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Comparative Impact Of Network Adequacy Standard Strategies On Medicaid Recipient Cvd Outcomes: A Computer Simulation Modeling Study

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ABSTRACT

Context: Medicaid managed care network adequacy standards vary widely across states and are not typically informed by scientific evidence. The comparative efficacy of these standards for protecting the health of the Medicaid population has not yet been comprehensively researched.

Objective: The aims of this study are to construct simulation modeling methods to approach this policy problem and to determine which numeric values for network adequacy standards are most effective for producing favorable health outcomes for Medicaid recipients who develop CVD.

Design and Setting: A continuous-time Markov model was used to simulate the natural history of cardiovascular disease, using a cohort that is representative of the Medicaid population over 40, under different provider appointment wait times and CVD emergency travel time delays.

Input and Output Measures: Medicaid claims data from Tennessee in 2019, Social Security life expectancy data, the Centers for Disease Control and Prevention's Wide-ranging Online Data for Epidemiologic Research (CDC WONDER) database, and values pulled from existing literature were used to inform input parameters. Survival time, age at death, number of lifetime hospital visits, number of lifetime provider visits, time spent in recovery, time spent waiting for an appointment, lifetime healthcare costs, and lifetime healthcare costs attributable to hospitalization were collected as simulation outputs.

Results: It was found that the strategy with a 45-day appointment wait time and 0-minute emergency travel time delay yielded the most favorable health outcomes for individuals with CVD: mean age at death of 83.79 (83.10, 84.47) and mean survival time of 32.08 (31.09, 33.07). When the strategies hypothesized to be the "best" (7-day wait times and no travel delay) and "worst" (90-day wait times and 90-min travel delay for emergencies) were run in comparison to one another, statistically significant differences were found for time spent in recovery, time spent waiting for an appointment, provider visit quantity, and healthcare system cost burden. Statistically significant differences were not found for life expectancy, hospital visit quantity, and costs attributable to hospitalization.

Conclusion: There is not enough evidence of robustness in these results to recommend that policy decisions should be made using them; further complexities and calibration should be incorporated into the model before doing so.

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INTRODUCTION

Background

Network adequacy standards are quantitative requirements put in place by state governments to ensure that the provider networks created by Medicaid managed care organizations (MCO) provide sufficient access to care for the populations served.[1] These standards specify the minimum quantity of providers, healthcare facilities, and appointments in an area and set requirements for their availability to Medicaid MCO recipients. Narrow-network health plans, which are typically defined as plans where less than a quarter of the physicians in a locality participate, are frequently used as cost containment strategies in Medicaid managed care and constrain choice[2]—despite evidence that these plans make it more difficult for patients to access care.[3] Robust network adequacy standards could be leveraged to protect and enhance a recipients' ability to receive care from a provider or healthcare facility by setting a floor on how restrictive these networks can be. Although the federal government requires that states practice transparency and make these standards available online to all,[4] it is incredibly difficult to locate these documents. The most recent compilations of standards across U.S. states were created by the Department of Health and Human Services in 2014[5], the National Conference of State Legislatures in 2018[6], and the Legal Action Center in March 2020.[7]

In the past, states were required to use travel time and distance, at a minimum, as standards for assessing provider network adequacy.[8] In November 2020, the Centers for Medicare and Medicaid Services removed this requirement to accommodate for growth in telehealth.[9] States are now given the flexibility to choose to use one or more of the following standards or other quantitative measures[10]: geographic criteria (e.g. travel time, travel distance), appointment access (e.g. appointment wait time, hours of operation for a provider), and provider characteristics (e.g. provider-to-enrollee ratio, providers accepting new patients). The Legal Action Center reports that twenty-six states have adopted geographic standards, seventeen states have adopted appointment wait time standards, and thirteen states have adopted provider characteristic standards.[11]

For geographic criteria, both travel time (maximum number of minutes it takes for a patient to travel from their residence to their provider's location) and travel distance (maximum number of miles a patient must travel from their residence to their provider's location) are typically defined. Across states, these standards range from 30-120 minutes and 5-75 miles depending on rurality and the health service being sought. As maximum time and distance limits increase, individuals have a harder time accessing care. There is some evidence that an increase in time and distance to a healthcare provider is associated with a decay in health outcomes.[12] Medicaid serves the low-income population—individuals who are less likely to have disposable time and income to allocate towards travel—increased geographic criteria could serve as a potential deterrent for care seekers. This network adequacy standard is represented in this model in the form of 0-, 30-, or 90-minute delays in getting to a hospital, with the assumption that these delays impact the survival rate from a hospitalization due to a cardiovascular event.

For appointment access, appointment wait time (maximum number of business days a patient must wait for an appointment with a provider after requesting a medically necessary service) or hours of operation for a provider (minimum hours a provider's practice is open during a week including extended or weekend hours) are typically defined. Across states, these standards vary depending on the type of care needed and the setting where that care is administered. Urgent and emergency care is often required to be accessible within 0-96 hours for 24 hours per day and 7 days a week. Appointment access standards for primary care range from

7-90 calendar days and some states require primary care providers to keep their offices open for at least 20 hours per week. Scenarios were modeled under which individuals wait 7, 45, or 90 days for an appointment with a primary care provider or a cardiologist.

For provider characteristics, Provider-to-Enrollee ratios (maximum number of enrollees a plan may have per available provider) or the minimum percentage of providers in a plan that are actively accepting new patients are typically included. Larger Provider-to-Enrollee ratios are expected to give patients less scheduling difficulty when seeking care and receive more personalized attention from their provider. The simplifying assumptions made for this model's structure prevent provider characteristic network adequacy standards from adequate incorporation into the simulation.

This simulation model will assess how different network adequacy standard strategies impact lifespan, care access, and economic burden of Medicaid recipients who develop cardiovascular disease (CVD). CVD is the leading cause of death globally[13] and prevalence rates are disproportionately higher in low-income populations[14]—the population served by Medicaid. As a disease that requires high frequency of management and intervention, it is plausible that changing Medicaid network design standards, thus affecting how low-income CVD patients access and utilize care, would ultimately have an impact on population health outcomes.

Aims and Hypotheses

The aims of this study are to construct simulation modeling methods to approach this policy problem and determine which numeric values for appointment wait time and travel time delay network adequacy standards are most effective for protecting the health of Medicaid MCO recipients who develop CVD. For the purposes of this project, life expectancy is considered the most important performance indicator; the “best” strategy will be the one that yields the largest mean survival time and oldest mean age at death for those who eventually die of CVD-related causes.

It is expected that maximum access to care for individuals with CVD will occur under the shortest appointment wait time and smallest travel time to a hospital. There is a well-established connection between health service access and population health outcomes.[15] Therefore, the strictest network adequacy standards, “Short” appointment wait time (7 day wait) and “None” travel time delay (0 min delay), should in combination produce the most favorable health outcomes. This strategy would be expected to produce the largest survival time for those who die of non-CVD causes, longest amount of time spent in recovery, shortest amount of time spent waiting for an appointment, greatest percent of individuals who die in recovery, and the highest burden on the healthcare system (hospital visits, provider visits, and Medicaid costs).

