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Research Article

NIH-AARP: Association of Caregiving with Lifestyle Cardiovascular Disease Risk Factors

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Abstract

Objectives: Adult caregiving has been associated with adverse effects on cardiovascular risk factors and health outcomes, with most research focused on caregivers of individuals with dementia and single risk factors. We sought to explore the association of adult and child caregiving, across a spectrum of intensity, with multiple lifestyle risk factors. **Methods:** We evaluated the association of caregiving with behavioural and metabolic cardiovascular risk factors, using unconditional logistic regression analyses in the NIH-AARP Diet and Health Study. **Results:** While the overall association of self-reported caregiving with cardiovascular risk factors suggested a mostly positive relationship with healthy lifestyle traits (other than sleep duration), our findings also revealed that higher duration caregiving of adults (≥7 hours per week) was associated with an increased frequency of unhealthy behaviours, including diet, and smoking. **Discussion:** Our findings suggest that the association of caregiving and behavioural cardiovascular risk factors differ by type and intensity of caregiving.

Keywords: Caregiving; Cohort studies; Lifestyle risk factors; Cardiovascular disease

Introduction

Caregivers are individuals who provide regular assistance with personal and instrumental activities of daily living (ADLs) to those with functional or cognitive impairment [1]. Previous observational studies have suggested that women caregiving for grandchildren and unwell spouses are at higher risk of coronary heart disease (CHD) compared to non-caregivers [2,3], which may be mediated by an increased prevalence of cardiovascular risk factors, or lower frequency of screening and management of risk factors such as hypertension [4]. There are reasons to suspect that caregiving may adversely affect lifestyle risk factors, whereby individuals may be at higher risk of sleep disruption and stress and may be less likely to have opportunities for regular physical activity or healthy dietary choices. Higher caregiver strain is associated with increased risk of mortality [5-7], so identifying modifiable risk factors within high intensity long-term caregivers is an important priority to consider in the overall wellbeing of households impacted by dementia.

The association of caregiving with cardiovascular risk factors has been evaluated in a number of studies of caregivers for individuals with dementia. A recent systematic review reported lower levels of physical activity and social support among caregivers [8]. Other studies have reported an association between caregiving and hypertension, poor dietary quality, sleep impairment, smoking and physical inactivity [9-12]. A key limitation of those studies is the relatively small sample sizes included, meaning that studies were underpowered to detect associations for many risk factors. These

studies also included specific caregiver populations (usually high burden caregivers) rather than a population across the spectrum of caregiving type and intensity. In addition, most studies have not evaluated multiple risk factors simultaneously, although studies have reported a higher mean Framingham score in caregivers of individuals with dementia, compared to non-caregivers [13] supporting an overall increased frequency of risk factors, but does not lend insights into the specific burden of individual risk factors, which may be the more relevant interventional targets.

In this study, we evaluated the association of caregiving with prevalence of cardiovascular risk factors, with a particular focus on lifestyle risk factors including diet, physical activity, and sleep. As a large prospective cohort study, the National Institutes of Health American Association of Retired Persons (NIH-AARP) Diet and Health Study provides a unique opportunity to explore lifestyle risk factors and their association with caregiving to further identify new hypotheses for future research targeting caregiver health outcomes.

Methods

Study Population

This study-analyzed data from NIH-AARP [14], a prospective study, established primarily to understand the association between diet and cancer. Questionnaires were mailed to current members of the AARP aged 50-69 years, and who resided in one of six states (California, Florida, Pennsylvania, New Jersey, North Carolina, and Louisiana) or in two metropolitan areas (Atlanta, Georgia and Detroit, Michigan).

The NIH-AARP had three phases of data collection; a baseline questionnaire sent in 1995-1996 (Phase I; completed satisfactorily by 566,398 respondents), a supplementary survey sent in 1996 (Phase II) and a final questionnaire sent to all living participants in 2004 (Phase III). The Special Studies Institutional Review Board of the U.S. National Cancer Institute approved the original study; no ethical approval was required for these analyses. A data sharing agreement was signed between the National Institutes of Health and National University of Ireland Galway (NUI Galway).

Assessment of caregiving

Caregiving of adults and children was captured at Phase III data collection and represents the inception cohort for the current analyses. Records were excluded if there was no information on caregiving of adults and/or children. After exclusions, 288,267 participants were included in this analysis.

Caregiving of adults was determined using a question in the Phase III questionnaire asking, "During the past 12 months, approximately how much time per week did you participate in caring for another adult (for example, lifting, pushing a wheelchair, etc.)". Caregiving of children was determined using a question in the follow up questionnaire asking, "During the past 12 months, approximately how much time per week did you participate in caring for children (for example, pushing a stroller, playing, lifting, etc.)." Each participant selected average total time per week spent caregiving adults and children separately. Respondents were grouped into non-caregivers, caregivers of adults and caregivers of children.

Cardiovascular Risk Factor Assessment

Along with caregiving status (self-reported), Phase III of data collection recorded information on smoking status, age, Body Mass Index (BMI), hours in a twenty-four-hour period spent sleeping at night or napping, and most up to date background medical history including previous history of cardiovascular disease (CVD), diabetes, hypertension, chronic obstructive pulmonary disease (COPD) and end stage kidney disease (ESKD). Phase III also measured if the participant had trouble with ADLs in the past year due to physical or emotional ill health. Previous history of CVD was defined as a participant ever receiving a diagnosis of myocardial infarction, angina, or coronary disease. Physical activity was reported using the variable vigorous physical activity. Vigorous physical activity comprised of the sum of the following individual activities; jogging, tennis, swimming, cycling and aerobic exercise measured in hours per week. Participants could select from the following categories; none, 5 minutes, 15 minutes, 30 minutes, 1 hour, 1.5 hours, 2-3 hours, 4-6 hours, 7-10 hours and greater than 10 hours. The World Health Organization (WHO) and Physical Activity Guidelines for Americans recommend 75 minutes to 150 minutes a week of vigorous-intensity aerobic physical activity for adults [15]. For the purpose of this analysis, physical activity was divided into two categories: less 75 minutes per week and greater than or equal to 75 minutes per week.

