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Myrna del Mar González-Montalvo 04/21/2022

Understanding the effect of COVID-19 on the management of non-communicable diseases in patients in a Federally Qualified Health Center in Puerto Rico

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Abstract

Understanding the effect of COVID-19 on the management of non-communicable diseases in patients in a Federally Qualified Health Center in Puerto Rico

By Myrna del Mar González-Montalvo

Introduction: In March 2020, the COVID-19 pandemic broke out in Puerto Rico and an island wide lockdown period from March 15 to April 12 was put into effect. Asthma, diabetes, and hypertension are three of the most frequent chronic illnesses in Puerto Rico, and they are among the major causes of disability and mortality. Patients with chronic conditions were disproportionately impacted during the early stages of the COVID-19 pandemic.

Project goals: The goal of this project is to understand the extent to which health service delivery disruption affected control of common NCDs such as hypertension and diabetes. Secondarily, to understand if that disproportionately affected more vulnerable groups based on SDoH such as income and insurance.

Methodology: This study was conducted using electronic health record data from patients who receive medical services at any of HealthproMed's clinics throughout Puerto Rico. We compared the proportion of patients with uncontrolled diabetes (HbA1c $\geq$ 9%) and uncontrolled hypertension (SBP $\geq$ 150mmHg) before and during the COVID-19 pandemic. A univariate analysis was conducted, as well as a bivariate analysis and tests of association to determine if there is an association between changes in the proportion of patients with uncontrolled SBP and HbA1c and the social determinants of health of income and insurance.

Results: After reviewing both the hypertension and diabetes results, we can see concerning trends with a rise in uncontrolled diabetes and hypertension and a reduction in visits to the healthcare centers after the start of the COVID-19 pandemic in 2020. Our findings showed that HealthproMed site location, as a proxy for income, was associated with control of hypertension and diabetes, except in diabetes for 2019 ($p > 0.05$). Insurance type was associated with worse health outcomes in all cases, except for control of SBP in 2020 ($p > 0.05$). For both SBP and HbA1c controlled and uncontrolled measurement proportions, a significant difference was observed when comparing both, pre COVID-19 period (January-March 2020) and post COVID-19 period (April-June 2020) to the same periods in 2019.

Discussion: It is critical to develop strategies that enable and promote effective self-management and inform individuals on how to identify challenges and ways to manage adversities associated with their illness that might arise after an event of such magnitude. More robust policies should also be developed to achieve management of NCDs, whether it is through state or federal governments. The need for a unified, multi-sector strategic approach to not only identify areas of insufficiency in the present management system, but also to devise meaningful solutions to this public health disaster is clear.

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Esta tesis se la dedico a mi abuelita Q.E.P.D.

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Chapter 1: Introduction

Introduction and Rationale

In March 2020 Puerto Rico faced the beginning of the COVID-19 pandemic. The island has had already more than 465,021 coronavirus cases, as of February 6th, 2022, and approximately 3,953 deaths, with transmission rates rising up the last week of April 2021 to 28 cases per 100,000 people a day, compared with 17 per 100,000 on the U.S. mainland (Departamento de Salud de Puerto Rico, 2022).

Puerto Rico suffers a disproportionate burden of common chronic diseases: asthma, diabetes, and hypertension are three of the leading causes of disability and death. A study among island Puerto Rican and mainland US older adults showed that a large proportion of adults reported hypertension, with rates ranging from 51 to 69%. Island Puerto Ricans also reported diabetes as the second most common condition (Pérez & Ailshire, 2017). Another study showed that among Hispanics, Puerto Ricans (12.8%) were more likely to have asthma (Stern & Litonjua, 2020). The burden of chronic diseases is shared unequally across the population. Puerto Rico suffers from a triple burden of limited healthcare services, high poverty rate, and high prevalence of chronic diseases. This situation impacts COVID-19 outcomes; it has been demonstrated that people with diabetes are more likely to have worse complications from COVID-19 compared to those without diabetes (Palaiodimos et al, 2021).

The island's social and economic inequalities give way to vulnerability when it comes to disasters (Santos, 2007). When compared to the rest of the population, people in low socioeconomic strata and older adults have usually higher levels of disability, morbidity and mortality from adverse events, such as COVID-19 (Patel et al., 2020; Shadmi et al., 2020; Shahid et al., 2020; García et al., 2021). During early COVID-19 pandemic, it was observed that patients

with chronic diseases were disproportionately affected, possibly because physical exercise was reduced during lockdown mitigation measures, routine checkup and lab testing were missed, and access to healthcare services was compromised.

The goal of this project is to work with one of the largest Federally Qualified Health Centers (FQHCs) in Puerto Rico to identify factors amenable to improvements in the management of non-communicable diseases (NCDs) during a major event, such as the COVID-19 pandemic. FQHCs such as HealthproMed provide care to underserved populations that are most vulnerable to the negative effects of any disruptions associated with major events such as natural disasters or pandemics.

HealthproMed is a nonprofit organization in a network of primary medical services supported by the U.S. federal government. The organization provides access to essential health services to citizens of Puerto Rico who are medically vulnerable due to poverty, lack of medical insurance, and who are identified in the U.S. Department of Human Health and Services (HHS) categories of Medically Underserved Areas (MUAs) and Medically Underserved Populations (MUPs) (United States Department of Health and Human Services [HHS], 2020). According to the World Bank, Puerto Rico falls in the category of an upper-middle-income economy country. This study will serve as a thesis project experience intended to benefit HealthproMed as it seeks to optimize the identification and treatment of NCDs in Puerto Rico in the time of a disaster such as a pandemic. The output will facilitate the application of public health knowledge and skills through a partnership with HealthproMed and the community being served to advance the wellbeing of one of Puerto Rico's most vulnerable populations. After the completion of this project the data collected and analyzed regarding chronic disease service provision before and

during the COVID-19 pandemic will help inform HealthproMed on specific areas for improvement of services for patients with NCDs.

Project objective

The objective of this study is to determine if there is a change in the proportion of individuals with uncontrolled diabetes and hypertension preceding and after the COVID-19 pandemic. A secondary objective will be to see if changes in the level of control differed by clinical site or by insurance type. The hypothesis is that there will be an increase in the proportion of people with uncontrolled hypertension and diabetes related to health service disruptions during the ongoing COVID-19 pandemic.

At the conclusion of this project we will have three deliverable products:

1. A comprehensive analysis of the impact of COVID-19 on management of diabetes and hypertension at HealthproMed clinics
2. A final report of findings and recommendations
3. A manuscript for submission to be published in a peer-reviewed journal.

Chapter 2: Literature Review

In this chapter, we first present information related to the novel coronavirus disease (COVID-19) and how it has led to health service delivery disruptions globally. We discuss the implications of this on individuals with non-communicable diseases (NCDs). The research conducted on numerous scenarios affected by the pandemic, as well as the function of social determinants of health in the socioeconomic context of the population under investigation, will be discussed in the second half of the chapter.

Coronaviruses (CoV) are a family of viruses that cause diseases ranging from the common cold to more severe clinical manifestations, such as Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS) (WHO & EMRO, n.d.). On December 2019, a cluster of novel human pneumonia cases were reported in Wuhan, China. When testing was conducted, genome sequencing results proved that the causative agent was a novel coronavirus, the seventh member of the coronavirus family able to infect humans (Wu et al, 2020 & Liu, Y. et al 2020). The etiologic agent was designated as SARS-CoV-2 by the International Committee on Taxonomy of Viruses (International Committee on Taxonomy of Viruses [ICTV]). The World Health Organization (WHO) named the disease caused by this new virus 2019 novel coronavirus (2019-nCoV) on January 12, 2020 and then renamed this infectious disease as coronavirus disease 2019 (COVID-19) a month later (Liu, Y. et al 2020). As COVID-19 began spreading in Wuhan, it became an epidemic where there was widespread occurrence of the disease within Wuhan and adjacent cities. The disease then rapidly spread across several continents and countries and affected a large number of people; it was classified as a pandemic by WHO on March 11, 2020 (Centers for Disease Control and Prevention [CDC], 2020).

Burden of NCDs and importance of uninterrupted health service delivery

Yearly, 15 million individuals between the ages of 30 and 69 years die from NCDs (WHO, 2021). COVID-19 might detrimentally affect NCD outcomes in patients of every age group across different settings, including increased vulnerability to COVID-19 disease outcomes and higher mortality levels. The COVID-19 pandemic has also been associated with setbacks in diagnosis of NCDs – such as diabetes and hypertension. During the ongoing pandemic, both of these NCDs have also been associated with more severe expressions of the disease due to cessation or disruptions of treatment for NCDs and temporal increase in behavioral NCDs risk factors (Okereke, M. et al, 2020 & WHO, 2020). This convergence has given rise to a syndemic associated with various driving factors, such as inadequate diet, poor nutrition, and scarcity of health services (Yadav et al, 2020). Merrill Singer coined the word "syndemic" in the mid-1990s, and it was later formalized in a textbook published in 2009. "The term syndemic, at its simplest level, refers to two or more epidemics interacting synergistically and contributing, as a result of their interaction, to the clustering of excess burden of disease in a location or population, more than just the sum of both" (Fronteira et al, 2021; Singer, 2009; Singer, 2010). A synergistic impact has been exhibited likewise with different social determinants of health which appear to contribute to more impoverished health and accumulating social drawbacks (Fronteira et al, 2021).

Studies across the world have predicted that COVID-19 mitigation lockdowns will bring about a rise in HbA1c and future diabetes-related complications (Ghosal et al, 2020). Stay-at-home executive orders can compromise diabetes and hypertension management as non-urgent healthcare services are interrupted and essential health services are delayed. COVID-19 also exposes patients to other NCDs risk factors when socioecological and biological factors interact,

giving way to unfavorable outcomes (Yadav et al, 2020). Reports already confirm that the pandemic has led to decreased HbA1c monitoring with testing volume reduced by as much as 66% and females having a larger initial decline than males (69% versus 62%, $P < 0.001$) (Fragala et al, 2020). Based on previous analysis, missed HbA1c monitoring due to absence from regular medical check-ups may be associated with HbA1c increases of 0.50%–0.83%.2 (Karter et al, 2004 & Samuels et al, 2008). The perceptions propose that missed HbA1c testing during the pandemic could prompt undesirable effects as far as glucose control, clinical results, and diabetes-related clinical expenses. The possible negative consequences of interrupted diabetes monitoring bring to light the importance of effective ways to maintain good glycemic management in diabetes control. Managing and monitoring glucose and associated risk factors such as blood pressure and lipids is critical. Control of HbA1c, blood pressure, and lipid levels has been associated with a reduction of diabetes-related complications by 43% to 67% (Fitch et al, 2013 & Fragala et al, 2020). Additionally, many studies have assessed the frequent phenomenon that has emerged regarding lack of health education on management of insulin when communication with a diabetic patient's primary healthcare center is hard, especially in disadvantaged populations and in elderly patients (Eliaschewitz et al, 2018 & Myers et al, 2020).

