CHANGES IN CORONARY HEART DISEASE INCIDENCE AND MORTALITY IN NEW JERSEY 2000-2017

By

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ABSTRACT OF THE DISSERTATION

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Even though coronary heart disease (CHD) incidence and mortality has been declining for several decades, it continues to be the number one cause of death in the United States. This decline has been shown to occur in all age, gender and racial/ethnic groups but not in equal measures. However, recent studies have shown a slowing or a taper in the decline in CHD incidence and mortality. We used data from the Myocardial Infarction Surveillance System (MIDAS), a statewide hospitalization database in New Jersey that contains all hospital discharge abstracts submitted to the New Jersey Hospital Discharge Data Collection System by nonfederal acute care hospitals in the state to update trends in incidence and New Jersey State Health Assessment Data from the Department of Health to examine mortality trends through 2017. We specifically looked at CHD and myocardial infarction (MI) data to see how the landscape of CHD has changed between 2000 and 2017 in the state.

In chapter 1 we reviewed what the landscape of CHD is at the present. This included the decline that has occurred in CHD and a review of the probable reasons for the remarkable improvement over the last several decades.

In chapter 2 we were interested in determining if the decline in CHD mortality has been steady from 2000 through 2017 and whether it has been similar in men and women, in blacks, whites and Hispanics and in different age groups. Outcomes were analyzed in total and in major demographic strata: for the three race/ethnic groups; for men and women; and for those 40-44, 45-49, 50-54, 55-59, 60-64, 65-69 , 70-74, 75-79 and 80-84 years of age. The results showed that there was an overall decline of more than 50% over the time period. The rate of CHD death declined similarly in each of the demographic subgroups. However, the decline was more robust in those over age 64 than in younger age groups and more in females than males. One concerning result was that most of the decline in CHD mortality occurred early in the study period with an attenuation of this decline that occurred in 2008-2009 and after. This attenuation may be due to the plateauing in the use of interventional and pharmacological therapies and/or by the increase in the rate of some cardiovascular risk factors, especially diabetes mellitus and obesity.

In chapter 3, we examined the continuing trends in the incidence of hospitalizations for myocardial infarction (MI) in the years 2000-2014 and the case fatality rates for first hospitalizations for MI at discharge, by one year post admission, and by five years post admission using data from MIDAS. Outcomes were analyzed in total and in major demographic strata: for men and women; for whites and black and for those 40-44, 45-49, 50-54, 55-59, 60-64, 65-69 , 70-74, 75-79 and 80-84 years of age. We also wanted to see if the decline in mortality described in Chapter 2 may be partly explained by a decline in incidence of MI, and if so whether the two trends are strongly correlated in terms of demographic distribution and timing. Results show that there was an overall decline of more than 30% in the rate of first MIs from the year 2000 to 2014 but as seen in chapter 2, most of the decline occurred before 2009. Males had a higher incidence of first MIs through the study period, but they also had a greater decline in the incidence rate than females. A decline in MI incidence was observed in all but the youngest age groups with the most dramatic decline seen in the 80-84 age group. A decline of more than 30% was seen in the hospital MI case fatality rate in the population during this period. This was seen in all the demographic strata. Interestingly, women had a higher in-hospital death rate than men at the beginning of the study period, but by 2014 the steeper decline in women resulted in a lower hospital fatality rate than in men. The decline was similar between the racial groups. The oldest age groups exhibited more pronounced declines than the younger age groups. The 1 year case fatality rate showed a decline of almost 16% over the time period. This was seen in all demographic strata. Females showed a greater decline in the one year MI fatality rate than males. The oldest age groups had greater decline than the younger age groups. No significant decline in mortality was seen at 5 years after an initial MI. Similar non-significant results were seen when the data was broken down by gender, race and age groups. This lack of decline at five years may be due to competing risks with non-cardiovascular causes of death that could obscure any improvements in CHD deaths.

In chapter 4 we wanted to determine the cause of the fall in mortality, whether this was more due to the effect of primary prevention (dietary change, physical activity, and the reduction in cholesterol and blood pressure) or from the effect of modern invasive medical or surgical treatment. Using the same demographic strata as used in chapter 3, we quantified and compared the decline in out of hospital CHD deaths per 100,000 in persons with no history of hospitalized CHD in the previous 10 years to the decline in fatalities among those who did have a CHD hospitalization in the 10 years prior to death. The study showed a decline in both populations and across all demographic strata but the decline in CHD mortality was larger in those without a prior hospitalization for CHD than in those with such hospitalization(s). This provides more evidence of the importance of improved lifestyle and out-patient care in accounting for the falling rates of coronary heart disease. The majority of those who died, more than 73%, did not have a history of CHD. This is very concerning and provides an opportunity from where further improvements could come from in the future.

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I would like to thank my wife for her patience and support in helping me complete my studies. We both sacrificed time and energy to make this possible. I dedicate this dissertation to my father, Elias A. Tuppo, who instilled in his children the love of learning that still endures to this day.

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CHAPTER 1

THE LANDSCAPE OF CORONARY HEART DISEASE

The mortality rates of Coronary heart disease (CHD), defined as the narrowing of coronary arteries by plaque buildup that can lead to reduced blood flow to the heart and heart damage, in the United States have been falling since the 1960s in conjunction with improvements in the major coronary risk factors, blood pressure levels, serum lipid levels, and cigarette smoking (1). Recent data from The National Health and Nutrition Examination Survey (NHANES) suggests that blood pressure control (2,3) and non-high-density lipoprotein (HDL) cholesterol levels (4) in the United States have continued to improve. Cigarette smoking continues to decline as a percentage of population in the United States (5). The decline in CHD mortality rates has occurred across all age, gender and ethnic groups. In the time period between 1999 and 2009 there was a dramatic and continuing 32% decline in CHD death rate from 266.5 deaths to 180.1 deaths per 100,000 (6). The decline in mortality due to myocardial infarction (MI) has been attributed not only to a decline in the number of MIs but also to the falling case fatality rate seen in hospitalized patients (7).

Despite these improvements, CHD remains a major health problem. On the basis of data from NHANES in 2007–2010 an estimated 15.4 million Americans ≥20 years of age have CHD (8) with a total CHD prevalence of 6.4% in adults≥20 years of age. CHD prevalence is 7.9% for men and 5.1% for women. Among non-Hispanic whites, CHD prevalence is 8.2% for men and 4.6% for women. Among non-Hispanic blacks, CHD prevalence is 6.8% for men and 7.1% for women. Among Mexican Americans, CHD prevalence is 6.7% for men and 5.3% for women. Approximately every 34 seconds, an

American will experience a coronary event, and every minute someone will die of a coronary event (8). Approximately 34% of the people who experience a coronary attack (first hospitalized MI or coronary heart disease death) in a given year will die of it, and 15% who experience a myocardial infarction (MI) will die of it. This overall improvement in risk profile suggests that there should be a continuing fall in CHD (9) across most segments of the population yet there is newer disturbing evidence indicating that the improvement may have stopped, and that there may be increasing CHD rates in some segments of the population (10,11).

Our understanding of CHD and MI has been illuminated by large population-based studies such as the Atherosclerosis Risk in Communities (ARIC) Study, which has included continuous retrospective surveillance of hospital discharges for MI and deaths due to CHD occurring in or out of the hospital among residents 35 through 74 years at four locations in the United States since 1987 (12-15), and the Myocardial Infarction Surveillance System (MIDAS) project in the State of New Jersey which uses hospital billing data to explore areas of interest in myocardial infarction epidemiology (16).

In New Jersey the incidence of MI has been tracked over several decades by MIDAS. MIDAS is a statewide hospitalization database in New Jersey that contains all hospital discharge abstracts submitted to the New Jersey Hospital Discharge Data Collection System by nonfederal acute care hospitals in the state and includes all records with a primary diagnosis of MI (International classification of Diseases, Ninth Revision [ICD-9] codes 410.0 to 410.9), Ischemic Heart Disease (ICD-9 410-414), Congestive Heart Failure (ICD-9 428), cerebrovascular disease (ICD-9 430-438) and diseases of arteries, arterioles, and capillaries (ICD-9 440-449). The database also contains basic socio-demographic and CVD clinical data and other coexisting conditions on the patients along with data on hospitalizations involving invasive cardiac procedures. The strength of MIDAS is that it includes a very large and comprehensive database of patients with CVD, the linkage of these hospital admission data to the New Jersey death certificate file, and the extensive follow-up of many years. The race/ethnic composition in New Jersey is similar to the United States at large, suggesting that findings from MIDAS are likely to be generalizable to the country as a whole (17). Since its inception, MIDAS has been under the direction of Dr. John Kostis, Director of the Cardiovascular Institute at Robert Wood Johnson Medical School, Rutgers University.

To see if there continues to be a decline in overall CHD mortality and whether it has been equivalent in men and women, in whites, blacks and Hispanics and how it has changed based on age groups, we will look at the trend of CHD mortality from 2000-2017 in the state of New Jersey using the State Health Assessment Data from the Department of Health in chapter 2. The data will be analyzed in major demographic strata such as gender, race and age groups.

To determine if the rates of MI, the destruction of heart tissue resulting from obstruction of the blood supply to the heart muscle, usually as a result of CHD, have continued to decline, we will look at the changes in the incidence of MI hospitalization, case fatality for 1st MI hospitalization, one year and 5 year case fatality for the period of 2000-2014 using the MIDAS data in chapter 3. The data will also be analyzed in major demographic strata such as gender, race and age groups.

The extent to which the decline in CHD mortality has been caused by better control of coronary risk factors (dietary change, physical activity, and the reduction in cholesterol and blood pressure) in the general population and the extent to which it has been the result of modern invasive coronary interventions in symptomatic individuals has been the subject of considerable debate. Research has shown that both have contributed to the decline of CHD mortality in almost equal parts (18,19). If the decline is seen in those with no history of CHD, then we hypothesize that the bulk of the decline is in fact due to reduced risk factors and better care of hypertension, dyslipidemia, and reductions in cigarette smoking. This implies that CHD deaths outside the hospital in individuals who have not benefited from access to acute coronary interventions should have fallen. In chapter 4, using MIDAS data, we will compare the CHD death rates in persons who have been hospitalized for a coronary event in the preceding 10 or more years with those that have not been hospitalized for a coronary event in the preceding 10 years to compare the contribution between public health interventions vs invasive medical treatment to the improved CHD rates. Again, the data will be analyzed in major demographic strata such as gender, race and age groups.

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CHAPTER 2

TRENDS IN CORONARY HEART DISEASE MORTALITY: 2000-2017

ABSTRACT

Although the mortality from coronary heart disease (CHD) has declined over the past several decades, it continues to be a leading cause of death in persons over the age of 45 in the United States. We examined time trends in CHD mortality in total and by gender, race/ethnicity and age groups from the year 2000 to the year 2017. There was a continuing decline in the overall CHD mortality rate of 52% over the time period but there was an attenuation of that decline beginning in 2008-2009 with modest subsequent decline. Males had higher mortality than females and the difference between the two genders remained similar across the study period but females had a greater decline in CHD mortality compared to males. Blacks had higher CHD mortality than whites throughout the study period with a similar decline in both groups. Hispanics had lower rates than whites throughout and showed a similar decline. The decline was more striking in persons aged 65+ years than in those aged 40-64.

INTRODUCTION

Heart disease (CHD) continues to be the leading cause of death and recently accounted for over 23% of all US deaths in persons 45 years of age and older (1). Although heart disease rates are substantially higher in men than in women, it nevertheless is the leading cause of death in both sexes (1,2). The decline in heart disease mortality has been driven almost entirely by the decrease in coronary heart disease (CHD) which began in the 1960s (2,3) and has continued until recently. Using data from the Atherosclerosis Risk in

Communities (ARIC) study it was shown that significant annual decreases in CHD mortality occurred from the years 1987 to 1994 (4). A decline was shown to occur in persons aged 65 and older during the period of 2006-2016 but this decline was not steady as it averaged about 3.5% per year from 2006-2012 and only about 1.6% per year from 2012-2016. Among persons aged 45-64, heart disease declined by an average of 1.4% per year during 2006-2011 but began to increase by 1% per year during the 2011-2016 time period. This disturbing reversal of heart disease trends may be due to increasing CHD risk factors such as obesity and diabetes mellitus, which have reached epidemic proportions in the United States. Obesity and overweight prevalence among men aged 20 and over reached 75.0% and among women it reached 67.8% in 2015-2016 (1). In the state of New Jersey, CHD mortality dropped by 40% from 1990-2004 (5) but the CHD decline was not evenly distributed between genders or age groups.

CHD kills more women in the United States than all cancers combined (6,7) and has long been the leading cause of death. Prior to menopause the risk of heart disease in women is much less than in men, but the difference narrows after age 50 (7). The incidence of CHD in women lags behind men by 10 years for total CHD and by 20 years for more serious clinical events such as myocardial infarction (MI) and sudden death (8). For MI, 28.4% of hospital stays for people 45 to 64 years of age were for women, but this increased to 63.7% of stays for those 85 years of age or older (9). For coronary atherosclerosis, 32.7% of stays among persons 45 to 64 years of age were for women and increased to 60.7% of stays among those 85 years of age.

Despite the lower CHD rates in women, their MI case fatality rates have been somewhat higher than those in men: 9.3% versus 6.2% (9). CHD is often fatal in women with nearly two-thirds who die suddenly of it having no previously recognized symptoms (10). Women with confirmed CHD were twice as likely as men to suffer death or nonfatal MI during the 1-year follow-up period even after adjusting for age and medical illness (11). The use of invasive cardiovascular procedures after an acute MI has been shown to be lower in women than in men and this has not been completely explained by factors such as comorbidities, insurance type, age or complications (11,12). Yet women derive the same benefits from interventions, such as intracoronary stents and coronary artery bypass graft (CABG), as do men (13-16).

There are several possible reasons that may contribute to the gender differences in treatment. Women tend to present with different and atypical symptoms of heart disease than men, such as abdominal discomfort, back pain, nausea and fatigue rather than the typical chest pain with radiation to the left shoulder and down the left arm, making it easy to overlook or misdiagnose (17-20). Women who do undergo cardiac procedures are also older, have more comorbidities, have smaller coronary arteries, have a higher prevalence of hypertension (HTN), diabetes mellitus (DM), hypercholesterolemia, peripheral vascular disease, unstable angina, and more severe angina than men (6,16). In the Women's Ischemia Syndrome Evaluation study, coronary microvascular dysfunction was found to be present in approximately half of the women with chest pain in the absence of obstructive coronary artery disease (CAD) and could not be predicted by risk factors for atherosclerosis and hormone levels (21). This may be why a higher proportion of women than men with angina are found not to have treatable obstruction of the coronary arteries (16,22). In this regard it is of interest that syndromes such as polycystic ovary syndrome that are accompanied by elevated androgen levels have been associated with more angiographic CAD and diminished cardiovascular event-free survival (23).

Women tend to have smaller hearts and heart vessels than men (20,24). It is possible that the difference in anatomy, especially relating to the smaller size of women's arteries make diagnostic and interventional procedures more complicated or difficult to carry out. Another problem is that traditional diagnostic tests, such as the ECG stress test, have been found to be less sensitive in women than in men (6,7,19). Women with heart disease are more likely than men to have endothelial and smooth muscle dysfunction (6,19,20,25). This may be a contributing factor as to why women have higher rates of angina in addition to the ischemia with the absence of obstructive coronary artery disease (CAD) that occurs so frequently (16,22). There has been an increased awareness in the medical community (from public awareness outreach by medical and public health organizations to cardiac centers specifically catering to women) and with the lay public of the differences between men and women in regards to the gender gap in CHD. It is not known if this has translated into increased use of interventions in women, outcome improvements or the narrowing of morbidity and mortality between the genders.

Racial differences in CVD rates have been extensively documented with blacks having the highest rates of CVD mortality as compared to whites or Hispanics (26, 27). Based on NHANES 2007–2010 data for adults aged 20 or older, CHD prevalence was 8.2% for white men and 4.6% for white women and 6.8% for black men and 7.1% for black women (28). Overall cardiovascular disease (including congestive heart failure and stroke) was more prevalent in blacks than whites in all adult age groups, but an excess of prevalent MI was seen in blacks only at ages 35-44. More than a quarter of CVD deaths in blacks occurred in those under the age of 65, which is more than double the proportion in whites (29).

Some of the differences in the mortality rates between whites and blacks and Hispanics have been attributed to the higher rates of CVD risk factors in the black population. Blacks and Hispanics are more likely to have DM, obesity, HTN, elevated low-density lipoprotein cholesterol level and inadequate physical activity, than whites (30,31,32). Data from the 2003 Centers for Disease Control Behavioral Risk Factor Surveillance System survey of adults≥18 years of age showed the prevalence of respondents who reported having ≥2 risk factors for CHD and stroke was highest among blacks (33). Several community studies have shown that the 28-day case fatality rate after an acute CHD event was higher in blacks than in whites, with black men having the highest overall case fatality rate (34). The disparity in CHD mortality contributes to the racial gap in life expectancy in New Jersey, which is one of the largest among the 50 states for both men and women (35).

Although CHD mortality rates have declined overall, the decline has not been equal between the races (36). Black male mortality rates have declined more slowly than white males and the same is true for black females when compared to white females (26). In one study, the decline in CHD mortality has been shown to be twice as large in white men as it is in black men over a 22 year period (37). The same study showed that white men experienced a 24% decrease in hospitalized MI rates from 2002 to 2007, whereas black men experienced a decline of only 18%. Blacks have a higher mortality within 1 year and 5 years of an MI, higher recurrent MI and higher overall CHD mortality rates than do whites (38). CVD in blacks has contributed more than any other cause to the disparity in mortality between blacks and whites (39).

OBJECTIVES

In this chapter we will examine the continuing trends in New Jersey in the incidence of CHD mortality in the years of 2000-2017. Outcomes will be analyzed in total and in major demographic strata: for whites, blacks and Hispanics; for men and women; and for those 40-44, 45-49, 50-54, 55-59, 60-64, 65-69 , 70-74, 75-79 and 80-84 years of age. We are interested to determine whether the decline in CHD mortality has continued at the same rate through 2017 and whether it has been equivalent in men and women and in whites, blacks and Hispanics. We hypothesized that any slowing of the decline would be seen first in younger individuals meaning that the rate of decline may have been larger in the older age groups. We expected to see an overall continuing decline in CHD deaths rates over the study time period.

METHODS

All New Jersey deaths between the ages of 40 and 84, from the years of 2000 to 2017, attributed to coronary heart disease (ICD-9 410-414) were obtained from the state vital registration system for the study years. Rates for ICD codes 410-414 and for a broader definition of heart disease were examined, and the code 410-414 outcomes were analyzed in major demographic strata: for whites, blacks and Hispanics; for men and women; and for each five year age group between 40 and 84. Statistical analysis was performed using R software (41). The overall data and data for men, women and the three race/ethnic groups were adjusted for age using weights derived from the 2000

United States Census. Statistical tests are not presented because, given the administrative sources of data and the large sample size, statistical error is expected to be small compared to errors of ascertainment and classification.

The study has been approved by the Rutgers New Brunswick/Piscataway Institutional Review Board.

RESULTS

Table 2.1 shows the number of persons dying from CHD in total, from 2000-2017, and by gender, race/ethnicity and five year age groups. Despite a modest increase in the median age of the population, the number of CHD deaths declined in each of the demographic subgroups.

Table 2.2 provides age specific CHD mortality rates as well as age adjusted CHD mortality for the entire population as well as separately for men and women and for blacks, whites, and Hispanics. All groups showed a decline in CHD mortality over the study period. Substantial improvement was seen in all five year age groups except the youngest (ages 40-43) where CHD mortality declined by only 12% over the 17 year period. The percentage decline was larger in the older age groups, ranging from 12% at ages 40-44 to 57% at ages 80-84. The absolute decline was much larger in the older age groups, which, of course, started with much higher rates of CHD death. All three race/ethnic groups showed declines of about 50% over the 17 year period, but, as shown in Figures 2.1 to 2.3, most of that occurred prior to 2009 with smaller declines thereafter. The % decline in women (57%) exceeded that in men (51%), but the absolute decline in men was larger. Overall the 17 year period saw decreases in the absolute differences between men and women and among the race/ethnic groups, although percentage differences changed only slightly.