Sleep was reported as time spent per day over past 12 months sleeping at night or napping during the day. Participants could select from the following categories; None, less than 3 hours, 3-4 hours, 5-6 hours, 7-8 hours, 9-10 hours, 11-12 hours and more than 12 hours. BMI was calculated using height reported in Phase I data collection and the weight specified on Phase III of data collection using the formula weight in kilograms divided by height in meters squared. The smoking variable considered all questions asked about smoking during Phase III of data collection and categorised participants as never smoked, former smoker and current smoker

Demographics and baseline frequency of risk factors including sex, race, marital status, educational status and alcohol use and diet were measured at Phase I of data collection. Alcohol use was reported as current use of alcohol in the past year, with respondents answering yes or no. A summary estimate of diet quality was reported using the Healthy Eating Index (HEI) score. The HEI score is a measure of adherence to federal diet recommendations, and the score in this study aligns with the 2010 Dietary guidelines for Americans [16].

This score comprises of 12 components for a total of 100 points. Six components score up to five points (dark green vegetables, fruit, seafood and total protein and plant protein foods); 5 components score up to ten points (whole and refined grains, low-fat dairy, fatty acids and sodium) and 1 component can

score up to twenty points (energy from solid fats, added sugars, and any alcohol in excess of 13 g/1000 kcal). An ideal overall HEI score of 100 reflects that the set of foods aligns with key dietary recommendations where a higher score reflects a healthier diet. For the purpose of this analysis, HEI score was divided into two categories; HEI score less than 50 (poor diet) or HEI score greater than or equal to 50 (good diet), but we also explored it as a continuous variable.

Statistical Analyses

Descriptive statistics were used to present baseline demographics and risk factors for caregivers of adults, caregivers of children and non-caregivers. Continuous variables were reported as mean (SD) and compared using linear model Analysis of variance (ANOVA). Categorical variables were reported in proportions and compared using Pearson's Chi-squared test. Unconditional logistic regression analyses were performed to determine the univariate and multivariable association of caregiving with cardiovascular risk factors, generating individual models for each cardiovascular risk factor, including physical activity, smoking, alcohol use, diet and history of hypertension, diabetes, or CVD. For sleep and BMI, where a J-shaped association has been reported with cardiovascular risk, we used multinomial logistic regression to determine the association with caregiving.

In each of these models, we estimated the odds ratios (OR) and 95% confidence intervals (95% CI). The fully adjusted model (aOR) adjusted for the following continuous variables; age, vigorous physical activity, diet (HEI score) and body mass index (BMI) and the following categorical variables; race (non-Hispanic white [reference], African American, Hispanic, Asian), sex, smoking (never/former [reference] or current smoker), current alcohol use (within last 12 months), average hours of sleep (≤6 hrs, 7-8 hrs [reference] or ≥9 hours), and self-reported history of diabetes, hypertension, prior history of CVD, COPD and ESKD.

We completed subgroup analyses by age (< 65 years or ≥65 years), sex, formal education level achieved (educated 0-12 years; those educated between 12 years of age and completing high school; those educated post high school, to college or postgraduate level), ethnicity (Non-Hispanic white, African American, Hispanic, Asian), among those with and without trouble with ADLs, participants self-reporting history of CVD and stroke and those with no reported history of CVD or stroke. The Wald test was used to test for interaction. All statistical analysis was performed using R version 3.6.3.

Results

The total cohort (n=288,267) had a mean age of 70.0 (5.4) years, 41.5% (n=119,659) were female, 70% (n=201,913) were married and 92.6% (n=267,040) were non-Hispanic white. Further details of the characteristics of the study population are outlined in Table 1.

	Caregiver of Adults (N=35262)	Caregiver of children (N=52063)	Non-caregiver (N=200942)	Total (N=288267)	P value
Age					< 0.001
Mean (SD)	69.6 (5.5)	68.6 (5.1)	70.5 (5.3)	70.0 (5.4)	
Sex					< 0.001
Female	15564 (44.1%)	23884 (45.9%)	80211 (39.9%)	119659 (41.5%)	
Marital Status					< 0.001
Married	25222 (71.5%)	38458 (73.9%)	138233 (68.8%)	201913 (70.0%)	
Widowed	2998 (8.5%)	5278 (10.1%)	20894 (10.4%)	29170 (10.1%)	
Separated/Divorced	4870 (13.8%)	7303 (14.0%)	28876 (14.4%)	41059 (14.3%)	
Never Married	1942 (5.5%)	730 (1.4%)	11708 (5.8%)	14380 (5.0%)	
Race					< 0.001
Non-Hispanic White	32401 (91.9%)	47936 (92.1%)	186703 (92.9%)	267040 (92.6%)	
Black	1433 (4.1%)	1771 (3.4%)	6218 (3.1%)	9422 (3.3%)	
Hispanic	560 (1.6%)	895 (1.7%)	3144 (1.6%)	4599 (1.6%)	
Asian	481 (1.4%)	947 (1.8%)	2845 (1.4%)	4273 (1.5%)	
Educational Status					< 0.001
Less than 8 years	1344 (3.8%)	1857 (3.6%)	8930 (4.4%)	12131 (4.2%)	

