Time perspective profile and self-reported health on the EQ-5D

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Abstract

Objectives: Few previous studies reported significant associations between EQ-5D responses and different psychological characteristics, such as personality, locus of control and optimism. Time perspective (TP) is a psychological construct that describes how one subjectively focuses on the past, present and future. TP has been found to be associated with several health-related behaviours, including healthy eating, smoking and adherence to medications. It is possible that two people with different psychological traits and the same health status rate their health differently, which is commonly referred to as response heterogeneity. Cut-point shift, a form of response heterogeneity, occurs if certain subgroups of respondents use systematically different category thresholds when self-reporting health. In this study, we aim to examine the associations of TP profile with self-reported health on the EQ-5D and to detect which EQ-5D domains display cut-point shift for TP.

Methods: We conducted a secondary analysis of EQ-5D-5L data from a representative general population sample in Hungary (n=996). The 17-item Zimbardo Time Perspective Inventory was used to measure individuals' TP on five subscales: past-negative (PN), past-positive (PP), present-fatalist (PF), present-hedonist (PH) and future (F). The associations between TP subscales and EQ-5D-5L domain scores were analysed by using partial proportional odds models adjusting for socio-demographic (age, gender, education, income) and health status (12 chronic health conditions). We used an iterative procedure to allow the parallel-lines constraint to be relaxed for those TP subscales that drive response heterogeneity. The results are reported in odds ratios and their 95% confidence intervals. The associations between TP subscales and EQ VAS and EQ-5D-5L index scores were analysed by multivariate linear regressions adjusting for socio-demographic and health status.

Results: Respondents that scored higher on the PN and PF and lower on the PH and F subscales were more likely to report more health problems in at least one EQ-5D-5L domain ($p<0.05$). Adjusting for socio-economic and health status, three EQ-5D-5L domains exhibited significant associations with various TP subscales (usual activities: PF and F, pain/discomfort: PN and F, anxiety/depression: PN, PF, PH and F). The anxiety/depression domain showed evidence of cut-point shift; individuals with higher PH or F scale scores were less likely to report moderate-to-extreme problems vs. no or slight problems (PH: 0.58, 95%CI 0.40-0.86 and F: 0.42, 95%CI 0.26-0.69) relative to slight-to-extreme problems vs. no problems (PH: 0.90, 95%CI 0.73-1.10 and F: 0.75, 95%CI 0.57-0.99). Adjusting for socio-demographic and health status, EQ VAS scores were associated with PN, PF, PH and F and EQ-5D-5L index scores with PF and F subscales. Respondents' TP profile increased the explained variance in EQ VAS from 26.6% to 30.2% and in EQ-5D-5L index from 30.9% to 32.6%.

Conclusions: This is the first study to explore the association between individuals' TP and self-reported health on the EQ-5D and also the first to identify response heterogeneity (cut-point shift) stemming from psychological characteristics in the EQ-5D. These findings increase our understanding of the non-health-related factors that affect self-reported health and the potential sources of bias in QALYs and cost-effectiveness outcomes.

"It is far more important to know what person
the disease has than what disease the person has."

Hippocrates

Introduction

The belief that psychological dispositions are related to health dates back to *Hippocrates* ('the theory of the four humours') in the 5th century B.C. and has since been generating substantial interest. Over the past decades, an increasing body of evidence demonstrated that personality characteristics are linked to a wide spectrum of health outcomes, including longevity, predicting the development and course of various chronic physical conditions and self-reported health status [1-4]. However, little is known about the role of psychological factors in self-reporting own health on the EQ-5D. The EQ-5D is the most widely used generic preference-accompanied health status measure with a variety of economic (e.g. cost-utility analysis) and non-economic applications (e.g. observational clinical studies, clinical trials, population health surveys and measuring health inequalities) [5-9]. Previous streams of research with the EQ-5D mostly concentrated on the associations between self-reported health and certain personality traits and lifestyle-related attitudes. In these studies, self-reporting less health problems was related to conscientiousness and internal locus of control, while neuroticism, openness, type D personality, 'live-for-today' and 'unconfident fatalist' attitudes were related to reporting more health problems on the EQ-5D [10-14].

