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ORIGINAL ARTICLE

Twenty-year trends in cardiovascular risk among men and women in the United States

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Abstract

Background Relative to men, women have experienced slower improvement in mortality in the US in recent decades.

Aims We investigated 20-year trends in cardiovascular risk for men and women age 40 and over in the US to determine whether there was differential change in risk for men and women.

Methods Using the National Health and Nutrition Examination Survey (NHANES), we estimated total cardiovascular risk, the prevalence of individual risk factors, and potential factors contributing to change in risk.

Results Men showed steady reductions in cardiovascular risk over the 20 years; women experienced increased risk from 1990 to 2000, but decreased risk from 2000 to 2010. Sex differences in cardiovascular risk changed so that there was no significant difference by sex at any age over 50 in 2010. Large decreases in the prevalence of high risk lipids were important causes of reduction in risks for both sexes; changes in blood pressure were less important, except for women in the 2000–2010 period when they equaled the effect of changing lipids. Increasing medication usage and effectiveness drove improvements in blood pressure and total cholesterol for both sexes. In 2010 there was no difference between men and women in the use of antihypertensives or cholesterol-lowering medications. Metabolic risk, as indexed by obesity and HbA1c, increased over time and went against the trend in the summary measure. Diabetes, smoking, and hormone therapy use did not explain changes in high blood pressure or high total cholesterol for either gender.

Conclusions Recent decreases in cardiovascular risk may lead to future reduction in cardiovascular events and mortality among both women and men.

Keywords Sex difference · Cardiovascular risk · NHANES · Trends

Introduction

Women's improvement in life expectancy in the US in recent decades has been slow both in comparison to American men and to women in other developed countries [1]. After 1980, the rate of increase in life expectancy slowed for women, and as a result the difference in life expectancy between women and men was reduced from 7.4 years in 1980 to 5.2 years in 2000 and 4.8 years in 2010 [2]. Deterioration in women's health was reflected in women's worsening cardiovascular risk between 1990 and 2000, both relative to men and absolutely [3]. Between 1990 and 2000 American women experienced an increasing prevalence of high blood pressure and obesity; while men experienced a decrease in the prevalence of hypertension.

The continued reduction in the male–female difference in life expectancy, due to stagnation in life expectancy gains among women, is one indication of worsening relative health of women [3]. The worsening of women's cardiovascular risk between 1990 and 2000 is inconsistent with increases in treatment and improvements in effectiveness of prescription drugs designed to lower cardiovascular risk [4–9]. Since the decrease in the prevalence of hypertension among men between 1990 and 2000 was related to successful treatment and control, it is possible that women are not being treated as effectively for hypertension as men [10, 11].

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There are several trends over the past decade that could adversely affect cardiovascular risk among both women and men such as increasing diabetes and obesity. There have been increases in obesity [12] and diabetes [13] for both genders, but larger increases for women. Smoking rates have been steadily decreasing in the past two decades both for men and women, though fluctuating for men after 2000 [14]. Both the use and effectiveness of prescription drugs designed to lower cardiovascular risk have been increasing markedly [4–8]. Use of hormone therapy first increased and then decreased over time [15–19]. Hormone therapy use among women increased when it was thought to be effective in preventing cardiovascular events, and then there was sharp decline after 2002 when it was linked to adverse cardiovascular events [10, 20–22]. Sex differences in these trends may be related to changes in cardiovascular risk over time.

In light of these trends, a reassessment of time trends in the relative cardiovascular risk of men and women is appropriate. Since future changes in life expectancy should be related to cardiovascular risk, it is valuable to clarify how changes in cardiovascular risk differ for men and women in recent years and how change in the relative cardiovascular risk of men and women is related to changes in potential explanatory factors.

