TITLE: Does Life Satisfaction Reduce Risk of Incident Hypertension and Stroke? Evidence from the Whitehall II Cohort

RUNNING HEAD: Life satisfaction and hypertension and stroke risk

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Abstract

Background: Previous studies showed life satisfaction is related to reduced risk of coronary heart disease and diabetes, but its association with other cardiometabolic endpoints including hypertension and stroke remains unexplored. This study examined life satisfaction's prospective association with incident hypertension and stroke in middle-aged adults. **Methods:** At baseline (1985–1988), 6,225 healthy British civil servants aged 35-55 from the Whitehall II cohort completed the validated Satisfaction with Life Scale and provided information regarding sociodemographics, a range of health-related factors, and psychological distress. Incident hypertension was ascertained according to clinic-derived measures of systolic or diastolic blood pressure of ≥140/90 mmHg, respectively, or self-reports of either physician-diagnosed hypertension or hypertensive medication use. Incident stroke and transient ischemic attack (TIA) were ascertained by self-reported physician diagnosis. Follow-up assessments occurred every 2-5 years through 2017. Cox proportional hazards regression models estimated hazard ratios (HR) and 95% confidence intervals (CI) of hypertension and stroke/TIA risk separately. **Results:** Over a 31-year follow-up, 2,703 cases of hypertension and 370 cases of stroke/TIA occurred. Life satisfaction was not related to risk of developing hypertension but was associated with 12% decreased risk of stroke/TIA after controlling for sociodemographics, health status, and health behaviors ($HR_{per\ 1\text{-}SD}$=0.88; 95%CI=0.79-0.98). However, the association was attenuated after adjustment for psychological distress. **Conclusions:** No robust associations were found between life satisfaction and incident hypertension and stroke/TIA, respectively, after accounting for well-established risk factors and psychological distress. More research is needed to understand why associations of life satisfaction with cardiometabolic health seem to vary across endpoints.

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Increasingly, research suggests multiple facets of psychological well-being play a protective role in the development of chronic health conditions.[1,2] In particular, life satisfaction, which refers to an overall cognitive evaluation of one's life,[3] has been linked prospectively with reduced risk of cardiometabolic outcomes. For example, in 7,956 middle-aged and older civil servants from the British Whitehall II cohort, higher versus lower life satisfaction levels averaged across seven life domains (e.g., work, family) were associated with 26% reduced risk of coronary heart disease assessed via medical records, over five years of follow-up. This reduction was evident after accounting for risk factors that could act as potential confounders or pathways including health behaviors, blood pressure, and metabolic function.[4] Associations were only slightly attenuated when further controlling for psychological distress. Using the same global life satisfaction measure, another study of the Whitehall II cohort investigated life satisfaction in relation to both self-reported physician-diagnosed and screen-detected (i.e., oral glucose tolerance test) diabetes over 11 years.[5] Every standard deviation (SD) increase in life satisfaction was associated with up to 13% decreased odds of physician-diagnosed, but not screen-detected, diabetes beyond traditional risk factors and psychological distress. These findings on global life satisfaction and reported physician-diagnosed diabetes have been replicated in other large population-based studies with up to 20 years of follow-up.[6,7] Although such results suggest that life satisfaction may impact cardiometabolic outcomes favorably, the extent to which this facet of psychological well-being relates to other presentations of cardiometabolic disease such as hypertension and stroke remains understudied.

To our knowledge, only one prospective study has investigated the association between life satisfaction and incident stroke, and none has examined life satisfaction’s relationship with future hypertension risk. Data from the European Prospective Investigation into Cancer and

Nutrition (EPIC)-Germany study (N=50,358) found midlife women with lower versus higher levels of life satisfaction had a 69% (95% confidence interval, CI=1.05-2.73) increased risk of stroke, after adjusting for risk factors including health behaviors, diabetes, and high blood pressure. By contrast, the association did not persist when controlling for these covariates in men.[7] One limitation of this study is that psychological distress, an established risk factor for stroke[8] and also a construct generally moderately correlated with life satisfaction,[3] was not included as a covariate. Hence, limited conclusions can be drawn as to whether life satisfaction protects against stroke risk beyond reflecting simply the absence of negative emotions.[9] In fact, positive psychological states are increasingly regarded as independent health assets that may help prevent diseases and promote better health.[2,10] Considering these positive states is consistent with a "positive epidemiology" framework that highlights the importance of studying potentially protective determinants of health in particular.[9]