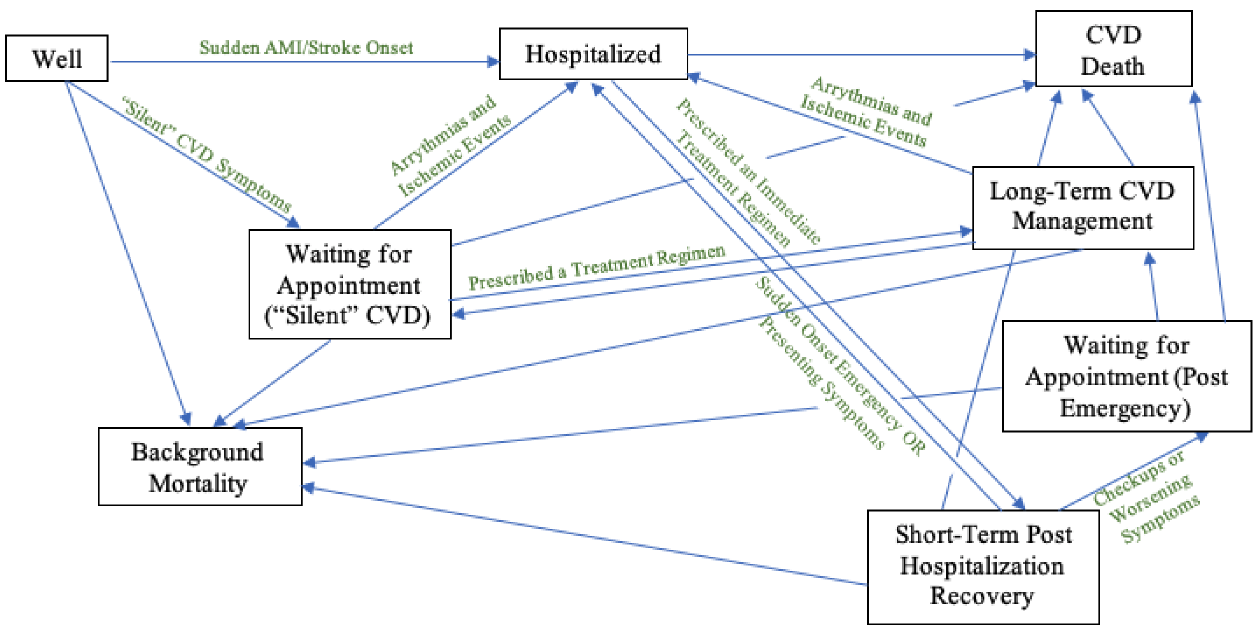
METHODS

Model Structure and Assumptions

A continuous-time Markov model was used to simulate cardiovascular disease health and outcomes in Medicaid recipients older than age 40 under different network adequacy standard strategies. The cohort was initialized at the start of the simulation to represent the age and gender distribution of the Medicaid population. The simulation settings include: a cohort population size of 10,000 people, a simulation length of 150 years, a significance level for calculating confidence intervals of 0.05, and an annual discount rate of 0.03. The program was written using Version 3.9 of the Python programming language and employs the Simulation in Medicine (SimPy) library to support analyses and operations.[16, 17]

At the start of the simulation, all patients are assumed to be healthy and with no symptoms or history of CVD. The stochastic simulation method used in this model, the Gillespie algorithm[18], continuously determines which state a patient will progress to next and at what time point in the future that progression will occur. The Gillespie algorithm calculates this movement using transition rates specific to the age and gender of the individual in the cohort being simulated. **Figure 1** depicts the eight states included in this model and how individuals flow between these states.

FIGURE 1. SCHEMATIC OUTLINE OF MODEL STRUCTURE



The natural history of cardiovascular disease is simplified significantly for the purposes of this model. Individuals can only exist in the following states (defined in **Table 1**): Well, Hospitalized, CVD Death, Waiting for Appointment ("Silent" CVD), Waiting for Appointment (Post-Emergency), Short-Term Post Hospitalization Recovery, Long-Term CVD Management, Background Mortality.

TABLE 1. DESCRIPTION OF MODEL STATES

State	Description
Well	Medicaid recipients with no CVD-related symptoms.
Waiting for Appointment (“Silent” CVD)	Individual has requested a visit with a PCP or Cardiologist after experiencing CVD symptoms or for regular checkups while managing their CVD long term. Movement out of this state into a recovery state indicates the completion of a visit.
Waiting for Appointment (Post Emergency)	Individual has requested a visit with a PCP or Cardiologist during or after post hospitalization recovery. Movement out of this state into a recovery state indicates the completion of a visit.
Hospitalized	Patient is receiving emergency care (for a heart attack, heart failure, stroke, etc.) or surgery.
Short-Term Post Hospitalization Recovery	Individual is managing post-hospitalization health status through a prescribed treatment regimen (medication, specific behaviors, etc.).
Long-Term CVD Management	Individual is managing current health status through a prescribed treatment regimen (medication, specific behaviors, etc.). It is assumed that the patient will revisit this state after CVD events and checkups until death.
CVD Death	Death after hospitalization or treatment in recovery for CVD-related causes
Background Mortality	Death due to non-CVD-related causes

An individual who develops CVD in this model is assumed to have done so through one of two pathways: sudden cardiac emergency or “silent” CVD. In the sudden cardiac emergency pathway, a well individual experiences the onset of sudden AMI or stroke and is then hospitalized. This hospitalized patient will then either die from CVD-related causes or be moved to short-term post-hospitalization recovery. In this short-term recovery stage, an individual is managing post-hospitalization health status through a prescribed treatment regimen. They may then be readmitted to the hospital due to sudden onset emergency or the presentation of symptoms. Otherwise, they will wait for an appointment with a PCP or Cardiologist where they are prescribed a treatment regimen to manage their health status in the long term. This health status will be sustained, with frequent transitions to the Waiting for Appointment state and back to simulate check-ups with a provider, until hospitalization readmission or death occurs. Those who are recovering in short-term post-hospitalization and those waiting for a post-emergency appointment are at an elevated risk of CVD death.

In the “silent” CVD pathway, a well individual notices symptoms of cardiovascular disease (angina, heart arrythmia, and other risk factors of CVD) and schedules an appointment with a provider. As they are waiting for an appointment, they may experience a CVD death from their symptoms or become hospitalized. If the wait time elapses without either scenario occurring, the individual is prescribed a treatment regimen and moves to the long-term CVD management state. Individuals can die from non-CVD causes (background mortality) in any model state.

Model Inputs – Transition Rate Parameters

This model’s parameters were informed by Medicaid claims data, Social Security life expectancy data, the CDC WONDER database, and values pulled from existing literature. Detailed eligibility, enrollment, inpatient, outpatient, and pharmaceutical claims for Medicaid managed care beneficiaries in Tennessee were used to inform age and gender demographics, prevalence of CVD, hospital admission and readmission rates, and provider visit rates. Social Security Administration and CDC WONDER data were used to inform the background mortality rate and CVD death rates in and out of a medical facility setting. Parameters were calculated, partitioned by gender, for five-year age groups beginning at age 40 and ending at 100+.

Table 2 outlines the calculations done to obtain the mortality rates used to inform the model parameters. Background mortality was calculated by subtracting annual cardiovascular disease mortality rates from all-cause mortality rates. Annual all-cause mortality rates were pulled from the Social Security Administration's 2019 Period Life Table; each five-year age/gender group is represented by the death probability value corresponding to the median age of the group.[19] Crude CVD-related mortality rates were taken directly from the CDC WONDER dataset for the ages 40-84 in 2019.[20] Due to the unavailability of population counts, the CDC WONDER data request was unable to return crude rates per 100,000 for the 85 and older population. These age groups were assumed to have the same CVD-related mortality rates as the 80-84 age group.

This model assumes that individuals who develop CVD will either have a low or high risk of CVD-related death, depending on which state they are in. Those who are Waiting for Appointment ("Silent" CVD) or Long-Term CVD Management are subjected to the low-risk mortality parameters. Those who are Hospitalized, Waiting for Appointment (Post Emergency), or Short-Term Post Hospitalization Recovery are subjected to the high-risk mortality parameters. For the purposes of this model, a CVD death is classified as one that is marked with one or more of the ICD-10 Codes I00-I99 (Diseases of the circulatory system) in 2019 in the CDC WONDER dataset. CVD deaths that occurred in a medical facility (marked as Medical Facility – Inpatient, Medical Facility - Outpatient or ER, Medical Facility - Dead on Arrival, Medical Facility – Status unknown) were considered high-risk deaths.[21] CVD deaths that occurred outside of a medical facility (marked as Decedent's home, Hospice facility, Nursing home/long term care, Other, Place of death unknown) were considered low-risk deaths.[22] The final transition rates were determined by dividing the crude CVD death counts for each age/gender group by the estimated number of people with CVD in that age/gender group (2019 population size from the United States Census Bureau[23] multiplied by the American Heart Association's 2016 CVD prevalence estimates[24]).

