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COVID-19 Vaccine and Survival of Diabetes Patient on Dialysis

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This is to certify that the doctoral dissertation by

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has been found to be complete and satisfactory in all respects,
and that any and all revisions required by
the review committee have been made.

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Walden University
2024

Abstract

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MPH, Liberty University, 2019

MS, University of Sciences, Arts & Technology, 2018

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Dissertation Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

Public Health

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Abstract

This was a quantitative, secondary data analysis focused on investigating the association between the surviving status of diabetic patients on dialysis within a hospital setting in Puerto Rico as 3 separate manuscripts: (a) surviving status given by vaccination status together with the diabetes type risk factor; (b) surviving status given by vaccination status together with the dialysis frequency risk factor; (c) surviving status given by vaccination status together with the hypertension risk factor, controlling for other important protective and risk factors. The social ecological model was used theorical framework. Data were obtained from December 15, 2020, to December 31, 2022, from electronic medical records in a hospital in Puerto Rico. Binary logistic regression analyses revealed a statistically significant association between COVID-19 vaccine status by diabetes type, COVID-19 vaccine status and presence of hypertension, and the survival status of diabetes patients on dialysis ($p < 0.001$). Age, body mass index, A1C level, and smoking status were found to be protective and/or risk factors ($p < 0.001$) that influenced this association. Sex and educational level were not associated with survival status ($p > .05$). These findings highlight the importance of COVID-19 vaccination, age-related factors, weight and A1C levels management, and smoking cessation programs in improving the survival outcomes of this vulnerable population.

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Dedication

To Carlos A. Rodríguez Rivera, who was been a constant pillar of support and belief in my abilities, you has always been there for me, encouraging me to strive for greatness and reminding me of my potential. Your unwavering faith in me has been a driving force behind my journey, and I am forever grateful for your guidance and mentorship. This dissertation is dedicated to you, as a token of my appreciation for your belief in me.

Additionally, I would like to dedicate this dissertation to all diabetic patients on dialysis who lost their lives during the COVID-19 pandemic. Their strength and resilience in the face of adversity serve as a constant reminder of the importance of our work. May their memory inspire us to continue our efforts to improve the lives of those affected by diabetes and kidney disease.

In memory of those who have gone too soon, this dissertation stands as a testament to our commitment to finding solutions and making a positive impact in the public health and preventive medicine.

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Finally, I am deeply thankful to all those who have played a part in making this dissertation book a reality. Your support and encouragement have been instrumental in my academic journey, and I am forever grateful for your presence in my life.

Table of Contents

List of Tables

List of Figures

Part 1: Overview

Introduction

Public health problem and priorities require scientific knowledge to address strategies to identify risk factors and populations vulnerable to disease and anticipate future care challenges. For example, SARS-CoV-2 (COVID-19) is an infectious disease that can generally be mild to moderate or, in some cases, cause death (CDC, 2021c). Susceptibility to COVID-19 is universal, but people over 65 years of age, with preexisting medical conditions, and pregnant or recently pregnant women are more likely to experience severity from COVID-19 infection (CDC, 2022c; WHO, 2020b). On the other hand, diabetes mellitus (DM) is a chronic disease in which glucose metabolism is affected by different causal factors, characterized by elevated blood glucose levels resulting from dysfunction in insulin secretion, action, or both (Banday et al., 2020). Diabetes is an important risk factor for experiencing severity due to infection with SARS-CoV-2 (COVID-19), with DM being a risk factor for the rapid progression and poor prognosis of COVID- 19. (ADA, n.d.a.; Guo et al., 2020; Deng et al., 2021). Furthermore, diabetes is one of the chronic conditions in which the mortality rate from COVID-19 is higher than the general population (Ghadamgahi et al., 2021). However, Ghadamgahi et al. (2021) reported that despite substantial evidence of the vulnerability to COVID-19 in the diabetic population, follow-up and vaccination should be addressed, which can reduce the mortality rate in this population.

Puerto Rico has monitored COVID-19 cases on the island through the Municipal Case Investigation and Contact Tracing System (SMICRC, for its acronym in Spanish),

which works in collaboration with the regional and central levels of the Puerto Rico Department of Health (PRDoH, n.d.). The Centers for Disease Control and Prevention (CDC, 2022) have reported that people with chronic diseases, including diabetes, have a six times higher risk of hospitalization and twelve times higher risk of death due to COVID-19 infection than the general population. In Puerto Rico, in 2020, it is estimated that 15.8% (429,720), or 2 out of every 13 people in the island's population, live with diabetes (PRDoH, 2020). In addition, diabetes in Puerto Rico was the third leading cause of death, or approximately 61 people per 100,000 inhabitants died from this disease on the island in 2019 (PRDoH, 2020). Comparing these figures, Puerto Rico has maintained a higher age-adjusted prevalence of diabetes than the continental United States from 2011 to 2020 (PRDoH, 2020). Therefore, COVID-19 represents a severe threat to the diabetic population on the island and requires an understanding of this phenomenon to address evidence-based strategies that support actions for the management and protection of this population at high risk of experiencing the severity and death from COVID-19.

Problem Statement

The public health crisis of SARS-CoV-2 (COVID-19) has increased the mortality rate per year that Puerto Rico registers, with an increase of 13,258 more deaths from multiple causes between 2019 and 2020, of which 1,683 deaths were from COVID-19 (PRDoH, 2022b; SCD-PR, n.d.). Similarly, by 2021 there were 1,640 deaths, and so far, in 2022, 1,711 deaths due to COVID-19, especially those with chronic diseases (PRDoH, 2022b). There is strong evidence that people with chronic illnesses are more vulnerable to COVID-19 than the general population (Hacker et al., 2021); particularly, those with

diabetes, hypertension, chronic kidney disease (CKD), and dialysis have a higher mortality rate (Cai et al., 2021; D'Marco et al., 2020; Ghonimi et al., 2021; Leon-Abarca et al., 2020). The American Diabetes Association (ADA, n.d.a) has estimated that 40% of COVID-19 deaths in the United States are in diabetic patients. On the other hand, hypertension (HTN) is one of the most prevalent comorbidities among diabetes; two out of three people with diabetes have high blood pressure (de Boer et al., 2017; Dedefo et al., 2020; ADA, n.d.d.). Furthermore, diabetes and hypertension interact to promote kidney dysfunction that usually develops slowly and with few symptoms until the person is in an advanced stage and needs dialysis (Wang et al., 2017; Wang et al., 2022; CDC, 2021d). In addition, it was found that dialysis patients have short-term mortality of 20% or more if they are infected by COVID-19 (Hsu & Weiner, 2020). Consequently, diabetic patients with hypertension receiving dialysis are at risk of severe health complications secondary to COVID-19 infection, including death.

According to Geng et al. (2021), identifying risk factors for severity and mortality from COVID-19 could benefit the development of public health strategies that protect these vulnerable populations. The COVID-19 vaccine appears to protect against severe COVID-19 disease on dialysis patients (El Karoui et al., 2022). However, there is still a need to understand better how COVID-19 vaccination status in diabetic patients with comorbid kidney disease/dialysis and hypertension might contribute to surviving status when controlling for other important risk factors and protective factors.

Purpose of the Study

Public health researchers have carried out multiple studies in which they have evidenced the vulnerability to COVID-19 in the diabetic population, in which they agree that monitoring and vaccination could reduce the mortality rate in this population (Ghadamgahi et al., 2021). Furthermore, Mohseni et al. (2021) state that diabetes is one of the chronic conditions that has been most affected in terms of access to and monitoring of medical care. In addition, hypertension (HTN) is one of the most prevalent comorbidities among diabetes; two out of three people with diabetes have high blood pressure (de Boer et al., 2017; Dedefo et al., 2020; ADA, n.d.d.). On the other hand, diabetes and hypertension interact to promote kidney dysfunction that usually develops slowly and with few symptoms until the person is in an advanced stage and needs dialysis (Wang et al., 2017; Wang et al., 2022; CDC, 2021d). In addition, it was found that dialysis patients have short-term mortality of 20% or more if they are infected by COVID-19 (Hsu & Weiner, 2020). However, there is a research gap on how COVID-19 vaccination status, given the type of diabetes, the frequency of dialysis, and the presence of hypertension, impact the surviving status of diabetic patients on dialysis infected with COVID-19 in the hospital setting. Thus, this quantitative, secondary data analysis study is to describe the association between the surviving status of diabetic patients on dialysis within a hospital setting in Puerto Rico (as three separate components: (a) surviving status given by vaccination status together with the diabetes type risk factor; (b) surviving status given by vaccination status together with the dialysis frequency risk factor; (c)

surviving status given by vaccination status together with the hypertension risk factor), controlling for age, sex, educational level, body mass index (BMI), A1C level, smoking.

Framework

The theories and/or concepts that ground this study include the socio-ecological model (SEM), which focuses on addressing health behaviors by attributing health outcomes to factors that exist on different levels beyond individual-level characteristics (Kolff et al., 2018). This theory stems from the concept that multiple factors can affect health status (Kolff et al., 2018). Also, some of the SEM levels are closely related to other theories; for example, the individual level can use the transtheoretical model and the Health Belief Model; the interpersonal level can use the theory of planned behavior and social cognitive theory, while the community level can use the Rogers Diffusion of Innovation. Although for this study, I focus on two levels of the SEM, the intrapersonal and community level, and the ways they interact.

The logical connections between the framework presented and the nature of my study that include the SEM, which has been used in the public health field to assess factors and barriers to vaccine promotion at several levels, including the intrapersonal, interpersonal, organizational, community, and society and the ways they interact (Kolff et al., 2018). Using the SEM, I can assess risk and protective factors against COVID-19 infection in diabetic patients with comorbidity of kidney disease /dialysis at two levels, including the intrapersonal and community and how they interact. Many risk factors target the individual level of the SEM, including diabetes type, dialysis frequency, and presence of hypertension. On the community level, perceptions of the risk of vaccine-

preventable COVID-19 in the hospital setting may play an essential role in the vaccination rate. Such protective and risk factors could interact and impact the surviving status of diabetic patients on dialysis within the hospital setting. At the same time, the surviving status may be controlling by other individual factors of age, sex, educational level, body mass index (BMI), A1C level, and current smoking.

Social Impact

The research has the potential to impact positive social change in Puerto Rico. The results can provide critical information for decision-making and planning for adults diagnosed with diabetes with comorbidity of kidney disease /dialysis faced with COVID-19 infection. They will also justify needed attention and resources towards considering diabetes patients and access to the COVID-19 vaccine in outpatient and inpatient settings. This is critical in improving the person's overall health with diabetes on the dialysis population, decreasing mortality, and reducing the burden the COVID-19 can have on the Puerto Rico Public Health System.

Background

Research has indicated that mortality from SARS-CoV-2 (COVID-19) among the diabetic population is higher than in the general population. Saha et al. (2021) found through a meta-analysis that included 475 publications and 22 studies that included Europe, the United States, and Asia that the risk of mortality from COVID-19 in diabetic patients is 20% and 1.82-time higher than in nondiabetic patients. At the same time, the American Diabetes Association (n.d.a) has estimated that 40% of deaths from COVID-19 in the United States are in diabetic patients. According to Rawshani et al. (2021), there is

no substantial evidence to support differences between type I diabetes and type II diabetes in the risks of COVID-19 severity. In addition, among the complications of diabetes, we find dialysis that presents short-term mortality of 20% or more if they are infected with COVID-19 (Hsu and Weiner, 2020). However, in diabetic nephropathy patients are 87.9% more likely to develop COVID-19 pneumonia, 5% more likely to be admitted to an ICU, 101.7% more likely to be intubated, and 20.8% more likely to die from COVID-19 compared to patients with chronic kidney disease (Leon-Abarca et al., 2020). Also, the risk of death from COVID-19 increases in diabetic patients with comorbid hypertension regardless of age (Gupta et al. 2021). On the other hand, the American Diabetes Association (n.d.b.) establishes that the COVID-19 vaccine is a fundamental tool to protect the health and safety of people with diabetes.

Coronavirus and SARS-CoV-2 (COVID-19)

Coronaviruses are a large and diverse family of viruses caused by four main groups (alpha, beta, gamma, and delta) characterized by mild to severe respiratory symptoms (CDC, 2017). Each is known as a subtype, of which only 229E (alpha), NL63 (alpha), OC43 (beta), HKU1 (beta), MERS-CoV (beta), SARS-CoV-1 (beta), and SARS-CoV-2 (beta) can infect humans (CDC, 2020; Liu et al., 2020). Specifically, Severe Acute Respiratory Syndrome 2 (SARS-CoV-2) is the cause of COVID-19, which is characterized by clinical manifestations such as fever, cough, tiredness, loss of taste or smell, even developing difficulty breathing or shortness of breath, loss of speech or mobility, or confusion, and chest pain (WHO, n.d.). Coronaviruses are not new viruses; they were first identified in humans in the mid-1960s, after which SARS-CoV-1 emerged

in Guangdong, China, in 2003, and MERS-CoV in the Middle East in 2012, which can cause severity (CDC, 2020; Liu et al., 2020). However, SARS-CoV-2 (COVID-19) was first identified as a novel coronavirus in Wuhan, China, in 2019, causing the current pandemic (Liu et al., 2020).

Transmission Chain

COVID-19 spreads from an infected person through the exhalation of respiratory droplets or particles containing the virus, which can be inhaled by other people or deposited in their eyes, nose, or mouth (CDC, 2021a). These particles can also be deposited on surfaces or objects that people can contact with their hands and then carry to the eyes, nose, or mouth, causing transmission (CDC, 2021a). Therefore, not practicing physical distancing, not wearing a mask, and not washing the hands increase the spread risks. The COVID-19 incubation period is within a range of two to fourteen days but generally lasts five days, where two days before the manifestation of symptoms and ten days after it, a person can infect others; although this varies according to the course and severity of the infection (CDC, 2021b; CDC, 2022b; WHO, 2020a). At the same time, the reproductive period (R0) of SARS-CoV-2 is between 2 to 4, representing an epidemiological metric to measure the average number of people that an infected person can infect (WHO, 2020a; Achaiah et al., 2020).

The Vector

The sequenced bat *Rhinolophus affinis* coronavirus RaTG13 is the closest relative to SARS-CoV-2, with 96.2% genomic sequence identity and 89.3% amino acid identity in the receptor-binding domain (RBD) (Pei & Yau, 2021; Liu et al., 2021; Wu et al.,

2020). While the RmYN02 coronavirus detected in the bat, *Rhinolophus malayanus* is the second closest relative to SARS-CoV-2 with an identity of 93.3% of the nucleotides of the genome, and they share three insertions of amino acid residues (PAA) in the cleavage site S1/S2 of its protein S (Liu et al., 2021). However, the bat coronavirus RaTG13 is commonly considered the origin of SARS-CoV-2 (Pei & Yau, 2021; Liu et al., 2021). Although it is challenging to infer reliable evolutionary lineages, given the high rate of recombination of coronaviruses that violate the assumption of standard phylogenetic approaches, each part of the genome varies in different lineages (Boni et al., 2020). In addition, the distance ranges prior to the outbreak in Wuhan, China, suggest that person-to-person transmission of SARS-CoV-2 was already occurring in other countries such as France, India, the Netherlands, England, and the United States (Pei & Yau, 2021).

The Virus

The severity spectrum of SARS-CoV-2 (COVID-19) is classified according to the clinical manifestations of the disease into five categories. Asymptomatic or presymptomatic infection is characterized by people who test positive for the virus by a virologic test or antigen test without presenting symptoms consistent with COVID-19 (NIH, 2021a; CDC, 2021b). Mild disease is characterized by any manifestation of fever, cough, sore throat, malaise, headache, muscle pain, nausea, vomiting, diarrhea, or loss of taste and smell, but without experiencing shortness of breath, dyspnea, or abnormal chest imaging (NIH, 2021a; CDC, 2021b). The moderate disease is described by the presence of lower respiratory tract disease by clinical evaluation or diagnostic imaging and oxygen saturation (SpO2) ≥ 94% in room air at sea level (NIH, 2021a; CDC, 2021b). Severe

disease occurs in those with a SpO2 < 94% in room air at sea level, a ratio of arterial partial pressure of oxygen to fraction of inspired oxygen (PaO2/FiO2) < 300 mmHg, a respiratory rate > 30 respirations/min, or pulmonary infiltrates > 50% (NIH, 2021a; CDC, 2021b). Finally, critical illness is characterized by respiratory failure, septic shock, and multi-organ dysfunction (NIH, 2021a; CDC, 2021b). It is essential to mention that the severity spectrum of COVID-19 varies from one person to another according to their comorbidities.

The Host, Susceptibility, and Resistance

In humans, SARS-CoV-2 (COVID-19) was first described in December 2019 in Wuhan, China (CDC, 2021c; Mohan & Nambiar, 2020). Animal-to-human transmission is believed to have originated in the Huanan, in the animal and seafood market in Wuhan City, Hubei Province, which subsequently occurs infections among people who were not exposed to the market (Nohan & Nambiar, 2020). SARS-CoV-2 (COVID-19) enters human cells via the cell surface receptor angiotensin-converting enzyme-2 (ACE2), which binds to the receptor-binding domain (RBD) of the spike protein (S) of the virus (Kumar et al., 2021; Jackson et al., 2022; Pizzato et al., 2022). For this, the priming of the viral spike protein (S) is fused with the host cell using transmembrane serine protease 2 (TMPRSS2) or by cathepsin B or L (CTS-B or -L) and furin present in the membrane of human cells (Kumar et al., 2021; Jackson et al., 2022; Pizzato et al., 2022). The acute phase of COVID-19 infection, which lasts from days to weeks, ranges from the appearance of signs and symptoms, viral replication, and the initial response of the innate immune system (Datta et al., 2020). Specific cells, such as dendritic cells and

macrophages or antigen-presenting cells (APC), act through the innate immune system until the moment of activation of T cells that promote clonal expansion of B cells to produce virus-specific antibodies through the adaptive immune system (Datta et al., 2020; Yuki et al., 2020). After SARS-CoV-2 (COVID-19 infection, immunity is induced in T cells that memorize multiple epitopes of the spike protein of the virus and other of its components that serve as protection at least for reinfection or against other variants of SARS-CoV-2, including alpha (B.1.1.7), beta (B.1.351), and gamma (P.1) (Kojima & Klausner, 2021). However, the duration of this immune response after COVID-19 infection continues to be investigated (NIH, 2021b).

Susceptibility is universal, but people over 65 years of age, with pre-existing medical conditions, and pregnant or recently pregnant women are more likely to experience severity from COVID-19 infection (CDC, 2022c; WHO, 2020b). The incidence of COVID-19 is represented in a more significant proportion among people 18 to 29 years of age, but the rate of hospitalization and death increases with increasing age (CDC, 2022d). People aged 65 and older have a five to ten times higher hospitalization rate than an 18 to 29-year-old and a thirty-three to three hundred- and thirty-times higher death rate than an 18 to 29-years-old (CDC, 2022d). People with cancer, chronic kidney disease (CKD), chronic liver disease, chronic lung disease, cystic fibrosis, dementia, diabetes, disabilities, heart conditions, HIV, or immunocompromised are at increased risk of hospitalization, severity, and death from COVID-19 compared to the general population (CDC, 2022e). Pregnant or recently pregnant women are at higher risk of hospitalization, intensive care unit (ICU) admission, and need for a ventilator or special

equipment to help them breathe than the general population if they become infected with COVID-19 (CDC, 2022f). While the risk of reinfection with SARS-CoV-2 (COVID-19) increases slowly over time in previously infected or fully vaccinated persons, naturally acquired antibodies against the virus provide 84% protective efficacy, although evidence is currently limited in determining an antibody titer threshold that indicates when an individual is protected against COVID-19 (CDC, 2022g; Chen et al., 2022; Pilz et al., 2022).

Diagnosis, Treatments, and Prevention

To obtain a diagnosis of SARS-CoV-2 (COVID-19) infection, confirmation of a viral detection test is required, which allows the detection of the virus or biomarkers of COVID-19 through a sample from the nose or mouth (CDC, 2022h; CDC, 2022i). Viral detection tests indicate if the person is infected at the test time. The two primary diagnostic tests for identifying COVID-19 infection include antigen tests and nucleic acid amplification tests (NAATs) (CDC, 2022h; CDC, 2022i). However, the Food and Drug Administration (FDA) created a page on other diagnostic tests for SARS-CoV-2 that they have approved, such as the breath test to detect volatile organic compounds associated with SARS-CoV-2 infection, which, when the result is positive, must be interpreted as presumptive and confirmed by the NAAT (CDC, 2022i; FDA, 2022). While antibody or serologic tests cannot be used to diagnose an ongoing infection, only can be used to indicate a prior COVID-19 infection (CDC, 2022h).

Regarding the treatment of SARS-CoV-2 (COVID-19), there are medications to reduce the risk of severity or death from the infection or other treatments to reduce

symptoms and help manage the course of the disease. Antiviral drugs and monoclonal antibodies are among the treatments available to reduce the risk of severity or death from COVID-19 (CDC, 2022j). Antiviral drugs have their mechanism of action by attacking certain parts of the virus, preventing it from multiplying in the body while reducing the possibility of experiencing severity or death from COVID-19 (CDC, 2022j). These include Paxlovid, an investigational oral antiviral drug to treat mild to moderate COVID-19 in adults and children 12 years of age and older who weigh at least 88 pounds (40 kg) and have tested positive for a viral test in the past five days (CDC, 2022j; HHS, n.d.a, NIH, 2022c).

Lagevrio (molnupiravir) is another investigational oral antiviral drug used in adults 18 years and older to slow the progression of COVID-19 infection (CDC, 2022j; HHS, n.d.a, NIH, 2022c). However, Remdesivir is the only antiviral treatment approved by the Food and Drug Administration (FDA) for the treatment of COVID-19 in adult and pediatric patients (≥ 12 years and weighing ≥ 40 kg) (CDC, 2022j; HHS, n.d.a; NIH, 2022c). Remdesivir is administered intravenously in high-risk outpatients in a 3-day course starting within seven days of symptom onset and for treating hospitalized patients with COVID-19 in a 5-day course (CDC, 2022j; HHS, n.d.a; NIH, 2022c). On the other hand, the mechanism of action of monoclonal antibodies is to help the immune system recognize COVID-19 to combat the infection more effectively (CDC, 2022j). Bebtelovimab is an investigational monoclonal antibody treatment used in adults and children 12 years of age and older, which is administered via intravenous injection within

seven days of symptom onset to combat the infection (CDC, 2022j; HHS, n.d.a, NIH, 2022c).

Most people infected with COVID-19 experience mild illness and tend to recover without the need for hospitalization. However, for symptom management of COVID-19 infection, taking acetaminophen (Tylenol) or ibuprofen (Motrin, Advil) is recommended for symptom relief (CDC, 2022j). Regarding the prevention of COVID-19, medicines and vaccines are available. Evusheld (tixagevimab plus cilgavimab) is an investigational medication for pre-exposure prophylaxis of COVID-19 used in adults and children 12 years of age and older who weigh at least 88 pounds (40kg) and who are not currently infected with COVID-19 and have not recently been exposed to an infected person (CDC, 2022j; FDA, 2021). Still, the COVID-19 vaccines available in the United States, including Pfizer-BioNTech, Moderna, and Johnson & Johnson's Janssen, are the most effective way to protect people from the severe form of the disease, from hospitalizations and of dying, especially if they have received a booster dose (CDC, 2022j; CDC, 2022k). Pfizer-BioNTech and Moderna vaccines are the preferred ones to prevent severity and death from COVID-19 (CDC, 2022k).

Diabetes Mellitus (DM)

Diabetes mellitus is a chronic disease in which glucose metabolism is affected by different causal factors. According to Banday et al. (2020), diabetes is characterized by elevated blood glucose levels resulting from dysfunction in insulin secretion, action, or both. The metabolic disorders of diabetes are classified into four types: type 1, type 2, gestational diabetes, and diabetes secondary to other health conditions. Type 1 diabetes is

characterized by the autoimmune destruction of pancreatic beta cells and constitutes 5-10% of all diabetes cases (Banday et al., 2020). Type 2 diabetes is characterized by insulin resistance or insulin deficiency and constitutes 90-95% of all diabetes cases (Banday et al., 2020). Gestational diabetes is characterized by a rise in glucose levels during the second and third trimesters of pregnancy and constitutes 1-14% of all pregnancies (Banday et al., 2020). Diabetes secondary to other conditions, pathologies or health disorders constitutes very low percentages of all cases of diabetes (Banday et al., 2020). Hyperglycemia in the body is a significant risk factor for developing other health complications, such as diabetic nephropathy, hypertension, and others that affect the general health status of a person diagnosed with diabetes. Also, diabetes mellitus (DM) is a risk factor for experiencing severity due to infection with SARS-CoV-2 (COVID-19), with DM being a risk factor for the rapid progression and poor prognosis of COVID- 19. (ADA, n.d.a.; Guo et al., 2020; Deng et al., 2021).