Despite the lack of evidence on life satisfaction's role in hypertension and stroke risk, findings from prospective studies targeting other facets of psychological well-being are informative. For instance, higher versus lower emotional vitality levels were associated with 9% lower hypertension risk (95% CI=0.82-1.00) over more than a decade of follow-up in the Whitehall II cohort, beyond conventional risk factors and psychological distress.[11] However, evidence on optimism's role in hypertension risk is mixed, with findings showing both null[11] and protective associations.[12] Similarly, emotional vitality was associated with decreased risk of stroke in the National Health and Nutrition Examination Survey Epidemiologic Follow-up Study,[13] whereas findings on the relationship between optimism and incident stroke are inconsistent thus far.[14,15] How to interpret differences in findings across psychological well-being facets relate to a larger debate, namely whether effects are uniformly distributed (i.e., all facets are similarly beneficial for health outcomes) or specific (i.e., distinct facets impact health differently).[16] These studies on hypertension and stroke incidence imply that effects of well-being may vary across facets, and given limited findings with life satisfaction to date, additional research is needed to ascertain if life satisfaction truly confers protection against these outcomes. Such work has the potential to inform the development of preventive psychosocial interventions specifically targeting the reduction of these two cardiometabolic conditions that engender a major societal and financial burden.[17]

In the current study, we examined the prospective association of life satisfaction with risk of incident hypertension and stroke/transient ischemic attack (TIA), separately, in middle-aged adults using data from the Whitehall II cohort. Following prior research,[4,5,11] numerous sociodemographic, health-related, and behavioral factors were considered as potential covariates. We also considered the role of psychological distress, as measured by anxiety and depression symptoms, in the relationships of interest to evaluate whether life satisfaction relates to each outcome independently, that is, over and above simply signaling the absence of distress. We hypothesized that higher versus lower life satisfaction levels would be associated with reduced risk of incident hypertension and stroke/TIA, respectively. Based on previous work suggesting that associations of psychological functioning with cardiometabolic outcomes may differ by specific sociodemographic, health-related, and behavioral factors,[7,18,19] secondary analyses evaluated associations stratified by age, sex, body mass index (BMI), and smoking status.

Methods

Study Sample

The Whitehall II cohort comprises 10,308 British civil servants who were first assessed during 1985–1988 (phase 1).[20] All civil servants aged 35–55 years in 20 London-based departments were invited to participate by letter and 73% agreed. Phase 1 comprised both a clinical examination and a self-report questionnaire and serves as the baseline for the current research. Subsequent assessments comprising both a clinical examination and the completion of a self-reported questionnaire took place every 4-6 years (phase 3 [1991–1993], phase 5 [1997–1999], phase 7 [2003–2004], phase 9 [2008–2009], phase 11 [2012-2013], and phase 12 [2016-2017]). Because phase 10 (2011) included only a subsample of participants, it is not included in the current study. Self-reported questionnaires were also mailed at intermediate phases (phases 2 [1989-1990], 4 [1995-1997], 6 [2001], and 8 [2006]). Response rates among eligible participants were 79% or above from phases 2-12. Detailed description of the protocol for recruitment and procedures were previously published.[20] All participants provided written informed consent. Human research ethics committees at University College London, University College London Hospital, and Harvard T.H. Chan School of Public Health approved the research.

For prospective analyses on incident hypertension, participants were excluded if they had missing data on life satisfaction (*n*=2,750), a history of or missing data on hypertension (*n*=2,048), cancer (*n*=76), or myocardial infarction (*n*=3) at baseline, or if they were missing hypertension information at all phases after the phase 1 baseline (*n*=346), yielding an analytic sample of 5,085. Missing data on covariates were documented for 0.0% to 0.8% of participants in this sample. At baseline, excluded versus included participants tended to be older, women, non-White, and single, and to have lower employment grade, a history of diabetes, higher BMI and blood cholesterol levels, lower levels of fruit and vegetable consumption and physical activity, and be current smokers.