Table 2.1. CHD deaths by gender, race, 5 year age group and year. New Jersey 2000-2017.

year	Total	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	Male	Female	White	Black	Hispanic
2000	10,479	129	234	393	597	693	1,092	1,699	1,699	3,166	6,053	4,426	8,830	1,255	394
2001	9,975	127	234	383	505	668	998	1,580	1,580	3,137	5,695	4,280	8,291	1,266	418
2002	9,533	144	247	380	565	636	894	1,466	1,466	2,944	5,521	4,012	7,889	1,246	398
2003	9,224	129	221	385	509	682	885	1,352	1,352	2,948	5,304	3,920	7,613	1,204	407
2004	8,641	117	221	333	522	620	800	1,210	1,210	2,811	4,976	3,665	7,070	1,163	408
2005	8,246	121	239	341	528	658	726	1,137	1,137	2,661	4,786	3,460	6,697	1,141	408
2006	7,716	113	218	392	493	612	727	1,053	1,053	2,407	4,527	3,189	6,286	1,045	385
2007	7,201	91	236	326	476	555	722	971	971	2,306	4,356	2,845	5,839	1,010	352
2008	6,880	95	198	346	467	605	689	890	890	2,133	4,054	2,826	5,472	988	420
2009	6,647	118	228	320	448	599	707	848	848	2,028	4,027	2,620	5,261	957	429
2010	6,497	105	193	374	450	642	709	819	819	1,956	4,031	2,466	5,098	980	419
2011	6,278	88	214	354	459	613	679	821	821	1,835	3,874	2,404	4,907	963	408
2012	6,152	83	201	335	507	671	743	799	799	1,690	3,841	2,311	4,830	935	387
2013	6,042	92	181	327	471	638	776	846	846	1,655	3,911	2,131	4,741	892	409
2014	5,872	65	172	340	485	612	762	864	864	1,500	3,696	2,176	4,495	952	425
2015	5,640	58	132	315	464	612	756	845	845	1,464	3,619	2,021	4,337	871	432
2016	5,647	73	150	296	484	604	799	850	850	1,399	3,659	1,988	4,355	870	422
2017	5,760	86	137	294	512	663	726	942	942	1,343	3,730	2,030	4,350	924	486

Table 2.2. Age adjusted CHD mortality rates per 100,000 persons by gender, race, age, and year of study. New Jersey 2000-2017.

Year	Total	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	Male	Female	White	Black	Hispanic
2000	310.40	4.20	7.59	12.93	18.84	22.23	34.11	51.08	71.65	87.77	425.54	213.99	306.49	393.46	195.40
2001	292.26	4.02	7.41	11.82	15.34	21.36	31.85	47.96	68.00	84.51	395.73	203.77	286.43	394.53	201.22
2002	276.50	4.51	7.57	11.69	16.12	19.39	28.67	45.00	66.00	77.55	376.37	190.81	281.47	377.06	168.71
2003	265.18	4.06	6.59	11.87	14.25	19.44	27.99	42.00	61.96	77.02	357.51	184.17	260.85	353.21	165.90
2004	247.89	3.74	6.53	10.18	14.18	17.39	24.88	39.18	59.89	71.93	336.11	172.21	243.11	339.19	158.93
2005	236.88	3.70	6.94	10.12	13.69	18.16	22.60	37.30	55.56	68.81	319.11	164.65	232.84	324.61	152.55
2006	223.10	3.74	6.30	11.33	12.43	16.36	22.58	35.52	52.40	62.46	300.55	153.11	221.76	288.52	132.85
2007	207.11	3.03	6.84	9.11	12.46	14.19	21.48	32.58	48.00	59.43	288.97	136.39	206.32	276.11	116.23
2008	196.98	3.37	5.66	9.41	11.68	14.87	19.65	29.85	46.75	55.75	265.68	135.44	193.57	268.13	130.58
2009	188.84	4.18	6.37	8.31	10.96	14.41	19.31	28.01	44.10	53.19	259.82	125.78	187.41	246.03	125.27
2010	182.68	3.78	5.62	9.62	10.67	14.32	19.09	27.44	41.65	50.50	253.48	119.02	179.53	257.82	120.74
2011	175.59	3.25	6.32	9.03	10.53	13.14	17.85	26.87	40.87	47.73	241.70	113.66	173.29	241.90	112.92
2012	169.05	3.21	6.16	8.59	11.23	14.39	17.96	25.31	37.77	44.43	232.24	109.74	169.57	225.87	94.74
2013	165.38	3.49	5.83	8.38	10.39	13.53	18.25	25.24	35.56	44.71	236.41	100.29	166.66	215.93	102.92
2014	158.54	2.82	5.60	8.83	10.49	12.94	17.25	24.54	35.24	40.82	219.87	99.67	157.68	215.91	100.65
2015	151.41	2.64	4.47	8.12	9.76	12.54	16.50	23.62	32.83	40.93	211.64	93.23	152.32	192.09	97.40
2016	149.50	3.09	5.01	7.93	10.10	12.13	16.86	23.32	31.73	39.35	210.22	90.51	151.90	190.59	91.63
2017	148.79	3.66	4.70	8.05	10.55	12.91	15.34	23.54	32.28	37.77	208.38	91.14	148.92	198.58	100.06

Figure 2.1. Age adjusted CHD mortality rate per 100,000 persons by year of study. New Jersey 2000-2017.

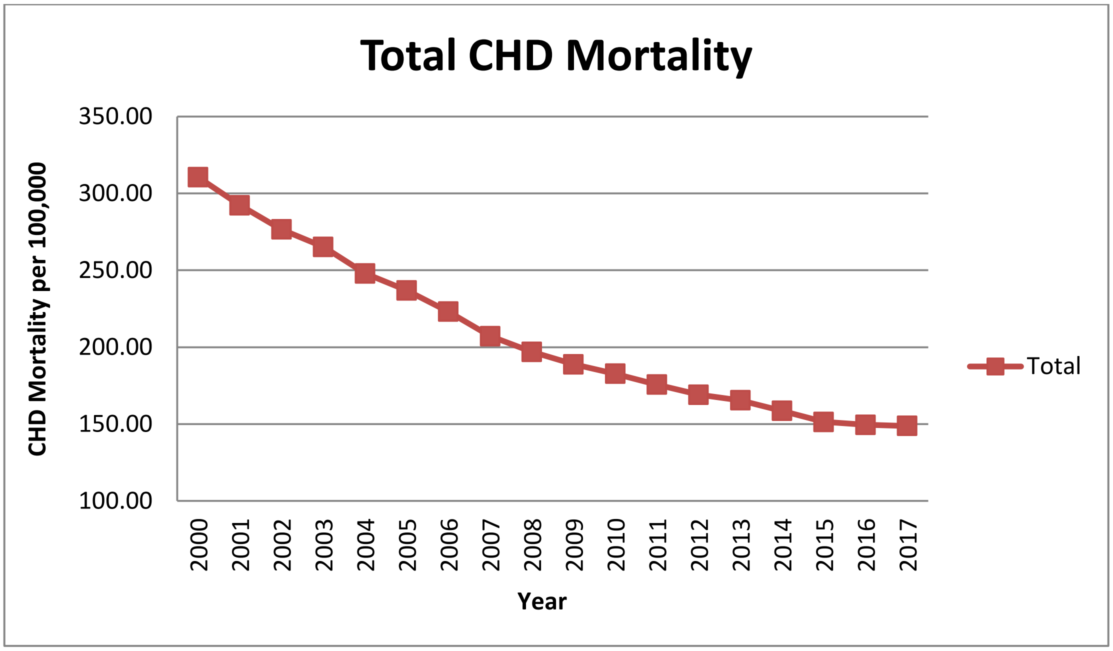


Figure 2.2. Age adjusted CHD mortality rate per 100,000 persons by age group and year of study. New Jersey 2000-2017.

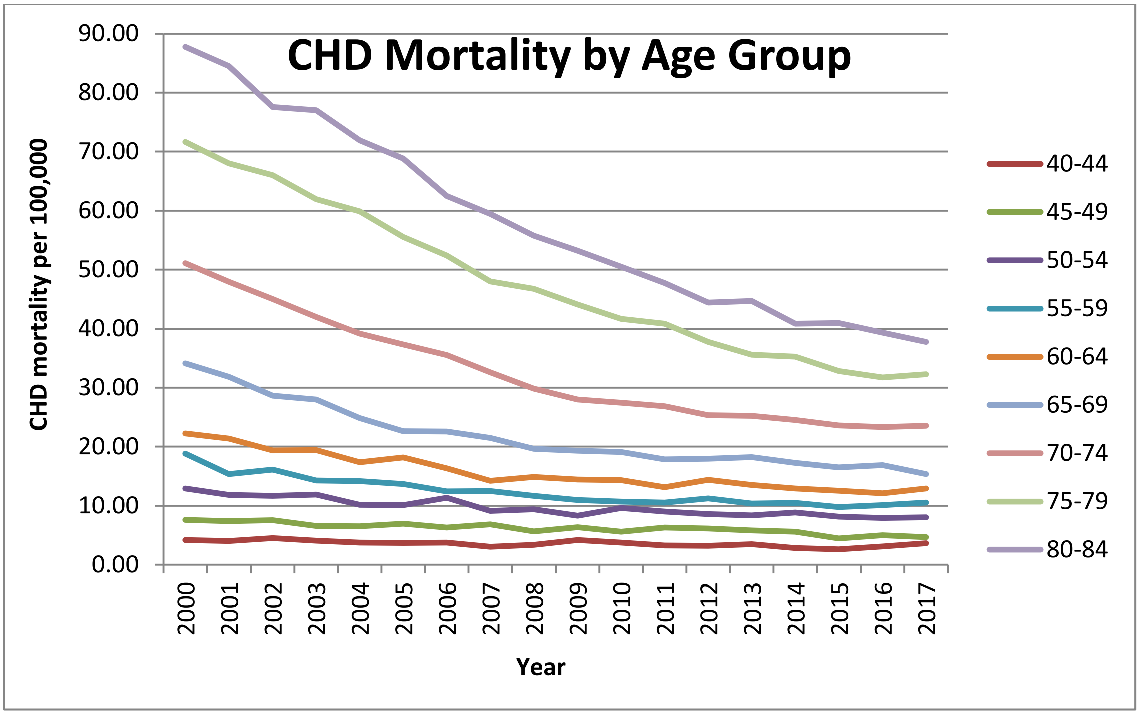


Figure 2.3.Age adjusted CHD mortality per 100,000 persons by gender and year of study. New Jersey 2000-2017.

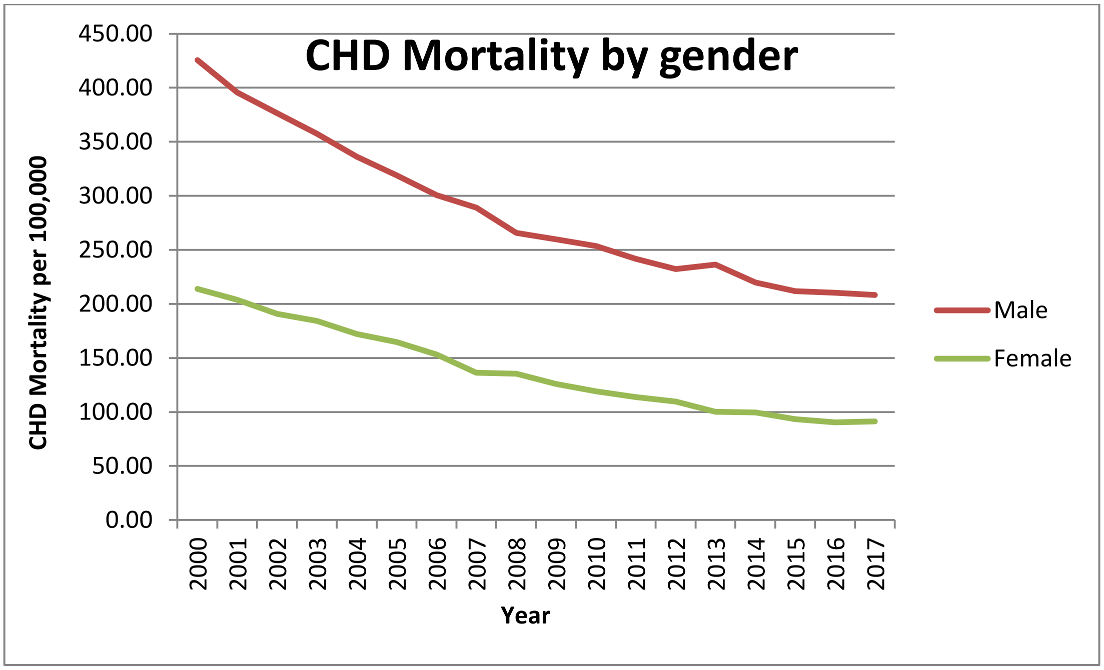
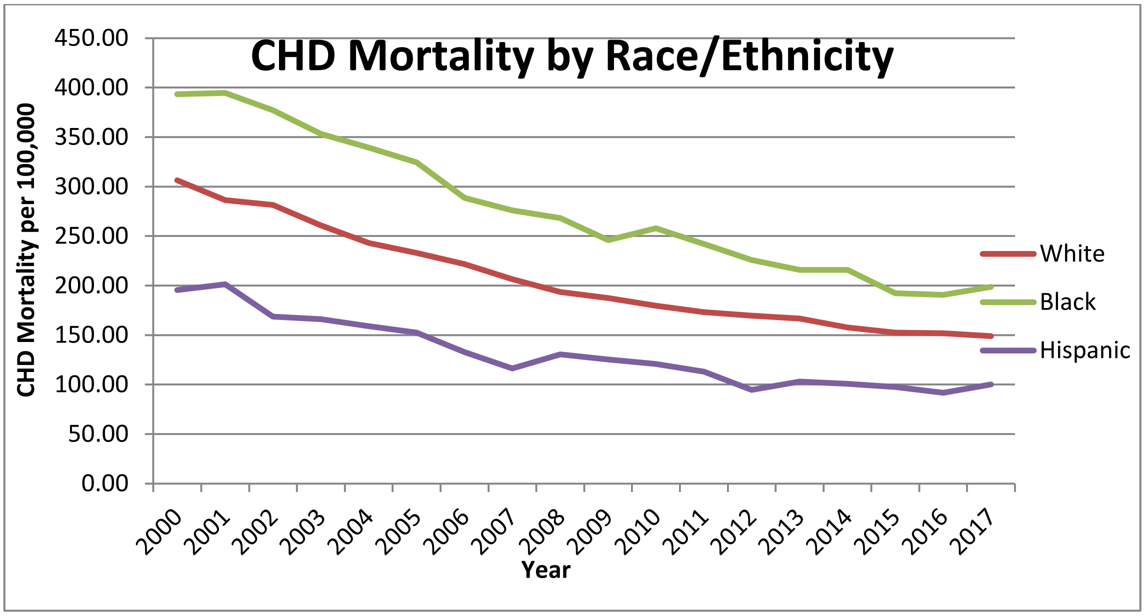


Figure 2.4. Age adjusted CHD mortality per 100,000 persons by race/ethnicity and year of study. New Jersey 2000-2017.



DISCUSSION

This population-based analysis of CHD mortality in New Jersey during the 2000-2017 time period confirmed two salient findings: 1) A continuation of the decline in CHD mortality beyond the year 2000 and, 2) Attenuation of that decline beginning in 2008-2009 with minimal subsequent decline. Most of the overall 52% decline in CHD mortality during the study period occurred by 2009. The slowing in the rate of decline in more recent years has been reported by others (43,44). The reasons why the favorable trend has slowed are not well understood, but it but may be due to the plateauing in the use of interventional and pharmacological therapies and/or by the increase in the rate of some cardiovascular risk factors, especially diabetes mellitus and obesity (1,44). A slight reversal of the trend in blacks and Hispanics from 2016 to 2017 requires another few years of observation to interpret.

CHD mortality rates were strongly linked to age. The similarity of the timing of the decline across a broad age range argues against important birth cohort effects and supports potential causes that affected a broad age range of persons simultaneously. The larger declines in older person would be compatible with a cumulative effect of improved lifestyle and outpatient treatment of risk factors that would have had more years to operate in the elderly. It is also possible that the elderly, who see their physicians more often than younger persons, have benefited from more widespread use of statins and antihypertensive medications.

The possibility that changing classification of cardiac related deaths may have contributed to the decline, needs to be considered. Comparing 2000 to 2017 the decline in number of CHD deaths (n = 6898) exceeded the decline in deaths attributed to all diseases of the heart (4898) by 2000 deaths. This suggests that some deaths classified as CHD in the year 2000 data would have been classified to other heart disease rubrics in 2017. The magnitude of the differences suggests this change in misclassification might have accounted for 29% of the CHD decline (2000/6898). It is of interest that the cause - specific number of deaths in 2017 differed from the number in 2000 by an increase of 756 for congestive heart failure and by a decrease of 50 for pulmonary embolism (45).

Males had higher mortality than females and the difference between the two genders remained similar across the study period. But, females had a greater decline in CHD mortality of 57% over the study period compared to males who only had a 51% decline. The curve started to flatten for both genders around the 2008-2009 time period. That women's rates fell more than men's should help to allay fears that the overall care received by women is inferior to that of men.

Blacks had higher CHD mortality than whites throughout the study period. The race difference in rates declined from 87 to 50 per 100,000 but the risk for blacks relative to whites increased slightly from 1.28 to 1.33 (because of the slightly greater rate fall in whites). The failure of the relative race difference to narrow has been reported on before (26,34,37). We need to do a better job in diagnosing and treating CHD risk factors in the black community to reduce the mortality disparity in CHD.

LIMITATIONS AND STRENGTHS

The most important limitations of this study concern uncertainty regarding undocumented secular changes in assigning and coding heart disease deaths over the 17 year time period. In addition, population estimates for the various years are imperfect and there may be selective in or out migration of older persons who move to be closer to their families in the year(s) immediately before death. Population estimates for Hispanics may be subject to underestimates of undocumented persons and the correspondence of the way people are classified in the census and in the American Community Survey with race/ethnic classification on death certificates is a likely additional source of error. While it is believed that nearly all deaths of New Jersey residents that take place in New York and Pennsylvania are captured, out-of-state deaths occurring in more distant states or in other countries are more likely to be missed.

Strengths of the study include the large number of deaths studied, the manageable size of New Jersey that may add consistency to mortality classification and population estimates (compared with the US as a whole) and the presence in the state of good representation of blacks and Hispanics. The very large decline in CHD mortality documented in these state-wide data is almost certainly real and its continuation through 2017, albeit with a smaller rate of decline, is a contribution that has not been widely appreciated.

SUMMARY

Our study provides further evidence of the decline in CHD mortality for the years 2000-2017, obtained from a statewide database in New Jersey. There is an attenuation of the decline that begins around the years 2008-2009 in all groups except in the oldest age groups. This decline affected blacks, whites and Hispanics in almost equal measure, but was a bit more prominent in women than in men. The larger declines seen in older, rather than younger persons is a reversal of the pattern seen before the year 2000 and could reflect more rigorous application and/or longer duration of primary prevention strategies in those over age 65.

