TITLE: Is more, better? Relationships of multiple psychological well-being facets with cardiometabolic disease

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Anne-Josée Guimond was supported by salary and training support from the Canadian Institutes of Health Research (postdoctoral fellowship) and the Lee Kum Sheung Center for Health and Happiness. The authors have no conflicts of interest to disclose.

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Abstract

Abstract word count: 250/250

Objective: Cardiometabolic disease (CMD) is a leading cause of death and disability worldwide. Assessments of psychological well-being taken at one time point are linked to reduced cardiometabolic risk, but psychological well-being may change over time and how longitudinal trajectories of psychological well-being may be related to CMD risk remains unclear. Furthermore, psychological well-being is a multidimensional construct comprised of distinct facets, but no work has examined whether sustaining high levels of multiple facets may confer additive protection. This study tested if trajectories of four psychological well-being facets would be associated with lower risk of self-reported non-fatal CMD.

Methods: Participants were 4,006 adults aged ≥50 years in the English Longitudinal Study of Ageing followed for 18 years at biyearly intervals. Psychological well-being facets were measured in waves 1-5 using subscales of the Control, Autonomy, Satisfaction, and Pleasure scale (CASP-19). Latent class growth modeling defined trajectories of each facet. Incident CMD cases were self-reported at waves 6-9. Cox regression models estimated likelihood of incident CMD associated with trajectories of each facet individually and additively (i.e., having persistently high levels on multiple facets over time).

Results: After adjusting for relevant covariates, CMD risk was lower for adults with persistently high versus persistently low levels of control and autonomy. When considering potential additive effects, lower CMD risk was also related to experiencing persistently high levels of ≥2 versus 0 psychological well-being facets.

Conclusions: Findings suggest having and sustaining multiple facets of psychological well-being is beneficial for cardiometabolic health, and that effects may be additive.

Keywords: Psychological well-being; Cardiometabolic disease; Trajectories; Longitudinal study; Psychosocial factors; Risk factors

Introduction

Cardiometabolic diseases (CMD) including diabetes, heart disease, and stroke are leading causes of death and disability worldwide and engender a high societal and financial burden (American Heart Association, 2019). Research suggests that psychological well-being (PWB) is protective against the development and progression of CMD (Boehm, Chen, Williams, Ryff, & Kubzansky, 2016; Lambiase, Kubzansky, & Thurston, 2015; Panagi, Hackett, Steptoe, & Poole, 2020). Although the term 'psychological well-being' has been used to refer specifically to eudemonic well-being facets such as purpose in life and mastery (Ryff & Keyes, 1995), other authors define PWB as a broad construct that encompasses several facets including eudemonic well-being (e.g., autonomy, mastery) and hedonic well-being (e.g., positive affect, life satisfaction) (Diener, Pressman, Hunter, & Delgadillo-Chase, 2017). Because several of these well-being facets are associated with physical health (Boehm & Kubzansky, 2012; Trudel-Fitzgerald et al., 2019), in the current study, we adopted the broader definition of PWB.

To date, most studies assess PWB at a single point in time, but PWB may fluctuate over time as a result of developmental processes (Lucas & Donnellan, 2007) or major life experiences (e.g., unemployment). Prior work indicates that changes in PWB may even occur late in life. Further, existing evidence suggests that well-being does not change uniformly in older adults, but rather follows heterogeneous trajectories. For example, a study examined life satisfaction trajectories among 3,517 Korean adults aged ≥65 years who rated their life satisfaction five times over 8 years and found five distinct trajectories, one of which marked change over time: low-stable, middle-stable, improving, upper middle-stable, and high (Lim, Min, Thorpe, & Lee, 2017). While no study has examined longitudinal trends in PWB in relation to CMD risk, prior work on depression found that individuals with persistently high versus persistently low levels of depressive symptoms experienced elevated stroke risk (Gilsanz et al., 2017), suggesting that similar dynamics could be at play with PWB. Further, evidence suggests repeated assessments of PWB are more strongly associated with mortality than single assessments (Zaninotto, Wardle, &

Steptoe, 2016), and that highly variable PWB levels are associated with greater risk of mortality (Boehm, Winning, Segerstrom, & Kubzansky, 2015). These findings suggest that longer durations of exposure to PWB may be more health protective than fleeting experiences, perhaps because effects of PWB accumulate over time (Zaninotto et al., 2016).

Various facets of PWB represent theoretically distinct constructs that may have differential associations with health outcomes (Trudel-Fitzgerald et al., 2019). To date, only a handful of studies have examined trajectories of more than one PWB facet in relation to health outcomes. In a prospective investigation of 1,054 participants from the Midlife in the United States (MIDUS) study, longitudinal patterns of six PWB facets (i.e., autonomy, environmental mastery, personal growth, positive relations with others, purpose in life, and self- acceptance) were defined using assessments at study baseline and 9-10 years later; these patterns were then evaluated in relation to multiple lipid measures at follow-up (Radler, Rigotti, & Ryff, 2018). Results demonstrated that participants with persistently high versus persistently low PWB on four of the six facets had healthier lipid profiles at follow-up. Using the same PWB facets and follow-up period, another MIDUS study found that across all six facets, individuals with persistently high versus low PWB had better self-reported physical health and fewer chronic conditions, physical symptoms, and functional limitations at follow-up after accounting for baseline health status (Ryff, Radler, & Friedman, 2015). Notably, findings regarding increasing or decreasing patterns of PWB were mixed across both studies; while no associations were observed with lipids (Radler et al., 2018), participants with decreasing levels reported worse self-reported health and symptoms at follow-up compared to those with persistently high levels (Ryff et al., 2015). Other work in MIDUS and its sister study, the Midlife in Japan cohort (MIDJA), has demonstrated that sustaining high levels of life satisfaction and positive affect across two (MIDJA) or three (MIDUS) time points at 10 year intervals was associated with lower risk of mortality (Willroth, Ong, Graham, & Mroczek, 2020). In the same study, decreases in life satisfaction and positive affect were related to having more chronic conditions at follow up. In a model including life satisfaction and positive affect as simultaneous predictors of health, both facets were uniquely associated with having more chronic health conditions. Taken together, these results suggest that PWB trajectories are evident across time but have different associations with health depending on the specific outcome or pattern of PWB

One limitation of the MIDUS studies described above is that they measured the health outcomes at the same time as the last measurement from which the well-being trajectories are derived. Thus, the levels of well-being observed at the last time point might have been affected by the presence of illness. Fully prospective studies that measure change in well-being before disease onset are needed to preserve the temporal order of the linkage between well-being and disease onset and reduce concerns about reverse causality. Another limitation of prior work pertains to the scarcity of PWB assessments available in most studies. Although two or three temporally separated observations of PWB provide useful information about change over time, additional observations are needed to provide more nuanced characterization of PWB trajectories, including potential nonlinear patterns (Duncan & Duncan, 2004). In addition, while previous findings suggest unique associations between trajectories of individual PWB facets and health (Willroth et al., 2020), several outstanding questions remain. Notably, it remains unclear whether PWB facets are equally protective, and if experiencing high PWB levels on multiple facets confers stronger protection against CMD incidence. Although PWB facets are generally recognized to be intercorrelated (Trudel-Fitzgerald et al., 2019), individuals can experience high levels on one facet (e.g., life satisfaction) without necessarily experiencing high levels of other types of PWB (e.g., positive affect) (Steptoe, 2019). Earlier work showed that experiencing multiple co-occurring indicators of negative psychological functioning (e.g., anxiety, depression, anger, hostility), relative to none or a single indicator, is associated with increased risk of cardiometabolic outcomes (Boyle, Michalek, & Suarez, 2006; Garfield et al., 2014). Research on the linkage between cumulative stress and health also demonstrated that exposure to multiple stressors exceeds the detrimental health consequences of single exposures

(Slopen, Meyer, & Williams, 2018). Other work looking at psychosocial resources has found that exposure to a higher number of *favorable* psychosocial factors in youth (e.g., social adjustment, favorable emotional family environment) is associated with better cardiovascular health in adulthood and that the effects of psychosocial factors are additive (Appleton et al., 2013; Pulkki-Råback et al., 2015). These findings suggest there is value in moving beyond a single factor approach to considering how multiple indicators of psychological functioning may jointly be associated with CMD risk. From a clinical perspective, a nuanced examination of separate and additive effects of trajectories of multiple PWB facets in relation to CMD risk has the potential to help determine which and how many facets might be targeted in psychological interventions aiming to improve PWB as well as potentially reduce CMD risk.