TABLE 2. MORTALITY PARAMETERS

Transition(s)	Calculation	Value(s)	Source
→ Background Mortality	All-Cause Mortality - CVD-related Mortality	Appendix A (**Table 12**)	All-Cause Mortality (Social Security Administration), CVD-related Mortality (CDC WONDER)
Hospitalized, Waiting for Appointment (Post Emergency) or Short-Term Post Hospitalization Recovery → CVD Death	(Crude CVD death counts/(Population Size*CVD Prevalence))*Multiplier	Appendix A (**Table 12**), Multipliers (**Table 5**)	Crude CVD Death Counts (CDC WONDER), Population Size (2019 Census), CVD Prevalence (AHA),
Waiting for Appointment ("Silent" CVD) or Long-Term CVD Management → CVD Death	Crude CVD death counts/(Population Size*CVD Prevalence)	Appendix A (**Table 12**)	Crude CVD Death Counts (CDC WONDER), Population Size (2019 Census), CVD Prevalence (AHA),

The remaining transition rates in this model (**Table 3**) were informed by Medicaid claims data and values taken from published research and guidelines. Incidence of stroke, acute myocardial infarction, angina, arrythmia, and other CVD symptoms and hospital admission, hospital readmission, and provider appointment rates were pulled from the cohort of 2016 Tennessee Medicaid managed care beneficiaries (N = 1,669,258 members). The rate at which patients moved out of the hospital and into short-term post hospitalization recovery was informed by mean lengths of hospital stay for AMI and stroke in the United States. The American Heart Association's 2019 update to their annual Heart Disease and Stroke Statistics report listed a mean rehabilitation length of stay for stroke of 14.6 days.[25] The Healthcare Cost and Utilization Project from the Agency for Healthcare Research and Quality reported an average length of stay of 5.3 days in 2010.[26] These values were averaged together to calculate the transition rate parameter. The annual provider checkup rate during long-term CVD management was taken from average office visit utilization for Medicaid beneficiaries with CVD in 2009 from the Kaiser Commission on Medicaid and the Uninsured.[27]

TABLE 3. OTHER MODEL PARAMETERS

Transition(s)	Calculation	Value(s)	Source
Well → Hospitalized	Annual incident stroke rate + Annual incident AMI rate	Appendix A (**Table 13**)	Tennessee Medicaid claims
Well → Waiting for Appointment ("Silent" CVD)	Annual incident angina rate + Annual incident arrythmia rate + Annual incident other CVD rate	Appendix A (**Table 13**)	Tennessee Medicaid claims
Waiting for Appointment ("Silent" CVD) or Long-Term CVD Management → Hospitalized	Annual probability of CVD-related hospitalization	Appendix A (**Table 14**)	Tennessee Medicaid claims
Short-Term Post Hospitalization Recovery → Hospitalized	(30-day readmission after emergency + 30-day readmission after symptoms) * (365.25/30)	Appendix A (**Table 14**)	Tennessee Medicaid claims
Short-Term Post Hospitalization Recovery → Waiting for Appointment (Post Emergency)	Annual probability of care with CVD specialist due to worsening symptoms	Appendix A (**Table 14**)	Tennessee Medicaid claims
Hospitalized → Short-Term Post Hospitalization Recovery	Average of mean length of hospital stay AMI (5.3 days) + stroke (14.6 days)	9.95 days	Mean length AMI (AHRQ), Mean length stroke (AHA)
Long-Term CVD Management → Waiting for Appointment ("Silent" CVD)	Average number of office visits for Medicaid beneficiaries with CVD in 2009 was 10.2	1/10.2	KFF

Model Inputs – Network Adequacy Strategies

Two types of network adequacy standard strategies were explored in this model. First, the maximum amount of time a Medicaid MCO enrollee would have to wait to see a provider after initiating an appointment. The Legal Action Center's 2020 report[28] was used to survey existing or previously used standards to select wait times to be considered "short", "medium", and "long" (**Table 4**). Colorado had the strictest quantitative criteria; Medicaid MCO enrollees had to be given an appointment date within 7 calendar days of requesting primary care from a contracted physician. Vermont had the most lenient quantitative criteria; Medicaid MCO enrollees had to be given an appointment date within 90 days of requesting preventative care. All other states that defined emergency or non-emergency quantitative criteria fell within this range. Wait times were assumed to impact the transition rate from Waiting for Appointment ("Silent" CVD) and Waiting for Appointment (Post-Emergency) to the Long-Term CVD Management state. Since the time an individual spends with a provider during an appointment is likely a small fraction of one day, it was considered negligible for the purposes of this model.

TABLE 4. APPOINTMENT WAIT TIME NETWORK ADEQUACY STANDARD PARAMETERS

Strategy Name	Source	Value
Short	Colorado (primary care)	7 days
Medium	No specific state; chosen as a potential new strategy	45 days
Long	Vermont (preventive care)	90 days

Second, the time taken for an enrollee to arrive at a hospital due to distance was assumed to impact the risk of mortality. The Legal Action Center's 2020 report was again used to survey existing or previously used standards to select travel times to be considered "none", "short", and "long" (**Table 5**).[29] Vermont had the most lenient quantitative criteria; Medicaid MCO enrollees needed to receive major trauma treatment within 90 minutes of initiating care. Eight states specified a 30-minute travel time maximum. As taken from research on acute myocardial infarction in 2010, every 30 minutes of delay increases the annual mortality risk for an individual by 7.5%.[30] The calculated increased risk was multiplied by the annual rate of medical facility mortality (**Table 2**) to calculate the high-risk death rate.

TABLE 5. TRAVEL TIME DELAY NETWORK ADEQUACY STANDARD PARAMETERS

Strategy Name	Description	Value
None	No specific state; chosen to depict no increased mortality risk due to delay	0 minutes (0% increased risk)
Short	California, Florida, Kentucky, Minnesota, New Jersey, Oklahoma, Pennsylvania, Tennessee	30 minutes (7.5% increased risk)
Long	Vermont (major trauma treatment)	90 minutes (22.5% increased risk)

Model Inputs – Costs

To complete an analysis of health system cost burden under different network adequacy standards, estimated cost values for events (hospital and provider visits) and annual existence in a state were taken from published research (**Table 6**). Due to lack of access to data, these costs were not stratified by age and gender and were taken from studies spanning the last 20 years. The 2012 Kaiser Family Foundation report called Medicaid and the Uninsured provided data on average annual per capita spending on Medicaid beneficiaries with or without CVD.[31] Nichols et al. used patient data across health plans from the Kaiser Permanente Northwest CVD registry (2000-2005) to calculate the average annual outpatient costs for patients with established CVD; this value was used as the average cost burden for an individual in a recovery state in the simulation model.[32] Lump sum costs were taken from average hospitalization (stroke and heart failure) costs[33,34] and average provider visit events.[35] It is assumed that individuals who die in this model do not incur any more health care costs. This simulation model applies a discounting method which weights costs incurred closer to the simulation start as more valuable than those that occur farther in the future.[36]