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CHAPTER 3

TRENDS IN HOSPITALZATION RATES FOR A FIRST MI AND FIRST MI CASE FATALITY

ABSTRACT

There has been a remarkable decline in the incidence of myocardial infarction (MI) for the past several decades. However, scant data are available on whether this decline has increased, diminished, or remained stable over the last 15 years. Using the Myocardial Infarction Data Acquisition System, a statewide database of all cardiovascular hospital admissions in New Jersey, we identified 168,966 patients with a primary diagnosis of MI. We examined time trends in MI incidence and mortality in gender, racial and age groups from the year 2000 to the year 2014. A steep decline in MI incidence was observed in all groups with an overall decline of 30.2% over the time period. The decline was seen in all age groups but was most pronounced in the 80-84 age group. Whites had a greater decline than blacks. Males had a greater decline than females. A decline in in-hospital MI case fatality was observed in all age groups, most pronounced in the oldest age group. Females had a greater decline than males and after 2013 had a lower case fatality than males. Similar findings were seen in one year mortality but no significant difference was seen in MI mortality at 5 years. The decline began to plateau after 2008. In conclusion, this study provides further evidence of the decline in MI incidence and mortality but the rates began to level off after 2008.

INTRODUCTION

Although the incidence of a myocardial infarction (MI) has declined over time (1-6), it remains an important cause of morbidity and death with an American having an MI nearly every 40 seconds. Not only has the incidence of MI declined but so has mortality associated with a MI (3). The annual incidence of MI new attacks was 605,000 in 2018 with 200,000 recurrent attacks; about 14% of persons who have an MI will die of it (7). The age-adjusted hospitalization rate for MI in the US was 215 per 100,000 persons from the years 1979 to 1981, increased to 342 in the years 1985 to 1987, stabilized for the next decade, and then declined after 1996 to 242 per 100,000 during the period from 2003 to 2005 (8). Looking at data from the Cardiovascular Research Network for the time period of 2000 to 2008 showed an incidence rate decline from 230.5 to 168.6 per 100,000 person-years which translated into an annual decline of 3.8% (9). Another study showed the observed rates of hospitalization for MI declined significantly across all age, sex and race groups, from 1283 to 801 per 100,000 person-years, between the years of 1999 and 2011 for an adjusted annual decline of 4.6% (10). An analysis of the Atherosclerosis Risk in Communities (ARIC) data showed that the severity of incident hospitalized myocardial infarction has declined over a 16-year period from 1987 to 2002 (11). The authors speculate that this decline in severity may have contributed to the decrease in the coronary heart disease (CHD) death rates. Among Medicare fee-for-service beneficiaries, the 30-day mortality rate after hospitalized MI declined by 29.4% between the years of 1999 and 2011 (10). Another study showed declines in 30-day mortality after MI occurred in all US census divisions between the years of 2000 and 2008 (3). At age of 45 or older, 18% of males and 23% of females will die within 1 year after a first MI (7). A systematic review of literature looking at morbidity and mortality in survivors who are 1 year or more post MI revealed that there was still a significant increase in morbidity and mortality when compared to the general population, especially if associated with hypertension, diabetes mellitus or older age (4).

MI is the leading cause of death for women today. The average age of a first MI is 65.6 for males but is six years older at 72.0 for females (7). For MI, 28.4% of hospital stays for people 45 to 64 years of age were for women, but this increased to 63.7% of stays for those 85 years of age or older. For women 55 years of age and younger, hospitalization rates for acute MI increased from 2000 to 2009 (12) while another study looking at hospitalization rates among patients aged 35 to 64 years old from 1997 to 2006 showed that although both genders had a decline, it was greater in men than in women (13). The incidence of acute MI has been shown to be increasing in younger women and they have greater in-hospital, early and late mortality when compared to men (14). An analysis of data from the Variation in Recovery: Role of Gender on Outcomes of Young Acute MI Patients (VIRGO) cohort study of men and women 55 years or younger hospitalized for acute MI showed that women with acute MI had higher rates of risk factors such as cardiovascular disease and comorbidities such as DM, congestive heart failure, chronic obstructive pulmonary disease, renal failure, and morbid obesity than men (15). These same women also exhibited lower physical and mental health status than men along with higher levels of depression and stress and lower quality of life. And as noted in chapter 1, women had more delays in presentation, presented with higher clinical risk scores than men and were less likely to undergo revascularization procedures or reperfusion during hospitalization. Another study looking at acute MI hospitalization rates and in-hospital mortality for patients with acute MI across 30–54 age groups from the years 2001 to 2010 showed no decline in hospitalization over the time period for either men or women but women had higher comorbidities and in hospital mortality than men (16). A systematic review of gender differences in long term mortality, 5 year and 10 year, after a MI showed that while women had higher unadjusted mortality than men, these differences were mostly attenuated after adjustment for age, comorbidities and treatment used (17).

The prevalence of MI among the races is as follows: 4.0% for white males and 2.4% for white females, 3.3% for black males and 2.2% for black females (7). The decline has not been equal between the races with Blacks having a higher incidence of MI in all age groups (7) and a slower decline in CHD and MI incidence (1,18,19). The same is true for black females when compared to white females (19). The same study showed that white men experienced a 24% decrease in hospitalized MI rates from 2002 to 2007, whereas black men experienced a decline of only 18% (20). Another study looking at acute MI hospitalization in a Medicare population showed that while there was a decline across races over a 10-year period, from 2002 to 2011, the decline was greater for whites than for blacks (21). Whites had a decline of 36.6% in hospitalization rates for an annual decline in of 5.1% while blacks had a smaller decline of 26.4% for an annual decline of 3.4%. A study using data from the Cooperative Cardiovascular Project, survival and life expectancy after acute MI were higher in whites than in blacks, 7.4% versus 5.7% (22). Blacks have a higher mortality within 1 year and 5 years of a MI, higher recurrent MI mortality and higher overall CHD mortality rates than do whites (23). Blacks were found to be less likely to undergo invasive procedures compared with white men (24).

OBJECTIVES & HYPOTHESES

In this chapter we will examine the continuing trends in New Jersey in the incidence of hospitalizations for MI in the years 2000-2014 and the case fatality rates for first hospitalizations for MI at discharge, by one year post admission, and by five years post admission. We will look at overall rates as well as rates in major demographic strata: for men and women, whites and blacks and for the following age groups, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74, 75-79, and 80-84. We are interested to determine if the decline in mortality described in Chapter 2 may be partly explained by a decline in incidence of MI.

METHODS

The present study uses data from the Myocardial Infarction Data Acquisition System (MIDAS) dataset from 2000 to 2014. MIDAS is a statewide hospitalization database in New Jersey that contains all hospital discharge abstracts submitted to the New Jersey Hospital Discharge Data Collection System by nonfederal acute care hospitals in the state that has been maintained since the late 1980s. It includes all records with a primary diagnosis of MI (International Classification of Diseases, Ninth Revision [ICD-9] codes 410.0 to 410.9), Ischemic Heart Disease (ICD-9 410-414), Congestive Heart Failure (ICD-9 428), cerebrovascular disease (ICD-9 430-438) and diseases of arteries, arterioles, and capillaries (ICD-9 440-449).

MIDAS is a statewide hospitalization database in New Jersey that contains all hospital discharge abstracts submitted to the New Jersey Hospital Discharge Data Collection System by nonfederal acute care hospitals in the state that has been maintained since the late 1980s. It includes all records with a primary diagnosis of MI (International classification of Diseases, Ninth Revision [ICD-9] codes 410.0 to 410.9), Ischemic Heart Disease (ICD-9 410-414), Congestive Heart Failure (ICD-9 428), cerebrovascular disease (ICD-9 430-438) and diseases of arteries, arterioles, and capillaries (ICD-9 440-449). MIDAS includes data on New Jersey residents who died in state and on a substantial but undefined proportion of out-of-state deaths whose deaths were reported back to the New Jersey State Health Department. The database also contains basic socio-demographic and CVD clinical data and other coexisting conditions on the patients as well as data on hospitalizations involving invasive cardiac procedures. Data on cardiovascular deaths were obtained from the New Jersey death registration files and matched to the MIDAS records using automated record linkage software (40). Persons younger than 40 or older than 84 years of age were excluded from this analysis.

Data was age, gender, and race adjusted to the 2010 United States Census data. For the rates for gender, they are adjusted for race and age. For the rates for race, they are adjusted for gender and age. And for the rates for age, they are adjusted for gender, race, and the ages included in the grouping. The following variables were of interest: MI incidence, in-hospital MI fatality, 1 year MI fatality and 5 year MI fatality. Statistical analysis was performed using R software (25). Subjects having their first MI documented in MIDAS or dying of CHD (ICD-9 codes 410-11, 413-14) without a prior MI in MIDAS were considered incident MI cases, including primary or secondary diagnosis.

Any subject with a previous diagnosis of MI (ICD-9 code 410) within the past 10 years of the incident case in the MIDAS database was considered to have had a recurrent MI. The one year mortality rate was calculated as subjects who survived an initial incident of MI in MIDAS but go on to die within one year after hospital discharge (this includes those that have died of a MI while in the hospital). Similarly, the five year mortality rate was calculated as subjects who survived an initial incident of MI in MIDAS but go on to die within five years from hospital discharge. Statistical tests were not used because, given the administrative sources of data and the large sample size, statistical error is expected to be small compared to errors of ascertainment and classification. The information from the database, including the diagnosis of MI, has been validated previously using a random sample of the medical charts (26,27).

The study has been approved by the Rutgers New Brunswick/Piscataway Institutional Review Board and the MIDAS database has already been approved by the Rutgers New Brunswick/Piscataway Institutional Review Board and by the New Jersey Department of Health Institutional Review Board.

RESULTS

Baseline characteristics. A total of 168,966 subjects were discharged from New Jersey hospitals between the years of 2000 and 2014. Males made up 61.6% of this population of persons with an MI (Table 3.1) while whites made up 71.4%. Persons 65 years of age or older made up 54.7% of the study population with the 80-84 age group making up the largest single age segment at 14.7%.

Changes in incidence.

Table 3.2 provides the rates of first MI by gender, race and 5 year age group by year of study per 100,000. Figure 3.1 shows that there was an overall decline of 30.2% in the rate of first MIs from the year 2000 to 2014 but most of the decline occurred before 2009. Although males had a higher incidence of first MIs through the study period, they also had a greater decline in the incidence rate, at 31.7%, compared to females, who had a 29.5% decline as shown in Figure 3.2. Males and females had similar patterns of decline in MI incidence, but females started with much lower rates and declined somewhat less, so that the male excess incidence narrowed modestly over the 15 years. The decline in whites at 28.6% exceeded that in blacks, 13.9%, increasing the black-white disparity over the study period, Figure 3.3.

A substantial decline in MI incidence was observed in all but the youngest age groups, Table 3.2. The most dramatic decline was seen in the 80-84 age group, Figure 3.4, where the incidence rate dropped from 1233 per 100,000 in 2000 to 778 per 100,000 in 2014 for a decline of 36.9%. This was followed by the 75-79 age group where the incidence rate dropped from 926 per 100,000 in 2000 to 599 per 100,000 in 2014 for a decline of 35.4%. The percentage decline became progressively smaller with decreasing age so that at 40-44 it was only 3.1%, from 69 to 66 per 100,000. In all of the age groups above age 44 the declines occurred mainly between the year 2000 and 2008, with little further improvement to 2014.

Changes in case fatality. Table 3.3 gives the breakdown of the in hospital MI case fatality rate by gender, race and 5 year age group over the study period. Figure 3.5 shows a 31.3% decline in the hospital MI case fatality rate in the population during this period. This improvement was seen in both men and women and was most striking before 2007.

Initially, women had a 20% higher in-hospital death rate than men, but by 2014 the steeper decline in women resulted in a 6.3% lower hospital fatality rate than in men (Figure 3.6). Figure 3.7 shows the decline was similar in the race groups: 31.9% in whites and 31.0% in blacks. Figure 3.8 shows that the oldest age groups exhibited more pronounced declines led by the 70-74 age group followed by the 75-79 age group and finally by the 80-84 age group.

The 1 year case fatality rate calculates the rate of those who survived an initial MI but go on to die within 1 year after discharge from the hospital (this includes those that have died while in the hospital) as shown in table 3.4. Figure 3.9 shows there was a decline of 15.7% in the fatality rate between 2000 and 2014. This was also noted when the data was analyzed by gender (Figure 3.10), with females showing a greater decline in the one year fatality rate than males (18.1% vs 12.5%). Figure 3.11 shows a decline in 1 year case fatality among the race groups. In a pattern similar to the in-hospital case fatality, the 1 year mortality decline was observed in all age groups (Figure 3.12) with the exception of the youngest group, 40-44 where there was no decline over the study period. The oldest age groups showed the greatest decline, with a 13.8% drop in mortality in persons aged 80-84 years of age, a 15.8% drop in those aged 75-79 and a 22.0% drop in those aged 70-74.

To analyze the change in 1 year mortality between in-hospital and post hospital components, and to compare the older with the younger subjects, we calculated the average adjusted rates for 2000-01 and 2012-13 for older subjects (ages70-84) and younger subjects (ages 40-54) as shown in table 3.5. As noted, the older subjects showed a substantial absolute decline, in this grouping from 27.1% to 22.7% mortality. This improvement was entirely explained by the decline in in-hospital mortality. In the younger subjects 1 year mortality was much lower and did not change substantially across the study period. Table 3.6 provides the breakdown of those who survived an initial MI but go on to die within 5 years after discharge from the hospital. Figure 3.14 shows that no significant decline in mortality was seen at 5 years after an initial MI. Similar non-significant results were seen when the data was broken down by gender (Figure 3.15), race/ethnicity (Figure 3.16) or age group (Figure 3.17).

Table 3.1. Number of patients hospitalized for first MI by gender, race and age and year of study. New Jersey 2000-2014.

TOTAL	13108	12782	13089	12459	11681	10980	10703	10211	10531	10302	10467	10368	10805	10581	10899	168966	100.0%
MALE	7991	7715	7946	7546	7017	6676	6520	6306	6468	6497	6518	6593	6706	6731	6843	104073	61.6%
FEMALE	5117	5067	5143	4913	4664	4304	4183	3905	4063	3805	3949	3775	4099	3850	4056	64893	38.4%
WHITE	10052	9589	9237	8644	8176	8116	7929	7261	7483	7319	7425	7216	7453	7300	7393	120593	71.4%
BLACK	1125	1122	1081	1067	983	1060	1047	1076	1129	1172	1207	1250	1380	1239	1326	17264	10.2%
HISPANIC	851	1100	1336	1029	994	922	825	892	850	860	950	974	939	953	999	14474	8.6%
OTHER	1080	971	1426	1714	1524	882	902	969	1069	951	885	928	1033	1089	1181	16604	9.8%
40-44	486	492	515	503	483	458	448	404	393	435	432	386	415	414	403	6667	4.0%
45-49	775	793	870	856	821	767	784	762	799	772	776	773	747	744	733	11772	7.0%
50-54	1185	1122	1185	1152	1087	993	1088	1035	1078	1106	1074	1113	1137	1136	1202	16693	9.9%
55-59	1364	1357	1507	1413	1331	1293	1294	1265	1228	1274	1348	1283	1416	1378	1429	20180	11.9%
60-64	1442	1403	1450	1457	1380	1273	1348	1283	1354	1357	1400	1497	1504	1524	1503	21175	12.5%
65-69	1629	1545	1641	1446	1361	1285	1222	1197	1310	1264	1346	1342	1506	1500	1546	21140	12.5%
70-74	1981	1890	1862	1712	1546	1448	1319	1272	1261	1249	1211	1235	1305	1355	1436	22082	13.1%
75-79	2228	2195	2056	1964	1835	1669	1640	1472	1501	1377	1357	1293	1271	1244	1322	24424	14.5%
80-84	2018	1985	2003	1956	1837	1794	1560	1521	1607	1468	1523	1446	1504	1286	1325	24833	14.7%

Table 3.2. Adjusted rates of first MI per 100,000 by gender, race/ethnicity and 5 year age group. New Jersey 2000-2014.

Year	Total	Male	Female	White	Black	Hispanic	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
2000	364.9	507.2	246.1	352.2	322.7	361.4	68.5	126.1	214.2	319.8	434.3	557.2	704.3	925.9	1233.0
2001	351.3	483.9	238.9	335.0	313.3	458.0	68.2	125.7	195.9	309.9	415.0	533.1	678.8	918.1	1173.5
2002	356.1	487.8	243.6	322.1	291.8	520.1	70.9	133.6	209.8	319.9	415.1	567.4	679.7	861.0	1157.4
2003	334.4	456.7	229.6	299.8	287.4	368.8	69.2	128.1	202.6	293.1	394.7	494.4	637.8	826.4	1118.0
2004	310.0	418.2	215.6	283.3	255.0	332.6	66.4	120.1	187.5	267.1	363.1	458.0	589.4	782.4	1030.2
2005	289.0	393.5	199.9	281.2	271.6	287.2	63.6	110.3	167.9	249.7	328.0	427.1	562.7	719.6	1005.5
2006	280.4	378.8	194.5	276.8	265.0	244.0	63.3	111.3	179.7	241.8	339.3	401.7	517.9	716.0	880.5
2007	264.4	361.4	180.2	252.6	265.5	254.8	58.5	107.8	165.8	240.1	299.8	380.7	500.7	652.6	858.3
2008	269.2	364.8	186.0	259.0	275.2	231.4	58.5	112.9	167.6	230.5	308.9	393.9	489.9	677.6	906.6
2009	259.7	358.6	172.7	253.2	276.4	217.2	66.5	108.8	168.2	233.4	297.3	367.6	475.5	630.2	832.1
2010	259.0	353.4	176.8	254.7	277.5	230.9	66.7	110.3	158.5	236.4	289.2	380.4	463.2	631.4	848.9
2011	253.1	351.2	167.0	247.2	281.3	227.2	60.0	111.6	162.4	218.6	298.2	367.4	462.3	605.9	810.4
2012	259.8	351.0	179.5	254.4	304.5	208.8	65.5	109.9	165.1	233.5	302.1	382.1	469.5	595.7	852.2
2013	250.6	346.0	166.5	249.1	263.3	202.8	66.7	112.0	164.8	221.1	301.5	369.0	459.6	573.8	741.7
2014	254.8	346.3	173.5	251.4	277.9	202.3	66.4	112.9	174.4	224.5	290.3	366.4	471.0	598.5	777.6

First MI defined by primary diagnosis of MI in a patient with no hospitalized MI in the preceding 10 years.

The data are adjusted for age, gender and race/ethnicity. For the rates for gender, they are adjusted for race/ethnicity and age. gender and age.

For the rates for race, they are adjusted for gender and age. And for the rates for age, they are adjusted for gender, race, and the ages included in the grouping.

Figure 3.1. Incidence rate of first MI per 100,000 by year of admission.

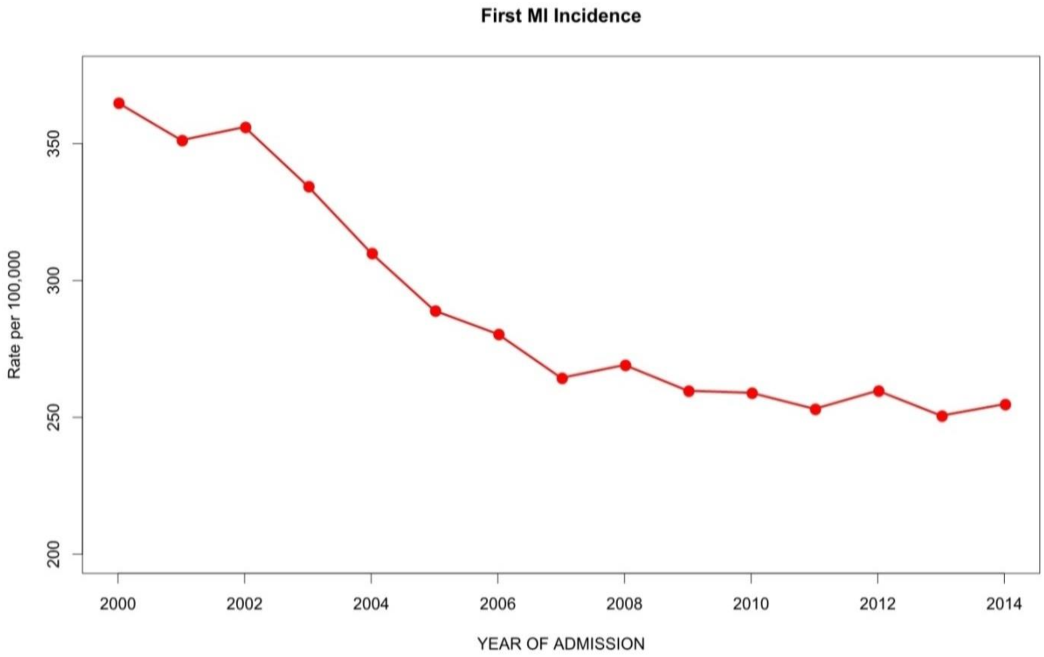


Figure 3.2. Incidence rate of first MI per 100,000 by sex and year of admission.