This study aimed to examine the association between heterogeneous trajectories of multiple PWB facets and CMD incidence in older adults. We characterized latent trajectories of four facets of PWB (control, autonomy, self-realization, and pleasure) measured on 5 occasions over 9 years among adults initially aged 50 and older in the English Longitudinal Study of Ageing (ELSA). We then used these trajectories to evaluate prospective associations with incident self-reported non-fatal CMD over 9 additional years of follow-up. Based on previous work (Lim et al., 2017; Radler et al., 2018; Ryff et al., 2015), we hypothesized that distinct trajectories of each facet of PWB would be evident (e.g., persistently high, persistently moderate, persistently low, decreasing, and increasing). We also hypothesized that for each PWB facet, having persistently high levels (vs. persistently low) would be associated with lower CMD risk. Additionally, we examined potential additive effects of reporting persistently high levels of multiple PWB facets in relation to risk of incident CMD. Based on prior work (Boehm et al., 2018), we considered relevant covariates that could either confound the associations of interest (e.g., health status) or lie on the pathway (e.g., health behaviors). Given prior work demonstrating increased risk of CMD with depression (Carney & Freedland, 2017), we also evaluated whether PWB related to CMD independently, that is, over and above simply signaling the absence of depression.

Methods

Participants

We used data from the English Longitudinal Study of Ageing (ELSA; Banks et al., 2019) a nationally representative biennial longitudinal survey of men and women aged ≥50 living in private households in England (Steptoe, Breeze, Banks, & Nazroo, 2013). Adults from households that participated in the annual cross-sectional Health Survey for England between 1998 and 2000 were recruited for ELSA. The first ELSA interview in 2002–2003 (wave 1; N=11,497) serves as the current study's baseline (Steptoe et al., 2013). Follow-up interviews took place in 2004–2005 (wave 2), 2006–2007 (wave 3), 2008–2009 (wave 4), 2010–2011 (wave 5), 2012–2013 (wave 6), 2014–2015 (wave 7), 2016–2017 (wave 8), and 2018–2019 (wave 9), with response rates ≥73% at each wave (NatCen, 2019; Steptoe et al., 2013). PWB and physician-diagnosed CMD were self-reported at each wave. For the present analyses, participants were excluded if they were missing PWB data on >3 waves during waves 1-5 (*n*=4,816), reported a history of CMD at wave 1 or incident CMD between waves 1 and 5 when PWB trajectories were created (*n*=1,889), or were missing outcome information during all assessments between waves 6-9 (*n*=966), resulting in an analytic sample of 3,826 participants. Missing data on covariates were documented for 0.0% to 2.8% of participants in this analytic sample.

At baseline, excluded versus included participants tended to be older, more likely to be male, non-white, and single, have lower educational attainment, be unemployed, have a history of hypertension, have lower levels of alcohol consumption and physical activity, be current or former smokers, have higher BMI and depressive symptoms, and have lower PWB (see Supplemental Table 1). To mitigate potential selection bias induced by differential attrition, we created inverse probability weights based on the exposure and covariates of interest (Seaman &

White, 2013). Estimates from analyses using these weights were similar to unweighted estimates, therefore only the latter are presented.

ELSA has been approved by the UK National Research Ethics Service and all participants provided written informed consent. All ELSA data are available to qualified researchers through the UK Data Service (https://ukdataservice.ac.uk/use-data.aspx). Analytic methods will be provided upon request to the first author.

Measures

Psychological Well-Being

Participants completed the 19-item Control, Autonomy, Self-realization, Pleasure scale (CASP-19; Hyde, Wiggins, Higgs, & Blane, 2003) at waves 1-5 (see Figure 1 for a visual representation of the study design). The CASP-19 includes four subscales developed specifically to assess PWB in older adults: control (6 items), autonomy (5 items), self-realization (4 items) and pleasure (4 items). Based on previous work (Boehm et al., 2017; Boehm et al., 2018), to prevent physical health from confounding the association between PWB and CMD, we removed two items related to health ('My age prevents me from doing the things I would like to' and 'My health stops me from doing things I want to do'), thereafter referred to as CASP-17. Items were scored on a 4-point Likert scale and summed by subscale, with higher values representing greater levels of each individual PWB facet. Following prior work with psychological measures (Bell, Fairclough, Fiero, & Butow, 2016), if participants completed ≥60% of the items for a subscale at each wave, then missing values were imputed with the mean value of non-missing items at that wave for the subscale. Across waves 1-5, the proportion of individuals that required imputed values for each subscale was ≤3.4% for control, ≤1.5% for autonomy, ≤1.0% for self-realization, and ≤0.7% for pleasure.

The CASP-19 was previously validated in ELSA (Hyde et al., 2003; Wiggins, Netuveli, Hyde, Higgs, & Blane, 2008). In our analytic sample, internal consistency reliability varied for the individual CASP-17 subscales (α across waves 1-5: control = 0.57-0.67; autonomy = 0.56-0.62; self-realization = 0.78-0.79; pleasure = 0.67-0.72). Although reliability was modest on several subscales, we maintained them in their original form to be consistent and comparable with prior work. Moreover, in this sample, the subscales demonstrated good convergent and divergent validity, with scores on each subscale correlated in the expected direction with scores of life satisfaction at wave 2 (the first wave where life satisfaction was measured in ELSA; *r*s range: 0.48 – 0.63), and with depressive symptoms at wave 1 (*r*s range: -0.42 – -0.35), respectively. Finally, these subscales were associated in the expected direction with other health outcomes in earlier ELSA studies, including type 2 diabetes, mortality, and inflammation (Fancourt & Steptoe, 2019; Panagi et al., 2020; Zaninotto et al., 2016).

Cardiometabolic Diseases

CMDs were self-reported during each wave. At baseline, participants were asked if a physician ever told them they had heart attack, angina, congestive heart failure, stroke, or diabetes. In subsequent waves, participants were asked if they experienced new diagnoses since their last interview. Cases of heart attack, angina, congestive heart failure, stroke, and diabetes were combined to create a composite CMD measure (0=no condition, 1= ≥1 condition). Incident CMD cases were documented between waves 6 and 9 (mean follow-up=6.5 years, *SD*=2.3; Figure 1). Time of diagnosis was indexed as the wave at which the participant first reported a diagnosis of any of the five CMD conditions. Mortality data from the National Health Service central data registry was not available after wave 6 so the current study's outcome included self-reported non-fatal CMD only.