8-11 years	5787 (16.4%)	9016 (17.3%)	35488 (17.7%)	50291 (17.4%)	
12 years or completed high school	3713 (10.5%)	4800 (9.2%)	18648 (9.3%)	27161 (9.4%)	
Post-high school, College and postgraduate	23574 (66.9%)	35313 (67.8%)	133294 (66.4%)	192181 (66.7%)	
Smoking Status					< 0.001
Never	13839 (39.2%)	21203 (40.7%)	71197 (35.4%)	106239 (36.9%)	
Former	16339 (46.3%)	23743 (45.6%)	99136 (49.3%)	139218 (48.3%)	
Current	1930 (5.5%)	2725 (5.2%)	11745 (5.8%)	16400 (5.7%)	
Use of alcohol in last year					< 0.001
Yes	26824 (76.4%)	40671 (78.4%)	157510 (78.7%)	225005 (78.4%)	
BMI					< 0.001
Underweight	442 (1.4%)	578 (1.3%)	2914 (1.7%)	3934 (1.6%)	
Healthy Weight	10126 (32.8%)	14827 (33.0%)	60813 (34.7%)	85766 (34.1%)	
Overweight	12711 (41.2%)	18714 (41.6%)	71486 (40.8%)	102911 (41.0%)	
Obese	7560 (24.5%)	10842 (24.2%)	40143 (22.9%)	58545(23.4%)	
HEI 2015 Score					< 0.001
HEI <40	105 (0.3%)	201 (0.4%)	720 (0.4%)	1026 (0.4%)	
HEI 40-59	6535 (18.5%)	9844 (18.9%)	37889 (18.9%)	54268 (18.8%)	
HEI 60-79	25491 (72.3%)	37582 (72.2%)	143635 (71.5%)	206708 (71.7%)	
HEI ≥80	3131 (8.9%)	4436 (8.5%)	18698 (9.3%)	26265 (9.1%)	
Vigorous Physical activity					< 0.001
<75mins per week	18208 (51.7%)	27437 (52.7%)	116437 (58.0%)	162082 (56.2%)	
≥75 mins per week	17032 (48.3%)	24619 (47.3%)	84481 (42.0%)	126132 (43.8%)	
Sleep*					< 0.001
≤ 6 hours	9884 (30.8%)	13352 (28.5%)	51648 (28.2%)	74884 (28.6%)	
7-8 hours	18325 (57.1%)	28073 (60.0%)	106518 (58.1%)	152916 (58.4%)	
≥ 9 hours	3874 (12.1%)	5371 (11.5%)	25021 (13.7%)	34266 (13.1%)	
History of Diabetes					< 0.001
Yes	5291 (15.0%)	7648 (14.7%)	32528 (16.2%)	45467 (15.8%)	
History of CVD					< 0.001
Yes	6050 (17.2%)	8660 (16.6%)	38374 (19.1%)	53084 (18.4%)	
History of Hypertension					< 0.001
Yes	18709 (53.1%)	27293 (52.4%)	109651 (54.6%)	155653 (54.0%)	
History of COPD					< 0.001
Yes	2857 (8.1%)	3876 (7.4%)	16670 (8.3%)	23403 (8.1%)	

History of ESKD					< 0.001
Yes	122 (0.3%)	217 (0.4%)	939 (0.5%)	1278 (0.4%)	
History of Depression					< 0.001
Yes	5431 (15.4%)	6849 (13.2%)	26145 (13.0%)	38425 (13.3%)	
Trouble with ADLS					< 0.001
None/Slight amount	24293 (68.9%)	37298 (71.6%)	138213 (68.8%)	199804 (69.3%)	
Moderate amount	5601 (15.9%)	6948 (13.3%)	28813 (14.3%)	41362 (14.3%)	
Quite a bit/Enormous amount	3088 (8.8%)	4058 (7.8%)	21111 (10.5%)	28257 (9.8%)	

Data are n (%) or mean (SD). BMI= Body Mass Index; CVD= Cardiovascular disease; ADL = Activities of Daily Living, HEI: Healthy Eating Index; COPD = Chronic Obstructive Pulmonary Disease; ESKD= End Stage Kidney Disease. *Reported time spent sleeping or napping in a 24-hour period. Data were missing in 1745 for marital status; 2933 for race; 6503 for educational status; 26410 for smoking status; 1256 for alcohol use; 37111 for BMI; 53 for vigorous physical activity; 26201 for Sleep; 24302 for diabetes; 18999 for history of CVD; 12086 for hypertension; 23495 for ESKD, 24003 for COPD, 23565 for depression; 18844 for Trouble with ADLs.

Table 1: Baseline characteristics in the NIH-AARP Diet and Health study population by caregiving.

Among the total cohort, 12.2% (n=35,262) reported being a caregiver of adults, 18.1% (n=52,063) being a caregiver of children, 4.0% (n=11,595) reported being caregiver for both and 69.7% (n=200,942) were non-caregivers.

Within the caregiving population, caregivers were more likely to be female, married, black and have completed high school (p-value=<0.001). (Figure 1) illustrates the proportion of respondents within each group (caregiver of adults, caregiver of children and non-caregivers) by sex, race, marital status, and level of education.