TABLE 6. MODEL STATE AND EVENT COSTS

State/Event	Description	Cost	Source
Well (State)	Average annual per capita spending on Medicaid beneficiaries without CVD was $4,456 in 2009	$4,456/year	KFF
Hospitalized, Waiting for Appointment (States)	Average annual per capita spending on Medicaid beneficiaries with CVD was $9,694 in 2009	$9,694/year	KFF
In Recovery (States)	Total mean annual direct medical costs for CVD patients ($18,953) * Outpatient proportion (57.2%)	$10,841.12/year	Nichols et al.
CVD Death, Background Mortality (States)	Assumed no economic burden for death	$0/year	N/A
Hospitalization (Event)	Average of cost of stroke (mean of ischemic, hemorrhagic, or other strokes ($23,415.33)) + cost of heart failure ($14,631)	$19,023/event	Heart Failure (Kilgore et al.), Stroke (Wang et al.)
Provider Visit (Event)	Average total payment for Medicaid-covered primary care checkups in 2014-15 was $106	$106/event	Biener and Selden

Model Outputs

Various performance indicators were collected for each patient over the course of the simulation. These included survival time (years), age at death (years), number of lifetime hospital visits, number of lifetime provider visits, total time spent in recovery (years), total time spent waiting for an appointment (years), lifetime healthcare costs ($), and lifetime healthcare costs attributable to hospitalization ($). Cohort averages and 95% confidence intervals for each of these indicators were reported for each strategy, along with the percent of CVD deaths that occurred while in recovery and the percent of CVD deaths that occurred while hospitalized.

RESULTS/DISCUSSION

All Strategy Combination Outputs

All nine possible strategy combinations were run separately to allow for visual inspection of "best" and "worst" strategies. As noted earlier, the "best" strategy is considered the one that yields the largest mean survival time and oldest mean age at death for individuals with CVD. The "worst" strategy is the one that yields the smallest mean survival time and youngest mean age at death for individuals with CVD. Selected results are displayed in **Table 7** through **Table 8** (notable outcomes highlighted) and the full simulation output is presented in Appendix B.

TABLE 7. MEAN AGE AT DEATH (CVD)

	Short Wait Time (7 days)	Medium Wait Time (45 days)	Long Wait Time (90 days)
No Travel Delay (0 mins)	83.11 (82.39, 83.84) years	**83.79 (83.10, 84.47) years**	82.96 (82.24, 83.68) years
Short Travel Delay (30 mins)	82.92 (82.21, 83.62) years	83.42 (82.73, 84.12) years	83.24 (82.51, 83.98) years
Long Travel Delay (90 mins)	**82.35 (81.58, 83.12) years**	82.94 (82.21, 83.67) years	83.01 (82.31, 83.71) years

After all strategy combinations were run, it was found that the strategy with a 45-day appointment wait time and 0-minute travel time delay yielded the most favorable health outcomes for individuals with CVD (**Table 7**); a mean age at death of 83.79 (83.10, 84.47) and a mean survival time of 32.08 (31.09, 33.07). The least favorable outcomes occurred under the 7-day appointment wait time and 90-minute travel delay strategy; a mean age at death of 82.35 (81.58, 83.12) and a mean survival time of 30.76 (29.73, 31.79). For individuals who develop CVD who experience short or medium wait times, life expectancy decreases as travel time delay increases. If hospitalized individuals experience a 90-minute travel delay, increasing appointment wait time increases life expectancy. There were no other clearly discernable trends.

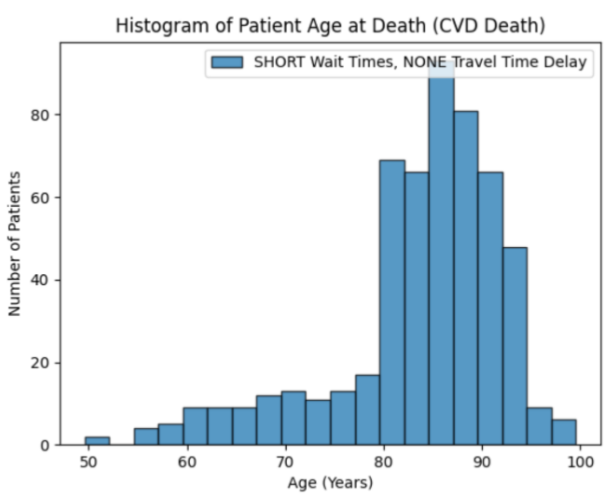
TABLE 8. MEAN AGE AT DEATH (NON-CVD)

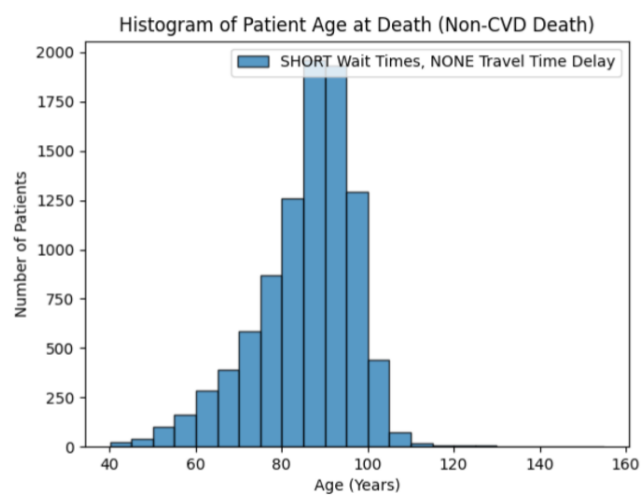
	Short Wait Time (7 days)	Medium Wait Time (45 days)	Long Wait Time (90 days)
No Travel Delay (0 mins)	85.43 (85.20, 85.67) years	85.33 (85.09, 85.57) years	**85.74 (85.50, 85.97) years**
Short Travel Delay (30 mins)	85.59 (85.36, 85.83) years	85.53 (85.30, 85.77) years old	85.65 (85.42, 85.88) years
Long Travel Delay (90 mins)	85.37 (85.13, 85.61) years	85.39 (85.15, 85.62) years	**85.30 (85.07, 85.54) years**

It must be noted that the life expectancy in the United States in 2019 was 78.8 years.[37] In the simulation results, CVD and non-CVD death mean age at death outcomes range from 82.35 (81.58, 83.12) to 83.79 (83.10, 84.47) and 85.30 (85.07, 85.54) to 85.74 (85.50, 85.97), respectively. Although these results did align with the expectation that individuals with CVD live shorter lives than those without CVD, individuals in the simulation model lived much longer than they would have in reality. The histograms for CVD and non-CVD death were visually inspected (**Figure 2.**) for anomalies and no oddities were found in the distributions. This disparity is likely due to two concessions that were made when selecting data to inform mortality parameters. First, mortality data for the low-income population was unavailable through

Medicaid claims; Social Security Administration and CDC WONDER mortality data for the general population were used instead. This may have inflated the simulated life expectancy as studies have shown that lower income is associated with lower life expectancy.[38] Second, due to unavailability of data, the 85 and older population was assumed to have the same CVD-related mortality rates as the 80-84 age group. This may have overestimated the simulated life expectancy for CVD death as it is probable that the 85 and older population would have higher CVD mortality rates than the 80-84 age group, as evidenced by the continuous increase in age-stratified CVD mortality rates (**Table 12**).

FIGURE 2. HISTOGRAMS OF PATIENT AGE AT DEATH (CVD AND NON-CVD DEATHS)





Despite being the preferred strategy for CVD life expectancy, the medium appointment wait time and no travel delay strategy did not yield the best outcomes for individuals who died of non-CVD causes (**Table 8**). This group had the largest life expectancy under the long wait time and no travel delay strategy at 85.74 years (85.50, 85.97). This result is peculiar; larger appointment wait times were hypothesized to curtail lifespan for Medicaid recipients due to a decline in care access. It is possible that this occurs because this simulation model only applies modified network adequacy standards to CVD-afflicted individuals. In reality, changes in appointment wait times or travel times do not solely affect those with CVD—they impact care accessibility across the full spectrum of health conditions, especially those that require high levels of management and intervention. It would add an unmanageable amount of complexity to amend the model's structure and input parameters to account for this.