Covariates

Covariates were selected based on past research (e.g., Boehm et al., 2017; Panagi et al., 2020) and were self-reported at baseline, except for self-reported physician diagnosed high blood cholesterol and body mass index (BMI), which were measured at wave 2. Sociodemographic factors, which can be related to both PWB and CMD and thus act as confounders (Boehm & Kubzansky, 2012), included age (measured continuously in years, with participants aged >90 years assigned the value of 91 to preserve confidentiality), sex (men, women), ethnicity (White, non-White), marital status (married/cohabitating, not married/cohabitating), educational attainment (university degree or equivalent, higher education but not university degree, A-level [high school equivalent], O-level [national school exam at age 16 years], or less than O-level) and employment status (currently working, not currently working, including unemployed, retired, and on sick leave). Health-related confounders included self-reported physician-diagnosed hypertension (yes, no) and high blood cholesterol (yes, no), as well as BMI. BMI in kg/m^2 was derived from height and weight measurements taken by a nurse at wave 2. For participants whose height and weight were not ascertained at wave 2, measures from either the Health Survey for England or wave 4 of ELSA were used when available. Health behaviors were included to account for their potential confounding effects on associations of interest. While these factors can be considered both as potential confounders and mediators of the association between PWB and cardiometabolic health (Kubzansky et al., 2018), adjusting for behaviors assessed at baseline rather than later during the follow-up ensures that we did not adjust for their potential indirect mediating effects which may obscure the true association between PWB and CMD. We included the following health behaviors: cigarette smoking (current, former, or never smoker), alcohol consumption (daily, once or twice a week, a few times a year, not at all), and physical activity (sedentary/low, moderate/vigorous). Physical activity was assessed with a single item asking participants about the amount of physical activity they engaged in at work, as well as three items asking about how often they engaged in vigorous, moderately energetic, and mildly energetic sports or activities. ELSA data managers categorized responses (sedentary, low, moderate, and high levels of activity) to reflect classifications used in the Allied Dunbar Survey of Fitness (U.K. Activity and Health Research, 1992). Lastly, depressive symptoms were included to test if the relationship between PWB and CMD is independent of depression. Depressive symptoms were self-reported by participants using the eight-item version of the Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977) and the internal consistency in our analytic sample was acceptable ($\alpha = 0.79$).

Statistical Analyses

All analyses were conducted using SAS 9.4 (SAS Institute inc., 2013) and 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 (Roth, 1994). We employed latent class growth modeling (LCGM) to identify subgroups of participants displaying similar trajectories within the four CASP-17 subscales separately between waves 1-5. Although several statistical approaches can be used to analyze trajectories of change in a variable over time, including multilevel models (MLM), we selected LCGM because we were specifically interested in examining how potentially distinct trajectories of well-being relate to CMD incidence. LCGM is a semi-parametric technique that estimates categorical latent classes that group participants with a similar PWB pattern over the study period. This technique is highly appropriate to our research question because it can identify distinct subgroups of individuals within the population who exhibit different trajectories over time on a variable (Andruff, Carraro, Thompson, Gaudreau, & Louvet, 2009; Columbia Public Health, 2021). We performed LCGM using SAS PROC TRAJ, a procedure that uses all available data and employs an imputation technique to assign values for missing data on the variable of interest (PWB facets in our study) (Jones & Nagin, 2007; Jones, Nagin, & Roeder, 2001). We considered models with up to 6 trajectories. Drawing on prior work (Andruff et al., 2009; Nagin, 2005), we used a combination of criteria to select the optimal number of latent classes. These included the Bayesian Information Criterion (BIC), where a lower value indicates a better fit, the log Bayes Factor, calculated as 2 ∗ (BIC of the more complex model − BIC of the simpler model; a simpler model refers to one with fewer estimated classes), and subjective judgment (i.e., class size >5% of the total sample and/or distinctively different trajectories). Next, we selected the optimal shape of each group's mean trajectory (i.e., linear, quadratic, or cubic) based on the statistical significance of linear, quadratic, and cubic polynomial terms. The final model was further tested for model adequacy by examining the following indices: 1) whether there was good correspondence between the estimated probability of group membership and proportion assigned to that group based on posterior probability of group membership; 2) whether the odds of correct classification (OCC) for each group suggested good assignment accuracy for groups, with greater values suggesting better assignment accuracy and with values > 5 indicating high assignment accuracy; and 3) whether there was good internal reliability for each trajectory group based on the average posterior probability of assignment (> 0.70)(Nagin, 2005). Participants were assigned to a single trajectory group based on the maximum probability assignment rule (Andruff et al., 2009). Trajectories were labeled based on visual interpretation of their graphical representation and taking into consideration the mean scores obtained for the trajectory groups at each time assessment (e.g., 'persistently low'; 'persistently high').

Hazard ratios (HRs) and 95% confidence intervals (CIs) of incident CMD associated with PWB trajectory groups were estimated using multivariate Cox proportional hazards models using SAS PROC PHREG. For each CASP-17 subscale, associations between trajectory groups and CMD were tested in five nested models adjusting progressively for baseline covariates. The first model reported unadjusted associations. The second model adjusted for sociodemographic factors (age, sex, ethnicity, marital status, education, and employment status). The third model further adjusted for health status (BMI and history of hypertension and high blood cholesterol). The fourth model added behavioral covariates (smoking status, alcohol consumption, and physical activity). The last model further controlled for depressive symptoms. Follow-up time was calculated as time from the end of the assessment of PWB (i.e., wave 5) to the first CMD event, last participation date, or end of follow-up (i.e., wave 9)—whichever came first. For each CASP-17 subscale, the trajectory group reflecting the lowest levels of PWB was used as the reference group in the models. However, due to a low count of CMD cases in the lowest trajectory groups of control and self-realization, we conducted sensitivity analyses using the trajectory reflecting moderate-low levels of PWB as the reference group; because results were similar when using the 'low' trajectory as reference group, we reported findings from these models only. Additionally, we assessed whether displaying persistently high levels of multiple PWB facets was associated with a reduced risk of incident CMD in the same set of models using a categorical variable indicating whether participants reported persistently high levels of 0, 1, 2, or 3-4 PWB facets. Due to a low count of CMD cases among those with persistently high levels of either 3 or 4 PWB facets, we combined these groups into a single category. Verification of the scaled Schoenfeld residuals indicated that the proportional hazard assumption was met in all models (Grambsch & Therneau, 1994; Kleinbaum & Klein, 2010).

As highly stable trajectories of PWB were observed (see Results section), we conducted post-hoc secondary analyses to clarify the extent to which measuring PWB across several time points provides more meaningful information than PWB measured at a single time point. Following prior work (Lambiase et al., 2015), we created tertiles of each CASP-17 subscale based on the distribution of scores in the analytic sample at study baseline and estimated associations with incident CMD using multivariate Cox proportional hazards models, as described above. Then, in order to facilitate comparisons between these models and the Cox models on the association between PWB trajectory groups and incident CMD, we converted the hazard ratios (HR) into Cohen's *d*s (Azuero, 2016) for the sociodemographics-adjusted models.

Results

Participant Characteristics

Table 1 presents characteristics of the analytic sample at baseline. Participants were on average 61 years old (*SD*=8; range=50-91). More participants were women (59.2%), White (98.5%), married/cohabitating (76.2%), and not currently working (53.4%). Mean BMI was 27.5

kg/m[2], 27.8% of the participants reported a history of hypertension, and 15.1% reported a history of high blood cholesterol. The correlations between facets of PWB ranged from .48 to .66, with pleasure and self-realization being the strongest. Over a mean follow-up of 6.5 years (range=1-9 years), 481 incident CMD cases occurred.