This study examines change for men and women over the last 20 years, in eight indicators of cardiovascular risk which have been related to increased cardiovascular events and mortality [23–29]. We address four specific questions in this paper: How has cardiovascular risk changed over time for men and women? How has this change affected sex differences in cardiovascular risk? What specific cardiovascular and metabolic biomarkers explain the change in overall cardiovascular risk for men and women? How have trends in medication use, smoking, obesity and diabetes contributed to changes in cardiovascular risk for men and women? We use nationally representative samples of Americans aged 40 and over at three dates, about 10 years apart, covering change from 1990 to 2010.

Methods

Data come from the National Health and Nutrition Examination Surveys (NHANES), cross-sectional studies of the civilian, non-institutionalized population of the US conducted by the National Center for Health Statistics, Centers for Disease Control (NCHS/CDC) and include interviews, clinical examinations, and laboratory tests. NHANES III data were collected in 3 years cycles; we begin with data from the 6 years, 1988–1994. More recent NHANES data collections are for 2-year cycles, so we pool 4 years of data from two periods to have sufficient sample size for analysis at the two later dates. Our three data periods are approximately 10 years apart: 1988–1994, centered on approximately 1990; 1999–2002, centered on approximately 2000; and 2009–2012, centered on approximately 2010.

Our sample is limited to persons age 40 and over, who had fasted at least 6 h prior to their blood draw, and who provide data on all of the markers used in this study ($N = 3802$ for 1988–1994, $N = 2291$ for 1999–2002, and $N = 2133$ for 2009–2012). The age and sex profile of those who were excluded from the sample because of missing data is similar to the analytic sample. All analyses are weighted to reflect the non-institutionalized US population of ages 40 and over and conducted on Statistical Analysis System (SAS) 9.4.

Cardiovascular risk indicators include systolic and diastolic blood pressure, body mass index (BMI), total cholesterol, high-density lipoprotein (HDL) cholesterol, low-density lipoprotein (LDL) cholesterol, triglycerides, and glycated hemoglobin (HbA1c). Risk levels for each indicator are defined as measured levels above (or below) the clinical cutoff shown in Supplemental Table 1. We compute a summary indicator of cardiovascular risk by summing the number of indicators at high risk, range 0–8. This is a simple but frequently adopted approach in a number of analyses of summary biological risk [29, 30]. Other summary risk scores such as the Framingham risk score and allostatic load use similar biological indicators, sometimes combined with behavioral indicators [31, 32].

We examine in detail potential factors that might be related to changes in two important indicators of cardiovascular health (systolic blood pressure and total cholesterol). Factors examined include prescription medication use, current smoking status, obesity (BMI ≥ 30), high HbA1c levels indicative of diabetes (HbA1c $\geq 7.0\%$), and use of hormone replacement therapy (for women only).

Data analysis

Mean numbers of high risk cardiovascular indicators by age are estimated for men and women for 1990, 2000, and 2010 with 95% confidence intervals. We show differences across the three periods by age for each sex; then, we show sex differences in cardiovascular risk by age in each period. Then we examine the contribution of each biomarker to the change in the total cardiovascular risk score from 1990 to 2000 and from 2000 to 2010. The sum of changes in individual markers in each period is equal to the overall change in risk; we segment the overall change in the age-adjusted summary cardiovascular risk score into the portion due to groups of markers indicating blood pressure, lipids, and metabolic measures.

To better understand the role of medication and diagnosis on some of the important components of change, we incorporate self-reports of diagnosis by a doctor and use of medications along with measured levels of high systolic blood pressure, total cholesterol and HbA1c. This allows us to divide the sample into those who do not have a problem (no self-report or measured high risk), controlled (users of medication who measure in the normal range), uncontrolled (users of medication who measure in the risk range), and undiagnosed (measured in the risk range but not previously diagnosed).

We also estimate the effect of changes over time in obesity, HbA1c at a level indicating diabetes, smoking and hormone therapy use on high systolic blood pressure and high total cholesterol. We estimate logistic regression equations for men and women at each date, to look for different associations of the independent variables over time and by sex. We then use these equations to estimate the effect of assuming there was no change over time in the potential explanatory variables and compare this to the observed level. The difference between the two is the reflection of the effect of change in the independent variables.

