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ORIGINAL ARTICLE | CARDIOVASCULAR MORTALITY

Marked Disparities in Cardiovascular Disease Mortality by Levels of Happiness and Life Satisfaction in the United States

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ABSTRACT

Background: The impact of happiness and life satisfaction on cardiovascular disease (CVD) mortality is not well-studied. Using a longitudinal dataset, we examined the association between levels of happiness/life satisfaction and CVD mortality in the United States.

Methods: We analyzed the 2001 National Health Interview Survey (NHIS) prospectively linked to 2001-2014 mortality records in the National Death Index (NDI) (N=30,933). Cox proportional hazards regression was used to model survival time as a function of happiness, life satisfaction, and sociodemographic and behavioral characteristics.

Results: In Cox models with 14 years of mortality follow-up, CVD mortality risk was 59% higher (hazard ratio [HR]=1.59; 95% CI=1.26,2.02) in adults with little or no happiness, controlling for age, and 30% higher (HR=1.30; 95% CI=1.01,1.67) in adults with little/no happiness, controlling for sociodemographic, behavioral and health characteristics, when compared with adults reporting happiness most or all of the time. Mortality risk was 81% higher (HR=1.81; 95% CI=1.40,2.34) in adults who were very dissatisfied with their life, controlling for age, and 39% higher (HR=1.39; 95% CI=1.05,1.82) in adults who were very dissatisfied, controlling for all covariates, when compared with adults who were very satisfied.

Conclusions and Implications for Translation: Adults with lower happiness and life satisfaction levels had significantly higher CVD mortality risks than those with higher happiness and life satisfaction levels. Subjective well-being is an important determinant of CVD mortality.

Key words: • Happiness • Life satisfaction • Cardiovascular • Mortality • Longitudinal • Social determinants

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1. Introduction

Despite being one of the richest nations in the world, the United States ranks lower than many

European countries in happiness and life satisfaction, two important indicators of subjective well-being.^{1,2} Happiness and life satisfaction have long been shown

as protective factors for physical health, morbidity, and mortality.²⁻⁸ Despite the well-established morbidity studies, studies examining the association between subjective well-being and cardiovascular disease (CVD) mortality, particularly for the US, are limited and have reported inconsistent findings.⁴ To contribute further to this growing field of research on happiness and health, we examined the association between happiness/life satisfaction and CVD mortality in the US by using longitudinal cohort data and by considering a wide range of sociodemographic, behavioral, and health risk factors.

2. Methods

The data source for this study was the 2001 National Health Interview Survey (NHIS) prospectively linked to the death certificate data from the National Death Index (NDI).⁹ As a nationally representative, cross-sectional household interview survey, NHIS provides socio-economic, demographic, and health characteristics of the US civilian, non-institutionalized population. We used the public-use linked NHIS-NDI mortality file, developed by the National Center for Health Statistics, that includes mortality follow-up from the date of survey participation in 2001 through December 31, 2014.¹⁰

The study sample consisted of 31,376 adults aged ≥ 18 years in the 2001 NHIS. The portion of the sample ineligible for mortality follow-up was eliminated from the analysis. More specifically, approximately 1.41% of the sample had missing data on happiness and life satisfaction, and, as such, were excluded from the analysis. The final eligible sample size was 30,933. All the study covariates except poverty status had less than 1.8% of missing cases. About 21.7% of the cases had missing data on poverty status for which we included a covariate category in the analysis to avoid the loss of a large number of observations.

Our outcome of interest was mortality from CVD (ICD-10 codes: I00-I09, I11, I13, I20-I51, I60-I69), which included deaths from heart disease and stroke. Follow-up time for the deceased was defined by the number of months from the month/year of interview to the month/year of death. Since

NHIS-NDI provides only the quarter of death, we assumed that death occurred in the middle of the quarter, February, May, August, or November.

The independent variables were happiness and life satisfaction. The level of happiness was measured by responses to the question, "During the past 30 days, how often did you feel happy?" Happiness was categorized by none or a little of the time, some of the time, and most or all of the time. Life satisfaction was measured by responses to the question, "In general, how satisfied are you with your life?" Life satisfaction was categorized by very dissatisfied or dissatisfied, satisfied, and very satisfied.