Trajectories of Psychological Well-Being Facets

For *control*, we retained a 4-group solution (see Supplemental Table 2 for all model selection statistics, and Supplemental Table 3 for all model fit statistics). Trajectories reflected groups of individuals with persistently low (*n*= 281; 7.7% of the total sample), moderate (*n*=1,134; 29.8%), moderate-high (*n*=2,040; 51.5%) and high (*n*=371; 11.0%) levels of control (see Figure 2a). For *autonomy*, a 3-group solution provided the optimal and parsimonious fit (Figure 2b). The trajectories reflected groups of participants with persistently low (*n*=572; 15.3%), moderate (*n*=2,194; 56.2%), and high (*n*=1,060; 28.5%) autonomy levels. For *self-realization*, we retained a 4-group solution of persistently low (*n*= 251; 6.6%), moderate (*n*=915; 24.4%), moderate-high (*n*=1,693; 43.1%) and high (*n*=967; 25.8%; Figure 2c) levels. Finally, for *pleasure*, we identified a 3-group solution that reflected persistently low (*n*=572; 15.3%), moderate (*n*=2,194; 56.2%), and high (*n*=1,060; 28.5%; Figure 2d) levels. For each subscale, mean scores obtained in the trajectory groups at each time point are shown in Supplemental Table 4. Across facets, trajectories were relatively flat over time. We found no trajectories displaying marked decreasing, increasing, or fluctuating PWB.

Trajectories of Individual Facets of Psychological Well-Being and Incident CMD

For *control*, in the model adjusting for sociodemographic factors, participants in the trajectory reflecting persistently high versus persistently low levels had a 50% decreased risk of incident CMD (HR=0.50, 95% CI=0.30-0.81; see Table 2). Associations remained evident after controlling for health status, health behaviors, and depressive symptoms (e.g., fully adjusted HR=0.56, 95% CI=0.34-0.94). For *autonomy,* persistently high versus low levels were associated with a 35% decreased risk of incident CMD in the model adjusting for sociodemographic factors (HR=0.65, 95% CI=0.49-0.86). Associations were maintained after adjusting for health- and behavior-related covariates as well as depressive symptoms (e.g., fully adjusted HR=0.71, 95% CI=0.53-0.96). For *self-realization,* risk of incident CMD was 40% lower for participants with persistently high versus low levels in the model adjusting for sociodemographic factors (HR=0.60, 95% CI=0.40-0.88). Associations were slightly attenuated after adjustment for health- and behavior-related covariates as well as depressive symptoms (fully adjusted HR=0.68, 95% CI=0.45-1.03). For *pleasure,* persistently high versus persistently low levels were associated with a 38% reduction in subsequent CMD risk when adjusting for sociodemographic factors (HR=0.62, 95%CI=0.44-0.86). Associations were slightly attenuated after adjustment for health status, health behaviors, and depressive symptoms (e.g., fully adjusted HR=0.72, 95% CI=0.50-1.01). For the four PWB facets, results obtained in unadjusted models were comparable to those obtained in models adjusting for sociodemographic factors.

Combined Facets of Psychological Well-Being and Incident CMD

Considering the total number of facets on which participants reported being in the highest trajectory group (i.e., persistently high levels), about half of the sample (*n*=2,123) had persistently high levels on no facets, whereas 18.9% (*n*=722), 13.7% (*n*=523), and 12.0% (*n*=458) participants reported being persistently high on 1, 2, or 3-4 facets, respectively. As shown in Figure 3, individuals who reported persistently high levels on a single subscale had a marginally lower risk of incident CMD compared to those without high levels on any PWB facet (e.g., sociodemographics-adjusted HR=0.80, 95% CI=0.63-1.02). Participants with persistently high levels on 2 facets versus none had a 33% reduced risk of CMD (sociodemographics-adjusted HR=0.67, 95% CI=0.50-0.90), whereas risk of CMD was 46% lower for those with persistently high levels on 3-4 facets (sociodemographics-adjusted HR=0.54, 95% CI=0.38-0.77). Associations were robust to further adjustment for health status, health-related behaviors, and depression (persistently high levels of 2 facets HR=0.70, 95% CI: 0.52-0.94; 3-4 facets HR=0.59, 95% CI=0.42-0.84).

Baseline Facets of Psychological Well-Being and Incident CMD

Participants in the highest versus lowest tertile of autonomy and pleasure had reduced risk of incident CMD in models adjusting for sociodemographic factors (autonomy HR=0.76, 95% CI=0.59-0.97; pleasure HR=0.66, 95% CI=0.50-0.87; see Supplemental Table 5 for full results). Fully adjusted associations with pleasure were maintained but associations with autonomy were attenuated. High levels of control and self-realization were weakly associated with incident CMD in all models (e.g., in models adjusting for sociodemographic factors, control: HR=0.90, 95% CI=0.72-1.12; self-realization: HR=0.81, 95% CI=0.65-1.02). Cohen's *d*s suggested that in most cases, the associations of high levels of PWB measured at baseline only with CMD were of a smaller magnitude than the associations of persistently high (vs. persistently low) PWB trajectories and CMD (e.g., control: highest vs. lowest baseline tertile *d*=0.08, persistently high vs. persistently low PWB *d*= 0.54; self-realization: highest vs. lowest baseline tertile *d*=0.16, persistently high vs. persistently low PWB *d*= 0.40; see Supplemental Table 6 for full results).

Discussion

This study describes latent trajectories of specific facets of PWB over 9 years in older adults and investigated their prospective associations with incident CMD over an additional 9 years of follow-up. For each facet, we found 3 or 4 distinct trajectories of persistently low, moderate, moderate high, or high levels. Somewhat surprisingly, levels were remarkably stable over the follow-up, and we found no marked declining, increasing, or variable levels of any individual facets over time. After adjusting for all covariates, experiencing persistently high levels of control and autonomy were robustly associated with reduced risk of developing CMD during the follow-up period. Persistently high levels of self-realization and pleasure were also related with reduced CMD risk, but the associations were attenuated after adjusting for depressive symptoms. These findings were similar to those examining levels of each PWB facet at baseline only, but associations with the trajectories were of stronger magnitude. Risk of CMD did not differ meaningfully between participants who reported high levels of a single facet versus none, whereas individuals with persistently high levels on 2 or 3-4 facets exhibited a substantially reduced CMD risk over follow-up.

Overall, these results are consistent with earlier work demonstrating associations of persistently high levels of PWB facets with better health outcomes (Radler et al., 2018; Ryff et al., 2015; Zaninotto et al., 2016). Moreover, findings supported our hypothesis that persistently high levels of individual facets of PWB would be similarly associated with reduced risk of incident CMD. Also in line with previous findings (Zaninotto et al., 2016), we found that associations between baseline levels of PWB facets and reduced risk of incident CMD were of smaller magnitude than those observed with trajectories of PWB. More specifically, in the fully adjusted models, only baseline pleasure was strongly associated with reduced CMD risk. This might indicate that protective effects of PWB facets accumulate over time (Zaninotto et al., 2016), suggesting that while single measurements of PWB are informative, there may be added value in conducting repeated assessments across several time points when examining associations with health.

When adjusting for depressive symptoms, associations for the PWB trajectories were maintained for control and autonomy, and somewhat attenuated for self-realization and pleasure. These findings suggest the relationship of PWB facets with risk of developing CMD is at least partly independent of depression. In fact, the presence of high levels of PWB is not synonymous with the absence of depression and having additional information about individuals' experiences of positive psychological functioning may add important predictive information regarding CMD risk (Kubzansky et al., 2018). Also worth noting is that our results were maintained after adjustment for baseline health status and health-related behaviors, factors hypothesized to confound the association between PWB and cardiometabolic health. Future research should investigate potential mechanisms in more detail, potentially considering conventional health related behaviors assessed at time points after the assessment of PWB or additional health behaviors not measured in our study, like sleep (Leger, Blevins, Crofford, & Segerstrom, 2020). PWB may also relate to cardiometabolic health by enhancing biological functioning (Kubzansky et al., 2018). More research is warranted to investigate whether biomarkers such pro-inflammatory cytokines may help explain the PWB and cardiometabolic disease association (Kubzansky et al., 2018).