For prospective analyses on incident stroke/TIA, participants with missing data on life satisfaction (*n*=2,750), or with a history of or missing data on stroke/TIA (*n*= 35), cancer (*n*=89), or myocardial infarction (*n*=9) at baseline, or who were missing stroke/TIA information at all phases after the phase 1 baseline (*n*=1,267) were excluded, yielding an analytic sample of 6,158. Missing data on covariates were documented for 0.0% to 3.1% of participants in this sample. At baseline, excluded versus included participants were more likely to be women, non-White, single, and to have lower employment grade, a history of hypertension, higher blood cholesterol levels, lower fruit and vegetable consumption and physical activity, and to be current smokers.

Measures

Life satisfaction. Global life satisfaction was self-reported at baseline using the validated 5-item Satisfaction with Life Scale (SWLS) which has demonstrated good psychometric qualities.[3,21,22] Items were rated on a Likert scale ranging from 0 ('strongly disagree') to 6 ('strongly agree') and summed to obtain a total score; higher scores indicated greater life satisfaction. This variable was derived by Whitehall II data managers for participants with complete data on the five items. In the current study, life satisfaction scores were used continuously (standardized scores, *M*=0, *SD*=1; per 1-SD increase) and categorically into tertiles based on each analytic sample's distribution of scores (e.g., in the hypertension analytic sample: Lower, scores 0-11=32.7%, Moderate, scores 12-19=34.0%, Higher, scores 20-30=33.3%). In the current study, internal consistency was high (Cronbach □□= .89 in both hypertension and stroke analytic samples).

Hypertension. Hypertension was assessed beginning at phase 1 through phase 12 (2015–2017; mean follow-up=17.6 years, *SD*=9.4) from various sources of information. Medical examinations, which were conducted during phases 1, 3, 5, 7, 9, 11, and 12, provided clinically-assessed levels of systolic blood pressure (SBP) and diastolic blood pressure (DBP).[23] Blood pressure was measured twice while sitting after 5 min of rest with the Hawksley random-0 sphygmomanometer (phases 1- 5) and OMRON HEM 907 (phase 7). The two readings were averaged for measures of SBP and DBP. Self-reported questionnaires queried physician-diagnosed hypertension (phases 1, 2, 4, 5, and 7) and medication use for hypertension (phases 1, 2, 4, 5, 7, 9, 11, and 12). Hypertensive status (yes/no) was ascertained according to whether participants met at least one of the following criteria: 1) SBP ≥140 mmHg or DBP ≥90mmHg as measured during medical examinations; or 2) self-reported physician-diagnosed hypertension; or 3) self-reported use of hypertensive medication. In the final analytic sample, no participants were missing data on clinically measured blood pressure at any time-point, whereas 1,931 (38.0%) were missing data on self-reported physician-diagnosed hypertension for at least one assessment and 2,901 (57.1%) were missing data on self-reported use of hypertensive medication for at least one assessment.

Stroke and transient ischaemic attack (TIA). At phases 1, 4, 5, 6, 7, 8, 9, 11, and 12, participants reported whether they had received a physician's diagnosis of stroke or TIA [e.g., "Since (date of the last phase), have you ever been told by a doctor that you have had a stroke or transient ischaemic attack (mini stroke/TIA)?"]. Medically verified assessments of health outcomes derived from electronic health records did not include complete information regarding fatal and non-fatal strokes until after phase 6 (2001): therefore, the current study's outcome included self-reported (non-fatal) stroke and TIA only.

Covariates. All covariates were self-reported at baseline, except BMI and blood cholesterol, which were measured during the baseline medical examination. Following previous research[4,5,11] we considered the following sociodemographic variables: age (years), sex (men, women), race (White, non-White), marital status (married/cohabitating, other), and employment grade [administrative (highest level), professional (middle level), clerical/support (lowest level)].