Based on the previous literature, we selected the following covariates for modeling: age, gender, race/ethnicity, nativity/immigrant status, marital status, social support, education, poverty status, homeownership, region, activity limitation, body mass index (BMI), smoking status, alcohol consumption, and hypertension.^{2,3}

We computed age-adjusted mortality rates per 100,000 person-years of exposure by happiness and life satisfaction levels.¹¹ Cox proportional hazards regression models were used to derive relative risks of mortality, controlling for individual characteristics.¹¹ Individuals surviving beyond the follow-up period and those dying from other causes were treated as right-censored observations. All analyses were conducted by Stata 15, accounting for complex survey design effects.¹²

3. Results

Approximately 4.5% of the sample responded that they felt happy none or a little of the time during the past 30 days. About 5.9% of the sample responded that they were very dissatisfied or dissatisfied with their life in general. Compared with men, women reported lower levels of happiness and life satisfaction (Table 1).

Adults with lower levels of happiness and life satisfaction had higher age-adjusted CVD mortality rates (Figure 1). The CVD mortality rate for adults with "none or a little of the time" happiness was 386.1 deaths per 100,000 person-years, 40% higher than the mortality rate of 275.5 for adults with "most or all of the time" happiness. The CVD mortality rate

for adults who were very dissatisfied or dissatisfied with their life was 48% higher than the rate for those who were very satisfied.

In Cox regression models, the age-adjusted CVD mortality risk was 59% higher (hazard ratio [HR]=1.59; 95% CI=1.26,2.02) in adults with “none or a little of the time” happiness, compared with adult with “most or all of the time” happiness (Table 1, Model 1). After controlling for socioeconomic and demographic covariates, the mortality risk was 39% higher (HR=1.39; 95% CI=1.09,1.78) in adults with “none or a little of the time” happiness, compared with adults with “most or all of the time” happiness (Table 1, Model 2). After controlling for all covariates, the mortality risk was 30% higher (HR=1.30; 95% CI=1.01,1.67) in adults with “none or a little of the time” happiness, compared to those with “most or all of the time” happiness (Table 1, Model 3).

In Cox regression models, the age-adjusted CVD mortality risk was 81% higher (HR=1.81; 95% CI=1.40,2.34) among adults who were very dissatisfied or dissatisfied with their life, compared with adults who

were very satisfied (Table 1, Model 1). After controlling for socioeconomic and demographic covariates, the CVD mortality risk was 46% higher (HR=1.46; 95% CI=1.14,1.88) in adults who were very dissatisfied or dissatisfied, compared with adults who were very satisfied (Table 1, Model 2). After controlling for all covariates, the CVD mortality risk was 39% higher (HR=1.39; 95% CI=1.05,1.82) in adults who were very dissatisfied or dissatisfied with their life, compared with adults who were very satisfied (Table 1, Model 3). The association between happiness/life satisfaction and fully-adjusted CVD mortality risks was stronger for women than for men (Table 1).

We tested the issue of reverse causality by comparing the analysis between the sample with and without baseline history of heart disease or stroke diagnoses. We found in the fully-adjusted model no substantial association between happiness and CVD mortality for both respondents with and without heart disease or stroke, while the association between life satisfaction and CVD mortality was statistically significant only among those with a history of heart disease or stroke diagnosis (Table 2). We conducted