COVID-19 accounted for 5.94 million deaths worldwide, between 2020 and 2021, with the United States being the second country with the highest figures for cumulative excess deaths, estimated at 1.13 million, and has had indirect adverse effects on the detection, prevalence, and control of diabetes (Wang et al., 2022; Gregg et al., 2021). These indirect effects are reflected in poor control and management of diabetes in obesity and high levels of hemoglobin A1C, which represent clear predictors of the severity of COVID-19 (Randhawa et al., 2021; Merzon et al., 2021). While the male gender is at higher risk of COVID-19 severity and death, the evidence among diabetic patients by gender in terms of COVID-19 severity is equivocal (Kautzky-Willer, 2021; Schlesinger

et al., 2021). On the other hand, age is a risk factor for experiencing the severity of COVID-19 among diabetic patients (Schlesinger et al., 2021; Stoian et al., 2020). In addition, changes in stress and depression among diabetic patients during the COVID-19 pandemic have increased smoking, increasing the risk of severity and death from COVID-19 (Kim & Kim, 2022; Utli & Vural Doğru, 2021). COVID-19 (Kim & Kim, 2022; Utli & Vural Doğru, 2021). Therefore, diabetic patients are at increased risk of experiencing the adverse effects of COVID-19 infection

Diabetes Type Risk Factor

Rawshani et al. (2021) state in their study that there is no substantial evidence to support differences between type I diabetes and type II diabetes in the risks of the severity of COVID-19 (Rawshani et al., 2021; ADA, n.d.c.). Furthermore, it has been found that there are no significant differences in COVID-19 severity between type 1 and type 2 diabetes (Shafiee et al., 2022). However, people with diabetes who become infected with COVID-19 are at increased risk of diabetic ketoacidosis (DKA), more commonly in type I diabetes than in people with type II diabetes (Rawshani et al., 2021; Vellanki & Umpuerrez, 2021; ADA, n.d.c.). Furthermore, the COVID-19 mortality rate of people with type 1 diabetes was lower than that of those with type 2 diabetes (Shafiee et al., 2022). Even so, most studies have shown mixed results, with some establishing type II diabetes as the highest risk group while others establish type I diabetes. (Shafiee et al., 2022; Demirci et al., 2022). Therefore, the researchers agree that more studies with adequate sample sizes are needed to demonstrate the differences more accurately in COVID-19 outcomes between type I and type II diabetes and to support more evidence

that one diabetes type has a worse prognosis than another (Shafiee et al., 2022; Demirci et al., 2022).

Dialysis Risk Factor

Chronic kidney disease (CKD) is one of the severe complications of diabetes, with approximately one in three diabetics living with CKD in the United States (CDC, 2021d; Mayo Clinic, 2021). Risk factors for nephropathy diabetes range from susceptibility factors such as age, gender, race/ethnicity, and family history; to initiating factors such as hyperglycemia and acute kidney injury; and progression factors such as hypertension, nutrition, and obesity; where hypertension and hyperglycemia have a more significant influence (Alicic et al., 2017; Natesan & Kim, 2021). In addition, nephropathy diabetes is one of the leading causes of end-stage kidney disease (ESKD), which requires dialysis or kidney transplantation treatment and is associated with increased morbidity and mortality (Selby & Tall, 2020; Ty et al., 2022). Similarly, diabetic nephropathy is among the independent risk factors that predict an unfavorable outcome in SARS-CoV-2 infection (Maremonti et al., 2022; Leon-Abarca et al., 2020). Also, recent research studies on the severity of COVID-19 in patients with diabetic nephropathy show that there is an increased risk of medical complications, including death and exposure to the virus in dialysis units (Leon-Abarca et al., 2020; Nogueira et al., 2021; Lodge et al., 2020). However, more research is needed to understand the impact of dialysis frequency on the risk of developing worse outcomes against COVID-19 infection in the hemodialysis patient population (Lodge et al., 2020).

Hypertension Risk Factor

Hypertension (HTN) is one of the most prevalent comorbidities among diabetes; two out of three people with diabetes have high blood pressure (de Boer et al., 2017; Dedefo et al., 2020; ADA, n.d.d.). Inappropriate activation of the renin-angiotensin-aldosterone system (RAAS) and the sympathetic nervous system, mitochondrial dysfunction, excessive oxidative stress, and systemic inflammation are a series of mechanisms that promote hypertension in diabetes (Jia & Sowers, 2021; Lin et al., 2018). In addition, diabetes and hypertension increase the risk of developing diabetic nephropathy (Lin et al., 2018; Wagnew et al., 2018). Similarly, diabetes and hypertension interact to promote kidney dysfunction that usually develops slowly and with few symptoms until the person is in an advanced stage and needs dialysis (Wang et al., 2017; Wang et al., 2022; CDC, 2021d). Also, evidence has shown that COVID-19 represents a real threat to patients with diabetes, hypertension, and chronic kidney disease comorbidities, among others (D'Marco et al., 2020). Current knowledge shows that comorbid diabetes and hypertension have adverse effects on patients infected with COVID-19; however, the evidence needs to be supported by more extensive studies to establish more evident correlations on the magnitude between diabetes and hypertension against COVID-19 (de Almeida-Pititto et al., 2020; Parveen et al., 2020; Landstra & de Koning, 2021).

Vaccine Protective Factor

Vaccines are one of the most significant advances in public health, significantly impacting morbidity and mortality from infectious diseases. According to the World

Health Organization (n.d.b.), vaccination is a simple, safe, and effective way to protect people against diseases before having contact with them. Each year, vaccination prevents between 3.5 and 5 million deaths from diphtheria, tetanus, whooping cough, influenza, and measles (WHO, n.d.b.). In the United States, the Advisory Committee on Immunization Practices (ACIP) is a group of public health and medical experts who develop recommendations on how to use vaccines to control vaccine-preventable diseases, where COVID-19 vaccines are not they are the exception (CDC, 2022d; HHS, n.d.). There is a high recommendation for people with diabetes to receive their COVID-19 vaccines to prevent the adverse effects of the infection in this high-risk population (CDC, 2022d; ADA, n.d.a.; ADA, n.d.b.).

However, current research evidence does not differentiate the protective factor of COVID-19 vaccines by type of diabetes; therefore, more research is needed to understand this phenomenon (Pal et al., 2021; ADA, n.d.b.). Also, more studies are needed to assess the efficacy of COVID-19 vaccines in the population of people with diabetes with comorbid hypertension as the pandemic evolves with the potential for new variants to emerge (Swamy et al., 2022). On the other hand, the current literature establishes that hemodialysis patients show a variation in the reduction in antibody response after receiving two doses of the COVID-19 vaccine over time, suggesting continued research to address the lack of knowledge about the vaccine efficacy and safety on this population (Ma et al., 2022; Bouwmans et al., 2022; El Karoui & De Vriese, 2022).

COVID-19 and Diabetes in Puerto Rico

SARS-CoV-2 (COVID-19) is an infectious disease that has affected 411,490 American citizens in Puerto Rico (PRDoH, 2022a). The island presents a mortality rate of 1.44 per 100,000 inhabitants (PRDoH, 2022b). In addition, 5,118 cumulative deaths have been reported, of which 56% (*N* = 2,851) have occurred in men and 44% (*N* = 2,667) in women (PRDoH, 2022b). While most deaths have occurred in people over 60 years of age, that is, 80.8% (*N* = 4,136 (PRDoH, 2022b).

On the other hand, those with diabetes are more likely to experience severe complications from COVID-19 infection compared to the general population (ADA, n.d.a). From 2011 to 2020, the age-adjusted prevalence of diabetes in Puerto Rico has been consistently between 13.7% and 13.3%, representing a higher age-adjusted prevalence than that of the continental United States, which has maintained between 8.9% and 10.6% (PRDoH, 2021). Similarly, between 2019 and 2020, the comorbidities present among people with diabetes in Puerto Rico were hypertension (72.9%), high cholesterol (57.0%), arthritis (46.4%), depression (22.7%), asthma (15.9 %), coronary heart disease (14.1%), heart attack (13.7%), and kidney disease (9.7%) (PRDoH, 2021). The current knowledge based on scientific evidence regarding COVID-19 suggests that having diabetes and other health conditions increases the chances of becoming seriously ill from the virus due to the combination of these conditions that make it difficult for the body to fight infection (ADA, n.d.a). On the other hand, the American Diabetes Association (n.d.b.) establishes that the vaccine against COVID-19 is an essential tool to protect the health and safety of people with diabetes.

Socio-Ecological Model (SEM)

The SEM was developed in the 1970s by the American psychologist, Bronfenbrenner to understand the relationship between an individual and the environmental factors that influence health behaviors and outcomes (Campell, 2021; Kilanowski, 2017). Bronfenbrenner proposed that human development arises within relationships rather than independently of environmental influences, considering the complex interaction between individual, interpersonal, organizational, community, and political factors (Campell, 2021; Kilanowski, 2017). SEM has been a conceptual framework that has helped public health researchers understand the risk and protective factors influencing health outcomes. For example, this model has been used in previous interventions and studies to address diabetes, where each level of the SEM influences health outcomes. Physical activity is influenced by self-efficacy at the individual level, social support and the role of family and friends at the interpersonal level, and perceptions of crime and safety that influence a person's ability to exercise outdoors at the community level. Workplaces and schools also play a role at the institutional/organizational level, as do local, state, and national policies related to nutrition and healthy eating at the policy level.

Previous Studies

The SEM is a conceptual framework focused on multiple factors or levels that can affect health status. Although some of the SEM levels are closely related to other theories, for example, the individual level can use the transtheoretical model and the Health Belief Model; the interpersonal level can use the theory of planned behavior and

social cognitive theory; while the community level can use the Rogers' diffusion of innovation. Most interventions and research using SEM focus on health promotion and prevention. In a study by Jang (2022), SEM was used to examine multilevel factors associated with COVID-19 preventive practices in South Korea. Jang (2022) examined individual, interpersonal, community, and policy-level factors related to COVID-19 preventive measures, which included wearing a mask, washing hands, covering coughs or sneezes, and social distancing. Jang found that other factors beyond the individual level could impact an individual's health behaviors regarding COVID-19 and the importance of the application of SEM for the study of preventive behaviors.

Su et al. (2020) used the SEM conceptual framework to describe the spatial distribution of COVID-19 around the world and assess the effects of various socio-ecological factors on the risk of infection. The authors used SEM to examine various socio-ecological factors that may influence the risk of COVID-19. The SEM on global factors (climatic and socioeconomic) examines how it can influence the agent, host, and environment for the risk of transmission of COVID-19 (Su et al., 2020). According to urban development, economic growth, health, infrastructure, poverty, science and technology, labor, and social protection, socioeconomic factors were measured. Climatic factors were measured according to temperature, relative humidity, wind speed, and precipitation. Both socioeconomic and climatic factors were used to determine the risk of COVID-19 through incidence rate (IR), the cumulative mortality rate (CMR), and the Daily cumulative index (DCI).

In another article by Singh et al. (2021), the SEM was used to examine the effects of sociodemographic data at the individual level (perceptions), at the interpersonal level (exposure to information in social networks), and the sociostructurally level (cultural) that influence the prevalence of COVID-19 vaccine acceptance among South Asians in Hong Kong. Singh et al. (2021) uses the SEM to analyze the multilevel effects on the understanding of the acceptance of the COVID-19 vaccine for planning vaccination promotional strategies based on the target population.

Singh et al. (2021) found that positive attitudes toward COVID-19 vaccination, perception of support networks, and behavioral control were associated with higher vaccination acceptance at the individual level. At the same time, knowing about people vaccinated was associated with greater acceptance. At the interpersonal level, having access to information about deaths or other severe conditions caused by vaccination against COVID-19 was associated with lower acceptance. While at the sociocultural level, cultural and religious reasons for hesitancy against the COVID-19 vaccine were associated with lower vaccination acceptance.

Overview of the Manuscripts

In these three studies, I will address the association between surviving status of diabetic patients on dialysis within a hospital setting in Puerto Rico (as three separate components) and vaccination status against COVID-19, along with risk and protective factors in this population. The surviving status was divided into three aspects to assess the predictive association of COVID-19 vaccination status more comprehensively with risk and protective factors for diabetic patients on dialysis within a hospital setting in

Puerto Rico with the surviving status. The three aspects of surviving status are (a) surviving status given by vaccination status together with the diabetes type risk factor, controlled for other important risk and protective factors of diabetic patients on dialysis; (b) surviving status given by vaccination status together with the dialysis frequency risk factor, controlled for other important risk and protective factors of diabetic patients on dialysis; (c) surviving status given by vaccination status together with the hypertension risk factor, controlled for other important risk factors and protection of diabetic patients on dialysis. Although the surviving status given by vaccination status together with the diabetes type risk factor, the surviving status given by vaccination status together with the dialysis frequency risk factor, and the surviving status given by the vaccination status along with the hypertension risk factor are interrelated, three separate studies are used to clarify the association of each aspect with surviving status of diabetic patients on dialysis within a hospital setting in Puerto Rico. All three studies intend to analyze the association between COVID-19 vaccination status given the specific risk factor and each component of surviving status, in parallel with the other components.

Manuscript 1

The specific research problem that will be addressed through this study is that it is not known if the COVID-19 vaccine status by diabetes type in diabetic patients with comorbidity of kidney disease /dialysis could contribute to surviving status than in unvaccinated diabetics patients with comorbidity of kidney disease /dialysis within a hospital setting in Puerto Rico, controlling for other important risk and protective factors.

Research Question

What is the association between COVID-19 Vaccine Status by diabetes type and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, A1C level?

H_0—There is no statistically significant association between COVID-19 Vaccine Status by diabetes type and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, A1C level.

H_1—There is statistically significant association between COVID-19 Vaccine Status by diabetes type and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, A1C level.

Nature of Study and Design

To address the research question in this quantitative study, the specific research design will include retrospective cohort design (Salkind, 2010) with binary logistic regression analysis from December 2020 until February 2023. This quantitative analysis should help pinpoint the difference in on how COVID-19 Vaccine Status by diabetes type could contribute to surviving status of diabetics with comorbidity of kidney disease /dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, and A1C level.

Source(s) of Data

For my planned research design, I have already contacted the several hospital setting in Puerto Rico to notify my interest in having access to the medical records on the survival or death of diabetic patients with comorbidity of kidney disease /dialysis and the independent variables of COVID-19 vaccine status by diabetes type, age, sex, educational level, BMI, A1C level. The hospital setting in Puerto Rico will be my secondary data source because of the willingness of several hospitals to provide the data within their medical records to answer the research questions. However, my secondary data sources are limited in terms of the availability of information on the years on dialysis (or duration of dialysis), and they do not have specific details about the vaccine brands. Therefore, it may lead to limited results if not analyzed these confounding variables in the study.

Manuscript 2

The specific research problem that will be addressed through this study is that it is not known if the COVID-19 vaccine status by dialysis frequency in diabetic patients with comorbidity of kidney disease /dialysis could contribute to surviving status than in unvaccinated diabetics patients with comorbidity of kidney disease /dialysis within a hospital setting in Puerto Rico, controlling for other important risk and protective factors.

Research Question

What is the association between COVID-19 vaccine status by dialysis frequency and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, smoking?

H_0—There is no statistically significant association between COVID-19 vaccine status by dialysis frequency and the surviving status of diabetes patients on dialysis

within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, smoking.

H_1—There is a statistically association between COVID-19 vaccine status by dialysis frequency and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, smoking.

Nature of Study and Design

To address the research question in this quantitative study, the specific research design will include retrospective cohort design (Salkind, 2010) with binary logistic regression analysis from December 2020 until February 2023. This quantitative analysis should help pinpoint the difference in on how COVID-19 Vaccine Status by dialysis frequency could contribute to surviving status of diabetics with comorbidity of kidney disease /dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, and smoking.

Source(s) of Data

For my planned research design, I have already contacted the several hospital setting in Puerto Rico to notify my interest in having access to the medical records on the survival or death of diabetic patients with comorbidity of kidney disease /dialysis and the independent variables of COVID-19 vaccine status by diabetes type, age, sex, educational level, BMI, smoking. The hospital setting in Puerto Rico will be my secondary data source because of the willingness of several hospitals to provide the data within their medical records to answer the research questions. However, my secondary data sources are limited in terms of the availability of information on the years on dialysis (or duration

of dialysis), and they do not have specific details about the vaccine brands. Therefore, it may lead to limited results if not analyzed these confounding variables in the study.

Manuscript 3

The specific research problem that will be addressed through this study is that it is not known if the COVID-19 vaccine status by present of hypertension in diabetic patients with comorbidity of kidney disease /dialysis could contribute to surviving status than in unvaccinated diabetics patients with comorbidity of kidney disease /dialysis within a hospital setting in Puerto Rico, controlling for other important risk and protective factors.

Research Question

What is the association between COVID-19 Vaccine Status by present of hypertension and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, smoking?

H_0—There is no statistically significant association between COVID-19 Vaccine Status by present of hypertension and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, smoking.

H_1—There is a statistically association between COVID-19 Vaccine Status by present of hypertension and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, smoking.

Nature of Study and Design

To address the research question in this quantitative study, the specific research design will include retrospective cohort design (Salkind, 2010) with binary logistic

regression analysis from December 2020 until February 2023. This quantitative analysis should help pinpoint the difference in on how COVID-19 Vaccine Status by present of hypertension could contribute to surviving status of diabetics with comorbidity of kidney disease /dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, and smoking.

Source(s) of Data

For my planned research design, I have already contacted the several hospital setting in Puerto Rico to notify my interest in having access to the medical records on the survival or death of diabetic patients with comorbidity of kidney disease /dialysis and the independent variables of COVID-19 vaccine status by diabetes type, age, sex, educational level, BMI, smoking. The hospital setting in Puerto Rico will be my secondary data source because of the willingness of several hospitals to provide the data within their medical records to answer the research questions. However, my secondary data sources are limited in terms of the availability of information on the years on dialysis (or duration of dialysis), and they do not have specific details about the vaccine brands. Therefore, it may lead to limited results if not analyzed these confounding variables in the study.

Significance

This study can be significant in that findings will provide vital insights to Puerto Rico and the continental United States as to the death risks adults diagnosed with diabetes with comorbidity of kidney disease /dialysis faced to COVID-19 infection. The findings will also contribute knowledge to Puerto Rico healthcare organizations, physicians, and the public regarding the COVID-19 vaccine as a death prevention strategy for diabetic

patients on dialysis. It will also inform public health officials and persons with diabetes with comorbidity of kidney disease /dialysis how the COVID-19 vaccine is a possibly effective way to prevent death from COVID-19 infection. By filling a gap, public health and prevention professionals will be better equipped to address COVID-19 infection management by translating the information into action in the person with diabetes on dialysis population.

The research also has the potential to impact positive social change in Puerto Rico. The results can provide critical information for decision-making and planning for adults diagnosed with diabetes with comorbidity of kidney disease /dialysis faced with COVID-19 infection. They will also justify needed attention and resources towards considering diabetes patients and access to the COVID-19 vaccine in outpatient and inpatient settings. This is critical in improving the person's overall health with diabetes on the dialysis population, decreasing mortality, and reducing the burden the COVID-19 can have on the Puerto Rico Public Health System.

Summary

The surviving status of diabetic patients on dialysis against COVID-19 infection within a hospital setting in Puerto Rico as a public health problem merits a comprehensive approach to ensure that predictive associations are understood from different perspectives. By segmenting surviving status into three components, the association with important risk and protective factors in this target population could be analyzed in detail. Furthermore, the association between the covariates is more clearly defined for each of the three components of the surviving status. The component of the

surviving status given by vaccination status together with the diabetes type risk factor, the surviving status given by vaccination status together with the dialysis frequency risk factor, and the surviving status given by vaccination status together with the hypertension risk factor are the three aspects of the comprehensive definition of the surviving status of diabetic patients on dialysis against COVID-19 infection in a hospital setting in Puerto Rico. The evaluation of these three components will provide a more detailed understanding of the association between surviving status, control variables, and vaccination status against COVID-19 in diabetic patients on dialysis within a hospital setting in Puerto Rico.

Part 2: Manuscripts

COVID-19 Vaccine by Diabetes Type and Survival of Diabetes Patients on Dialysis

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Outlet for Manuscript

Diabetes was the journal selected as the outlet for Manuscript 1 due to the journal's focus on the physiology, pathology, and complications of diabetes through scientific research. The intent of Manuscript 1 is to examine the association between COVID-19 vaccine status by type of diabetes, age, gender, educational level, BMI, A1C level, and the proportion surviving of diabetes patients on dialysis within a hospital setting in Puerto Rico. The information obtained from the manuscript will contribute to improving evidence-based practices by identifying the important risk and protection factors according to the diabetes type against COVID-19 infection, as well as the measures of protection and prevention of associated deaths in the population of diabetic patients on dialysis.

Diabetes requires that all original articles present an unstructured abstract that does not exceed 200 words (includes the objectives, the findings, the conclusion, and the possible translational impact of the results). The original article must be double-spaced with justified margins and not exceed 4,000 words (excluding the title page, abstract, acknowledgments, references, tables, and figures, and table/figure legends). In addition, the article should not contain more than 50 references, which should be single-spaced with justified margins. Likewise, the article should not contain more than a combination of eight tables and/or figures. Once written and structured according to this format, it can be sent for review to the following URL: https://mc.manuscriptcentral.com/diabetes

Abstract

This retrospective study investigated how COVID-19 vaccination status by diabetes types are associated with the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico. Ethical approval was obtained, and the data was collected from 392 hospitalized diabetic patients on dialysis with COVID-19 from December 15, 2020, to December 31, 2022. The study found that COVID-19 vaccination status by diabetes type significantly influenced the likelihood of survival in diabetes patients on dialysis who contracted COVID-19 ($\chi 2(17) = 312.543$, $p < 0.001$). Age ($p < 0.001$), BMI ($p < 0.001$), and A1C levels ($p < 0.001$), also contributed to the statistical significance of the model, while sex ($p = 0.696$) and educational level ($p = 0.017$) did not show a significant association. Vaccinated diabetes type 2 patients had higher odds of survival compared to vaccinated diabetes type 1 patients. These findings highlight the importance of COVID-19 vaccination in diabetic patients with dialysis. Targeted vaccination strategies and education programs are needed to increase vaccine uptake, especially among diabetes type 1 patients. The results provide evidence for healthcare providers, policymakers, and public health authorities to prioritize COVID-19 vaccination in this vulnerable population. By promoting vaccination in this high-risk group, the study's findings can reduce the burden of COVID-19 fatality.

Introduction

Chronic diseases, including heart disease, diabetes, cancer, chronic obstructive pulmonary disease, chronic kidney disease, and obesity, are conditions that increase the likelihood of experiencing the severity of COVID-19 (Hacker et al., 2021; Geng et al., 2021). Pre-existing diabetes has been revealed to be associated with a twofold increased risk of experiencing the severity of COVID-19 (Mantovani et al., 2020). Diabetes with comorbid kidney disease/dialysis is associated with increased mortality risk from COVID-19 infection compared to the general population (Iryaningrum et al., 2022; Leon-Abarca et al., 2020). Age, sex, and academic achievement are also important predictors of the severity of COVID-19 (Statsenko et al., 2022; Jian et al., 2021). In addition, it has been found that there is a strong association between elevated glycosylated hemoglobin levels with the risks of hospitalization and adverse health outcomes in diabetic patients (Zhu et al., 2021; Zhang et al., 2020). Similarly, the risk of hospitalization, ICU admission, and the need for invasive mechanical ventilation increases as BMI increases (Yang et al., 2022).

In addition, it has been found that there are no significant differences between type 1 diabetes and type 2 diabetes in the risks of severity due to COVID-19 (Rawshani et al., 2021; Shafiee et al., 2022). Nonetheless, people with diabetes who become infected with COVID-19 are at increased risk of diabetic ketoacidosis (DKA), more commonly in type 1 diabetes than in people with type 2 diabetes (Rawshani et al., 2021; Vellanki et al., 2021). Similarly, the COVID-19 mortality rate of people with type 1 diabetes has been lower than that of those with type 2 diabetes (Shafiee et al., 2022). However, most studies

have shown mixed results, with some establishing type 2 diabetes as the highest risk group while others establish type 1 diabetes (Shafiee et al., 2022; Demirci et al., 2022).

On the other hand, there is a high recommendation for people with diabetes to receive their COVID-19 vaccines to prevent the adverse effects of the infection (ADA, n.d.). Vaccines against COVID-19 have been found to appear to protect against severe COVID-19 disease in dialysis patients (El Karoui & De Vriese, 2022). However, no evidence has been found that establishes differences in the protective factor of vaccines against COVID-19 by type of diabetes (Pal et al., 2021).

Five risk factors for COVID-19 severity, including age, gender, academic achievement, BMI, and glycosylated hemoglobin, have been examined in multiple studies. In addition, the COVID-19 vaccine has also been evaluated as a protective factor against the severity of COVID-19. Therefore, it has been hypothesized that COVID-19 vaccine status by diabetes type may be associated with the surviving status of diabetes patients on dialysis within a hospital setting, controlling for other important risk and protective factors.

Using the social ecological model (SEM), risk and protective factors against COVID-19 infection in diabetic patients with comorbid kidney disease/dialysis can be assessed at two levels, including intrapersonal and community, and how they interact. A clear assessment of this COVID-19 severity and mortality risk associations, differentiated by diabetes type, could benefit the development of strategies for managing, protecting, and preventing death from diabetic patients with comorbid kidney disease/dialysis in a hospital setting. Here, a quantitative secondary data analysis study is carried out to

describe the association between COVID-19 Vaccine Status by diabetes type and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, A1C level.

Research Design & Methods

Research Question

What is the association between COVID-19 Vaccine Status by diabetes type and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, A1C level?

H_0—There is no statistically significant association between COVID-19 Vaccine Status by diabetes type and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, A1C level.