Based on previous work (e.g., Lim et al., 2017), we expected to find trajectories of stable, decreasing, and increasing PWB. Our hypothesis was partly confirmed, as we found trajectories of persistently low, moderate, and high levels of each facet, but no fluctuations over time. Interestingly, close examination reveals that the majority of participants in previous studies outside of ELSA were also classified in stable trajectories of well-being (e.g., Radler et al., 2018; Ryff et al., 2015). It is possible that PWB varies more early in life or in periods surrounding important life transitions, such as starting college or entering the job market. More research is warranted to investigate how changes in PWB among younger populations relate to the maintenance of cardiometabolic health.

Our study extends previous findings by considering the additive effects of experiencing persistently high levels of multiple facets of PWB. As hypothesized, we found having high levels on more than one facet seemed to have additional benefits regarding risk of incident CMD, regardless of which facets were involved. More specifically, results suggest a dose-response relationship whereby protective effects of PWB facets on CMD risk become more pronounced with each increase in the number of individual PWB facets on which individuals report persistently high levels. This is noteworthy because studies on PWB's association with physical health typically consider facets of PWB separately (Trudel-Fitzgerald et al., 2019), which limits our understanding of how their additive effects impacts subsequent health. Our findings are consistent with previous work that showed additive effects of psychosocial factors on health (Appleton et al., 2013; Pulkki-Råback et al., 2015), and may suggest the value of monitoring multiple facets of PWB in ongoing and future health cohorts. At present relatively few large-scale studies include any measures of PWB and, when they do, it is often a single item assessing life satisfaction (e.g., https://health.gov/healthypeople/objectives-and-data/overall-health-and-well-being-measures). Moreover, researchers should consider how the accumulation of multiple facets of PWB may influence health, instead of considering facets separately.

Study limitations include the use of self-reported physician-diagnosed CMD. Although other work indicates self-reports show strong agreement with medical records (Okura, Urban, Mahoney, Jacobsen, & Rodeheffer, 2004), they can be susceptible to recall bias. Another limitation is that we could not include death due to CMD in our endpoint because it was unavailable for the duration our study's follow-up. As a result, our findings may provide conservative estimates of the associations between PWB facets and CMD and might not be generalizable to fatal CMD. Also, CMD was reported every 2 years. More precise estimates might have been obtained with a less coarse measurement scale (e.g., exact date of diagnosis). Although numerous studies have used the CASP subscales to examine PWB's relationship with health in older adults (e.g., Boehm et al., 2017; Panagi et al., 2020; Poole, Hackett, Panagi, & Steptoe, 2019; Zaninotto et al., 2016), the CASP is not an exhaustive measure of all relevant PWB facets. As a result, key facets associated with health in past studies (e.g., optimism, purpose and meaning in life, life satisfaction) (Boehm et al., 2020; Kim, Sun, Park, & Peterson, 2013) were not included in our study; future research should examine their potential additive effects on CMD risk. Moreover, the homogeneity of our sample of White English adults limits generalizability, and the observational study design limits our ability to make conclusive statements about causality. One limitation pertaining to the use of LCGM is that at least 3 time-points are necessary to perform this analysis, which can lead to selection bias. In our study, individuals included versus excluded from the analytic sample tended to be younger, more socioeconomically advantaged, and healthier; however, we implemented inverse probability weighting to account in part for attrition and found results in models with versus without the weights to be highly comparable. Finally, even though some of our study's covariates (e.g., depression, health behaviors) could have changed over time, all covariates were assessed as static variables at baseline primarily to mitigate potential confounding bias. Study strengths include multiple time assessments of several PWB facets and a prospective design that excluded people with pre-existing CMD and those who developed CMD during the exposure period, mitigating concerns about potential reverse causality. Another strength is the use of LCGM, which allowed us to identify subgroups of participants displaying similar patterns of changes on each PWB facet and led to a more nuanced characterization of temporal changes in PWB compared to considering average PWB change in the group as a whole.

Conclusion

In this study of older adults, levels of multiple facets of PWB remained fairly stable over a 9-year period. Persistently high levels of individual PWB facets were associated with reduced risk of developing CMD. Of note, each facet of PWB demonstrated protective associations, suggesting that attaining high levels on any PWB can benefit health. As importantly, effects of sustained high PWB on CMD risk seem to be additive, with participants experiencing persistently high levels on several facets showing reduced risk of CMD relative to those with none. Such findings are particularly relevant in the context of a growing interest in monitoring not only mental health problems but also PWB (Roger et al., 2020). Our findings have clinical implications as well. Given the relative stability of PWB over time and its associations with CMD risk, patients with lower PWB levels may benefit from heightened surveillance and monitoring of their health by their health care providers. Moreover, our findings suggest psychosocial interventions targeting multiple facets of PWB might be more beneficial for cardiometabolic health than those focusing on one.

Acknowledgements

Statistical support was provided by data science specialist Drs. Steven Worthington and Jinjie Liu, at the Institute for Quantitative Social Science, Harvard University, and by Dr. Sebastien Haneuse, Professor of Biostatistics at the Harvard T. H. Chan School of Public Health.

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Table 1.

Distribution of covariates at baseline (*N* = 3,826).

Covariates	N (%)
Mean age, years (*SD*)	61.8 (8.0)
Female	2,264 (59.2%)
White	3,769 (98.5%)
Married or cohabitating	2,916 (76.2%)
Education level	
University degree	633 (16.6%)
Higher education, no degree	560 (14.6%)
A-level	276 (7.2 %)
O-level	789 (20.6%)
Less than O-level	1,567 (41.0%)
Employed	1,784 (46.6%)
Mean BMI, kg/m^2 (*SD*)	27.5 (4.7)
Prevalent hypertension	1,062 (27.8%)
Prevalent high blood cholesterol	560 (15.1%)
Smoking status	
Never smoker	1,566 (41.0%)
Former smoker	1,677 (44.0%)
Current smoker	573 (15.0%)
Daily alcohol consumption	1,229 (32.2%)
Sedentary/low physical activity	700 (18.4%)
Mean depressive symptoms (*SD)*	1.2 (1.7)

Notes. *SD* = standard deviation.

Table 2.
Hazard ratios (HR) and 95% confidence intervals (CI) for the association between trajectory groups of psychological well-being and incident CMD (N=3,826).