Results

Change in summary cardiovascular risk score

First, we show how cardiovascular risk changed over time for men and women by age. Both men and women experienced improvement in cardiovascular risk over the 20 years, as indicated by the decrease in the mean number of risk factors, with the most improvement made at ages 60–69 (Fig. 1). For women, the decade from 1990 to 2000 showed no change, but between 2000 and 2010 there was dramatic improvement at ages 60 and over (from 1.80 to 1.27 for ages 60–69; from 1.70 to 1.11 for ages 70–79; and from 1.65 to 1.36 for ages 80+). For men, there was a steady decrease in the number of high risk indicators in both periods, although change between 2000 and 2010 was concentrated at ages 60–69 (from 1.68 to 1.18). The youngest women did not change much over time (from 0.88 to 0.92–0.95); while young men improved (from 1.55 to 1.47–1.24).

Looking at this from the perspective of sex differences at each of the three periods (Fig. 2), we see marked changes in the differences between men and women. In 1990, women younger than 60–69 had lower cardiovascular risk than men; women in their 60s and older had risk similar to men. In 2000, women older than their 60s had higher risk than men (1.80 for women and 1.68 for men for ages 60–69; 1.70 for women and 1.36 for men for ages 70–79; and 1.65 for women and 1.21 for men for ages 80+), while women younger than 60 had lower risk than men (0.92 for women and 1.47 for men for ages 40–49; and 1.30 for women and 1.50 for men for ages 50–59). In 2010, there was no significant difference between men and women in cardiovascular risk after age 50; among people in their 40s the level for males (1.24) exceeded that for females (0.95).

These figures also indicate change in the age pattern of cardiovascular risk. In 1990 and 2000 the risk among men increased up to ages 70, but in 2010 the differences across ages were not significant. Among women there was a significant increase in cardiovascular risk from ages in the 40s through the 60s in 1990 and 2000, with a slight decrease at older ages; this was no longer true in 2010.

Contribution of markers of risk to change in the age-adjusted summary score

To examine the contribution of groups of biomarkers in explaining the change in overall cardiovascular risk for men and women, we indicate the contribution of three sets of markers to the change in the age-adjusted summary score in Table 1. Lowered high risk levels of lipids (including total, HDL, and LDL cholesterol and triglycerides) explained a large part of improvement in both periods for both men and women. In fact, these declines exceeded the total decline for men at both times, and for women in the first period.

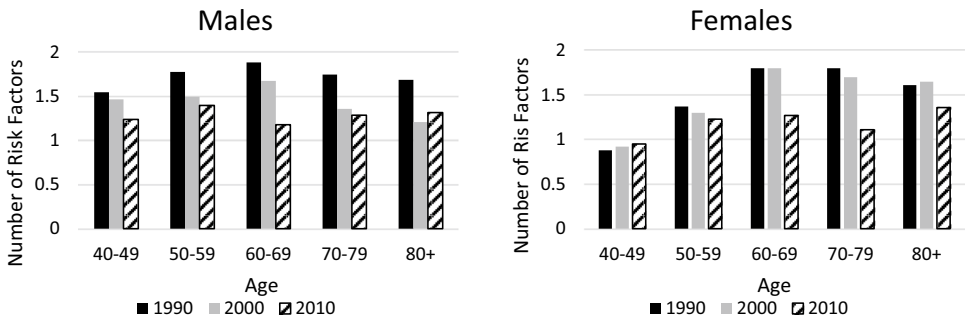

Fig. 1 Mean number of high risk cardiovascular risk factors 1990, 2000, 2010 by age: males and females. Numbers with 95% CI are shown in supplemental table 2