Time perspective (TP) is a psychological construct that describes how one subjectively focuses on the past, present and future [15]. Some authors consider it to be a trait, while others argue that it is a flexible cognitive structure that may change over the life course, or in response to life events (e.g. traumatic exposure), psychological interventions or social environment [15,16]. In their seminal work, *Zimbardo and Boyd* distinguished two main aspects of TP, the directionality of one's thoughts towards time (i.e. past, present or future orientation) and their emotional valence (i.e. positive or negative) [17]. Based on their approach, five TP dimensions may be described: past-negative (i.e. generally negative, aversive view of the past), past-positive (i.e. warm and sentimental attitude towards the past), present-fatalistic (i.e. belief that uncontrollable forces determine one's fate), present-hedonistic (i.e. orientation towards present pleasure, spontaneity and risk-taking propensity) and future (i.e. striving for long-term goals and rewards) [17]. TP has also gained increasing attention in the contexts of health and healthcare over the past 30 years. Evidence from a few studies suggests an association between individuals' TP profile and their self-reported health measured by a five-point excellent-to-poor scale, SF-36 or SF-12 [18-21]. To date, no studies have investigated the association between TP and self-reported health using the EQ-5D.

A major measurement issue related to self-reporting own health is that, in addition to the probable link between different psychological factors and health outcomes; for example, as a result of variation in health behaviours or lifestyle choices, psychological characteristics such as TP profile, may also lead to systematic variations in self-reporting own health across respondents with the same health status. It is therefore possible that two people with different psychological traits and the same health status perceive and rate their health differently. This latter variation is commonly referred to as response heterogeneity [22] or, in psychometrics, differential item functioning [23]. There has been little empirical work exploring response heterogeneity in the context of the EQ-5D [24]. Few studies found sizeable differences in response styles across geographical regions, countries, age groups, sexes, ethnicities, patients vs. proxies and clinically relevant patient groups (e.g. types of cancer or psychosis) [25-32]. However, none of these have attempted to detect response heterogeneity from psychological characteristics.

Guided by the framework outlined by *Lindeboom and van Doorslaer*, two forms of response heterogeneity may be distinguished: cut-point shift and index shift [22]. Cut-point shift occurs when the relative positions of the level thresholds change for certain subgroups of respondents directly influencing the shape of the distribution of responses [33]. For example, the response 'slight pain or discomfort' in an elderly person may be equivalent to 'moderate pain or discomfort' in a young adult due to a shift in expectations, and possible adaptation to and coping with rising health problems with age. Index shift refers to a parallel shift in all of the reporting thresholds for certain subgroups of respondents that leads to a shift in the distribution of responses either to the right or left [33]. It may be possible, for example, that all response level thresholds in the pain/discomfort domain are exactly one level lower in men compared to women, implying that 'no pain or discomfort' in men will be equivalent to 'slight pain or discomfort' in women, 'slight pain or discomfort' in men will be equivalent to 'moderate pain or discomfort' in women and so forth. An extensive body of studies provided evidence of the existence of cut-point or index shift in self-reported health mainly using a single health question [22,33-35]; however, none of these have investigated individuals' psychological characteristics as a source of response heterogeneity in self-reported health.

This study seeks to explore the possible link between individuals' TP profile and self-reported health on the five dimensions of EQ-5D-5L, EQ VAS and index scores. We aim to go beyond merely demonstrating the association between TP and self-reported health by attempting to detect which EQ-5D-5L domains display response heterogeneity for TP. Among the two forms of response heterogeneity, our sample enabled to investigate the presence of cut-point shift. We hypothesized that respondents with future, present-hedonistic and past-positive TP reported fewer health problems and respondents with present-fatalistic and past-negative TP reported more health problems [20,21]. We expected that the pain/discomfort and anxiety/depression domains would be more likely to exhibit response heterogeneity for TP given the more subjective nature of these domains [36].

Methods

Study design and population

We conducted a secondary analysis of the cross-sectional data from the 'DCE sample' of the EQ-5D-Y-3L (youth) valuation study in Hungary (n=996) [37]. Respondents were recruited from a large online panel in April and May 2021. The target population for the online panel survey was the Hungarian adult general population aged 18 years or over, and quota sampling methods were used to achieve a representative sample in terms of gender and age (across seven age groupings: 18-24, 25-34, 35-44, 45-54, 55-64, 65-74 and 75+). Ethical approval to conduct the data collection was granted by the

Research Ethics Committee of the Corvinus University of Budapest (no. KRH/31/2021). All respondents entering the survey were asked to provide informed consent. After finishing 18 discrete choice experiment tasks as part of the EQ-5D-Y-3L valuation study, respondents completed the EQ-5D-5L, the 17-item Zimbardo Time Perspective Inventory (ZTPI) and socio-demographic and health-related questions in a fixed order. For the latter, a list of 12 common chronic health conditions was provided for respondents. The question specifically asked respondents to report those health conditions that had been diagnosed by a physician.