Health-related covariates included self-reported diabetes (yes, no) and, in the models predicting incident stroke/TIA, hypertension (yes, no; ascertained with the composite score described above). We also considered health behaviors and clinically-assessed risk factors that could be confounders or on the pathway linking life satisfaction with hypertension or stroke/TIA including: smoking status (current, former, never), alcohol consumption (low/moderate [women: <15 units/week; men: <22 units/week], high [women: ≥15units/week; men: ≥ 22units/week]), physical activity (<1.5 h/week, ≥1.5 h/week of moderate-to-vigorous exercise), as well as daily fruit and vegetable consumption (yes, no). Clinically-assessed factors included blood cholesterol (mmol/L) and BMI (kg/m^2), which were measured according to standard operating protocols.[20,24] Psychological distress was self-reported using the 30-item General Health Questionnaire (GHQ-30), a well-validated instrument used to screen psychiatric problems (e.g., anxiety, depression).[25,26] In the current study, all items were summed for a total distress score (continuous; higher scores indicate greater distress) and the internal consistency was excellent (Cronbach □□= .92).

Statistical analyses

We conducted all statistical analyses using the SAS 9.4 University Edition software.[27] The alpha level was set at 5%, two-tailed. Missing data on covariates were imputed using the multivariate expectation maximisation algorithm available in SAS PROC MI.[28] Frequency tables and descriptive statistics characterized the distribution of baseline covariates in the whole sample and across life satisfaction tertiles. For longitudinal analyses, Cox proportional hazards regression models estimated hazard ratios (HR per 1-SD increase) and 95% confidence intervals (CI) of the association of continuous on life satisfaction scores with incident hypertension and stroke/TIA risk, separately, in five nested models that controlled progressively for more baseline covariates.

The first model adjusted for age only. The second model adjusted for sociodemographics (age, sex, race, marital status, employment grade), and the third model further added health status covariates (diabetes, hypertension status [stroke/TIA sample only]), blood cholesterol). The fourth model additionally considered health behaviors (smoking status, alcohol consumption, exercise, fruit and vegetable consumption) and BMI, while the fully adjusted fifth model further included psychological distress. Follow-up time was calculated as time from baseline assessment of life satisfaction to the first hypertension or stroke/TIA event (depending on the analytic sample), last participation date, or end of follow-up—whichever came first. When considering incident hypertension, we contrasted results from analyses including only participants with complete hypertension information (*n*=2,184) to those obtained with the final analytic sample (*N*=5,085); as they were highly comparable, we reported findings from the final analytic sample only. When considering incident stroke/TIA, we separately examined the association of life satisfaction with incident stroke (*n*=105) only; because results were similar when considering combined stroke and TIA, we reported findings from the combined outcome only.

Secondary analyses considered potential effect modification by age (using median age as cut-off point; <44 versus ≥44 years), sex (men versus women), smoking status (never smokers versus current/former smokers), and BMI (<25 kg/m^2 versus ≥25 kg/m^2) by adding an interaction term of life satisfaction (continuous) with each of these covariates to Model 3, which controlled for sociodemographic and health-related covariates. We also examined the association of psychological distress with incident hypertension and stroke/TIA, separately. Lastly, tertiles of life satisfaction were used to examine possible threshold effects in the same set of models as described above.

For a few of the sociodemographic and health-related covariates, but not the exposure itself, associations between the scaled Schoenfeld residuals and time were statistically significant, indicating partial violation of the proportional hazard assumption.[29,30] Because findings remained comparable when interactions terms between time and violating predictors were added to the models, we present findings with standard proportional hazards.

Results

Baseline characteristics

Table 1 shows the distribution of covariates across baseline life satisfaction levels in the hypertension analytic sample. Participants were on average 44.5 years old (*SD*=5.9; range 34-56) at baseline. Most participants were men (70.5%), White (92.3%), and married (76.0%). Mean BMI was 24.2 kg/m^2 and few participants reported a history of diabetes (0.7%). Life satisfaction was normally distributed, with a mean of 15.4 (*SD*=7.1, range 0-30), and higher scores were moderately correlated with lower psychological distress scores (r=-0.34, p<.001). A similar distribution of covariates was obtained in the stroke analytic sample (Table 2).