PWB trajectory groups		Model 1- Unadjusted HR (95% CI)	p	Model 2- Socio-demographics[a] HR (95% CI)	p	Model 3- + health status[b] HR (95% CI)	p	Model 4- + health behaviors[c] HR (95% CI)	p	Model 5- + depressive symptoms HR (95% CI)	p
Control	*n* (cases)										
Low	281 (40)	Reference									
Moderate	1,134 (144)	0.87 (0.61-1.23)	.42	0.87 (0.61-1.24)	.44	0.88 (0.62-1.25)	.48	0.88 (0.62-1.25)	.47	0.91 (0.63-1.31)	.61
Moderate-high	2,040 (270)	0.88 (0.63-1.23)	.45	0.90 (0.64-1.25)	.53	0.94 (0.67-1.31)	.71	0.94 (0.67-1.32)	.71	0.99 (0.69-1.42)	.96
High	371 (27)	0.50 (0.31-0.81)	.01	0.50 (0.30-0.81)	.01	0.53 (0.32-0.86)	.01	0.53 (0.32-0.86)	.01	0.56 (0.34-0.94)	.03
Autonomy											
Low	572 (88)	Reference									
Moderate	2,194 (280)	0.84 (0.66-1.06)	.15	0.80 (0.63-1.02)	.07	0.81 (0.64-1.03)	.09	0.83 (0.65-1.05)	.14	0.85 (0.65-1.08)	.18
High	1,060 (113)	0.69 (0.52-0.91)	.01	0.65 (0.49-0.86)	.004	0.68 (0.51-0.90)	.01	0.69 (0.52-0.92)	.01	0.71 (0.53-0.96)	.03
Self-realization											
Low	251 (37)	Reference									
Moderate	915 (137)	0.91 (0.63-1.30)	.60	0.89 (0.62-1.29)	.55	0.95 (0.66-1.38)	.80	0.95 (0.66-1.37)	.78	0.97 (0.66-1.40)	.86
Moderate-high	1,693 (216)	0.77 (0.54-1.09)	.14	0.80 (0.56-1.14)	.22	0.86 (0.60-1.23)	.41	0.86 (0.60-1.24)	.43	0.89 (0.61-1.29)	.53
High	967 (91)	0.54 (0.37-0.80)	.01	0.60 (0.40-0.88)	.01	0.65 (0.44-0.97)	.03	0.66 (0.44-0.97)	.04	0.68 (0.45-1.03)	.07
Pleasure											
Low	575 (74)	Reference									
Moderate	2,376 (336)	1.08 (0.84-1.39)	.53	1.07 (0.83-1.38)	.59	1.08 (0.83-1.39)	.57	1.10 (0.85-1.42)	.47	1.14 (0.87-1.48)	.35
High	875 (71)	0.58 (0.42-0.80)	.001	0.62 (0.44-0.86)	.004	0.66 (0.48-0.92)	.02	0.68 (0.49-0.95)	.02	0.72 (0.50-1.01)	.06

Note. PWB = psychological well-being; CI = confidence interval; HR = hazard ratio.
[a] Adjusted for sociodemographic characteristics (age, sex, race, marital status, education, employment status); [b] Adjusted for covariates in Model 1 and health status (hypertension, high blood cholesterol, body mass index); [c] Adjusted for covariates in Model 2 and health behaviors (smoking status, alcohol intake, physical activity).

Supplemental Table 1.
Distribution of psychological well-being and baseline covariates in included versus excluded participants.

Covariates N (%)	Included (N = 3,826)	Excluded (N = 7,671)
Mean age, years (*SD*)	61.8 (8.0)	67.3 (10.6)
Female	2,264 (59.2%)	4,009 (52.3%)
White	3,769 (98.5%)	7,370 (96.5%)
Married or cohabitating	2,916 (76.2%)	5,021 (65.6%)
Education level		
University degree	633 (16.6%)	642 (8.4%)
Higher education, no degree	560 (14.6%)	700 (9.2%)
A-level	276 (7.2 %)	410 (5.4%)
O-level	789 (20.6%)	1,020 (13.4%)
Less than O-level	1,567 (41.0%)	4,869 (63.7%)
Employed	1,784 (46.6%)	1,901 (24.8%)
Mean BMI, kg/m^2 (*SD*)	27.5 (4.7)	28.1 (5.0)
Prevalent hypertension	1,062 (27.8%)	3,287 (42.9%)
Prevalent high blood cholesterol	560 (15.1%)	1,130 (22.0%)
Smoking status		
Never smoker	1,566 (41.0%)	2,466 (32.9%)
Former smoker	1,677 (44.0%)	3,590 (47.9%)
Current smoker	573 (15.0%)	1,447 (19.3%)
Daily alcohol consumption	1,229 (32.2%)	1,956 (26.1%)
Sedentary/low physical activity	700 (18.4%)	2,963 (39.6%)
Mean depressive symptoms (*SD)*	1.2 (1.7)	1.8 (2.1)
Mean psychological well-being (*SD*)		
Control	11.3 (2.6)	10.7 (3.0)
Autonomy	9.6 (1.9)	9.2 (2.1)
Self-realization	8.9 (2.3)	7.9 (2.7)
Pleasure	10.4 (1.6)	9.9 (1.8)

Notes. *SD* = standard deviation; BMI = body mass index.

Supplemental Table 2.
Model selection statistics of latent class growth modeling analyses of CASP-17 subscales across waves 1-5.

Nb. of trajectories	BIC	Log Bayes factor	Proportion of participants per trajectory group (%)					
Control			1	2	3	4	5	6
1	-39581.3	-	100.0					
2	-37549.4	4063.7	32.1	68.0				
3	-36926.7	1245.4	13.9	52.7	33.4			
4	**-36693.2**	**466.9**	**8.0**	**30.2**	**51.0**	**10.8**		
5	-36627.5	131.5	1.5	10.6	32.5	46.4	8.9	
6	-36823.8	-392.6	1.5	9.0	22.6	41.6	4.7	21.2
Autonomy								
1	-34498.9	-	100.0					
2	-32322.3	4353.2	32.11	67.89				
3	**-31520.6**	**1603.5**	**15.29**	**56.22**	**28.49**			
4	-31382.4	276.4	3.76	16.66	37.22	42.35		
5	-31122.5	519.7	3.00	13.98	32.46	39.03	11.53	
6	-31192.5	-139.8	3.66	2.93	13.17	2.57	36.61	41.07
Self-realization								
1	-38112.2	-	100.0					
2	-35375.7	5473.0	32.8	67.2				
3	-34370.4	2010.6	12.1	44.8	43.1			
4	**-34068.7**	**603.4**	**6.4**	**23.9**	**43.3**	**26.4**		
5	-33922.2	293.0	2.1	10.8	29.5	39.8	17.8	
6	-33854.8	134.8	2.1	10.3	0.9	29.2	39.5	18.0
Pleasure								
1	-31836.8	-	100.0					
2	-29628.8	4416.0	28.1	71.9				
3	**-28732.8**	**1792.2**	**15.2**	**61.1**	**23.8**			
4	-28395.2	675.2	4.5	22.3	55.9	17.4		
5	-28306.2	178.0	1.9	10.0	26.1	47.7	14.3	
6	-28178.0	256.3	1.9	10.3	0.3	26.2	47.1	14.3

Note. Abbreviations: Nb = number; BIC = Bayesian information criterion (a lower absolute value suggests that the proposed number of classes better fit the observed data). Bold indicates the selected model.

Supplemental Table 3.

Model fit statistics of latent class growth modeling analyses of CASP-17 subscales across waves 1-5.

Trajectory group	Model estimate of group probability (95% CI)	Proportion classified into group	Odds of correct classification[a]	Average posterior probability of assignment[b]
Control				
Low	7.69% (7.66, 7.71)	7.34%	95.84	0.88
Moderate	29.83% (29.78, 29.87)	29.64%	11.52	0.83
Moderate-high	51.57% (51.42, 51.51)	53.32%	5.60	0.86
High	11.02% (10.98, 11.05)	9.70%	51.29	0.85
Autonomy				
Low	15.25% (15.23, 15.28)	14.95%	53.69	0.90
Moderate	56.21% (56.16, 56.25)	57.34%	6.48	0.90
High	28.54% (28.48, 28.59)	27.71%	19.06	0.88
Self-realization				
Low	6.61% (6.59 ,6.63)	6.56%	137.60	0.91
Moderate	24.43% (24.39, 24.47)	23.92%	20.14	0.86
Moderate-high	43.14% (43.10,43.18)	44.25%	6.73	0.84
High	25.82% (25.77, 25.87)	25.27%	19.93	0.87
Pleasure				
Low	15.07% (15.05, 15.10)	15.03%	57.31	0.91
Moderate	61.09% (61.05, 61.12)	62.10%	7.12	0.92
High	23.84% (23.80, 23.88)	22.87%	27.07	0.89

a. A value of > 5 indicates high assignment accuracy. b. A value of >.70 indicates good internal reliability.

