services providers at 23 health facilities in the major IDPs camps and the irregular settlement in Khartoum State was presented in Tables 1 and 2. Ten facilities belong to NGOs and the rest were private facilities and both have been established years ago. All managers were male and 8 of them were medical doctors and all has considerable work experience. Despite that, few were aware about EPI policies, plans and target for immunization (Table 1) and that may explain the findings in Table 5 where the majority of health facilities reported a much higher coverage compared to target. Managers reports that they are willing to have vaccination services and they offer office, furniture and personnel for that. Moreover, they state *"we benefit from that. It is a chance to promote for the other services provided at our center"* they added

“when the mother came to vaccinate her child, she gets to know the center... that is working”. The majority of the managers are not involved in the monitoring process, as they only sign the reports prepared by the service providers.

the majority was in the age group between 30-59-years and with only basic education (Table 2). Two-third of them reported a work experience less than 10-years. Thirteen of them were vaccination technicians and eight were doing both vaccination and nutrition services at the center. While only 11 (52.4%) of them trained in vaccination, most of participants (95.2%) were trained in communication and health education skills. However, 13 of them reported that the last training was more than 10-years-ago.

Table 1. Characteristics of Health Facilities and their Managers (n=16)

Variable	Description	Frequency	%
Manger affiliated to	Private	9	56.3
	NGOs	7	43.8
Years since establishment in the current area of work	Less than 10-years	7	43.8
	10-20-years	6	37.5
	More than 20-years	3	18.8
Sex of the mangers	Male	16	100.0
	Female	0	0.0
Age group in years	<30	0	0.0
	30-59	14	87.5
	60 and above	2	12.5
Managers qualification/ specialities	Medical doctors	8	50.0
	Allied health personnel	3	18.8
	Others	5	31.3
Managers work experience	10-years or less	7	43.8
	More than 10-years	9	56.3
Managers were aware about EPI policies, plans and targets	Yes	3	18.8
	No	13	81.3

Data obtained from EPI service providers through the self-administered questionnaire showed that: 20 were female and

Ten of the facilities surveyed offered vaccination services (including poliomyelitis vaccination) on daily basis and 7 more provided the services three times a week. Almost all (95.2%) have an outreach service and 16 (76.2%) served general population as well as displaced population and offering health education services on regular basis at both facility and community level. Twelve facilities (57.1%) have a known catchment area. The majority of health facilities have a contact with the general population in the area but less (only 14, 66.4%) have such contact with displaced people. Twenty (95.2%) facilities perceived that the general population were willingness in vaccination while only 15 (71.4%) have this perception regarding the willingness in vaccination among displaced people. The major gaps in EPI services at facility level include: Lack of awareness (28.6%), the center is far (access issues) from the target population (28.6%), shortage in staff (23.8%), shortage in vaccine supply (14.3%), specified days for immunization are not enough (14.3%), and financial barriers (14.3%), (Table 3).

Table 4 lists the enabling factors and barriers to vaccination services at facility level comparing between general population and displaced people. With exception of the service availability nearby the residential areas, EPI services providers perceived that

Table 2. Characteristics of EPI Service Providers (n=21)

Variable	Description	Frequency	%
Age group in years	Less than 30	02	09.5
	30-59	16	76.2
	60 and above	03	14.2
Sex	Male	01	04.8
	Female	20	95.2
Education	Basic education	18	85.7
	University and above	03	14.3
Job title	Vaccination technicians	13	61.9
	Vaccination and nutritionist technicians	08	38.1
Service provider trained in vaccination	Yes	11	52.4
	No	10	47.6
Service provider trained in health education and communication	Yes	20	95.2
	No	01	04.8
Time since last training	Less than 10-years	08	38.1
	10-years and above	13	61.9
Works only for vaccination and/ or nutrition	Yes	13	61.9
	No	08	38.1
Work experience	Less than 10-years	14	66.7
	10-years and above	07	33.3

Table 3. Status of EPI Services in the Surveyed Facilities (n=21)

