THE EFFECT OF COVID-19 ON CARDIAC REHABILITATION ATTENDANCE RATES AND ITS POTENTIAL EFFECT ON REOCCURING MYOCARDIAL INFARCTIONS AND MEDICAL CARE COSTS IN THE MIDDLE TENNESSEE AREA

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ABSTRACT

Cardiac rehabilitation is a vital source of therapy after a patient experiences a myocardial infarction. Cardiac rehabilitation aides in decreasing the risk of having a reoccurring myocardial infarction. The purpose of this study is to determine the changes in CR enrollment rates, dropout rates, and completion rates from pre lockdown to post lockdown. The secondary purpose of this study is to predict how these changes will affect potential increases in myocardial infarctions (MI) and hospital costs within the region. Due to the COVID-19 pandemic, facilities shut down for weeks at a time and patients were unable to attend cardiac rehabilitation. Enrollment rates, completion rates, and dropout rates were compared between pre COVID-19 shutdown and post COVID-19 shutdown. Medical care costs were also estimated due to a potential increase in myocardial infarctions due to the shutdown. Out of the eight hospitals that were contacted, two facilities met the criteria and chose to participate. Results showed a significant decrease in enrollments ($F(1,34) = 43.18$, $p= .000$) and completion rates of a cardiac rehabilitation program ($F(1,34) = 5.374$, $p= .027$). The estimated increase of myocardial infarctions over the 16 month post shutdown period was 33.1 with an associated increased cost of $626,829.10. Since the shutdown from COVID-19, the Greater Nashville region can potentially see an increase in recurrent myocardial infarctions and an increase in medical care costs. A push for an increase in participation in a CR program will need to be addressed in order to alleviate the influx of heart attacks in the next few years.

TABLE ON CONTENTS

LIST OF TABLES

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

There is an abundant amount of research done on cardiovascular disease (CVD). According to the Centers for Disease Control and Prevention, heart disease is the number one leading cause of death in the United States (FastStats [CDC], 2021). Roughly 659,000 Americans die from heart disease; equaling to about 1 in 4 people each year (Virani et al., 2021). CVD can be accompanied by other comorbidities including diabetes mellitus II, behavioral and mental disorders, as well as respiratory complications (Comin-Colet et al., 2020). Symptoms of CVD include pain or discomfort in the center of the chest or in the arms, left shoulder, elbows, jaw or back (World Health Organization [WHO] n.d.).

Once an individual has developed CVD severe enough that intervention is needed, cardiac rehabilitation (CR) will be prescribed as a form of recovery. This type of therapy involves aerobic activities followed by a short bout of resistance training. A study from 2020 states that the goal for CR is to help increase exercise capacity, independence, cognition, mental health, and over-all quality of life (Epstein et al., 2020). Cardiac rehabilitation is effective at helping patients achieve these goals and has improved outcomes after a cardiac event with all ages (Pasquali, Alexander & Peterson, 2001).

Studies have predicted that the government shutdown would affect the well-being, physical activity levels, and sleep patterns in individuals that are affected by the pandemic (De Pue et al., 2021). Older adults have better well-being when they have both kin and non-kin socialization and support (Merz & Huxhold, 2010). De Pue et al (2021) confirmed that there

were decreases in well-being within older adults due to COVID-19. With the lock down in place and programs shut down, vulnerable patients were unable to participate in therapy for periods of time.

While barriers exist for patients needing CR, COVID-19 has made it much harder for older adults to receive the level of care needed to improve post event outcomes. With a decrease in access to care, and the potential health and monetary ramification, there is a need to predict how this pandemic will affect healthcare in the coming years. The purpose of this study is to determine the changes in CR enrollment rates, dropout rates, and completion rates from pre lockdown to post lockdown. The secondary purpose of this study is to predict how these changes will affect potential increases in myocardial infarctions (MI) and hospital costs within the region.