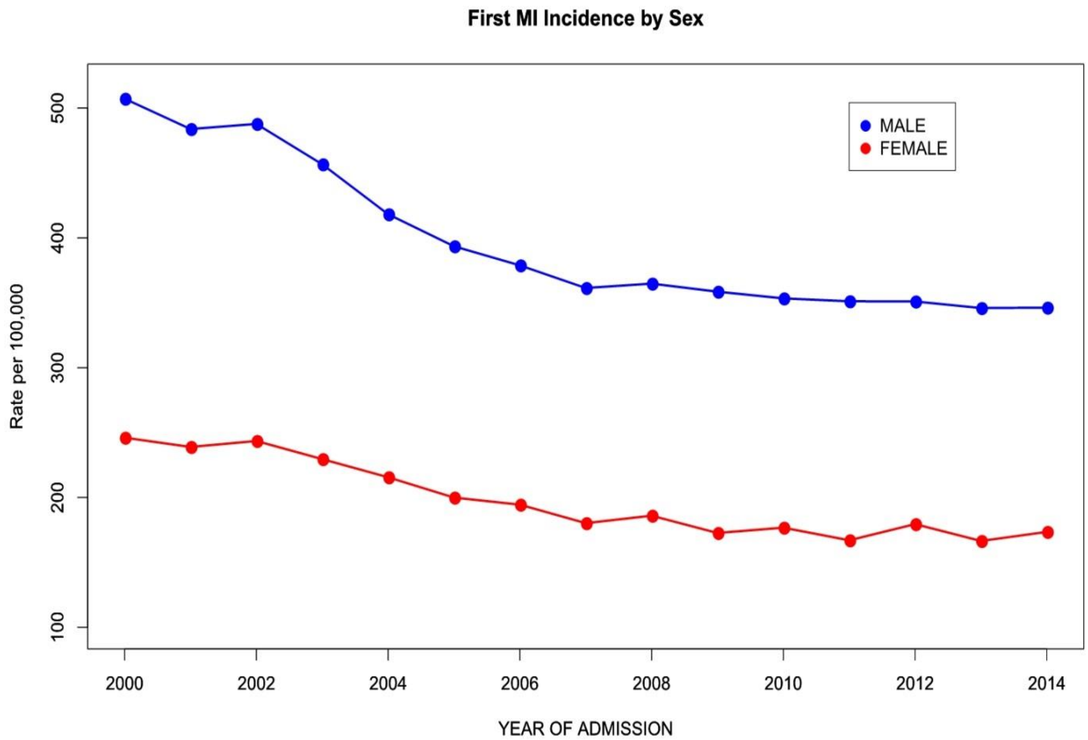


Figure 3.3. Incidence rate of first MI per 100,000 by race and year of admission.

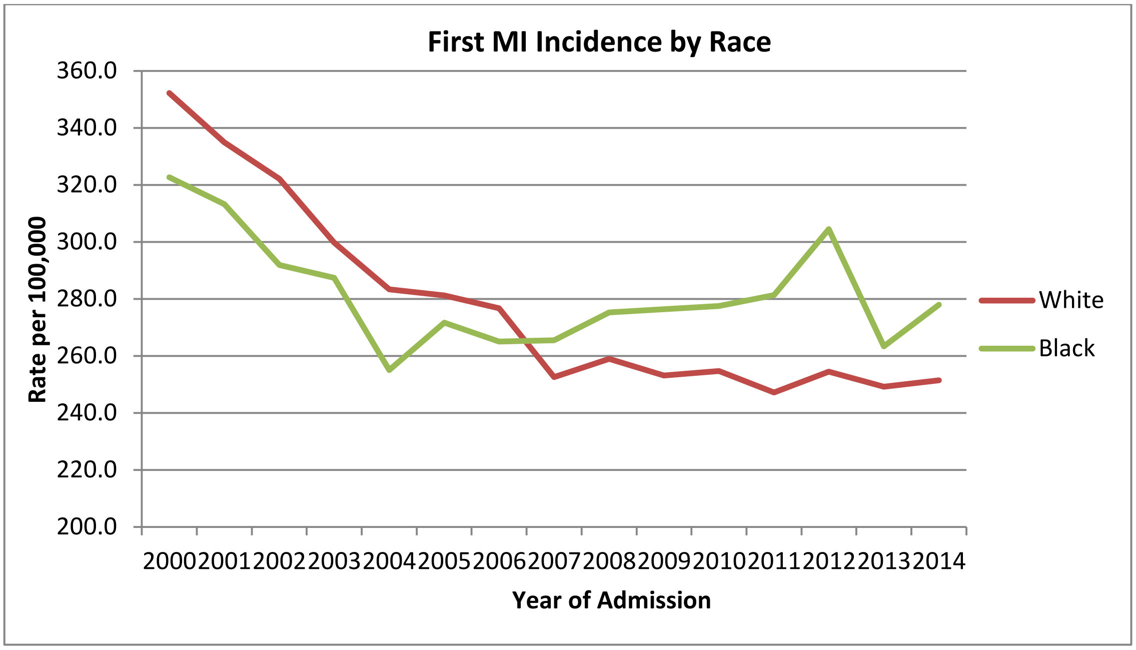


Figure 3.4. Incidence rate of first MI per 100,000 by age and year of admission.

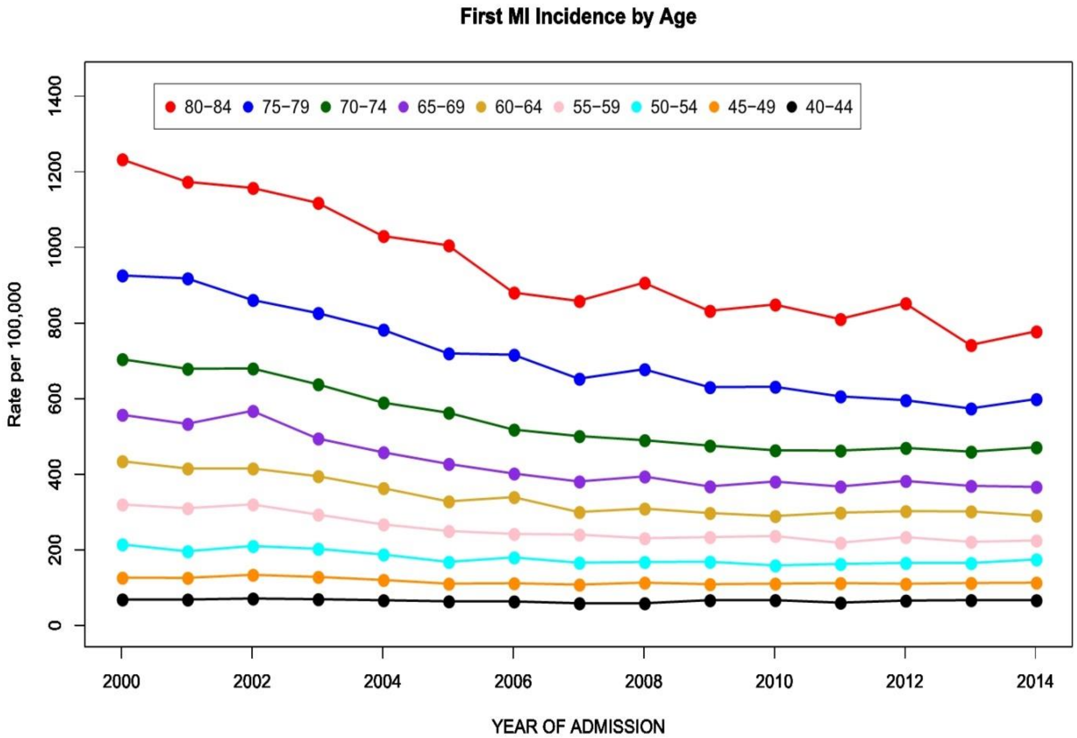


Table 3.3. Adjusted in hospital MI case fatality rates per 100 by gender, race/ethnicity and 5 year age group. New Jersey 2000-2014.

Year	Total	Male	Female	White	Black	Hispanic	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
2000	4.8	4.5	5.6	4.7	5.8	4.4	1.9	2.7	2.8	3.7	5.6	6.4	8.9	12.2	13.9
2001	4.3	4	4.9	3.9	5.9	4	2.2	1.3	2.4	2.6	4.5	6.3	9.1	12	14.7
2002	4.1	3.9	4.6	4	5.5	3.5	1.6	1.5	2.4	2.9	4.6	5.8	7.7	10.3	14.4
2003	4.1	3.9	4.6	3.8	6.2	3.6	2.4	1.8	2.2	3.3	4.2	5.5	7	9.5	14.6
2004	3.6	3.4	4.3	3.2	4.8	4.2	1.2	0.9	2.7	2.4	4.6	4.9	7.2	8.6	13.9
2005	3.7	3.5	4.3	3.5	4.9	3.9	1.1	1.7	2	3.3	4.3	5.6	7.4	9.7	10.4
2006	3.5	3.4	4.1	3.3	5.5	2.6	1.1	1.7	2.3	3.2	4.2	4.3	6.4	8.1	11.6
2007	3.3	3.1	3.7	3.1	4	3.2	1.7	1.4	1.9	2.7	3.8	4.8	6.7	6.1	9.8
2008	3.3	3.2	3.8	3	4.2	3	1.5	1.5	2.4	3.1	2.7	3.6	6	8.5	10.7
2009	3.8	3.6	4.3	3.4	5.4	3.9	2.1	2.3	2.7	3.2	4.3	5.5	5.6	6.7	10.8
2010	3.4	3.4	3.5	3.3	3.5	3.1	1.9	1.7	2.1	3.6	3.6	5.5	4.8	6.3	7.8
2011	3.5	3.5	3.4	3.6	3.6	2.7	2.3	2.6	1.4	2.7	4.3	4.6	5.8	7.6	9.1
2012	3.1	3.1	3.3	2.7	3.6	3.5	1.9	1.3	1.5	3.1	4.4	3.9	5	6	8.6
2013	3.3	3.5	3.2	3.3	3.9	3.1	2.2	2.4	1.8	3.2	3.9	2.9	5.1	6.8	9.8
2014	3.3	3.4	3.2	3.2	4	2.9	1.2	2.3	3.6	2.1	3.3	4.7	4.7	7.4	8.2

The data are adjusted for age, gender and race/ethnicity. For the rates for gender, they are adjusted for race/ethnicity and age. For the rates for race/ethnicity, they are adjusted for gender and age. And for the rates for age, they are adjusted for gender, race/ethnicity, and the ages included in the grouping.

Figure 3.5. In hospital case fatality rate per 100. New Jersey 2000-2014.

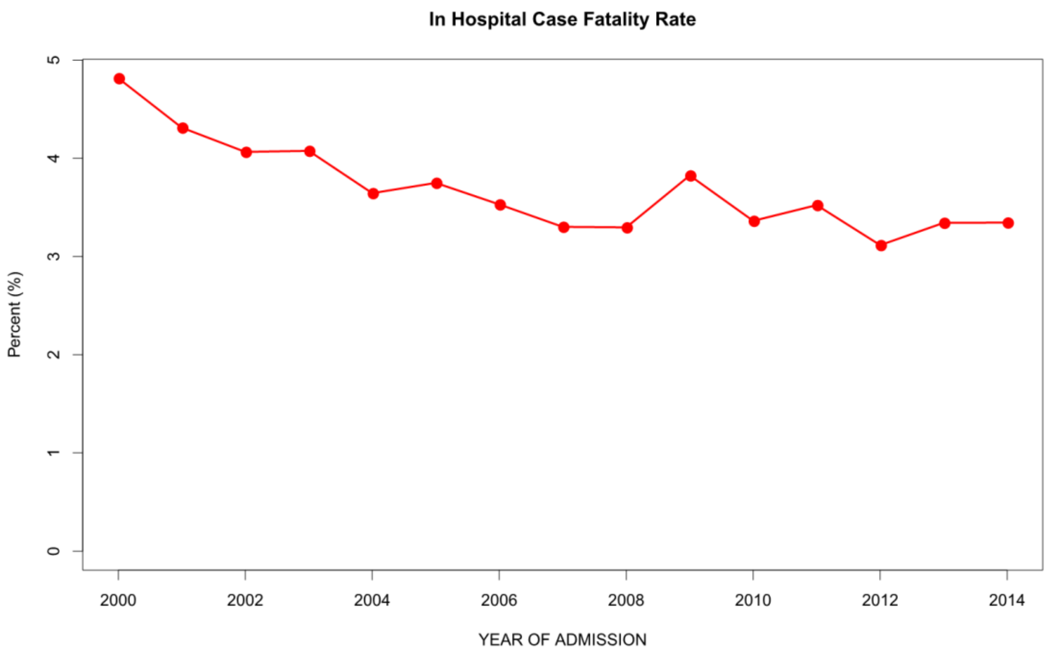


Figure 3.6. In hospital case fatality rate per 100 by gender and year of admission.

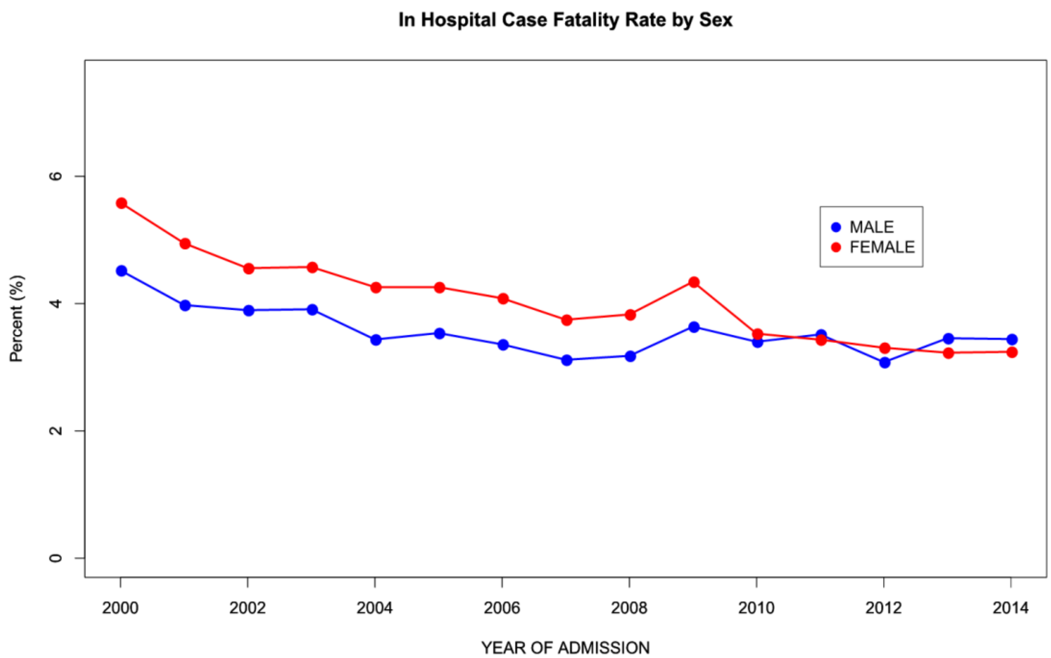


Figure 3.7. In hospital case fatality rate per 100 by race and year of admission.

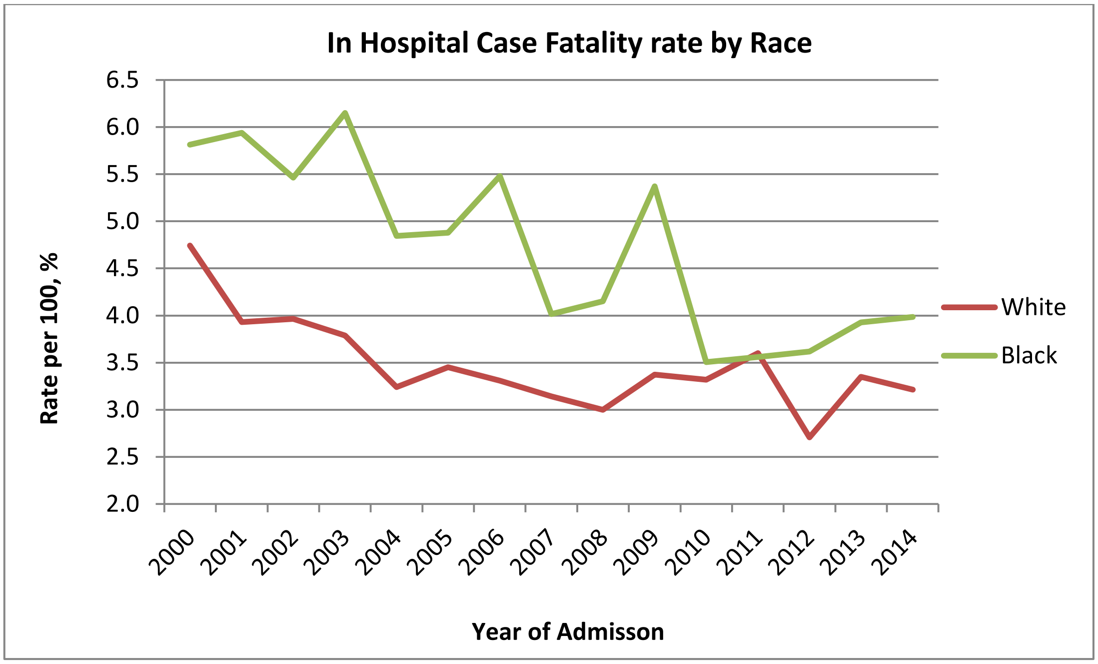


Figure 3.8. In hospital case fatality rate per 100 by age group and year of admission.

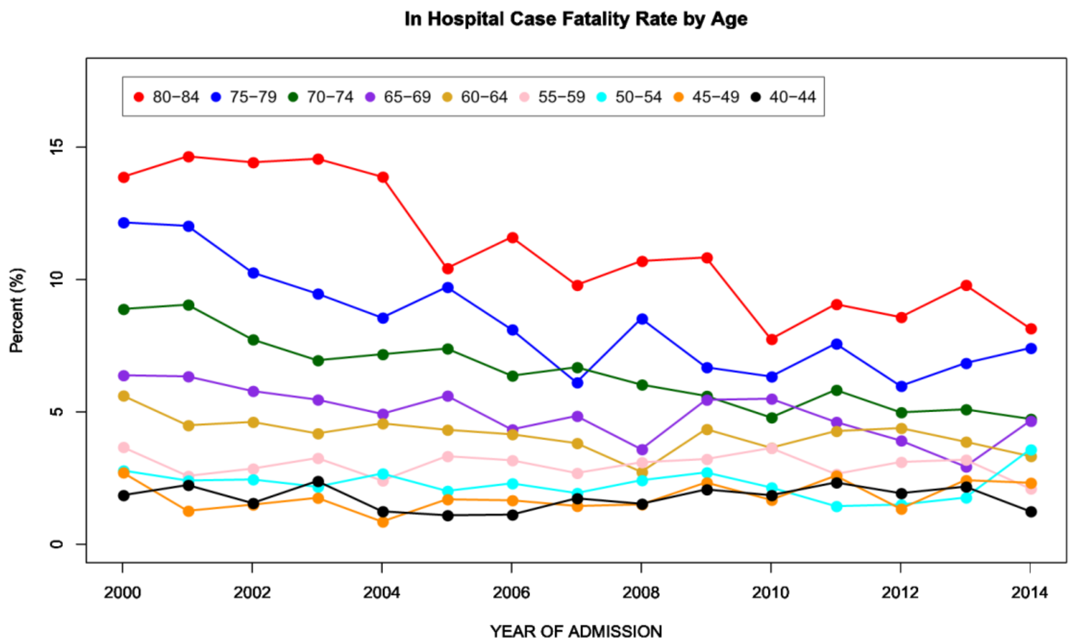


Table 3.4. Adjusted 1 year MI case fatality rate per 100 by gender, race and 5 year age group. New Jersey 2000-2014.