H_1—There is statistically significant association between COVID-19 Vaccine Status by diabetes type and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, A1C level.

Study Design and Participants

A retrospective cohort study was conducted using data from a sample of diabetic patients with comorbidity kidney disease/dialysis who were diagnosed with COVID-19 by nucleic acid amplification test (NAAT) or antigen test (CDC, 2022) and received any of the COVID-19 vaccines or not. The nucleic acid amplification test (NAAT) is used in unvaccinated patients, while the antigen test is used in vaccinated patients (CDC. 2022).

Patients were identified through ICD-10 diagnostic codes within a hospital setting in Puerto Rico from December 15, 2020, to December 31, 2022. The International Classification of Diseases (ICD-10) is a diagnostic tool used worldwide for epidemiological, health management, and clinical purposes (CDC, 2015). Diabetic patients with comorbidity of kidney disease /dialysis who were hospitalized as a result of COVID-19 infection from December 15, 2020, to December 31, 2022, are included in such a way that each patient was followed up until discharge unless the event (death) occurred first. Patients younger than 18 years or pregnant and those who did not have positive NAAT, or antigen test results were excluded.

Because this study involved analyzing data from protected health information (PHI) not publicly available, the *safe harbor*, deidentification method was required to comply with the Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule (HHS, 2022). In addition, this process was evaluated and approved by the Institutional Review Board (IRB) of Walden University and the Health Information Management Administration of the hospital setting in Puerto Rico.

Sample and Power

A sample of diabetic patients with comorbid kidney disease/dialysis who were hospitalized due to COVID-19 infection and who met the inclusion criteria previously described is included in the study. The sample size for this study was determined by performing an a priori power analysis using the Sample Size Calculator software (Calculator, n.d.). Power analysis was completed assuming a two-tailed test with an alpha of 0.05, an effect size of 0.50, and a power of 0.95, the power analysis for the statistical

test of binary logistic regression analysis indicates that size would be needed sample of 381 matched participants to ensure sufficient power and reduce the probability of a type 2 error. (Calculator, n.d.; PRDoH, 2021).

Variables / Sources of Data

The variables selected to describe the association between COVID-19 Vaccine Status by diabetes type and the surviving status of diabetes patients with comorbidity of kidney disease /dialysis within a hospital setting in Puerto Rico, controlling for other important risk and protective factors; were obtained from the medical records, which are not publicly available. For this study, the independent variable COVID-19 vaccination status by type of diabetes were based on nominal scales used to assign items into discrete categories (1 = *Vaccinated/Type I*; 2 = *Unvaccinated/Type I*; 3 = *Vaccinated/Type II*; 4 = *Unvaccinated/Type II*). Similarly, the dependent variable surviving status of diabetes patient with comorbidity of kidney disease /dialysis within a hospital setting in Puerto Rico, nominal scales were used to assign items into discrete categories (1 = *Death*; 2= *Survival*). While for the potentially confounding variables, sex nominal scales were used to assign items to discrete categories (1 = *Male*; 2 = *Female*), age reveals nominal scales used to assign items to discrete categories (1 = 18 – 29 years; 2 = 30 – 39 years; 3 = 40 – 49 years; 4 = 50 – 59 years; 5 = 60 – 69 years; 6 = 70 – 79 years; 7 = 80 years or more), the level of education reveals nominal scales was used to assign items into discrete categories (1 = *High School*; 2 = *Associate Degree*; 3 = *Bachelor's Degree*; 4 = *Master's Degree*; 5 = *Doctoral Degree*), body mass index was based on nominal scales used to assign items into discrete categories (1 = Below 18.5 [*Underweight*]; 2 = 18.5 – 24.9

[*Healthy*]; 3 = 25.0 – 29.9 [*Overweight*]; 4 = 30.0 and Above [*Obese*]), and the A1C level reveals ratio scales continuously.

Statistical Analysis

This study included descriptive statistics to summarize the data from the sample of diabetic patients with comorbidity of kidney disease /dialysis. Frequencies were calculated for the variables of vaccination status by type of diabetes, sex, age, level of education, BMI, proportion surviving of diabetic patients with comorbidity of kidney disease /dialysis within a hospital setting in Puerto Rico, and the means for the variable A1C. In addition, Binary Logistic Regression was used, using the Statistical Package for the Social Sciences (SPSS) to describe the probability being survive by COVID-19 vaccine status of diabetic patients on dialysis against COVID-19 infection within a hospital setting in Puerto Rico, controlling for other important risk and protective factors. Unvaccinated Type II will be the reference group for all the vaccination statuses. 80-years or more was the reference group for all the age report in years. Female was the reference group for sex. Doctoral Degree was the reference group for all the educational levels, and 30 and Above (Obese) was the reference group for all the body max index (BMI).

Results

Execution

The study was conducted in accordance with the original protocol and design. Ethical approval was sought from the Health Information Administrative Board of the Hospital in Puerto Rico in order to obtain access to the necessary data. Subsequently,

approval was granted by the Walden University Institutional Review Board and the Hospital Health Information Administrative Board.

The data collected for this study included various demographic and clinical variables, including COVID-19 vaccination status, diabetes type, age, sex, education level, body mass index, and A1C levels. It is important to note that these variables were not publicly available.

To ensure a robust and representative sample, a total of 392 diabetic patients with comorbid kidney disease/dialysis, aged 18 years and above, who were hospitalized due to COVID-19 infection, were included in the study. The data collection period spanned from December 15, 2020, to December 31, 2022.

It is noteworthy that no missing data was identified in the final dataset, as indicated in Table 1. This signifies the completeness and reliability of the collected data, thereby enhancing the validity of the study findings.

Table 1

Study Sample

		COVID-19 Vaccines Status by Diabetes Type	Sex	Age Report in Years	Educational Level	Body Max Index	Survival or Death of Diabetic Patients with Comorbidity of Kidney Disease/Dialysis
N	Valid	392	392	392	392	392	392
	Missing	0	0	0	0	0	0

Descriptive Analysis

Table 2 presents an analysis of a sample comprising 392 eligible diabetic patients undergoing dialysis. The primary objective is to investigate the distribution of patients based on their vaccination status and diabetic type. Among the sample, most patients, constituting 43.1% ($N = 169$), belonged to the group of vaccinated type 2 diabetic patients. Following closely, the second largest proportion was observed in the group of unvaccinated type 2 diabetic patients, accounting for 30.4% ($N = 119$). Additionally, a subset of patients, equivalent to 15.3% ($N = 60$), represented the vaccinated type 1 diabetic patients. Conversely, the minority of patients, comprising 11.2% ($N = 44$), were categorized as unvaccinated type 1 diabetic patients. For a more detailed visual representation of these findings, please refer to Figure 1.

Table 2

Frequencies for COVID-19 Vaccine States by Diabetes Type (Categorical/Independent) Variable

Vaccine State	*N*	%
Vaccinated/Type 1	60	15.3%
Unvaccinated/Type 1	44	11.2%
Vaccinated/Type 2	169	43.1%
Unvaccinated/Type 2	119	30.4%

Figure 1

Histogram- COVID_VAC_STAT_BY_DM_TYPE (Categorical/Independent Variable)

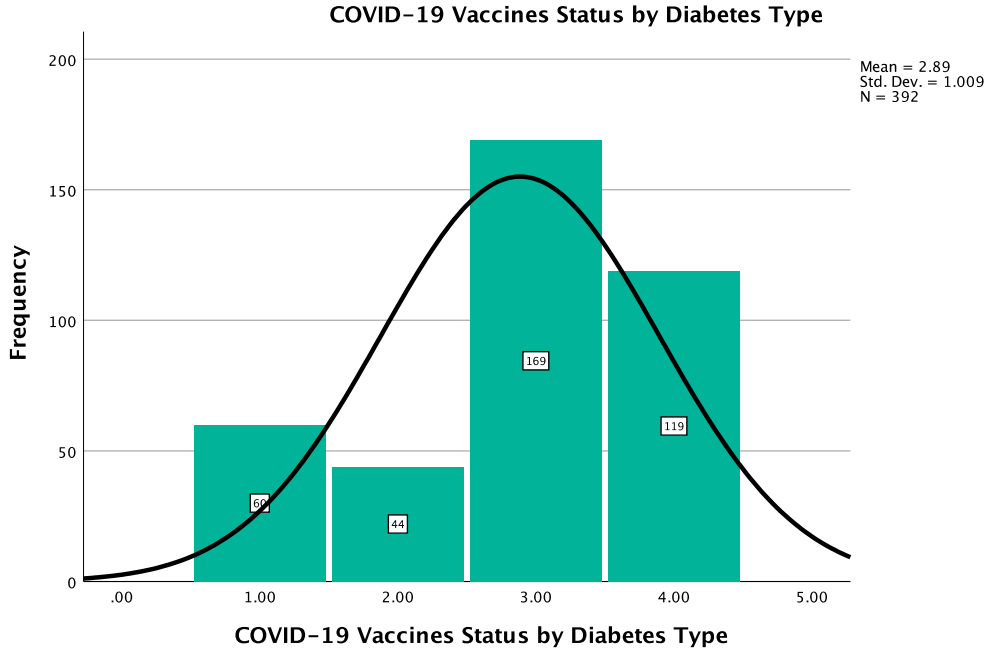


Table 3 present an analysis of a sample consisting of 392 eligible diabetic patients undergoing dialysis. The data reveals the distribution of patients based on their gender, specifically examining the proportion of female and male patients. Among the sample, most patients, accounting for 52.8% ($N = 207$), were female. In contrast, the minority of patients, comprising 47.2% ($N = 185$), belonged to the male category. For a more comprehensive depiction of these findings, please refer to Figure 2.

Table 3

Frequencies for Sex (Categorical) Variable

Sex	*N*	%
Male	185	47.2%
Female	207	52.8%

Figure 2

Histogram- SEX (Categorical) Variable

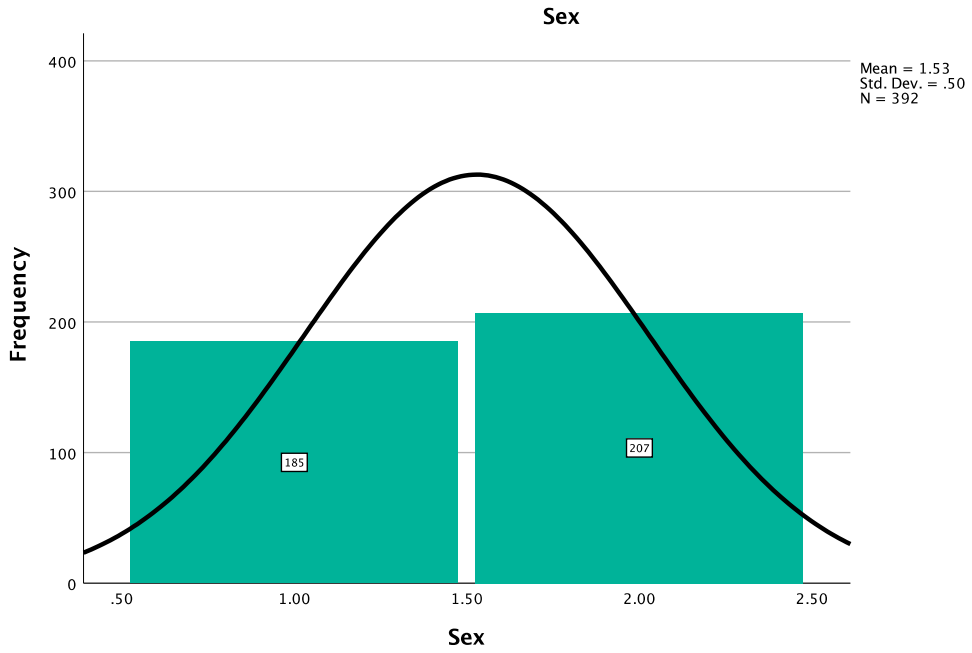


Table 4 presents a comprehensive examination of a sample of 392 eligible diabetic patients undergoing dialysis. The data reveals the distribution of patients across different age groups and their corresponding percentages. The largest segment of patients, accounting for 23.7% ($N = 93$), belonged to the 70-79-year-old age group. Following closely, the second largest percentage, comprising 23.0% ($N = 90$), was

observed among patients aged 80 years or above. The third largest proportion, representing 20.9% ($N = 82$), consisted of patients aged 60-69. Moving further, the fourth most significant percentage was found among patients aged 50-59 years, with a value of 14.8% ($N = 58$). Likewise, the fifth most notable proportion was identified in the 40-49-year-old age group, constituting 10.7% ($N = 42$) of the total sample. Furthermore, a smaller proportion of patients, specifically 3.6% ($N = 14$), were classified within the 30-39 year age range. In contrast, the youngest group, consisting of patients aged 18-29, exhibited the most minor proportion, amounting to 3.3% ($N = 13$). For a more detailed visualization and understanding of these findings, please refer to Figure 3.

Table 4

Frequency for Age Report in Years (Categorical) Variable

Age	*N*	%
18-29 Years	13	3.3%
30-39 Years	14	3.6%
40-49 Years	42	10.7%
50-59 Years	58	14.8%
60-69 Years	82	20.9%
70-79 Years	93	23.7%
80 Years or More	90	23.0%

Figure 3

Histogram- AGE (Categorical) Variable

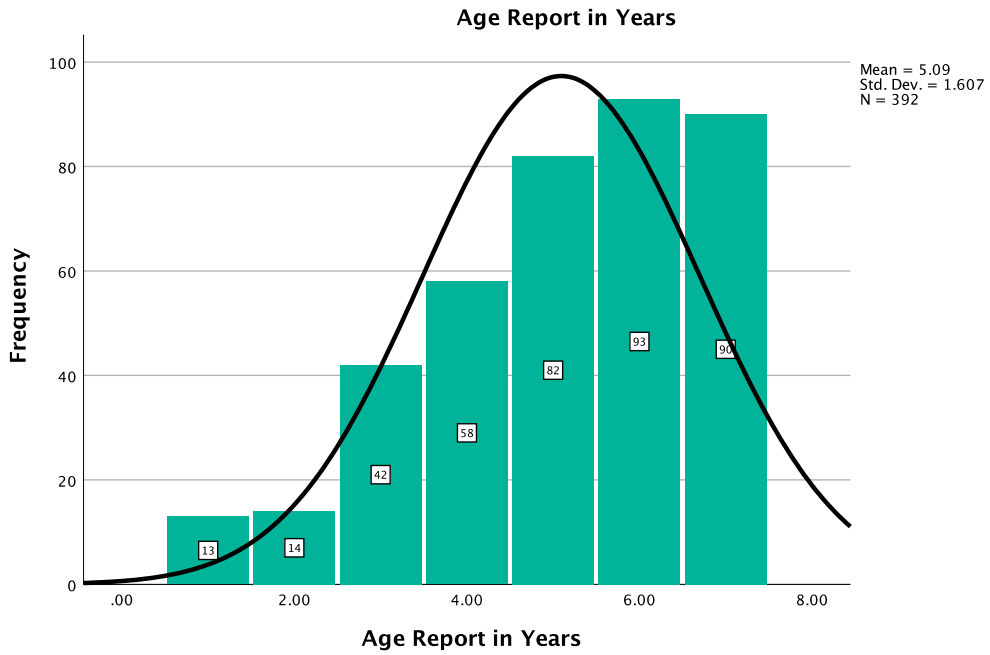


Table 5 presents an analysis of the sample consisting of 392 eligible diabetic patients undergoing dialysis. Most patients, comprising 64.0% (N = 251), possessed a high school educational level. The second largest percentage, accounting for 17.9% (N = 70), belonged to the group of patients with an associate degree educational level. Following this, 12.2% (N = 48) of patients held a bachelor's degree educational level. Subsequently, 4.3% (N = 17) of patients were classified under the master's degree educational level. In contrast, the smallest proportion, comprising 1.5% (N = 6), belonged to the group of patients with a doctoral degree educational level. For a more comprehensive depiction of these findings, please consult Figure 4.

Table 5

Frequency for Educational Level (Categorical) Variable

Educational Level	*N*	%
High School	251	64.0%
Associate's Degree	70	17.9%
Bachelor's Degree	48	12.2%
Master's Degree	17	4.3%
Doctoral Degree	6	1.5%

Figure 4

Histogram- EDUC (Categorical) Variable

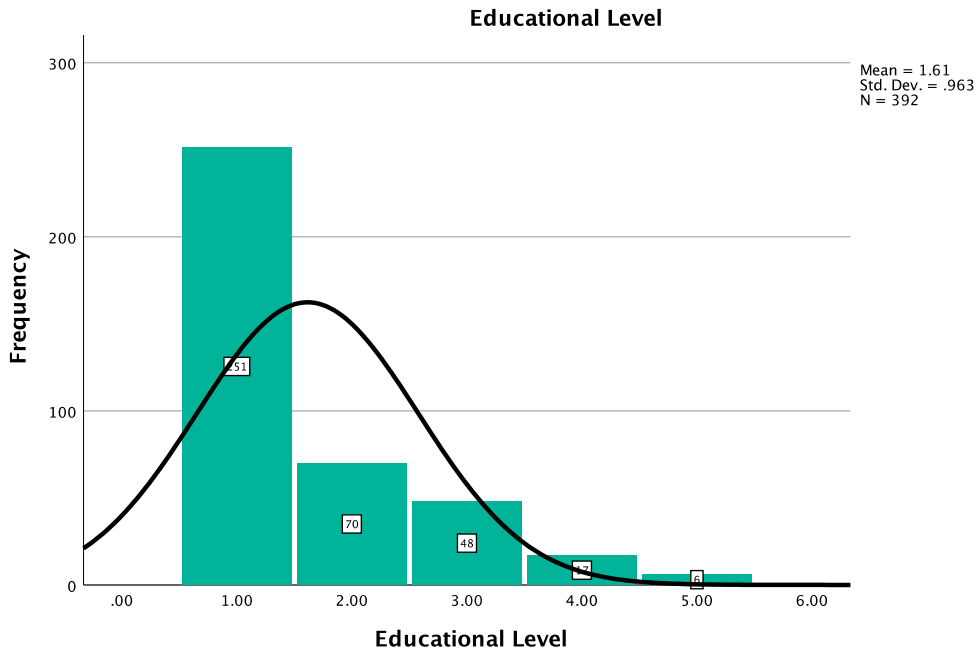


Table 6 provides an overview of the sample comprising 392 eligible diabetic patients undergoing dialysis. Most patients, accounting for 46.9% (*N* = 184), fell within

the BMI range of 25.0-29.9, indicating overweight status. This was followed by 37.8% (*N* = 148) of patients falling within the BMI range of 18.5-24.9, representing a healthy weight category. Conversely, a minority of patients, specifically 15.3% (*N* = 60), belonged to the BMI category of 30.0 and above, signifying obesity. For a more comprehensive understanding of these findings, please refer to Figure 5.

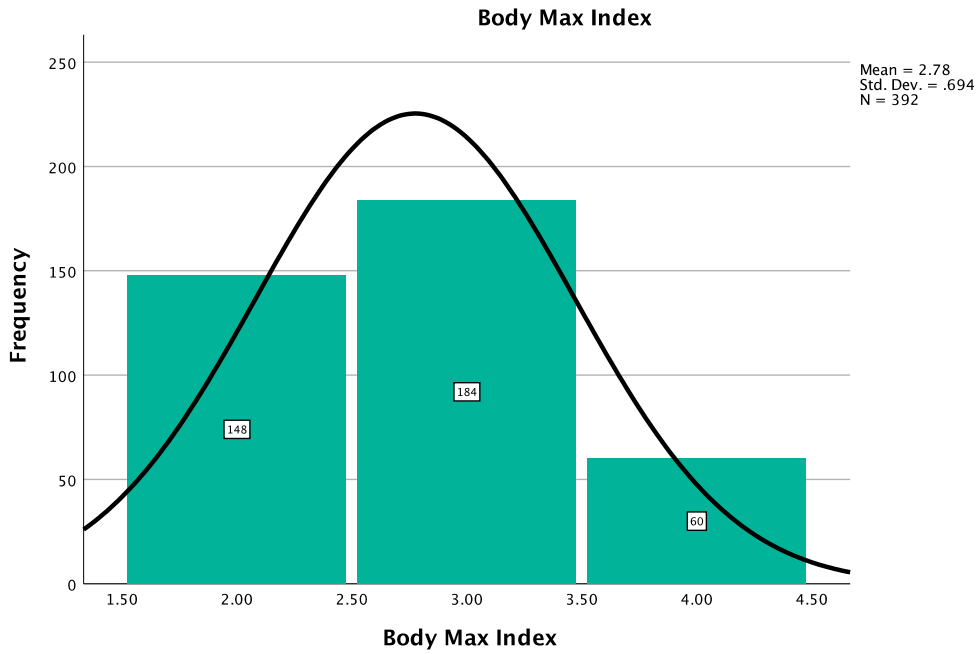
Table 6

Frequency for Body Mass Index (Categorical) Variable

BMI	*N*	%
18.5 - 24.9 (Healthy)	148	37.8%
25.0 - 29.9 (Overweight)	184	46.9%
30 & Above (Obese)	60	15.3%

Figure 5

Histogram- BMI (Categorical) Variable



The comprehensive analysis of continuous A1C levels data revealed that among the 392 eligible diabetic patients undergoing dialysis, the mean value was found to be 8.45, with a standard deviation of 1.70 (as depicted in Table 7). This indicates that the data points are relatively less dispersed around the mean, resulting in a smaller standard deviation. For a more visual representation and further insights, please refer to Figure 6.

Table 7

Descriptive Statistical for A1C Level (Continuous) Variable

A1C Level	*N*	Minimum	Maximum	Mean	Std. Deviation
A1C Levels	392	6.04	14.89	8.4503	1.80720
Valid N (listwise)	392				

Figure 6

Boxplot- A1C (Continuous) Variable

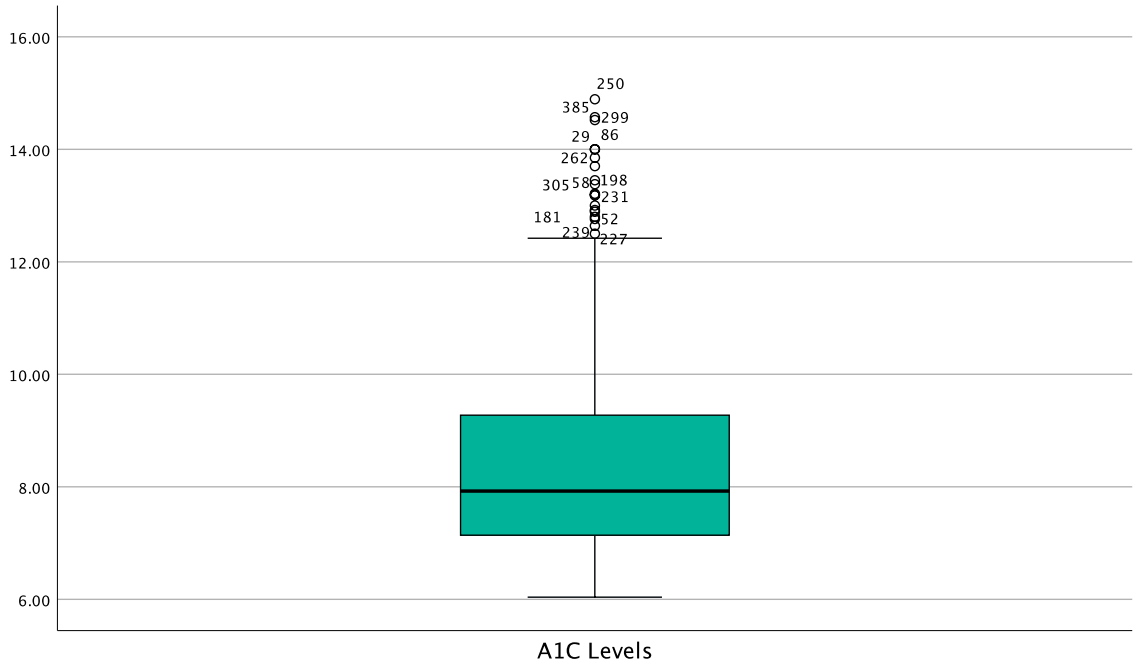


Table 8 presents the sample characteristics of 392 eligible diabetic patients on dialysis, with most of the participants being classified as survival patients. Specifically, 61.7% of the sample (*N* = 242) comprised individuals who survived, while the remaining

38.3% (N = 150) constituted the deceased patients. For a visual representation of this distribution, please refer to Figure 7.