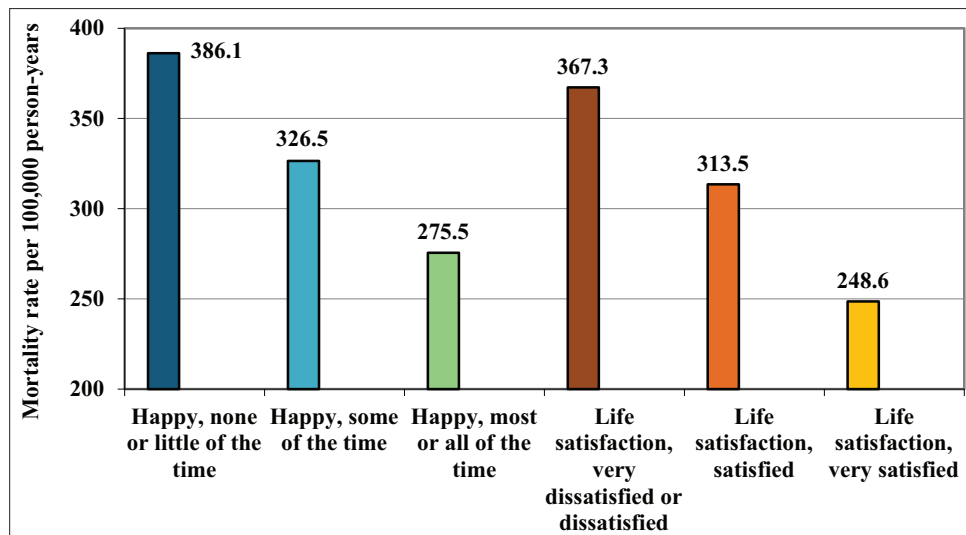


Figure 1: Age-adjusted Cardiovascular Disease (CVD) Mortality Rates per 100,000 Person-Years by Levels of Happiness and Life Satisfaction, United States, 2001-2014

Source: Data derived from the 2001-2014 NHIS-NDI Record Linkage Study. The mortality rate ratio between low and high happiness levels, none/little of the time and most/all of the time was RR = 1.40; 95% CI = 1.09,1.71; p<0.01. The mortality rate ratio between low and high life satisfaction levels, was RR = 1.48; 95% CI = 1.15,1.81; p<0.01

Table 1. Age-adjusted and covariate-adjusted hazard ratios (HRs) for Cardiovascular disease (CVD) mortality among adults aged ≥18 years, United States, 2001-2014

	Sample size	Cox model HR (95% CI)		
	Observations (weighted %)	Age-adjusted Model 1 ¹	SES-adjusted Model 2 ²	Fully-adjusted Model 3 ³
Both sexes combined				
CVD deaths	1,218			
Happiness	30,933		30,933	
None / a little of the time	1,575 (4.46)	1.59*** (1.26,2.02)	1.39*** (1.09,1.78)	1.30** (1.01,1.67)
Some of the time	5,603 (16.88)	1.33*** (1.15,1.54)	1.25*** (1.07,1.45)	1.20** (1.03,1.41)
Most or all of the time	23,755 (78.65)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Life satisfaction ⁵	30,928		30,928	
Very dissatisfied or dissatisfied	2,109 (5.92)	1.81*** (1.40,2.34)	1.46*** (1.14,1.88)	1.39** (1.05,1.82)
Satisfied	16,115 (50.20)	1.34*** (1.17,1.54)	1.23*** (1.06,1.41)	1.22** (1.04,1.42)
Very satisfied	12,704 (43.88)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Male				
Happiness	13,463		13,463	
None / a little of the time	649 (4.21)	1.43* (0.99,2.05)	1.17 (0.80,1.69)	1.12 (0.75,1.67)
Some of the time	2,352 (16.36)	1.47*** (1.17,1.85)	1.31** (1.04,1.65)	1.30*** (1.02,1.66)
Most or all of the time	10,462 (79.43)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Life satisfaction	13,462		13,462	
Very dissatisfied or dissatisfied	868 (5.64)	1.96*** (1.42,2.7)	1.40** (1.01,1.94)	1.32 (0.92,1.90)
Satisfied	6,959 (49.98)	1.33*** (1.11,1.59)	1.16 (0.95,1.41)	1.13 (0.92,1.40)
Very satisfied	5,635 (44.38)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Female				
Happiness	17,470		17,470	
None / a little of the time	926 (4.69)	1.81*** (1.31,2.50)	1.60*** (1.15,2.22)	1.46** (1.04,2.06)
Some of the time	3,251 (17.37)	1.26** (1,1.58)	1.15 (0.91,1.44)	1.10 (0.86,1.39)
Most or all of the time	13,293 (77.94)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Life satisfaction	17,466		17,466	
Very dissatisfied or dissatisfied	1,241 (6.17)	1.83*** (1.24,2.71)	1.52** (1.04,2.23)	1.47* (0.97,2.23)
Satisfied	9,156 (50.41)	1.44*** (1.17,1.76)	1.29** (1.06,1.58)	1.31** (1.06,1.63)
Very satisfied	7,069 (43.42)	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)