Year	Total	Male	Female	White	Black	Hispanic	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
2000	10.2	9.6	11.6	9.8	15.2	9.2	4.1	5.2	5.3	7.3	10.9	14.1	20.9	25.9	32.6
2001	10.4	9.8	12.2	9.9	16.4	9.1	4.7	3.9	5.7	6.8	11.3	15.7	20.7	26.9	35.9
2002	9.8	9.3	11.3	9.7	13.2	9.1	3.5	3.4	4.2	8	10.8	15.4	19.7	27.1	32.2
2003	9.7	9.1	11.3	9.2	14.3	10	3.6	4.1	5.3	7	10.1	13.3	19.1	26	35.3
2004	9.2	8.7	10.6	8.6	14	8.9	3.3	2.7	5	6.4	11	12.4	19.5	24.9	34
2005	9.3	9	10.3	8.8	13.8	9	3.1	4.6	4.6	6.3	9.7	13.2	18.1	27	33
2006	9.2	8.8	10.6	9.1	13.6	7	2	4	5.9	6.8	8.8	13.5	18.7	25.7	31.5
2007	9.3	8.8	10.9	9.1	11.7	8.2	3.7	4.6	4.1	6.8	9.2	14	18.8	23.6	32.3
2008	9.8	9.2	11.3	9.6	13.2	7.8	3.6	4.5	5.9	7.1	10.5	12.9	20.3	25.8	31.4
2009	10.1	9.6	11.5	9.9	14	8.8	4.8	5.4	5.3	7	9.4	15.1	19.4	24.2	34.4
2010	9.4	8.8	10.8	9.2	11.8	7.8	3.7	4	4.8	8	10.9	14.7	16.3	21.8	30
2011	9.3	9.2	9.6	9.3	11.3	6.8	3.9	4.4	4.1	5.9	10.4	14.5	18.3	23.3	32.8
2012	9.4	9.2	10.1	8.9	11.9	9	4.8	5	5.1	7.1	10.5	12	17	22.3	29.7
2013	8.6	8.4	9.5	8.6	10	8.3	4.1	4.7	4.9	6.5	8.3	11.2	16.3	21.8	28.1

The data are adjusted for age, gender and race/ethnicity. For the rates for gender, they are adjusted for race/ethnicity and age. For the rates for race/ethnicity, they are adjusted for gender and age. And for the rates for age, they are adjusted for gender, race/ethnicity, and the ages included in the grouping.

Figure 3.9. One year case fatality rate per 100 by year of hospital admission.

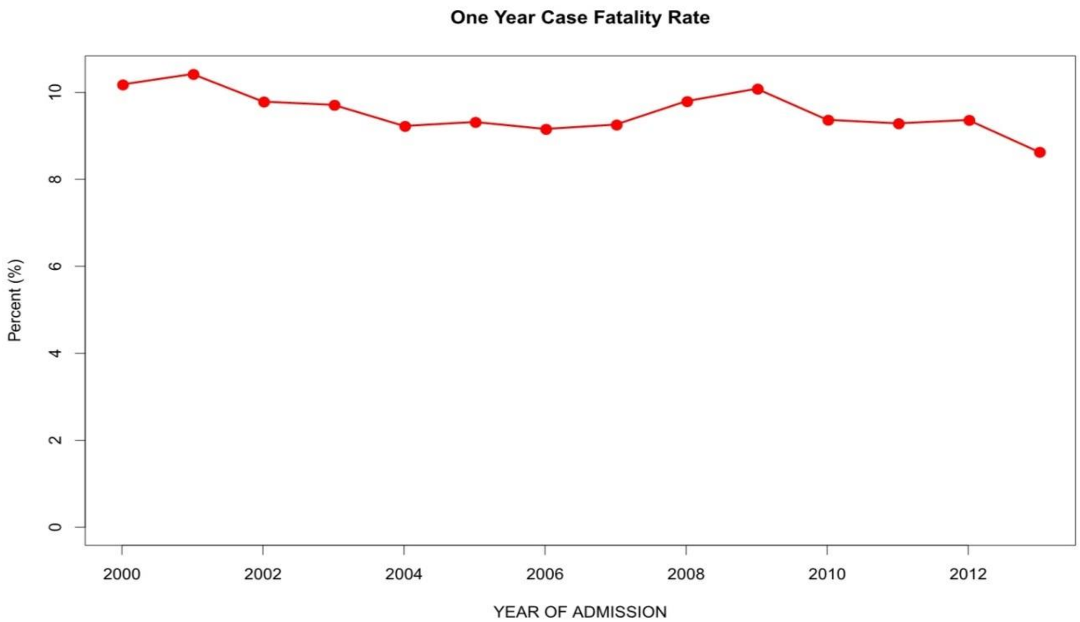


Figure 3.10. One year case fatality rate per 100 by gender and year of hospital admission.

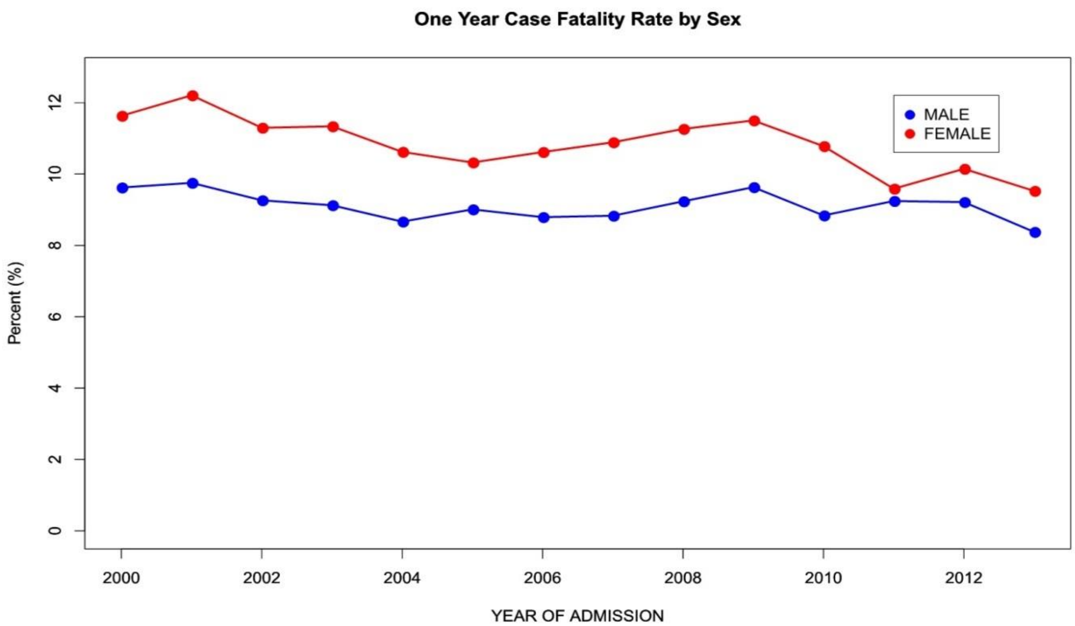


Figure 3.11. One year case fatality rate per 100 by race and year of hospital admission.

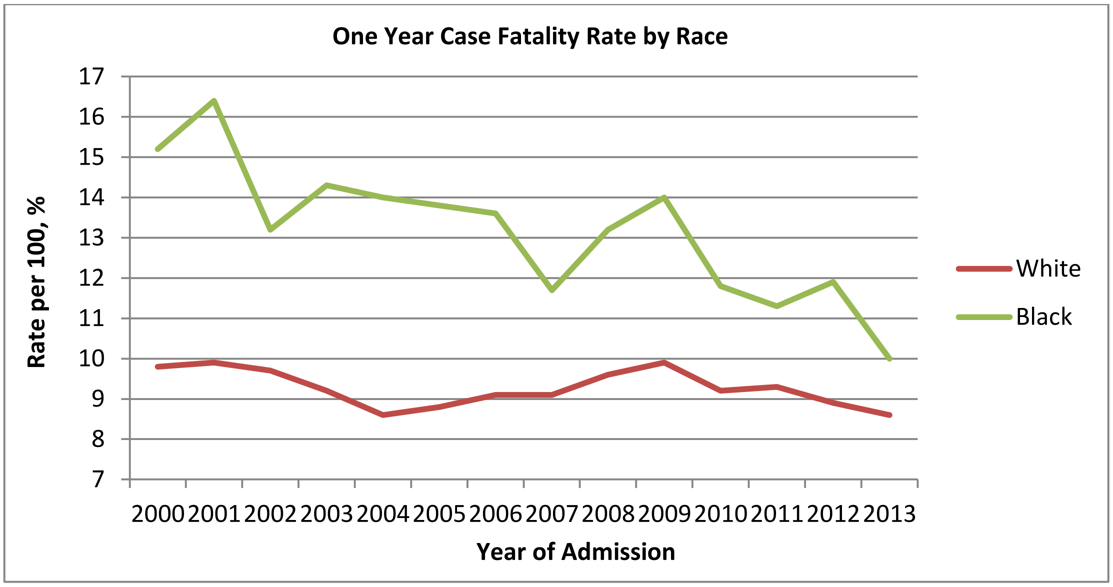


Figure 3.12. One year case fatality rate per 100 by age group and year of hospital admission.

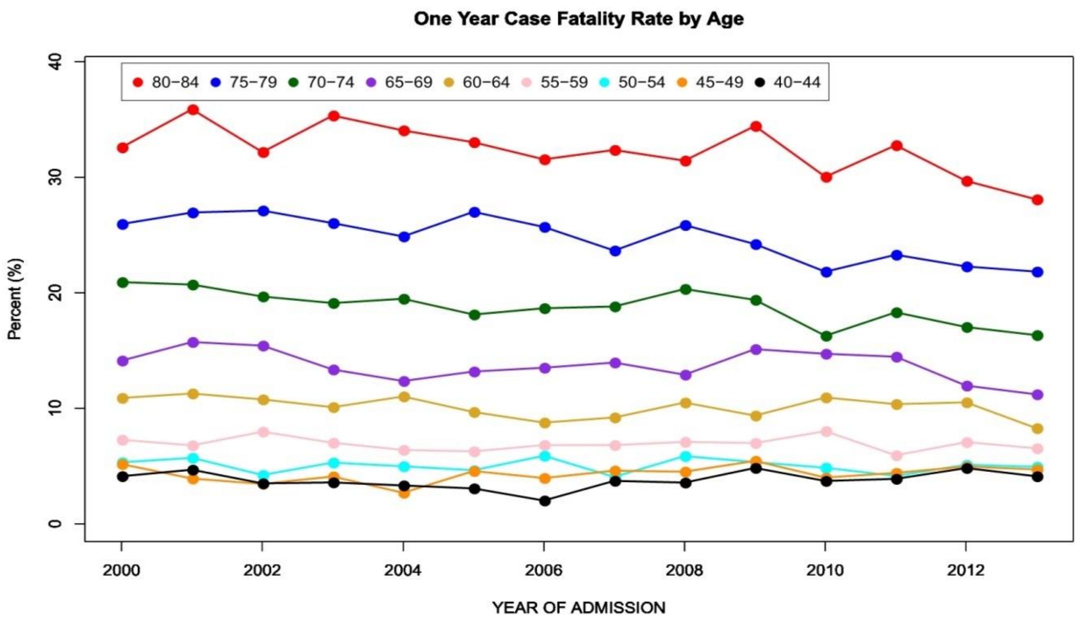


Table 3.5. Change in In-hospital and 1 year Mortality from 2000-01 to 2012-13 for the 40-54 and 70-84 age groups.

	2000-2001	2012-2013	Difference	Change
Ages 40-54				
In-hospital deaths/100	2.2	1.9	-0.3	-14%
Post-hospital 1 year deaths/100	2.3	2.9	0.6	26%
Total 1 Year deaths/100	4.5	4.8	0.3	7%
Ages 70-84				
In-hospital deaths/100	11.6	6.9	-4.7	-41%
Post-hospital 1 year deaths/100	15.5	15.8	0.3	2%
Total 1 Year deaths/100	27.1	22.7	-4.4	-16%

Table 3.6. Adjusted 5 year MI case fatality rate per 100 by gender, race/ethnicity and 5 year age group. New Jersey 2000-2009.

Year	Total	Male	Female	White	Black	Hispanic	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
2000	18.98	17.93	21.89	18.19	29.36	16.59	7.82	9.81	10.97	14.61	19.63	27.19	38.23	45.69	56.37
2001	18.46	17.37	21.48	17.38	29.67	17.63	7.11	6.94	9.98	14.74	20.4	29.06	36.16	45.21	58.94
2002	18.49	17.34	21.36	17.93	26.79	18.09	8.35	6.55	9.79	14.87	19.86	29.43	36.92	45.6	56.19
2003	17.6	16.6	20.36	16.84	26.79	17.41	6.16	6.89	9.55	13.02	19.22	26.56	35.28	45.88	59
2004	17.86	16.78	21.01	16.95	25.84	18.16	8.49	6.21	10.96	13.67	19.78	24.93	34.54	44.06	57.3
2005	17.35	16.49	19.83	16.46	26.84	15.53	6.11	8.6	9.47	11.37	17.85	26.19	34.83	47.03	56.5
2006	17.54	17.07	19.47	17.36	26.3	13.8	4.69	8.55	12.22	12.14	19.51	24.06	33.97	46.67	54.74
2007	17.89	17.18	20.38	17.02	26.01	17.17	7.92	8.27	10.72	12.97	17.93	26.15	35.41	44.29	56.21
2008	19.16	17.88	22.28	18.3	28.46	17.32	8.14	9.76	11.62	15.07	20.31	25.73	36.98	47.77	56.25
2009	18.62	17.82	20.91	18.1	26.85	16.92	8.74	9.07	10.67	13.66	18.5	28.09	34.83	44.26	60.6

The data are adjusted for age, gender and race/ethnicity. For the rates for gender, they are adjusted for race/ethnicity and age. For the rates for race/ethnicity, they are adjusted for gender and age. And for the rates for age, they are adjusted for gender, race/ethnicity, and the ages included in the grouping.

Figure 3.13. Five year case fatality rate per 100 by year of hospital admission.

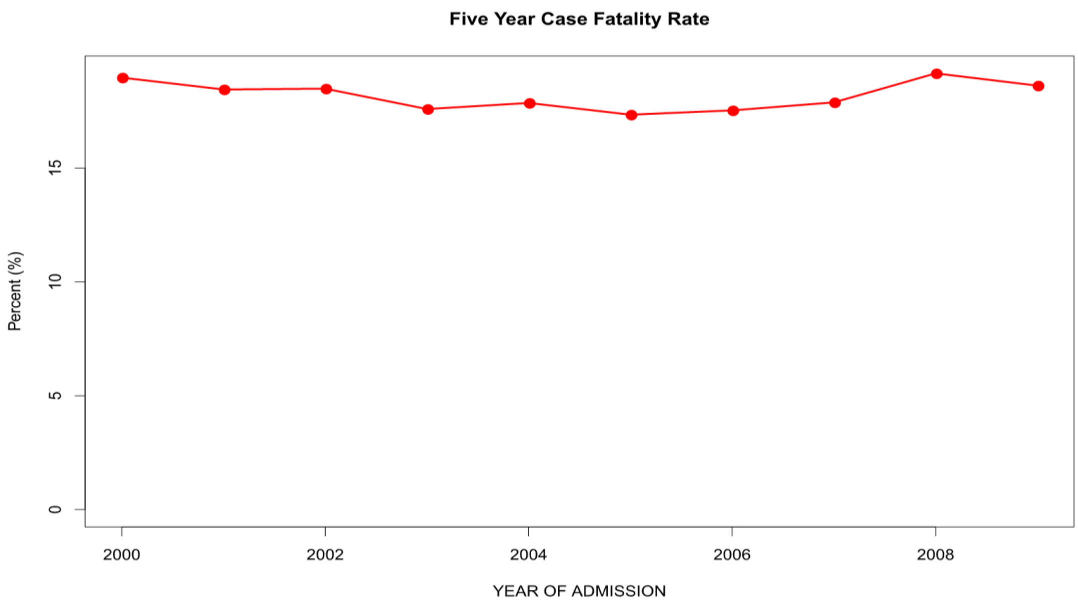


Figure 3.14. Five year case fatality rate per 100 by gender and year of hospital admission.