Role of primary care for management of NCDs

Primary care is essential for patients living with NCDs. Primary care increases access to healthcare services, improves positive health results and quality of life and reduces hospital visits. Primary health care addresses the needs of patients at the community level by fusing prevention and promotion. Additionally, effective primary healthcare lowers healthcare expenditure by ameliorating production of health systems (Van Weel & Kidd, 2018). When

compared to other high-income countries, the United States fails to meet expectations on various components of primary care performance, including number of avoidable deaths from chronic conditions. During the COVID-19 pandemic, some physicians have expressed lack of time or availability for those who might want to get tested or any form of preventive care because they have been dealing mostly with a large burden of acutely ill COVID-19 patients. This has been, undoubtedly, a challenge for every country's healthcare system and for patients with chronic conditions that have suffered service and treatment interruptions from their usual healthcare facility. Primary care has been extremely compromised during the pandemic and two groups have been the most affected; one of them being patients with chronic conditions and the other includes patients with health conditions that require regular access to, and monitoring by, primary care providers (Lewis et al, 2020). Diabetic and hypertensive patients who might need ongoing monitoring of their health conditions and weight seem to lack proper preventive care measures when a pandemic or other adverse events occur. Blood glucose and blood pressure need to be measured periodically in order to adjust medications aimed at improving control and reducing complications associated with diabetes and hypertension. Sadly, most low-income patients lack proper devices to monitor themselves at home and need ongoing assistance from primary care physicians to control and reduce complications from their chronic conditions (Shrivastav et al, 2018). When adequate medication adherence levels are maintained, beneficial treatment results across a wide range of chronic disease conditions will be expected (Kretchy et al, 2021). Adding to mismanagement of NCDs, besides missed medication refills, interruption of preventive care services and postponing non-urgent care visits, lifestyle changes have been described that can lead to uncontrolled exacerbation of chronic conditions. Lifestyle changes, including a reduction in physical activity and fruit and vegetable intake can make it more

difficult to control NCDs. A cross-sectional study conducted in Brazil by means of survey data analysis reported that those with NCDs had mentioned a reduction in physical activity after the onset of the pandemic by 58% and in the intake of fruits and vegetables by 12.7%. Likewise, there was an increase in time used for television and computer by 196.5% and 30.6% respectively. As it has been seen worldwide, a consumption of unhealthy foods such as snacks has been seen with it accounting for 31.2% in those with NCDs (Malta et al, 2021). As another study in Europe pointed out: "Many countries have made changes to routine management of NCD patients, e.g., cancelling non-urgent outpatient visits, which will have important implications for NCD management, diagnosis of new-onset NCDs, medication adherence, and NCD progression" (Palmer et al, 2020)

Health service disruptions due to COVID-19

Since the start of the COVID-19 pandemic, prevention and treatment services around the world have been severely compromised. The disruption of services is worse in countries where there is a high percentage of underserved and vulnerable populations and where prevalence of non-communicable diseases (NCDs) is highest. A systematic review by Moynihan et al, was conducted to determine the extent and nature of changes in utilization of healthcare services during the COVID-19 pandemic. Results of this review showed that across 20 countries there were more than 11 million services pre-pandemic and about 6.9 million post onset of the pandemic. These services included visits, admissions, diagnostics, and treatments (Moynihan et al, 2021).

A survey completed by 155 countries in May 2020 brough to light the global impact the pandemic has had. Health services around the world have been partially or completely disrupted. "More than half (53%) of the countries surveyed have partially or completely disrupted services for hypertension treatment; 49% for treatment for diabetes and diabetes-related complications" (WHO, 2020b). Most of these countries reported medical staff assigned to the areas of NCDs being reassigned to support COVID-19 efforts. This delayed preventive services as well as screening programs. Non-urgent facility-based care was minimized and a correlation between levels of disruption of services for treating chronic diseases and the progression of the COVID-19 pandemic was seen (WHO, 2020b). Based on a study conducted in Brazil, hospital admissions for NCDs before the pandemic were stable (January-June 2017-2019), but the number of these admissions decreased after the onset of the pandemic (January-June 2020) with average reductions of 505 admissions for cardiovascular diseases and 76 for metabolic diseases such as stroke and diabetes (Maselli-Schoueri et al, 2021). A retrospective cross-sectional study conducted with data from 141 emergency departments across 16 states brought to light the great decrease in emergency room utilization. The study conducted by Lucero, et al. concluded that emergency department visits decreased significantly by 39.6% after the lockdown period due to the COVID-19 pandemic. Urgent care visits decreased by 35.8% while non-urgent visits decreased by 52.1% (Lucero et al, 2020).

Solutions for health service disruption

The COVID-19 pandemic has brought many changes to the way in which patients with NCDs are managed, with telemedicine and electronic health becoming more common (T. A. Hassan et al, 2021). A study conducted in the United States by Mann et al, highlighted various

outcomes of the COVID-19 pandemic, one being the impact of telemedicine in urgent care. Between March and April 2020, telemedicine visits increased by 683% in urgent care after promotion of the service was implemented. Telemedicine usage was found to be highest among 20-44 year age group, particularly for urgent care (Mann et al, 2020). The study by Misra and Bloomgarden, described how telemedicine studies before the COVID-19 pandemic show that these communication strategies can effectively be mobilized to lower hemoglobin A1c (HbA1c) (Misra & Bloomgarden, 2020). In a 4-year follow-up of a study of almost 1,000 persons with diabetes randomized to a telemedicine self-management behavioral intervention, diabetes-related hospitalizations were reduced by 17%. Telemedicine has been used for over 30 years to help improve adherence with medications and treatments used to manage NCDs and has proven to be extremely effective when used properly (T. A. Hassan et al, 2021).

Burden of COVID-19 pandemic on people with NCDs

During the COVID-19 pandemic, everyone has needed to adapt to new changes and ways of living daily life, as well as encountering obstacles for things they might have done before differently. Specifically, patients living with chronic conditions have been affected by lockdowns as they were unable to receive preventive care at healthcare facilities or receive their medications. This is a threat to these patients as those with NCDs tend to have a weaker immune system which fails to combat COVID-19. For patients with diabetes, continuous use of medications to maintain good glycemic control and avoid complications such as ulcers and uncontrolled blood pressure which further compromises their chances of survival if infected with COVID-19, is important. Poor glycemic control in a short term can lead to diabetic coma and diabetic ketoacidosis (DKA). DKA is a dangerous diabetic complication that happens when your body creates excessive amounts of blood acids called ketones (Mayo Clinic, n.d.). In the long

term, it can lead to microvascular and macrovascular complications. Long-term effects of diabetes that impact tiny blood vessels are known as microvascular complications. Retinopathy, nephropathy, and neuropathy are the most common (Zimmerman, 2016). Coronary heart disease, cardiomyopathy, arrhythmias, cerebrovascular disease, and peripheral artery disease are those among macrovascular consequences (Viigimaa et al., 2020). By controlling comorbid hypertension and hyperlipidemia, a person is able to reduce cardiovascular risk (Bozkurt, 2016).

Though data defining the risk is somewhat ambiguous, people with diabetes appear to be at a greater risk of more severe COVID-19 infection. Evidence relating greater BMI and higher HbA1c to poorer outcomes in people with diabetes with COVID-19 is emerging. COVID-19, in addition to posing direct immediate dangers to people with diabetes, may also contribute to poorer diabetes outcomes as a result of pandemic-related disturbances, including stress and changes in regular treatment, food, and physical activity (Hartmann-Boyce et al., 2020). Ran et al. compared diabetes death rates during the pandemic to those in the pre-pandemic era in 2020. They estimated the increase in diabetes deaths associated with the pandemic by calculating the ratio of the relative change in death rates in 2020 versus 2015–2019, while controlling for seasonal variations in deaths and variables that do not change significantly over time, such as age, sex, and race. Between January 1st and November 3rd, 2020, there were 82,928 diabetes-related fatalities recorded, with 62,561 instances occurring during the pandemic period. They found a rise in diabetes mortality related with the pandemic in the 39 states or towns they looked at (relative change in death rates 1.19 [95% CI 1.13, 1.25]) (Ran et al., 2021). Another research published in 2020 found that the COVID-19 death rate among diabetics was 7.3%, more than three times that of the general population. Cardiovascular disease and hypertension, two other

illnesses that are frequent in diabetics, were similarly linked to greater death rates: 10.5% for cardiovascular disease and 6.0% for hypertension (Riddle et al., 2020).

Patients diagnosed with diabetes and high blood pressure are prone to an increased risk of acute COVID-19 infection (Misra & Bloomgarden, 2020). Since the first COVID-19 epidemic in China, much attention has been paid to patients with diabetes because of the infection's dismal prognosis. Although early reports focused mostly on persons with type 2 diabetes, current surveys have revealed that those with type 1 diabetes are also at risk for severe COVID-19. The explanation for a poor prognosis in diabetics is likely multifaceted, reflecting the syndromic nature of the disease. Age, sex, ethnicity, comorbidities like hypertension and cardiovascular disease, obesity, and a pro-inflammatory and pro-coagulative condition are all thought to play a role in the probability of poor outcomes (Apicella et al, 2020). Likewise, various studies found during the literature review indicated that hypertension was linked to a significantly higher chance of severe COVID-19 infection, as well as a similarly significant elevated risk of death (Kulkarni et al, 2020; Lippi et al, 2020; Shah et al, 2021). A literature review conducted by Hassan et al, also highlighted that in individuals infected with COVID-19, those with preexisting NCDs such as diabetes mellitus and cardiovascular disease (CVD) were at a greater risk of poor outcomes and mortality than those without (Hassan et al, 2021).

Studies have revealed that individuals with pre-existing cardiovascular illness and risk factors are more likely to have negative effects due to COVID-19 (Ganatra et al., 2020; Mehra et al., 2020). Many individuals may require medical attention as the virus spreads rapidly, whether for COVID-19-related or typical cardiovascular concerns. Patients with pre-existing cardiovascular risk factors and illness are among the most susceptible, with a higher likelihood of contracting COVID-19 infection, developing COVID-19-related cardiovascular problems, and

suffering negative outcomes (Ganatra et al., 2020). Another study analyzed the connection of cardiovascular illness and pharmacological therapy with in-hospital death among hospitalized patients with COVID-19 who were admitted between December 20, 2019, and March 15, 2020, using a database from 169 hospitals in Asia, Europe, and North America. Coronary artery disease (10.2% vs. 5.2%; OR, 2.70; 95% CI, 2.08-3.51), heart failure (15.3% vs. 5.6%; OR, 2.48; 95%CI, 1.62-3.79), cardiac arrhythmia (11.5%vs. 5.6%; OR, 1.95; 95% CI, 1.33-2.86) and chronic obstructive pulmonary disease (14.2%, vs. 5.6%; OR, 2.96; 95% CI, 2.00-4.40) were among the factors found to be independently associated with an increased risk of in-hospital death due to COVID-19 (Mehra et al., 2020).

Other chronic conditions that go hand in hand and have been exacerbated due to COVID-19 have been asthma and mental illnesses. Asthma is linked to a higher risk of anxiety and depression, and statistics from general population studies show that anxiety and depression levels rose during the pandemic (Morrison et al., 2016; Qiu et al., 2020). Due to the lack of pre-pandemic detailed clinical history or prior psychological assessment in available population studies, one study's goal was to see if people with asthma across a range of age groups had worse mental health, wellbeing, physical symptoms, and social restrictions during COVID-19 lockdown than people without asthma. Shortness of breath, trouble sleeping, food and sleep alterations, fear of contracting COVID-19, and lengthier self-isolation were all mentioned by asthmatic individuals during lockdown (Higbee et al., 2021). COVID-19 has had an impact on physical and mental and well-being by deteriorating both. People with non-communicable diseases such as diabetes, hypertension and asthma need to have a balanced diet, adequate amount of exercise, sufficient supplies of medicine (i.e., insulin) and proper interaction with healthcare professionals when needed (Misra & Bloomgarden, 2020). These healthcare

professionals include not only primary care providers, but also mental health specialists as COVID-19 gave way to a surge of anxiety, stress and depression in a great part of the population and, especially, those in need of continuous medical assistance, medication or treatment and with chronic conditions (Wang, C., 2020). Psychological stress can further escalate blood pressure and blood glucose and vice versa (Misra & Bloomgarden, 2020).

Social Determinants of Health, COVID-19 and people with NCDs

The seniors, immunosuppressed, and those with noncommunicable and preexisting conditions like asthma, CVD and hypertension experience higher risk of becoming severely ill with COVID-19. Structural social disparities in financial status contribute to higher occurrence of these diseases in vulnerable and low-income populations. To help these communities with an increased risk of acquiring COVID-19 due to medical conditions and risk factors, social determinants of health (SDOH) must be taken into account. The SDOHs are a set of five social and economic factors that influence one's health. Health and medical treatment, social and cultural context, neighborhood and constructed environment, education, and financial stability are all important factors to consider. Access to health care, primary care, health insurance coverage, and health literacy are all aspects of health and health care (Lewis et al, 2020 & Singu et al, 2020). Income, education, job, and social support are all examples of SDOH. To put it another way, these are the circumstances under which one is born, grows, lives, works, and ages. Disparities in any of these circumstances are translated into a social hierarchy metric known as socioeconomic status (SES) (Chapman, 2010 & Lowcock et al, 2012). Concentrating on SDOHs, and how they influence a vulnerable populations' health, will aid governments with greater control over health crises so that every individual has equivalent chance of remaining healthy

(Singu et al, 2020). Social determinants of health are progressively being perceived as assuming a significant part in the development of NCDs. (Marmot & Bell, 2019; Murray et al, 2005). Social determinants of health are basic components that can affect not simply the probability of having a NCD or becoming infected with COVID-19, yet in addition, admittance to medical care, and a patient's adherence and continuity with their treatment (T. A. Hassan et al, 2021).