Variable	Description	Frequency	%
Facilities provided vaccination services on	Daily basis	10	47.6
	Once a week	01	04.8
	Twice a week	03	14.3
	Three times a week	07	33.3
Facilities with outreach services	Yes	20	95.2
	No	01	04.8
Facilities have a known catchment area	Yes	12	57.1
	No	07	33.3
	Not exactly	02	09.5
Facilities offering vaccination services for displaced people	Yes	16	76.2
	No	05	23.8
Facilities arranged health education sessions	Yes, on regular basis	14	66.7
	Yes, when needed	02	09.5
	No	05	23.8
Health facilities arranged education session at (n=16)	Facility level	01	06.2
	Community level	15	93.8
Health facilities has a contact with the community in the area	Yes	20	95.2
	No	01	04.8
Health facilities has a contact with displaced in the area	Yes	14	66.7
	No	07	33.3
Facilities perceived general population willingness in vaccination	Highly willingness	20	95.2
	Moderately willingness	01	04.8
Facilities perceived displaced population willingness in vaccination	Highly willingness	15	71.4
	Moderately willingness	06	28.6
Major gaps in EPI services at facility level	Shortage in vaccine supply	03	14.3
	Shortage in staff	05	23.8
	Specified days for immunization are not enough	03	14.3
	Lack of awareness	06	28.6
	Access issues (centre is far from the target population)	06	28.6
	Financial barriers	03	14.3

Table 4. Enabling Factors and Barriers to Vaccination Services at Facility Level

Variables	General Population		Displaced People	
	Frequency	%	Frequency	%
Enabling Factors				
Services are available nearby their residence	13	61.9	17	81.0
They are aware about immunization benefits	17	81.0	10	47.6
They are aware about the consequence of non-vaccination	16	76.2	13	61.9
Services are free of charge	15	71.4	14	66.7
Frequency of services (2 or 3 times per week)	14	66.7	11	52.4
Staff are welcoming and encouraging	10	47.6	7	33.3
Barriers to vaccination				
Too far to reach	14	66.7	14	71.4
One has to pay to get services	12	57.1	11	52.4
Lack of awareness about immunization benefits	13	61.9	14	66.7
Lack of awareness about the consequences of non-vaccination	13	61.9	17	81
Limited availability of staff (only one session per week)	12	57.1	13	66.7
Staff disinteresting and mismanagement	12	57.1	11	52.4

the general population have a better chance in terms of enabling factors compared with displaced people. Regarding the barriers to vaccination, EPI service providers reported that the barriers were almost the same or slightly different with exceptions of displaced people awareness about consequences of non-vaccination (Table 4). With exception of 3 health facilities in general population and 5 in displaced people, health facilities largely exceeded their assigned monthly target (Table 5).

DISCUSSION AND CONCLUSION

The health facilities belonging to civil societies and private sector (in areas known as residence for displaced) in Khartoum State provide vaccination services for general population and for displaced people. The managers of these facilities were relatively young (30-50-years) and 50% of them were physicians. The fact that 80% of the managers were not aware of the policies and plans of EPI at state level complies with the finding from Nigeria.¹⁸ To reach the target, the experience with other programs showed the need for special efforts to involve frontline managers and staff in health reforms, as well as provision of adequate resources, and an enabling practice environment.¹⁹

What is good in the experience of Sudan is that provision of free immunization services is the pre-requisite to be authorized as a primary health centre. The locality health authorities (LHA)

asked the center to spare a space with furniture and to nominate a person to be trained by the locality and to be supplied with supplies and equipment such as vaccines on regular basis. The Locality accepts only reports that were signed by the center managers although most of the managers are not involved directly in the vaccination process. This system made immunization unit is more like a delegation from the locality that is settled in those health centers. Although being linked to the locality directly made the communication easier and quicker, but it is obvious that the Ministry of Health (MOH) has to have clear policy towards the private and civil societies health facilities and there should be a special effort to involve frontline managers and staff in health reforms, as well as provision of adequate resources, and an enabling practice environment.¹⁸ More involvement of primary health care (PHC) managers in the monitoring process such as being part of coordination committees could ensure the quality of services provided. A study conducted in Asia showed that these coordination committees are important in information sharing and the global alliance for vaccines and immunisation (GAVI) application processes.¹⁹