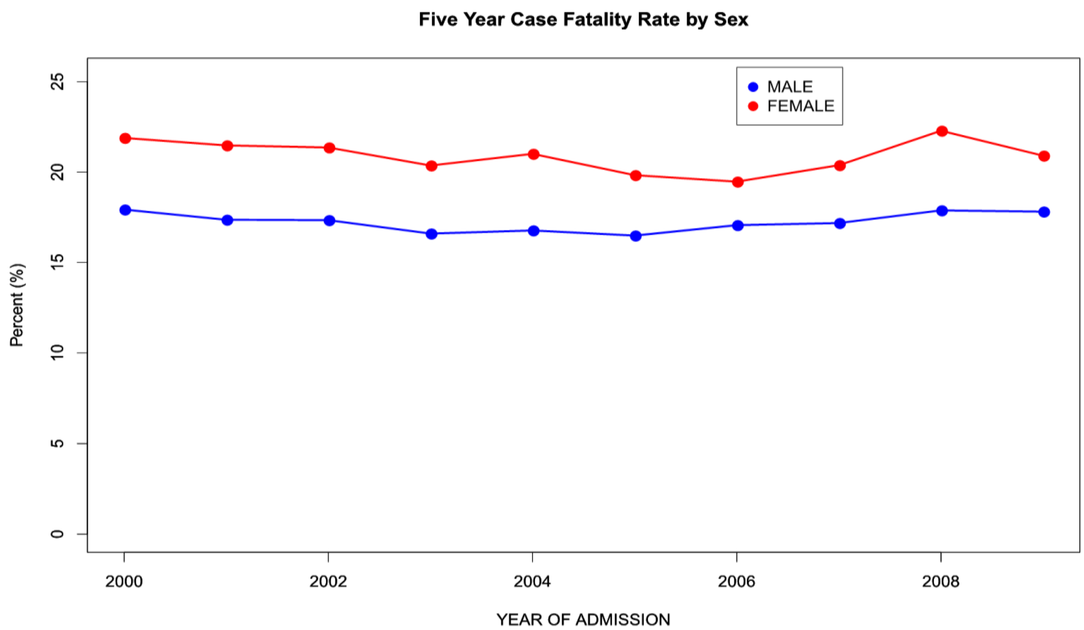


Figure 3.15. Five year case fatality rate per 100 by race and year of hospital admission

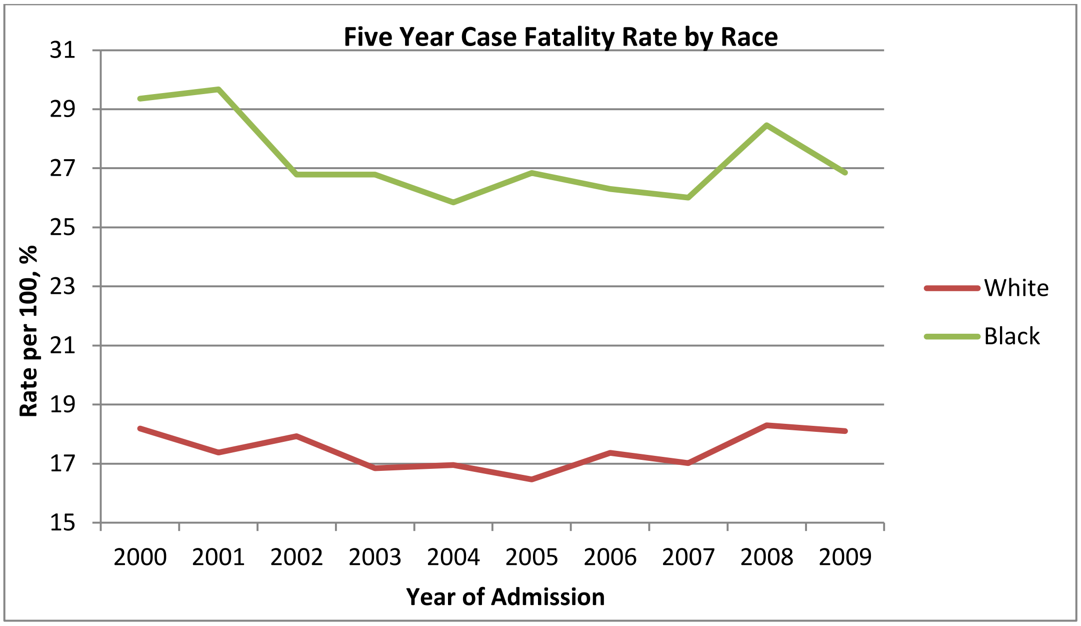
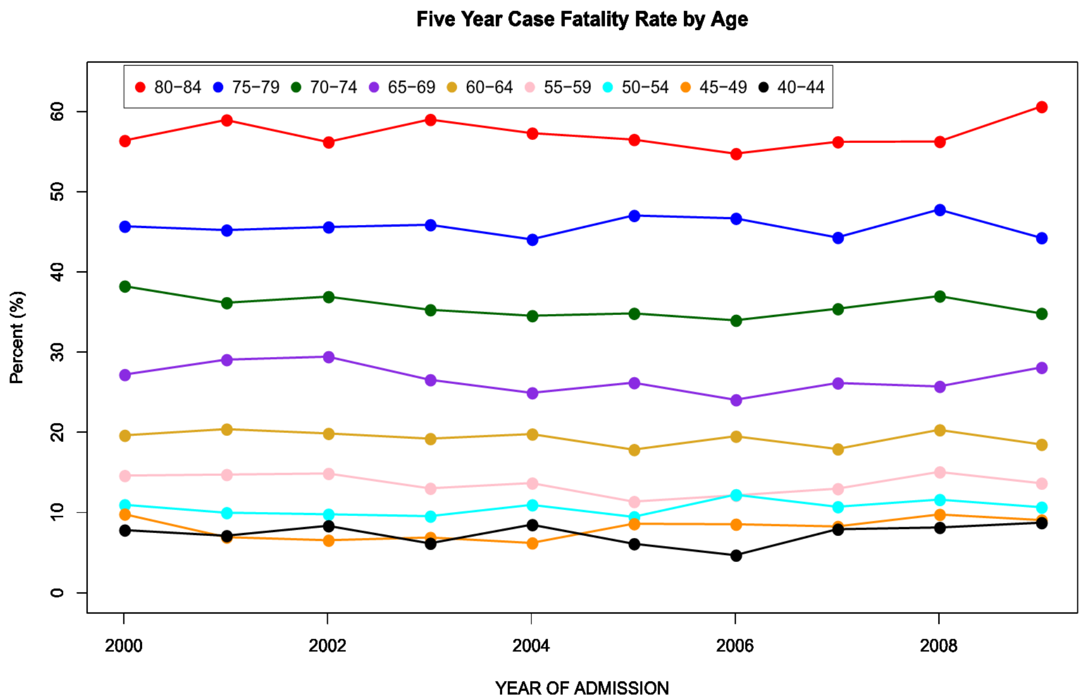


Figure 3.16. Five year case fatality rate per 100 by age group and year of hospital admission.



DISCUSSION

At the outset of the study period in 2000 the CHD death rate in the US had been falling for 30 years and the MI rate had been falling for a shorter and less well defined period of time. The introduction of troponins probably distorted trends in MI rates but this change in diagnostic practice was mostly complete by the year 2000. The overall continuing fall in MI incidence in New Jersey from 2000-2008 cannot have been due to invasive cardiac treatments and is almost certainly related to changes in lifestyle and pharmacological control of risk factors over the preceding decades, especially falling serum cholesterol, lower blood pressure levels and less smoking. The relative absence of this decline in persons under 50 years of age (Table 3.2) and its more or less complete cessation after 2008 are worrisome and suggest that further positive changes in risk factors are either not substantial or are being superseded by the obesity epidemic and the consequent increase in diabetes mellitus.

We found a continuing decline in in-hospital mortality that occurred mainly in older persons and that also was attenuated after 2008. Although the absolute difference in in-hospital death rates between 2000-01 and 2012-13 persisted at 1 year, it appeared less striking because the post hospital deaths in the first year were more numerous than in-hospital deaths and did not diminish over the study time period (Table 3.5). The improvement in survival to hospital discharge and at 1 year from 2000-01 to 2008-09 had no visible impact on 5-year mortality, implying that the improvement in in-hospital mortality, while very desirable, did not make a large difference in long term outcomes.

The incidence of MI in women declined from 2000 to 2009 with little further change following a pattern that was nearly identical to that in men. However, in each year the rate in women was roughly 50% lower than in men. As has been reported by others, the in-hospital mortality in women who did have an MI was somewhat higher than that in men from 2000 to 2008, but this difference narrowed and disappeared after 2009. It is tempting to attribute this improvement to the considerable attention that heart disease in women has had over the past 15 years. However, the 1 year mortality remained higher for women. Five year follow-up for these later MI's was not available in the study dataset.

All age groups showed a decline in MI incidence but this was most pronounced in the older age groups. The lack of further decline in MI incidence after 2008-09 was a disturbing finding that likely contributed to the slowdown in rates of decline in CVD mortality (28). The reasons for this are not well understood but may be due to the plateauing in the use of interventional and pharmacological therapies seen after 2008-09 and/or by the increase in the rate of cardiovascular risk factors, such as diabetes mellitus, obesity and hypertension in the population. A decline in in-hospital MI case fatality was observed in all age groups (except the 50-54 age group) but was more pronounced in absolute terms in the oldest age groups.

This study shows that for the first time females not only had a greater decline in in-hospital mortality than males during the study period but had a lower case fatality rate in 2013. This remarkable improvement in female MI case fatality is important considering that CHD kills more women in the United States than all cancers combined (29,30) and has long been the leading cause of death. This improvement maybe attributable to an increased awareness of CHD in women by society and more aggressive treatment of CHD by the medical community. Numerous major hospitals and university centers now boast of cardiac centers for women, many of which are staffed by women cardiologists. A similar result was shown in the 1 year fatality data where the female decline narrowed the gap between women and men over the study period. While a big improvement, females continue to lag males in 1 year fatality rates and it may take some time before they reach parity. This may indicate that outside of the hospital women are still not getting the care and intervention that is needed to treat their CHD and more work needs to be focused on outpatient treatment of CHD in women.

A decline in one year MI case mortality was observed in all age groups but was more pronounced in absolute terms in the oldest age group. When comparing in-hospital MI mortality to one year MI mortality, More than 63% of the reduction in case fatality in the age group 80-84 at discharge was lost at one year. This difference may be due to competing risk with non-cardiovascular causes of death such as cancer, lung disease, stroke, infection or dementia. Competing risks occur when other events compete with the outcome of interest to remove people from the population at risk. If a person survives an initial MI but dies from any of these competing risks within 1 year, he or she will have a reduced opportunity to die from CHD within 1 year or 5 years and be included in the data.

There was no substantive change in 5 year survival after MI during the study period. This lack of improvement was seen across all gender, racial/ethnic and age groups. Again, competing risks with non-cardiovascular causes of death could obscure an improvement in CHD deaths, although it is not obvious why that should be the case. Other possible causes could be that follow-up treatment after MI is not as aggressive as would be optimal or possibly an improvement in the out years is obscured by out-migration or other loss to follow up. This is an area that needs further study.

LIMITATIONS AND STRENGTHS

Limitations of this study include the possibility that some out-of-state deaths of present and former New Jersey residents may be missing, marginally reducing the incidence rates shown, but this should be ameliorated since MIDAS includes records of New Jersey residents whose out-of-state death certificates are copied back to Trenton. Also, data on former New Jersey residents living in other states with CHD who did not die maybe missing. Another limitation is the exclusion of Veterans Administration (VA) hospital data from the MIDAS study. The VA has two medical centers in the state of New Jersey but since they make up a small percentage of hospitals in New Jersey and since most veterans with an emergency would be taken to the closest hospital, this is likely to be a small omission. Another likely limitation is the misclassification of ethnic identity of patients in the hospital versus the census, which might distort rates calculated for Hispanics.

Strengths of the study include the very large and comprehensive database of patients with CVD, the linkage of these hospital admission data to the New Jersey death certificate file, and the extensive follow-up of many years. Along with this and having a population racial breakdown in New Jersey that is similar to the United States at large (18), we believe that our study findings are generalizable to the country.

SUMMARY

This study provides evidence that there was a continuing decline in MI incidence, from 2000-2008, a change that cannot have been due to invasive cardiac treatments and is thus evidence for the value of lifestyle change and outpatient control of CHD risk factors. There was also a decline in-hospital MI mortality and 1-year MI mortality from 2000 to 2008-09 that leveled off in subsequent years. It is of interest that secular improvements in incidence and in hospital survival stopped in the same two year period, suggesting they may somehow be linked. One possibility is that reductions in atherosclerosis in the population resulting from lifestyle change and outpatient treatment might lead both to fewer and to less severe MI's.

The absolute and relative improvement in MI hospital outcomes for women was a heartening development during the study period, but unfortunately neither this change nor the reductions in in-hospital mortality overall appeared to affect five year survival. This appears also to emphasize the importance of population-wide reductions in CHD risk factors in controlling heart disease. The cessation of the declines in incidence and in-hospital survival implies that risk factors are no longer coming under better population-wide control. This is likely due, at least in part, to the influence of the obesity epidemic which contributes to hypertension, hyperlipidemia, lower HDL cholesterol, less physical activity, and increased diabetes mellitus.

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CHAPTER 4

CHD MORTALITY DECLINE IN PERSONS WITH AND WITHOUT IN-HOSPITAL TREATMENT FOR THEIR DISEASE IN THE PRECEDING TEN YEARS: 2000-2014

ABSTRACT

There has been considerable debate on the extent to which the decline in coronary heart disease (CHD) has been caused by better control of coronary risk factors in the general population versus the result of invasive coronary interventions in symptomatic individuals. Using the Myocardial Infarction Data Acquisition System, a statewide database of all cardiovascular hospital admissions in New Jersey, we examined time trends in incidence of death from CHD in the years 2000 to 2014 in persons with a history of hospitalization for CHD in the past 10 years and those without such a history. There was a pronounced decline in CHD related mortality over the 10 year study period in both persons with a history of CHD and persons without a history of CHD but the decline was higher in those without a prior history of CHD. The decline occurred across all gender, racial and age groups. This shows that the decline in CHD was not only due to advanced invasive medical and surgical treatment but also equally due to improved lifestyle and public health interventions.

INTRODUCTION

A decline in both outpatient and inpatient age adjusted death rates due to coronary heart disease (CHD) and myocardial infarction (MI) has been reported in both men and women, but in the years before 2000 the decline was more pronounced in the inpatient than the outpatient setting, where the majority of CHD mortality presently occurs (1-3). In a community study covering the years 1990-2001 the decline itself plateaued toward the latter part of the study (1). The importance of lifestyle and control of coronary risk factors has been suggested in more recent mortality data. Fifty percent of men and 64% of women who die suddenly of CHD have no previous symptoms of the disease (4,5). Between 70% and 89% of sudden cardiac deaths occur in men, and the annual incidence is 3 to 4 times higher in men than in women but this disparity decreases with advancing age. Also, people who previously have had an MI have a sudden death rate 4 to 6 times that of the general population. The percentage of CHD deaths that occurred out of the hospital in 2009 was 73% (4) and the incidence of out-of-hospital cardiac arrest was 6.0/1000 subject-years in subjects with any clinically recognized heart disease compared with 0.8/1000 subject-years in subjects without heart disease. According to the National Center for Health Statistics mortality data, 281,000 CHD deaths occur either out of the hospital or in hospital emergency departments annually (6). Comparison of hospital versus out-of-hospital CHD mortality showed that women aged 35-54 years of age had greater in-hospital mortality rate than men (5.2% vs 2.5%) but had lower out-of-hospital death rate than men (11/100,000 vs 55/100,000) (7). The authors proposed that the reason for this disparity is that men were more likely to have out-of-hospital CHD death. Further evidence shows that immediate and 1-year survival of out of-hospital cardiac arrests was only 3.7% with only 2.3% surviving without neurologic deficits (8).

Since the decline in cardiovascular disease (CVD) was first noted several decades ago, epidemiologists and cardiologists have been trying to determine the cause of the fall in mortality. The difficulty has been separating the effect of primary prevention (dietary change, physical activity, and the reduction in cholesterol and blood pressure) from the effect of modern invasive medical or surgical treatment (9). Several models have been created to estimate the share of the reduction that could be attributed to improvement in risk factors and use of lipid lowering agents, aspirin and antihypertensive medications as compared to the impact of invasive coronary interventions. Although conclusions have differed based on the population or risk factor under study, many have estimated an almost equal contribution of modern medical treatment and risk factor reduction (9,10).

The treatment of CHD and MIs has progressed from simple bed rest years ago to the present use of intensive care units and coronary care units. Medical interventions to prevent and treat MIs has evolved to include the use of multiple drugs such nitrates, beta-blockers, angiotensin-converting enzyme inhibitors, aspirin, statins, Angiotensin II receptor blockers, glycoprotein 2b/3a inhibitors, coumarins, heparin and heparin derivatives, clopidogrel with other future agents that are in the pipeline. Today common interventions used in the revascularization of coronary arteries in patients having an MI or at high risk for an MI include artery bypass grafts, coronary angioplasty and use of clot busting medicines. Newer interventions today include the use of implantable cardiac defibrillators. All these medical treatments have presumably contributed to the decline in deaths due to CHD. But analyzing more specifically the contribution of healthier lifestyles or the pharmacological control of risk factors of population based interventions at the community and national levels have also shown effectiveness in reducing the mortality of CHD. One of the early trials that showed the effectiveness of intervention was the North Karelia study in Finland. This landmark study was carried out in the early 1970s at both the local and national level to lower CHD mortality by lowering the rates of three CHD factors: blood pressure, smoking and total cholesterol. Several years of intervention showed a significant decline not only in adverse risk factors but, more importantly, in the CHD mortality (11). Several community intervention trials were carried out in the United States targeting CHD risk factors such as smoking, obesity, diet, hypertension (HTN) and physical activity (12). The results of these trials were mixed, underscoring the complexity of the issues involved in a community based intervention for risk reduction. Nonetheless, programs such as those that reduce smoking in teens, encourage healthier eating in the population, encourage physical activity in all age groups and programs to screen for risk factors such as HTN, high cholesterol and diabetes mellitus remain a cornerstone of public health in the United States.

OBJECTIVES & HYPOTHESES

We reasoned that if improvement in medical treatment of acute coronary events was the main driver of the decline in CHD mortality, then the decline should be greatest in deaths following a treated episode and not so striking in out-of-hospital deaths without a history of CHD or MI. Conversely, if improvements in lifestyle and outpatient treatment of risk factors were the principal reason for the decline, then the decline in outpatient and emergency room deaths should be at least as great as the decline among persons previously hospitalized for MI. Following this idea, the primary objectives of this chapter are to quantify and compare the decline in out of hospital CHD deaths per 100,000 in persons with no history of hospitalized CHD in the previous 10 years to the decline in fatalities among those who did have a CHD hospitalization in the 10 years prior to death. If most of the decline in CHD deaths has occurred among persons not hospitalized for

CHD in many years, it would argue strongly for the importance of role played by primary prevention.

METHODS

The present study used data from the Myocardial Infarction Data Acquisition System (MIDAS) dataset. MIDAS is a statewide hospitalization database in New Jersey that contains all hospital discharge abstracts submitted to the New Jersey Hospital Discharge Data Collection System by nonfederal acute care hospitals in the state that has been maintained since the late 1980s. It includes all records with a primary diagnosis of MI (International classification of Diseases, Ninth Revision [ICD-9] codes 410.0 to 410.9), Ischemic Heart Disease (ICD-9 410-414), Congestive Heart Failure (ICD-9 428), cerebrovascular disease (ICD-9 430-438) and diseases of arteries, arterioles, and capillaries (ICD-9 440-449). MIDAS also includes data on hospital discharges with codes for invasive cardiac procedures. Data on cardiovascular deaths were obtained from the New Jersey death registration files and matched to the MIDAS records using automated record linkage software (13). Persons younger than 40 or older than 84 years of age were excluded from this analysis.

For this analysis all New Jersey deaths between the ages of 40 and 84, from the years of 2005 to 2014, attributed to coronary heart disease (ICD-9 410-414) were obtained from the state vital registration system and were matched to the MIDAS file of persons hospitalized for acute MI, percutaneous coronary angioplasty or coronary artery bypass graft, as well as those hospitalized for other related heart disease codes. The primary analysis focused on persons certified to codes 410-414 and age-adjusted death rates for the New Jersey population was partitioned between those dying with a history of hospitalization for CHD in the preceding 10 years and those without such a history.

Rates for ICD codes 410-414 were examined, and the code 410-414 outcomes was analyzed in major demographic strata: for whites and blacks; for men and women; and for those 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74, 75-79 and 80-84 years of age. Statistical analysis was performed using R software (14). The data are adjusted for age, gender and race/ethnicity to the 2010 United States Census data. Sex-specific rates are adjusted for race/ethnicity and age. Rates for race are adjusted for sex and age, and age specific rates are adjusted for sex, and race. Rates are not shown separately for Hispanics because of uncertainty about the comparable identification of ethnicity in the death certificates, hospitalization records, and population data. Statistical tests were not used because, given the administrative sources of data and the large sample size, statistical error is expected to be small compared to errors of ascertainment and classification. The information from the database, including the diagnosis of MI, has been validated previously using a random sample of the medical charts (15,16).

The study has been approved by the Rutgers New Brunswick/Piscataway Institutional Review Board and the MIDAS database has been approved by the Rutgers New Brunswick/Piscataway Institutional Review Board and by the New Jersey Department of Health Institutional Review Board.

RESULTS

Table 4.1 Provides data on total CHD deaths per 100,000 population for each year of study and broken down based on gender (male or female), race (whites and blacks) and age. There was a decline of 37.3% in the total CHD mortality from the year 2005 to 2014 (figure 4.1). This decline was noted in all gender, race and age groups. Males had higher CHD mortality than females (figure 4.2) but females had a greater percentage decline in age-adjusted mortality than males (40.5% vs 36.0%). Blacks had 28% higher CHD mortality than whites in 2005-06, a disparity that remained unchanged in 2013-14 (figure 4.3). CHD mortality was closely linked to age, but the secular decline was similar in percentage terms in all age groups. Thus, the absolute decline and the largest number of deaths averted were in the older age groups.