Primary analyses

Hypertension. Over an average of 18 years, 2,663 cases of incident hypertension occurred (follow-up period range: 2-31 years). Continuous life satisfaction scores were not associated with risk of developing hypertension in the age-adjusted model (HR per 1-SD increase=1.00, 95%CI: 0.96-1.04). Comparable results showing null associations were obtained in models further controlling for other sociodemographics, health status, health behaviors and BMI, and psychological distress (Table 3).

Stroke/TIA. Over the follow-up period (mean: 20 years; range: 7-30 years), 362 cases of stroke/TIA were reported (stroke cases n=105; TIA cases n=257). Each SD increase in life satisfaction was associated with 12% decreased risk of developing stroke/TIA in the age-adjusted model (HR=0.88, 95%CI: 0.79-0.98). Estimates were robust to adjustment for other sociodemographics, health status, health behaviors, and BMI, but were attenuated after adding psychological distress to the model (HR=0.94, 95%CI: 0.84-1.05; Table 3).

Secondary analyses

Hypertension. There was no evidence of effect modification of the life satisfaction-hypertension association by baseline age, sex, BMI, or smoking status (interaction term *p*s range: .13 to .76). Psychological distress was not associated with risk of incident hypertension in a model including sociodemographics and health status, (HR=1.00, 95%CI: 0.96–1.04). When considering tertiles of life satisfaction, results were similar to those obtained with the continuous scores (i.e., higher and moderate versus lower life satisfaction levels, HR=0.97, 95%CI: 0.87-1.07 and HR=0.92, 95%CI: 0.84-1.02, respectively, in the fully adjusted model).

Stroke/TIA. There was also no evidence of effect modification between life satisfaction and baseline age, sex, BMI, or smoking status in relation to stroke/TIA risk (interaction term *p*s range: .11 to .53). When considering psychological distress in a model including only sociodemographic characteristics and health status, every 1-*SD* increase of psychological distress was associated with a 17-20% increased risk of incident stroke/TIA (e.g., HR=1.20, 95%CI: 1.09-1.31). Results based on life satisfaction tertiles were similar to those obtained with the continuous score (i.e., higher and moderate versus lower life satisfaction levels, HR=0.95, 95%CI: 0.72-1.24 and HR=0.82, 95%CI: 0.63-1.07, respectively, in the fully adjusted model), with no evidence of dose-response relationship.

Discussion

This research investigated life satisfaction as a potential health asset that might protect against two forms of cardiometabolic disease, and further evaluated if any apparent associations were independent of psychological distress, i.e., due to more than primarily signaling the absence of poor mental health.[9] We examined the prospective association of life satisfaction with risk of developing hypertension and stroke/transient ischemic attack (TIA), separately, over a 31-year period among middle-aged men and women. Based on previous work showing that greater levels of other facets of psychological well-being (e.g., emotional vitality) were associated with decreased risk of these cardiometabolic outcomes,[7,11,13,19,31-35] we expected life satisfaction would be inversely associated with incident hypertension and stroke/TIA. Contrary to our hypothesis, life satisfaction was not linked to hypertension onset. Although every 1-*SD* increase in life satisfaction was related to 12% decreased risk of stroke/TIA when controlling for sociodemographic and health-related factors, this association was attenuated towards the null when further adjusting for psychological distress.

Several explanations for this unexpected hypertension finding are possible. First, it is possible that life satisfaction's role is *disease-specific*, whereby this positive state would relate to certain, but not all, cardiometabolic conditions. However, it is also possible that our failure to find an association with incident hypertension may be unique to the participants in our study. Indeed, hypertension was a common outcome in our sample of middle-aged adults, with half of them developing the condition over the follow-up period. Such a high prevalence implies that many pathways to hypertension are possible, hence making it more difficult to parse the magnitude of effects according to specific protective factors.[11] Future studies should investigate the association between life satisfaction and hypertension onset earlier in life.