Table 9 outlines the proportion of each simulated cohort that died from CVD or non-CVD causes while waiting for an appointment with a provider. The results show that increasing wait times increases this death percentage. This is likely because as wait times increase, individuals in long-term recovery spend more time living and dying in the Waiting for Appointment state as they do in the Long-Term CVD Management state. There are some other trends in these results; increasing travel delay for those with medium wait times increases the percentage of deaths that occur while waiting and increasing travel delay for those with long wait times decreases this percentage. If reducing this statistic is the main goal of policymakers, the best strategy would be the 7-day wait time and 30-minute travel delay strategy.

TABLE 9. PERCENT OF INDIVIDUALS WHO DIED WHILE WAITING FOR APPOINTMENT

	Short Wait Time (7 days)	Medium Wait Time (45 days)	Long Wait Time (90 days)
No Travel Delay (0 mins)	12.9%	43.14%	**56.12%**
Short Travel Delay (30 mins)	**12.84%**	43.45%	55.95%
Long Travel Delay (90 mins)	13.27%	43.92%	55.72%

If having less CVD deaths occur in hospitals is the primary goal for policymakers, a 0-min travel delay and 7-day wait time strategy would be the preferred network adequacy standard strategy **(Table 10**). Under this strategy, 0.1678% of CVD deaths occur in a hospital, 83.22% occur in recovery, and the remaining occur while waiting for an appointment with a provider. It must be noted that a lower percentage of CVD deaths occurring in hospitals does not necessarily indicate better population health outcomes; individuals may be dying from a CVD emergency before they get to the hospital. Ideally, a lower percentage of deaths occurring in a hospital means that CVD deaths are being shifted towards occurring in long-term recovery. In this recovery state, individuals take medication and receive checkups frequently while living relatively similar lifestyles to individuals who do not develop cardiovascular disease. Only one trend is found in these outcome data; increasing travel time delay for individuals experiencing medium wait times decreases the proportion of CVD deaths that occur in-hospital.

TABLE 10. PERCENT OF CVD DEATHS WHILE HOSPITALIZED

	Short Wait Time (7 days)	Medium Wait Time (45 days)	Long Wait Time (90 days)
No Travel Delay (0 mins)	**0.1678%**	0.8143%	0.4975%
Short Travel Delay (30 mins)	0.4902%	0.4823%	**1.0256%**
Long Travel Delay (90 mins)	0.9317%	0.3328%	0.9756%

This study focuses only on costs borne by Medicaid. **Table 11** outlines the average cost burden per person that Medicaid patients accumulate over their lifetime under different network adequacy standard strategies. The most expensive strategy is the 0-minute travel delay and 7-day appointment wait time strategy at $2,126,374 (2,099,855, 2,152,893) and the least expensive strategy is the 90-minute travel delay and 90-day appointment wait time strategy at $895,665 (884,272, 907,059). This is not an unexpected result; stricter network adequacy standards lead to more interactions with the health care system. Each of these interactions (e.g. hospitalization, provider visit) have costs associated with them—costs that individuals who have died or are not accessing care do not have to bear. Future studies of the economic burden resulting from network adequacy standard changes should run cost-benefit analyses and incorporate data on quality of life, lost productivity, the value of statistical life lost,[39] and emotional harm into the simulation.

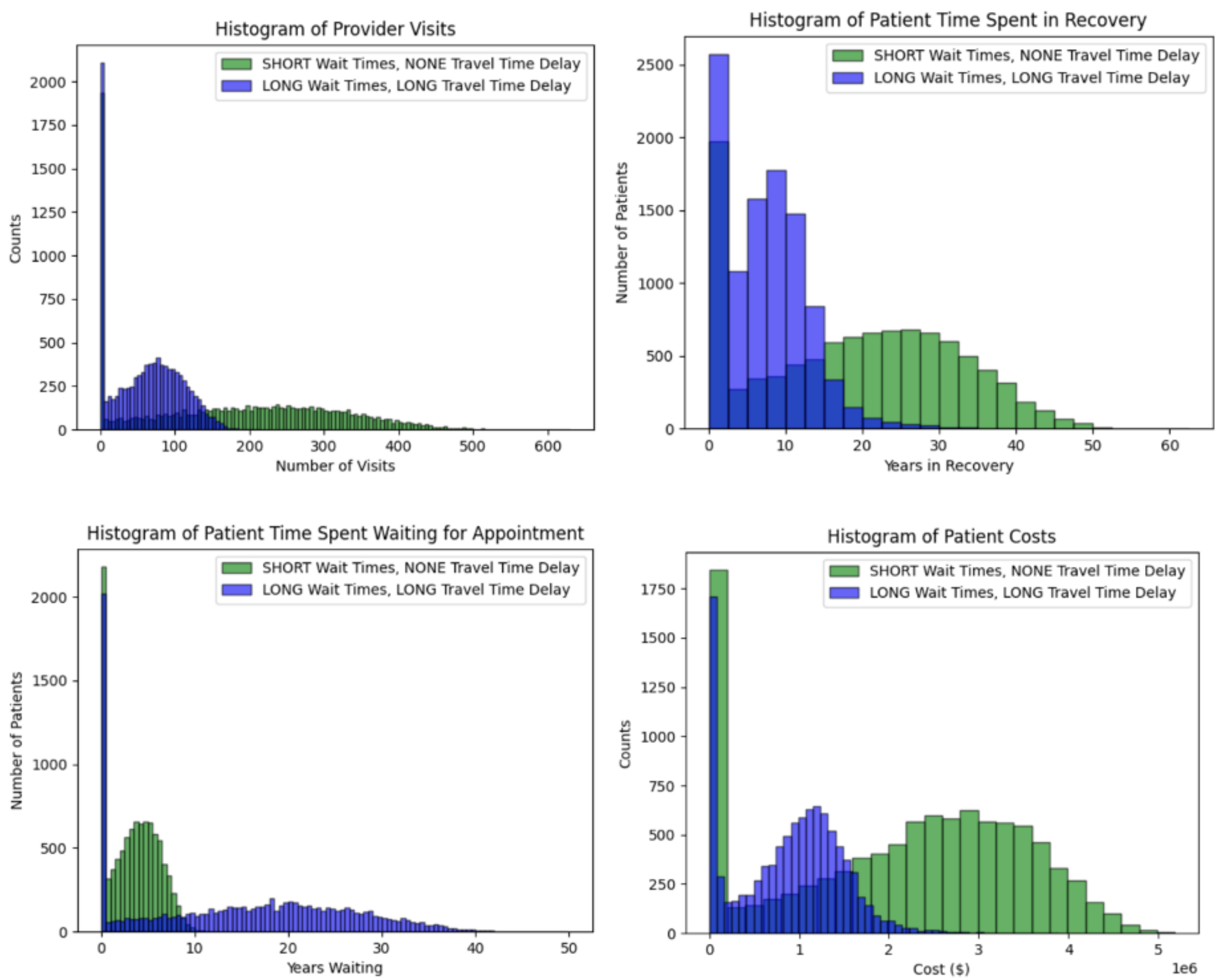
TABLE 11. HEALTH SYSTEM COST BURDEN (DISCOUNTED)

	Short Wait Time (7 days)	Medium Wait Time (45 days)	Long Wait Time (90 days)
No Travel Delay (0 mins)	**$2,126,374 (2,099,855, 2,152,893)**	$1,243,781 (1,228,372, 1,259,189)	$905,448 (894,189, 916,707)
Short Travel Delay (30 mins)	$2,120,245 (2,093,932, 2,146,557)	$1,256,276 (1,240,837, 1,271,715)	$906,935 (895,582, 918,288)
Long Travel Delay (90 mins)	$2,096,170 (2,069,591, 2,122,749)	$1,244,368 (1,229,009, 1,259,728)	**$895,665 (884,272, 907,059)**

Comparison of Expected "Best" vs. "Worst" Strategies

The strategies expected to be the "best" (7-day appointment wait times and no travel delay) and "worst" (90-day appointment wait times and 90-min travel delay for emergencies) were run in comparison to one another. Statistically significant differences were found for time spent in recovery, time spent waiting for an appointment, number of provider visits, and healthcare system cost burden. Statistically significant differences were not found for mean survival time (CVD death or non-CVD death), mean age at death (CVD death or non-CVD death), number of hospital visits, and costs attributable to hospitalization. Graphical representations of the outcome comparisons that yielded statistical significance are presented in **Figure 3**.