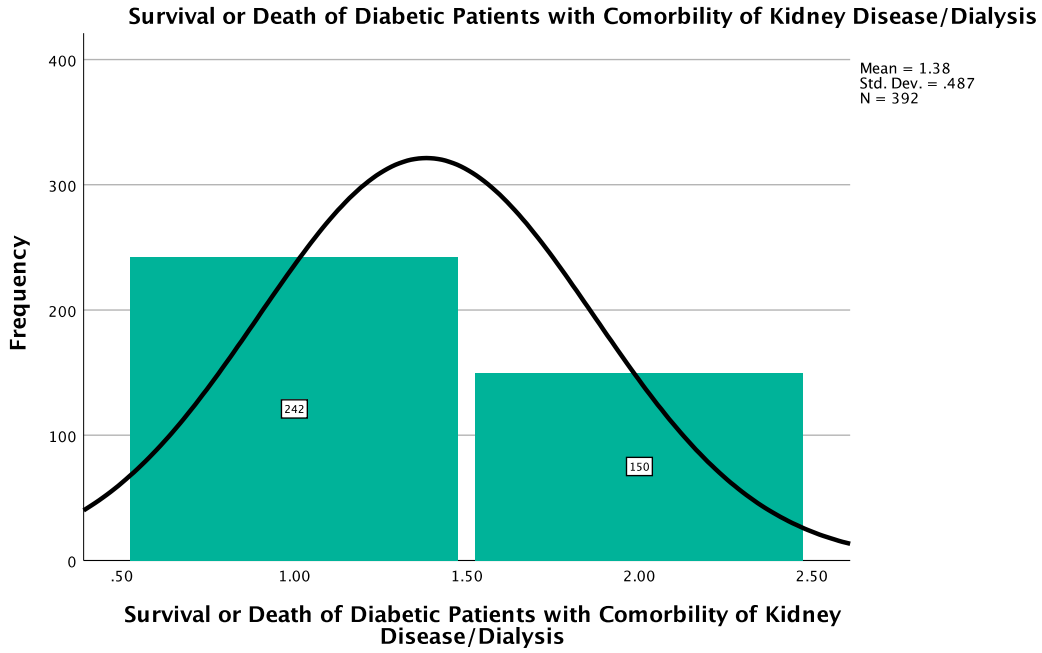
Table 8

Frequency for Survival or Death of Diabetic Patients with Comorbidity of Kidney Disease/Dialysis (Dichotomous/Dependent) Variable

Survival or Death	*N*	%
Survival	242	61.7%
Death	150	38.3%

Figure 7

Histogram- SURV_OR_DEATH (Dichotomous/Dependent) Variable



Inferential Analysis

A binary logistic regression analysis was conducted to examine the association between COVID-19 vaccine status by Diabetes Type, Sex, Age, Educational Level, BMI, and A1C Level, and the likelihood of survival in diabetes patients on dialysis who contracted COVID-19. The analysis ensured that all assumptions of the model were met. The dependent variable, survival, was dichotomous, with categories of Survival and *Death*, while the independent variables were measured as categorical and continuous variables. The linearity of the continuous variable A1C Levels with respect to the logit of the dependent variable was assessed using the Box-Tidwell procedure. A Bonferroni correction was applied to account for multiple comparisons, with statistical significance accepted when $p < 0.000217$.

The logistic regression model was found to be statistically significant compared to the null model ($\chi 2(17) = 312.543$, $p < 0.001$), indicating that the model provided a good fit to the data (as shown in Table 9). The model explained 74.7% of the variation in survival (Nagelkerke R2) and accurately predicted 90.3% of cases (as shown in Table 10, Table 11). The sensitivity of the model was 91.1%, specificity was 81.9%, the positive predictive value was 93.4%, and the negative predictive value was 85.3% (as shown in Table 11).

Among the predictor variables, COVID-19 Vaccine Status by Diabetes Type ($p < 0.001$), Age Report in Years ($p < 0.001$), BMI ($p = 0.004$), and A1C Level ($p < 0.001$) were found to be statistically significant in their association with survival. However, Sex ($p = 0.696$) and Educational Level ($p = 0.017$) did not show a significant association.

Males and females had similar odds of exhibiting survival. (For more details, see Table 12).

The analysis revealed that unvaccinated diabetes type 2 patients on dialysis had 0.41 times lower odds of survival compared to vaccinated diabetes type 1 patients on dialysis. Similarly, unvaccinated diabetes type 2 patients had 8.746 times higher odds of survival compared to unvaccinated diabetes type 1 patients. Moreover, unvaccinated diabetes type 2 patients had 0.15 times lower odds of survival compared to vaccinated diabetes type 2 patients.

In terms of age, diabetes patients on dialysis who were 80 years or older had lower odds of survival compared to those in the age group of 18-29 years. This trend continued for different age groups, with older patients showing lower odds of survival compared to younger patients.

Furthermore, diabetes patients on dialysis with a BMI of 30 and above (Obese) had lower odds of survival compared to those with a BMI between 18.5 and 24.9 (Healthy), as well as those with a BMI between 25.0 and 29.9 (Overweight). Increasing A1C levels were associated with an increased likelihood of death.

Based on these findings, it can be inferring that COVID-19 Vaccine Status by Diabetes Type, along with Age, BMI, and A1C Level, significantly influence the likelihood of survival in diabetes patients on dialysis who contract COVID-19. Therefore, the null hypothesis is rejected., and the alternative hypothesis is accepted.

Table 9

Omnibus Tests of Model Coefficients

Step		Chi-square	*df*	Sig.
Step 1	Step	312.543	17	<.001
	Block	312.543	17	<.001
	Model	312.543	17	<.001

Table 10

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	209.090[a]	.549	.747

Note: Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.

Table 11

Classification Table

	Observed		Predicted		
			Survival or Death of Diabetic Patients with Comorbidity of Kidney Disease/Dialysis		Percentage Correct
			Survival	Death	
Step 1	Survival or Death of Diabetic Patients with Comorbidity of Kidney Disease/Dialysis	Survival	226	16	93.4
		Death	22	128	85.3
	Overall Percentage				90.3

Note: The cut value is .500.

Table 12

Binary Logistic Regression Predicting Likelihood of Survival

		B	*SE*	Wald	*df*	Sig.	Exp(B)	95% CI for EXP(B)	
								Lower	Upper
Step 1[a]	COVID-19 Vaccines Status by Diabetes Type			89.976	3	<.001			
	COVID-19 Vaccines Status by Diabetes Type (1)	-3.199	.580	30.427	1	<.001	.041	.013	.127
	COVID-19 Vaccines Status by Diabetes Type (2)	2.169	.734	8.725	1	.003	8.746	2.074	36.876
	COVID-19 Vaccines Status by Diabetes Type (3)	-4.191	.506	68.562	1	<.001	.015	.006	.041
	Sex (1)	.151	.386	.152	1	.696	1.163	.546	2.477
	Age Report in Years			24.154	6	<.001			
	Age Report in Years (1)	-3.770	1.408	7.164	1	.007	.023	.001	.364
	Age Report in Years (2)	-3.516	1.182	8.845	1	.003	.030	.003	.302

	B	*SE*	Wald	*df*	Sig.	Exp(B)	95% CI for EXP(B)	
							Lower	Upper
Age Report in Years (3)	-3.656	.833	19.269	1	<.001	.026	.005	.132
Age Report in Years (4)	-1.308	.596	4.814	1	.028	.270	.084	.870
Age Report in Years (5)	-1.435	.569	6.353	1	.012	.238	.078	.727
Age Report in Years (6)	-.781	.530	2.173	1	.140	.458	.162	1.294
Educational Level			12.110	4	.017			
Educational Level (1)	-2.627	1.183	4.926	1	.026	.072	.007	.736
Educational Level (2)	-3.072	1.253	6.009	1	.014	.046	.004	.540
Educational Level (3)	-3.563	1.298	7.528	1	.006	.028	.002	.361
Educational Level (4)	-4.702	1.490	9.967	1	.002	.009	.000	.168
Body Max Index			10.865	2	.004			
Body Max Index (1)	-1.951	.611	10.189	1	.001	.142	.043	.471
Body Max Index (2)	-1.750	.589	8.834	1	.003	.174	.055	.551
A1C Levels	.702	.141	24.820	1	<.001	2.018	1.531	2.660
Constant	.859	1.837	.219	1	.640	2.361		

Note: Variable(s) entered on step 1: COVID-19 Vaccines Status by Diabetes Type, Sex, Age Report in Years, Educational Level, Body Max Index, A1C Levels.

Discussion

Interpretation

The results of the binary logistic regression analysis indicate a statistically significant association between COVID-19 Vaccine Status by Diabetes Type and the survival status of diabetes patients on dialysis within a hospital setting in Puerto Rico ($p < 0.001$). The covariates of Age Report in Years, BMI, and A1C Level were found to be protective and risk factors that potentially influence this association, as they showed statistically significant levels concerning the survival status ($p < 0.001$). However, the covariates of Sex ($p = 0.696$) and Educational Level ($p = 0.017$) did not show statistically significant levels in relation to the survival status.

Further analysis revealed that diabetes type 2 patients on dialysis who were unvaccinated were 0.41 times less likely to experience survival than diabetes type 1 patients on dialysis who were vaccinated, controlled for Age, BMI, and A1C levels. Similarly, unvaccinated diabetes type 2 patients on dialysis were 8.746 times more likely to experience survival than unvaccinated diabetes type 1 patients on dialysis, controlled for Age, BMI, and A1C levels.

In addition, unvaccinated diabetes type 2 patients on dialysis were 0.15 times less likely to experience survival than vaccinated diabetes type 2 patients on dialysis, controlled for Age, BMI, and A1C levels. These findings suggest that unvaccinated type 2 diabetic patients have a higher proportional survival compared to unvaccinated type 1 diabetic patients, while vaccinated type 2 diabetic patients have a higher proportional survival than vaccinated type 1 diabetic patients. These results support the statistical

association between COVID-19 Vaccine Status by Diabetes Type and the survival status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlled for Age, BMI, and A1C levels.

In addition, the analysis revealed that diabetes patients on dialysis aged 80 years and older were less likely to experience survival compared to those between 18 and 29 years, controlled for BMI and A1C levels. This trend continued for different age groups, with older patients showing lower chances of survival compared to younger patients. This indicates that age, along with BMI and A1C levels, is an important protective and risk factor that influences the association between COVID-19 Vaccine Status by Diabetes Type and the survival status of diabetes patients on dialysis within a hospital setting in Puerto Rico.

Moreover, the analysis showed that diabetes patients on dialysis with a BMI of 30 and above (Obese) were less likely to experience survival compared to those with a BMI between 18.5 and 24.9 (Healthy), controlled for Age and A1C levels. Similarly, patients with a BMI of 30 and above were less likely to experience survival compared to those with a BMI between 25.0 and 29.9 (*Overweight*), controlled for Age and A1C levels. These findings highlight the importance of BMI, along with Age and A1C levels, in influencing the association between COVID-19 Vaccine Status by Diabetes Type and the survival status of diabetes patients on dialysis within a hospital setting in Puerto Rico. In addition, A1C level was identified as an important protective and risk factor, along with Age and BMI, in controlling the statistically significant association.

In this study, I employed the SEM as a theoretical framework to examine the risk and protective factors against COVID-19 infection in diabetic patients with comorbidity of kidney disease/dialysis at two levels: intrapersonal and community. The diabetes type risk factor was measured at the individual level of the SEM, while the community level encompassed perceptions of the risk of vaccine-preventable COVID-19 in the hospital setting, which played a crucial role in the vaccination rate. These protective and risk factors interacted and influenced the survival status of diabetic patients on dialysis within the hospital setting. The analysis also revealed that the survival status by diabetes type was controlled by individual factors such as Age, BMI, and A1C level, while no significant control was observed for Sex and Educational Level.

Based on the findings, it is recommended to conduct further research using this specific theoretical framework to obtain more evidence-based information that strengthens the statistical association between COVID-19 Vaccine Status by Diabetes Type and the survival status of diabetes patients on dialysis within a hospital setting in Puerto Rico, while controlling for Age, BMI, and A1C level. This additional research would provide a deeper understanding of the factors influencing the observed associations and contribute to the development of targeted interventions and strategies for improving the survival outcomes of diabetic patients on dialysis.

Limitations

This study is subject to several limitations that should be acknowledged. Firstly, the use of secondary data sources poses a significant limitation. The lack of control over the data collection methods in the hospital setting introduces uncertainty regarding the

validity and reliability of the data. In addition, the presence of biases in the original hospital data source may have influenced the accuracy and generalizability of the study findings.

A second limitation stems from the small sample size and the study's reliance on data from a single geographical location. This restricts the generalizability of the findings and limits the statistical power of the analysis. To overcome this limitation, future studies could consider collecting data from multiple hospitals across the United States, thereby increasing the sample size and enhancing the robustness of the statistical tests.

It is important to note that a major limitation of the data source used in this study is the lack of information on specific COVID-19 vaccine brandings. This limitation hinders the scope and depth of the research findings. The specific brand of the COVID-19 vaccine administered can potentially influence the association between COVID-19 Vaccine Status by diabetes type, and the survival outcomes of diabetes patients on dialysis within a hospital setting in Puerto Rico, even when controlling for factors such as Age, Sex, Educational Level, BMI, and A1C level. The absence of this information may have implications for the statistical significance of the observed associations.

Therefore, for future studies, it is recommended to include COVID-19 vaccine brandings as a covariate. This additional information would provide a more comprehensive understanding of the association between COVID-19 vaccine status by diabetes type, and survival outcomes among patients on dialysis. By considering the specific brand of the vaccine, researchers can better assess the potential impact of

different vaccines on the observed associations, potentially leading to more nuanced and accurate conclusions.

Implications

This study has made significant contributions to the existing body of evidence regarding the risks of mortality faced by adults diagnosed with different types of diabetes, specifically those with comorbidities of kidney disease/dialysis, in the context of COVID-19 infection. The findings of this study have demonstrated a statistically significant association between COVID-19 Vaccine Status by Diabetes Type, and the survival outcomes of diabetes patients on dialysis within a hospital setting in Puerto Rico. The analysis controlled for important factors such as Age, BMI, and A1C level.

The outcomes of this study have important implications for healthcare organizations, physicians, and the general public in Puerto Rico. They provide valuable insights into the role of the COVID-19 vaccine as a preventive measure against mortality for diabetic patients on dialysis. These findings can be used by healthcare professionals to educate individuals with diabetes and comorbid kidney disease/dialysis about the potential effectiveness of the COVID-19 vaccine in preventing death from COVID-19 infection. It is particularly crucial to highlight the importance of vaccination for individuals with type 1 diabetes, who face a higher risk of mortality compared to those with type 2 diabetes.

Furthermore, these research findings serve as a valuable tool for public health officials and prevention professionals in managing COVID-19 infections among the dialysis population with both types of diabetes. They provide actionable information that

can guide hospital interventions and health education programs, with a specific focus on reducing individual risk factors such as Age, BMI, and A1C levels, in order to mitigate the risk of mortality in this population.

Importantly, the implications of this research extend beyond the healthcare setting and have the potential to drive positive social change in Puerto Rico. The results of this study inform decision-making and planning processes for adults diagnosed with diabetes and comorbid kidney disease/dialysis who are at risk of COVID-19 infection. They underscore the need for increased attention and allocation of resources towards ensuring access to the COVID-19 vaccine for individuals with type 1 diabetes in both outpatient and inpatient settings. This is crucial in improving overall health outcomes for individuals with type 1 diabetes in the dialysis population, reducing mortality rates, and alleviating the burden on the Puerto Rico Public Health System.

Recommendations

In this research study, I used secondary data obtained from the Electronic Medical Record system within a hospital in Puerto Rico. The data pertained to diabetic patients with comorbidities of kidney disease/dialysis who were hospitalized due to COVID-19 infection between December 15, 2020, and December 31, 2022. The study aimed to examine the relationship between COVID-19 Vaccine Status by Diabetes Type, and the survival outcomes of diabetes patients on dialysis within a hospital setting in Puerto Rico. The analysis controlled for variables such as Age, Sex, Educational Level, BMI, and A1C level, using binary logistic regression analysis.

It is worth noting that there is a limited number of research studies investigating the association between COVID-19 Vaccine Status by Diabetes Type, and the survival outcomes of diabetes patients on dialysis within a hospital setting in Puerto Rico. Therefore, it is recommended to expand this study by including the impact of different COVID-19 vaccine brands on the aforementioned factors. In addition, extending the study to include data from other hospitals, both in the United States and other organizations in the public and private sectors, focusing on diabetes patients on dialysis would enhance the generalizability of the findings and provide a larger sample size for more robust statistical analysis.

Conclusion

This study investigated the impact of COVID-19 Vaccine Status by Diabetes Type, Age, Sex, Educational Level, BMI, and A1C Level on the likelihood of survival in diabetes patients on dialysis who contract COVID-19. The findings highlight several important factors that influence the outcomes of COVID-19 in this vulnerable population.

The results of the binary logistic regression analysis revealed that COVID-19 vaccination status plays a crucial role in determining the survival odds of diabetes patients on dialysis. Specifically, unvaccinated diabetes type 2 patients on dialysis exhibited higher odds of survival compared to their unvaccinated counterparts with diabetes type 1. This finding underscores the significance of COVID-19 vaccination in mitigating the adverse effects of the virus in diabetes patients on dialysis, particularly among those with type 1 diabetes.

Age emerged as a significant predictor variable of survival outcomes, with older patients showing lower odds of survival compared to younger individuals. This finding suggests that age-related factors may contribute to the increased vulnerability of older diabetes patients on dialysis to severe COVID-19 complications. Healthcare professionals should consider age as a critical factor when assessing and managing COVID-19 in this population.

Furthermore, the study identified a notable association between BMI and survival odds in diabetes patients on dialysis who contract COVID-19. Specifically, individuals with higher BMI (*Obese*) exhibited lower odds of survival compared to those with a healthy BMI range (18.5-24.9) and those in the overweight BMI range (25.0-29.9). This finding underscores the importance of weight management and obesity prevention strategies in diabetes patients on dialysis to enhance their resilience against severe COVID-19 outcomes.

Lastly, the analysis revealed a positive association between A1C levels and the likelihood of death in diabetes patients on dialysis who contract COVID-19. Higher A1C levels were associated with an increased risk of mortality, indicating the significance of glycemic control in reducing the adverse effects of COVID-19. This finding highlights the importance of regular monitoring and management of A1C levels in diabetes patients on dialysis, particularly in diabetes type 1.

The findings of this study have implications for healthcare professionals, policymakers, and researchers involved in the care of diabetes patients on dialysis during future outbreak of COVID-19 or other emerging infectious diseases. The results

underscore the critical role of COVID-19 vaccination, age, BMI, and A1C control in determining the survival outcomes of this population. These findings can inform targeted interventions and strategies aimed at improving the prognosis of diabetes patients on dialysis who contract COVID-19.

Further research is warranted to gain a deeper understanding of the complex interactions between individual, interpersonal, community, and societal factors that influence the associations observed in this study. Future investigations employing a socio-ecological framework can provide valuable insights into the multifaceted determinants of COVID-19 outcomes in diabetes patients on dialysis. Such comprehensive research endeavors will contribute to the development of evidence-based guidelines and interventions that enhance the survival rates and overall well-being of this vulnerable population during future outbreaks and beyond.

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COVID-19 Vaccine by Dialysis Frequency and Survival of Diabetes Patient on Dialysis

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Outlet for Manuscript

Journal of Diabetes and Its Complications was the journal selected as the outlet for Manuscript 2 due to the journal's focus in all areas of diabetes and its related syndromes through scientific research to assist the practitioner in his/her care of such patients. The goal of Manuscript 2 is to examine the association between COVID-19 vaccine status by dialysis frequency, age, sex, educational level, BMI, smoking, and the proportion surviving of diabetes patients on dialysis within a hospital setting in Puerto Rico. The information obtained from the manuscript will contribute to improving evidence-based practices by identifying the important risk and protection factors according to dialysis frequency against COVID-19 infection, as well as the measures of protection and prevention of associated deaths in the population of diabetic patients on dialysis.

Journal of Diabetes and Its Complications requires that all original articles present a structured abstract that does not exceed 200 words (includes the aims, methods, results, conclusions, and keywords). The original article should be 5,000 words (includes a combined of figures or tables with legends but exclude the references and an abstract). In addition, the article should not contain more than 50 references, which should be in AMA style. Likewise, the article should not contain more than a combination of five tables and/or figures. Once written and structured according to this format, it can be sent for review to the following URL: https://www.editorialmanager.com/jdc/default.aspx

Abstract

This study aimed to investigate the association between COVID-19 Vaccine Status by Dialysis Frequency and the survival outcomes of diabetes patients on dialysis within a hospital setting in Puerto Rico. The analysis controlled for variables such as Age, Sex, Educational Level, BMI, and Smoking. Secondary data obtained from EMR's system withing a hospital setting in Puerto Rico were utilized. The study included diabetic patients on dialysis who were hospitalized due to COVID-19 infection. Binary logistic regression analysis was conducted to examine the association between COVID-19 Vaccine Status by Dialysis Frequency and survival outcomes, while controlling for other important protective and risk factors. The analysis revealed a statistically significant association ($p < 0.001$) between COVID-19 Vaccine Status by Dialysis Frequency and the survival status of diabetes patients on dialysis. Unvaccinated patients undergoing three dialysis sessions per week had lower odds of survival compared to vaccinated patients undergoing one or two dialysis sessions per week, controlled for Age, BMI, and Smoking. COVID-19 vaccination status, along with Age, BMI, and Smoking, plays a critical role in determining the survival outcomes of diabetes patients on dialysis who contract COVID-19. Vaccinated patients and those with lower dialysis frequency exhibited higher odds of survival. Older age, higher BMI, and smoking were associated with decreased survival odds. These findings highlight the importance of COVID-19 vaccination, age-related factors, weight management, and smoking cessation programs in improving the survival outcomes of this vulnerable population.

Introduction

Chronic kidney disease (CKD) is one of the severe complications of diabetes; approximately one in three people with diabetes lives with CKD in the United States (CDC, 2021; Mayo Clinic, 2021). Diabetic nephropathy is one of the leading causes of end-stage renal disease (ESKD), requiring dialysis treatment or kidney transplantation, and is associated with increased morbidity and mortality (Selby & Taal., 2020; Tye et al., 2022). Diabetic nephropathy is among the independent risk factors that predict poor outcomes in COVID-19 infection (Maremonti et al., 2022; Leon-Abarca, 2020). Age is also a risk factor for experiencing COVID-19 severity among diabetic patients (Schlesinger et al., 2021; Stoian et al., 2020). Although males are at higher risk of severity and death from COVID-19, the evidence among diabetic patients by sex in terms of severity of COVID-19 is equivocal (Schlesinger et al., 2021; Kautzky-Willer, 2021). Similarly, academic performance is an important predictor of the severity of COVID-19 (Jian et al., 2021). Furthermore, changes in stress and depression among diabetic patients during the COVID-19 pandemic have increased smoking, which has increased the risk of severity and death from COVID-19 (Kim & Kim, 2022; Utli & Vural-Dogrou, 2021).

In addition, patients with diabetic nephropathy are at increased risk of medical complications, including death and exposure to COVID-19 in dialysis units (Leon-Abarca et al., 2020; Nogueira et al., 2021; Lodge et al., 2020). Studies show that alternating dialysis frequencies could help mitigate the risk of transmission of COVID-19 among dialysis patients (Lodge et al., 2020). However, more research is needed to understand the impact of dialysis frequency on the risk of developing worse outcomes

against COVID-19 infection in the hemodialysis patient population (Lodge et al., 2020). Similarly, studies are needed that evaluate the impact of alternating dialysis for two to three times a week, but that comply with the dialysis parameters that satisfy the physiological demand of the patient (Lodge et al., 2020).

On the other hand, COVID-19 vaccines have been found to protect against severe COVID-19 disease in dialysis patients (El Karoui & De Vriese, 2022). However, information on the impact of COVID-19 vaccines in protecting the population of patients with diabetic nephropathy with ESRD on dialysis is limited, and their effectiveness could vary depending on their comorbidities and other risk factors (Hou et al., 2021; Windpessl et al., 2021; Chen et al., 2021). Similarly, no studies have been found that establish differences in the protective factor of vaccines against COVID-19 by frequency of dialysis.

Five risk factors for COVID-19 severity, including age, sex, academic achievement, BMI, and smoking, have been examined in multiple studies. In addition, the COVID-19 vaccine has also been evaluated as a protective factor against the severity of COVID-19. Therefore, it has been hypothesized that COVID-19 vaccine status by dialysis frequency may be associated with the surviving status of diabetes patients on dialysis within a hospital setting, controlled for other important risk and protective factors. Using the social ecological model (SEM), risk and protective factors against COVID-19 infection in diabetic patients with comorbid kidney disease/dialysis can be assessed at two levels, including intrapersonal and community, and how they interact. A clear assessment of this COVID-19 severity and mortality risk associations, differentiated

by dialysis frequency, could benefit the development of strategies for managing, protecting, and preventing death from diabetic patients with comorbid renal disease/dialysis withing a hospital setting. Here, a quantitative secondary data analysis study is carried out to describe the association between COVID-19 vaccine status by dialysis frequency and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, smoking.

Methods

Research Question

What is the association between COVID-19 vaccine status by dialysis frequency and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, smoking?

H_0—There is no statistically significant association between COVID-19 vaccine status by dialysis frequency and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, smoking.

H_1—There is a statistically association between COVID-19 vaccine status by dialysis frequency and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, smoking.

Study Design and Participants

A retrospective cohort study was conducted using data from a sample of diabetic patients with comorbidity kidney disease/dialysis who were diagnosed with COVID-19

by nucleic acid amplification test (NAAT) or antigen test and received any of the COVID-19 vaccines or not. The nucleic acid amplification test (NAAT) is used in unvaccinated patients, while the antigen test is used in vaccinated patients (CDC, 2022). Patients are identified through ICD-10 diagnostic codes within a hospital setting in Puerto Rico from December 15, 2020, to February 15, 2023. The International Classification of Diseases (ICD-10) is a diagnostic tool used worldwide for epidemiological, health management, and clinical purposes (CDC, 2015). Diabetic patients with comorbidity of kidney disease /dialysis who were hospitalized as a result of COVID-19 infection from December 15, 2020, to March 15, 2023, are included in such a way that each patient was followed u*p*until discharge unless the event (death) occurred first. Patients younger than 18 years or pregnant and those who did not have positive NAAT, or antigen test results were excluded.