An alternative explanation is that different facets of psychological well-being might relate differently to hypertension risk, implying that positive determinants of hypertension are *exposure-specific*. Life satisfaction is typically viewed as an indicator of cognitive well-being,[21] whereas emotional vitality, which has been consistently found to be protective for cardiometabolic outcomes including hypertension risk in the Whitehall II cohort,[11] represents affective well-being. More specifically, cognitive well-being refers to global evaluations of life, and is influenced mostly by individuals' overall life circumstances, whereas affective well-being refers to the frequency and intensity of emotions and moods, and is based on subjective evaluations of recent activities and events.[36,37] For example, emotional vitality is characterized by "a sense of energy, positive well-being, and effective emotion regulation."[38] Thus, cognitive and affective well-being are related, but constitute separate constructs.[36] As a result, they might influence risk of developing hypertension differently, both directly and indirectly through distinct pathways. For instance, early work showed separate gene regulation profiles associated with life satisfaction versus happiness, another indicator of affective well-being.[39] Future studies comparing the cognitive and affective facets of psychological well-being are necessary to confirm whether their effects are uniform or specific in relation to hypertension risk.

With regard to stroke, our results are consistent with previous work with the EPIC cohort that found a protective effect of life satisfaction beyond health status and health-related behaviors.[7] Our study adds to these findings by further considering psychological distress which, when included in our statistical models, substantially attenuated the association between life satisfaction and incident stroke/TIA. Depression, a marker of psychological distress, has been identified as a risk factor for stroke in many studies,[40] an association we also observed in our investigation. Our findings, together with prior work showing that depression is associated with subsequent decreases in life satisfaction,[41] may suggest distress confounds the association between life satisfaction and stroke.

Tests of potential effect modification revealed no statistically significant differences in the associations of life satisfaction with hypertension and stroke/TIA, respectively, by age, sex, BMI, or smoking status. These results are somewhat different from those of a few existing studies in which relationships between stroke risk and indicators of psychological functioning, including life satisfaction, differed by these factors.[7,18,19] For example, in the EPIC study,[7] lower life satisfaction was related to increased risk of stroke in women but not men. However, our results are congruent with previous work in the Whitehall II cohort suggesting associations of life satisfaction and other facets of PWB with subsequent coronary heart disease, diabetes, and hypertension did not differ across age groups, sexes, or levels of health-related factors.[4,5,11]

Our study has some limitations. The use of self-reported physician-diagnosed stroke/TIA is one. Although other studies suggest such self-reports tend to show moderate to strong agreement with reports directly from physicians or medical records,[42,43] they may be subject to recall bias. Another limitation is that death due to stroke was not included in our endpoint because it became available only later in the cohort follow-up. Medically verified assessments of health outcomes in the Whitehall study are derived from electronic health records; however, these records did not include complete information regarding fatal and non-fatal strokes until after 2001 (after phase 6). Hence, our findings might not be generalizable to fatal stroke. Likewise, information on stroke subtypes (i.e., ischemic versus hemorrhagic) was not available. Additionally, the measures of health behaviors were somewhat limited. For example, lifestyle habits such as daily fruit and vegetable consumption were assessed using a single item. The Whitehall II cohort comprises mostly White individuals who worked as civil servants; this homogeneity improves the study's internal validity but limits the generalizability of the results. Moreover, individuals included versus excluded from the analytic samples tended to be younger and more socioeconomically advantaged. They were also healthier: as a result, our findings may provide conservative estimates of the associations between life satisfaction and hypertension and stroke. Strengths of the present study include a large and well-characterized cohort, a prospective research design encompassing more than 30 years of follow-up, as well as the use of a validated multi-item measure of life satisfaction. Additionally, the use of both clinically assessed and self-reported criteria to define hypertension enhanced internal validity. Lastly, the common work setting for participants and high initial response rate at baseline (73% all London-based government workers aged 35–55 years old in 1985–1988) and subsequent phases (79% or above) reduces concerns regarding bias due to sample selection and panel attrition. Despite lower levels of risk factors and incidence of cardiovascular disease in the Whitehall II study, when considering risk factor–cardiovascular disease associations findings from this occupational cohort study and population-based studies, such as the UK-wide British Heart Study and the community-based US Framingham study, are highly congruent.[44]