Data derived from the 2001-2014 NHIS-NDI record linkage study. CI=confidence interval. ¹Cox proportional hazards models were adjusted for age. ²Cox models were adjusted for age, gender, race/ethnicity, nativity/immigrant status, marital status, education, poverty status, housing tenure, and region of residence. ³Cox models were adjusted for all variables in model 2 plus social support, activity limitation, bmi, smoking status, alcohol consumption, and hypertension. ⁴Hazard ratios were statistically significantly different from 1. ***P<0.01; **P<0.05; *P<0.10. ⁵Cox models for life satisfaction and for other covariates were separately estimated but coefficients of life satisfaction are being reported in the same table

sensitivity analyses to evaluate temporal robustness of happiness/life satisfaction by re-estimating models using 2-year, 5-year, and 10-year follow-up times. The longer follow-up dilutes the mortality impact of baseline happiness and life satisfaction, as they are expected to differ from their baseline levels over the longer follow-up (Table 3).

4. Discussion

In this large prospective study of 30,933 US adults using a long mortality follow-up of 14 years, we found that adults with lower levels of happiness and life satisfaction had substantially higher CVD mortality risks. Even after controlling for several

Table 2. Age-adjusted and covariate-adjusted hazard ratios (HRs) for cardiovascular disease (CVD) mortality among adults aged ≥ 18 years with and without a history of heart disease or stroke diagnosis at baseline, 2001-2014

	Age-adjusted model	SES-adjusted model	Fully-adjusted model
Adults without the heart disease or stroke diagnosis at baseline			
Happiness	26,994	26,994	26,994
None / a little of the time	1.50** (1.07,2.1)	1.27 (0.89,1.81)	1.21 (0.87,1.71)
Some of the time	1.26** (1.03,1.54)	1.18 (0.96,1.44)	1.14 (0.91,1.42)
Most or all of the time	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Life satisfaction	27,003	27,003	27,003
Very dissatisfied or dissatisfied	1.65*** (1.15,2.36)	1.29 (0.9,1.83)	1.2 (0.82,1.75)
Satisfied	1.26** (1.05,1.51)	1.13 (0.94,1.36)	1.09 (0.89,1.34)
Very satisfied	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Adults with history of heart disease or stroke diagnosis at baseline			
Happiness	3,939	3,939	3,939
None / a little of the time	1.43** (1.01,2.03)	1.30 (0.92,1.85)	1.28 (0.88,1.86)
Some of the time	1.26** (1.01,1.57)	1.19 (0.95,1.49)	1.21 (0.95,1.53)
Most or all of the time	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Life satisfaction	3,925	3,925	3,925
Very dissatisfied or dissatisfied	1.61** (1.12,2.31)	1.40* (0.96,2.04)	1.44* (0.96,2.16)
Satisfied	1.35*** (1.1,1.66)	1.25** (1,1.56)	1.28** (1.02,1.6)
Very satisfied	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)

Source: Data derived from the 2001-2014 NHIS-NDI Record Linkage Study. ¹Coronary heart disease, congenital heart disease, heart attack, and any other heart condition/disease. ***p<0.01; **p<0.05; *p<0.10

sociodemographic, health status, and behavioral characteristics, significantly higher risks of CVD mortality existed for the total population who did not experience happiness or were dissatisfied, compared with those who reported happiness most or all of the time or those who were very satisfied with their lives. Our study contributes to the empirical literature that shows happiness and life satisfaction are inversely related to CVD mortality.