Since this study involves analyzing data from protected health information (PHI) not publicly available, the "Safe Harbor" de-identification method is required to comply with the Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule (HSS, 2022). In addition, this process must be evaluated and approved by the Institutional Review Board (IRB) of Walden University and the Health Information Management Administration of the hospital setting in Puerto Rico.

Sample and Power

A sample of diabetic patients with comorbid kidney disease/dialysis who were hospitalized due to COVID-19 infection and who met the inclusion criteria previously described is included in the study. The sample size for this study was determined by

performing an a priori power analysis using the Sample Size Calculator software (Calculator, n.d.). Power analysis was completed assuming a two-tailed test with an alpha of 0.05, an effect size of 0.50, and a power of 0.90, the power analysis for the statistical test of binary logistic regression analysis indicates that size would be needed sample of 381 matched participants to ensure sufficient power and reduce the probability of a type 2 error (Calculator, n.d.; PRDoH, 2021).

Variables / Sources of Data

The variables selected to describe the association between COVID-19 vaccine status by type of dialysis frequency and the surviving status of diabetes patients with comorbidity of kidney disease /dialysis within a hospital setting in Puerto Rico, controlling for other important risk and protective factors; will be obtained from the medical records, which are not publicly available. For this study, the independent variable COVID-19 vaccination status by dialysis frequency reveals nominal scales used to assign items into discrete categories (1 = *Vaccinated/One Time/Week*; 2 = *Vaccinated/Two Time/Week*; 3 = *Vaccinated/Three Time/Week*; 4 = *Unvaccinated/One Time/Week*; 5 = *Unvaccinated/Two Time/Week*; 6 = *Unvaccinated/Three Time/Week*). Similarly, the dependent variable surviving status of diabetes patient with comorbidity of kidney disease /dialysis within a hospital setting in Puerto Rico reveals nominal scales used to assign items into discrete categories (1 = *Death*; 2 = *Survival*). While for the potentially confounding variables, sex reveals nominal scales used to assign items to discrete categories (1 = *Male*; 2 = *Female*), age reveals nominal scales used to assign items to discrete categories (1 = 18 – 29 years; 2 = 30 – 39 years; 3 = 40 – 49 years; 4 =

50 – 59 years; 5 = 60 – 69 years; 6 = 70 – 79 years; 7 = 80 years or more), the level of education reveals nominal scales used to assign items into discrete categories (1= *High School*; 2 = *Associate Degree*; 3 = *Bachelor's Degree*; 4 = *Master's Degree*; 5 = *Doctoral Degree*), body mass index reveals nominal scales used to assign items into discrete categories (1 = Below 18.5 [*Underweight*]; 2 = 18.5 – 24.9 [*Healthy*]; 3= 25.0 – 29.9 [*Overweight*]; 4= 30.0 and Above [*Obese*]), and smoking reveals nominal scales used to assign items into discrete categories (1 = *Smoking*; 2 = *Not Smoking*).

Statistical Analysis

This study included descriptive statistics to summarize the data from the sample of diabetic patients with comorbidity of kidney disease /dialysis. Frequencies were calculated for the variables of vaccination status by dialysis frequency, sex, age, level of education, BMI, smoking, and proportion surviving of diabetic patients with comorbidity of kidney disease /dialysis within a hospital setting in Puerto Rico. In addition, Binary Logistic Regression was used, using the Statistical Package for the Social Sciences (SPSS) to describe the probability being survive by COVID-19 vaccine status of diabetic patients on dialysis against COVID-19 infection within a hospital setting in Puerto Rico, controlling for other important risk and protective factors. *Unvaccinated/Three Time/Week* was the reference group for all the vaccination statuses; *80-years or more* was the reference group for all the age report in years. *Female* was the reference group for sex. *Doctoral Degree* was the reference group for all the educational levels. 30 and Above (*Obese*) was the reference group for all the body max index (BMI). *Not Smoking* was the reference group for the smoking status.

Results

Execution

The study was conducted in accordance with the original protocol and design. Ethical approval was sought from the Health Information Administrative Board of the Hospital in Puerto Rico in order to obtain access to the necessary data. Subsequently, approval was granted by the Walden University Institutional Review Board and the Hospital Health Information Administrative Board.

The data collected for this study included various demographic and clinical variables, including COVID-19 vaccination status, diabetes type, age, sex, education level, body mass index, and A1C levels. It is important to note that these variables were not publicly available.

To ensure a robust and representative sample, a total of 392 diabetic patients with comorbid kidney disease/dialysis, aged 18 years and above, who were hospitalized due to COVID-19 infection, were included in the study. The data collection period spanned from December 15, 2020, to December 31, 2022.

It is noteworthy that no missing data was identified in the final dataset, as indicated in Table 1. This signifies the completeness and reliability of the collected data, thereby enhancing the validity of the study findings.

Table 1

Study Sample

		COVID-19 Vaccines Status by Dialysis Frequency	Sex	Age Report in Years	Educational Level	Body Max Index	Smoking	Survival or Death of Diabetic Patients with Comorbidity of Kidney Disease / Dialysis
N	Valid	392	392	392	392	392	392	392
	Missing	0	0	0	0	0	0	0

Descriptive Analysis

Table 2

Frequency of COVID-19 Vaccine Status by Dialysis Frequency (Categorical/Independent) Variable

Vaccine Status	*N*	%
Vaccinated/One Time/Week	39	9.9%
Vaccinated/Two Time/Week	88	22.4%
Vaccinated/Three Time/Week	102	26.0%
Unvaccinated/One Time/Week	28	7.1%
Unvaccinated/Two Time/Week	39	9.9%
Unvaccinated/Three Time/Week	96	24.5%

Table 2 presents an analysis of a sample consisting of 392 eligible diabetic patients who are undergoing dialysis. The main objective of this analysis is to examine the distribution of patients based on their vaccination status and the frequency of dialysis. Among the sample, most patients, accounting for 26.0% (N = 102), belonged to the group of patients who are vaccinated and undergo three dialysis sessions per week. Following closely, the second largest proportion was observed in the group of patients who are not vaccinated and undergo three dialysis sessions per week, representing 24.5% (N = 96) of the sample. The third largest proportion was found in the group of patients who are vaccinated and undergo two dialysis sessions per week, accounting for 22.4% (N = 88). In addition, a subset of patients, equivalent to 9.9% (N = 39), consisted of those

who are vaccinated and undergo one dialysis session per week, as well as those who were not vaccinated and undergo two dialysis sessions per week. Conversely, a minority of patients, comprising 7.1% (*N* = 28), were categorized as those who are not vaccinated and undergo one dialysis session per week. For a more detailed visual representation of these findings, please refer to Figure 1.

Figure 1

Histogram - COVID_VAC_STAT_BY_DIAL_FREQ (Categorical/Independent) Variable

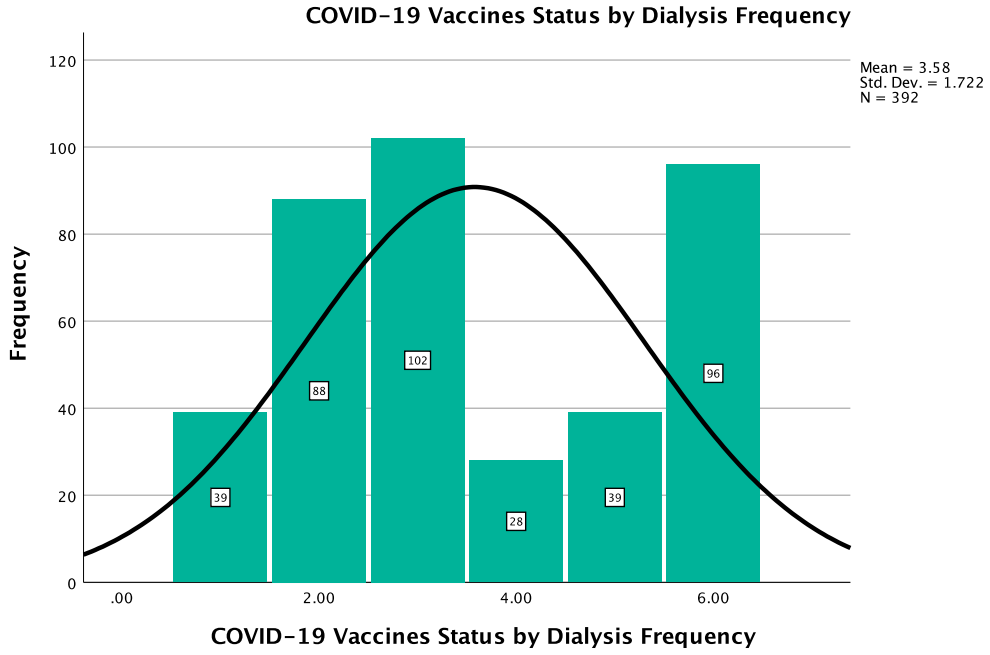


Table 3

Frequency for Sex (Categorical) Variable

Sex	*N*	%
Male	185	47.2%
Female	207	52.8%

Table 3 present an analysis of a sample consisting of 392 eligible diabetic patients undergoing dialysis. The data reveals the distribution of patients based on their sex, specifically examining the proportion of female and male patients. Among the sample, most patients, accounting for 52.8% (N = 207), were female. In contrast, the minority of patients, comprising 47.2% (N = 185), belonged to the male category. For a more comprehensive depiction of these findings, please refer to Figure 2.

Figure 2

Histogram - SEX (Categorical) Variable

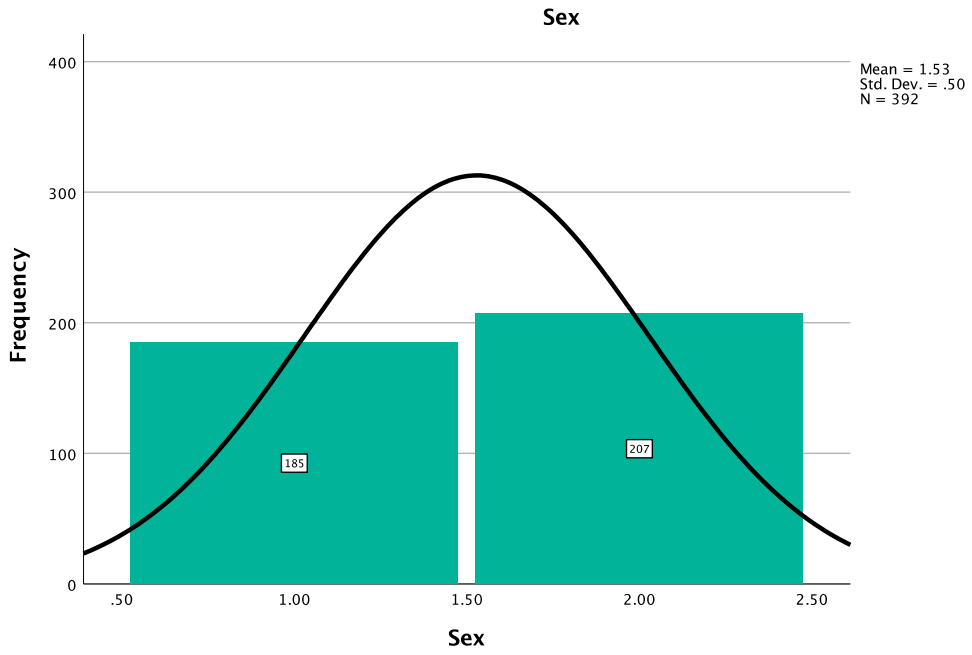


Table 4

Frequency for Age Report in Years (Categorical) Variable

Age	N	%
18-29 Years	13	3.3%
30-39 Years	14	3.6%
40-49 Years	42	10.7%
50-59 Years	59	15.1%
60-69 Years	83	21.2%
70-79 Years	93	23.7%
80 Years or More	88	22.4%

Table 4 presents a comprehensive examination of a sample of 392 eligible diabetic patients undergoing dialysis. The data reveals the distribution of patients across different age groups and their corresponding percentages. The largest segment of patients, accounting for 23.7% (N = 93), belonged to the 70-79-year-old age group. Following closely, the second largest percentage, comprising 22.4% (N = 88), was observed among patients aged 80 years or above. The third largest proportion, representing 21.2% (N = 83), consisted of patients aged 60-69. Moving further, the fourth most significant percentage was found among patients aged 50-59 years, with a value of 15.1% (N = 59). Likewise, the fifth most notable proportion was identified in the 40-49-year-old age group, constituting 10.7% (N = 42) of the total sample. Furthermore, a smaller proportion of patients, specifically 3.6% (N = 14), were classified within the 30-39 year age range. In contrast, the youngest group, consisting of patients aged 18-29,

exhibited the most minor proportion, amounting to 3.3% (N = 13). For a more detailed visualization and understanding of these findings, please refer to Figure 3.

Figure 3

Histogram - AGE (Categorical) Variable

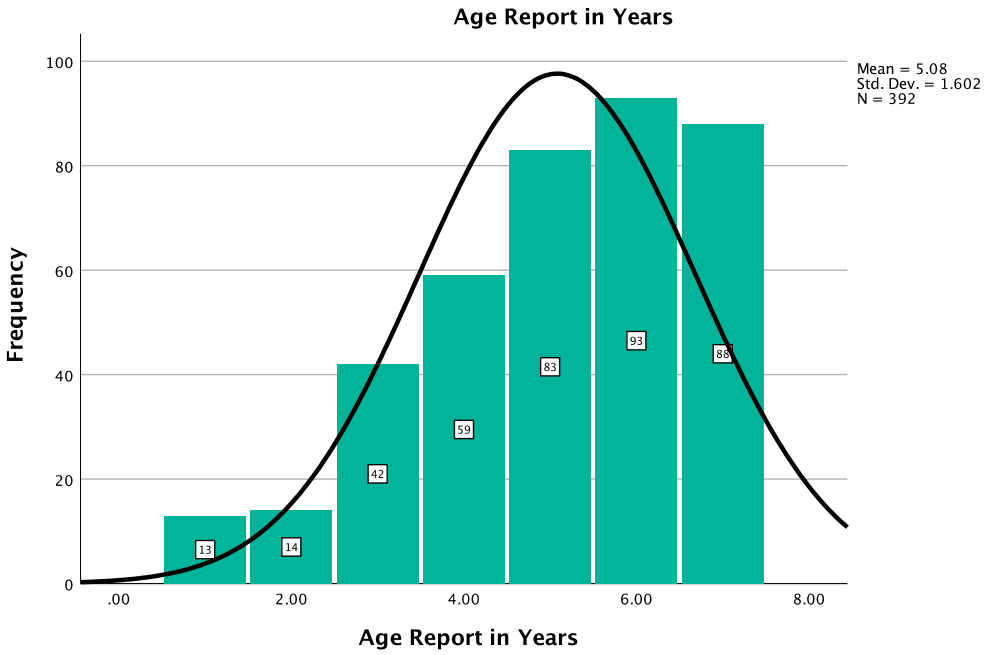


Table 5

Frequency for Educational Level (Categorical) Variable

Educational Level	*N*	%
High School	251	64.0%
Associate's Degree	70	17.9%
Bachelor's Degree	48	12.2%
Master's Degree	17	4.3%
Doctoral Degree	6	1.5%

Table 5 presents an analysis of the sample consisting of 392 eligible diabetic patients undergoing dialysis. Most patients, comprising 64.0% (N = 251), possessed a high school educational level. The second largest percentage, accounting for 17.9% (N = 70), belonged to the grou*p*of patients with an associate degree educational level. Following this, 12.2% (N = 48) of patients held a bachelor's degree educational level. Subsequently, 4.3% (N = 17) of patients were classified under the master's degree educational level. In contrast, the smallest proportion, comprising 1.5% (N = 6), belonged to the group of patients with a doctoral degree educational level. For a more comprehensive depiction of these findings, please consult Figure 4.

Figure 4

Histogram - EDUC (Categorical) Variable

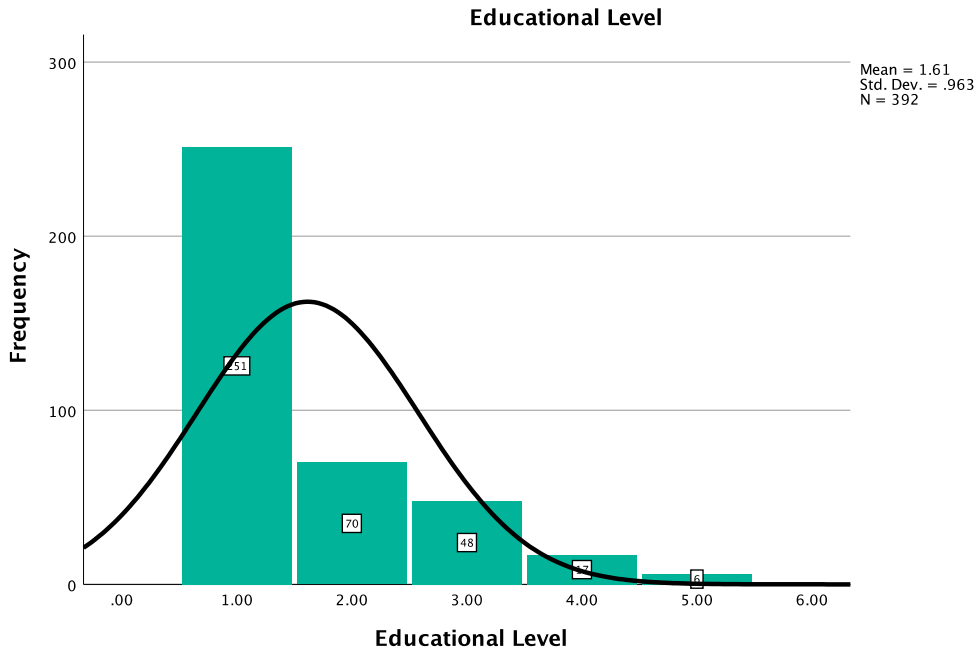


Table 6

Frequency for Body Mass Index (Categorical) Variable

BMI	*N*	%
18.5 - 24.9 (Healthy)	148	37.8%
25.0 - 29.9 (Overweight)	184	46.9%
30 & Above (Obese)	60	15.3%

Table 6 provides an overview of the sample comprising 392 eligible diabetic patients undergoing dialysis. Most patients, accounting for 46.9% (*N* = 184), fell within the BMI range of 25.0-29.9, indicating overweight status. This was followed by 37.8% (*N* = 148) of patients falling within the BMI range of 18.5-24.9, representing a healthy

weight category. Conversely, a minority of patients, specifically 15.3% (*N* = 60), belonged to the BMI category of 30.0 and above, signifying obesity. For a more comprehensive understanding of these findings, please refer to Figure 5.

Figure 5

Histogram - BMI (Categorical) Variable

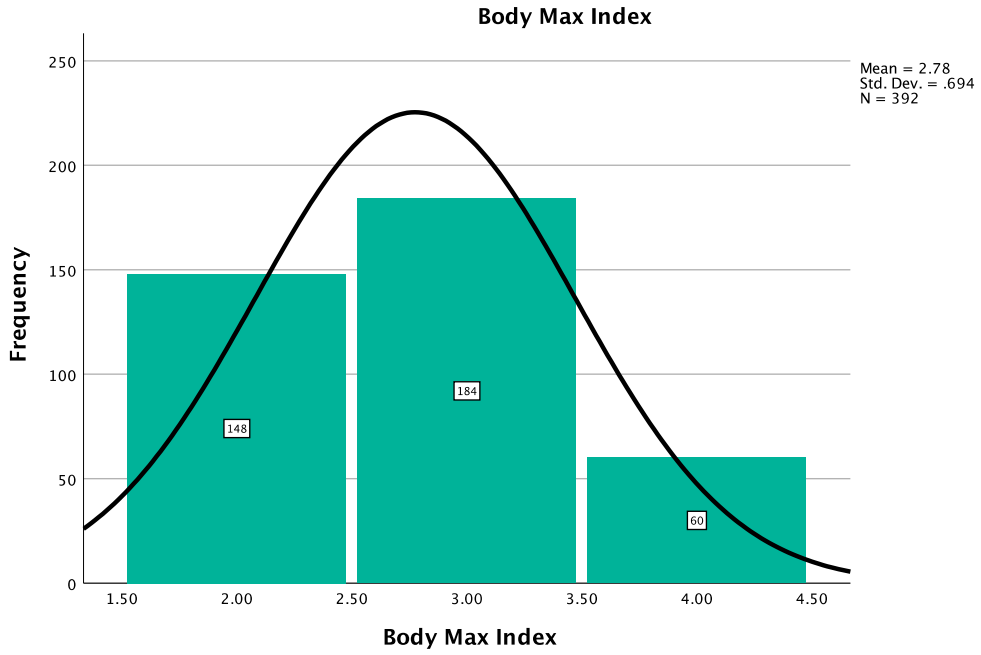


Table 7

Frequency for Smoking (Categorical) Variable

Smoking	*N*	%
Smoking	44	11.2%
Not Smoking	348	88.8%

Table 7 present an analysis of a sample consisting of 392 eligible diabetic patients undergoing dialysis. The data reveals the distribution of patients based on their smoking

status, specifically examining the proportion of smokers and non-smokers patients. Among the sample, most patients, accounting for 88.8% (N = 348), were smokers. In contrast, the minority of patients, comprising 11.2% (N = 44, belonged to the non-smokers category. For a more comprehensive depiction of these findings, please refer to Figure 6.

Figure 6

Histogram - SMOKING (Categorical) Variable

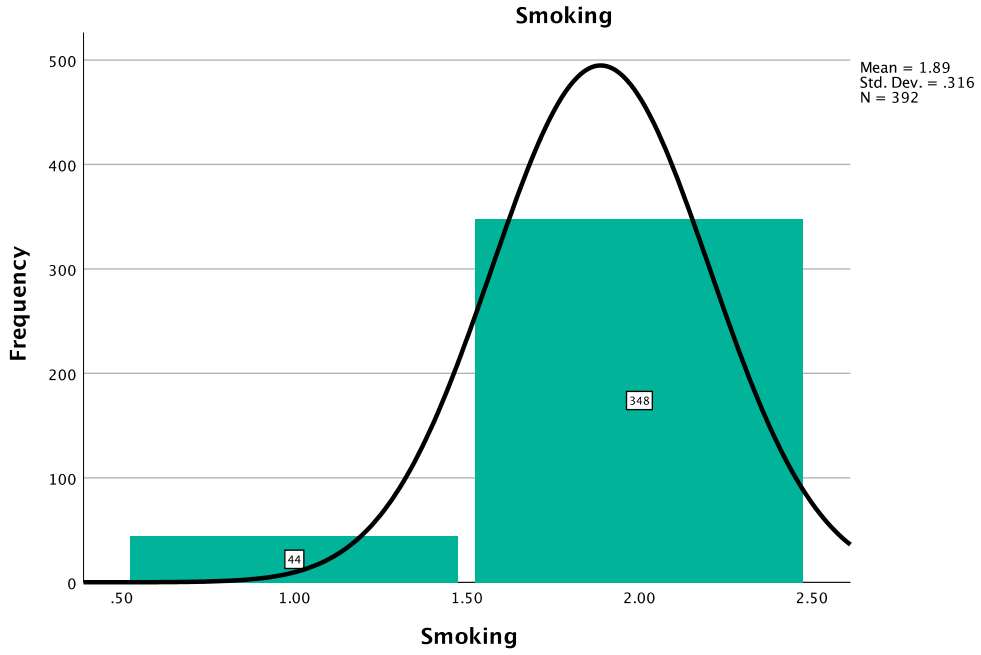


Table 8

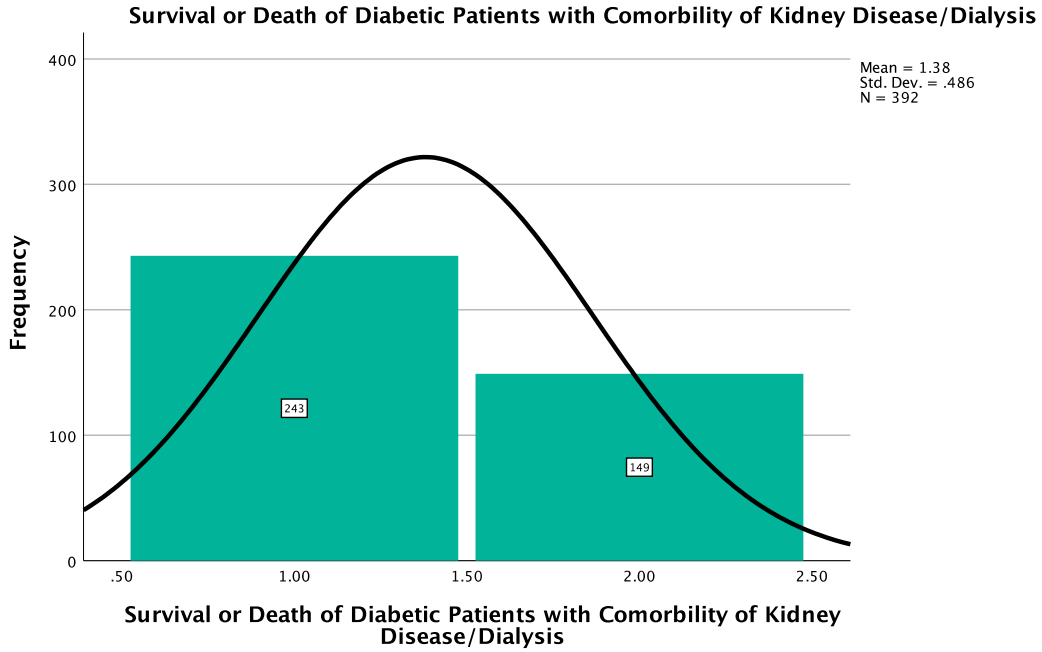
Frequency for Survival or Death of Diabetic Patients with Comorbidity of Kidney Disease/Dialysis (Dichotomous/Dependent Variable)

Survival or Death	*N*	%
Survival	243	62.0%
Death	149	38.0%

Table 8 presents the sample characteristics of 392 eligible diabetic patients on dialysis, with most of the participants being classified as survival patients. Specifically, 62.0% of the sample (N = 243) comprised individuals who survived, while the remaining 38.0% (N = 149) constituted the deceased patients. For a visual representation of this distribution, please refer to Figure 7.