EPI service providers at the surveyed centers were female who were having basic education and with experience of more than 10-years. The last training courses received by the majority were more than 10-years-ago. This calls for giving more attention for continuous professional development as it is found that care providers (medical doctors, medical assistant, health visitors and

Table 5. Children Under 5-years Vaccinated for Poliomyelitis in the Last Month at the Facility Level*

Facility	General Population				Displaced Population			
	Target/Year	Target/Month	Children Vaccinated Last Month	%	Target/Year	Target/Month	Children Vaccinated Last Month	%
1	192	16	82	512.5	368	31	165	532.3
2	168	14	73	521.4	156	13	50	384.6
3	360	30	49	163.3	240	20	45	225.0
4	660	55	302	549.1	528	44	121	275.0
5	996	83	150	180.7	996	83	107	128.9
6	336	28	75	267.9	264	22	25	113.6
7	84	7	21	300.0	841	70	46	65.7
8	-	-	-	-	267	25	97	388.0
9	340	28	22	78.6	684	57	63	110.5
10	120	10	12	120.0	360	30	28	93.3
11	-	-	-	-	720	60	260	433.3
12	660	55	423	769.1	528	44	125	284.1
13	336	28	72	257.1	264	22	36	163.6
14	936	78	94	120.5	468	39	32	82.1
15	384	32	54	168.8	336	28	24	85.7
16	552	46	194	421.7	456	38	133	350.0
17	-	-	-	-	708	59	125	211.9
18	384	32	25	78.1	576	48	50	104.2
19	396	33	36	109.1	540	45	145	322.2
20	252	21	62	295.2	384	32	102	318.8
21	372	31	21	67.7	408	34	32	94.1
Overall	1404	117	144	123.1	1908	159	329	206.9

*Source: Data obtained from vaccination register at facility level

nutritionists), at facility and community levels represent a backbone for these services.¹² Moreover, there is a need for special efforts to involve frontline managers and staff in health reforms, as well as provision of adequate resources, and an enabling practice environment.¹⁹ Such special efforts need more engagement from private sector and NGOs.

Displaced' area in general is lacking education services as evident in the shortage of schools thus the reported illiteracy rate was 63%.²⁰ Health facilities in the area suffer from shortage of basic services which affects the provision of vaccination services regularly as evident from this study. There is no tap water and they have to pay on daily basis to get water from mobile water venders. Moreover, the available water does not comply with the standards for safe water supply.²¹ The area lacks sanitation, which made the population rely mainly on traditional toilets and open defecation which creates a suitable environment for domestic flies breeding with its negative consequences.²²

EPI services providers and health facilities managers have listed gaps, enabling factors and barriers to vaccination services in their respective areas. These were varying between general population and displaced people as perceived by the participants. The enabling factors include that the majority of frontline personnel in the targeted areas are available to provide vaccination services, awareness sessions, and they have established link with the communities in their catchment areas. This is not unique for Sudan and call for more attention for frontline providers and for allocation of more resources for primary care level.^{18,19}

The Ministry of Health documents revised by the team, showed little attention in displaced people and it seems that no special attention was given to them during planning despite the fact that the majority of children who were not vaccinated were coming from these areas (Ministry of Health reports). Furthermore, the health system profile highlighted that there is a deficiency in the available information about NGOs working in Sudan regarding their plans, budget and distribution. However, they play an important role in filling some of the gaps identified by the government system. Until recently there was no clear national policy towards NGOs and the monitoring and coordination mechanisms were weak.¹²

In conclusion, the major gaps for vaccination in general and poliomyelitis in particular are low awareness about EPI policies, plans and targets among health facilities managers, low access to EPI services and underestimation of the role of the private and civil societies. This is further complicated by the lack of bad consequences resulted from missing vaccination among displaced people. The Ministry of Health in the State and localities would gain a lot if they adopted a bottom-up approach to ensure primary health facilities manager's engagement in planning for EPI services in their areas. A clear agreement with a clear mandate for engagement with the private sector and NGOs could add a lot. More attention should also be given to the concept of catchment area as it is become the base for monitoring the progress towards the specified monthly and annual targets for each area.