CHAPTER 2

LITERATURE REVIEW

Cardiovascular disease is one of the leading causes of death in the United States. Once CVD has progressed to the point of needing intervention, cardiac rehabilitation (CR) will be needed in order to improve quality of life for those patients. Cardiac rehabilitation is a form of therapy that uses aerobic and resistance training to improve the heart's function. Cardiac rehabilitation is beneficial for exercise capacity, risk factors, and creating healthier lifestyles. However, it is important for patients to attend a full cardiac rehabilitation program to receive these benefits. Participation in a CR program has been shown to decrease due to location, insurance, and a decrease in mental health after a cardiac event. During the pandemic, programs were shut down for periods of time and vulnerable patients were left without therapy. With this gap in healthcare, being able to see the trends in attendance pre pandemic through March 2022 can help prepare these facilities for the future consequences of the pandemic.

Cardiovascular Disease

The American Heart Association (AHA) has defined atherosclerosis, also known as cardiovascular disease, as a buildup of plaque in the walls of the arteries, causing blood flow to be reduced. The American Heart Association also states that the reduction of blood flow through the heart can then cause a myocardial infarction or stroke. The American Heart Association also defined a MI as blood flow being blocked in the artery (American Heart Association [AHA], n.d.). With cardiovascular disease, risk factors increase the likelihood of developing CVD. These risk factors are tobacco use, physical inactivity, hypertension, elevated low-density level

cholesterol, and metabolic syndrome (Cannon, 2007). One meta-analysis showed that waist circumference had the strongest correlation with CVD, compared to all other risk factors, with all of the CVD risk factors for both men and women (van Dijk et al., 2012).

Hospital Costs of CVD

The risk of a post-acute MI readmission rate increases as patients get older (Khera et al., 2017). Khera et al (2017) also found that woman were more likely to be readmitted to the hospital based off of when considering all cause readmissions, unplanned readmissions, and cardiac related readmissions. Cowper et al.(2019) proclaimed that the average length of stay for a patient hospitalized due to a MI is 3.1 days and 1.2 days in intensive care. The American Heart Association averaged the cost of stay to roughly $18, 931 (Cowper et al., 2019). McDermott et al (2020) also found that if the patient is needing intervention, the average cost of a catheterization with zero complications can cost almost $75,700 while a catheterization with complications can costs up to $117,000. If the patient ends up in the intensive care unit, the prices of hospital stays increase. The average daily cost of an ICU bed is roughly $3,968 if the patient is on a ventilator and $3,184 if the patient is not on a ventilator (Dasta et al., 2005). With the pandemic in place, patients with CVD are more likely to have the more severe cases of COVID-19 and require ventilators to breathe (He et al., 2020). The use of cardiopulmonary rehabilitation is needed for patients with CVD to help reduce the risk of being readmitted to the hospital and increasing medical costs. A recent study has predicted that the productivity losses due to CVD will increase from $555 billion in 2015 to $1.1 trillion by 2035 (Dunbar et al., 2018). Thankfully, there is CR for patients with CVD.

Cardiac Rehabilitation

After a cardiovascular event, a patient will be ordered by their cardiologist to attend an outpatient CR program once they are discharged from the hospital. Phase I of CR is when a registered nurse, or exercise physiologist, meets with the patient post operatively and asses the patient to determine if CR is feasible. During phase II, all attendees are monitored by an exercise physiologist and a registered nurse while hooked up to portable electocardiographs. Cardiac rehabilitation involves standard aerobic training and resistance training. Cardiac rehabilitation programs should be modified to help maximize the patient's outcome (Puthoff & Youngs, 2017). A typical CR program is three weeks to three months (Eser et al., 2020). However, a study found that a seven-week program had the same results as a standard CR program (Hansen, 2009). A study that was done in 2000 found that attending cardiac rehabilitation classes twice a week for six months had improvements in coronary risk factors (Morrin et al., 2000). Morrin, Black & Reid (2000) included these exercises in the study: walking, rowing, stationary cycling, or jogging for 30 minutes at 50-75% of the heart rate reserve. Patients in this study were also encouraged to exercise outside of the sessions two to five times a week at a similar target heart rate (Morrin, Black & Reid, 2000). Follow up's have shown to be beneficial during phase II of cardiac rehabilitation (Phillips, 2014).