The rapid emergence of the COVID-19 pandemic and sustained waves of transmission driven by viral variants have necessitated rapid acquisition and application of health information, as well as rapid behavioral adaptation. Information about COVID-19 and how to avoid contracting or transmitting the infection have become widely available through health communication. The most useful information is presented in an easy-to-understand format that provides simple and practical answers, such as hand cleaning, preserving physical distance, and knowing where to get the most up-to-date recommendations and guidance. Unfortunately, there is also a lot of confusing, inconsistent, and incorrect information in various readily accessible social media platforms. Individuals are deemed health literate if they can acquire, understand, and apply this information in a sound and ethical manner. The COVID-19 pandemic, on the other hand, has revealed that low health literacy among a population is an underappreciated, global, social determinant of health issue (Kiesha, 2020 & Zarocostas, 2020). The COVID-19 pandemic has shown significant discrepancies among communities as a whole as well. Perhaps the most important notion that ties together the various social variables that influence health is socioeconomic status (Stringhini et al., 2017). For example, socioeconomic status has an impact on where people reside, which has an impact on housing conditions and the safety of public areas (Braveman et al., 2011). Poor living circumstances can lead to overcrowding and poor sanitation, both of which increase the likelihood of COVID-19 transmission. Similarly, socioeconomic

status has an impact on food availability and nutrition. Healthy meals are frequently more expensive, keeping them out of reach for individuals who are financially disadvantaged. Grocery shops and farm markets are typically few in economically deprived areas, limiting access to nutritious foods. Healthy diets, like exercise, lead to better health, reducing comorbidity and one's vulnerability to COVID-19 problems (American Family Physician, 2018).

Because of comorbidities and a lack of access to proper health care, food, and proper information, infection fatality rates and morbidity tend to be greater in lower-income areas. Testing delays and capacity also reveal differences between locations in the quality of health-care delivery systems (Mena et al, 2021). Like a study conducted in Chile concluded, as well as a few others, COVID-19 affects those who are part of the lower socioeconomic status group. Mortality is substantially higher in the elderly, the poor, and ethnic minorities, and its economic impact is likewise unevenly spread throughout the population (Whitehead et al, 2021). A study by Misra and Bloomgarden (2020) also reinforced that prevalence of COVID-19 is altered by social determinants of health such as ethnicity, social-class, access to healthcare and the conditions a person works and lives in, which influence the severity of the pandemic (Dubey, S., 2020).

COVID-19, NCDs and SDOH: Puerto Rico and its territorial health disparities

By April 18, 2022, there had been approximately 504 million COVID-19 cases worldwide (Worldometer, our world in data, JHU CSSE COVID-19 Data). The Caribbean region, divided into the Greater Antilles and the Lesser Antilles, has had a large burden of COVID-19 cases since the beginning of the pandemic. The Greater Antilles are composed of Cuba, Jamaica, Hispaniola (divided into Haiti and Dominican Republic) and Puerto Rico. These 5 countries account for 2.33 million COVID-19 cases. Puerto Rico alone accounts for 491,000

COVID-19 cases (Worldometer, our world in data, JHU CSSE COVID-19 Data). Latin America and the Caribbean region have the highest ratio of confirmed cases to tests performed (around 19%) (Azarpazhooh, M.R., 2020). The region is also one with high rates of uncontrolled NCDs which are constantly increasing, giving way to untimely mortality and placing the region number one in all the Americas for NCD mortality (Hassan, S., 2020; Hassell T, & Hennis A., 2016). Management of NCDs in the Island can be difficult for low-income groups as insurance acquisition has been a constant struggle.

There is no place in the U.S. where Medicare Advantage health insurance is as common as it is in Puerto Rico, where more than 7 out of 10 Medicare-qualified adults participate in the program. While Medicare Advantage plans are as often as possible applauded for the capacity to carry out an innovative inclusion, a conjunction of administrative conditions in the island—including vastly lower reimbursement rates—have promoted instability to the island's medical care framework and made a gigantic gap in patient care assets. Healthcare accounts for 20% of the Puerto Rican economy and low reimbursement rates affect physicians and the island's healthcare infrastructure by forcing closure of individual medical establishments. Somewhere in the range of 2012 and 2017, reimbursement rates in Puerto Rico dropped 5-6% points a year. Subsequently, in 2019, Medicare Advantage reimbursement rates were 43% lower in Puerto Rico than the normal reimbursement rate for the whole U.S. (Richman, 2018). The island's situation is noticeable even among the U.S. Virgin Islands (USVI) with Puerto Rico having a reimbursement rate 26% lower than that of the USVI. A large number of Puerto Ricans have a government-aided medical care and the government's prime concern was to integrate Medicare and Medicaid for dual-eligible adults and to promote more affordable Medicare Advantage plans. The Affordable Care Act changed the manner in which Medicare Advantage reimbursement rates are

determined. Starting in 2010, the law tied the Medicare Advantage reimbursement benchmark to the assessed cost of conventional Federal health care.

Systemic power, economic, political, and social imbalances that lead to social vulnerability and health disparity have repeatedly surfaced as the COVID-19 pandemic evolved. Individual or group traits are rarely to blame for higher rates of disaster-related illness and mortality among marginalized populations. Rather, they are the result of inequities rooted in social and economic systems, which result in people and communities having different options for protecting themselves, different opportunities for seeking and receiving quality healthcare, and generally fewer resources across a range of dimensions. Food, water, housing, and economic security, as well as freedom from racism, prejudice, and gender bias, all minimize the risk of death and suffering from natural catastrophes, especially infectious diseases/COVID-19. Starting with a Zika virus outbreak in 2016, Hurricane Maria in 2017, earthquakes in 2019-2020, and now COVID-19, Puerto Rico has faced a compounded succession of catastrophes with no rest in almost five years. These occurrences are compounded by great societal inequity. Puerto Rico's GDP per capita is around half that of the United States, to which it is a territory, and four out of ten residents live in poverty. The US government provides less funds to the Puerto Rican healthcare system than it does to the mainland, and this limited federal assistance has accelerated the decline in the quality and availability of healthcare services in Puerto Rico (Garriga-López, 2020). In 2020, there were still new cases of symptomatic Zika virus, necessitating ongoing surveillance and attention. The island was still recovering from the devastating aftermath of Hurricane Maria in January 2020, when a 6.4 magnitude earthquake struck the island, displacing more than 7,500 residents. In late Spring 2020 Puerto Rico enforced stringent lockdown measures and social separation in an attempt to mitigate the rapid surge of COVID-19, despite

the fact that some people who were displaced out of their homes during the earthquake were still living in tents. Puerto Rico continues to rebuild and recover in the face of COVID-19, and government support, such as Hurricane Maria relief funds, lags behind the rest of the United States. These conditions have contributed to Puerto Rico having the lowest COVID-19 testing rates per capita in the United States (Glassman, 2019; Hernández, 2020; Roman, 2015; Thomas & Scandlyn, 2020; World Bank, n.d.). In the context of COVID-19, Puerto Rico is one of several places around the world where calamities are wreaking havoc on already fragile socioeconomic institutions. Conditions of compounding societal vulnerability decrease the ability to tolerate any future hazard incidents.

The literature review has highlighted that we have indirect evidence on how NCD care has been disrupted by COVID-19, but not information specific to the magnitude of the change in outcomes, specifically in Caribbean. This, because information obtained related to these topics is limited and more so in this geographic region. There was no literature for non-communicable diseases and the role social determinants of health play on NCDs management and control in Puerto Rico, although this information is available for US mainland. The aforementioned studies show the need to investigate the association between sociodemographic and geographic factors that are associated with a change in the level of control of diabetes and hypertension in correlation with the COVID-19 pandemic. Similarly, this work can provide health care organizations with robust data to inform disaster preparedness efforts and secure additional funding to support preparedness of vulnerable populations with NCDs. Improved monitoring, therapy, and/or control of NCDs, such as diabetes and hypertension may lead to better clinical outcomes in patients infected with COVID-19, according to growing evidence (Ran et al, 2020 &

Zhu et al, 2020). Research is necessary in order to better prepare and control NCDs before and after an adverse natural event such as a pandemic.

Chapter 3: Manuscript

Abstract

Introduction: In March 2020, the COVID-19 epidemic broke out in Puerto Rico and an island wide lockdown period from March 15 to April 12 was put into effect. Asthma, diabetes, and hypertension are three of the most frequent chronic illnesses in Puerto Rico, and they are among the major causes of disability and mortality. Patients with chronic conditions were disproportionately impacted during the early stages of the COVID-19 pandemic. **Methodology:** This study was conducted using electronic health record data from patients who receive medical services at any of HealthproMed's clinics throughout Puerto Rico. We compared the proportion of patients with uncontrolled diabetes (HbA1c ≥ 9%) and uncontrolled hypertension (SBP ≥ 150mmHg) before and during the COVID-19 pandemic. A univariate analysis was conducted, as well as a bivariate analysis and tests of association to determine if there is an association between changes in the proportion of patients with uncontrolled SBP and HbA1c and the social determinants of health of income and insurance. **Results:** After reviewing both the hypertension and diabetes results, we can see concerning trends with a rise in uncontrolled diabetes and hypertension and a reduction in visits to the healthcare centers after the start of the COVID-19 pandemic in 2020. Our findings showed that HealthproMed site location, as a proxy for income, was associated with control of hypertension and diabetes, except in diabetes for 2019 ($p > 0.05$). Insurance type was associated with worse health outcomes in all cases, except for control of SBP in 2020 ($p > 0.05$). For both SBP and HbA1c controlled and uncontrolled measurement proportions, a significant difference was observed when comparing both, pre COVID-19 period (January-March 2020) and post COVID-19 period (April-June 2020) to the same periods in 2019. **Discussion:** It is critical to develop strategies that enable and promote effective self-

management and inform individuals on how to identify challenges and ways to manage adversities associated with their illness that might arise after an event of such magnitude. More robust policies should also be developed to achieve management of NCDs, whether it is through state or federal governments. The need for a unified, multi-sector strategic approach to not only identify areas of insufficiency in the present management system, but also to devise meaningful solutions to this public health disaster is clear.

Introduction

In March 2020 Puerto Rico faced the beginning of the COVID-19 pandemic. The island has had already more than 465,021 coronavirus cases, as of February 6th, 2022, and approximately 3,953 deaths, with transmission rates rising up the last week of April 2021 to 28 cases per 100,000 people a day, compared with 17 per 100,000 on the U.S. mainland (Departamento de Salud de Puerto Rico, 2022).

Puerto Rico suffers a disproportionate burden of common chronic diseases: asthma, diabetes, and hypertension are three of the leading causes of disability and death. A study among island Puerto Rican and mainland US older adults showed that a large proportion of adults reported hypertension, with rates ranging from 51 to 69%. Island Puerto Ricans also reported diabetes as the second most common condition (Pérez & Ailshire, 2017). Another study showed that among Hispanics, Puerto Ricans (12.8%) were more likely to have asthma (Stern & Litonjua, 2020). The burden of chronic diseases is shared unequally across the population. Puerto Rico suffers from a triple burden of limited healthcare services, high poverty rate, and high prevalence of chronic diseases. This situation impacts COVID-19 outcomes; it has been

demonstrated that people with diabetes are more likely to have worse complications from COVID-19 compared to those without diabetes (Palaiodimos et al, 2021).

The island's social and economic inequalities give way to vulnerability when it comes to disasters (Santos, 2007). When compared to the rest of the population, people in low socioeconomic strata and older adults have usually higher levels of disability, morbidity and mortality from adverse events, such as COVID-19 (Patel et al., 2020; Shadmi et al., 2020; Shahid et al., 2020; García et al., 2021). During early COVID-19 pandemic, it was observed that patients with chronic diseases were disproportionately affected, possibly because physical exercise was reduced during lockdown mitigation measures, routine checkup and lab testing were missed, and access to healthcare services was compromised.