The private and civil society's health facilities were not well utilized by EPI program in Khartoum, Sudan to improve the access of people living in areas known as displaced areas to vaccination services. The adoption of a bottom-up approach to engage the private and civil society's facilities managers in planning for EPI services in their catchment areas is highly needed. A clear mandate for engagement and periodic training for the service providers in private and civil society's health facilities is highly needed.

ACKNOWLEDGEMENT

Authors would like to acknowledge the support provided for this study by the GHD/EMPHNET "EMR Operational Research Studies" The mini-grants funding opportunity.

INSTITUTIONAL REVIEW BOARD (IRB)

Ethical clearance has been obtained from the national ethical committee at the Federal Ministry of Health on the third of November 2019 and permission from the Khartoum Ministry of Health was obtained also. Written informed consent was obtained from each participant separately. Consent was documented as a tick on each questionnaire together with signature.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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Retrospective Study

Developing a Probit Regression Model for Estimating the Chance of Mortality for Coronavirus Disease-2019 Patients

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Article information

Received: December 6th, 2021; Revised: December 18th, 2021; Accepted: December 24th, 2021; Published: December 28th, 2021

Cite this article

Mahmoudabadi A. Developing a probit regression model for estimating the chance of mortality for coronavirus disease-2019 patients. *Public Health Open J.* 2021; 6(2): 62-67. doi: [10.17140/PHOJ-6-160](https://doi.org/10.17140/PHOJ-6-160)

ABSTRACT

Rational

Although the number of deaths of coronavirus disease-2019 (COVID-19) is decreasing over the world due to vaccination process, but appearing its new variants remain it as the remarkable challenge for health authorities.

Purpose

The aim of this study is to develop a probit regression model to estimate the chance of mortality for the patients infected to COVID-19.

Methodology

The contributing factors of age, symptoms and underlying diseases have been considered as independent variables as well as the clearance type of death as dependent variable have been studied for estimating the mortality rate. Patients have been divided into two categories; 1) recovered or transferred and 2) death, followed by developing a probit regression model by the well-known technique of Max likelihood method.

Data Collection

Data have been collected for 1015 patients tested positively to COVID-19 and subsequently received clinical treatment or intensive care.

Conclusion

The results revealed the model is capable of estimating the chance of mortality based on age, symptoms and underlying diseases. As implication, the health authorities ultimately can estimate the patient mortality rate prior to admission procedures in hospitals.

Keywords

COVID-19; Mortality rate; Healthcare management; Probit regression; Maximum likelihood.

INTRODUCTION

Rational

The COVID-19 virus with a rapid human-to-human transmission makes patients experience a variety of symptoms and causes a significant risk to patients who are suffering from weak immune systems.^{1,2} In this case, the elderly people or those who are suffering from underlying diseases may experience more severely symptoms than the others³ followed by receiving particular healthcare at the intensive care unit (ICU).⁴ This situation leads health authorities to manage medical operations, according to a rough

estimation of admitted patients' mortality rate. There is a specific statistical method, called probit regression, to estimate the rate of mortality based on data collected for the patients, those have received medical treatment and invention resulted into death or recovered. Therefore, developing a probit regression model would support health authorities to provide a rough estimation of the mortality chance prior to admission process.

Scientific Background

By definition, the mortality rate is a measure defined as the number of deaths in a particular population, scaled to the size of that,

per unit of time.⁵ There is another term of case fatality⁶ in which the chance of death is estimated based on the patients' personal individuality such as gender and age. The case fatality can be also interpreted by a mortality rate where the particular population is set as the number of patients who were contracted to a specific disease, accordingly.