FIGURE 3. COMPARISON OF EXPECTED BEST VS. WORST STRATEGIES – STATISTICALLY SIGNIFICANT DIFFERENCES



The top left and bottom right panels contain comparative histograms of provider visits and individual costs, respectively, under these two strategies. These results indicate that shorter appointment wait times and no travel delay led to greater utilization of the healthcare system through significantly larger quantities of provider visits. Since there was no statistically significant increase in hospitalizations, the increase in costs per individual per lifetime are likely attributable to this increase in provider visits. The top right and bottom left panels contain comparative histograms of time spent in recovery and waiting for appointment. These histograms seem to be inverses of one another; as appointment wait times increase, individuals spend more of their long-term recovery actively waiting for an appointment for a checkup with a provider.

Limitations

Since major assumptions and simplifications were made to keep this simulation manageable, this model may not fully capture the complexities of the ways in which the natural history of cardiovascular disease and the healthcare system interact. First, it would be beneficial to consult with cardiovascular disease experts to ensure accuracy in the assumed natural history of cardiovascular disease and treatment practices. It is possible that the long-term manifestations of the two CVD pathways specified in this model (sudden cardiac emergency or "silent" CVD) require starkly different methods of treatment—this model assumes identical treatment after individuals who experience sudden cardiac emergency recover. In addition, Medicaid is not the only government-run social safety net program that aids the low-income population; certain individuals are dually eligible to enroll in Medicaid and Medicare when they turn 65.[40] It would add value to this model to incorporate dual enrollees and investigate how access to further services under Medicare alters health outcomes and alleviates some of the economic burden on Medicaid.

Second, the ways in which network adequacy standards are applied in this model may not be wholly representative of reality. Minimum travel time standards are typically defined for the broad array of provider and hospital visit types. In this model, due to the availability of minimal data on the impact of travel on CVD health, travel time is only applied in the form of a delay en route to a hospital in the case of emergency. Also, appointment wait time standards are defined as allowed maximums. Data on the actual distributions of wait times were unavailable (e.g. a 45-

day wait time does not necessarily mean an individual will wait the full 45 days in all scenarios) and further models should attempt to incorporate this nuance. Third, most of the parameter data came from the 2019 Tennessee Medicaid MCO cohort but data were also taken, as needed, from research that investigated other populations. As previously mentioned, the mortality and cost data, length of hospital stays, and average number of provider visits used in this study were taken from research on the general population that spanned the years 2000-2019. Although, parameters were taken from reputable sources, this overall lack of consistency across localities, income levels, and time periods may have dampened the quality and accuracy of the study results.

Fourth, more robust calibration must be done to alleviate existing doubts on the internal validity of the simulation results. As seen in the cohort means produced in the simulation results (Appendix B), individuals are estimated to live between 82.35 (81.58, 83.12) to 83.79 (83.10, 84.47) years, visit a hospital 9.88 (9.37, 10.39) to 10.67 (10.13, 11.21) times in their lives, visit a provider 60.59 (59.70, 61.48) to 180.59 (177.97, 183.21) times in their lives, and cost Medicaid $895,665 (884,272, 907,059) to $2,126,374 (2,099,855, 2,152,893). Medicaid population-specific data on life expectancy, lifetime number of hospital or provider visits, and lifetime healthcare system cost burdens are needed to confirm the realness and accuracy of these model output ranges. Additionally, a big indicator of model inaccuracy is that approximately 6-7% of the cohort in this model die of CVD; this is starkly different from the CDC's estimate that 1 in 4 deaths are due to CVD.[41]

CONCLUSION

This is the first study done to analyze the impact of state-level network adequacy standards on health through the usage of a continuous-time Markov model. The goals of this project were to formulate appropriate simulation modeling methods and provide a strategy recommendation to policymakers. After all strategy combinations were run, it was found that the strategy with a 45-day appointment wait time and 0-minute travel time delay yielded the most favorable health outcomes for individuals with CVD (**Table 7**); a mean age at death of 83.79 (83.10, 84.47) and a mean survival time of 32.08 (31.09, 33.07). When the strategies expected to be the "best" (7-day appointment wait times and no travel delay) and "worst" (90-day appointment wait times and 90-min travel delay for emergencies) were run in comparison to one another, statistically significant differences were found for time spent in recovery or waiting for an appointment, provider visit quantity, and healthcare system cost burden. Statistically significant differences were not found for life expectancy, hospital visit quantity, and costs attributable to hospitalization.

These results are preliminary and should not be used to make policy decisions until further complexities are incorporated and calibration is completed. Such model modifications may include updating mortality rate parameters to be representative of low-income populations, taking cost data directly from Medicaid claims, consulting with cardiovascular disease experts to ensure accuracy natural history of CVD and treatment regimen assumptions, expanding definition of economic burden, and running cost-benefit analyses. The third type of network adequacy standard, provider characteristics, went unexplored in this study; a discrete time model would be best suited for investigating the impact of changing provider-to-enrollee ratios and/or hours of operation on CVD outcomes. This inaugural research attempt is a step towards settling the network adequacy standard policy debate and imbuing some level of standardization within Medicaid MCOs across the nation.

APPENDIX A – Detailed Parameter Tables

TABLE 12. AGE- AND GENDER-STRATIFIED MORTALITY RATES IN 2019

Age Group	Gender	Background Mortality	Total CVD Death	CVD Death Medical Facility	CVD Death Non-Medical Facility
40-44	F	0.001596	0.000282	0.000118	0.000073
40-44	M	0.002828	0.000578	0.000196	0.000160
45-49	F	0.002332	0.000458	0.000188	0.000130
45-49	M	0.003831	0.000996	0.000342	0.000285
50-54	F	0.003529	0.000745	0.000280	0.000241
50-54	M	0.005808	0.001689	0.000532	0.000530
55-59	F	0.005425	0.001181	0.000469	0.000424
55-59	M	0.009047	0.002686	0.000843	0.000939
60-64	F	0.008006	0.001851	0.000452	0.000447
60-64	M	0.013248	0.004057	0.000914	0.001084
65-69	F	0.011158	0.002748	0.000563	0.000589
65-69	M	0.018280	0.005681	0.001062	0.001267
70-74	F	0.017892	0.004569	0.000722	0.000837
70-74	M	0.026249	0.008095	0.001195	0.001436
75-79	F	0.029837	0.008093	0.000836	0.001121
75-79	M	0.042159	0.012814	0.001202	0.001564
80-84	F	0.051658	0.01565	0.003311	0.005965
80-84	M	0.069190	0.022111	0.005548	0.009022
85-89	F	0.091587	0.01565	0.003450	0.008694
85-89	M	0.117771	0.022111	0.004720	0.010427
90-94	F	0.159491	0.01565	0.002708	0.010153
90-94	M	0.197287	0.022111	0.002759	0.008995
95-99	F	0.249466	0.01565	0.001118	0.006030