Research on management of NCDs after an adverse event can help inform future policy and emergency preparedness decisions regarding proper ways to control NCDs and what factor influence this control. As such, the objective of this study was to determine if there was a change in the proportion of individuals with uncontrolled diabetes and hypertension preceding and after the COVID-19 pandemic. A secondary objective was to see if changes in the level of control differed by clinical site or by insurance type, as proxies to income level. The hypothesis was that an increase in the proportion of uncontrolled hypertension and diabetes was to be seen.

Methods

This study was conducted using electronic health record data of patients who receive medical services at any of HealthproMed's clinics throughout Puerto Rico. HealthproMed is comprised of 5 centers across Puerto Rico. These 5 centers are located in Carolina, Culebra, Guaynabo, San Juan, and Vieques. HealthproMed San Juan is the center with the largest amount

of patients with hypertension as this is the largest HealthproMed center in Puerto Rico. Electronic health record data was received for patients 18 or older . Data were acquired from de-identified electronic health record data from patients with a diagnosis of diabetes and/or hypertension from 2019-2021. This study was exempt from full IRB committee review as the study was considered an evaluation of existing de-identified data routinely collected by the participating FQHC and did not entail any risks associated with human subjects research.

The dependent variables that were used included hemoglobin A1c (HbA1c) for diabetes, and systolic blood pressure (SBP) for hypertension. For the independent variables, we included data on age, gender, insurance, and HealthproMed center in which service was received. Variables insurance and HealthproMed center were used as proxies to analyze the impact of social determinants of health on management of NCDs due to the absence of other indicators. The location of HealthproMed center was used to establish an approximation of median household income for patients served by each particular center **(Table 1).**

Table 1. Median household incomes per center and zip codes (2019)

HealthproMed center	zip code	Median household income
Vieques	00765*	$15,539
San Juan	00901, 00902, 00906, 00907, 00908, 00909, 00910, 00911, 00912, 00913, 00914, 00915*, 00916, 00917, 00919, 0920, 00921, 00923, 00924, 00925, 00926, 00927, 00928, 00929, 00930, 00931, 00933, 00934, 00936, 00940	$22,146
Culebra	00775*	$23,802
Carolina	00979, 00981, 00982, 00983*, 00984, 00985, 00986, 00987, 00988	$29,434
Guaynabo	00965, 00966, 00968, 00969*, 00970, 00971	$33,937

*zip code of HPMcenter; Source: Instituto de Estadísticas de Puerto Rico (2019)

We excluded outliers (above 260mmHg and below 74mmHg) because we concluded these were not clinically relevant; 10 values were excluded previous to description of the range. We collapsed all systolic measures into two categories: controlled blood pressure (systolic measurement < 150mmHg) and uncontrolled blood pressure (systolic measurement ≥ 150mmHg). For diabetes, we excluded outliers above 17.6% and below 3.8%; 15 values were excluded. We then classified measurements into controlled diabetes (HbA1c measurement < 9%) and uncontrolled diabetes (HbA1c measurement ≥ 9%).

For the analysis, we compared the proportion of patients with uncontrolled diabetes (HbA1c ≥ 9%) and uncontrolled hypertension (SBP ≥ 150mmHg) over time. According to the American Heart Association and the American College of Cardiology, when discussing only SBP, a normal SBP would be <120mmHg, an elevated SBP would be at 120-129mmHg, a SBP classified into stage 1 hypertension would be between 130-139mmHg and a SBP of ≥140mmHg would be classified as stage 2 hypertension (Goetsch et al., 2021 & Unger et al., 2020). To give way to values greater than, but close to 140mmHg SBP, we made our cutoff for data points at 150mmHg SBP. According to the American Diabetes Association, a normal HbA1c level is below 5.7%, a level of 5.7-6.4% indicates prediabetes, and a level of 6.5% or more indicates diabetes (ADA, n.d.). For our analysis, the threshold of and HbA1c of 9% was chosen as it is a position high enough across the HbA1c scale to determine a definite uncontrolled level of HbA1c but it is still not in an emergency state when observed in an HbA1c continuum. In addition, this is the level defined by the Centers for Medicare and Medicaid (CMS) for their Merit-Based Incentive Payment System (MIPS); it is important for the clinic to minimize the proportion of patients with HbA1c > 9% because of the CMS MIPS Quality Indicator (AMA, 2020 & CMS, 2022). An emergency state occurs when HbA1c is severely elevated and can give

way to risk of complications such as heart attack, stroke, blindness, kidney failure and/or amputations (Angela Manderfeld, 2020). A univariate analysis resulted in tables of frequency distributions and measures of central tendency and spread.

For the bivariate analysis of categorical variables, the Pearson's Chi-square test of association was used to determine if there was a significant difference in the proportion between uncontrolled SBP and HbA1c measurements and our categorical variables (facility, age, gender and type of insurance). Because the sample size consisted of more than 30,000 SBP measurements and more than 2,900 HbA1c measurement, a chi-square test was chosen over a Fisher's exact test. It is worth mentioning that despite having data for 7,925 patients with a diagnosis of hypertension and 6,830 patients with a diagnosis of diabetes, when analysis was divided by year, the number of measurements does not correspond to the number of patients because measurement frequency varies greatly among patients in both groups (i.e. some patients have monthly measurements, some patients have weekly measurement, etc.)

Knowing times of beginning of COVID-19 pandemic, we used a chi-squared test to analyze if there was any significant change in the proportion of SBP and HbA1c the 3-months before and after the onset of the COVID-19 pandemic, these being January 2020 to March 2020 and April 2020 to June 2020 (3-months was chosen because of interval for HbA1c change and average time for restoration of health services).

Additionally, we analyzed data acquired from "teleconsulta", or telehealth, visits. Data was provided for amount of patients who utilized "teleconsulta" services after the onset of the COVID-19 pandemic. Unfortunately, the service of "teleconsulta" had never been used before in any of the five HealthproMed centers. Figures were created to observe number of "teleconsulta" visits per center.

Results

HYPERTENSION

We received data for a total of 7,925 patients diagnosed with hypertension. Of those, 59.38% (n=4,706) identified as female, 40.56% (3,214) as male and 0.06% (5) as unknown. Age of patients included in the data spreadsheet ranged from 18 to 106 years of age with the average age being 58 years **(Table 2).**

Table 2. Sex, age-groups, HPM facility, and source of health insurance of study population with diagnosis of hypertension (2019-2021)

Variable	N (col. %)	Controlled SBP n (row %)	Uncontrolled SBP n (row %)	p-value
Patient Gender				
Female	4,706 (59.38)	15,439 (77.88)	4,386 (22.12)	
Male	3,214 (40.56)	8,060 (77.34)	2,361 (22.66)	0.372
Unknown	5 (0.06)	3 (100)	0 (0)	
Total	7,925 (100)			
Patient Age				
18-39	747 (9.43)	1,769 (88.94)	220 (11.06)	
40-59	3,419 (43.14)	11,302 (82.31)	2,429 (17.69)	0.000
60-79	3,266 (41.21)	9,624 (73.33)	3,500 (26.67)	
80 ≤	493 (6.22)	807 (57.44)	598 (42.56)	
Total	7,925 (100)			
Patient Facility				
HPM Carolina	1,128 (14.23)	4,297 (80.35)	1,051 (19.65)	
HPM Culebra	630 (7.96)	3,219 (85.77)	534 (14.23)	0.000
HPM Guaynabo	708 (8.93)	3,148 (78.35)	870 (21.65)	
HPM San Juan	4,664 (58.85)	10,918 (74.61)	3,715 (25.39)	
HPM Vieques	795 (10.03)	1,920 (76.89)	577 (23.11)	
Total	7,925 (100)			
Patient Insurance				
Medicaid	4,680 (59.05)	15,558 (77.24)	4,584 (22.76)	
Medicare	989 (12.48)	2,903 (78.29)	805 (21.71)	0.000
Private	762 (9.62)	1,786 (82.27)	385 (17.73)	
Uninsured	1,494 (18.85)	3,255 (76.99)	973 (23.01)	
Total	7,925 (100)			

SBP= systolic blood pressure, N= total number of patients within each subgroup of each categorical variable; n= number of SBP measurements recorded and classified as either controlled or uncontrolled within each subgroup of each categorical variable (gender, age, facility and insurance type).

A total of 4,664 patients (58.85%) received services in HealthproMed San Juan. The smallest HealthproMed center is located in Culebra and serves a total of 630 patients with hypertension (7.96%). **Table 2** lists all HealthproMed centers with the proportion of their patients with a diagnosis of hypertension. We examined the insurance status of patients with hypertension (i.e. Medicaid, Medicare, any private insurance, or uninsured). Our results in **Table 2** indicate that the majority of patients were insured by Medicaid (59.05%). Another 989 patients were insured by Medicare (12.48%), 762 patients had private insurance (9.62%), and 1,494 patients that had no type of insurance (18.85%).

When we divided our analysis by year into 2019 and 2020, HPM facility was found to be associated with control of SBP both years while insurance was only found to be associated with level of control of SBP in 2019 ($p < 0.05$) (see **Table A** and **Table B** in appendix). These tables include analysis based on patients who had at least one measurement of SBP recorded for the respective year.

After creating our descriptive sociodemographic statistics consisting of gender, age, HealthproMed center, and insurance, we analyzed systolic blood pressure (SBP) between 2019 and 2021. We encountered a total of 30,249 systolic blood pressure measurements after the data was cleaned, meaning we removed incorrectly formatted, duplicate or incomplete data from the dataset. The average systolic blood pressure was 138.4mmHg (SD 20.0); minimum blood pressure was of 77mmHg and maximum of 255mmHg (range = 77-255mmHg). Summary results by HPM center and year are shown in **Table C** and **Table D** in appendix, respectively .

When it comes to hypertension, the proportion of uncontrolled SBP reduces from 26.29% in March 2020 to 24.21% in April 2020 **(Table 3)**. We observed the proportion of uncontrolled SBP decrease over time after the onset of the COVID-19 pandemic and drastically increase in

September 2020 to 29.67%, peaking in October 2020 and December 2020 to 32.6% and 32.4%, respectively (**Table 3**, **Figure 1**). We can see how this correlates with the COVID cases count in the island (see **Figure A** in appendix). Proportions of controlled and uncontrolled SBP measurements per month of 2019 and 2021 can be found in appendix (**Table E** and **Table F**).

Table 3. Number and Proportion of controlled/uncontrolled SBP measurements per month for 2020

Date	Hypertension		Total
	Controlled SBP n (row %)	Uncontrolled SBP N (row %)	
Jan 2020	807 (74.52)	276 (25.48)	1,083
Feb 2020	944 (75.34)	309 (24.66)	1,253
Mar 2020	600 (73.71)	214 (26.29)	814
Apr 2020	191 (75.79)	61 (24.21)	252
May 2020	390 (75.44)	127 (24.56)	517
Jun 2020	568 (75.23)	187 (24.77)	755
Jul 2020	567 (76.31)	176 (23.69)	743
Aug 2020	569 (78.37)	157 (21.63)	726
Sep 2020	602 (70.33)	254 (29.67)	856
Oct 2020	616 (67.40)	298 (32.60)	914
Nov 2020	638 (69.96)	274 (30.04)	912
Dec 2020	595 (67.61)	285 (32.39)	880

SBP= systolic blood pressure, n= number SBP measurements recorded and classified as either controlled or uncontrolled for a given month and year.