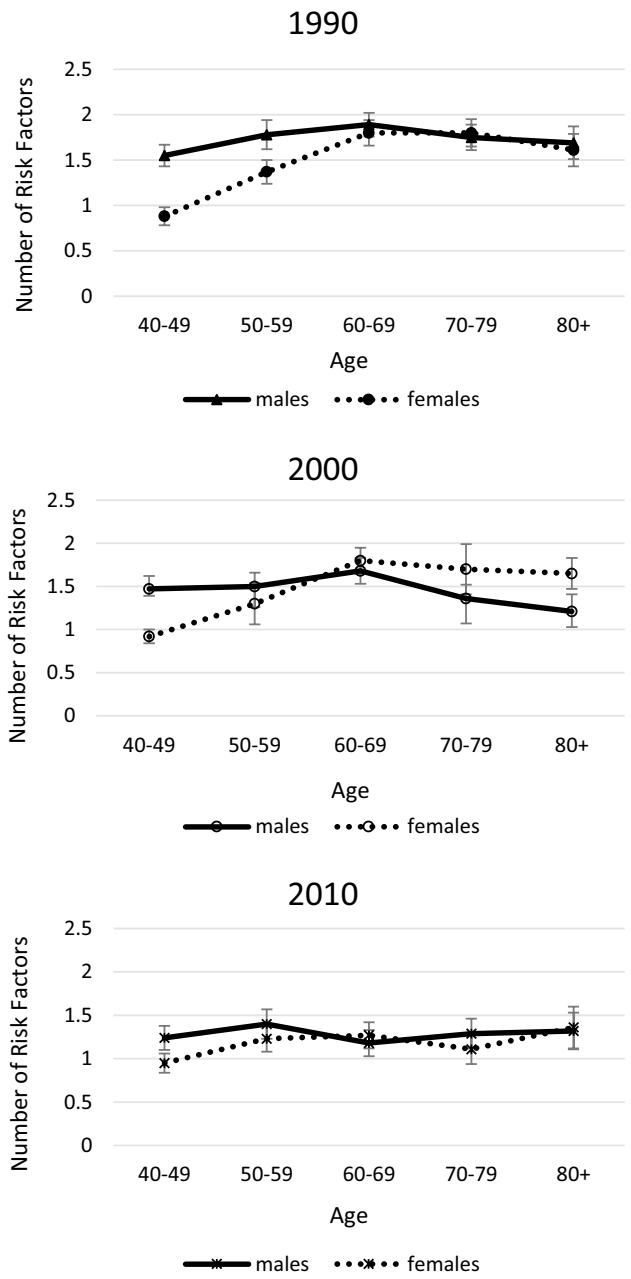

Fig. 2 Mean number of high risk cardiovascular risk factors by age and sex: 1990, 2000, 2010

Changes in systolic and diastolic blood pressure contributed much less for men in each of the periods; for women there was a mixed pattern of increase in the first period, and then decrease in the last period on blood pressure indicators that was equal to the decline in lipids. Both men and women experienced increases in metabolic risk as indexed by obesity and HbA1c in both periods, but this countervailing force was larger in the more recent (2000–2010) period.

Table 1 Changes in age-adjusted mean of grouped cardiovascular risk factors and summary number of risk factors between 1990 and 2000 and between 2000 and 2010

	Males		Females	
	Changes 2000–1990	Changes 2010–2000	Changes 2000–1990	Changes 2010–2000
High SBP + high DBP	−0.03	−0.05	0.11	−0.15
High TC + high LDL + low HDL + high trig	−0.25	−0.27	−0.19	−0.15
Obesity + high HbA1c	0.05	0.11	0.04	0.12
Summary risk	−0.22	−0.21	−0.04	−0.18

Trends that contributed to changes in cardiovascular risk for men and women

Change in measured hypertension, cholesterol and diabetes and usage of medication

We now clarify how trends in antihypertensive, statin and diabetic medication use have contributed to changes in cardiovascular risks for men and women. First, to see how usage of medication affected both change over time in risk and sex differences in risk, we examine change in systolic blood pressure, total cholesterol and glycated hemoglobin incorporating respondents' statements about previous diagnosis and use of medication with their measured levels reported above (Table 2).