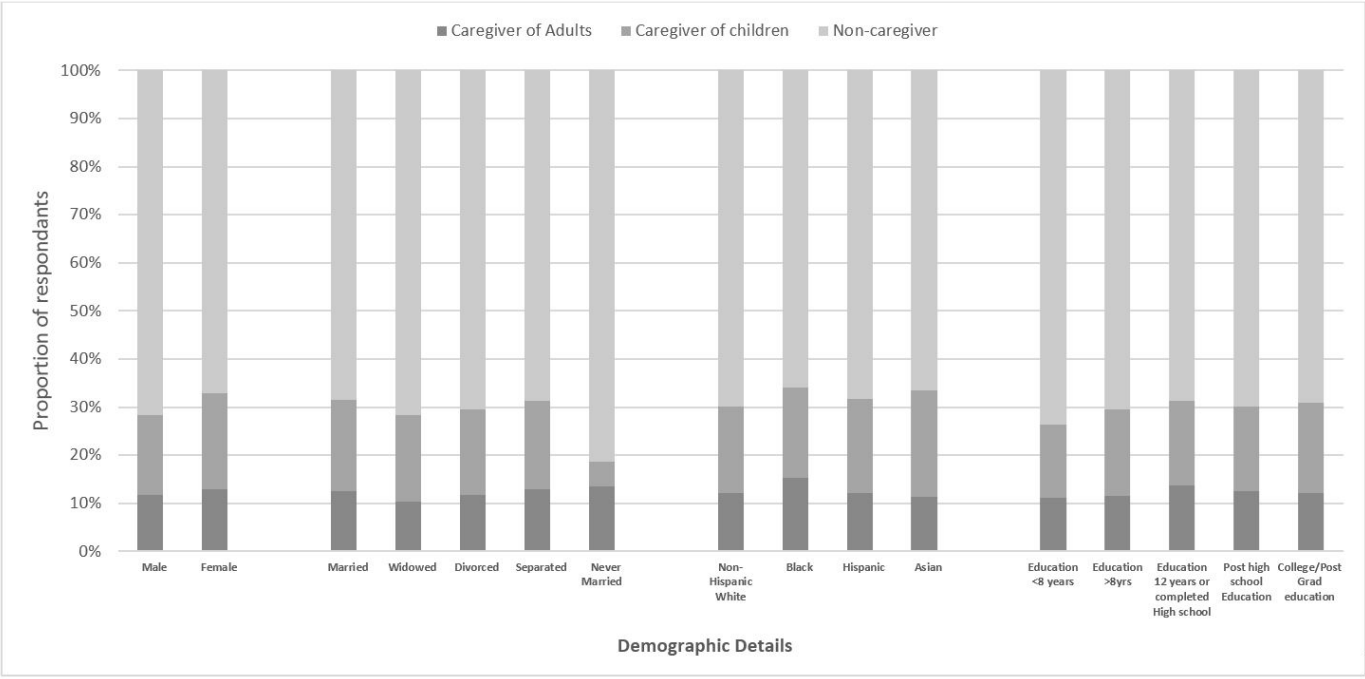

Figure 1: Breakdown of Sex, Race, Marital Status and Level of Education by Caregiving Type.

Figure 1 reports a stacked column chart of caregiving use by sex, marital status, race, and level of education. The dark grey represents use of caregiver of adults, while medium grey represents caregivers of children and the light grey represents non-caregivers. The stacked columns represent proportion of respondents in each category.

Association of Caregiving with Cardiovascular Risk Factors

Vigorous Physical Activity

On multivariable analyses, caregiving of adults (aOR 1.30; 95% CI 1.27-1.34) and of children (aOR 1.20; 95% CI 1.17-1.23) were associated with a significantly increased odds of regular vigorous physical activity, compared to no caregiving (Table 2). In the analysis by duration of caregiving, any caregiving over 30 minutes per week was association with a significantly higher odds of vigorous physical activity (Table 3), while caregiving of children for less than 30 minutes per week was associated with a significantly lower odds of participating in vigorous physical activity (aOR 0.91; 95% CI 0.87-0.95) (Table 4).

Type of Caregiving	N	Vigorous physical Activity	Poor Diet (HEI Score <50)	Sleep [c]		BMI [d]:		Current Smoker	Alcohol (Current)*	History of Diabetes	History of Hypertension	History of Cardiovascular Disease
				≤6hrs	≥9hrs	<18.5 kg/ m2	≥25 kg/m2[f]					
Model 1												
		OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
Non-caregiving	154,503	1	1	1	1	1	1	1	1	1	1	1
Caregiving Adults	27,471	**1.28 (1.25-1.32)**	0.94 (0.88-1.01)	**1.12 (1.09-1.16)**	**0.89 (0.85-0.93)**	0.93 (0.83-1.05)	**1.08 (1.05-1.11)**	**0.93 (0.88-0.98)**	**0.87 (0.84-0.90)**	**0.90 (0.87-0.94)**	**0.94 (0.92-0.97)**	**0.88 (0.85-0.91)**
Caregiving Children	41,061	**1.22 (1.20-1.25)**	0.99 (0.94-1.05)	0.99 (0.97-1.02)	**0.82 (0.79-0.85)**	**0.84 (0.76-0.93)**	**1.07 (1.04-1.10)**	**0.88 (0.84-0.92)**	0.97 (0.95-1.00)	**0.89 (0.86-0.92)**	**0.91 (0.89-0.93)**	**0.84 (0.81-0.86)**
Model 2												
Non-caregivers	154,503	1	1	1	1	1	1	1	1	1	1	1
Caregiving Adults	27,471	**1.30 (1.27-1.34)**	**0.92 (0.86-0.99)**	**1.10 (1.07-1.14)**	**0.92 (0.88-0.96)**	0.94 (0.83-1.06)	**1.09 (1.06-1.12)**	**0.90 (0.85-0.96)**	**0.86 (0.83-0.89)**	**0.93 (0.89-0.97)**	**0.96 (0.93-0.99)**	**0.95 (0.91-0.99)**
Caregiving Children	41,061	**1.20 (1.17-1.23)**	0.99 (0.93-1.05)	0.98 (0.96-1.02)	**0.91 (0.88-0.95)**	**0.89 (0.80-0.99)**	**1.07 (1.04-1.10)**	**0.80 (0.76-0.84)**	**0.96 (0.94-0.99)**	0.97 (0.93-1.00)	0.99 (0.96-1.01)	**1.05 (1.02-1.09)**

[a] Model 1 Univariate; [b] Model 2 adjusting for age, race, sex, diet, smoking, alcohol, sleep, BMI, physical activity; history of Diabetes, Hypertension, Cardiovascular disease, Chronic obstructive pulmonary disease, End stage renal disease, , depression, Quality of life since retirement compared to working life, personal trouble with activities of daily living, self-reported overall health; [c] Reference category 7-8 hours of sleep; [d] Reference category 18.5 - 24.9 kg/m2; [e] Underweight = BMI <18.5 kg/m2; [f] Overweight = BMI ≥25 kg/m2; *Current defined as use in the past year. BMI= Body Mass Index; HEI= Healthy Eating Index; OR = odds ratio, CI = Confidence Interval

Table 2: Overall Caregiving and Association with behavioral risk factors.