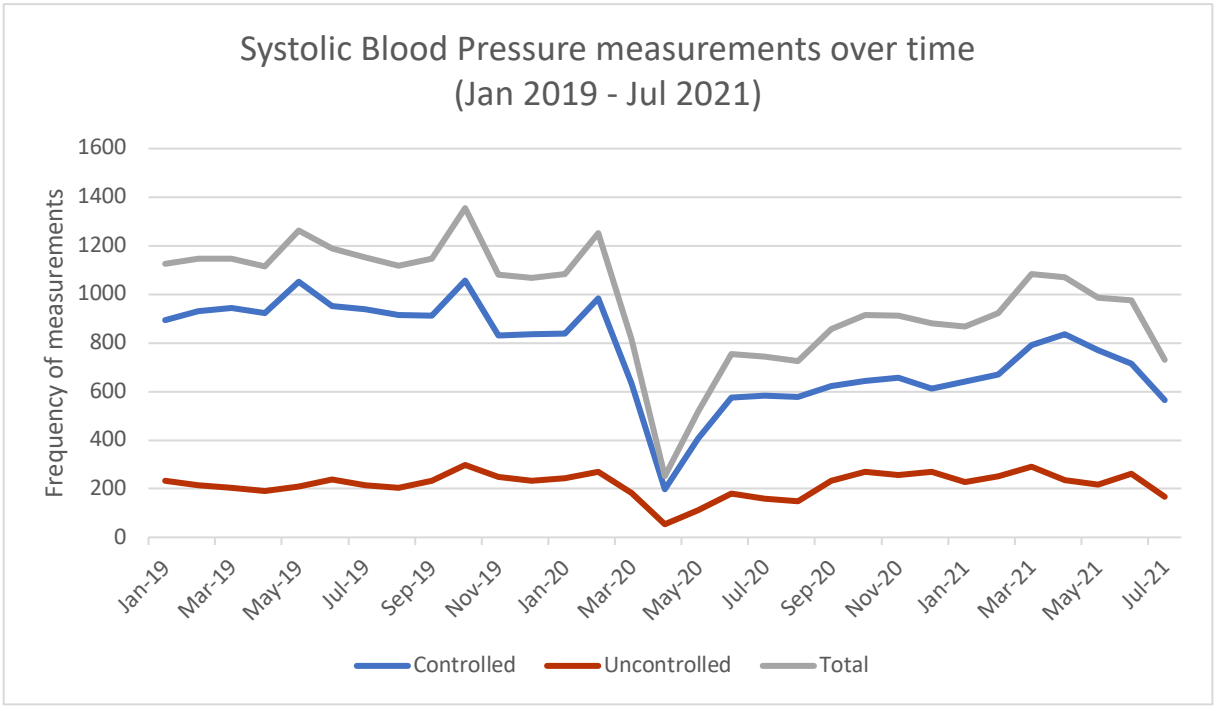
The onset of the COVID-19 pandemic was mid-March 2020. We compared the pre-COVID period measurements of SBP from January 2020 – March 2020 with measurements from the same period in 2019 (January 2019 – March 2019). We then did this as well for the 3 months following the onset of the COVID pandemic (April 2020 – June 2020) and compared these

measurements with those from the same period in 2019 (April 2019 – June 2019). A chi-squared test was conducted and differences among the same period in two different years were found to be significant across all time intervals **(Table 4)**.

Table 4. Analysis of proportion of controlled/uncontrolled SBP measurements by time intervals (2019 vs. 2020)

Time intervals	Proportion of controlled measurements (% 2019 / % 2020)	Proportion of uncontrolled measurements (% 2019 / % 2020)	*p-value*
Jan.-Mar. 2019/2020	81.01 / 77.94	18.99 / 22.06	0.002
Apr.-Jun. 2019/2020	82.09 / 77.43	17.91 / 22.57	0.000
Jul.-Sep. 2019/2020	80.92 / 76.73	19.08 / 23.27	0.000
Oct.-Dec. 2019/2020	77.70 / 70.58	22.30 / 29.42	0.000

Figure 1. Distribution of systolic measurements (Jan. 2019 – Jul. 2021)



DIABETES

There were a total of 6,830 patients diagnosed with diabetes. Of those, 4,114 (60.23%) identified as female, 2,712 (39.71%) as male and 4 (0.06%) as unknown. Age of patients included in the data spreadsheet ranged from 18 to 106 years of age with the average age being 58 **(Table 5)**.

Table 5. Sex, age-groups, HPM facility, and source of health insurance of study population with diagnosis of diabetes (2019-2021)

Variable	N (col. %)	Controlled HbA1c n (row %)	Uncontrolled HbA1c n (row %)	p-value
Patient Gender				
Female	4,114 (60.23)	1,001 (54.08)	850 (45.92)	
Male	2,712 (39.71)	509 (47.93)	553 (52.07)	0.004
Unknown	4 (0.06)	1 (100)	0 (0)	
Total	6,830 (100)			
Patient Age				
18-39	614 (8.99)	73 (54.89)	60 (45.11)	
40-59	3,014 (44.13)	589 (46.16)	687 (53.84)	0.000
60-79	2,811 (41.16)	764 (54.89)	628 (45.11)	
80 ≤	391 (5.72)	85 (75.22)	28 (24.78)	
Total	6,830 (100)			
Patient Facility				
HPM Carolina	978 (14.32)	454 (54.05)	386 (45.95)	
HPM Culebra	544 (7.97)	190 (54.76)	157 (45.24)	0.002
HPM Guaynabo	642 (9.40)	202 (46.76)	230 (53.24)	
HPM San Juan	3,982 (58.30)	607 (50.21)	602 (49.79)	
HPM Vieques	684 (10.01)	58 (67.44)	28 (32.56)	
Total	6,830 (100)			
Patient Insurance				
Medicaid	4,105 (60.10)	1,029 (49.40)	1,054 (50.60)	
Medicare	2,712 (11.52)	206 (71.78)	81 (28.22)	0.000
Private	633 (9.27)	56 (62.22)	34 (37.78)	
Uninsured	1,305 (19.11)	220 (48.46)	234 (51.54)	
Total	6,830 (100)			

HbA1c= Glycated hemoglobin/blood test that is used to help diagnose and monitor people with diabetes**,** N= total number of patients within each subgroup of each categorical variable; n= number of HbA1c measurements recorded and classified as either controlled or uncontrolled within each subgroup of each categorical variable (gender, age, facility and insurance type).

HealthproMed San Juan is the center with the largest number of patients diagnosed with diabetes as this is the largest HealthproMed center in Puerto Rico. A total of 3,982 patients

(58.30%) received services in HealthproMed San Juan. Culebra served the smallest number of patients with diabetes (7.97%) from 2019-2021 for a total of 544 patients. **Table 5** lists all HealthproMed centers with their respective patients with diabetes.

Analyzing the patient's health insurance, results in **Table 5** indicate that the majority of patients were insured by Medicaid (60.10%), as was the case with the patients diagnosed with hypertension. Medicare was the primary source of health insurance for 11.52% of the patients, 9.27% of patients had private insurance and 19.11% were uninsured.

When we divided our analysis by year into 2019 and 2020. HPM facility was found to be associated with control of HbA1c in 2020 only ($p < 0.05$). Insurance was found to be associated with level of control of HbA1c in both, 2019 and 2020 ($p < 0.05$) (see **Table H** and **Table I** in appendix). These tables include analysis based on patients who had at least one measurement of HbA1c recorded for the respective year.

We observed a total of 2,914 HbA1c measurements after the data was cleaned, meaning we removed incorrectly formatted, duplicate or incomplete data from the dataset. The average HbA1c was of 9.3% (SD 2.4) and we had a minimum value of 3.8% and a maximum measurement of 17.6% (range = 3.8-17.6%). Measurements smaller than 3% and greater than 17.6% were excluded for a total of 15 exclusions. These measurements were considered not clinically relevant. It is worth mentioning that most laboratories also just report > 16%, therefore anything much greater than that is prone to be an incorrectly recorded measurement. Summary results by HPM center and year are shown in **Table J** and **Table K** in appendix, respectively .

We divided all HbA1c measures into controlled HbA1c (HbA1c measurement < 9%) and uncontrolled HbA1c (HbA1c measurement ≥ 9%). Over time, patients with measurements of uncontrolled diabetes (HbA1c ≥ 9%) increased from 41.6% in December 2019 to 51% in March

2020. Up to 82.4% of measurements had uncontrolled HbA1c in April 2020. We observe a drastic reduction in measurements recorded for April 2020, immediately after the onset of the COVID-19 pandemic. Additionally, lockdown period in Puerto Rico was from March 15th to April 12th, with the exception of essential businesses and medical centers. Even before the COVID-19 pandemic, the proportions of uncontrolled HbA1c were upward trending. Proportions of controlled and uncontrolled HbA1c measurements per month of 2019 and 2021 can be found in appendix (**Table L** and **Table M**). However, we see the proportion of uncontrolled HbA1c reach 82% in April 2020 immediately after the onset of the pandemic (**Table 6**, **Figure 2**).

Table 6. Number and Proportion of controlled/uncontrolled HbA1c measurements by month, 2020

Date	Diabetes		Total
	Controlled HbA1c n (row %)	Uncontrolled HbA1c n (row %)	
Jan 2020	36 (42.86)	48 (57.14)	84
Feb 2020	50 (47.62)	55 (52.38)	105
Mar 2020	25 (49.02)	26 (50.98)	51
Apr 2020	3 (17.65)	14 (82.35)	17
May 2020	72 (46.75)	82 (53.25)	154
Jun 2020	103 (40.71)	150 (59.29)	253
Jul 2020	32 (51.61)	30 (48.39)	62
Aug 2020	27 (42.86)	36 (57.14)	63
Sep 2020	20 (32.26)	42 (67.74)	62
Oct 2020	28 (31.11)	62 (68.89)	90
Nov 2020	17 (33.33)	34 (66.67)	51
Dec 2020	15 (26.32)	42 (73.68)	57

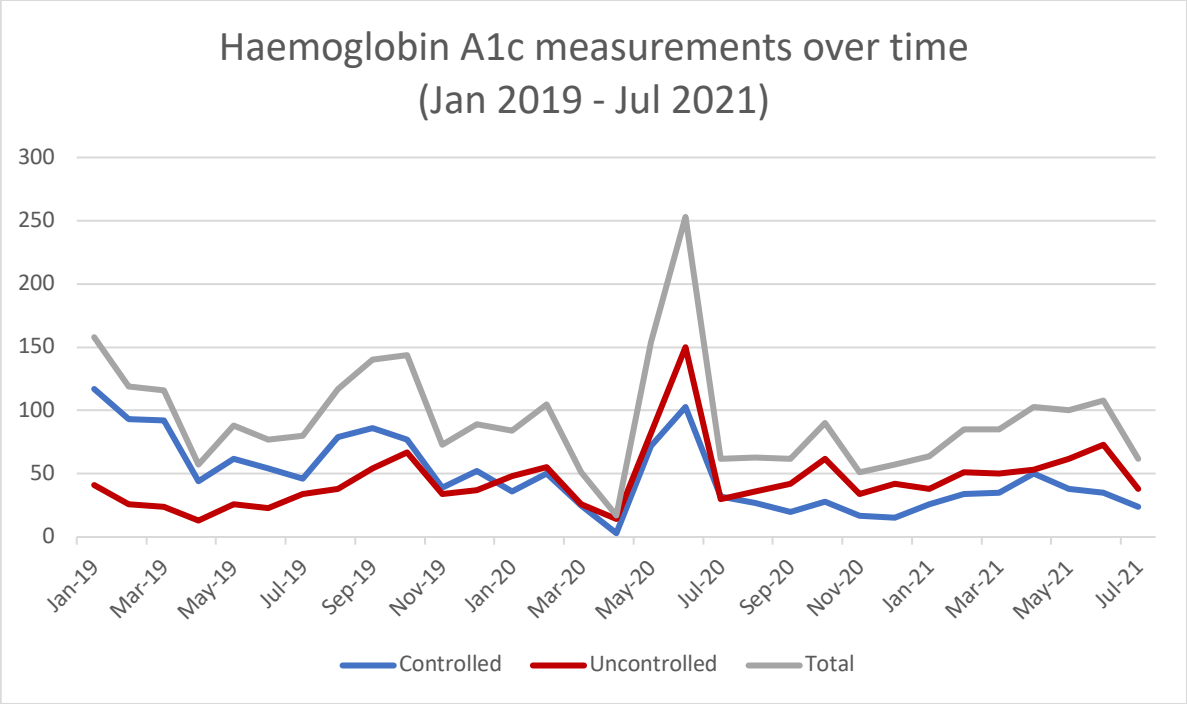
HbA1c= Glycated hemoglobin/blood test that is used to help diagnose and monitor people with diabetes; n= number HbA1c measurements recorded and classified as either controlled or uncontrolled for a given month and year.