In summary, we found no evidence of an association between life satisfaction and incident hypertension in middle-aged adults from the Whitehall II cohort. Additionally, while life satisfaction was associated with a decreased risk of stroke/TIA when controlling for sociodemographic, health-related, and behavioral covariates, the relationship did not persist after adjusting for psychological distress, suggesting that life satisfaction is not an independent protective factor for stroke. When compared to existing studies on life satisfaction and coronary heart disease and diabetes,[4-7] our results suggest that associations between this cognitive facet of psychological well-being and cardiometabolic health might vary across endpoints. More research is needed to confirm this hypothesis and to investigate potential behavioral and biological pathways that might explain those differences. Prior research has also indicated that other facets of psychological well-being, including affective ones such as emotional vitality, have been associated with hypertension and stroke onset.[11,13] Therefore, future research should also aim to understand why cognitive and affective facets of psychological well-being may be differently associated with cardiometabolic health. Lastly, whether life satisfaction *preserves* cardiometabolic health, such as promoting favorable levels of blood pressure and insulin, deserves more empirical attention. Such investigation will contribute to ongoing efforts that aim to identify positive determinants that shape population health.

Declaration of competing interests

All authors have completed the Unified Competing Interest form at http://www.icmje.org/coi_disclosure.pdf and declared that AJG received salary and training support from the Canadian Institute of Health Research (postdoctoral fellowship) and the Lee Kum Sheung Center for Health and Happiness, and that MK received support from the NordForsk (the Nordic Research Programme on Health and Welfare), the UK Medical Research Council (K013351 and R024227), and the Academy of Finland (311492) for the submitted work. The other co-authors have no competing interests to disclose.

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Tables

Table 1.
Distribution of covariates at baseline according to tertiles of life satisfaction in the hypertension analytic sample (N = 5,085).

Covariates	Life satisfaction		
	Lower (0-11)[a] (*n*=1,661)	Moderate (12-19) (*n*=1,731)	Higher (20-30) (*n*=1,693)
Demographic Characteristics			
Mean age, years (*SD*)	44.2 (5.8)	44.5 (5.9)	44.91 (5.9)
Male	1,163 (70.0%)	1,248 (72.1%)	1,173 (69.3%)
White	1,532 (92.2%)	1,589 (91.8%)	1,573 (92.9%)
Married or cohabitating	1,037 (62.6%)	1,354 (78.5%)	1,458 (86.4%)
Grade of employment			
Clerical/support	351 (21.1%)	321 (18.5%)	345 (20.4%)
Professional	944 (56.8%)	898 (51.9%)	749 (44.2%)
Administrative	366 (22.0%)	512 (29.6%)	599 (35.4%)
Health Status			
Mean blood cholesterol, mmol/L (*SD*)	5.8 (1.0)	5.9 (1.0)	5.9 (1.0)
Mean BMI, kg/m^2 (*SD*)	24.1 (3.3)	24.3 (3.2)	24.3 (3.1)
Prevalent diabetes	13 (0.8%)	12 (0.7%)	8 (0.5%)
Health Behaviors			
Smoking status			
Never smoker	750 (45.4%)	843 (48.9%)	884 (52.4%)
Former smoker	559 (33.8%)	571 (33.1%)	559 (33.2%)
Current smoker	343 (20.8%)	311 (18.0%)	243 (14.4%)
Low-moderate alcohol consumption[b]	1,387 (84.2)	1,457 (84.8%)	1,443 (85.8%)
<1.5 hour/week of moderate-to-vigorous exercise	564 (34.0%)	524 (30.3%)	473 (27.9%)
Fruit/vegetable intake < once a day	797 (48.0%)	684 (39.5%)	603 (35.6%)
Psychological distress (*SD*)[c]	5.7 (6.5)	3.1 (4.6)	1.9 (3.5)

[a] Raw scores on the Satisfaction With Life Scale; [b] Women: <15 units/week; men: < 22 units/week. *SD* = standard deviation. [c] Raw scores on the 30-item General Health Questionnaire (range 0-30, where a higher score reflects greater psychological distress).
Notes. There were 0.0-0.8% of missing data on baseline covariates. Percentages refer to the column percentage of individuals within each life satisfaction category with that characteristic.