Time caregiving for Adults per week	N	Vigorous physical Activity	Poor Diet (HEI Score <50)	Sleep [b]		BMI [c]		Current Smoker	Alcohol (Current)*	History of Diabetes	History of Hypertension	History of CVD
				≤6hrs	≥9hrs	Underweight [d]	Overweight-Obese [e]					
		OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
0 hrs	195564	1	1	1	1	1	1	1	1	1	1	1
Less than 30mins	6359	0.97 (0.92-1.03)	**0.79 (0.67-0.92)**	0.97 (0.91-1.04)	0.98 (0.90-1.07)	0.96 (0.76-1.23)	0.98 (0.93-1.05)	**0.69 (0.60-0.79)**	0.99 (0.92-1.06)	0.96 (0.89-1.04)	**0.93 (0.88-0.99)**	0.95 (0.88-1.03)
30mins-1.5hrs	10625	**1.35 (1.29-1.41)**	**0.86 (0.77-0.97)**	1.04 (0.99-1.09)	**0.93 (0.87-0.99)**	0.91 (0.76-1.10)	**1.08 (1.03-1.13)**	0.98 (0.90-1.07)	**0.87 (0.83-0.91)**	**0.89 (0.83-0.95)**	0.98 (0.94-1.03)	**0.93 (0.87-0.98)**
2-6hrs	5179	**1.40 (1.32-1.49)**	0.97 (0.83-1.13)	**1.11 (1.03-1.18)**	**0.84 (0.76-0.93)**	**0.76 (0.74-0.79)**	**1.11 (1.03-1.18)**	0.99 (0.87-1.12)	**0.86 (0.81-0.93)**	1.02 (0.94-1.11)	0.96 (0.90-1.02)	0.96 (0.88-1.04)
≥7 hrs	5308	**1.31 (1.24-1.40)**	**1.16 (1.01-1.33)**	**1.41 (1.33-1.51)**	1.02 (0.92-1.11)	1.23 (0.99-1.54)	**1.17 (1.09-1.24)**	**1.14 (1.02-1.28)**	**0.77 (0.72-0.82)**	0.92 (0.85-1.01)	0.98 (0.92-1.04)	0.92 (0.85-1.01)

[a] Multivariable Model adjusting for age, race, sex, diet, smoking, alcohol, sleep, BMI, physical activity; history of Diabetes, Hypertension, Cardiovascular disease, Chronic obstructive pulmonary disease, End stage renal disease, depression, Quality of life since retirement compared to working life, personal trouble with activities of daily living, self-reported overall health; [b] Reference category 7-8 hours of sleep; [c] Reference category 18.5 - 24.9 kg/m2; [d] Underweight = BMI <18.5 kg/m2; [e] Overweight = BMI ≥25 kg/m2; *Current defined as use in the past year. BMI= Body Mass Index; HEI= Healthy Eating Index; OR = odds ratio; CI = Confidence Interval; hrs= hours; CVD= Cardiovascular Disease

Table 3: Association between time spent Caregiving of Adults and lifestyle behavioral risk factors.

Time caregiving for Children per week	N	Vigorous physical Activity	Poor Diet (HEI Score <50)	Sleep [b]		BMI [c]		Current Smoker	Alcohol (Current)*	History of Diabetes	History of	History of CVD
				≤6hrs	≥9hrs	Underweight [d]	Overweight-Obese [e]					
		OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)	OR (95%CI)
0 hrs	172961	1	1	1	1	1	1	1	1	1	1	1
Less than 30mins	10471	**0.91 (0.87-0.95)**	**0.85 (0.76-0.95)**	**0.92 (0.87-0.96)**	1.01 (0.94-1.07)	0.85 (0.69-1.04)	0.98 (0.93-1.02)	**0.63 (0.56-0.70)**	1.01 (0.96-1.07)	**0.88 (0.82-0.94)**	**0.95 (0.90-0.99)**	1.00 (0.94-1.06)
30mins-1.5hrs	21123	**1.33 (1.28-1.37)**	0.98 (0.91-1.07)	1.00 (0.97-1.04)	**0.88 (0.85-0.94)**	**0.81 (0.70-0.94)**	**1.07 (1.04-1.11)**	**0.86 (0.80-0.91)**	0.99 (0.95-1.03)	1.00 (0.96-1.05)	0.97 (0.94-1.00)	1.03 (0.99-1.08)
2-6hrs	11031	**1.48 (1.41-1.54)**	1.07 (0.96-1.18)	1.02 (0.97-1.07)	**0.89 (0.83-0.95)**	0.95 (0.79-1.13)	**1.09 (1.04-1.14)**	**0.80 (0.73-0.88)**	0.96 (0.91-1.01)	0.96 (0.90-1.02)	1.00 (0.96-1.05)	**1.08 (1.02-1.15)**
≥7 hrs	7449	**1.47 (1.40-1.55)**	**1.30 (1.15-1.46)**	**1.08 (1.02-1.14)**	1.04 (0.95-1.13)	0.86 (0.69-1.07)	**1.21 (1.14-1.28)**	0.90 (0.81-1.00)	**0.79 (0.75-0.84)**	1.01 (0.93-1.09)	1.01 (0.95-1.06)	**1.12 (1.04-1.21)**

[a]Multivariable Model adjusting for age, race, sex, diet, smoking, alcohol, sleep, BMI, physical activity; history of Diabetes, Hypertension, Cardiovascular disease, Chronic obstructive pulmonary disease, End stage renal disease, depression, Quality of life since retirement compared to working life, personal trouble with activities of daily living, self-reported overall health; [b]Reference category 7-8 hours of sleep; [c]Reference category 18.5-24.9 kg/m2; [d]Underweight = BMI <18.5 kg/m2; [e] Overweight = BMI ≥25 kg/m2; *Current defined as use in the past year. BMI= Body Mass Index; HEI= Healthy Eating Index; OR = odds ratio; CI = Confidence Interval; hrs= hours; CVD= Cardiovascular Disease

Table 4: Association between Time spent Caregiving of Children and lifestyle behavioral risk factors.

Diet

On multivariable analyses, caregiving of adults was associated with a significantly lower odds of poor diet (HEI score <50, aOR 0.92; 95% CI 0.86-0.99), while caregiving of children was not significantly associated with diet (aOR 0.99, 95% CI 0.93-1.05), compared to non-caregivers. In an analysis by duration of caregiving, we observed that lower intensity caregiving was significantly associated with a lower odds of unhealthier diets (aOR 0.79; 95% CI 0.67-0.92 for adults and, aOR 0.85; 95% CI 0.76-0.95 for children less than 30 minutes per week) while caregiving for 7 hours or more per week was associated with a higher risk of poor diet among caregivers of adults (aOR 1.16; 95% CI 1.01-1.33) or children (aOR 1.30; 95% CI 1.15-1.46) (Table 3, Table 4).