As observed with SBP measurements, there were nearly 17% fewer measurements in 2020 compared with 2019 (1,049 vs 1,258) (see **Table K** in appendix). We also examined data for patients with a diagnosis of diabetes and looked at trends in their hemoglobin A1c (HbA1c). HbA1c is a measure of the average blood glucose (sugar) level over a 3-months period. We looked at the trend in the proportion of patients with controlled and uncontrolled diabetes (HbA1c ≥ 9%). We examined whether there was any significant change in these numbers 3-months before and after the start of the COVID-19 pandemic (3- months is chosen because of interval for HbA1c change and average time for restoration of health services). This analysis was done with a Pearson's chi-square test to assess significance in change. From the analysis we conducted we see that across time intervals included for analysis (**Table 7**), there seemed to be a significant change across all.

Table 7. Analysis of proportion of controlled/uncontrolled HbA1c measurements by time intervals (2019 vs. 2020)

Time intervals	Proportion of controlled measurements (% 2019 / % 2020)	Proportion of uncontrolled measurements (% 2019 / % 2020)	*p-value*
Jan.-Mar. 2019/2020	76.84 / 46.25	23.16 / 53.75	0.000
Apr.-Jun. 2019/2020	72.07 / 41.98	27.93 / 58.02	0.000
Jul.-Sep. 2019/2020	63.45 / 47.20	36.55 / 52.80	0.004
Oct.-Dec. 2019/2020	54.90 / 30.30	45.10 / 69.70	0.000

Figure 2. Distribution of HbA1c measurements, Jan. 2019 – Jul. 2021



Discussion

Adverse events such as the COVID-19 pandemic interrupt services for treatment and management of NCDs. Our analysis showed that number of SBP and HbA1c measurements drastically decreased after the onset of the COVID-19 pandemic and during the lockdown period (March 15 – April12, 2020) which suggests a reduction in patient visits over that time. in addition, there was an increase in the proportion of uncontrolled SBP and HbA1c. While the increase in uncontrolled SBP was seen after a period of about 5 months, the proportion of uncontrolled HbA1c was seen immediately in April 2020, after the onset of the pandemic.

Our findings showed that HealthproMed site location, as a proxy for income, was associated with control of hypertension in all years (2019-2021). For SBP, HealthproMed San Juan was the site with highest proportion of uncontrolled SBP measurements. Site was also associated with control of diabetes when overall analysis was conducted for 2019-2021 but showed to be not significant when analyzed by single years (not associated in 2019 and associated in 2020). For HbA1c, HealthproMed Guaynabo was the site with highest proportion of uncontrolled HbA1c measurements. It is important to keep in mind that from all the HealthproMed sites, Vieques has the lowest median household income and Guaynabo has the highest. Puerto Rico is considered a global north country as it is part of the United States. A systematic review conducted to assess association of location of health care site and health outcomes concluded that a link between traveling further and having poorer health outcomes cannot be ruled out and should be considered when planning healthcare service placement (Kelly et al., 2016). Further analysis in which patients are classified by distance from home to healthcare center should be conducted in order to clearly investigate this association, particularly in Puerto Rico and amongst FQHCs. Data was also acquired for “teleconsulta” or telehealth

visits. Expectedly, San Juan had the greatest amount of "teleconsulta" visits possibly due to it being the largest HealthproMed location with the greatest number of patients. Conversely, smaller centers might have fewer in-person visits due to limited capacity to accommodate patients on a schedule. "Teleconsulta" was implemented after the onset of the pandemic and no records show previous use of this service before April 2020. With health service disruption and limited in-person visits, control of NCDs appears to worsen.

Insurance type was associated with worse health outcomes in all cases, except for control of SBP in 2020 ($p > 0.05$). For SBP there was a larger proportion of uncontrolled measurements in those without insurance overall and when divided into years for the year 2019. For HbA1c, it was interesting to note that overall, the proportion of uncontrolled measurements was highest among those without insurance but when broken down by year, we see that in 2019 the highest proportion of uncontrolled measurements was found to be among those with Medicaid and 70% of patients had Medicaid for that year. This might explain the change in position between uninsured and those with Medicaid. For 2020, however, we see that those uninsured had the highest proportion of uncontrolled HbA1c measurements and, interestingly, there were 14% of patients that year that had no health insurance for which 71% of HbA1c measurements among this group were classified as uncontrolled. This finding is consistent with other literature as discussed in the literature review chapter. Management of NCDs and other conditions in Puerto Rico can be difficult for low-income groups as acquiring insurance can be a challenge for many, especially for immigrants served by FQHCs. Approximately 19% of patients had no type of insurance. This number is surprisingly high when compared to the average for Puerto Rico where 6% of the population is uninsured (KFF, 2017). This could reflect that HealthproMed centers

serve immigrants from nearby islands who lack proper documentation required for health insurance coverage in Puerto Rico.

To see if there was a significant difference in controlled and uncontrolled measurements proportions for SBP and HbA1c between pre (Jan.-Mar. 2020) and post (Apr.-Jun. 2020) COVID-19 periods to the same periods in 2019 (Jan.Mar. 2019 and Apr.-Jun. 2019), we conducted comparisons using chi-square tests. Findings yielded unexpected results as we expected not to find a significant difference among the comparison of pre COVID-19 period and the same period in 2019. For both SBP and HbA1c, a significant difference was observed when comparing both, pre COVID-19 period (January-March 2020) to the same period in 2019 and post COVID-19 period (April-June 2020) to the same period in 2019. The latter was expected. These significant differences can bring to light in a near future other things that might also influence control of NCDs, particularly in HealthproMed. For example, we can evaluate whether or not follow-up care was delayed during January-March 2019 due to earthquakes happening across the island as it was delayed due to COVID-19 in the same period in 2020. These types of analysis might help establish hypothesis and study associations.

As has been mentioned before, access to health insurance coverage is an aspect of health and health care that greatly determines a patients prognosis (Lewis et al, 2020 & Singu et al, 2020). As was seen in our analysis, those without health insurance were most vulnerable to uncontrolled HbA1c measurements. To optimize treatment and care for persons with NCDs before, during, and after an adverse event, disaster planning must include the factors for successful self-management. Access to medication, medical services, treatment and care, and food are all factors. Not surprisingly, for both SBP and HbA1c, we saw a decrease in

measurements in 2020 when compared to 2019. This might be attributed to the limited access to services during the implementation of pandemic mitigation measures.

The increase in uncontrolled SBP and HbA1c trends over time is likely related to multiple factors including, but not limited to, health system, provider and patient barriers. Puerto Rico is not the exception as in mainland US, these barriers have been well be attributed to contribute to uncontrolled hypertension and diabetes (Garg et al, 2020 & Skeet et al., 2020).. Some of these hurdles include social distancing, which limits access to care, clinic cancellations during lockdown periods, fear of seeking in-person care owing to the risk of being infected with COVID-19, job loss, which the associated financial stress and lack of financial resources to acquire medicines. In addition, increased reliance on telehealth and video visits may limit access to patients who have limited access to the required equipment, our could be less technically adept. These obstacles are likely to lead to treatment gaps that result in missed medicines and an increased risk of acute consequences of uncontrolled hypertension and diabetes. All of these barriers are plausible contributors to the increasing proportion of uncontrolled NCDs after the onset of the pandemic and disruption of health services. All these have been observed throughout the rest of mainland US as well (Skeet et al., 2020).

Similar to our study, others have shown that elsewhere in the US rates of controlled blood pressure are falling, particularly among people of color and those without health insurance (Bress et al., 2021). Another study found that during the COVID-19 pandemic, there was a significant decrease in emergency department visits for acute life-threatening conditions such as cardiovascular disease complications and hyperglycemic crisis, implying that patients may be delaying, avoiding care, or unable to access care (Lange et al., 2020). These observations are

consistent with our results documenting fewer patient visits following the start of the COVID-19 pandemic, as well as a significant reduction in the number of SBP and HbA1c readings collected.

This ongoing pandemic has caused remarkable morbidity and death, as well as tremendous economic and physical burdens. NCDs such as hypertension and diabetes continue to remain a major source of global disease burden. These NCDs are at risk of being relegated from public attention during the COVID-19 pandemic. Clearly hypertension and diabetes health problem cannot be ignored by healthcare practitioners, politicians, or the general public, as these continue to wreak havoc, particularly in vulnerable communities.

Trends in SBP and HbA1c control have been described throughout this research, as well as the associated impact of site location and insurance type as proxies for income. The potential causes of suboptimal NCD management were discussed and contrasted to analogous conditions on the US mainland. Our findings are concordant with those observations and are likely applicable to other nations with a high burden of NCDs and healthcare systems that may experience similar gaps in NCD management during disruptions that can be forecasted with future pandemics.

The main limitation of our study is the generalizability of these findings, which must be carefully considered. The analysis was conducted with data from Federally Qualified Health Centers in Puerto Rico. Puerto Rico is a U.S. territory located in the Caribbean region and where the prevalence of NCDs is higher than the U.S. mainland. We only focused on diabetes and hypertension and not other NCDs which can cause a change in trends if included in this analysis. Statistical analysis did not include controlling for confounders. To carry out analysis, we received aggregate data instead of patient-specific data. Lastly, we had an absence of other metrics to more precisely assess role of social determinants of health. Strengths of the study

included it being the first study of its kind to address NCD control after a disaster/adverse event in Puerto Rico. Other studies have addressed prevalence of NCDs but not exactly how proportions differ after an adverse event. The availability of data also made this study possible and allowed for different analysis without a need to excessively clean or reorganize the data. All analyses were efficient at describiding our population under study and methods can easily be complemented to include other NCDs for analysis,

Conclusion

This analysis emphasizes the difficulties in controlling NCDs following adverse events that interrupt normal daily health service operations. It is critical to develop strategies that enable and promote effective self-management and inform individuals on how to identify challenges and ways to manage adversities associated with their illness that might arise after an event of such magnitude. In addition, healthcare centers should learn from the COVID-19 pandemic and find innovative ways to overcome the need for in-person clinic visits and of the importance of task shifting within communities to reach individuals and provide adequate care. Every organization and center needs to provide the ability to patients of self-monitoring their blood pressure measurements and keeping a log of these which, hopefully, can be sent to HPM. Management of NCDs such as hypertension and diabetes is crucial, especially after an adverse event where medical care and follow-up treatment might be interrupted or scarce. It is paramount to ensure adequate medicine supplies to have at the time when disruptions in service is anticipated. Additionally, having plans of action to provide guidance for potential places for care in case of adverse events can be beneficial to those with uncontrolled conditions. These strategies and interventions should be multi-disciplinary and collaborative, where centers, such as HealthproMed, providers and patients work together for their communal well-being.

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Chapter 4: Conclusion and Recommendations

After reviewing both the hypertension and diabetes results, we can see concerning trends with a rise in uncontrolled diabetes and hypertension and a reduction in visits to the healthcare centers after the start of the COVID-19 pandemic in 2020. Although more research is needed to confirm a temporal trend that is different from what would be happening without COVID-19, this demonstrates the detrimental effect of adverse events on people living with NCDs and, in particular, the management of their chronic conditions. The causes for this trend in blood pressure and blood sugar control after an adverse event is likely multi-factorial. The lockdown periods limited the ability of patients to see their primary care physician for routine care and follow up. We speculate that access to routine medication and treatment might have been disrupted after an event of this magnitude. A contribution of pharmacies in managing chronic conditions and promoting adherence to a patient's medications is vital, not only to relieve burden on healthcare systems but also to ensure the least amount of patients with NCDs fail to manage their condition which can result in long term complications. Pharmacies and insurance companies should use a guide to allow them to alternate to another medication if the original one is not available. Patients should be able to get a refill if they can demonstrate they had prescribed medication for the last 3 months or so. At the policy level, companies and those with the responsibility of decision making should ensure there are exceptions made in time of disaster for those without official refill slips, those who lost their prescription but can provide proof of use, those who aren't able to cover their treatment, among many other. "This will provide support for the call by the WHO to maintain essential services in order to prevent non-COVID disease burden on already strained health systems especially in LMICs" (Kretchy et al, 2021). Another conjecture might be that the mental health burden caused by the pandemic and the lockdown

periods could have played a key role in negatively affecting levels of both, blood pressure and blood sugar.