The use of anti-hypertensive medication increased significantly for both sexes after 1990; from 17.72 to 21.91% in 2000, and to 33.31% in 2010 for men; and from 23.79 to 27.83% in 2000 to 31.87% in 2010 for women. Use of medications for hypertension by men and women did not differ significantly in 2010.

The subset of those who took medication and had controlled blood pressure, or measured systolic blood pressure below 140 mmHg, increased substantially between 2000 and 2010 from 15.05 to 27.15% (increase by 12.10%) among men, and from 15.17 to 24.48% (increase by 9.31%) among women. At the same time, the percent taking medication but with high measured systolic blood pressure, that is those with uncontrolled systolic blood pressure, decreased between 2000 and 2010, more for women (5.27%) than for men (0.70%). This means that the prevalence of control among those taking medication increased markedly for both men and women over the last 20 years (from 56.26 to 81.51% among men and 60.57–76.81% among women), but more for women in the recent 10-year period. This explains in part the dramatic improvement observed in the level of measured

Table 2 Prevalence (%) of measured level of risk, self-reported diagnosis and medication use for systolic blood pressure and total cholesterol by sex: 1990, 2000, 2010

	Males					Females				
	1990	2000	2010	% Change 2000–1990	% Change 2010–2000	1990	2000	2010	% Change 2000–1990	% Change 2010–2000
Systolic blood pressure										
Measured high systolic blood pressure										
Undiagnosed	8.69	9.26	6.16	0.57	−3.10	7.27	12.25	6.20	4.98	−6.05
Diagnosed, no medication	4.83	3.31	3.54	−1.52	0.23	3.02	3.44	1.53	0.42	−1.91
Diagnosed, taking medication	7.75	6.86	6.16	−0.89	−0.70	9.38	12.66	7.39	3.28	−5.27
Measured normal systolic blood pressure										
No history of high blood pressure	60.07	60.06	50.32	−0.01	−9.74	58.39	50.86	54.26	−7.53	3.40
Diagnosed, no medication	8.69	5.64	6.67	−3.05	1.03	7.53	5.62	6.13	−1.91	0.51
Diagnosed, taking medication	9.97	15.05	27.15	5.08	12.10	14.41	15.17	24.48	0.76	9.31
Total	100.00	100.00	100.00			100.00	100.00	100.00		
Total cholesterol										
Measured high total cholesterol										
Undiagnosed	9.33	5.76	2.47	−3.57	−3.29	11.71	7.40	6.44	−4.31	−0.96
Diagnosed, no medication	12.29	9.44	4.81	−2.85	−4.63	17.62	12.59	6.63	−5.03	−5.96
Diagnosed, taking medication	2.29	1.73	1.02	−0.56	−0.71	2.64	2.35	3.15	−0.29	0.80
Measured normal total cholesterol										
No history of high cholesterol	53.91	51.25	49.52	−2.66	−1.73	46.58	51.04	48.05	4.46	−2.99
Diagnosed, no medication	18.21	15.21	15.80	−3.00	0.59	16.49	13.86	12.54	−2.63	−1.32
Diagnosed, taking medication	3.98	16.60	26.38	12.62	9.78	4.95	12.76	23.19	7.81	10.43
Total	100.00	100.00	100.00			100.00	100.00	100.00		
HbA1c										
Measured high HbA1c										
Undiagnosed	4.07	3.00	5.41	−1.07	2.41	2.73	1.92	4.40	−0.81	2.48
Diagnosed, no medication	0.86	0.95	0.38	0.09	−0.57	0.58	0.36	0.38	−0.22	0.02
Diagnosed, taking medication	4.43	6.56	5.59	2.13	−0.97	5.26	5.37	4.55	0.11	−0.82
Measured normal HbA1c										
No history of diabetes	87.87	86.37	83.00	−1.50	−3.37	88.51	88.98	84.72	0.47	−4.26
Diagnosed, no medication	1.14	1.01	0.94	−0.13	−0.07	1.75	1.25	1.53	−0.50	0.28
Diagnosed, taking medication	1.63	2.11	4.68	0.48	2.57	1.18	2.11	4.41	0.93	2.30
Total	100.00	100.00	100.00			100.00	100.00	100.00		