Supplemental Table 4.
Mean scores (SD) obtained for the CASP-17 subscales trajectory groups at each time assessment.

	Data collection waves				
Trajectory groups on the CASP-17 subscales	1	2	3	4	5
Control[a]					
Low	7.1 (2.5)	6.7 (2.3)	5.8 (1.8)	6.0 (2.1)	6.2 (2.0)
Moderate	10.0 (2.0)	9.8 (1.9)	9.1 (1.8)	9.0 (1.8)	8.9 (1.9)
Moderate-high	12.1 (1.8)	12.3 (1.7)	11.8 (1.6)	11.7 (1.7)	11.7 (1.7)
High	14.3 (1.0)	14.1 (1.2)	14.0 (1.1)	14.0 (1.2)	13.9 (1.3)
Autonomy[b]					
Low	6.9 (1.9)	6.8 (1.7)	6.7 (1.6)	6.6 (1.8)	6.5 (1.8)
Moderate	9.5 (1.4)	9.6 (1.4)	9.4 (1.3)	9.3 (1.4)	9.4 (1.4)
High	11.0 (1.0)	11.4 (0.9)	11.3 (0.9)	11.2 (0.9)	11.2 (0.9)
Self-realization[b]					
Low	4.4 (2.1)	4.0 (2.0)	3.8 (1.9)	3.6 (1.9)	3.5 (1.9)
Moderate	7.2 (1.7)	6.7 (1.7)	6.6 (1.5)	6.4 (1.6)	6.3 (1.7)
Moderate-high	9.2 (1.4)	9.1 ()1.4	8.8 (1.4)	8.7 (1.4)	8.6 (1.5)
High	11.0 (1.0)	10.9 (1.0)	10.8 (1.0)	10.7 (1.0)	10.6 (1.1)
Pleasure[b]					
Low	8.0 (1.8)	7.7 (1.9)	7.5 (1.6)	7.5 (1.8)	7.5 (1.7)
Moderate	10.5 (1.1)	10.4 (1.1)	10.2 (1.1)	10.1 (1.3)	10.1 (1.2)
High	11.7 (0.6)	11.8 (0.5)	11.6 (0.6)	11.6 (0.6)	11.6 (0.7)

Notes. [a] Range 0-15; [b] Range 0-12.

Supplemental Table 5.
Hazard ratios and 95% confidence intervals for the association between tertiles of each psychological well-being subscale at baseline and incident cardiometabolic disease.

	Control			Autonomy			Self-realization			Pleasure		
Tertiles Model	HR	95% CI	*p*	HR	95% CI	*p*	HR	95% CI	*p*	HR	95% CI	*p*
1- Unadjusted												
Low	Reference											
Moderate	0.98	0.79-1.22	0.86	0.95	0.76-1.19	0.66	0.92	0.73-1.16	0.47	1.03	0.83-1.28	0.77
High	0.96	0.77-1.19	0.72	0.81	0.64-1.02	0.08	0.76	0.61-0.95	0.02	0.66	0.50-0.86	0.003
2-Sociodemographics[a]												
Low	Reference											
Moderate	0.99	0.79-1.23	.90	0.93	0.75-1.17	.54	0.95	0.75-1.20	0.65	0.99	0.79-1.24	.92
High	0.90	0.72-1.12	.33	0.76	0.59-0.97	.03	0.81	0.65-1.02	.075	0.66	0.50-0.87	.003
3- + health status[b]												
Low	Reference											
Moderate	0.97	0.78-1.22	.81	0.94	0.75-1.17	.56	0.94	0.74-1.19	.59	0.99	0.79-1.24	.92
High	0.90	0.72-1.12	.33	0.78	0.61-1.00	.05	0.83	0.66-1.04	.10	0.69	0.52-0.91	.01
4- + health behaviors[c]												
Low	Reference											
Moderate	0.99	0.79-1.24	.93	0.94	0.75-1.17	.58	0.96	0.76-1.22	.73	0.99	0.79-1.24	.94
High	0.90	0.72-1.12	.34	0.79	0.62-1.01	.06	0.84	0.66-1.05	.12	0.69	0.52-0.92	.01
5- + depressive symptoms												
Low	Reference											
Moderate	1.02	0.81-1.28	.90	0.96	0.76-1.21	.74	0.99	0.77-1.26	.90	1.01	0.80-1.28	.92
High	0.93	0.74-1.17	.54	0.81	0.63-1.05	.12	0.87	0.68-1.10	.25	0.71	0.53-0.96	.03

Note. CI = confidence interval; HR = hazard ratio.
[a] Adjusted for sociodemographic characteristics (age, sex, race, marital status, education, employment status); [b] Adjusted for covariates in Model 1 and health status (hypertension, high blood cholesterol, body mass index); [c] Adjusted for covariates in Model 2 and health behaviors (smoking status, alcohol intake, physical activity).

Supplemental Table 6. Hazards ratios and Cohen's *d*s for the association between persistently high vs. persistently low PWB and incident CMD, and for the association between highest vs. lowest baseline tertiles of PWB and incident CMD, in model adjusting for sociodemographic factors (N=3,826).[a]

CASP-17 subscales	Persistently high (vs. persistently low) PWB and incident CMD		Highest (vs. lowest) baseline PWB tertiles and incident CMD	
	HR	*d*[b]	HR	*d*[b]
Control	0.50	0.54	0.90	0.08
Autonomy	0.65	0.34	0.76	0.21
Self-realization	0.60	0.40	0.81	0.16
Pleasure	0.62	0.37	0.66	0.32

Note. PWB = psychological well-being; CMD = cardiometabolic disease; HR = hazard ratio.
[a] Models adjusted for wave 1 sociodemographic factors (age, sex, race, marital status, education, and employment status).
[b] Cohen's *d:* small effect = 0.20; medium effect = 0.50; large effect = 0.80 (Cohen, 1992).