As an organization that serves vulnerable populations with NCDs, HealthproMed can use this data to develop specific action plans to address the needs of people living with NCDs at both the organizational level and the individual level. At the organizational level, we have worked with HealthproMed to integrate NCD specific resources and recommendations into its all-hazards approach emergency preparedness plan. This includes action items such as catering of low sodium and low glycemic index foods, necessary equipment and medication to manage common NCDs and a registry of vulnerable persons to reach out to in case of an adverse event such as a pandemic or any other natural disaster. HealthproMed should ensure an action plan that is activated at time of emergency and for which patients receive notifications of in-person visits shifting automatically to a virtual format. At the individual level, we have worked with HealthproMed to develop disease-specific brochures to support the empowerment of patients with NCDs to better prepare for an emergency situation and properly record blood pressure and HbA1c measurements. The need for a united, multi-sector strategy approach to not only identify areas of insufficiency in the current management structure, but also to design significant solutions to solve this public health catastrophe is clear.

Future work will assess how these interventions work in the larger system of disaster response, as well as table-top exercises to practice using these items. In addition, ensuring robust data collection systems that can confidently gather data is needed to evaluate HealthproMed's disaster response system. More research is needed in order to fully understand the effects of an adverse event on management of NCDs, especially in the Caribbean. More robust policies should also be developed to achieve management of NCDs, whether it is through state or federal

governments. It is imminent that funding be allocated to evaluate existing educational and practical programs that contribute to NCD management. More research, financing, and the implementation of more linked NCD management and patient education programs will improve health outcomes in Puerto Rico while also contributing to the eradication of health care inequities.

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Appendices

Figure A. All time COVID-19 cases in Puerto Rico

Source: https://www.nytimes.com/interactive/2021/us/puerto-rico-covid-cases.html. (Accessed 04/17/2022).

Table A. Descriptive statistics of patients with diagnosis of hypertension (2019)

Variable	N (col. %)	Controlled SBP n (row %)	Uncontrolled SBP n (row %)	p-value
Patient Gender				
Female	2,504 (61.54)	7,426 (80.85)	1,759 (19.15)	
Male	1,565 (38.46)	3,760 (79.61)	963 (20.39)	0.081
Unknown	0 (0)	0 (0)	0 (0)	
Total	4,069 (100)			
Patient Age				
18-39	319 (7.84)	780 (90.28)	84 (9.72)	
40-59	1,800 (44.24)	5,110 (84.41)	944 (15.59)	
60-79	1,740 (42.76)	4,834 (77.26)	1,423 (22.74)	0.000
80 ≤	210 (5.16)	462 (63.03)	271 (36.97)	
Total	4,069 (100)			
Patient Facility				
HPM Carolina	709 (17.42)	2,097 (81.91)	463 (18.09)	
HPM Culebra	426 (10.47)	1,702 (87.96)	233 (12.04)	
HPM Guaynabo	431 (10.59)	1,341 (78.98)	357 (21.02)	0.000
HPM San Juan	2,062 (50.68)	5,038 (77.82)	1,436 (22.18)	
HPM Vieques	441 (10.84)	1,008 (81.22)	233 (18.78)	
Total	4,069 (100)			
Patient Insurance				
Medicaid	2,479 (60.92)	7,089 (79.57)	1,820 (20.43)	
Medicare	499 (12.26)	1,614 (82.30)	347 (17.70)	0.000
Private	398 (9.78)	928 (85.69)	155 (14.31)	
Uninsured	693 (17.03)	1,555 (79.54)	400 (20.46)	
Total	4,069 (100)			

SBP= systolic blood pressure, N= total number of patients within each subgroup of each categorical variable; n= number of SBP measurements recorded and classified as either controlled or uncontrolled within each subgroup of each categorical variable (gender, age, facility and insurance type).

Table B. Descriptive statistics of patients with diagnosis of hypertension (2020)

Variable	N (col. %)	Controlled SBP n (row %)	Uncontrolled SBP n (row %)	p-value
Patient Gender				
Female	2,408 (61.15)	4,726 (75.69)	1,518 (24.31)	
Male	1,530 (38.85)	2,603 (75.21)	858 (24.79)	0.599
Unknown	0 (0)	0 (0)	0 (0)	
Total	3,938 (100)			
Patient Age				
18-39	319 (8.10)	606 (88.86)	76 (11.14)	
40-59	1,858 (47.18)	3,654 (80.31)	896 (19.69)	
60-79	1,595 (40.50)	2,839 (70.12)	1,210 (29.88)	0.000
80 ≤	166 (4.22)	230 (54.25)	194 (45.75)	
Total	3,938 (100)			
Patient Facility				
HPM Carolina	694 (17.62)	1,360 (79.77)	345 (20.23)	
HPM Culebra	395 (10.03)	955 (84.74)	172 (15.26)	
HPM Guaynabo	503 (12.77)	1,044 (77.28)	307 (22.72)	0.000
HPM San Juan	1,945 (49.39)	3,383 (71.30)	1,362 (28.70)	
HPM Vieques	401 (10.18)	587 (75.55)	190 (24.45)	
Total	3,938 (100)			
Patient Insurance				
Medicaid	2,446 (62.11)	4,849 (75.06)	1,611 (24.94)	
Medicare	462 (11.73)	846 (76.08)	266 (23.92)	0.064
Private	369 (9.37)	564 (79.55)	145 (20.45)	
Uninsured	661 (16.79)	1,070 (75.14)	354 (24.48)	
Total	3,938 (100)			

SBP= systolic blood pressure, N= total number of patients within each subgroup of each categorical variable; n= number of SBP measurements recorded and classified as either controlled or uncontrolled within each subgroup of each categorical variable (gender, age, facility and insurance type).

Tables C. Proportion of controlled/uncontrolled SBP measurements per center per year

Year	Hypertension		Total
	Controlled n (row %)	Uncontrolled n (row %)	
Carolina			
2019 (Jan.-Dec.)	2,097 (81.91)	463 (18.09)	2,560
2020 (Jan.-Dec.)	1,360 (79.77)	345 (20.23)	1,705
2021 (Jan.-Jul.)	840 (77.56)	243 (22.44)	1,083
Total	4,297 (80.35)	1,051 (19.65)	5,348
Culebra			
2019 (Jan.-Dec.)	1,702 (87.96)	233 (12.04)	1,935
2020 (Jan.-Dec.)	955 (84.74)	172 (15.26)	1,127
2021 (Jan.-Jul.)	562 (81.33)	129 (18.67)	691
Total	3,219 (85.77)	534 (14.23)	3,753
Guaynabo			
2019 (Jan.-Dec.)	1,341 (78.98)	357 (21.02)	1,698
2020 (Jan.-Dec.)	1,044 (77.28)	307 (22.72)	1,351
2021 (Jan.-Jul.)	763 (78.74)	206 (21.26)	969
Total	3,148 (78.35)	870 (21.65)	4,018
San Juan			
2019 (Jan.-Dec.)	5,038 (77.82)	1,436 (22.18)	6,474
2020 (Jan.-Dec.)	3,383 (71.30)	1,362 (28.70)	4,745
2021 (Jan.-Jul.)	2,497 (73.14)	917 (26.86)	3,414
Total	10,918 (74.61)	3,715 (25.39)	14,633
Vieques			
2019 (Jan.-Dec.)	1,008 (81.22)	233 (18.78)	1,241
2020 (Jan.-Dec.)	587 (75.55)	190 (24.45)	777
2021 (Jan.-Jul.)	325 (67.85)	154 (32.15)	479
Total	1,920 (76.89)	577 (23.11)	2,497

Table D. Overview of number and proportion of controlled/uncontrolled hypertension measurements (2019-2021)

Year	Hypertension		Total
	Controlled SBP n (row %)	Uncontrolled SBP n (row %)	
2019 (Jan.-Dec.)	10,784 (77.54)	3,124 (22.46)	13,908
2020 (Jan.-Dec.)	7,087 (73.02)	2,618 (26.98)	9,705
2021 (Jan.-Jul.)	4,846 (73.03)	1,790 (26.97)	6,636
Total	22,717 (75.10)	7,532 (24.90)	30,249

SBP= systolic blood pressure, n= number SBP measurements recorded and classified as either controlled or uncontrolled for a given year.

Table E. Proportion of controlled/uncontrolled SBP measurements per month for 2019

Date	Hypertension		Total
	Controlled SBP n (row %)	Uncontrolled SBP n (row %)	
Jan 2019	860 (76.38)	266 (23.62)	1,126
Feb 2019	899 (78.45)	247 (21.55)	1,146
Mar 2019	909 (79.32)	237 (20.68)	1,146
Apr 2019	889 (79.73)	226 (20.27)	1,115
May 2019	1,007 (79.79)	255 (20.21)	1,262
Jun 2019	923 (77.56)	267 (22.44)	1,190
Jul 2019	902 (78.30)	250 (21.70)	1,152
Aug 2019	874 (78.18)	244 (21.82)	1,118
Sep 2019	885 (77.16)	262 (22.84)	1,147
Oct 2019	1,017 (75.06)	338 (24.94)	1,355
Nov 2019	807 (74.58)	275 (25.42)	1,082
Dec 2019	812 (75.96)	257 (24.04)	1,069

SBP= systolic blood pressure, n= number of total patients who had SBP measurements recorded and classified as either controlled or uncontrolled.

Table F. Proportion of controlled/uncontrolled BP measurements per month for 2021

Date	Hypertension		Total
	Controlled SBP n (row %)	Uncontrolled SBP n (row %)	
Jan 2021	614 (70.82)	253 (29.18)	867
Feb 2021	648 (70.21)	275 (29.79)	923
Mar 2021	773 (71.38)	310 (28.62)	1,083
Apr 2021	820 (76.56)	251 (23.44)	1,071
May 2021	746 (75.74)	239 (24.26)	985
Jun 2021	696 (71.31)	280 (28.69)	976
Jul 2021	549 (75.10)	182 (24.90)	731

SBP= systolic blood pressure, n= number of total patients who had SBP measurements recorded and classified as either controlled or uncontrolled.

Table G. Patients with hypertension that received "*teleconsulta*" visits by month

Year	Facility	Month	Frequency
2020	Carolina	April	3
		May	3
		June	3
		July	5
		August	12
		September	26
		October	31
		November	19
		December	24
	Culebra	April	2
		May	2
		June	6
		July	4
		August	2
		September	10
		October	14
		November	14
		December	16
	Guaynabo	April	1
		May	9
		June	15

		July	4
		August	21
		September	43
		October	34
		November	10
		December	38
	San Juan	April	50
		May	43
		June	41
		July	57
		August	172
		September	127
		October	86
		November	118
		December	91
	Vieques	April	2
		May	3
		June	4
		July	8
		August	9
		September	26
		October	16
		November	14
		December	28
2021	Carolina	January	13
		February	22
		March	22
		April	7
		May	8
		June	24
		July	23
		August	12
		September	30
		October	17
		November	33
		December	38
	Culebra	January	9
		February	26
		March	18
		April	12
		May	10
		June	34
		July	25

		August	20
		September	44
		October	27
		November	41
		December	67
	Guaynabo	January	14
		February	24
		March	19
		April	10
		May	10
		June	15
		July	23
		August	35
		September	26
		October	32
		November	35
		December	37
	San Juan	January	119
		February	93
		March	105
		April	61
		May	41
		June	38
		July	21
		August	22
		September	15
		October	37
		November	66
		December	65
	Vieques	January	16
		February	21
		March	18
		April	11
		May	24
		June	36
		July	23
		August	30
		September	39
		October	45
		November	43
		December	111

Figure B. Patients with a diagnosis of hypertension seen by "teleconsulta" by HPM center (April 2020 – December 2020)