According to the American Association of Cardiovascular and Pulmonary Rehabilitation, the primary goal for CR is to enable the participant to achieve their optimal physical, psychological, and social functioning through exercise training and lifestyle change (American Association of Cardiovascular and Pulmonary Rehabilitation [AACVPR] n.d.), Cardiac rehabilitation plays an important role in recovery by reducing risk factors such as smoking,

biophysical markers, and physical inactivity (Walters et. al., 2020). Patients who attend a cardiac rehabilitation program that utilizes education had fewer morbidities than patients who participated in physical activity but not in a CR setting (Yangun Hu et al., 2021). The patients that were in the CR program also had fewer risk factors, improved their walking capacity, and reduced their comorbidities when compared to a non-cardiac rehabilitation group (Yangun Hu et. al., 2021).

Cardiac rehabilitation attendance decreases your risk of having another heart attack by 17% within the first 12 months post CR, and 47% after two years of continuing secondary preventions like CR (Clark, Vandermeer & McAlister, 2005). A more recent study has shown that participating in CR can also reduce readmission rates and death after a MI (Dunlay et al., 2014). A long-term study done in 2019 showed that individuals who attend CR have a 17% chance of being readmitted to the hospital due to cardiovascular complications compared to a 30% chance for those who do not attend (Doimo et al., 2019). Studies have shown that by increasing the participation rate from 20% to 70% could positively affect patients with CVD and prevent 180,000 hospitalizations (Ades et al., 2017) The American College of Sports Medicine (ACSM) recommends that older adults should be participating in physical activity a minimum of 30 minutes five days a week (American College of Sports Medicine [ACSM] n.d.). Physical activity helps decrease the risk of developing CVD. Physical activity and exercise training has also shown to help improve cardiovascular mortalities and hospitalizations in patients with congestive heart failure with decreased ejection fractions (Rengo et al., 2018).However, not all improvements from CR are physical.

Participants in CR programs are given resources to improve non-physical benefits such as depression and anxiety. Individuals that participated in CR that had a coronary artery bypass

graft (CABG) had better improvements in depression and health related quality of life when compared to patients who underwent percutaneous coronary interventions (PCI) and did not attend a CR program (Montesano et. al., 2020). Cardiac rehabilitation has been shown to reduce all-cause and cardiovascular readmission rates (Davidson et al., 2010), as well as decreasing CVD risk factors and improving mental health and physical health for those individuals that participate (Gardiner et al., 2017).

While CR is important for improving the health outcomes for individuals who have CVD, it has been described as "the largest gap in clinical cardiology" (Rubin et al., 2019). One study found that not all patients eligible for cardiac rehabilitation are prescribed to attend (Rodrigo et al., 2021). Rubin et al. (2019) also mentioned that CR participation is lower for women, minorities, those who speak little English, and low-income individuals. Patients who have family history of CVD and have more risk factors at baseline are more compliant than others (O'Toole et. al., 2020). Patients are also more likely to complete the program when a nurse practitioner is overseeing their CR program (O'Toole et. al., 2020). There are other factors that lead to compliance with CR programs including individuals who 1) are older, 2), are on medications, 3) have higher social health scores, and 4) have lower anxiety and depression levels (Komorovsky et. al., 2008). There are disparate findings regarding the effect of gender on compliance, where one study found men have better compliance (Halm et. al., 1999) and another found women have better compliance (Doimo et al., 2019). Attending a CR program can be more difficult for some individuals. Patients that chose not to attend a CR program was due to lack of transportation, insurance, or they have equipment at home (Halm et. al., 1999). Other factors that play a role in not participating in a CR program is lack of referral from physicians, self-efficacy, self-esteem,

motivation, and support (Daly et al., 2002). With the pandemic in place, CR programs and gyms were closed leaving individuals without any guidance.