People with no diagnosis history were assumed not to take medication in NHANES 1988–1994, 1999–2002, and 2009–2010. There are 126 undiagnosed people who are taking medication from 2011 to 2012 surveys where the survey questions were changed so that people who do not have a diagnosed condition are also asked whether they take prescription drugs for cholesterol. They are coded as not taking medication for analysis to make estimates comparable to previous years

high systolic blood pressure among women between 2000 and 2010. From 2000 to 2010, the percent with no history or measurement of high blood pressure decreased by 9.74% for men, while it increased 3.40% for women indicating an increase in primary prevention among women but not men.

Changes in categories of total cholesterol defined by measured level, self-reported diagnosis and medication looked fairly similar for men and women. The use of cholesterol medication increased from 6.27% in 1990 to 18.33% in 2000 and 27.40% in 2010 for men and from 7.59% in 1990 to 15.11% in 2000 to 26.34% in 2010 for women. Similar to the use of antihypertensive medication, the use of cholesterol medication did not differ for men and women in 2010. The percent of those with undiagnosed high total cholesterol decreased for both men and women from 2000 to 2010 (3.29% for men and 0.96% for women). The percent controlled on medication increased substantially for both men and women (9.78% for men, 10.43% for women from 2000 to 2010). Over the 20 years, the effectiveness of cholesterol medication appeared to consistently increase for both men and women as the percentage of those taking medications who had controlled cholesterol went from 63.48 to 96.28% for men and from 65.22 to 88.04% for women.

Undiagnosed diabetes as indicated by high levels of HbA1c is higher in the more recent decade for both men and women. This contrasts with the change in undiagnosed high systolic blood pressure and high cholesterol, which both decreased in between 2000 and 2010. There were increases in the same decade of persons who had HbA1c controlled by medication for both men and women (2.57% for men, 2.3% for women). Additionally, the percentage of who were taking medication, but still had high HbA1c declined from 6.56 to 5.59% for men and from 5.37 to 4.55% for women between 2000 and 2010.

Change in measured hypertension and cholesterol and medication usage and effectiveness, obesity, diabetes, smoking, and hormone replacement therapy

While we have seen a major role for medication in changing levels of high systolic blood pressure and total cholesterol, it is possible that change in other risk factors, including metabolic risk, have affected these trends. We now examine other potential explanatory factors that could change over time, have differential effects for men and women at each time, and might have a change in effect over time. This will allow us to determine whether these might account for changes over time observed in measured hypertension and high total cholesterol. Table 3 shows the prevalence of the risk factors in 1990, 2000 and 2010 for men and women, and Supplemental Table 4 shows how the logistic regression results relating the factors to high systolic blood pressure and high total cholesterol at each time.

Obesity increased for men from 1990 to 2010 from 23.72 to 33.19%; women had the highest level of obesity in 2000 (35.65%). Obesity for women was lower and similar to men's in 2010 (32.95%). Smoking declined for men between 1990 and 2000 (26.93–22.71%) but not in the next 10 years. Declines in smoking over the 20 years for women were steady and slightly smaller (19.62–16.90%). The level of HbA1c indicative of diabetes increased slightly for males in the first 10 years, but then was steady; for females there was a decrease in the first 10 years. Hormone therapy use for women almost doubled from 1990 to 2000 (13.72–24.62%) and then fell sharply to 5.06% in 2010.

While there was a lot of change in these behaviors, they are not related to the likelihood of having high blood pressure or high cholesterol in most of the equations. For men none of these risks are related to having high systolic blood pressure; and only smoking is related to high cholesterol in 2000. This means they do not explain the trends for men in either high systolic blood pressure or high cholesterol. In fact, if smoking had not decreased the percent of men with high total cholesterol would have been 0.18 higher instead of 4.71% lower (Supplemental Table 5).