In statistics, there are many techniques to investigate and formulate the relationships between predictors and desired output measures. Regression analysis is one of the most prominent ones where a mathematical equation is formulated by a linear or non-linear form to interpret the relation between dependent and independent variables.⁷ Among the existing techniques, the probit regression modelling is specifically utilized when the independent variable represents binary values such as zero and one, true or false, yes and no, etc. In this case, the probit regression model predicts the chance of occurrence for the dependent variable in which the mathematical formulation is developed by equation (1), where X_1, X_2, \dots, X_k and Y are independent and dependent variables, respectively, $\beta_1, \beta_2, \dots, \beta_k$ are parameters (coefficients), and eventually Φ is the cumulative distribution function of the standard normal distribution.⁸

$$P(Y=1 | X_1, X_2, \dots, X_k) = \Phi(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k) \text{ -----(1)}$$

To estimate coefficients, a more developed statistical method of maximum likelihood is utilized. To estimate the coefficients of the above structure, the likelihood function is given by equation (2) where n is sample size. The coefficients are estimated through maximizing the likelihood function in mathematical or analytical approaches.

$$L(Y, X, \beta) = \sum_{i=1}^n y_i \log(\Phi(\beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_k X_{ki})) + \sum_{i=1}^n (1 - y_i) \log(1 - \Phi(\beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \dots + \beta_k X_{ki})) \text{ ----(2)}$$

In terms of validation, the suitability of an estimated binary model can be evaluated by counting the number of true observations equaling 1 for the predicted probability above 0.5, and the number equaling zero for the predicted probability below 0.5.⁹ In a non-parametric discrete choice model, semi-parametric or non-parametric approaches are more practical in use, like local-likelihood ratio, which avoids considering assumptions on a parametric form for the index function and are robust to the choice of the link function of probit.¹⁰ The process follows by calculating the stat (LR) that is obtained by equation (3) and compared to the Chi-Square (χ^2) distribution where L_{ur} is the maximum log likelihood for the unrestricted model, L_r is the maximum log likelihood for the restricted model, and $\Pr(\chi^2 > LR)$ represents the p value under the null hypothesis. The null hypothesis is defined as the under study variation does not have a significant effect on modeling.

$$LR = 2 \times (L_{ur} - L_r) \text{ -----(3)}$$

Relevant Studies

In the last decades, many studies have been conducted to utilizing forecasting methods in which data have been analyzed by utilizing data mining techniques and multiple linear regressions to improve the accuracy of estimations.¹¹ For example, a study on predicting the cost of public healthcare in Tsuyama Hospital, Japan, concluded that the forecasting models are capable of predicting more accurately costs for healthcare operations in which a linear regression has been developed.¹² Studies on estimating patients' mortality rate or other medical measurements have been also observed in the literature in which regression analysis techniques have been widely utilized over the populations under study.¹³ Comparing situations is another research field, where for example the study of the healthcare system forecast and its impact on health costs through linear regression in Colombia showed that long-term treatments are costly for insurers and patients.¹⁴

Among the recent studies, the Johns Hopkins University has predicted the prevalence of COVID-19 based on regression analysis and found out effective contributing factors in disease outbreak in short-term¹⁵ to manage healthcare operations during the COVID-19 pandemic. Modeling the mortality rate based on the patients' individuals such as age and gender is also observed in the literature,⁶ where the mortality rate is formulated by a regression model to weekly estimate it. The statistical analysis of the aforementioned study additionally showed that persons aged 65-years or older had higher mortality rates compared to younger persons, and men demonstrated a higher risk of death than women if they are infected to COVID-19. Studies show that many Iranian had been infected to COVID-19 before the outbreak was announced by the health authorities in particular in the northern provinces of Guilan, Mazandaran, Qom, and Golestan.¹⁶ While the Iranian big cities are currently receiving many travelers from other countries mainly from United Arab Emirates (UAE), Chian, Oman, Iraq, so the case-studies on COVID-19 are required to focus more on managing the healthcare system because there is no evidence of stopping the virus outbreak when its new variants appear in intermittently.

Following the above, developing a model to estimate the chance of mortality of the COVID-19 patients would support healthcare authorities to manage their health operations and nursing capabilities. The model would be more practical if it can predict the chance of mortality prior to admission process which is easily to measure or data are available in the health information system. Therefore, the study is to design a probit regression model to formulate the association between the chance of mortality, and personal characteristics of the patients infected to COVID-19.