Sleep Duration

On multivariable analysis, any caregiving was associated with a significantly lower odds of longer sleep duration (≥9 hours per night) (aOR 0.92; 95% CI 0.88-0.96 for adults and aOR 0.91; 95% CI 0.88-0.95 for children), compared to reference of 7-8 hours per night (Table 2). Caregiving of adults was associated with a significantly increased odds of short sleep duration (aOR 1.10; 95% CI 1.07-1.14), with a graded increase in odds by increasing duration of caregiving (aOR 1.41; 95% CI 1.33-1.51 for 7 hrs. or more caregiving) (Table 3). Caregiving of children was association with a significantly increased odds of short sleep duration for caregiving over 7 hour per week only (aOR 1.08; 95% CI 1.02-1.14) (Table 4).

Body Mass Index

On multivariable analysis (reference BMI 18.5-24.9), caregiving for adults (aOR 1.09; 95% CI 1.06-1.12) and children (aOR 1.07; 95% CI 1.04-1.10) were associated with a significantly increased odds of being overweight/obese (BMI ≥ 25), with a graded increase in odds ratio for increasing duration of caregiving. Caregiving of children was associated with lower odds of being underweight (aOR 0.89; 95% CI 0.80-0.99) (BMI <18.5), while longer duration caregiving of adults (≥ 7 hours per week) was associated with a significantly increased odds of being overweight (aOR 1.17; 95% CI 1.09-1.24) (Table 3, Table 4).

Smoking

On multivariable analysis, caregiving of adults (aOR 0.90; 95% CI 0.85-0.96) and caregiving of children (aOR 0.80; 95% CI 0.76-0.84) were associated with a significantly lower overall odds of being a current smoker compared to non-caregivers. However, longer duration caregiving of adults (≥ 7 hours per week) was significantly associated with higher odds of current smoking (aOR 1.14; 95% CI 1.02-1.28) (Table 3, Table 4).

Alcohol Intake

On multivariable analysis, caregiving of adults (aOR 0.86; 95% CI 0.83-0.89) and of children (aOR 0.96; 95% CI 0.94-0.99) compared to no caregiving was less likely to be associated with alcohol use in the past year. Caregiving of children for seven hours or more per week was associated with a significantly lower odds of alcohol consumption in the past year (aOR 0.79, 95% CI 0.75-0.84), but this association was not maintained among shorter durations of caregiving of children (Table 3, Table 4).

Self-reported History of Diabetes

On multivariable analysis, caregiving of adults (aOR 0.93; 95% CI 0.89-0.97) was associated with a significantly lower likelihood of diabetes than no caregiving (Table 3).

Self-reported History of Hypertension

On multivariable analysis, caregiving of adults (aOR 0.96; 95% CI 0.93-0.99) was associated with a significantly lower likelihood of history of hypertension compared to non-caregivers (Table 3).

Self-reported History of Cardiovascular Disease

On multivariable analysis, caregiving of adults (aOR 0.95; 95% CI 0.91-0.99) was associated with a lower likelihood of history of cardiovascular disease compared to non-caregivers. Caregiving of children (aOR 1.05; 95% CI 1.02-1.09) was associated with a greater likelihood of cardiovascular disease compared to non-caregivers. On analyses based on duration of caregiving, caregiving of children for 2-6 hours per week (aOR 1.08, 95% CI 1.02-1.15) and 7 hours or more per week was associated with a greater likelihood of cardiovascular disease (aOR 1.12, 95% CI 1.04-1.21) (Table 3, Table 4).

Subgroup Analyses

Subgroup analyses were performed based on sex, overall caregiving and association with behavioural risk factors (Table 5, Table 6) (Supplementary Material). Caregiving of adults was associated with increased odds of increased vigorous physical activity and abnormal BMI, while caregiving of children was associated with increased odds of increased vigorous physical activity (p for interaction <0.05). P for interaction were non-significant for poor diet, sleep, alcohol consumption, smoking and history of hypertension, diabetes and CVD.

Outcome	Model	Non-caregivers (Reference)	Caregiver (Men)	Caregiver (Women)	P For interaction
		Male N=93006 Female N=61497	N=15305	N=12166	
			OR (95% CI)	OR (95% CI)	
Vigorous physical Activity	Model 1	1.0	1.34 (1.30-1.39)	1.26 (1.21-1.31)	0.004
	Model 2	1.0	1.36 (1.31-1.41)	1.23 (1.17-1.28)	<0.001
Diet	Model 1	1.0	1.01 (0.93-1.09)	0.87 (0.77-0.97)	0.35
	Model 2	1.0	0.97 (0.88-1.06)	0.86 (0.75-0.97)	0.11
Sleep ≤6hrs	Model 1	1.0	1.10 (1.05-1.15)	1.13 (1.08-1.18)	0.98
	Model 2	1.0	1.09 (1.05-1.15)	1.13 (1.08-1.18)	0.53
Sleep ≥9hrs	Model 1	1.0	0.93 (0.89-0.99)	0.84 (0.78-0.90)	0.98
	Model 2	1.0	0.95 (0.90-1.00)	0.87 (0.80-0.93)	0.53
BMI: Underweight	Model 1	1.0	0.91 (0.75-1.10)	0.91 (0.78-1.05)	0.003
	Model 2	1.0	0.96 (0.79-1.16)	0.94 (0.81-1.09)	0.05
BMI: Overweight-Obese	Model 1	1.0	1.07 (1.02-1.11)	1.14 (1.09-1.19)	0.003
	Model 2	1.0	1.07 (1.03-1.12)	1.15 (1.09-1.20)	0.05
Current smoker	Model 1	1.0	0.87 (0.80-0.94)	0.95 (0.88-1.02)	0.23
	Model 2	1.0	0.88 (0.81-0.96)	0.93 (0.85-1.01)	0.01
Alcohol use in the past year	Model 1	1.0	0.84 (0.80-0.87)	0.94 (0.90-0.99)	0.16
	Model 2	1.0	0.83 (0.79-0.87)	0.88 (0.84-0.93)	0.73
History of Diabetes	Model 1	1.0	0.96 (0.92-1.00)	0.85 (0.80-0.90)	0.32
	Model 2	1.0	0.95 (0.90-1.00)	0.91 (0.85-0.97)	0.89
History of Hypertension	Model 1	1.0	0.97 (0.93-1.00)	0.93 (0.89-0.96)	0.06
	Model 2	1.0	0.97 (0.93-1.01)	0.97 (0.93-1.01)	0.19
History of Cardiovascular Disease	Model 1	1.0	0.93 (0.89-0.96)	0.87 (0.82-0.93)	0.09
	Model 2	1.0	0.92 (0.88-0.97)	1.03 (0.96-1.11)	0.46