On the other hand, among women being obese and having a diabetes level of HbA1c were significantly related to higher risk of high systolic blood pressure in 1990, but not at the later dates; and obesity was associated with significantly increased risk of having high total cholesterol in 1990 and 2000 for women, but was associated with decreased risk in 2010. So by 2010, neither obesity nor diabetes levels of HbA1c are related to higher blood pressure or cholesterol. Smoking and use of hormone replacement therapy, were not related to the risk of high systolic blood pressure among women at any date. Smoking was only significantly related to a higher likelihood of high total cholesterol in 2000; and current female smokers were less like to have high cholesterol in 2010. If obesity and diabetes had not increased between 1990 and 2000, the decrease in the percent with high cholesterol would have been 0.77 lower than it was but the overall trend was a decrease off 11.29; so these factors do not explain the trends at all.

Discussion

This study examined the 20-year trend in cardiovascular risk factors for men and women in the US. There were differences in time trends for men and women. Overall, the improvement in cardiovascular risk was fairly steady over the two decades for men; while the improvement for women occurred in the more recent decade. For both men and women decreases in lipids were important in both periods. Men experienced reduction in risk levels of systolic and diastolic blood pressure in the early period but women experienced an increase followed by a substantial decrease in the next 10 years. If obesity and HbA1c had not increased, the improvement in cardiovascular risk would have been somewhat greater.

The levels of the summary measure biological risk as well as the individual indicators in 2010 (Supplemental

Table 3 Changes in prevalence of potential factors related to high systolic blood pressure and high cholesterol in 1990, 2000 and 2010

	Males			Females		
	1990	2000	2010	1990	2000	2010
% Obese	23.72	30.25	33.19	28.19	35.65	32.95
% High HbA1c (indicative of Diabetes)	6.43	7.95	7.43	6.62	5.77	5.70
% Currently smoking	26.93	22.71	22.84	19.62	18.10	16.90
% Hormone replacement therapy				13.73	24.62	5.06

Table 3) all indicate a growing similarity in cardiovascular risk among men and women. The substantially greater reduction in the risk of high systolic blood pressure from 2000 to 2010 among women contributed to this. Increased medication usage and more effective control were at least partly responsible for the trend of high risk blood pressure and lipid markers. While both men and women had an increase in medication usage and improvement in control, the increase in effectiveness of medication in controlling systolic blood pressure was greater for women, which appears to explain the larger improvement of women's systolic blood pressure in the recent decade. While previous studies showed lower efficacy of hypertension treatment in achieving blood pressure control for women than men in the beginning of the century [11], our results show that women have now achieved a level of efficacy comparable to that of men.

Our summary risk measure indicates that there was a countervailing trend in metabolic risk from rising levels of obesity and HbA1c. However, our results also show that over time, obesity and HbA1c are less linked to blood pressure and cholesterol among women and they were not linked to levels of blood pressure and cholesterol for men. Our results indicate that changes in the prevalence of obesity, diabetes, smoking, and hormone replacement therapy use had little effect on the overall trends in hypertension and cholesterol. While the prevalence of these factors has changed over time, sometimes differentially for men and women, they did not explain changes in cardiovascular risks. We believe our results confirm the important role of increased use and efficacy of medication in improving cardiovascular risks.

Historically, it has been thought that women's cardiovascular risk would be higher than men's after menopause because of higher blood pressure [31] and either equal or higher risk of high cholesterol due to declining estrogen levels [32]. However, our analysis found that women's cardiovascular risk status after the age at menopause is now quite similar to men's in both high blood pressure and total cholesterol as well as in the overall cardiovascular risk measure. In addition to risks for men and women after the menopausal age becoming more similar, cardiovascular risk is now more similar across age groups over age 50.