COMMITTED VARIABLES AND DATA COLLECTION

Study Design

To develop the Probit regression model, the dependent variable is the clearance type of death, and the independent variables (predictors) include symptoms, age, gender and underlying diseases which patient maybe suffered from them in day-to-day life. The patient symptoms naturally require being under control and are regularly

measured and recorded¹⁷ while there are many underlying diseases¹⁸ committed to the patients.

According to the previous studies,¹⁹ in addition to underlying diseases that weaken the human immune system and make the patient be more committed to viruses, elderliness is also one of the risk factors for increasing the death of COVID-19. Therefore, the “Age” is getting under investigation as one of the most important contributing factors studied in this research work. Following the above consideration, the chance of death is estimated based on the symptoms, general conditions, and underlying disease as well. The probit regression model is developed for all patients resulted into recovered, transferred, and death, which all indicate the type of clearance in hospital terminology.

Data including age, gender, symptoms, and underlying disease, for 1015 patients have been collected from February 18 to August 20, 2020, in the northern Iranian province of Guilan for six months. Age is represented by year, but symptoms and underlying disease are indicated by a binary value of (0 and 1) where 1 repre-

sents the patient is suffering from underlying disease, otherwise 0. The similarity values are also denoted for symptoms where at least one symptom is observed during the treatment or prior to admission. Data composed of 603 (59%) recovered, 251 (25%) transferred or cleared according to personal satisfaction and 161 (16%) deaths, including 90 (9%) males and 71 (7%) females depicted (Figure 1). For more clarification, it should be noted that patients under the study had received healthcare treatments in hospitals and registered as the patients needs to receive healthcare and do not include those were taken care at home or had not been transferred to medical centers.

Demographic analysis has been carried out to find out more about data and the results (Table 1).

Age is divided into five groups with the number of patients in each group and mortality rates in the last two columns. All groups have been also indicated by gender shown in the middle of the table. The aggregate numbers of females and males are 427 and 588, respectively. The demographic analysis briefly shows that the mortality rate increases based on the age, suffering from un-