COVID-19 Barriers

As the pandemic began and the country shut down, older adults were advised to stay home for their safety (Wand et al., 2020). As COVID-19 is easily spread, it was thought that isolating the immunocompromised and elderly was the best course of action. While isolating those individuals helped decrease the risk of infection, being isolated had significant side effects including increased anxiety and depression rates (Wand et al., 2020). Although older adults are more susceptible to infection and need to be protected, it is important to minimize or eliminate social disconnect (Hwang et al., 2020). One study found that individuals who felt lonely before the pandemic had worsening symptoms of anxiety and depression during the pandemic (Robb et al., 2020). In the short term, COVID-19 social isolation has negatively influenced the mental health of older adults (Krendl and Perry, 2020). Krendl and Perry (2020) also stated that while long-term effect studies have not had time to assess the effects of COVID-19 social isolation on mental health, they believe that this isolation will have negative impacts on older adults well into the future.

Beyond concerns for mental health, social isolation also leads to reduced physical activity. Individuals who had lower incomes, high risk health conditions, higher BMI's, and experienced negative mental health prior to the pandemic had significantly lower physical activity levels during the pandemic (Robinson et al., 2021). Another study stated that barriers to physical activity during the pandemic included laziness, fatigue, lack of resources due to the lockdown, and lack of motivation (Farah et al., 2021. Vulnerable populations, such as the

elderly, were then expected to stay home. Home-based cardiac rehabilitation (HBCR) became more popular during the shutdown. However, a study found that although HBCR showed improvements, it excluded certain patient groups (O'Doherty et al., 2021). Programs were then using phone and email to communicate with patients regarding therapy (Marzolini et al., 2021). Marzolini et al (2021) mentioned that this effort was not time efficient and that programs should open to help the more vulnerable. Rodrigo et al. (2021) stated that elderly adults are not prescribed CR as often as other age groups. With this population being vulnerable to not participating in enough physical activity, older adults should be encouraged to attend CR.

With CR being described as the biggest gap in cardiac medicine and the pandemic hitting, researching how attendance rates were affected and what to expect in healthcare is needed. The purpose of this study is to determine if there is a difference in attendance rates in CR between 2018, 2019, and 2020 in the Middle Tennessee area. Predictions will then be made based off of previous literature on how much this will cost healthcare and predict the amount of potential MI's to come.

CHAPTER 3

METHODOLOGY

Participants

The participants in this study were CR facilities within the greater Nashville area between 2018-2021. Inclusion criteria included outpatient CR facilities that were active before and after the social shutdown associated with the COVID-19 pandemic. Each facility needed to be able to supply enrollment numbers, completion rates, and dropout rates. Recruitment of facilities consisted of sending an email explaining the purpose and importance of this research to each facility within the Greater Nashville area. For the facilities that did not respond to the email, a follow up phone call was made to each facility. All patients attending the outpatient cardiac rehabilitation programs were included in this data. This includes patients diagnosed with CVD, patients who had CVD intervention such as catheterization, stent placements, transcatheter aortic valve replacement, or left ventricle assist devices, open heart surgeries, and patients waiting for a heart transplant. Patients were to be six weeks post hospital stay to participate in outpatient CR.

Procedures

Data was collected from outpatient CR centers in the Greater Nashville area from the beginning of the 2019 fiscal year (i.e. July 2018) to the end of the 2021 fiscal year (June 2021). The Greater Nashville area is defined as the following counties: Cheatham, Davidson, Dickson, Montgomery, Robertson, Rutherford, Sumner, Williamson, and Wilson. From these counties, eight hospitals were identified as potential participates in this study. Each participating CR

facility provided preexisting deidentified data for the 36-month period. Collected data include the monthly enrollment, completions, and drop outsin and from the program.