There are limitations to our study. We cannot control for changes in the level of blood pressure or cholesterol at which medication was prescribed. If these are lower in more recent years, drugs may appear more efficacious as people with lower levels are being medicated. New statin use guidelines for lowering cholesterol were released in 2013 by the American Heart Association and the American College of Cardiology with cholesterol-lowering statin use now recommended not only for those with high cholesterol, but for those with higher cardiovascular risk for other reasons resulting in an increase in use among those with lower than high total cholesterol and LDL cholesterol [33, 34]. Similarly, the recently released 2017 American College of Cardiology (ACC)/American Heart Association (AHA) guideline for high blood pressure lowers the definition of high blood pressure to 130/80 mmHg [35]. This would mean that antihypertensive drugs will be prescribed for more people with lower levels of blood pressure [36–38]. In addition, we have no information on the medications prescribed or how well people adhere to medication regimes over time and the role of any changes in these. We also were unable to consider changes in diet and physical activity in our analysis because these were not measured consistently over time in the NHANES data.

Conclusion

Recent decreases in cardiovascular risk are likely to lead to a future reduction in cardiovascular events including myocardial infarctions, strokes and mortality for both women and men. Because antihypertensives and cholesterol-lowering prescription drugs are now highly effective and their usage is widespread, further reduction in cardiovascular risk and mortality through medication usage may be increasingly difficult. The fact that current levels of obesity, smoking, and the presence of diabetes show so little relationship to blood pressure and cholesterol does not mean these factors play no role. Life time exposure to these risks may be increasing at the same time as medications may be controlling the risk. We should note that others have reported a weakening of the links between obesity and mortality as we have seen a weakening of the links to cardiovascular risk [39]. There may still be potential improvement in cardiovascular risk status from behavior change including healthier diets leading to reduction in obesity, increased physical exercise, and reductions in smoking [40].

While we predict a future reduction of cardiovascular mortality due to reduced cardiovascular risks for both genders, particularly for women, there are other changes in cardiovascular health that may counteract this trend. For example, the prevalence and incidence of atrial fibrillation (AF), which is linked to increased cardiovascular mortality, have been increasing over the past several decades and are projected to continue to increase in the foreseeable future [33, 34]. We were not able to examine the links between AF and other risk factors.

In addition, trends in mortality have not been positive in recent years. The first consecutive 2-year decline in US life expectancy since 1993 occurred in 2015 and 2016. Life expectancy dropped for both genders (from 76.5 in 2014 to 76.1 in 2016 for males, from 81.3 in 2014 to 81.1 in 2016 for females) [35, 41]. On the other hand, life expectancy at

65 was either stagnant for males (18.0 years in 2015 and 2016) or improved a small amount for women (from 20.5 in 2015 to 20.6 in 2016). Women's life expectancy decline was driven by increases in mortality due to cardiovascular conditions while that of men was more affected by opioid overdose and homicide [42]. The relative worsening of cardiovascular risk for women from 1990 to 2000, might have been a cause of the worsening relative life expectancy among women compared to men in the subsequent years.

How cardiovascular risk factors and the increasing prevalence of AF and obesity will relate to future cardiovascular events and mortality is an important research agenda. It is possible that the links between risk factors and mortality and cardiac events are also changing over time. In addition, cardiovascular risk, AF, and diabetes are related to higher likelihood of cognitive decline or dementia [43, 44]. Changes in these risks may relate to dementia trends. For instance, decreased cardiovascular risk in the 2000 to 2010 decade was accompanied by a decrease in dementia prevalence [45].

Reduction in cardiovascular risk, and similarity of risk for men and women may result in some continuing narrowing of the gender life expectancy gap, as projected by a recent study [46]. Further research on the links between cardiovascular risk and cardiac outcomes and mortality and how these differ by age and sex is needed to understand the implications of these trends.

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Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

Statement of human and animal rights This article does not contain any results where the authors were in contact with human or animal participants.

Informed consent This study is based on existing public data. Informed consent was obtained by the original collector of the data.

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