Persons *without* a prior history of CHD hospitalization comprised the large majority of the total and patterns of decline seen in this group is very similar to that seen overall (table 4.2). The decline in CHD mortality in those without a prior history of CHD hospitalization was 38.5% over the study period (figure 4.5) which is greater than the 33.6% decline seen in those with a prior history of CHD. Females had a greater decline than males over the study period (figure 4.6) in both those with (37.1% vs 32.5%) and those without (41.6% vs 37.4%) a prior history of CHD hospitalization. Similar to the overall decline, both females and males had a bigger decline in those without prior history of CHD hospitalization than in those with a prior history of CHD hospitalization. Blacks without a history of CHD hospitalization had higher CHD mortality at 39.4% than did whites at 38.6%, but the percentage decline over the study period was very similar And this was similar in those with a history of CHD hospitalization where blacks had a higher CHD mortality at 31.3% as compared to whites at 29%. (figure 4.7). As seen before, the rates of CHD mortality for the races were higher in those with history of CHD hospitalization than those without. The percentage decline across age groups was quite similar but the absolute decline was largest in the older age groups (Figure 4.8 and 4.9) and less so in those persons their 50's. Also, the greater decline in the age groups was seen in those without a prior history of CHD hospitalization than in those with a prior history.

Figure 4.10 shows that both groups, those with and those without a prior history of CHD hospitalization, have declined over the years but the decline has been greater in those without a prior hospitalization for CHD (and who therefore are unlikely to have had cardiac revascularization procedures).

Table 4.1. Adjusted total CHD mortality per 100,000 by gender, race and age group. New Jersey 2005-2014.

YEAR	Total	MALE	FEMALE	WHITE	BLACK	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
2005	201.3	282.0	138.6	207.3	274.8	16.1	30.9	55.6	101.2	159.6	232.7	416.5	764.0	1418.2
2006	186.6	259.5	129.7	191.7	236.6	12.9	24.3	55.2	83.8	145.5	232.8	404.0	708.6	1301.0
2007	165.0	237.7	109.1	171.2	210.9	10.7	25.6	44.2	81.7	117.3	208.3	349.9	634.0	1159.6
2008	165.7	232.1	113.7	169.1	223.6	10.9	23.7	48.1	78.3	131.9	206.9	340.6	632.5	1155.9
2009	156.0	220.6	105.4	161.3	198.3	12.8	24.2	38.5	72.4	120.3	195.1	316.7	601.8	1111.7
2010	153.2	220.5	99.5	157.4	209.5	14.4	25.2	52.7	71.4	128.3	186.2	303.3	569.0	1043.5
2011	148.6	211.8	97.9	153.4	211.0	13.2	27.6	48.0	73.1	116.7	181.5	304.7	545.5	1013.0
2012	138.4	196.6	91.3	145.0	182.5	11.8	25.9	46.2	74.0	118.9	172.3	273.3	501.1	909.4
2013	132.9	194.3	83.4	140.2	176.0	10.9	22.4	39.3	65.8	114.0	177.6	268.5	462.9	908.9
2014	126.3	180.4	82.5	132.2	171.7	9.2	20.6	39.5	69.7	103.5	164.7	264.4	449.5	834.5

The data are adjusted for age, gender and race/ethnicity. For the rates for gender, they are adjusted for race/ethnicity and age.

For the rates for race/ethnicity, they are adjusted for gender and age.

For the rates for age, they are adjusted for gender, race/ethnicity, and the ages included in the grouping.

Figure 4.1. Total CHD mortality per 100,000 and year of death, 2005-2014.

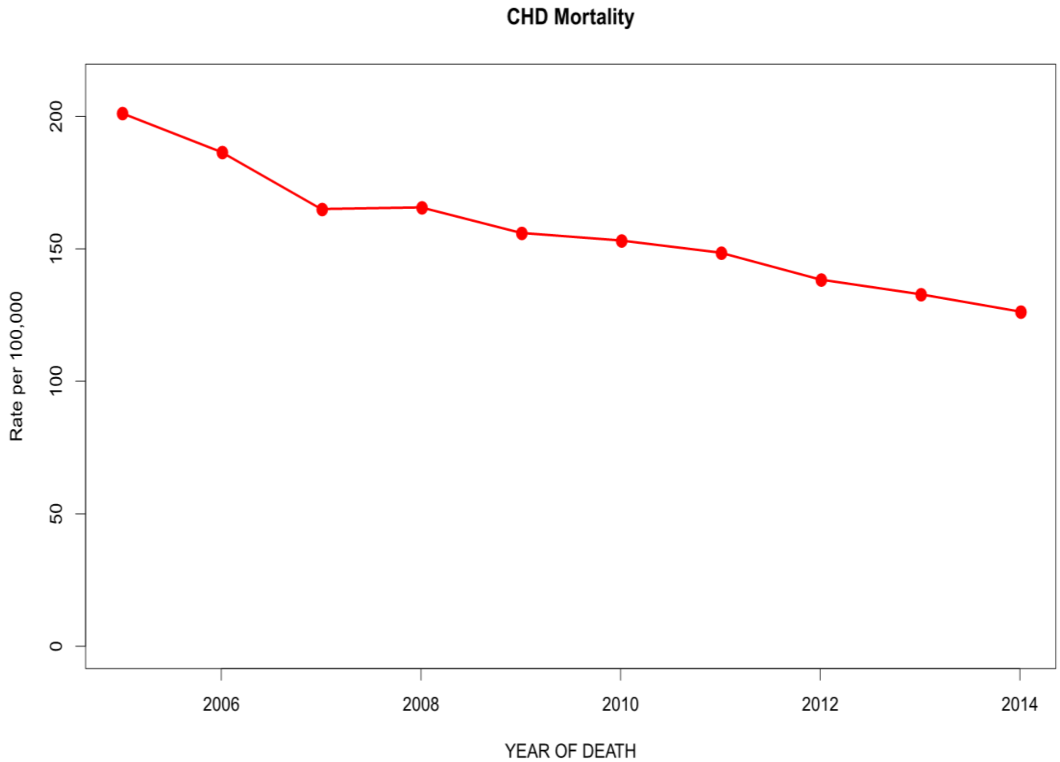


Figure 4.2. CHD mortality per 100,000 by gender and year of death, 2005-2014.

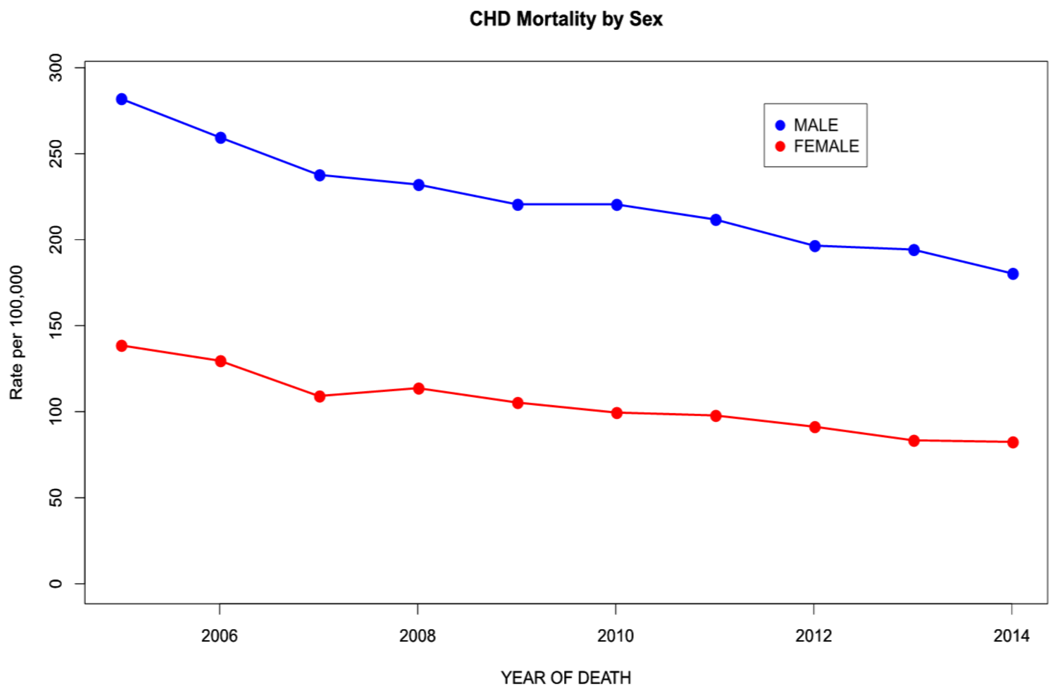


Figure 4.3. CHD mortality per 100,000 by race and year of death, 2005-2014.

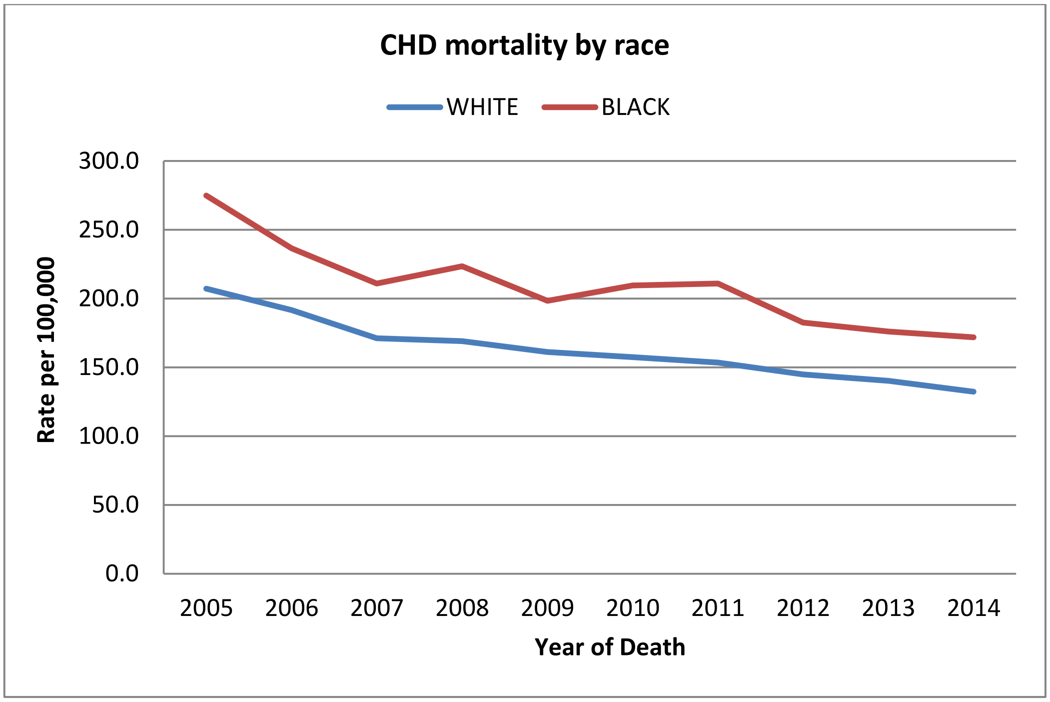


Figure 4.4. CHD mortality per 100,000 by age group and year of death, 2005-2014.

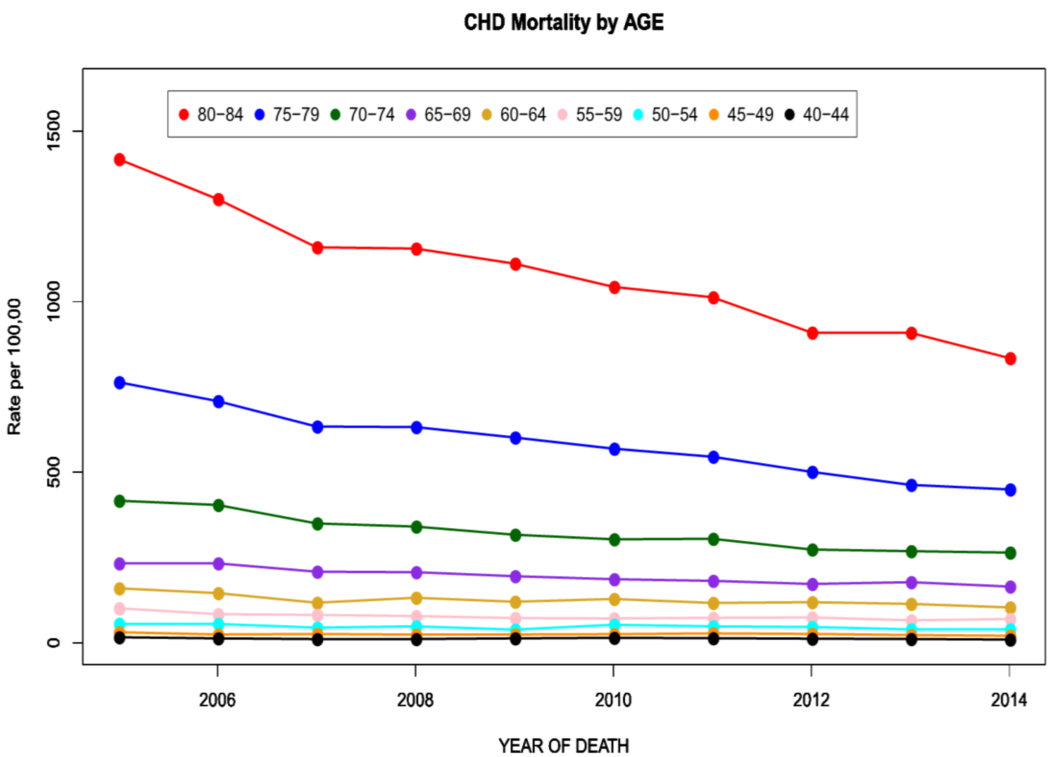


Table 4.2. Adjusted mortality per 100,000 in those with no prior history of CHD by gender, race and age group. New Jersey 2005-2014.

Year	Total	MALE	FEMALE	WHITE	BLACK	HISPANIC	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
2005	147.2	203.3	102.8	156.6	211.9	41.2	14.9	27.5	45.8	82.6	119.6	160.8	298.2	530.1	1016.1
2006	133.5	182.2	94.7	140.7	174.3	76.9	12.0	20.4	44.3	64.3	105.2	159.8	276.0	483.6	936.9
2007	117.9	166.5	79.7	126.6	153.6	51.0	9.4	22.1	36.8	61.2	83.9	138.3	240.3	437.1	834.0
2008	121.2	167.1	84.5	125.9	177.3	77.7	10.4	21.2	40.2	63.6	98.3	149.7	232.1	438.8	837.2
2009	110.7	151.9	77.1	117.4	149.2	68.5	11.5	20.2	30.7	57.0	92.7	139.3	216.2	405.3	753.8
2010	107.4	151.0	72.0	113.6	155.2	69.4	13.4	21.5	43.7	54.9	90.3	122.7	206.2	377.8	715.6
2011	106.1	149.6	70.6	112.3	158.0	64.4	12.6	23.1	40.4	59.5	89.0	123.5	202.2	366.9	700.4
2012	97.8	136.1	66.1	104.5	133.7	53.6	10.7	22.4	38.2	56.1	87.0	120.5	187.2	335.6	611.8
2013	94.2	134.7	61.2	101.4	128.2	57.6	10.6	18.7	31.2	50.9	86.3	124.5	172.1	305.4	642.5
2014	90.5	127.3	60.0	96.2	128.4	58.8	8.7	18.2	31.5	53.7	81.9	114.9	180.1	310.1	565.6

The data are adjusted for age, gender and race/ethnicity. For the rates for gender, they are adjusted for race/ethnicity and age. For the rates for race/ethnicity, they are adjusted for gender and age. And for the rates for age, they are adjusted for gender, race/ethnicity, and the ages included in the grouping.

Table 4.3. Adjusted mortality per 100,000 in those with prior history of CHD by gender, race and age group. New Jersey 2005-2014.

YEAR	Total	MALE	FEMALE	WHITE	BLACK	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84
2005	54.1	78.7	35.8	50.7	63.0	1.2	3.5	9.8	18.5	40.0	71.9	118.2	234.0	402.1
2006	53.1	77.3	35.0	51.0	62.3	0.8	3.8	10.9	19.4	40.3	73.0	128.0	225.0	364.0
2007	47.2	71.2	29.4	44.6	57.3	1.3	3.5	7.4	20.5	33.4	70.0	109.5	196.8	325.6
2008	44.5	64.9	29.2	43.2	46.3	0.4	2.5	7.9	14.6	33.5	57.1	108.5	193.7	318.7
2009	45.4	68.6	28.3	43.9	49.1	1.4	4.1	7.8	15.4	27.6	55.8	100.5	196.5	357.9
2010	45.8	69.5	27.5	43.8	54.3	0.9	3.7	9.0	16.5	38.0	63.6	97.2	191.2	327.9
2011	42.5	62.2	27.2	41.1	53.0	0.6	4.5	7.6	13.6	27.7	58.0	102.6	178.5	312.6
2012	40.6	60.5	25.2	40.5	48.8	1.1	3.5	8.0	18.0	31.9	51.8	86.1	165.5	297.7
2013	38.6	59.6	22.2	38.7	47.8	0.3	3.8	8.1	14.9	27.7	53.1	96.4	157.5	266.4
2014	35.9	53.1	22.5	36.0	43.3	0.5	2.5	8.0	16.0	21.6	49.8	84.3	139.4	269.0

The data are adjusted for age, gender and race/ethnicity. For the rates for gender, they are adjusted for race/ethnicity and age. For the rates for race/ethnicity, they are adjusted for gender and age. And for the rates for age, they are adjusted for gender, race/ethnicity, and the ages included in the grouping.

Figure 4.5. Mortality per 100,000 in those with and without a prior history of CHD and year of death, 2005-2014.

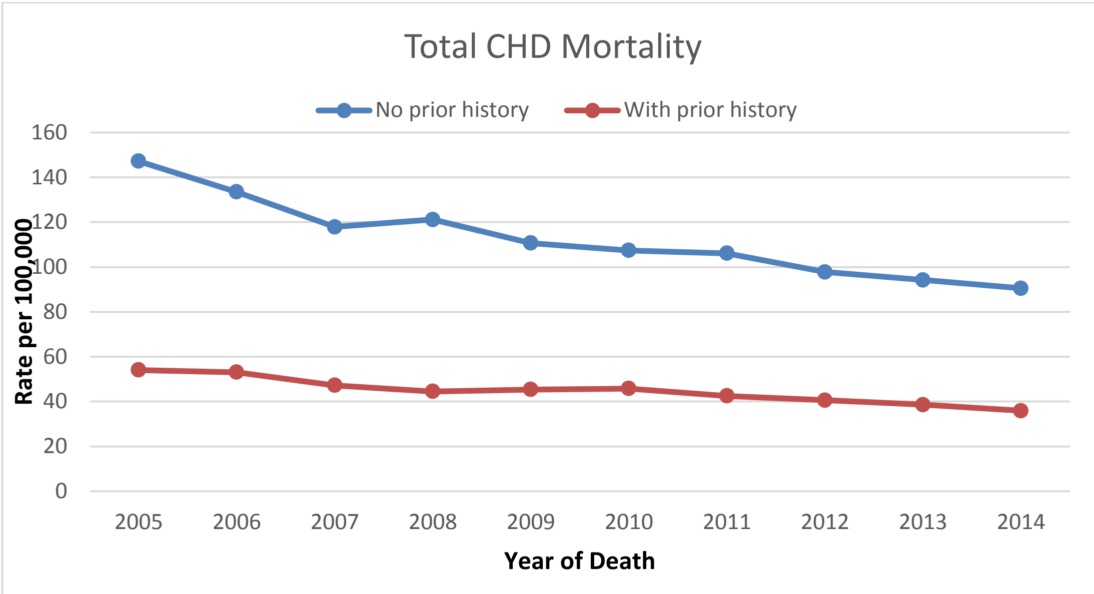


Figure 4.6. Mortality, per 100,000, in those with and without a prior history of CHD by gender and year of death, 2005-2014.