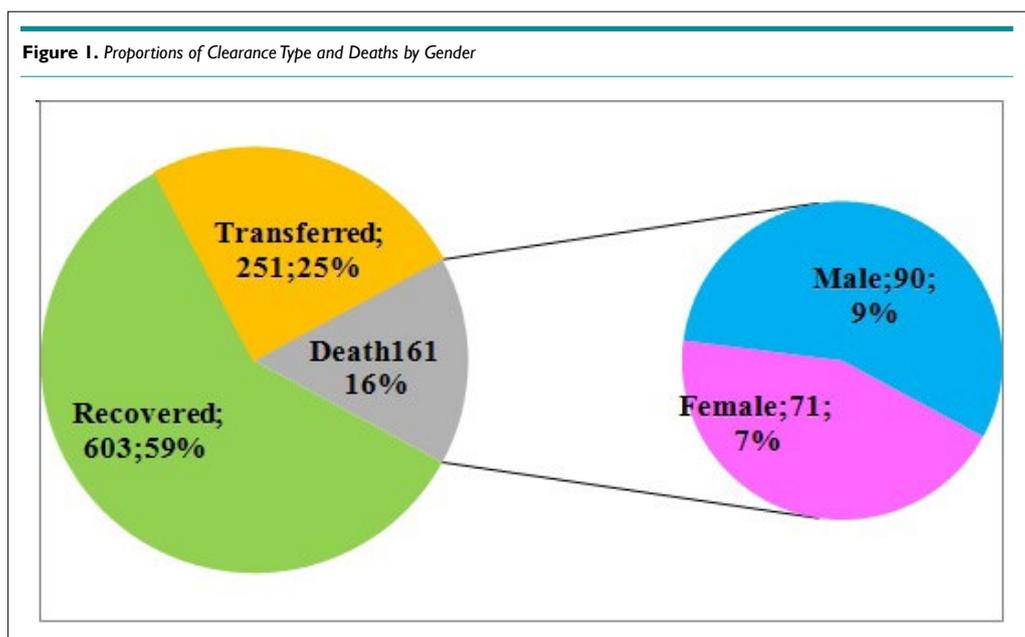


Table 1. Demographic Analysis of Patients Contracted to COVID-19

Variable	Group	Recovered		Dead		Transferred		Total	Mortality Rate
		Female	Male	Female	Male	Female	Male		
Age	01-20	5	13	0	1	0	2	21	4.76%
	21-40	44	68	5	5	15	25	162	6.17%
	41-60	89	120	15	21	24	35	304	11.84%
	61-80	81	124	30	43	50	62	390	18.72%
	81-100	30	29	21	20	18	20	138	29.71%
Symptoms	At least one	91	114	46	47	31	44	373	24.93%
	No Symptoms	158	240	25	43	76	100	642	10.59%
Underlying Disease	At least one	170	248	33	53	81	102	687	12.52%
	No Disease	79	106	38	37	26	42	328	22.87%
Total		427	588	71	90	107	144	1015	15.86%

derlying diseases and symptoms that prove the model can be fitted according to the nominated predictors. A quick look at the last column shows that the mortality rate is visibly increasing according to the patient's age. For example, it is less than 10% for the patients under 40-years-old, but it is likely to be around 30% for elderly people presented in Figure 2 as well. As shown in Figure 2, in which the horizontal axis represents the age group and the vertical axis represents the mortality rate, the mortality rates for females and males are some how the same but they have smoothly increased by the age. In addition, the sudden look at the other rows also shows that the patients, who were suffering from at least one symptom, are more likely to death comparing to those who have been admitted to receive healthcare treatments without symptoms.

MODELING PROCEDURES AND ANALYSIS

In order to utilize the analytical procedures, the probit regression model is developed for all patients. The committed variables "Age", patient symptom shown as "Sym", and being suffered from underlying diseases, indicated by "Dise" are considered in the modeling process. Age is scaled in year, and Sym is indicated by 1 if the patient experienced at least on symptom, otherwise 0, and Dise is also indicated as 1 if the patient was suffering from at least one underlying disease, otherwise 0. To obtain the coefficients, a non-linear mathematical model has been developed and solved by

an optimization software.

The mathematical formulation between predictors and dependent variable is obtained by equation (4) with the maximum log likelihood of -175.128 estimated by in equation (5) where y_i is the final situation of the i^{th} patient (1 for death, 0 for recovered or transferred clearance type).

$$P(Y=1; \text{Death}) = \Phi(-2.978 + 0.018\text{Age} + 1.062\text{Sym} + 0.606\text{Dise}) \tag{4}$$

$$\sum_{i=1}^{1015} y_i \log(\Phi(-2.978 + 0.018\text{Age}_i + 1.062\text{Sym}_i + 0.606\text{Dise}_i)) + \sum_{i=1}^{1015} (1 - y_i) \log(1 - \Phi(-2.978 + 0.018\text{Age}_i + 1.062\text{Sym}_i + 0.606\text{Dise}_i)) = -175.128 \tag{5}$$

To validate the probit regression model, the log likelihood ratio technique is utilized, and the obtained results are displayed in Table 2. The first column represents the contributing factors studied in the modeling process, the second column represents the unrestricted maximum log likelihood driven by the model where all contributing factors are employed in the modeling process fol-