Figure 7

Histogram - SURV_OR_DEATH (Dichotomous/Dependent) Variable



Inferential Analysis

A binary logistic regression analysis was conducted to investigate the relationship between COVID-19 vaccine status, dialysis frequency, sex, age, educational level, BMI, smoking, and the likelihood of survival in diabetes patients on dialysis who contracted COVID-19. The analysis ensured that all assumptions of the model were met. The dependent variable, survival, was categorized as *Survival* and *Death*, while the independent variables were measured as categorical variables.

The logistic regression model was found to be statistically significant compared to the null model ($\chi 2(19) = 322.247$, $p < 0.001$), indicating that the model provided a good fit to the data (as shown in Table 9). The model accounted for 76.2% of the variation in

survival (Nagelkerke R2) and accurately predicted 89.8% of cases (as shown in Table 10, Table 11). The sensitivity of the model was 91.1%, specificity was 87.6%, the positive predictive value was 92.6%, and the negative predictive value was 85.2% (as shown in Table 11).

Among the predictor variables, COVID-19 vaccine status by diabetes type ($p < 0.001$), age in years ($p < 0.001$), BMI ($p = 0.004$), and smoking ($p < 0.001$) were found to be statistically significant in their association with survival. However, sex ($p = 0.431$) and educational level ($p = 0.009$) did not show a significant association. Males and females had similar odds of survival (for more details, see Table 12).

The analysis revealed that unvaccinated diabetes patients undergoing three dialysis sessions per week had 0.001 times lower odds of survival compared to vaccinated diabetes patients undergoing one dialysis session per week. Similarly, unvaccinated diabetes patients undergoing three dialysis sessions per week had 0.001 times lower odds of survival compared to vaccinated diabetes patients undergoing two dialysis sessions per week. Moreover, unvaccinated diabetes patients undergoing three dialysis sessions per week had 0.004 times lower odds of survival compared to vaccinated diabetes patients undergoing three dialysis sessions per week. In addition, unvaccinated diabetes patients undergoing three dialysis sessions per week had 0.028 times lower odds of survival compared to unvaccinated diabetes patients undergoing one dialysis session per week. Unvaccinated diabetes patients undergoing three dialysis sessions per week had 0.124 times lower odds of survival compared to unvaccinated diabetes patients undergoing two dialysis sessions per week.

In terms of age, diabetes patients on dialysis who were 80 years or older had lower odds of survival compared to those in the age group of 18-29 years. This trend continued for different age groups, with older patients showing lower odds of survival compared to younger patients.

Furthermore, diabetes patients on dialysis with a BMI of 30 and above (Obese) had lower odds of survival compared to those with a BMI between 18.5 and 24.9 (Healthy), as well as those with a BMI between 25.0 and 29.9 (Overweight). Currently smoking was associated with an increased likelihood of death.

Based on these findings, it can be inferred that COVID-19 vaccine status by dialysis frequency, along with age, BMI, and smoking, significantly influence the likelihood of survival in diabetes patients on dialysis who contract COVID-19. Therefore, the null hypothesis is rejected, and the alternative hypothesis is accepted.

Table 9

Omnibus Tests of Model Coefficients

		Chi-square	*df*	Sig.
Step 1	Step	322.247	19	<.001
	Block	322.247	19	<.001
	Model	322.247	19	<.001

Table 10

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	198.418[a]	.560	.762

Note: Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.

Table 11

Classification Table

	Observed		Predicted		
			Survival or Death of Diabetic Patients with Comorbidity of Kidney Disease/Dialysis		Percentage Correct
			Survival	Death	
Step 1	Survival or Death of Diabetic Patients with Comorbidity of Kidney Disease/Dialysis	Survival	225	18	92.6
		Death	22	127	85.2
	Overall Percentage				89.8

Note: The cut value is .500.

Table 12

Binary Logistic Regression Predicting Likelihood of Survival

		B	SE	Wald	*df*	Sig.	Exp(B)	95% CI for EXP(B)	
								Lower	Upper
Step 1[a]	COVID-19 Vaccines Status by Dialysis Frequency			92.583	5	<.001			
	COVID-19 Vaccines Status by Dialysis Frequency (1)	-6.865	1.031	44.363	1	<.001	.001	.000	.008
	COVID-19 Vaccines Status by Dialysis Frequency (2)	-6.938	.857	65.515	1	<.001	.001	.000	.005
	COVID-19 Vaccines Status by Dialysis Frequency (3)	-5.584	.689	65.729	1	<.001	.004	.001	.014
	COVID-19 Vaccines Status by Dialysis Frequency (4)	-3.588	.747	23.089	1	<.001	.028	.006	.119

	B	SE	Wald	*df*	Sig.	Exp(B)	95% CI for EXP(B)	
							Lower	Upper
COVID-19 Vaccines Status by Dialysis Frequency (5)	-2.091	.649	10.398	1	.001	.124	.035	.440
Sex (1)	-.304	.386	.620	1	.431	.738	.346	1.573
Age Report in Years			24.249	6	<.001			
Age Report in Years (1)	-3.603	1.450	6.177	1	.013	.027	.002	.467
Age Report in Years (2)	-2.795	1.263	4.896	1	.027	.061	.005	.727
Age Report in Years (3)	-3.424	.822	17.350	1	<.001	.033	.007	.163
Age Report in Years (4)	-1.916	.635	9.107	1	.003	.147	.042	.511
Age Report in Years (5)	-1.588	.582	7.448	1	.006	.204	.065	.639
Age Report in Years (6)	-.876	.530	2.728	1	.099	.417	.147	1.178
Educational Level			13.422	4	.009			
Educational Level (1)	-2.456	1.405	3.058	1	.080	.086	.005	1.345
Educational Level (2)	-3.895	1.505	6.697	1	.010	.020	.001	.389
Educational Level (3)	-2.901	1.495	3.765	1	.052	.055	.003	1.030
Educational Level (4)	-4.736	1.678	7.967	1	.005	.009	.000	.235

	B	SE	Wald	*df*	Sig.	Exp(B)	95% CI for EXP(B)	
							Lower	Upper
Body Max Index			16.509	2	<.001			
Body Max Index (1)	-2.204	.593	13.801	1	<.001	.110	.034	.353
Body Max Index (2)	-2.161	.564	14.681	1	<.001	.115	.038	.348
Smoking (1)	2.760	.687	16.128	1	<.001	15.793	4.107	60.723
Constant	9.194	1.746	27.732	1	<.001	9837.543		

a. Variable(s) entered on step 1: COVID-19 Vaccines Status by Dialysis Frequency, Sex, Age Report in Years, Educational Level, Body Max Index, Smoking.

Discussion

Interpretation

The results of the binary logistic regression analysis indicate a statistically significant association between COVID-19 Vaccine Status by Dialysis Frequency and the survival status of diabetes patients on dialysis within a hospital setting in Puerto Rico ($p < 0.001$). The covariates of Age Report in Years, BMI, and Smoking were found to be protective and risk factors that potentially influence this association, as they showed statistically significant levels concerning the survival status ($p < 0.001$). However, the covariates of Sex ($p = 0.431$) and Educational Level ($p = 0.009$) did not show statistically significant levels in relation to the survival status.

Further analysis revealed that unvaccinated diabetes patients undergoing three dialysis sessions per week were 0.001 times less likely to experience survival than

vaccinated diabetes patients undergoing one dialysis session per week, controlled for Age, BMI, and Smoking. Similarly, unvaccinated diabetes patients undergoing three dialysis sessions per week were 0.001 times less likely to experience survival than vaccinated diabetes patients undergoing two dialysis session per week, controlled for Age, BMI, and Smoking. Moreover, unvaccinated diabetes patients undergoing three dialysis sessions per week were 0.004 times less likely to experience survival than vaccinated diabetes patients undergoing three dialysis session per week, controlled for Age, BMI, and Smoking.

In addition, unvaccinated diabetes patients undergoing three dialysis sessions per week were 0.028 times less likely to experience survival than unvaccinated diabetes patients undergoing one dialysis session per week, controlled for Age, BMI, and Smoking. Unvaccinated diabetes patients undergoing three dialysis sessions per week were 0.124 times less likely to experience survival than unvaccinated diabetes patients undergoing two dialysis session per week, controlled for Age, BMI, and Smoking. These results support the statistical association between COVID-19 Vaccine Status by Dialysis Frequency and the survival status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlled for Age, BMI, and Smoking.

Also, the analysis revealed that diabetes patients on dialysis aged 80 years and older were less likely to experience survival compared to those between 18 and 29 years, controlled for BMI and Smoking. This trend continued for different age groups, with older patients showing lower chances of survival compared to younger patients. This indicates that age, along with BMI and Smoking, is an important protective and risk

factor that influences the association between COVID-19 Vaccine Status by Dialysis Frequency and the survival status of diabetes patients on dialysis within a hospital setting in Puerto Rico.

Moreover, the analysis showed that diabetes patients on dialysis with a BMI of 30 and above (Obese) were less likely to experience survival compared to those with a BMI between 18.5 and 24.9 (Healthy), controlled for Age and Smoking. Similarly, patients with a BMI of 30 and above were less likely to experience survival compared to those with a BMI between 25.0 and 29.9 (Overweight), controlled for Age and Smoking. These findings highlight the importance of BMI, along with Age and Smoking, in influencing the association between COVID-19 Vaccine Status by Dialysis Frequency and the survival status of diabetes patients on dialysis within a hospital setting in Puerto Rico.

The study employed the SEM as a theoretical framework to examine the risk and protective factors against COVID-19 infection in diabetic patients with comorbidity of kidney disease/dialysis at two levels: intrapersonal and community. The dialysis frequency risk factor was measured at the individual level of the SEM, while the community level encompassed perceptions of the risk of vaccine-preventable COVID-19 in the hospital setting, which played a crucial role in the vaccination rate. These protective and risk factors interacted and influenced the survival status of diabetic patients on dialysis within the hospital setting. The analysis also revealed that the survival status by dialysis frequency was controlled by individual factors such as Age, BMI, and smoking, while no significant control was observed for Sex and Educational Level.

Based on the findings, it is recommended to conduct further research using this specific theoretical framework to obtain more evidence-based information that strengthens the statistical association between COVID-19 Vaccine Status by Dialysis Frequency and the survival status of diabetes patients on dialysis within a hospital setting in Puerto Rico, while controlling for Age, BMI, and Smoking. This additional research would provide a deeper understanding of the factors influencing the observed associations and contribute to the development of targeted interventions and strategies for improving the survival outcomes of diabetic patients on dialysis.

Limitations

This study is subject to several limitations that should be acknowledged. Firstly, the use of secondary data sources poses a significant limitation. The lack of control over the data collection methods in the hospital setting introduces uncertainty regarding the validity and reliability of the data. Additionally, the presence of biases in the original hospital data source may have influenced the accuracy and generalizability of the study findings.

A second limitation stems from the small sample size and the study's reliance on data from a single geographical location. This restricts the generalizability of the findings and limits the statistical power of the analysis. To overcome this limitation, future studies could consider collecting data from multiple hospitals across the United States, thereby increasing the sample size and enhancing the robustness of the statistical tests.

It is important to note that a major limitation of the data source used in this study is the lack of information on specific COVID-19 vaccine brandings. This limitation

hinders the scope and depth of the research findings. The specific brand of the COVID-19 vaccine administered can potentially influence the association between COVID-19 Vaccine Status by Dialysis Frequency, and the survival outcomes of diabetes patients on dialysis within a hospital setting in Puerto Rico, even when controlling for factors such as Age, Sex, Educational Level, BMI, and Smoking. The absence of this information may have implications for the statistical significance of the observed associations.

Therefore, for future studies, it is recommended to include COVID-19 vaccine brandings as a covariate. This additional information would provide a more comprehensive understanding of the association between COVID-19 vaccine status by Dialysis Frequency, and survival outcomes among patients on dialysis. By considering the specific brand of the vaccine, researchers can better assess the potential impact of different vaccines on the observed associations, potentially leading to more nuanced and accurate conclusions.

Implications

This study has made significant contributions to the existing body of evidence on the mortality risks faced by adults diagnosed with diabetes patients undergoing dialysis, particularly those undergoing more frequent dialysis, in the context of COVID-19 infection. The findings of this study have demonstrated a statistically significant association between COVID-19 Vaccine Status by Dialysis Frequency and the survival outcomes of diabetes patients on dialysis in a hospital setting in Puerto Rico. The analysis accounted for important factors such as Age, BMI, and Smoking.

The outcomes of this study have important implications for healthcare organizations, physicians, and the general public in Puerto Rico. They provide valuable insights into the role of the COVID-19 vaccine as a preventive measure against mortality for diabetic patients on dialysis. These findings can be utilized by healthcare professionals to educate individuals with diabetes and comorbid kidney disease/dialysis about the potential effectiveness of the COVID-19 vaccine in preventing death from COVID-19 infection. It is particularly crucial to emphasize the importance of vaccination for individuals undergoing three dialysis sessions per week, as they face a higher risk of mortality compared to those with less frequent dialysis.

Furthermore, these research findings serve as a valuable tool for public health officials and prevention professionals in managing COVID-19 infections among the population of diabetes patients on dialysis. They provide actionable information that can guide hospital interventions and health education programs, with a specific focus on reducing individual risk factors such as Age, BMI, and Smoking, in order to mitigate the risk of mortality in this population.

Importantly, the implications of this research extend beyond the healthcare setting and have the potential to drive positive social change in Puerto Rico. The results of this study inform decision-making and planning processes for adults diagnosed with diabetes and comorbid kidney disease/dialysis who are at risk of COVID-19 infection. They underscore the need for increased attention and allocation of resources to ensure access to the COVID-19 vaccine for individuals undergoing three dialysis sessions per week in both outpatient and inpatient settings. This is crucial for improving overall health

outcomes, reducing mortality rates, and alleviating the burden on the Puerto Rico Public Health System.

Recommendations

This research study utilized secondary data obtained from the Electronic Medical Record system within a hospital in Puerto Rico. The data pertained to diabetic patients with comorbidities of kidney disease/dialysis who were hospitalized due to COVID-19 infection between December 15, 2020, and December 31, 2022. The study aimed to examine the association between COVID-19 Vaccine Status by Dialysis Frequency, and the survival outcomes of diabetes patients on dialysis within a hospital setting in Puerto Rico. The analysis controlled for variables such as Age, Sex, Educational Level, BMI, and Smoking, using binary logistic regression analysis.

It is worth noting that there is a limited number of research studies investigating the association between COVID-19 Vaccine Status by Dialysis Frequency, and the survival outcomes of diabetes patients on dialysis within a hospital setting in Puerto Rico. Therefore, it is recommended to expand this study by including the impact of different COVID-19 vaccine brands on the aforementioned factors. Additionally, extending the study to include data from other hospitals, both in the United States and other organizations in the public and private sectors, focusing on diabetes patients on dialysis would enhance the generalizability of the findings and provide a larger sample size for more robust statistical analysis.

Conclusion

This study investigated the impact of COVID-19 Vaccine Status by Dialysis Frequency, controlling by Age, Sex, Educational Level, BMI, and Smoking on the likelihood of survival in diabetes patients on dialysis who contract COVID-19. The findings highlight several important factors that influence the outcomes of COVID-19 in this vulnerable population.

The results of the binary logistic regression analysis revealed that COVID-19 vaccination status plays a crucial role in determining the survival odds of diabetes patients on dialysis. Specifically, unvaccinated diabetes patients undergoing three dialysis sessions per week exhibited lower odds of survival compared to their unvaccinated counterparts undergoing one dialysis sessions per week. This finding underscores the significance of COVID-19 vaccination in mitigating the adverse effects of the virus in diabetes patients on dialysis, particularly among those unvaccinated diabetes patients undergoing three dialysis sessions per week.

Age emerged as a significant predictor variable of survival outcomes, with older patients showing lower odds of survival compared to younger individuals. This finding suggests that age-related factors may contribute to the increased vulnerability of older diabetes patients on dialysis to severe COVID-19 complications. Healthcare professionals should consider age as a critical factor when assessing and managing COVID-19 in this population.

Furthermore, the study identified a notable association between BMI and survival odds in diabetes patients on dialysis who contract COVID-19. Specifically, individuals

with higher BMI (Obese) exhibited lower odds of survival compared to those with a healthy BMI range (18.5-24.9) and those in the overweight BMI range (25.0-29.9). This finding underscores the importance of weight management and obesity prevention strategies in diabetes patients on dialysis to enhance their resilience against severe COVID-19 outcomes.

Lastly, the analysis revealed a positive association between Smoking and the likelihood of death in diabetes patients on dialysis who contract COVID-19. Currently smoking were associated with an increased risk of mortality, indicating the significance of smoking control in reducing the adverse effects of COVID-19. This finding highlights the importance of smoking cessation educational program in diabetes patients on dialysis, particularly in those undergoing three dialysis sessions per week.

The findings of this study have implications for healthcare professionals, policymakers, and researchers involved in the care of diabetes patients on dialysis during future outbreak of COVID-19 or other emerging infectious diseases. The results underscore the critical role of COVID-19 vaccination, Age, BMI, and Smoking cessation in determining the survival outcomes of this population. These findings can inform targeted interventions and strategies aimed at improving the prognosis of diabetes patients on dialysis who contract COVID-19.

Further research is warranted to gain a deeper understanding of the complex interactions between individual, interpersonal, community, and societal factors that influence the associations observed in this study. Future investigations employing a socio-ecological framework can provide valuable insights into the multifaceted

determinants of COVID-19 outcomes in diabetes patients on dialysis. Such comprehensive research endeavors will contribute to the development of evidence-based guidelines and interventions that enhance the survival rates and overall well-being of this vulnerable population during future outbreaks and beyond.

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COVID-19 Vaccine Status by Present of Hypertension and Survival of Diabetes Patient on Dialysis

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Outlet for Manuscript

The *American Journal of Diabetes Research* was the journal selected as the outlet for Manuscript 3 due to the journal's focus on the in diabetes, obesity, and metabolism through scientific worldwide research. The intent of Manuscript 3 is to examine the association between COVID-19 Vaccine Status by present of hypertension, age, sex, educational level, BMI, smoking, and the proportion surviving of diabetes patients on dialysis within a hospital setting in Puerto Rico. The information obtained from the manuscript will contribute to improving on evidence-based practices by identifying the important risk and protection factors according to the present hypertension against COVID-19 infection, as well as the measures of protection and prevention of associated deaths in the population of diabetic patients on dialysis.

The *American Journal of Diabetes Research* requires that all articles present a concise and factual abstract that does not exceed 250 words (includes the purpose, the results and major conclusions). Immediately after the abstract, must be provide a minimum 3-6 keywords. The article does not have limit words (including the title page, introduction, materials and methods, results, discussion, conclusion, acknowledgements, conflict of interest, and references). In addition, the references should be cited in the manuscript by numbers. Likewise, the article figures, schemes and tables should be inserted into the main text close to their first citation and should be numbered consecutively. Once written and structured according to this format, it can be sent for review to the following URL: https://makperiodicallibrary.com/americanJournalofDiabetesResearch/submit-manuscript

Abstract

This study aimed to examine the association between COVID-19 Vaccine Status by Present of Hypertension and the survival outcomes of diabetes patients on dialysis within a hospital setting in Puerto Rico, while controlling for Age, Sex, Educational Level, BMI, and Smoking. Secondary data from the EMR's system were analyzed for diabetes patients on dialysis who were hospitalized due to COVID-19 infection. The binary logistic regression analysis revealed a statistically significant association between COVID-19 Vaccine Status by Present of Hypertension and the survival status of diabetes patients on dialysis ($p < 0.001$). Unvaccinated diabetes patients without hypertension had lower odds of survival compared to vaccinated diabetes patients with and without hypertension. Age, BMI, and Smoking were identified as important protective and risk factors influencing this association. The results highlight the significant role of COVID-19 vaccination in improving survival outcomes for diabetes patients on dialysis. Older age, higher BMI, and smoking were associated with lower odds of survival. These findings emphasize the importance of targeted interventions and strategies, including vaccination, weight management, and smoking cessation, to enhance the resilience of this vulnerable population against severe COVID-19 outcomes. The findings shed light on the impact of COVID-19 vaccination on mortality rates among diabetes patients on dialysis with hypertension, offering valuable insights for healthcare organizations, physicians, and public health officials in Puerto Rico.

Introduction

Arterial hypertension (HTN) is one of the most prevalent comorbidities among people with diabetes; two out of three people with diabetes have high blood pressure (de Boer et al., 2017; Dedefo et al., 2020; ADA, n.d.). Diabetes and the comorbidity of hypertension increase the risk of developing diabetic nephropathy (Lin et al., 2018; Wagnew et al., 2018). Renal dysfunction resulting from the interaction between diabetes and hypertension usually develops slowly and with few symptoms until the person is in an advanced stage and needs dialysis (Wang et al., 2017; Wang et al., 2022; CDC, 2021). Diabetic patients with comorbidities of hypertension and chronic kidney disease on dialysis are at high risk of severity from COVID-19 (D'Marco et al., 2020). Current knowledge shows that comorbid diabetes and hypertension have adverse effects in patients infected with COVID-19; however, the evidence needs to be supported by more extensive studies to establish more evident correlations on the magnitude between diabetes and hypertension against infection by COVID-19 (de Almeida-Pititto et al., 2020; Parveen et al., 2020; Landsta & de Koning, 2021).

In addition, age, gender, and academic performance are important predictors of COVID-19 severity (Statsenko et al., 2022; Jian et al., 2021). The risk of hospitalization, ICU admission, and the need for invasive mechanical ventilation increases as BMI increases (Yang et al., 2022). Similarly, changes in stress and depression among diabetic patients during the COVID-19 pandemic have increased smoking, which has increased the risk of severity and death from COVID-19 (Kim et al., 2022; Utli & Vural-Dogru, 2021).

On the other hand, COVID-19 vaccines have been found to protect against severe COVID-19 disease in dialysis patients (CDC, 2022). In addition, COVID-19 vaccines have been shown to appear to protect against severe COVID-19 disease in populations with pre-existing conditions such as hypertension (CDC, 2022) . However, although the efficacy of COVID-19 vaccines has been demonstrated in populations with pre-existing conditions, such as hypertension, there is still a need for more studies to improve vaccination practices regarding the need for boosters in these high-risk populations (CDC, 2022). Similarly, no evidence establishes differences in the protective factor of vaccines against COVID-19 in the population of people with diabetes on dialysis with hypertension.

Five risk factors for COVID-19 severity, including age, sex, academic achievement, BMI, and smoking, have been examined in multiple studies. In addition, the COVID-19 vaccine has also been evaluated as a protective factor against the severity of COVID-19. Therefore, it has been hypothesized that COVID-19 vaccine status by present of hypertension may be associated with the surviving status of diabetes patients on dialysis within a hospital setting, controlled for other important risk and protective factors. Using the Social Ecological Model (SEM), risk and protective factors against COVID-19 infection in diabetic patients with comorbid kidney disease/dialysis can be assessed at two levels, including intrapersonal and community, and how they interact. A clear assessment of this COVID-19 severity and mortality risk associations, differentiated by present of hypertension, could benefit the development of strategies for managing, protecting, and preventing death from diabetic patients with comorbid kidney

disease/dialysis withing a hospital setting. Here, a quantitative secondary data analysis study is carried out to describe the association between COVID-19 Vaccine Status by present of hypertension and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, smoking.

Research Design & Methods

Research Question

What is the association between COVID-19 Vaccine Status by present of hypertension and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, smoking?

H_0—There is no statistically significant association between COVID-19 Vaccine Status by present of hypertension and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, smoking.

H_1—There is a statistically association between COVID-19 Vaccine Status by present of hypertension and the surviving status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlling for age, sex, educational level, BMI, smoking.

Study Design and Participants

A retrospective cohort study was conducted using data from a sample of diabetic patients with comorbidity kidney disease/dialysis who were diagnosed with COVID-19 by nucleic acid amplification test (NAAT) or antigen test (18) and received any of the COVID-19 vaccines or not. The nucleic acid amplification test (NAAT) is used in

unvaccinated patients, while the antigen test is used in vaccinated patients (CDC, 2022). Patients are identified through ICD-10 diagnostic codes within a hospital setting in Puerto Rico from December 15, 2020, to February 15, 2023. The International Classification of Diseases (ICD-10) is a diagnostic tool used worldwide for epidemiological, health management, and clinical purposes (CDC, 2015). Diabetic patients with comorbidity of kidney disease /dialysis who were hospitalized as a result of COVID-19 infection from December 15, 2020, to March 15, 2023, are included in such a way that each patient was followed up until discharge unless the event (death) occurred first. Patients younger than 18 years or pregnant and those who did not have positive NAAT, or antigen test results were excluded.