Model 1 Univariate; Model 2 adjusting for age, race, sex, diet, smoking, alcohol, sleep, BMI, physical activity; history of Diabetes, Hypertension, Cardiovascular disease, Chronic obstructive pulmonary disease, End stage renal disease, depression, Quality of life since retirement compared to working life, personal trouble with activities of daily living, self-reported overall health; BMI = Body Mass Index; Underweight = BMI <18.5 kg/m2; Overweight = BMI ≥25 kg/m2; OR = Odds Ratio; CI = Confidence Interval

Table 5: Sex Difference, Adult Caregiving and Association with behavioral risk factors.

Outcome	Model	Non-caregivers (Reference)	Caregiver (Men)	Caregiver (Women)	P For interaction
		Male N=93006 Female N=61497	N=22165	N=18896	
			OR (95% CI)	OR (95% CI)	
Vigorous physical Activity	Model 1	1.0	1.32 (1.28-1.36)	1.18 (1.14-1.22)	<0.001
	Model 2	1.0	1.26 (1.22-1.30)	1.12 (1.08-1.16)	<0.001
Diet	Model 1	1.0	1.02 (0.95-1.10)	0.99 (0.90-1.09)	0.30
	Model 2	1.0	0.98 (0.91-1.06)	1.00 (0.90-1.10)	0.09
Sleep ≤6hrs	Model 1	1.0	1.00 (0.96-1.04)	0.96 (0.92-1.00)	0.07
	Model 2	1.0	0.99 (0.96-1.03)	0.99 (0.95-1.03)	0.13
Sleep ≥9hrs	Model 1	1.0	0.83 (0.80-0.88)	0.81 (0.77-0.86)	0.07
	Model 2	1.0	0.94 (0.89-0.99)	0.87 (0.83-0.93)	0.13
BMI: Underweight	Model 1	1.0	0.92 (0.78-1.09)	0.75 (0.65-0.85)	0.31
	Model 2	1.0	1.01 (0.86-1.19)	0.82 (0.72-0.94)	0.09
BMI: Overweight-Obese	Model 1	1.0	1.11 (1.07-1.15)	1.09 (1.05-1.13)	0.31
	Model 2	1.0	1.06 (1.02-1.10)	1.09 (1.05-1.13)	0.09
Current smoker	Model 1	1.0	0.85 (0.79-0.91)	0.86 (0.81-0.92)	0.59
	Model 2	1.0	0.79 (0.73-0.85)	0.81 (0.76-0.87)	0.34
Alcohol use in the past year	Model 1	1.0	0.99 (0.95-1.03)	1.02 (0.98-1.05)	0.69
	Model 2	1.0	0.97 (0.93-1.01)	0.96 (0.92-1.00)	0.58
History of Diabetes	Model 1	1.0	0.91 (0.87-0.94)	0.91 (0.87-0.96)	0.99
	Model 2	1.0	0.96 (0.92-1.00)	0.98 (0.92-1.04)	0.48

History of Hypertension	Model 1	1.0	0.92 (0.89-0.95)	0.91 (0.88-0.94)	0.71
	Model 2	1.0	0.99 (0.95-1.02)	0.99 (0.95-1.03)	0.02
History of Cardiovascular Disease	Model 1	1.0	0.87 (0.84-0.90)	0.91 (0.86-0.96)	0.50
	Model 2	1.0	1.02 (0.98-1.06)	1.13 (1.06-1.20)	0.87

Model 1 Univariate; Model 2 adjusting for age, race, sex, diet, smoking, alcohol, sleep, BMI, physical activity; history of Diabetes, Hypertension, Cardiovascular disease, Chronic obstructive pulmonary disease, End stage renal disease, depression, Quality of life since retirement compared to working life, personal trouble with activities of daily living, self-reported overall health; BMI = Body Mass Index; Underweight = BMI <18.5 kg/m2; Overweight = BMI ≥25 kg/m2; OR = Odds Ratio; CI = Confidence Interval

Table 6: Sex Difference, Child Caregiving and Association with behavioural risk factors.

Discussion

In this large US-based cohort of older adults, we report a complex association of caregiving with prevalence of cardiovascular risk factors. While the overall association of self-reported caregiving with vascular risk factors suggested a mostly positive relationship with many healthy lifestyle traits (with the exception of sleep), our findings also revealed that higher duration caregiving of adults was associated with an increased frequency of unhealthy cardiovascular behavioural risk factors. This study adds to the findings of Xu et al . [8], which identified that duration of caregiving was a risk factor for CVD, supporting the need to develop and evaluate interventions to optimise cardiovascular risk factors in higher intensity caregivers.

We report a difference in association of caregiving with short sleep duration, among caregiver type and intensity. Short sleep duration, which has been associated with increased cardiovascular risk and mortality [17,18], was not associated with short-duration caregiving. In fact, caregiving of children (<30 minutes per week) was associated with a reduced odds of short sleep duration. In contrast, longer duration caregiving of both adults (> 2 hours per week) and children (>7 hours per week) was associated with an increased odds of shorter sleep duration, with a graded increased in magnitude of odds ratio with increasing duration of adult caregiving. Reducing sleep duration may be a direct implication of the practical need to provide caregiving at night or in the early morning. An association of shorter sleep duration and caregiving has been reported for caregivers of individuals with dementia, cancer and patients on dialysis [19-22], and bidirectionally associated with increased stress and mood impairment. A systematic review of previous studies that evaluated the association of caregiving and sleep impairment, reported that sleep impairment affected 50-70% of caregivers of family members with dementia [9] with many reporting adverse effects on sleep quality (e.g., falling asleep, sleep interruption). In some of those studies, sleep impairments were more common in women than men, [20,23-25] which we do not report in our study (P for interaction non-significant). Our analysis suggests that the association of caregiving and short sleep duration may emerge primarily as an outcome of duration of caregiving, and supports the opportunity of further interventional research to improve sleep patterns among caregivers.