The findings of our study are consistent with those from previous studies.^{2,4-8} For example, Martin-Maria and colleagues found that the pooled HR for the effect of subjective well-being including happiness and life satisfaction on coronary heart disease or CVD mortality ranged from 0.60 to 1.04; in their meta-analysis, only 10 studies estimated CVD-related mortality risks among 90 studies.⁴ Although these studies used job satisfaction, level of emotional vitality, life enjoyment as measures of subjective well-being, they found an association between subjective

well-being and CVD mortality.⁶⁻⁸ Furthermore, in our full model with controls for sociodemographic characteristics, health status, and behavioral risk factors of smoking, alcohol consumption, obesity, and hypertension, the adjusted risk of all-CVD mortality associated with dissatisfaction was 1.39, compared with 1.61 with low level of life enjoyment in Shirai study with similar covariates.⁸

Our study has provided evidence of a substantial link between happiness/life satisfaction and CVD mortality, but does not shed light on behavioral or biological mechanisms through which happiness/life satisfaction might affect CVD mortality. One potential mechanism is that individuals with greater happiness/life satisfaction levels have healthier lifestyles, including greater physical activity, higher consumption of fruits and vegetables, less drinking or smoking, and more preventive care, resulting in reduced morbidity and mortality risks.² The other mechanisms might involve biological processes of happiness relevant to health such as biomarker

Table 3. Age-adjusted and covariate-adjusted hazard ratios (HRs) for cardiovascular disease (CVD) mortality by different follow-up times among us adults aged ≥ 18 years, 2001-2014

	Age-adjusted model	SES-adjusted model	Fully-adjusted model
2-Year mortality follow-up			
Happiness			
None / a little of the time	1.65 (0.93,2.94) [†]	1.44 (0.82,2.52)	1.56 (0.87,2.79)
Some of the time	1.35 (0.94,1.94)	1.27 (0.89,1.82)	1.32 (0.92,1.89)
Most or all of the time	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Life satisfaction			
Very dissatisfied or dissatisfied	1.12 (0.61,2.06)	0.91 (0.52,1.59)	0.99 (0.53,1.83)
Satisfied	1.29 (0.93,1.8)	1.21 (0.85,1.72)	1.28 (0.9,1.82)
Very satisfied	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
5-Year mortality follow-up			
Happiness			
None / a little of the time	2.15 ^{***} (1.52,3.06)	1.88 ^{***} (1.32,2.69)	1.78 ^{***} (1.25,2.54)
Some of the time	1.42 ^{**} (1.13,1.78)	1.33 ^{**} (1.06,1.67)	1.27 ^{**} (1,1.6)
Most or all of the time	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Life satisfaction			
Very dissatisfied or dissatisfied	2.03 ^{***} (1.4,2.93)	1.62 ^{**} (1.11,2.35)	1.55 ^{**} (1.04,2.31)
Satisfied	1.56 ^{***} (1.24,1.95)	1.42 ^{***} (1.12,1.8)	1.42 ^{***} (1.12,1.8)
Very satisfied	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
10-Year mortality follow-up			
Happiness			
None / a little of the time	1.72 ^{***} (1.3,2.27)	1.47 ^{**} (1.1,1.97)	1.39 ^{**} (1.03,1.86)
Some of the time	1.37 ^{***} (1.16,1.61)	1.28 ^{***} (1.07,1.51)	1.22 ^{**} (1.02,1.46)
Most or all of the time	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)
Life satisfaction			
Very dissatisfied or dissatisfied	2.04 ^{***} (1.56,2.69)	1.66 ^{***} (1.26,2.18)	1.60 ^{***} (1.19,2.14)
Satisfied	1.50 ^{***} (1.28,1.75)	1.37 ^{***} (1.16,1.62)	1.37 ^{***} (1.16,1.62)
Very satisfied	1.00 (Reference)	1.00 (Reference)	1.00 (Reference)

Data derived from the 2001-2014 NHIS-NDI Record Linkage Study. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$.

neuroendocrine, inflammation, cardiovascular disease, metabolic, or allostatic load.² There are a wide range of risk factors for happiness/life satisfaction, such as personality, genetics, stress exposure, social support or network, race/ethnicity, socioeconomic status, marital status, physical activity, and health status.² In our analysis, we controlled for several of these factors, which are associated with both happiness/life satisfaction and CVD mortality in an expected manner.^{2,3} Further research is needed to examine differential associations between happiness or life satisfaction and CVD mortality by these factors or pathways.