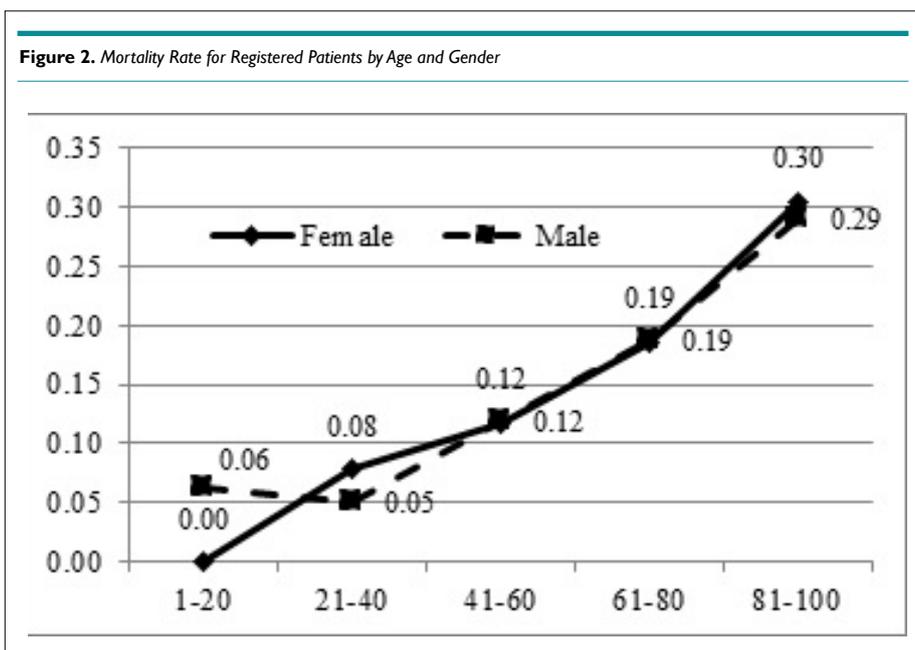


Figure 2. Mortality Rate for Registered Patients by Age and Gender

Contributing Factor	Log (Likelihood)		Statistical Measures		
	Unrestricted	Restricted	LR	p value	Conclusion
Model	-175.128	-305.545	260.834	≈0.000	Significant
Constant	-175.128	-197.356	44.456	≈0.000	Significant
Age	-175.128	-184.122	17.988	≈0.000	Significant
Sym	-175.128	-180.490	10.724	0.0011	Significant
Dise	-175.128	-176.848	3.440	0.0636	Not significant

lowed by the third column where the contributing factor is extracted from the model. For example, if “Age” is extracted from the modeling, the restricted log (likelihood) represent the maximum likelihood obtained without “Age”. The attractive significance level of regression modeling sets to 95%, so if the p value is less than 0.05, means that regression modeling is significant,²⁰ otherwise, the regression model cannot interpret the relation between mortality rate and age, symptoms or underlying disease.

The LR stats for the nominated contributing factors have been calculated using equation (3) followed by the p value of the Chi-Square (χ^2) distribution function using the degree of freedom 1 ($\chi^2=3.8415 | \alpha=0.05$). As shown, the LR stat for the full-variable model is 260.834 means that the Probit model significantly fits to interpret the association between variables with the significance level of 95%. In addition, the stats obtained from the constant, age, and symptoms are less than 0.05, approves that they have significant effects on mortality rate. The stat which is more than 0.05 for underlying diseases shows that data doesnot support any existing significant effect so Funderlying diseases on mortality rate. In brief, statistical procedure approved that the age and symptoms cause significant effects on both females and males mortality rates but data does not support the effects of underlying diseases on the studied mortalities. Therefore, the final model is finally formulated by equation (6), where age and symptoms have significant effects on the rate of mortality for the patients infected to COVID-19.

$$P(Y=1; \text{Death})=\Phi(-2.3308+0.01757\text{Age}+0.5348\text{Sym}) \text{ -----(6)}$$

SUMMARY AND CONCLUSION

Since the estimation of patients’ mortality rate is an crucial issue for health authorities, a probit regression model has been developed to predict it based on the patients’ personal characteristic of gender, age, symptoms, and underlying diseases of those were infected to COVID-19. The research has been conducted in the Iranian northern province of Guilan, where data for 1015 patients were available. After developing a probit regression model and validating their parameters, the model revealed the chance of mortality depends on patients’ age and symptoms but not necessarily on underlying diseases.

In terms of application, the results support health authorities to provide an estimation on the rate of mortality before admission process in hospital. Researchers interested in working in this field are recommended to focus more on the other factors contributing to the immunity of the human system resulted to death or recovery.

CONFLICTS OF INTEREST

The author declares that no research funding or scholarship has been gained for conducting this study. The author has no competing interests regarding this study.

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