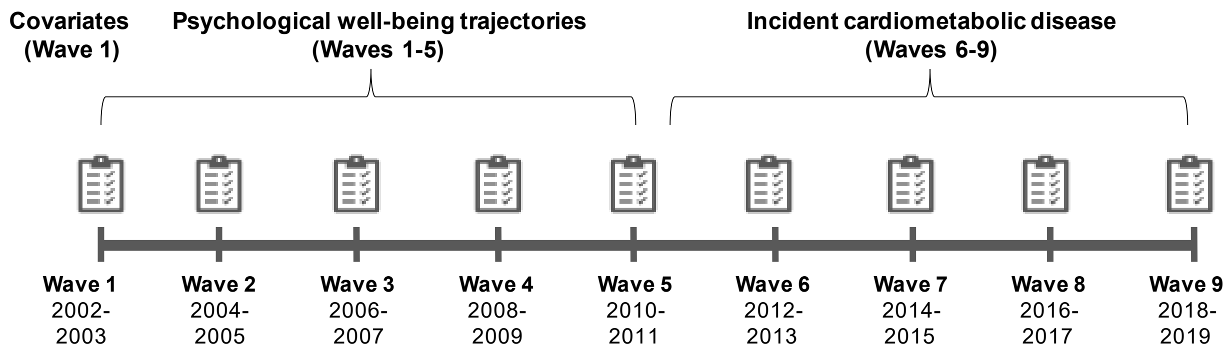
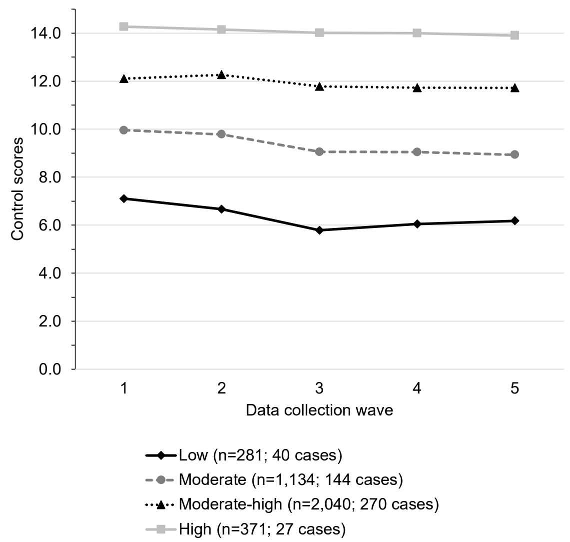
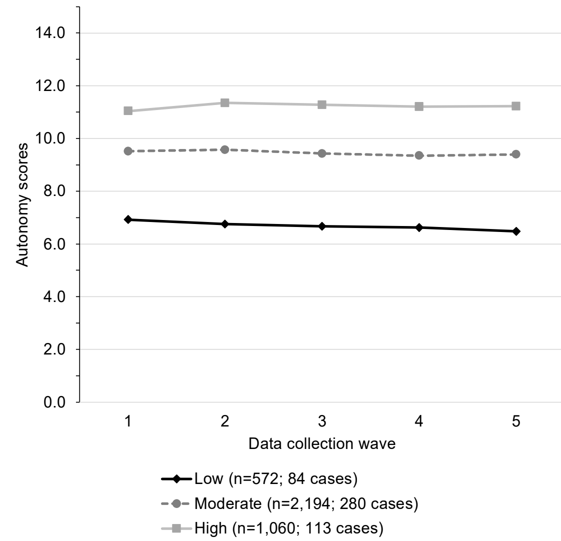


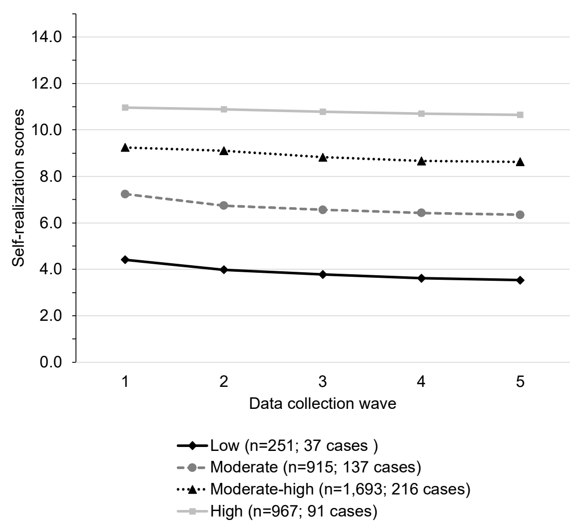
Figure 1. Study design



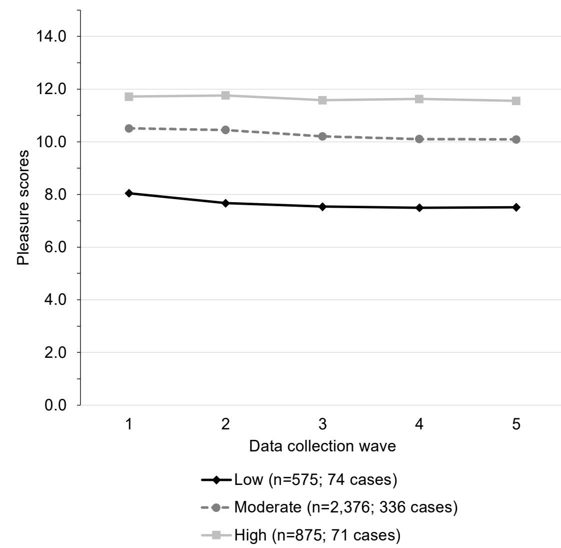
a. Trajectories of control



b. Trajectories of autonomy



c. Trajectories of self-realization



d. Trajectories of pleasure

Figure 2. Psychological well-being trajectories on the four CASP-17 subscales

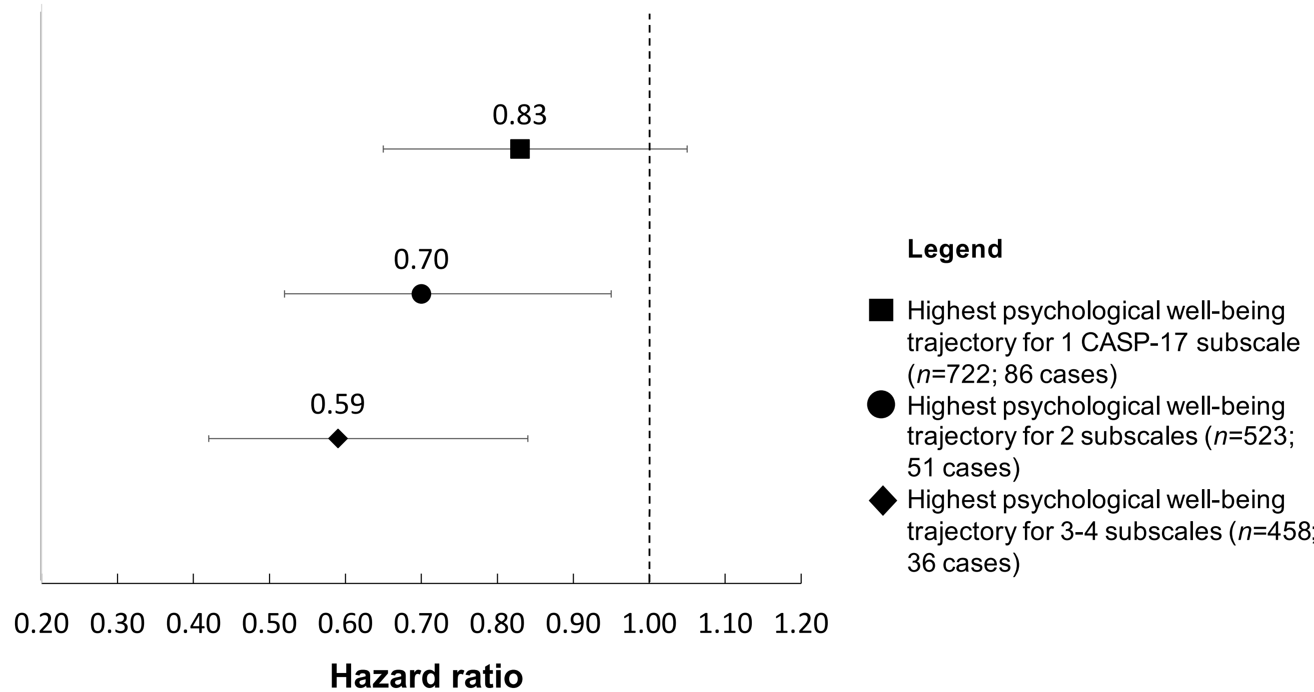


Figure 3. Fully adjusted hazard ratios and 95% confidence intervals for the association between additive trajectories of high psychological well-being across the CASP-17 subscales and incident cardiometabolic disease.

Note. The reference group is: Has highest psychological well-being on 0 subscales. The model adjusted for sociodemographic characteristics (age, sex, race, marital status, education, employment status), health status (hypertension, high blood cholesterol, body mass index), health behaviors (smoking status, alcohol intake, physical activity) and depressive symptoms.