95-99	M	0.297897	0.022111	0.000868	0.003811
100+	F	0.336563	0.01565	0.000194	0.001582
100+	M	0.383560	0.022111	0.000096	0.000576

TABLE 13. AGE- AND GENDER-STRATIFIED CVD SYMPTOM INCIDENCE RATES IN 2019

Age Group	Gender	Stroke	AMI	Angina	Arrythmia	Other CVD
40-44	F	0.0016	0.0039	0.0041	0.007	0.0511
40-44	M	0.0019	0.006	0.0041	0.0052	0.0472
45-49	F	0.0029	0.007	0.0067	0.0072	0.0677
45-49	M	0.0035	0.0101	0.008	0.0056	0.0651
50-54	F	0.0053	0.0122	0.0102	0.0069	0.0896
50-54	M	0.0052	0.015	0.0105	0.0065	0.0866
55-59	F	0.0083	0.0188	0.0137	0.0096	0.1182
55-59	M	0.0093	0.0245	0.0145	0.0108	0.1199
60-64	F	0.0111	0.0262	0.014	0.0104	0.1422
60-64	M	0.0129	0.0303	0.0143	0.0121	0.1569
65-69	F	0.014	0.0338	0.0156	0.013	0.1566
65-69	M	0.0158	0.043	0.0152	0.016	0.1912
70-74	F	0.0051	0.0158	0.0055	0.0058	0.0747
70-74	M	0.0055	0.02	0.0054	0.0055	0.0861
75-79	F	0.0024	0.0102	0.0026	0.0017	0.0383
75-79	M	0.0016	0.011	0.0027	0.0019	0.0421
80-84	F	0.002	0.0111	0.0016	0.0023	0.036
80-84	M	0.0025	0.0114	0.0022	0.0018	0.0392
85-89	F	0.0019	0.0125	0.002	0.0027	0.0379
85-89	M	0.0013	0.0124	0.0023	0.0023	0.034

90-94	F	0.0013	0.0145	0.0013	0.0038	0.0246
90-94	M	0.0011	0.0143	0.0011	0.0032	0.0328
95-99	F	0.0004	0.0106	0.0002	0.0015	0.0193
95-99	M	0.0022	0.0099	0.0011	0.0011	0.032
100+	F	0.0008	0.0105	0.0016	0.0012	0.0141
100+	M	0	0.0062	0	0	0.0156

Table 14. Age- and Gender-Stratified Hospitalization and CVD Specialist Visit Rates in 2019

Age Group	Gender	Probability of CVD-related Hospitalization	30-day Readmission after Emergency	30-day Readmission after Symptoms	Probability of care with CVD specialist
40-44	F	0.0023	0.2861	0.2727	0.1163
40-44	M	0.004	0.3592	0.2507	0.1146
45-49	F	0.0037	0.3031	0.2516	0.1658
45-49	M	0.0068	0.3322	0.2477	0.1568
50-54	F	0.0057	0.3537	0.2473	0.2097
50-54	M	0.0081	0.4296	0.2402	0.1886
55-59	F	0.0087	0.342	0.2471	0.2499
55-59	M	0.0132	0.3952	0.2504	0.2258
60-64	F	0.011	0.3553	0.245	0.2762
60-64	M	0.0164	0.3452	0.2577	0.2709
65-69	F	0.0122	0.4045	0.2283	0.2937
65-69	M	0.0203	0.3551	0.2375	0.3099
70-74	F	0.0038	0.2248	0.1804	0.1266
70-74	M	0.0072	0.3568	0.2132	0.1319
75-79	F	0.0013	0.2258	0.1037	0.0601
75-79	M	0.0029	0.2069	0.1229	0.0559

80-84	F	0.0013	0.2162	0.0827	0.0536
80-84	M	0.0007	0.0769	0.0893	0.052
85-89	F	0.0007	0.0196	0.1366	0.0472
85-89	M	0.0013	0.1667	0.0714	0.0392
90-94	F	0.0007	0.1212	0.0709	0.0315
90-94	M	0.0005	0	0.0947	0.0396
95-99	F	0.0004	0.3	0.0741	0.0266
95-99	M	0.0011	0	0.0841	0.0343
100+	F	0.0004	0	0.0545	0.0164
100+	M	0	0	0	0.0156

APPENDIX B – Simulation Results for All Strategies

SHORT Wait Times, NONE Travel Time Delay

Estimate of mean survival time (CVD death) and 95% confidence interval: 31.56 (30.59, 32.54)

Estimate of mean survival time (non-CVD death) and 95% confidence interval: 29.59 (29.27, 29.91)

Estimate of mean age at death (CVD death) and 95% confidence interval: 83.11 (82.39, 83.84)

Estimate of mean age at death (non-CVD death) and 95% confidence interval: 85.43 (85.20, 85.67)

% of individuals who died while waiting for appointment: 0.129

% CVD deaths that occurred while in recovery: 0.8322147651006712

% CVD deaths that occurred while hospitalized: 0.0016778523489932886

Estimate of number of hospital visits and 95% confidence interval: 10.44 (9.90, 10.98)

Estimate of number of provider visits and 95% confidence interval: 180.59 (177.97, 183.21)

Estimate of time spent in recovery and 95% confidence interval: 18.86 (18.61, 19.12)

Estimate of time spent waiting for appointment and 95% confidence interval: 3.47 (3.42, 3.52)

Estimate of discounted cost and 95% confidence interval: 2,126,374 (2,099,855, 2,152,893)

Estimate of hospitalization cost and 95% confidence interval: 125,407 (119,128, 131,686)

SHORT Wait Times, SHORT Travel Time Delay

Estimate of mean survival time (CVD death) and 95% confidence interval: 31.33 (30.36, 32.30)

Estimate of mean survival time (non-CVD death) and 95% confidence interval: 29.68 (29.36, 30.00)

Estimate of mean age at death (CVD death) and 95% confidence interval: 82.92 (82.21, 83.62)

Estimate of mean age at death (non-CVD death) and 95% confidence interval: 85.59 (85.36, 85.83)

% of individuals who died while waiting for appointment: 0.1284

% CVD deaths that occurred while in recovery: 0.8202614379084967

% CVD deaths that occurred while hospitalized: 0.004901960784313725

Estimate of number of hospital visits and 95% confidence interval: 10.33 (9.80, 10.86)

Estimate of number of provider visits and 95% confidence interval: 180.03 (177.42, 182.63)

Estimate of time spent in recovery and 95% confidence interval: 18.80 (18.55, 19.06)

Estimate of time spent waiting for appointment and 95% confidence interval: 3.45 (3.40, 3.50)

Estimate of discounted cost and 95% confidence interval: 2,120,245 (2,093,932, 2,146,557)

Estimate of hospitalization cost and 95% confidence interval: 123,753 (117,611, 129,894)

SHORT Wait Times, LONG Travel Time Delay

Estimate of mean survival time (CVD death) and 95% confidence interval: 30.76 (29.73, 31.79)

Estimate of mean survival time (non-CVD death) and 95% confidence interval: 29.24 (28.92, 29.56)

Estimate of mean age at death (CVD death) and 95% confidence interval: 82.35 (81.58, 83.12)

Estimate of mean age at death (non-CVD death) and 95% confidence interval: 85.37 (85.13, 85.61)

% of individuals who died while waiting for appointment: 0.1327

% CVD deaths that occurred while in recovery: 0.8229813664596274

% CVD deaths that occurred while hospitalized: 0.009316770186335404

Estimate of number of hospital visits and 95% confidence interval: 10.46 (9.92, 10.99)

Estimate of number of provider visits and 95% confidence interval: 177.24 (174.63, 179.86)

Estimate of time spent in recovery and 95% confidence interval: 18.56 (18.30, 18.82)