Because this study involves analyzing data from protected health information (PHI) not publicly available, the *Safe Harbor* de-identification method is required to comply with the Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule (HHS, 2022). In addition, this process must be evaluated and approved by the Institutional Review Board (IRB) of Walden University and the Health Information Management Administration of the hospital setting in Puerto Rico.

Sample and Power

A sample of diabetic patients with comorbid kidney disease/dialysis who were hospitalized due to COVID-19 infection and who met the inclusion criteria previously described is included in the study. The sample size for this study was determined by performing an a priori power analysis using the Sample Size Calculator software (Calculator, n.d.). Power analysis was completed assuming a two-tailed test with an alpha

of 0.05, an effect size of 0.50, and a power of 0.90, the power analysis for the statistical test of binary logistic regression indicates that size would be needed sample of 381 matched participants to ensure sufficient power and reduce the probability of a type 2 error. (Calculator, n.d.; PRDoH, 2021).

Variables / Sources of Data

The variables selected to describe the association between COVID-19 vaccine status by present of hypertension and the surviving status of diabetes patients with comorbidity of kidney disease /dialysis within a hospital setting in Puerto Rico, controlling for other important risk and protective factors; will be obtained from the medical records, which are not publicly available. For this study, the independent variable COVID-19 vaccination status by present of hypertension reveals nominal scales used to assign items into discrete categories (1 = *Vaccinated/HNT*; 2 = *Vaccinated/Not HNT*; 3 = *Unvaccinated/HNT*; 4 = *Unvaccinated/Not HNT*). Similarly, the dependent variable proportion surviving of diabetes patient with comorbidity of kidney disease /dialysis within a hospital setting in Puerto Rico reveals nominal scales used to assign items into discrete categories (1 = *Death*; 2 = *Survival*). While for the potentially confounding variables, sex reveals nominal scales used to assign items to discrete categories (1 = *Male*; 2 = *Female*), age reveals nominal scales used to assign items to discrete categories (1 = 18 – 29 years; 2 = 30 – 39 years; 3 = 40 – 49 years; 4 = 50 – 59 years; 5 = 60 – 69 years; 6 = 70 – 79 years; 7 = 80 years or more), the level of education reveals nominal scales used to assign items into discrete categories (1 = *High School*; 2 = *Associate Degree*; 3 = *Bachelor's Degree*; 4 = *Master's Degree*; 5 = *Doctoral Degree*),

body mass index reveals nominal scales used to assign items into discrete categories (1 = Below 18.5 [*Underweight*]; 2 = 18.5 – 24.9 [*Healthy*]; 3 = 25.0 – 29.9 [*Overweight*]; 4 = 30.0 and Above [*Obese*]), and smoking reveals nominal scales used to assign items into discrete categories (1 = *Smoking*; 2 = *Not Smoking*).

Statistical Analysis

This study will include descriptive statistics to summarize the data from the sample of diabetic patients with comorbidity of kidney disease /dialysis. Frequencies will be calculated for the variables of vaccination status by type of diabetes, sex, age, level of education, BMI, smoking, and proportion surviving of diabetic patients with comorbidity of kidney disease /dialysis within a hospital setting in Puerto Rico. In addition, Binary Logistic Regression will be used, using the Statistical Package for the Social Sciences (SPSS) to describe the probability being survive by COVID-19 vaccine status of diabetic patients on dialysis against COVID-19 infection within a hospital setting in Puerto Rico, controlling for other important risk and protective factors. *Unvaccinated/Not HNT* was the reference group for all the vaccination statuses; 80-years or more was the reference group for all the age report in years. *Female* was the reference group for sex. *Doctoral Degree* was the reference group for all the educational levels; 30 and Above (*Obese*) was the reference group for all the body max index (BMI). *Not Smoking* was the reference group for the smoking status.

Results

Execution

The study was conducted in accordance with the original protocol and design. Ethical approval was sought from the Health Information Administrative Board of the Hospital in Puerto Rico in order to obtain access to the necessary data. Subsequently, approval was granted by the Walden University Institutional Review Board and the Hospital Health Information Administrative Board.

The data collected for this study encompassed various demographic and clinical variables, including COVID-19 vaccination status, hypertension, age, sex, education level, body mass index, and smoking. It is important to note that these variables were not publicly available.

To ensure a robust and representative sample, a total of 392 diabetic patients with comorbid kidney disease/dialysis, aged 18 years and above, who were hospitalized due to COVID-19 infection, were included in the study. The data collection period spanned from December 15, 2020, to December 31, 2022.

It is noteworthy that no missing data was identified in the final dataset, as indicated in Table 1. This signifies the completeness and reliability of the collected data, thereby enhancing the validity of the study findings.

Table 1

Study Sample

		COVID-19 Vaccines Status by Present of Hypertension	Sex	Age Report in Years	Educational Level	Body Max Index	Smoking	Survival or Death of Diabetic Patients with Comorbidity of Kidney Disease / Dialysis
N	Valid	392	392	392	392	392	392	392
	Missing	0	0	0	0	0	0	0

Descriptive Analysis

Table 2

Frequency of COVID-19 Vaccine Status by Presentation of Hypertension (Categorical/Independent) Variable

Vaccine Status	*N*	%
Vaccinated/HTN	149	38.0%
Vaccinated/Not HTN	76	19.4%
Unvaccinated/HTN	120	30.6%
Unvaccinated/Not HTN	47	12.0%

Table 2 presents an analysis of a sample consisting of 392 eligible diabetic patients who are undergoing dialysis. The main objective of this analysis is to examine the distribution of patients based on their vaccination status and the present of hypertension. Among the sample, most patients, accounting for 38.0% (N = 149), belonged to the group of patients who are vaccinated and have hypertension. Following closely, the second largest proportion was observed in the group of patients who are not vaccinated and have hypertension, representing 30.6% (N = 120) of the sample. The third largest proportion was found in the group of patients who are vaccinated and not have hypertension, accounting for 19.4% (N = 76). Conversely, a minority of patients, comprising 12.0% (N = 47), were categorized as those who are not vaccinated and not have hypertension. For a more detailed visual representation of these findings, please refer to Figure 1.

Figure 1

Histogram - COVID_VAC_STAT_BY_PRES_HTN (Categorical/Independent) Variable

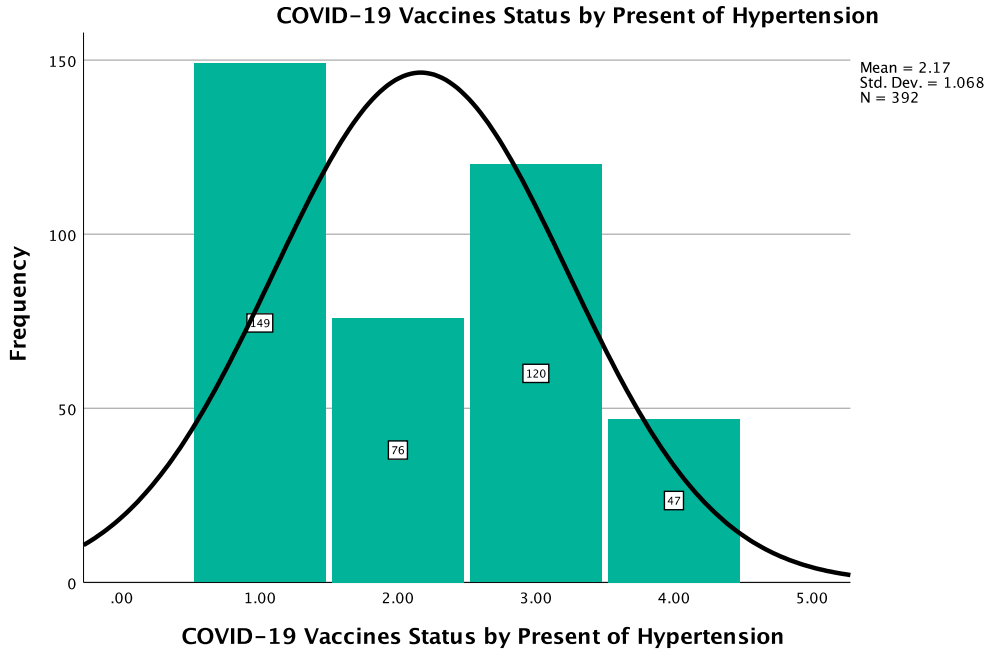


Table 3

Frequencies for Sex (Categorical) Variable

Sex	*N*	%
Male	185	47.2%
Female	207	52.8%

Table 3 presents an analysis of a sample consisting of 392 eligible diabetic patients undergoing dialysis. The data reveals the distribution of patients based on their sex, specifically examining the proportion of female and male patients. Among the sample, most patients, accounting for 52.8% (*N* = 207), were female. In contrast, the

minority of patients, comprising 47.2% (N = 185), belonged to the male category. For a more comprehensive depiction of these findings, please refer to Figure 2.

Figure 2

Histogram - SEX (Categorical) Variable

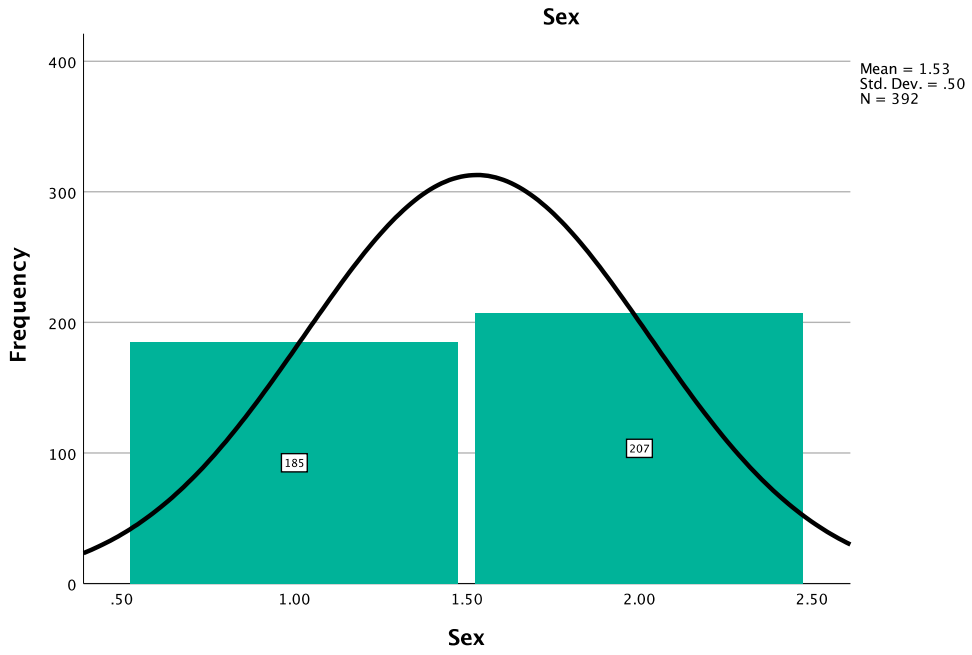


Table 4

Frequency for Age Report in Years (Categorical) Variable

Age	*N*	%
18-29 Years	13	3.3%
30-39 Years	14	3.6%
40-49 Years	42	10.7%
50-59 Years	58	14.8%
60-69 Years	81	20.7%
70-79 Years	93	23.7%
80 Years or More	91	23.2%

Table 4 presents a comprehensive examination of a sample of 392 eligible diabetic patients undergoing dialysis. The data reveals the distribution of patients across different age groups and their corresponding percentages. The largest segment of patients, accounting for 23.7% (N = 93), belonged to the 70-79-year-old age group. Following closely, the second largest percentage, comprising 23.2% (N = 91), was observed among patients aged 80 years or above. The third largest proportion, representing 20.7% (N = 81), consisted of patients aged 60-69. Moving further, the fourth most significant percentage was found among patients aged 50-59 years, with a value of 14.8% (N = 58). Likewise, the fifth most notable proportion was identified in the 40-49-year-old age group, constituting 10.7% (N = 42) of the total sample. Furthermore, a smaller proportion of patients, specifically 3.6% (N = 14), were classified within the 30-39 year age range. In contrast, the youngest group, consisting of patients aged 18-29,

exhibited the most minor proportion, amounting to 3.3% (N = 13). For a more detailed visualization and understanding of these findings, refer to Figure 3.

Figure 3

Histogram - AGE (Categorical) Variable

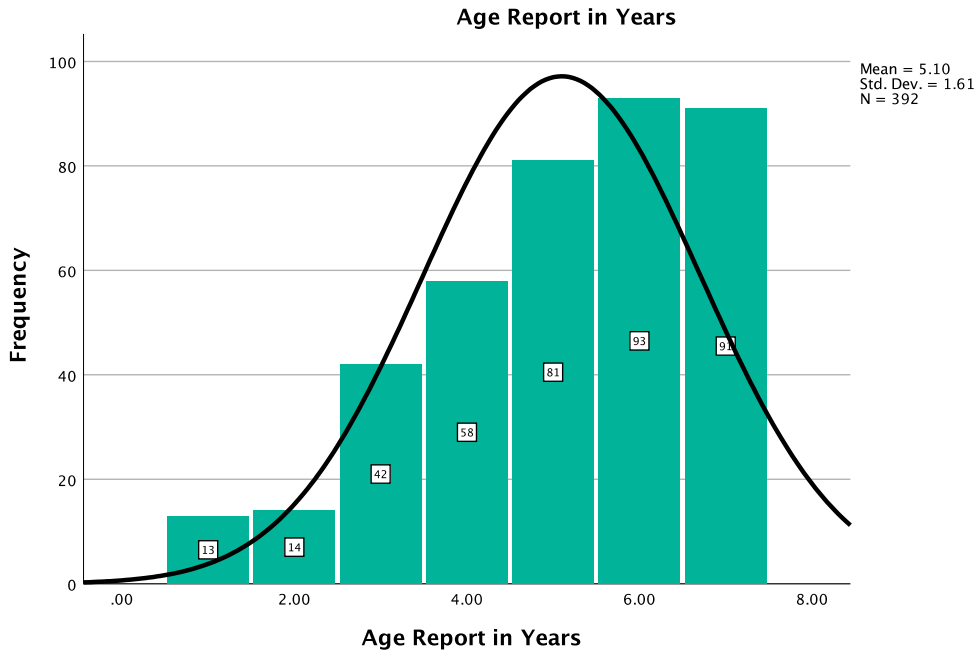


Table 5

Frequency for Educational Level (Categorical) Variable

Educational Level	*N*	%
High School	250	63.8%
Associate's Degree	71	18.1%
Bachelor's Degree	48	12.2%
Master's Degree	17	4.3%
Doctoral Degree	6	1.5%

Table 5 presents an analysis of the sample consisting of 392 eligible diabetic patients undergoing dialysis. Most patients, comprising 63.8% (N = 250), possessed a high school educational level. The second largest percentage, accounting for 18.1% (N = 71), belonged to the group of patients with an associate degree educational level. Following this, 12.2% (N = 48) of patients held a bachelor's degree educational level. Subsequently, 4.3% (N = 17) of patients were classified under the master's degree educational level. In contrast, the smallest proportion, comprising 1.5% (N = 6), belonged to the group of patients with a doctoral degree educational level. For a more comprehensive depiction of these findings, please consult Figure 4.

Figure 4

Histogram - EDUC (Categorical) Variable

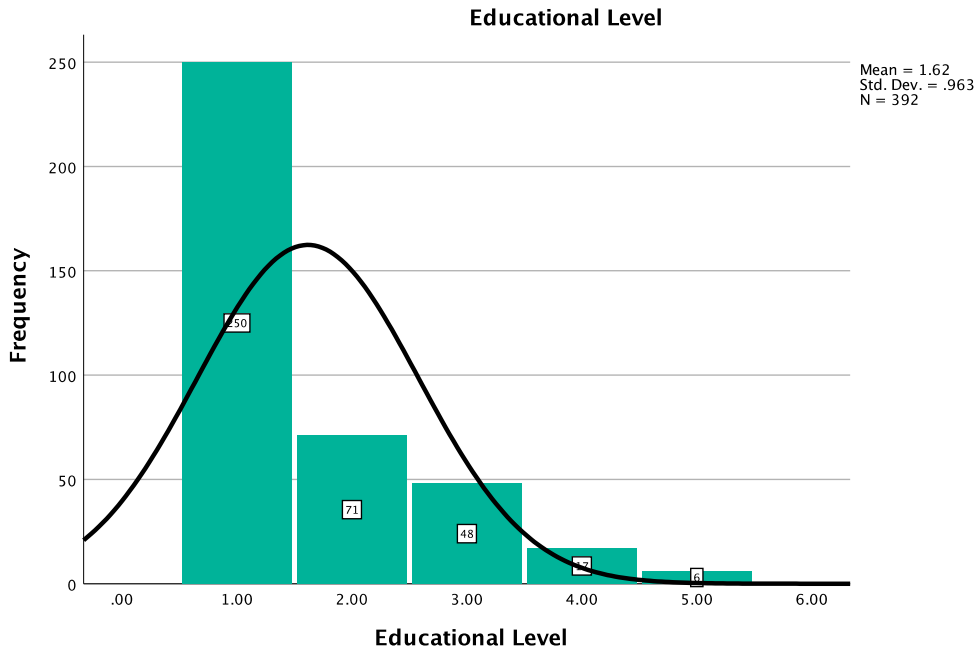


Table 6

Frequency for Body Max Index (Categorical) Variable

BMI	*N*	%
18.5 - 24.9 (Healthy)	148	37.8%
25.0 - 29.9 (Overweight)	184	46.9%
30 & Above (Obese)	60	15.3%

Table 6 provides an overview of the sample comprising 392 eligible diabetic patients undergoing dialysis. Most patients, accounting for 46.9% (*N* = 184), fell within the BMI range of 25.0-29.9, indicating overweight status. This was followed by 37.8% (*N*

= 148) of patients falling within the BMI range of 18.5-24.9, representing a healthy weight category. Conversely, a minority of patients, specifically 15.3% (*N* = 60), belonged to the BMI category of 30.0 and above, signifying obesity. For a more comprehensive understanding of these findings, please refer to Figure 5.

Figure 5

Histogram - BMI (Categorical) Variable

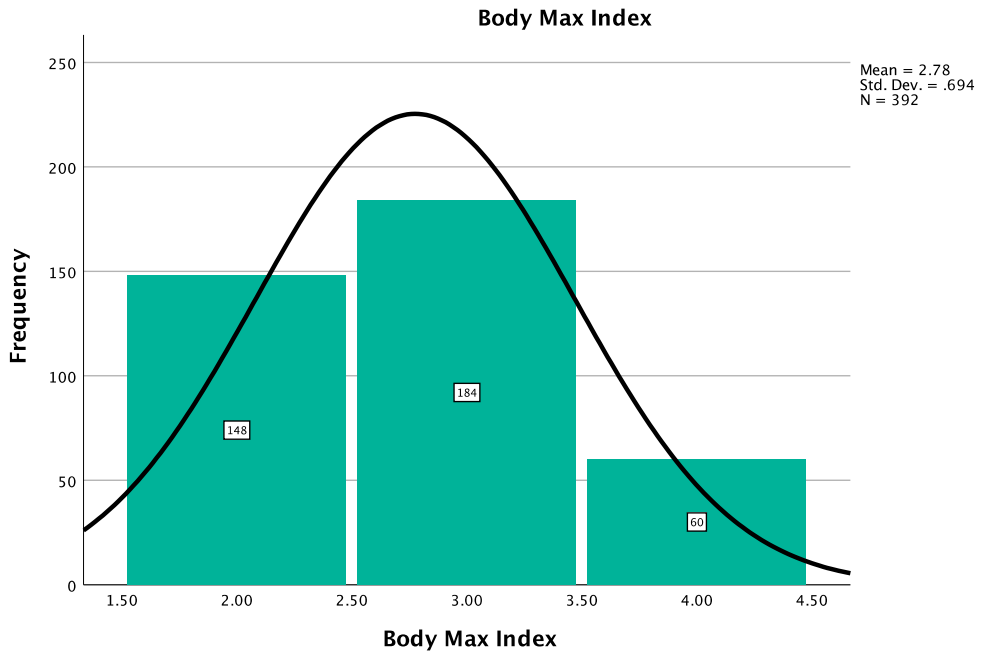


Table 7

Frequency for Smoking (Categorical) Variable

Smoking	*N*	%
Smoking	44	11.2%
Not Smoking	348	88.8%

Table 7 presents an analysis of a sample consisting of 392 eligible diabetic patients undergoing dialysis. The data reveals the distribution of patients based on their smoking status, specifically examining the proportion of smokers and non-smokers patients. Among the sample, most patients, accounting for 88.8% (N = 348), were smokers. In contrast, the minority of patients, comprising 11.2% (N = 44, belonged to the non-smokers category. For a more comprehensive depiction of these findings, please refer to Figure 6.

Figure 6

Histogram - SMOKING (Categorical) Variable

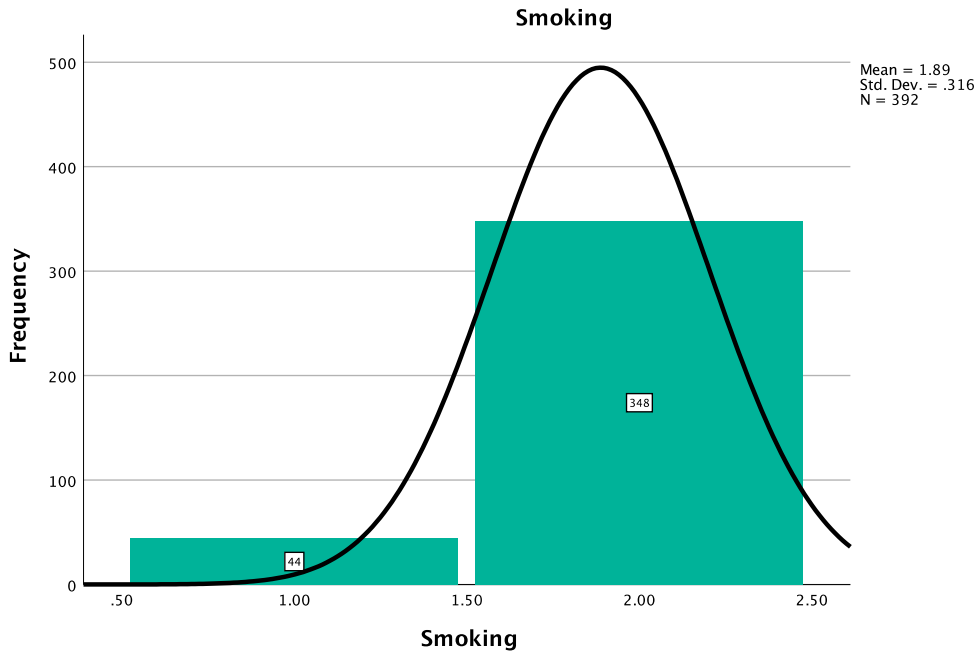


Table 8

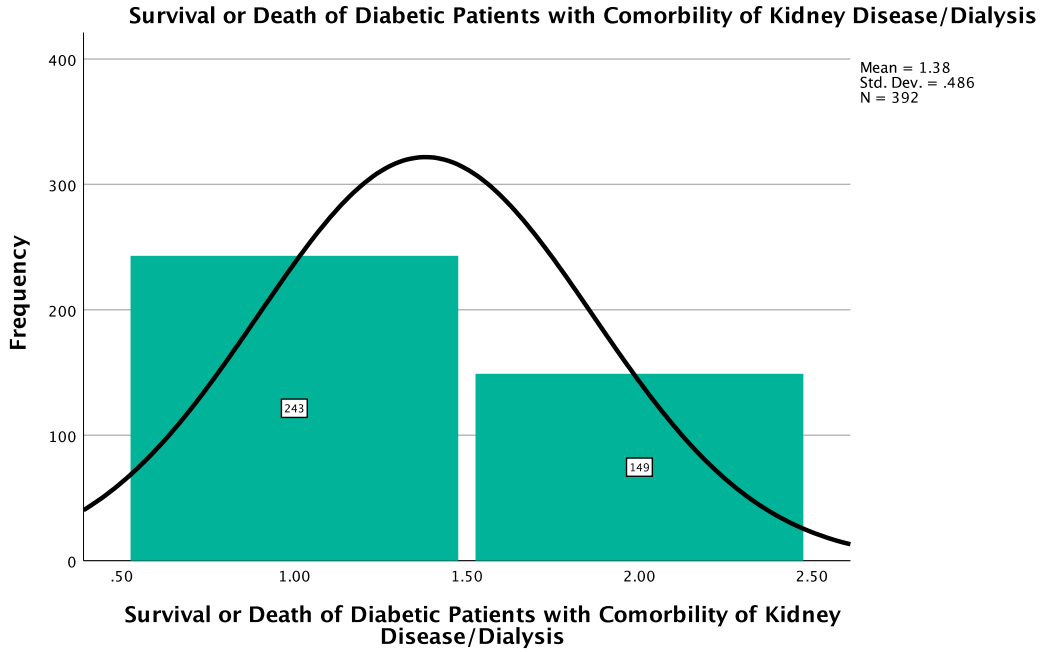
Frequency for Survival or Death of Diabetic Patients with Comorbidity of Kidney Disease/Dialysis (Dichotomous/Dependent) Variable

Survival or Death	*N*	%
Survival	243	62.0%
Death	149	38.0%

Table 8 presents the sample characteristics of 392 eligible diabetic patients on dialysis, with most of the participants being classified as survival patients. Specifically, 62.0% of the sample (N = 243) comprised individuals who survived, while the remaining 38.0% (N = 149) constituted the deceased patients. For a visual representation of this distribution, please refer to Figure 7.