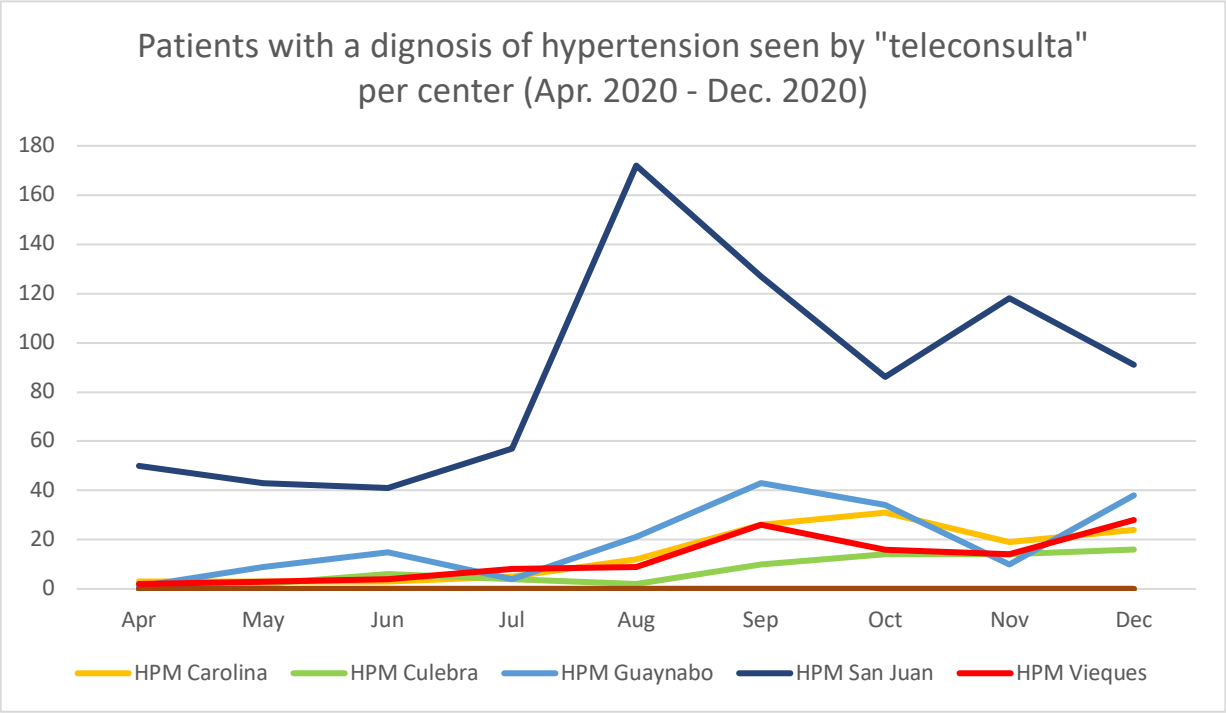

Table H. Sex, age-groups, HPM facility, and source of health insurance of study population with diagnosis of diabetes (2019)

Variable	N (col. %)	Controlled HbA1c n (%)	Uncontrolled HbA1c n (%)	p-value
Patient Gender				
Female	583 (64.00)	546 (67.91)	258 (32.09)	
Male	328 (36.00)	295 (64.98)	159 (35.02)	0.289
Unknown	0 (0)	0 (0)	0 (0)	
Total	911 (100)			
Patient Age				
18-39	50 (5.49)	42 (66.67)	21 (33.33)	
40-59	375 (41.16)	320 (60.84)	206 (39.16)	0.000
60-79	442 (48.52)	430 (70.03)	184 (29.97)	
80 ≤	44 (4.83)	49 (89.09)	6 (10.91)	
Total	911 (100)			
Patient Facility				
HPM Carolina	301 (33.04)	333 (66.33)	169 (33.67)	
HPM Culebra	106 (11.64)	89 (67.42)	43 (32.58)	0.725
HPM Guaynabo	124 (13.61)	100 (64.52)	55 (35.48)	
HPM San Juan	364 (39.96)	306 (67.55)	147 (32.45)	
HPM Vieques	16 (1.76)	13 (81.25)	3 (18.75)	
Total	911 (100)			
Patient Insurance				
Medicaid	634 (69.59)	552 (62.44)	332 (37.56)	
Medicare	112 (12.29)	118 (83.69)	23 (16.31)	0.000
Private	22 (2.41)	25 (80.65)	6 (19.35)	
Uninsured	143 (15.70)	146 (72.28)	56 (27.72)	
Total	911 (100)			

HbA1c= Glycated hemoglobin/blood test that is used to help diagnose and monitor people with diabetes**,** N= total number of patients within each subgroup of each categorical variable; n= number of HbA1c measurements recorded and classified as either controlled or uncontrolled within each subgroup of each categorical variable (gender, age, facility and insurance type).

Table I. Sex, age-groups, HPM facility, and source of health insurance of study population with diagnosis of diabetes (2020)

Variable	N (col. %)	Controlled HbA1c n (row %)	Uncontrolled HbA1c n (row %)	p-value
Patient Gender				
Female	520 (63.18)	283 (43.40)	369 (56.60)	
Male	303 (36.82)	145 (36.52)	252 (63.48)	0.028
Unknown	0 (0)	0 (0)	0 (0)	
Total	823 (100)			
Patient Age				
18-39	44 (5.35)	22 (44.90)	27 (55.10)	
40-59	368 (44.71)	166 (35.24)	305 (64.76)	0.002
60-79	379 (46.05)	217 (44.20)	274 (55.80)	
80 ≤	32 (3.89)	23 (60.53)	15 (39.47)	
Total	823 (100)			
Patient Facility				
HPM Carolina	167 (20.29)	79 (36.24)	139 (63.76)	
HPM Culebra	110 (13.37)	61 (43.88)	78 (56.12)	0.009
HPM Guaynabo	137 (16.65)	66 (35.87)	118 (64.13)	
HPM San Juan	378 (45.93)	198 (42.04)	273 (57.96)	
HPM Vieques	31 (3.77)	24 (64.86)	13 (35.14)	
Total	823 (100)			
Patient Insurance				
Medicaid	576 (69.99)	302 (40.32)	447 (59.68)	
Medicare	94 (11.42)	62 (56.88)	47 (43.12)	0.000
Private	33 (4.01)	20 (51.28)	19 (48.72)	
Uninsured	120 (14.58)	44 (28.95)	108 (71.05)	
Total	823 (100)			

HbA1c= Glycated hemoglobin/blood test that is used to help diagnose and monitor people with diabetes**,** N= total number of patients within each subgroup of each categorical variable; n= number of HbA1c measurements recorded and classified as either controlled or uncontrolled within each subgroup of each categorical variable (gender, age, facility and insurance type).

Tables J. Proportion of controlled/uncontrolled HbA1c measurements per center per year

Year	Diabetes		Total
	Controlled n (%)	Uncontrolled n (%)	
Carolina			
2019 (Jan.-Dec.)	333 (66.33)	169 (33.67)	502
2020 (Jan.-Dec.)	79 (36.24)	139 (63.76)	218
2021 (Jan.-Jul.)	42 (35.00)	78 (65.00)	120
Total	454 (54.05)	386 (45.95)	840
Culebra			
2019 (Jan.-Dec.)	89 (67.42)	43 (32.58)	132
2020 (Jan.-Dec.)	61 (43.88)	78 (56.12)	139
2021 (Jan.-Jul.)	40 (52.63)	36 (47.37)	76
Total	190 (54.76)	157 (45.24)	347
Guaynabo			
2019 (Jan.-Dec.)	100 (64.52)	55 (35.48)	155
2020 (Jan.-Dec.)	66 (35.87)	118 (64.13)	184
2021 (Jan.-Jul.)	36 (38.71)	57 (61.29)	93
Total	202 (46.76)	230 (53.24)	432
San Juan			
2019 (Jan.-Dec.)	306 (67.55)	147 (32.45)	453
2020 (Jan.-Dec.)	198 (42.04)	273 (57.96)	471
2021 (Jan.-Jul.)	103 (36.14)	182 (63.86)	285
Total	607 (50.21)	602 (49.79)	1,209
Vieques			
2019 (Jan.-Dec.)	13 (81.25)	3 (18.75)	16
2020 (Jan.-Dec.)	24 (64.86)	13 (35.14)	37
2021 (Jan.-Jul.)	21 (63.64)	12 (36.36)	33
Total	58 (67.44)	28 (32.56)	86

Table K. Number and proportion of controlled/uncontrolled diabetes measurements by year (2019-2021)

Year	Diabetes		Total
	Controlled HbA1c n (row %)	Uncontrolled HbA1c N (row %)	
2019 (Jan.-Dec.)	841 (66.85)	417 (33.15)	1,258
2020 (Jan.-Dec.)	428 (40.80)	621 (59.20)	1,049
2021 (Jan.-Jul.)	242 (39.87)	365 (60.13)	607
Total	1,511 (51.85)	1,403 (48.15)	2,914

HbA1c= Glycated hemoglobin/blood test that is used to help diagnose and monitor people with diabetes;
n= number HbA1c measurements recorded and classified as either controlled or uncontrolled for a given year.

Table L. Proportion of controlled/uncontrolled HbA1c measurements per month for 2019

Date	Diabetes		Total
	Controlled HbA1c n (row %)	Uncontrolled HbA1c n (row %)	
Jan 2019	117 (74.05)	41 (25.95)	158
Feb 2019	93 (78.15)	26 (21.85)	119
Mar 2019	92 (79.31)	24 (20.69)	116
Apr 2019	44 (77.19)	13 (22.81)	57
May 2019	62 (70.45)	26 (29.55)	88
Jun 2019	54 (70.13)	23 (29.87)	77
Jul 2019	46 (57.50)	34 (42.50)	80
Aug 2019	79 (67.52)	38 (32.48)	117
Sep 2019	86 (61.43)	54 (38.57)	140
Oct 2019	77 (53.47)	67 (46.53)	144
Nov 2019	39 (53.42)	34 (46.58)	73
Dec 2019	52 (58.43)	37 (41.57)	89

HbA1c= Glycated hemoglobin/blood test that is used to help diagnose and monitor people with diabetes; n= number of HbA1c measurements recorded and classified as either controlled or uncontrolled for a given month and year.

Table M. Proportion of controlled/uncontrolled HbA1c measurements per month for 2021

Date	Diabetes		Total
	Controlled HbA1c n (row %)	Uncontrolled HbA1c n (row %)	
Jan 2021	26 (40.62)	38 (59.38)	64
Feb 2021	34 (40.00)	51 (60.00)	85
Mar 2021	35 (41.18)	50 (58.82)	85
Apr 2021	50 (48.54)	53 (51.46)	103
May 2021	38 (38.00)	62 (62.00)	100
Jun 2021	35 (32.41)	73 (67.59)	108
Jul 2021	24 (38.71)	38 (61.29)	62

HbA1c= Glycated hemoglobin/blood test that is used to help diagnose and monitor people with diabetes, n= number HbA1c measurements recorded and classified as either controlled or uncontrolled for a given month and year.

Table N. Patients with diabetes that received "*teleconsulta*" by month

Year	Facility	Month	Frequency
2020	Carolina	April	2
		May	2
		June	1
		July	5
		August	13
		September	16
		October	11
		November	10
		December	2
	Culebra	June	1
		July	2
		August	0
		September	1
		October	9
		November	7
		December	7
	Guaynabo	April	1
		May	5
		June	4
		July	5
		August	9

		September	17
		October	13
		November	6
		December	19
	San Juan	April	33
		May	11
		June	21
		July	22
		August	78
		September	60
		October	46
		November	56
		December	40
	Vieques	April	1
		May	2
		June	1
		July	2
		August	0
		September	9
		October	6
		November	4
		December	4
2021	Carolina	January	8
		February	11
		March	11
		April	4
		May	3
		June	13
		July	8
		August	5
		September	9
		October	9
		November	17
		December	14
	Culebra	January	4
		February	11
		March	5
		April	5
		May	9
		June	14
		July	9
		August	11
		September	21

		October	19
		November	19
		December	34
	Guaynabo	January	5
		February	15
		March	9
		April	4
		May	4
		June	7
		July	13
		August	13
		September	17
		October	16
		November	15
		December	18
	San Juan	January	64
		February	45
		March	50
		April	35
		May	19
		June	15
		July	9
		August	7
		September	8
		October	17
		November	37
		December	24
	Vieques	January	6
		February	7
		March	5
		April	5
		May	5
		June	14
		July	4
		August	12
		September	10
		October	13
		November	14
		December	37

Figure C. Number of patients with a diagnosis of diabetes seen by "teleconsulta" by HPM center, April 2020 – December 2020