Estimate of time spent waiting for appointment and 95% confidence interval: 3.40 (3.35, 3.45)

Estimate of discounted cost and 95% confidence interval: 2,096,170 (2,069,591, 2,122,749)

Estimate of hospitalization cost and 95% confidence interval: 127,177 (120,815, 133,540)

MEDIUM Wait Times, NONE Travel Time Delay

Estimate of mean survival time (CVD death) and 95% confidence interval: 32.08 (31.09, 33.07)

Estimate of mean survival time (non-CVD death) and 95% confidence interval: 29.40 (29.08, 29.72)

Estimate of mean age at death (CVD death) and 95% confidence interval: 83.79 (83.10, 84.47)

Estimate of mean age at death (non-CVD death) and 95% confidence interval: 85.33 (85.09, 85.57)

% of individuals who died while waiting for appointment: 0.4314

% CVD deaths that occurred while in recovery: 0.4723127035830619

% CVD deaths that occurred while hospitalized: 0.008143322475570033

Estimate of number of hospital visits and 95% confidence interval: 10.32 (9.79, 10.85)

Estimate of number of provider visits and 95% confidence interval: 94.87 (93.49, 96.25)

Estimate of time spent in recovery and 95% confidence interval: 10.48 (10.33, 10.62)

Estimate of time spent waiting for appointment and 95% confidence interval: 11.72 (11.55, 11.89)

Estimate of discounted cost and 95% confidence interval: 1,243,781 (1,228,372, 1,259,189)

Estimate of hospitalization cost and 95% confidence interval: 123,970 (117,762, 130,178)

MEDIUM Wait Times, SHORT Travel Time Delay

Estimate of mean survival time (CVD death) and 95% confidence interval: 32.17 (31.20, 33.14)

Estimate of mean survival time (non-CVD death) and 95% confidence interval: 29.45 (29.13, 29.77)

Estimate of mean age at death (CVD death) and 95% confidence interval: 83.42 (82.73, 84.12)

Estimate of mean age at death (non-CVD death) and 95% confidence interval: 85.53 (85.30, 85.77)

% of individuals who died while waiting for appointment: 0.4345

% CVD deaths that occurred while in recovery: 0.4533762057877814

% CVD deaths that occurred while hospitalized: 0.00482315112540193

Estimate of number of hospital visits and 95% confidence interval: 10.57 (10.03, 11.11)

Estimate of number of provider visits and 95% confidence interval: 95.41 (94.02, 96.80)

Estimate of time spent in recovery and 95% confidence interval: 10.58 (10.43, 10.72)

Estimate of time spent waiting for appointment and 95% confidence interval: 11.77 (11.60, 11.94)

Estimate of discounted cost and 95% confidence interval: 1,256,276 (1,240,837, 1,271,715)

Estimate of hospitalization cost and 95% confidence interval: 128,861 (122,440, 135,282)

MEDIUM Wait Times, LONG Travel Time Delay

Estimate of mean survival time (CVD death) and 95% confidence interval: 31.16 (30.11, 32.21)

Estimate of mean survival time (non-CVD death) and 95% confidence interval: 29.52 (29.21, 29.84)

Estimate of mean age at death (CVD death) and 95% confidence interval: 82.94 (82.21, 83.67)

Estimate of mean age at death (non-CVD death) and 95% confidence interval: 85.39 (85.15, 85.62)

% of individuals who died while waiting for appointment: 0.4392

% CVD deaths that occurred while in recovery: 0.4492512479201331

% CVD deaths that occurred while hospitalized: 0.0033277870216306157

Estimate of number of hospital visits and 95% confidence interval: 9.88 (9.37, 10.39)

Estimate of number of provider visits and 95% confidence interval: 95.31 (93.92, 96.69)

Estimate of time spent in recovery and 95% confidence interval: 10.48 (10.34, 10.63)

Estimate of time spent waiting for appointment and 95% confidence interval: 11.75 (11.58, 11.92)

Estimate of discounted cost and 95% confidence interval: 1,244,368 (1,229,009, 1,259,728)

Estimate of hospitalization cost and 95% confidence interval: 120,626 (114,550, 126,702)

LONG Wait Times, NONE Travel Time Delay

Estimate of mean survival time (CVD death) and 95% confidence interval: 30.85 (29.82, 31.88)

Estimate of mean survival time (non-CVD death) and 95% confidence interval: 29.91 (29.59, 30.23)

Estimate of mean age at death (CVD death) and 95% confidence interval: 82.96 (82.24, 83.68)

Estimate of mean age at death (non-CVD death) and 95% confidence interval: 85.74 (85.50, 85.97)

% of individuals who died while waiting for appointment: 0.5612

% CVD deaths that occurred while in recovery: 0.3101160862354892

% CVD deaths that occurred while hospitalized: 0.004975124378109453

Estimate of number of hospital visits and 95% confidence interval: 10.62 (10.10, 11.14)

Estimate of number of provider visits and 95% confidence interval: 61.61 (60.72, 62.50)

Estimate of time spent in recovery and 95% confidence interval: 7.30 (7.19, 7.40)

Estimate of time spent waiting for appointment and 95% confidence interval: 15.22 (15.00, 15.44)

Estimate of discounted cost and 95% confidence interval: 905,448 (894,189, 916,707)

Estimate of hospitalization cost and 95% confidence interval: 128,241 (122,046, 134,436)

LONG Wait Times, SHORT Travel Time Delay

Estimate of mean survival time (CVD death) and 95% confidence interval: 31.52 (30.46, 32.57)

Estimate of mean survival time (non-CVD death) and 95% confidence interval: 29.61 (29.30, 29.93)

Estimate of mean age at death (CVD death) and 95% confidence interval: 83.24 (82.51, 83.98)

Estimate of mean age at death (non-CVD death) and 95% confidence interval: 85.65 (85.42, 85.88)

% of individuals who died while waiting for appointment: 0.5595

% CVD deaths that occurred while in recovery: 0.3282051282051282

% CVD deaths that occurred while hospitalized: 0.010256410256410256

Estimate of number of hospital visits and 95% confidence interval: 10.67 (10.13, 11.21)

Estimate of number of provider visits and 95% confidence interval: 61.37 (60.48, 62.26)

Estimate of time spent in recovery and 95% confidence interval: 7.23 (7.13, 7.34)

Estimate of time spent waiting for appointment and 95% confidence interval: 15.12 (14.91, 15.34)

Estimate of discounted cost and 95% confidence interval: 906,935 (895,582, 918,288)

Estimate of hospitalization cost and 95% confidence interval: 129,102 (122,743, 135,461)

LONG Wait Times, LONG Travel Time Delay

Estimate of mean survival time (CVD death) and 95% confidence interval: 31.42 (30.44, 32.39)

Estimate of mean survival time (non-CVD death) and 95% confidence interval: 29.20 (28.88, 29.52)

Estimate of mean age at death (CVD death) and 95% confidence interval: 83.01 (82.31, 83.71)

Estimate of mean age at death (non-CVD death) and 95% confidence interval: 85.30 (85.07, 85.54)

% of individuals who died while waiting for appointment: 0.5572

% CVD deaths that occurred while in recovery: 0.3073170731707317

% CVD deaths that occurred while hospitalized: 0.00975609756097561

Estimate of number of hospital visits and 95% confidence interval: 10.47 (9.93, 11.01)

Estimate of number of provider visits and 95% confidence interval: 60.59 (59.70, 61.48)

Estimate of time spent in recovery and 95% confidence interval: 7.17 (7.06, 7.28)

Estimate of time spent waiting for appointment and 95% confidence interval: 14.96 (14.74, 15.17)

Estimate of discounted cost and 95% confidence interval: 895,665 (884,272, 907,059)

Estimate of hospitalization cost and 95% confidence interval: 126,073 (119,739, 132,406)

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