Statistical Analysis

A one-way ANOVA was used to determine if significant changes occurred in enrollments, dropouts, and completions of CR programs in the Greater Nashville area before and after the COVID-19 related shutdown. The ANOVA compared the average enrollments, dropouts, and completions per month. Completions and dropouts were used to determine any significant changes with enrollments.

Myocardial infarction rates from the hospitals would have underestimated the number of reoccurring MI's due to the decrease in patients going to the emergency room during the COVID-19 shutdown (Solomon et al., 2020). Therefore, this value was estimated using the following calculations. First, the average monthly decline in enrollment rates post COVID-19 shutdown needed to be adjusted as most patients attend 36 sessions during their CR program. Because of this, a patient who completes the program is enrolled in the program spanning a 4-month period and is counted in the enrollment numbers for each month. To account for this overestimation, the average decline in enrollment due to COVID-19 was adjusted by removing the average number of dropouts. The remaining change in enrollment number represents participants who would have completed 36 visits over a 4 month span if the pandemic had not occurred. This remaining change in enrollment was then divided by 4 to account for the estimated 4 months each person would have been included in the monthly enrollment tally. The resultant enrollment value was then added to the average number of dropouts. This added sum

represent the average number of participants who did not attend CR each month over the 16 months post COVID-19 shutdown.

Second, the MI reoccurrence rate for individuals who do not attend a CR program needed to be assessed. This value was calculated using the articles sited in a 2019 meta-analysis (Ji etal., 2019). Of the 13 articles that reported MI reoccurrence risk, only four articles provided the necessary information to calculate MI reoccurrence rate. ((Lee et al. (2016), Zhang et al. (2018), Chen et al. (2015), and Coll-Fernandez et al. (2014)). This information includes the total number of recurrent MI in patients who did not attend CR and the total number of patients who did not attend CR. Using the MI reoccurrence rate from these articles, the following equation was used to calculate MI reoccurrence rate for our current population: MI / #NCR = X / AE. After solving for X, the equation changed to the following formula: AE x MI / #NCR = X. MI is described as the number of reoccurring MI who did not attend CR. AE is the adjusted enrollment difference between pre COVID-19 shutdown and after COVID-19 shutdown calculated in step 1. #NCR is defined as the number of patients who did not participate in a CR. X is the number of estimated reoccurring myocardial infarctions that occurred per month due to the shutdown in the current study. The monthly MI reoccurrence values was then multiplied by sixteen, predicting the total number of recurrent MI that will occur due to the reduced participation in CR during the sixteen months post shutdown.

Finally, the total cost of MI due to reduced participation in CR was predicted. Cowper et al. (2019) showed that the average cost of a MI was $18,931. The average cost of a myocardial infarction was multiplied by the total number of recurrent MI's.

CHAPTER 4

RESULTS

Of the eight potential facilities,. two CR programs had closed down due to COVID-19 and, therefore, did not meet the inclusion criteria. Three facilities chose not to participate due to one of the following, 1) short staffing, 2) joint commission auditing, or 3) did not get a response to emails and did not answer the follow up phone call. While one hospital agreed to participate, they did not track the needed information to be included in the analysis. Two hospitals met the criteria and agreed to participate.

There was a significant decrease in enrollment ($E(1,34) = 43.18$, $p= .000$) and completion rates ($F(1,34) = 5.374$, $p= .027$). There was also a large and moderate to large effect size, respectively, when comparing pre and post COVID 19 shutdown periods. There was not a significant change in dropout rates ($F(1, 34) = 1.598$, $p = .215$) when comparing pre COVID-19 shutdown to post COVID-19 shutdown. However, there was a moderate effect size in dropout rates. (see Table 1)

Table 1. Comparing Pre-COVID-19 Shutdown to Post COVID-19 Shutdown Enrollments, Completions, and Dropouts in Outpatient Cardiac Rehabilitation

	Pre Shutdown	Post Shutdown	Effect Size
Enrollment (n)	228 ± 22.4	*147 ± 49.1	0.93
Completion rate (%)	16.5 ± .032	*12.6 ± .066	0.70
Dropout rate (%)	14.4 ± .033	14.6 ± .016	0.53

*The data were significantly different when compared to Pre Shutdown, $p < 0.05$.