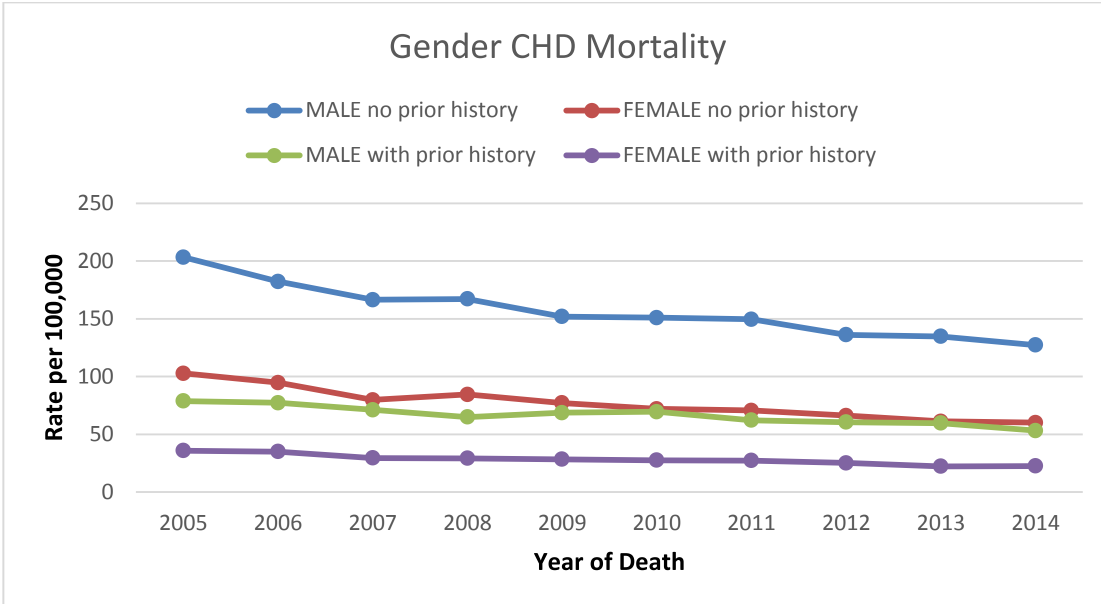


Figure 4.7. Mortality, per 100,000, in those with and without a prior history of CHD by race and year of death, 2005-2014.

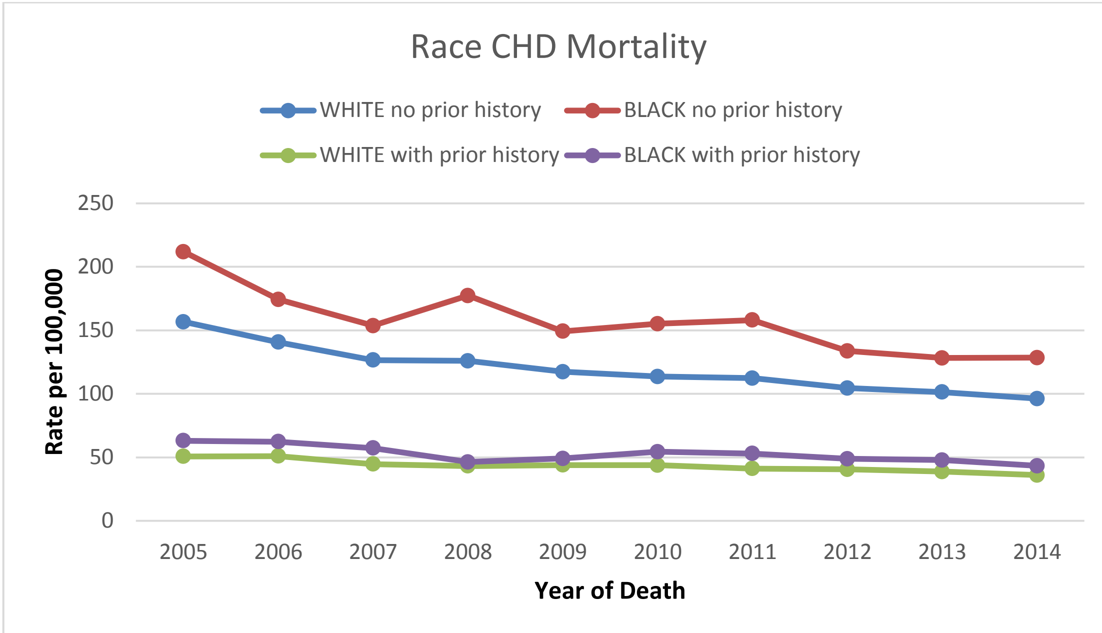


Figure 4.8. Mortality in those with no prior history of CHD based on age group and year of death, 2005-2014.

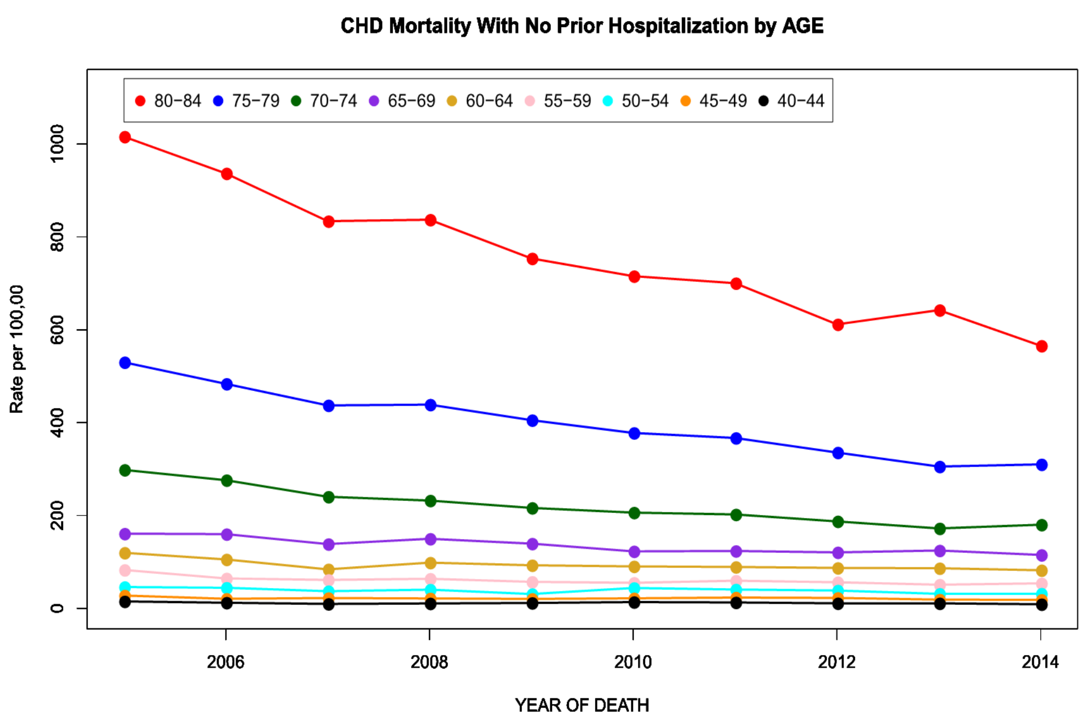


Figure 4.9. Mortality in those with prior history of CHD based on age group and year of death, 2005-2014.

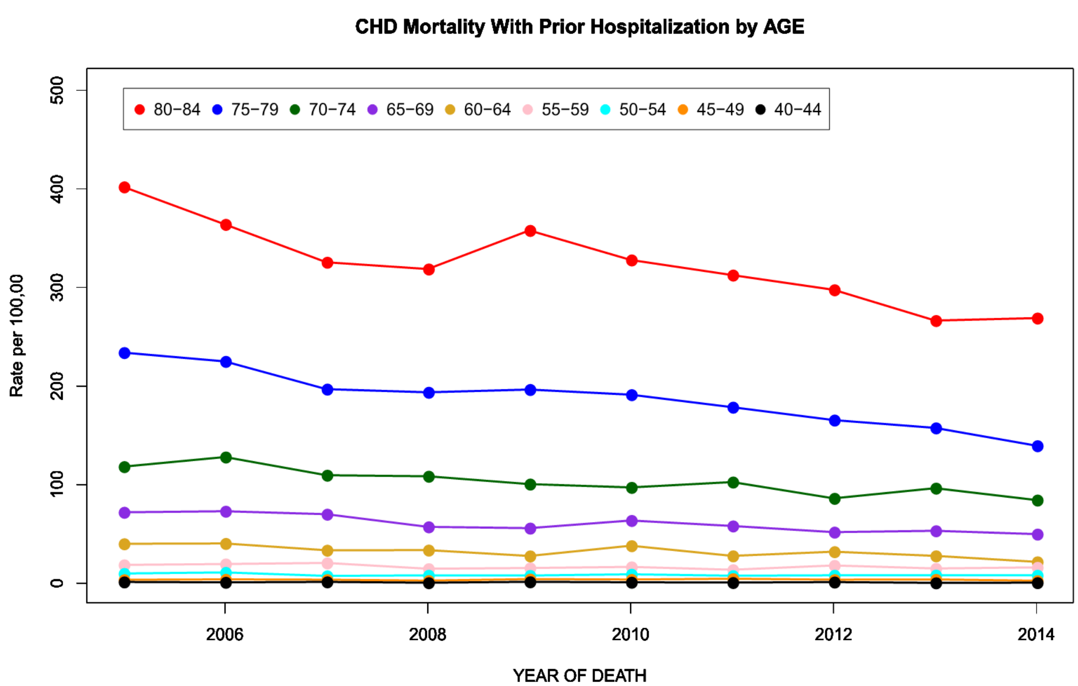
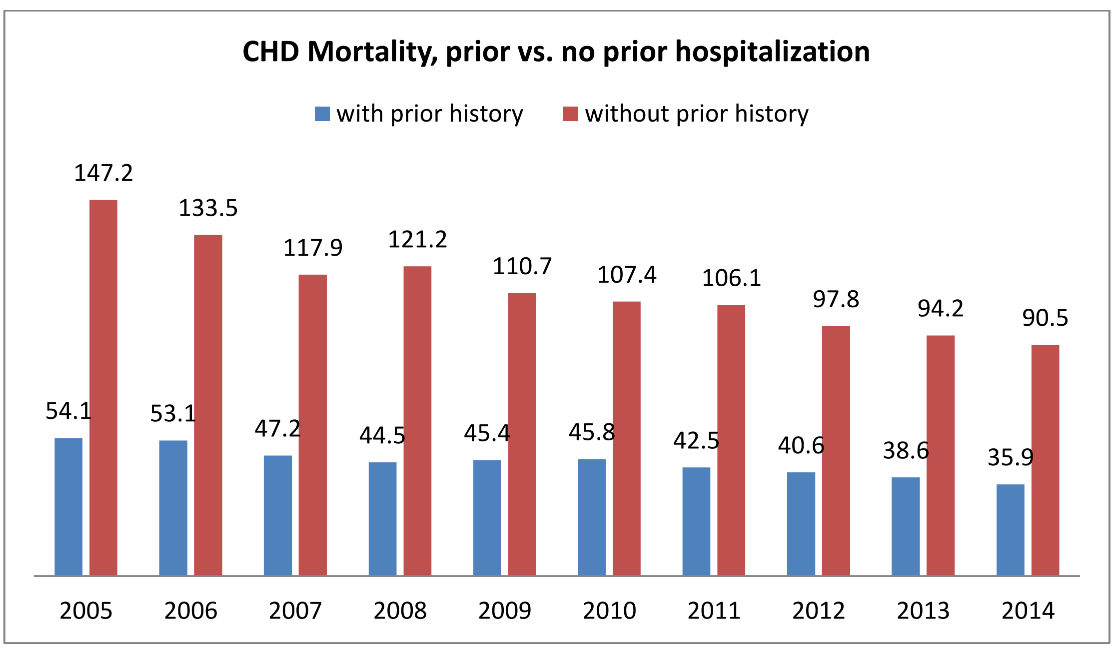


Figure 4.10. CHD Mortality: Prior vs. no prior hospitalization and year of death, 2005-2014.



DISCUSSION

Our study provides evidence of continuing decline in CHD mortality in both those with a history of CHD and in those without history of CHD. In both groups the decline has been seen in men and women, in blacks and whites and across all age groups over age 40 years. However, the extent of decline in CHD mortality has been greater in those without a prior history of CHD than in those with a history of CHD.

Females had a larger CHD mortality decline than males in those with and without a prior history of CHD. This could be due to a greater change in awareness and lifestyle among women as well as increasing attention to control of CHD risk factors in women by the medical community. Although there has been some recent attention to an increase in all-cause mortality of middle-aged white persons (17), blacks had the highest CHD mortality rates in these data. The secular improvements across both races were roughly equal. The best decline in CHD mortality in both those with and without a prior CHD history was seen in the older age groups. The reason for this is not clear but it may imply that improvements in risk factors are less striking in younger persons either because they never had such bad habits (e.g. cigarette smoking), or because of the increase in obesity. It is also possible that pharmacologic control of hypertension and hyperlipidemia yield their greatest benefits after a decade or two of implementation.

We note that while it seems obvious that a decline in CHD deaths among persons who have never had an opportunity to benefit from a revascularization procedure must be due to other changes, it is possible that primary prevention strategies may have contributed to better treatment outcomes. The strikingly similar demographic distribution of the improved incidence rates in persons with and without a CHD history is consistent with this possibility as is the changing presentation of MI from ST-Elevation Myocardial Infarction (STEMI) to non-STEMI presentation.

LIMITATIONS AND STRENGTHS

Limitations include a number of sources of error that are inherent in the use of death certificates and hospital discharge data over an extensive time period. These include misdiagnosis and coding errors as well as missing hospitalizations that took place out of state either prior to in-migration or because some state residents seek care at out-of-state medical facilities. It is likely that errors in assignment of cause of death will be more prevalent in patients not previously hospitalized for CHD although the magnitude of effect of this difference is unknown. We acknowledge that missing out-of-state hospitalizations will have somewhat inflated our estimate of the proportion of CHD deaths that had no hospitalization history, but believe the problem is limited since most patients having an MI are taken to a local hospital. New Jersey is not a major retirement destination and most in-migration is known to be by younger persons. A further limitation is likely to be the misclassification of ethnicity which could vary between the sources of health records and census data, distorting race-specific rates, especially for Hispanics, which group we have not shown separately in some of the tables.

Strengths of this analysis include its state-wide scope that has not focused only on persons willing to be in a longitudinal study and its use of state-wide hospital discharge codes as an objective way of separating among CHD decedents those who had a previous MI or revascularization procedure in the antecedent 10 years from those who did not. New Jersey has a demographic composition that is fairly representative of the nation as a whole (but with more immigrants and fewer Native Americans) and it seems reasonable to extrapolate the major secular changes to much of the U.S.

SUMMARY

We provide evidence that shows there was a substantial continuing decline in CHD mortality over the 10 year study period in both persons with a history of CHD and persons without a history of CHD. Whereas improved hospital survival appeared to be a major contributor to the improvements in CHD mortality in the late twentieth century, the fall in MI incidence and greater decline in those never hospitalized for CHD suggest that primary prevention has played the larger role in more recent years. Further improvement may require still more aggressive risk factor control or new treatment technologies. In the face of the obesity epidemic, achieving either will be a major challenge.

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CHAPTER 5

DISSERTATION SUMMARY

Using New Jersey state mortality data for 2000-2017 and data from the Myocardial Infarction Surveillance System (MIDAS) from the years 2000 to 2014 we tried to answer the following questions:

1. Has the decline in coronary heart disease (CHD) mortality continued for the study period and has it been similar between the males and females, whites, blacks and Hispanics and across age groups?

2. Has myocardial infarction (MI) incidence and mortality been declining over the study period and has it been similar between the males and females, blacks and whites and across age groups? And,
3. Has the decline in CHD mortality occurred mainly in persons with prior in-hospital treatment for heart attacks or in those without such a history?

Our study has shown that there has been a decline in CHD mortality over the time period from 2000 to 2017, but the decline is attenuated after 2009. We speculate the this attenuation could be due to a leveling off of medical interventions to treat CHD and/or due to an increase of CHD risk factors such as obesity and diabetes mellitus. Whites had a greater decline in CHD mortality than blacks, increasing the gap in mortality between the races. There are substantial public health implications to this gap as we know that Blacks have higher rates of risk factors for CHD, such as diabetes mellitus (DM), hypertension and obesity. We need to do a better job of not only diagnosing and treating those risk factors in blacks but also we need to do a better job of treating CHD once it is diagnosed in this population. This is where Public health can take the lead in supporting existing programs and push for new ones that can educate the black community and society at large about these risk factors and the need to treat them. More aggressive screening and treatment of those risk factors by the medical community is also needed to assure the continuation of the downward trend in CHD incidence and mortality in all groups. Men continued to have higher CHD mortality and women had a better decline than men by the end of the study. This better improvement in women could indicate a better awareness of CHD in women by society and the medical community. The highest rate of CHD mortality along with the best decline in CHD mortality occurred in the oldest age groups, which is the reverse of the declines seen before the year 2000 and may reflect the cumulative impact of reduced risk factors and/or more widespread use of statins and antihypertensive treatment in the elderly and this reverses with younger age groups. We have done a good job of improving mortality in the elderly but should consider placing more emphasis on the diagnosis and treatment of CHD in the younger age groups.

We noted a decline in myocardial infarction (MI) incidence over the study period but it was attenuated after 2008. Again we see this attenuation as we saw in CHD mortality and this may be due to the same possible reasons as noted for CHD mortality (above). Men had both a higher incidence of MI and a better decline of this incidence. Again, whites had a much greater decline in MI incidence than blacks. Improving CHD incidence will improve MI incidence and mortality in the black community. The oldest age groups had the biggest improvement in MI incidence and this declined as the age groups grew younger and this decline was attenuated after 2008. It is worrisome that the younger population saw little improvement. Is it because of the increase in CHD risk factors such as DM and obesity or are we not doing a good enough job of diagnosing the diseases?

When looking at in-hospital MI mortality, we still see an improvement over the study period but this was attenuated around 2008. We did see a bright spot where there was a greater decline in women than in men. Whites and blacks had similar declines but again the oldest age groups showed the best decline. The one year MI mortality also showed a decline but at almost half the rate. Women had a better decline than men but women continue to lag men in 1 year fatality rates and it may take some time before they reach parity. This may indicate that outside of the hospital women are still not getting the care and intervention that is needed to treat their CHD and we need to do a better job. The results for the age groups mirror that for in-hospital MI mortality. Comparing the in-hospital to 1 year MI mortality, we believe that most of the improvement of the reduction in case fatality in the older age groups at discharge was lost at one year. This difference may be due to competing risk with non-cardiovascular causes of death. At 5 years we did not see any decline in MI mortality and this is probably due to competing risks where if a person had an MI but dies in 1-2 years from cancer, the person will not live to go on and die from heart disease at a later time.

Persons without a hospitalization for CHD made up the majority of the study population. There was a continuing decline in CHD mortality in both those with a history of CHD hospitalization and in those without a history of CHD hospitalization in the past 10 years. In both groups the decline has been seen in men and women but the decline was greater in women. Both races, in blacks and whites, showed a decline but blacks had higher CHD mortality in both groups. The best decline in CHD mortality in both those with and without a prior CHD history was seen in the older age groups. The extent of decline in CHD mortality has been greater in those without a prior history of CHD than in those with a history of CHD. A decline in CHD deaths among persons who have never had an opportunity to benefit from a revascularization procedure must be due to other changes and it is possible that primary prevention strategies may have contributed to better treatment outcomes. Will this improvement continue into the future as we see an increase in some of the risk factors for CHD? It’s possible that there will be an attenuation of improvement if not outright stalling if we don’t better diagnose and treat these risk factors at a younger age.