4.1. Limitations

This study has several limitations. First, residual confounding and reverse causality might have affected our study findings. While we controlled for baseline self-reported health status, activity limitation, BMI, smoking, and hypertension, there could have been other potential confounders such as neighborhood environments or periods of economic downturn. Chronic poor health itself may be a determinant of self-reported happiness and life satisfaction at the survey time. Although we controlled for several baseline health factors, the issue of reverse causation cannot be fully addressed. Second, our measures of

happiness and life satisfaction might not capture all aspects of subjective well-being, including optimism, realization of personal potential and fulfillment of life goals or specific measures of happiness in different domains such as marriage/family, jobs, and finances. Third, because the NHIS excludes the institutionalized population, who may have lower happiness/life satisfaction and higher mortality levels, CVD mortality risks associated with happiness/life satisfaction might have been underestimated. Fourth, all covariates in the NHIS-NDI database were time-fixed at the baseline as of the survey date. Several covariates such as socioeconomic status, health status, health-risk behaviors, and happiness/life satisfaction could have varied over the 14-year follow-up, which would have influenced their estimated impacts on CVD mortality. Further studies are needed to evaluate the temporal robustness of happiness/life satisfaction patterns in CVD mortality using time-varying covariates.

5. Conclusions and Implications for Translation

With 14 years of mortality follow-up in a large, nationally representative study of 30,933 US adults aged ≥ 18 years, we found that people with low levels of happiness and life satisfaction had, respectively, 59% and 81% higher age-adjusted risks of CVD mortality compared to those with high levels of happiness and life satisfaction. The association between happiness/life satisfaction and CVD mortality remained marked and statistically significant even after controlling for several sociodemographic, behavioral, and health characteristics. Our study findings indicate happiness/life satisfaction to be an important predictor of CVD mortality; they underscore the significance of enhancing subjective well-being in the general population as a potential strategy for reducing CVD mortality. Social determinants such as education, income, work status, job security, housing conditions, social support, social environment, and access to green spaces and quality health care are key to enhancing happiness and life satisfaction. Policies addressing these social determinants will not only promote happiness and well-being among people and but may also lead to reductions in CVD mortality.

Compliance with Ethical Standards

Conflict of Interest: The author declare no conflict of interest. **Funding source:** Dr. Hyunjung Lee was supported in part by an appointment to the Research Participation Program at the Health Resources & Services Administration - Office of Planning, Analysis and Evaluation (HRSA-OPAE) and Office of Health Equity (OHE), administered by the Oak Ridge Institute for Science and Education (ORISE) through an interagency agreement between the US Department of Energy and HRSA. **Disclaimer:** The views expressed in this publication are solely the opinions of the authors and do not necessarily reflect the official policies of US Department of Health and Human Services, Health Resources and Services Administration, nor does mention of the department or agency names imply endorsement by the US Government. **Financial Disclosure:** The authors have no financial relationships relevant to this article to disclose. **Ethical approval:** The study was deemed exempt from Institutional Review Board approval as it utilized a de-identified public use dataset. **Acknowledgment:** None.

Key Messages

- Using a national longitudinal dataset with 14-years of mortality follow-up of 30,933 US adults, this study estimated the effects of various levels of happiness and life satisfaction on CVD mortality.
- People with low levels of happiness and life satisfaction had, respectively, 59% and 81% higher age-adjusted risk of CVD mortality compared with those reporting high levels of happiness and life satisfaction.
- The impact of happiness and life satisfaction on CVD mortality was greater for women than for men.
- Social determinants such as race/ethnicity, education, income, employment status, marital status, immigrant status, social support, activity limitation, and health-risk factors of smoking, obesity, alcohol consumption, and hypertension largely accounted for the excess CVD mortality associated with low levels of happiness and life satisfaction. However, the association between happiness/life satisfaction and CVD mortality remained marked and statistically significant even after controlling for these factors.
- Happiness and life satisfaction are important predictors of CVD mortality. Policies aimed at promoting happiness and well-being among people by addressing social determinants may lead to reductions in CVD mortality.

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