Figure 7

Histogram - SURV_OR_DEATH (Dichotomous/Dependent) Variable



Inferential Analysis

A binary logistic regression analysis was conducted to investigate the relationship between COVID-19 vaccine status, present of hypertension, sex, age, educational level, BMI, smoking, and the likelihood of survival in diabetes patients on dialysis who contracted COVID-19. The analysis ensured that all assumptions of the model were met. The dependent variable, survival, was categorized as "Survival" and "Death," while the independent variables were measured as categorical variables.

The logistic regression model was found to be statistically significant compared to the null model ($\chi2(17) = 293.139$, $p < 0.001$), indicating that the model provided a good fit to the data (as shown in Table 9). The model accounted for 71.6% of the variation in

survival (Nagelkerke R2) and accurately predicted 89.8% of cases (as shown in Table 10, Table 11). The sensitivity of the model was 92.1%, specificity was 86.1%, the positive predictive value was 91.4%, and the negative predictive value was 87.2% (as shown in Table 11).

Among the predictor variables, COVID-19 vaccine status by present of hypertension ($p < 0.001$), age in years ($p < 0.001$), BMI ($p < 0.001$), and smoking ($p < 0.001$) were found to be statistically significant in their association with survival. However, sex ($p = 0.431$) and educational level ($p = 0.006$) did not show a significant association. Males and females had similar odds of survival (for more details, see Table 12).

The analysis revealed that unvaccinated diabetes patients without hypertension had 0.034 times lower odds of survival compared to vaccinated diabetes patients with hypertension. Similarly, unvaccinated diabetes patients without hypertension had 0.025 times lower odds of survival compared to vaccinated diabetes patients without hypertension. In addition, unvaccinated diabetes patients without hypertension had 3.870 times higher odds of survival compared to unvaccinated diabetes patients with hypertension.

In terms of age, diabetes patients on dialysis who were 80 years or older had lower odds of survival compared to those in the age group of 18-29 years. This trend continued for different age groups, with older patients showing lower odds of survival compared to younger patients.

Furthermore, diabetes patients on dialysis with a BMI of 30 and above (Obese) had lower odds of survival compared to those with a BMI between 18.5 and 24.9 (Healthy), as well as those with a BMI between 25.0 and 29.9 (Overweight). Currently smoking was associated with an increased likelihood of death.

Based on these findings, it can be inferred that COVID-19 vaccine status by present of hypertension, along with age, BMI, and smoking, significantly influence the likelihood of survival in diabetes patients on dialysis who contract COVID-19. Therefore, the null hypothesis is rejected, and the alternative hypothesis is accepted.

Table 9

Omnibus Tests of Model Coefficients

		Chi-square	*df*	Sig.
Step 1	Step	293.139	17	<.001
	Block	293.139	17	<.001
	Model	293.139	17	<.001

Table 10

Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	227.527[a]	.527	.716

a. Estimation terminated at iteration number 7 because parameter estimates changed by less than .001.

Table 11

Classification Table

	Observed		Predicted		
			Survival or Death of Diabetic Patients with Comorbidity of Kidney Disease/Dialysis		Percentage Correct
			Survival	Death	
Step 1	Survival or Death of Diabetic Patients with Comorbidity of Kidney Disease/Dialysis	Survival	222	21	91.4
		Death	19	130	87.2
	Overall Percentage				89.8

a. The cut value is .500

Table 12

Binary Logistic Regression Predicting Likelihood of Survival

		B	SE	Wald	*df*	Sig.	Exp(B)	95% CI for EXP(B)	
								Lower	Upper
Step 1[a]	COVID-19 Vaccines Status by Present of Hypertension			104.220	3	<.001			
	COVID-19 Vaccines Status by Present of Hypertension (1)	-3.382	.544	38.645	1	<.001	.034	.012	.099
	COVID-19 Vaccines Status by Present of Hypertension (2)	-3.706	.691	28.797	1	<.001	.025	.006	.095
	COVID-19 Vaccines Status by Present of Hypertension (3)	1.353	.521	6.746	1	.009	3.870	1.394	10.745
	Sex (1)	-.449	.362	1.544	1	.214	.638	.314	1.296
	Age Report in Years			24.247	6	<.001			
	Age Report in Years (1)	-5.405	1.627	11.029	1	<.001	.004	.000	.467
	Age Report in Years (2)	-2.216	.982	5.094	1	.024	.109	.016	.727
	Age Report in Years (3)	-2.740	.674	16.537	1	<.001	.065	.017	.163

	B	SE	Wald	*df*	Sig.	Exp(B)	95% CI for EXP(B)	
							Lower	Upper
Age Report in Years (4)	-1.487	.581	6.554	1	.010	.226	.072	.511
Age Report in Years (5)	-1.299	.561	5.359	1	.021	.273	.091	.639
Age Report in Years (6)	-.926	.535	3.000	1	.083	.396	.139	1.178
Educational Level			16.266	4	.006			
Educational Level (1)	-2.745	1.224	5.027	1	.025	.064	.006	.708
Educational Level (2)	-3.679	1.289	8.142	1	.004	.025	.002	.316
Educational Level (3)	-2.951	1.296	5.180	1	.023	.052	.004	.664
Educational Level (4)	-5.124	1.452	12.446	1	<.001	.006	.000	.103
Body Max Index			17.768	2	<.001			
Body Max Index (1)	-1.926	.538	12.835	1	<.001	.146	.051	.418
Body Max Index (2)	-2.159	.529	16.674	1	<.001	.115	.041	.325
Smoking (1)	3.354	.678	24.473	1	<.001	28.622	7.578	108.104
Constant	6.472	1.457	19.729	1	<.001	647.041		

Note: Variable(s) entered on step 1: COVID-19 Vaccines Status by Present of Hypertension, Sex, Age Report in Years, Educational Level, Body Max Index, Smoking.

Discussion

Interpretation

The results of the binary logistic regression analysis indicate a statistically significant association between COVID-19 Vaccine Status by Present of Hypertension and the survival status of diabetes patients on dialysis within a hospital setting in Puerto Rico ($p < 0.001$). The covariates of Age Report in Years, BMI, and Smoking were found to be protective and risk factors that potentially influence this association, as they showed statistically significant levels concerning the survival status ($p < 0.001$). However, the covariates of Sex ($p = 0.638$) and Educational Level ($p = 0.006$) did not show statistically significant levels in relation to the survival status.

Further analysis revealed that unvaccinated diabetes patients without hypertension were 0.034 time less likely to experience survival than vaccinated diabetes patients with hypertension, controlled for Age, BMI, and Smoking. Similarly, unvaccinated diabetes patients without hypertension were 0.025 time less likely to experience survival than vaccinated diabetes patients without hypertension, controlled for Age, BMI, and Smoking. Moreover, unvaccinated diabetes patients without hypertension were 3.870 time most likely to experience survival than unvaccinated diabetes patients with hypertension, controlled for Age, BMI, and Smoking. These results support the statistical association between COVID-19 Vaccine Status by Present of Hypertension and the survival status of diabetes patients on dialysis within a hospital setting in Puerto Rico, controlled for Age, BMI, and Smoking.

In addition, the analysis revealed that diabetes patients on dialysis aged 80 years and older were less likely to experience survival compared to those between 18 and 29 years, controlled for BMI and Smoking. This trend continued for different age groups, with older patients showing lower chances of survival compared to younger patients. This indicates that age, along with BMI and Smoking, is an important protective and risk factor that influences the association between COVID-19 Vaccine Status by Present of Hypertension and the survival status of diabetes patients on dialysis within a hospital setting in Puerto Rico.

Moreover, the analysis showed that diabetes patients on dialysis with a BMI of 30 and above (*Obese*) were less likely to experience survival compared to those with a BMI between 18.5 and 24.9 (*Healthy*), controlled for Age and Smoking. Similarly, patients with a BMI of 30 and above were less likely to experience survival compared to those with a BMI between 25.0 and 29.9 (*Overweight*), controlled for Age and Smoking. These findings highlight the importance of BMI, along with Age and Smoking, in influencing the association between COVID-19 Vaccine Status by Present of Hypertension and the survival status of diabetes patients on dialysis within a hospital setting in Puerto Rico.

In this study, I employed the SEM as a theoretical framework to examine the risk and protective factors against COVID-19 infection in diabetic patients with comorbidity of kidney disease/dialysis at two levels: intrapersonal and community. The present of hypertension risk factor was measured at the individual level of the SEM, while the community level encompassed perceptions of the risk of vaccine-preventable COVID-19 in the hospital setting, which played a crucial role in the vaccination rate. These

protective and risk factors interacted and influenced the survival status of diabetic patients on dialysis within the hospital setting. The analysis also revealed that the survival status by present of hypertension was controlled by individual factors such as Age, BMI, and smoking, while no significant control was observed for Sex and Educational Level.

Based on the findings, it is recommended to conduct further research using this specific theoretical framework to obtain more evidence-based information that strengthens the statistical association between COVID-19 Vaccine Status by Present of Hypertension and the survival status of diabetes patients on dialysis within a hospital setting in Puerto Rico, while controlling for Age, BMI, and Smoking. This additional research would provide a deeper understanding of the factors influencing the observed associations and contribute to the development of targeted interventions and strategies for improving the survival outcomes of diabetic patients on dialysis.

Limitations

This study is subject to several limitations that should be acknowledged. Firstly, the use of secondary data sources poses a significant limitation. The lack of control over the data collection methods in the hospital setting introduces uncertainty regarding the validity and reliability of the data. Additionally, the presence of biases in the original hospital data source may have influenced the accuracy and generalizability of the study findings.

A second limitation stems from the small sample size and the study's reliance on data from a single geographical location. This restricts the generalizability of the findings and limits the statistical power of the analysis. To overcome this limitation, future studies

could consider collecting data from multiple hospitals across the United States, thereby increasing the sample size and enhancing the robustness of the statistical tests.

It is important to note that a major limitation of the data source used in this study is the lack of information on specific COVID-19 vaccine brandings. This limitation hinders the scope and depth of the research findings. The specific brand of the COVID-19 vaccine administered can potentially influence the association between COVID-19 Vaccine Status by Present of Hypertension, and the survival outcomes of diabetes patients on dialysis within a hospital setting in Puerto Rico, even when controlling for factors such as Age, Sex, Educational Level, BMI, and Smoking. The absence of this information may have implications for the statistical significance of the observed associations.

Therefore, for future studies, it is recommended to include COVID-19 vaccine brandings as a covariate. This additional information would provide a more comprehensive understanding of the association between COVID-19 vaccine status by Present of Hypertension, and survival outcomes among patients on dialysis. By considering the specific brand of the vaccine, researchers can better assess the potential impact of different vaccines on the observed associations, potentially leading to more nuanced and accurate conclusions.

Implications

This study has made significant contributions to the existing body of evidence on the mortality risks faced by adults diagnosed with diabetes patients undergoing dialysis, particularly those with hypertension, in the context of COVID-19 infection. The findings

of this study have demonstrated a statistically significant association between COVID-19 Vaccine Status by Present of Hypertension and the survival outcomes of diabetes patients on dialysis in a hospital setting in Puerto Rico. The analysis accounted for important factors such as Age, BMI, and Smoking.

The outcomes of this study have important implications for healthcare organizations, physicians, and the general public in Puerto Rico. They provide valuable insights into the role of the COVID-19 vaccine as a preventive measure against mortality for diabetic patients on dialysis. These findings can be utilized by healthcare professionals to educate individuals with diabetes and comorbid kidney disease/dialysis about the potential effectiveness of the COVID-19 vaccine in preventing death from COVID-19 infection. It is particularly crucial to emphasize the importance of vaccination for individuals with hypertension, as they face a higher risk of mortality compared to those with without of hypertension.

Furthermore, these research findings serve as a valuable tool for public health officials and prevention professionals in managing COVID-19 infections among the population of diabetes patients on dialysis. They provide actionable information that can guide hospital interventions and health education programs, with a specific focus on reducing individual risk factors such as Age, BMI, and Smoking, in order to mitigate the risk of mortality in this population.

Importantly, the implications of this research extend beyond the healthcare setting and have the potential to drive positive social change in Puerto Rico. The results of this study inform decision-making and planning processes for adults diagnosed with diabetes

and comorbid kidney disease/dialysis who are at risk of COVID-19 infection. They underscore the need for increased attention and allocation of resources to ensure access to the COVID-19 vaccine for individuals with hypertension in both outpatient and inpatient settings. This is crucial for improving overall health outcomes, reducing mortality rates, and alleviating the burden on the Puerto Rico Public Health System.

Recommendations

This research study utilized secondary data obtained from the Electronic Medical Record system within a hospital in Puerto Rico. The data pertained to diabetic patients with comorbidities of kidney disease/dialysis who were hospitalized due to COVID-19 infection between December 15, 2020, and December 31, 2022. The study aimed to examine the association between COVID-19 Vaccine Status by Present of Hypertension, and the survival outcomes of diabetes patients on dialysis within a hospital setting in Puerto Rico. The analysis controlled for variables such as Age, Sex, Educational Level, BMI, and Smoking, using binary logistic regression analysis.

It is worth noting that there is a limited number of research studies investigating the association between COVID-19 Vaccine Status by Present of Hypertension, and the survival outcomes of diabetes patients on dialysis within a hospital setting in Puerto Rico. Therefore, it is recommended to expand this study by including the impact of different COVID-19 vaccine brands on the aforementioned factors. Additionally, extending the study to include data from other hospitals, both in the United States and other organizations in the public and private sectors, focusing on diabetes patients on dialysis

would enhance the generalizability of the findings and provide a larger sample size for more robust statistical analysis.

Conclusion

This study investigated the impact of COVID-19 Vaccine Status by Present of Hypertension, controlling by Age, Sex, Educational Level, BMI, and Smoking on the likelihood of survival in diabetes patients on dialysis who contract COVID-19. The findings highlight several important factors that influence the outcomes of COVID-19 in this vulnerable population.

The results of the binary logistic regression analysis revealed that COVID-19 vaccination status plays a crucial role in determining the survival odds of diabetes patients on dialysis. Specifically, unvaccinated diabetes patients hypertension exhibited lower odds of survival compared to their unvaccinated counterparts without hypertension. This finding underscores the significance of COVID-19 vaccination in mitigating the adverse effects of the virus in diabetes patients on dialysis, particularly among those unvaccinated diabetes patients with hypertension.

Age emerged as a significant predictor variable of survival outcomes, with older patients showing lower odds of survival compared to younger individuals. This finding suggests that age-related factors may contribute to the increased vulnerability of older diabetes patients on dialysis to severe COVID-19 complications. Healthcare professionals should consider age as a critical factor when assessing and managing COVID-19 in this population.

Furthermore, the study identified a notable association between BMI and survival odds in diabetes patients on dialysis who contract COVID-19. Specifically, individuals with higher BMI (*Obese*) exhibited lower odds of survival compared to those with a healthy BMI range (18.5-24.9) and those in the overweight BMI range (25.0-29.9). This finding underscores the importance of weight management and obesity prevention strategies in diabetes patients on dialysis to enhance their resilience against severe COVID-19 outcomes.

Lastly, the analysis revealed a positive association between Smoking and the likelihood of death in diabetes patients on dialysis who contract COVID-19. Currently smoking were associated with an increased risk of mortality, indicating the significance of smoking control in reducing the adverse effects of COVID-19. This finding highlights the importance of smoking cessation educational program in diabetes patients on dialysis, particularly in those with hypertension.

The findings of this study have implications for healthcare professionals, policymakers, and researchers involved in the care of diabetes patients on dialysis during future outbreak of COVID-19 or other emerging infectious diseases. The results underscore the critical role of COVID-19 vaccination, Age, BMI, and Smoking cessation in determining the survival outcomes of this population. These findings can inform targeted interventions and strategies aimed at improving the prognosis of diabetes patients on dialysis who contract COVID-19.

Further research is warranted to gain a deeper understanding of the complex interactions between individual, interpersonal, community, and societal factors that

influence the associations observed in this study. Future investigations employing a socio-ecological framework can provide valuable insights into the multifaceted determinants of COVID-19 outcomes in diabetes patients on dialysis. Such comprehensive research endeavors will contribute to the development of evidence-based guidelines and interventions that enhance the survival rates and overall well-being of this vulnerable population during future outbreaks and beyond.

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Part 3: Summary

Integration of the Studies

Current literature has provided evidence of the vulnerability of individuals with diabetes to COVID-19, particularly those with high blood pressure and undergoing dialysis treatment. Furthermore, COVID-19 vaccines have demonstrated effectiveness in preventing COVID-19-related deaths among this high-risk population. However, there is a research gap in understanding the impact of COVID-19 vaccination status with the individual risk factor of diabetes type, dialysis frequency, and hypertension on the survival status of diabetic patients on dialysis within a hospital setting. Hence, this study aimed to conduct a quantitative secondary data analysis to investigate the association between the surviving status of diabetic patients on dialysis within a hospital setting in Puerto Rico as three separate manuscripts: (a) surviving status given by vaccination status together with the diabetes type risk factor; (b) surviving status given by vaccination status together with the dialysis frequency risk factor; (c) surviving status given by vaccination status together with the hypertension risk factor, controlling for other important protective and risk factors.

The results of the binary logistic regression analysis for the three manuscripts indicate a statistically significant association between COVID-19 Vaccine Status by Diabetes Type, COVID-19 Vaccine Status by Diabetes Type, COVID-19 Vaccine Status by Present of Hypertension, and the survival status of diabetes patients on dialysis within a hospital setting in Puerto Rico ($p < 0.001$). The covariates of Age Report in Years, BMI, A1C Level, and Smoking were found to be protective and risk factors that

potentially influence this association, as they showed statistically significant levels concerning the survival status ($p < 0.001$). However, the covariates of Sex ($p = 0.696$; $p = 0.431$; $p = 0.638$) and Educational Level ($p = 0.017$; $p = 0.009$; $p = 0.006$) did not show statistically significant levels of survival status.

In the first manuscript, further analysis demonstrated that unvaccinated diabetes type 2 patients on dialysis had a significantly lower likelihood of survival compared to vaccinated diabetes type 1 patients on dialysis after controlling for confounding factors such as Age, BMI, and A1C levels. Conversely, unvaccinated type 2 diabetic patients exhibited a higher proportional survival than unvaccinated type 1 diabetic patients, while vaccinated type 2 diabetic patients displayed a higher proportional survival than vaccinated type 1 diabetic patients. This finding is substantiated by the Social Ecological Model (SEM). According to SEM, the individual risk factor of diabetes type among dialysis patients can potentially have a community-level effect. This effect involves influencing risk perceptions, promoting higher vaccination rates, and ultimately preventing COVID-19-related deaths within this vulnerable population, controlled by Age, BMI, and A1C Levels.

In the second manuscript, further analysis revealed that unvaccinated diabetes patients undergoing three dialysis sessions per week had a significantly lower likelihood of survival than vaccinated diabetes patients undergoing one or two dialysis sessions per week, controlling for Age, BMI, and Smoking. Moreover, unvaccinated diabetes patients undergoing three dialysis sessions per week displayed a lower likelihood of survival compared to unvaccinated those undergoing one or two dialysis sessions per week. This

finding is substantiated by the Social Ecological Model (SEM). According to SEM, the individual risk factor of dialysis frequency among dialysis patients can potentially have a community-level effect. This effect involves influencing risk perceptions, promoting higher vaccination rates, and ultimately preventing COVID-19-related deaths within this vulnerable population, controlled by Age, BMI, and Smoking.

In the third manuscript, further analysis demonstrated that unvaccinated diabetes patients without hypertension had significantly lower survival odds than vaccinated diabetes patients with or without hypertension. Additionally, unvaccinated diabetes patients without hypertension exhibited higher odds of survival compared to unvaccinated diabetes patients with hypertension. This finding is substantiated by the SEM. According to SEM, the individual risk factor of the presence of hypertension among dialysis patients can potentially have a community-level effect. This effect involves influencing risk perceptions, promoting higher vaccination rates, and ultimately preventing COVID-19-related deaths within this vulnerable population, controlled by Age, BMI, and Smoking.

This study is subject to limitations due to secondary data analysis. However, the most significant limitation of the data source used in this study is the lack of information regarding specific COVID-19 vaccine brands. This limitation restricts the scope and depth of the research findings. The specific brand of the COVID-19 vaccine administered could potentially influence the association between the surviving status of diabetic patients on dialysis within a hospital setting in Puerto Rico: (a) surviving status given by vaccination status together with the diabetes type risk factor, (b) surviving status given by

vaccination status together with the dialysis frequency risk factor,(c) surviving status given by vaccination status together with the hypertension risk factor. This is especially true when considering other factors such as age, Sex, educational level, BMI, A1C levels, and smoking. The absence of this information may have implications for the statistical significance of the observed associations.

In terms of future studies, including COVID-19 vaccine brandings as a covariate is recommended. This additional information would provide a more comprehensive understanding of the association between COVID-19 vaccine administered could potentially influence the association between the surviving status of diabetic patients on dialysis within a hospital setting in Puerto Rico: (a) surviving status given by vaccination status together with the diabetes type risk factor, (b) surviving status given by vaccination status together with the dialysis frequency risk factor, and (c) surviving status given by vaccination status together with the hypertension risk factor. By considering the specific brand of the vaccine, researchers can better assess the potential impact of different vaccines on the observed associations, potentially leading to more nuanced and accurate conclusions.

Conclusion

This study investigated the impact of COVID-19 Vaccine Status by three separate risk factors: (a) diabetes type; (b) dialysis frequency; and (c) present of hypertension, controlling by Age, Sex, Educational Level, BMI, A1C Levels, and Smoking on the likelihood of survival in diabetes patients on dialysis who contract COVID-19. The

findings highlight several important factors that influence the outcomes of COVID-19 in this vulnerable population.

The results of the binary logistic regression analysis revealed that COVID-19 vaccination status plays a crucial role in determining the survival odds of diabetes patients on dialysis. Specifically, unvaccinated diabetes type 1 patients, unvaccinated diabetes patients undergoing three dialysis sessions per week, unvaccinated diabetes patients with hypertension exhibited lower odds of survival compared to their vaccinated counterparts without this risk factors. This finding underscores the significance of COVID-19 vaccination in mitigating the adverse effects of the virus in diabetes patients on dialysis, particularly among those unvaccinated diabetes type 1 patients, unvaccinated diabetes patients undergoing three dialysis sessions per week, unvaccinated diabetes patients with hypertension.

Age emerged as a significant predictor variable of survival outcomes, with older patients showing lower odds of survival compared to younger individuals. This finding suggests that age-related factors may contribute to the increased vulnerability of older diabetes patients on dialysis to severe COVID-19 complications. Healthcare professionals should consider age as a critical factor when assessing and managing COVID-19 in this population.

Furthermore, in this study, I identified a notable association between BMI and survival odds in diabetes patients on dialysis who contract COVID-19. Specifically, individuals with higher BMI (*Obese*) exhibited lower odds of survival compared to those with a healthy BMI range (18.5-24.9) and those in the overweight BMI range (25.0-29.9).

This finding underscores the importance of weight management and obesity prevention strategies in diabetes patients on dialysis to enhance their resilience against severe COVID-19 outcomes.

Also, the analysis revealed a positive association between A1C levels and the likelihood of death in diabetes patients on dialysis who contract COVID-19. Higher A1C levels were associated with an increased risk of mortality, indicating the significance of glycemic control in reducing the adverse effects of COVID-19. This finding highlights the importance of regular monitoring and management of A1C levels in diabetes patients on dialysis, particularly in diabetes type 1.

Lastly, the analysis revealed a positive association between Smoking and the likelihood of death in diabetes patients on dialysis who contract COVID-19. Currently smoking were associated with an increased risk of mortality, indicating the significance of smoking control in reducing the adverse effects of COVID-19. This finding highlights the importance of smoking cessation educational program in diabetes patients on dialysis, particularly in those undergoing more dialysis sessions per week, and with hypertension.

The findings of this study have implications for healthcare professionals, policymakers, and researchers involved in the care of diabetes patients on dialysis during future outbreak of COVID-19 or other emerging infectious diseases. The results underscore the critical role of COVID-19 vaccination, Age, BMI, A1C Levels and Smoking cessation in determining the survival outcomes of this population. These findings can inform targeted interventions and strategies aimed at improving the prognosis of diabetes patients on dialysis who contract COVID-19.

Further research is warranted to gain a deeper understanding of the complex interactions between individual, interpersonal, community, and societal factors that influence the associations observed in this study. Future investigations employing a socio-ecological framework can provide valuable insights into the multifaceted determinants of COVID-19 outcomes in diabetes patients on dialysis. Such comprehensive research endeavors will contribute to the development of evidence-based guidelines and interventions that enhance the survival rates and overall well-being of this vulnerable population during future outbreaks and beyond.

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