Using the difference between pre-shutdown and post-shutdown enrollments in table 1 (i.e. 80.931), the adjusted average monthly enrollment was calculated to be 29.14. The MI reoccurrence rate from the literature was calculated to be 7.10%. (see Table 2) The estimated number of recurrent MI due to patients not attending CR after a heart attack is 2.07 per month equaling 33.11 more MI due to the shutdown. This increase in MI's equals to an increased cost of $626,829.10.

Table 2. Reoccuring Myocardial Infarctions Due to Not Attending Cardiac Rehabilitation

Articles	Population	Non- cardiac rehabilitation participants (n)	Myocardial infarctions (n)	Estimated reoccurring myocardial infarction (%)
Lee et al. (2016)	Left main coronary artery	2444	1633.748	
Zhang et al. (2016)	Percutaneous coronary intervention	65	1	
Chen et al. (2015)	Acute myocardial infarctions	389	45	
Coll-Fernandez et al. (2014)	Recent myocardial infarctions	520	33	
TOTAL		3418	242.748	7.1

CHAPTER 5

DISCUSSION

Comparisons were made between enrollments, completion rates, and dropouts rates of CR centers within the Greater Nashville area. There were significant decreases in outpatient CR enrollment and completions after COVID-19 when compared to pre COVID-19 levels. There were no significant differences in dropout rates over the same period. There was an estimated 33.11 increase in MI as well as a $626,829.10 increase in medical care costs.

Resurrección et al. (2018) stated in a meta-analysis that individuals did not participate in CR or dropped out of the program after a MI because of clinical factors, logistical factors, and health care system factors. While these factors do apply to the current study, COVID-19 related factors significantly increased non-participation. It is hypothesized that these factors included mask mandates, smaller class sizes, and fear of contracting COVID-19, but there are no articles that asses this relationship. However, other research has shown that there was a decrease in patients coming to the hospital for myocardial infarctions post shutdown (Solomon et al., 2020). Gluckman et al. (2020) also found that there was a decrease in MI rates, but risk-adjusted mortality significantly increased.

One limitation to the study was that there were only two facilities that participated in this research. More CR facilities should be used to get a better understanding of the effect of Covid-19 on MI reoccurrence rates. However, the two included hospitals were the two largest facilities in this region. The data collected potentially makes up more than half of the population attending CR.

The study findings can help prepare the region for the probable MI influx and associated medical care cost changes due to COVID-19. The reduction in CR enrollments and completions

will cause an increase in resources needed in the area in the next few years. Future research should do a long-term study regarding how COVID-19 has affected CR centers and how it has affected healthcare costs with more facility participation.

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APPENDIX

Letter of Approval

Ms. Webb is a master's student at Middle Tennessee State University conducting research as part of her thesis. She is gathering the following data from all hospitals with a cardiac rehabilitation unit within the middle Tennessee area. All data will be averaged between hospitals. Individual hospital data will remain confidential. Data will be from 2018-2022. A data collection sheet will be provided.

Data to be collected

- Total myocardial infarctions per month
- Total enrollments in cardiac rehabilitation
- Number of individuals who completed the cardiac rehabilitation program per month
- Number of individuals who dropped outs of the cardiac rehabilitation program per month

To be approved to complete this research project by the university's Institutional Review Board (IRB), Ms. Webb needs to receive approval from the hospital that you will allow her to gather this data once she receives IRB approval. By signing this letter of approval, you agree to allow Ms. Webb to gather the above data from your facility, once she has received IRB approval, and include this data in her thesis research analysis.

_____ (signature)

_____ (date)

_____ (email)

_____ (phone number)