Table 2.
Distribution of covariates at baseline according to tertiles of life satisfaction in the stroke/TIA analytic sample (N = 6,158).

Covariates	Life satisfaction		
	Lower (0-11)[a] (*n*=1,975)	Moderate (12-19) (*n*=2,102)	Higher (20-30) (*n*=2,081)
Demographic Characteristics			
Mean age, years (*SD*)	44.6 (5.9)	45.0 (6.0)	45.3 (6.0)
Male	1,377 (69.7%)	1,477 (70.3%)	1,448 (69.6%)
White	1,809 (91.6%)	1,902 (90.5%)	1,919 (92.2%)
Married or cohabitating	1,228 (62.5%)	1,631 (77.9%)	1,789 (86.3%)
Grade of employment			
Clerical/support	414 (21.0%)	409 (19.5%)	418 (20.1%)
Professional	1,109 (56.2%)	1,077 (51.2%)	922 (44.3%)
Administrative	452 (22.9%)	616 (34.1%)	741 (35.6%)
Health Status			
Mean blood cholesterol, mmol/L (*SD*)	5.9 (1.0)	5.9 (1.0)	5.9 (1.1)
Mean BMI, kg/m^2 (*SD*)	24.5 (3.5)	24.6 (3.4)	24.6 (3.2)
Prevalent diabetes	18 (0.9%)	18 (0.9%)	15 (0.7%)
Prevalent hypertension	348 (18.1%)	380 (18.7%)	390 (19.4%)
Health Behaviors			
Smoking status			
Never smoker	919 (46.8%)	1,038 (49.6%)	1,087 (52.4%)
Former smoker	658 (33.5%)	700 (33.5%)	687 (33.1%)
Current smoker	385 (19.6%)	354 (16.9%)	300 (14.5%)
Low-moderate alcohol consumption[b]	1,632 (83.3)	1,758 (84.2%)	1,748 (84.6%)
<1.5 hour/week of moderate-to-vigorous exercise	668 (33.8%)	621 (29.5%)	593 (28.5%)
Fruit/vegetable intake < once a day	928 (47.2%)	818 (39.0%)	731 (35.2%)
Psychological distress (*SD)*[c]	6.0 (6.8)	3.2 (4.7)	1.9 (3.5)

[a] Raw scores on the Satisfaction With Life Scale; [b] Women: <15 units/week; men: < 22 units/week. *SD* = standard deviation, TIA = transient ischaemic attack. [c] Raw scores on the 30-item General Health Questionnaire (range 0-30, where a higher score reflects greater psychological distress).
Notes. There were 0.0-3.1% of missing data on baseline covariates. Percentages refer to the column percentage of individuals within each life satisfaction category with that characteristic.

Table 3.
Hazard ratios and 95% confidence intervals for the risk of incident hypertension and stroke/TIA, respectively, per 1-SD increase in life satisfaction.

	Hypertension (N = 5,085, cases n = 2,663)		Stroke/TIA (N = 6,158, cases n = 362)	
Model	HR	95% CI	HR	95% CI
1-age only	1.00	0.96-1.04	0.88	0.79-0.98
2-sociodemographics[a]	1.00	0.96-1.04	0.89	0.80-1.00
3-Model 2 + health status[b]	1.01	0.97-1.05	0.88	0.79-0.99
4-Model 3 + health behaviors and BMI[c]	1.01	0.97-1.05	0.88	0.79-0.98
5-Model 4 + psychological distress	1.01	0.97-1.05	0.94	0.84-1.05

Note. BMI = body mass index; CI = confidence interval; HR = hazard ratio; *SD* = standard deviation; TIA = transient ischaemic attack. a. Adjusted for sociodemographic characteristics (age, sex, race, marital status, and grade of employment); b. Adjusted for covariates in Model 2 and health status (blood cholesterol, diabetes, hypertension [stroke models only]); c. Adjusted for covariates in Model 3, health behaviors (smoking status, alcohol intake, exercise, fruit and vegetable consumption), and BMI.