The association of caregiving with diet quality also illustrates the contextually dependent association of caregiving with behavioural risk factors, in that lower intensity caregiving was associated with a healthier dietary quality (i.e., higher HEI score), but higher intensity (≥7 hours per week) was associated with a lower diet quality. While these findings support a potentially beneficial aspect of lower intensity caregiving, it identifies dietary quality as a potentially important target for intervention in higher burden caregivers, a finding that is also consistent with previous research studies. In a cross-sectional study by Tana et al, they reported a significant association between poor nutritional status and caregiver burden among 406 caregivers in Italy [26]. An analysis of the Caregiving in the Healthy Aging in Neighbourhoods of Diversity across Life Span (HANDLS) study (n=1,945) reported on the cross-sectional and prospective association of diet quality (also measured using the HEI) [10]. This study reported improvements in diet quality over time with caregiving for children, but a reduction in diet quality over time for older adult caregiving. Adverse effects on diet may manifest as increases or reductions in BMI, depending on type of adverse changes of dietary patterns, and we observed an increase in both lower and higher BMI among those with higher intensity caregiving.

Regular physical activity is an important determinant of cardiovascular health, and physical and cognitive functioning. Moreover, it has been identified as a potentially important target for caregiver dyads [27]. In our study, we observed an overall increase in levels of regular physical activity among caregivers, and suggestion of a graded increase in magnitude of association by duration of time spent caregiving. However, our findings contrast those of longitudinal studies of caregivers with dementia, which report a reduction in physical activity with increased longitudinal exposure to caregiving for a spouse with dementia [28,29]. Most likely, the inconsistency in findings, between our study and others, relates to

our inability to subclassify caregivers into a specific category of caregivers to individuals with dementia. Taken together, the collective findings suggest a transition in levels of physical activity among caregivers, with initial higher levels (compared to general older adult population), then gradual reduction over time, and as caregiver burden increases there is reduction in regular physical activity.

Within our analyses, we observe that adverse behavioural risk factors may emerge at different stages of increased caregiver exposure and burden, for example we observe the emergence of adverse patterns in diet and sleep behaviours, but not in physical inactivity for caregiving over 7 hours. The mechanisms underpinning these varying associations may differ by risk factors. Increased time spent on caregiving may simply limit the amount of time required to maintain healthy approaches to some behaviours (e.g., physical activity, shopping for healthy foods), while increased caregiver stress might mediate impairments in sleep, dietary patterns, and other behaviours. An example in our analysis of stress-related behaviours may be smoking, where we observe a 17% increase in odds of current smoking for adult caregivers of 7 hours or more, but a reduced odds among low duration caregiving. When caregivers smoke, there is the additional consequence of environmental tobacco smoke exposure to the individual requiring caregiving. The increase may reflect an impaired ability to quit smoking, or re-uptake of prior habit in a stressful situation [11]. We did not find an association of caregiving and current alcohol consumption, although increase in problem-drinking behaviours have been reported in studies of high-burden caregivers [30,31,32], again supporting the contention that the emergence of adverse behaviours may be different for different risk factors.

Consistent with our finding for cardiovascular risk factors, the current literature would suggest that caregiver health outcomes are dependent on caregiver intensity, with caregivers who are emotionally distressed more likely to report negative health outcomes. Accordingly, different definition of 'caregiving' among studies, either by level of care delivered or time spent caregiving, may translate into differing association with adverse health outcomes [33]. In this study, caregivers did not self-select to enrol, instead participants were targeted as they were members of the active retirement association. As caregivers were not the primary inception cohort, our findings may be more representative of a broader spectrum of older adult caregiver, albeit poorly classified.

Caregiving overall had no association with reported history of hypertension or CVD, but those who participated in higher intensity caregiving duties of children had higher odds of having a history of CVD. This is in contrast to previous findings in the Nurses' Health Study which identified higher risk of cardiovascular disease among women caregiving for a disabled or ill spouse for ≥9 hours per week [2], however, their study was a prospective cohort study, rather than a cross-sectional study, and an association with cardiovascular risk may require longer-term prospective follow-up.

Limitations

There are several limitations to this study. First, this study did not provide detail on type of caregiving e.g., level of dependence of care recipient, if there were other supports in place to assist the carer. This would provide greater insight into variation in lifestyle behaviours based on intensity of care provided. In addition, we were unable to categorize the burden of exposure of caregiving beyond 10 hours per week and the intensity of care provided across the duration of time spent delivering assistance to the care recipient. Moreover, we are unable to quantify the level of caregiver strain or burn-out. Second, the overall population included in this study were mainly Non-Hispanic white, highly educated, married individuals. As a result, the impact of socioeconomic status on lifestyle health behaviours could not be adequately explored. As this study required participants to complete and return questionnaires, the population were able and inclined to participate, but as previously mentioned it was not a self-selected caregiving population, which is of benefit given that most caregiving studies select caregivers with higher levels of distress. Third, it must be noted that many of the variables included may be subject to social desirability bias as the study was dependent on participants self-reporting on behaviours including smoking, alcohol use, diet and physical activity. As this study was questionnaire based, variables such as blood pressure and diabetes were based on history rather than objective ambulatory measurements. Fourth, some behaviours e.g., diet, were measured at different time points to the caregiving variable so it is possible that these behaviours may have undergone change during this time which we did not capture. In addition, many of the variables were not measured prospectively

Conclusions

Our study reports that low-moderate duration caregiving is associated with healthier lifestyle behaviours, compared to non-caregivers. However, our findings also revealed that higher duration caregiving of adults was associated with an increased frequency of unhealthy cardiovascular behavioural risk factors, namely shorter sleep durations, poor diet, increased BMI and smoking. Strategies targeting improved nutrition, weight loss, better sleep and engagement in preventative health screening should be considered for 'at risk' caregiver populations.

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Declaration of Conflicting Interests

The Authors declare that there is no conflict of interest.

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