EQ-5D-5L

The EQ-5D-5L is a generic preference-accompanied health status measure that comprises two parts, a descriptive system and a vertical visual analogue scale (EQ VAS) ranging from ‘the worst imaginable health state’ (0) to ‘the best imaginable health state’ (100) [38]. The descriptive system is composed of the following five health domains: mobility, self-care, usual activities, pain/discomfort and anxiety/depression. Each domain has five response levels: no problems (1), slight problems (2), moderate problems (3), severe problems (4) and extreme problems/unable to (5). These five domains describe overall 3125 unique health profiles, with 11111 being the best (full health) and 55555 being the worst possible health state (pits). Index scores (i.e. utilities) may be assigned to each profile using a value set that reflects societal preferences. In this study, we computed index scores using the Hungarian EQ-5D-5L value set that had been developed using composite time trade-off method [39].

17-item Zimbardo Time Perspective Inventory (ZTPI)

To measure respondents’ TP profile, we used the validated Hungarian version of the 17-item ZTPI that is a shorter version of the original 56-item questionnaire [17,40]. ZTPI is a multidimensional TP scale that is based on the considerations proposed by *Zimbardo and Boyd* [17]. Figure 1 presents the 17 items of the scale, with each being represented by a statement and assessed on a five-point scale with the endpoints of ‘very untrue’ and ‘very true’. Item scores were summed into subscale scores (past-negative, past-positive, present-fatalistic, present-hedonistic and future) following the official scoring of ZTPI (range of subscale scores 1-5, where a higher score indicates more of the trait being measured) [41].

Statistical analyses

There were no missing values as all questions were mandatory in the online survey. Descriptive statistics were used to provide an overview of the characteristics of the study population. Mean, SD, median, interquartile range, minimum and maximum were computed for continuous variables (EQ VAS, EQ-5D-5L index scores and each TP subscale).

Partial proportional odds models: exploring response heterogeneity

We adopted an analytical strategy that aims to test the equivalence in response level thresholds controlling for a variety of individual characteristics, such as socio-demographics and health status [22,34,35]. We treated EQ-5D-5L domain scores as ordinal data due to the hierarchy of response levels. The associations between TP subscales and EQ-5D-5L domain scores were analysed using partial proportional odds models [42]. A key assumption of the traditional ordered logit model (i.e. proportional odds model) is that the variables are required to comply with the proportional odds (i.e. parallel-lines) assumption. This constrains the coefficients for each independent variable to remain constant for all levels of the dependent variable, implying that the probability of experiencing health problems would be identical across the response level thresholds within each EQ-5D-5L domain. However, certain independent variables may lead to a higher or lower likelihood of experiencing some health problems depending on the level threshold, and therefore, may violate this requirement. The generalised ordered logit model offers a practical alternative to the traditional ordered logit that relaxes the proportional odds assumption for *all* variables. It is also common, however, that the proportional odds assumption is violated by only a subset of independent variables. The partial proportional odds model represents an intermediate model between the ordered and generalised ordered logit, that is able to overcome this limitation by flexibly allowing *any* independent variable to vary across the different response level thresholds of the dependent variable.

In the partial proportional odds models, EQ-5D-5L domain scores were selected as dependent variables. The self-care domain was omitted from the analysis due to limited variability of responses. For the other four domains, responses were collapsed into three categories (no problems, slight problems and moderate-to-extreme problems) to account for the low number of respondents reporting severe or extreme health problems. The three categories were divided by two response thresholds: level 1 vs. levels 2-5 ('no problems' vs. 'slight-to-extreme problems') and levels 1-2 vs. levels 3-5 ('no or slight problems' vs. 'moderate-to-extreme problems'). The five ZTPI subscale scores, four socio-demographic characteristics (age, gender, education, income) and 12 health condition groups were included in the models as independent variables. These latter were considered as proxies for 'true' health. For all independent variables, the proportional odds assumption was tested using Brant test [43]. This performs a series of Wald tests on each variable to identify which of these fail to meet the proportional odds assumption. We used an iterative procedure starting from a generalised ordered logit (i.e. all coefficients varying) and then imposed proportionality constraints in a stepwise manner on those variables that passed the Wald test. The model was sequentially refitted until no variables complied with this assumption. We report the results as odds ratios (ORs) and their 95% confidence intervals. Independent variables that satisfy the proportional odds assumption (i.e. Wald test $p \geq 0.05$) have a single OR for both response thresholds. Whereas, independent variables not meeting the proportional odds assumption (i.e. Wald test $p < 0.05$) have different ORs for the threshold of 'no problems' vs. 'slight-to-extreme problems' relative to 'no or slight problems' vs. 'moderate-to-extreme problems' providing evidence of response heterogeneity (cut-point shift).

Multivariate linear regressions

Multivariate linear regressions were performed to investigate the association between TP subscales and EQ VAS and EQ-5D-5L index scores. Two separate regressions were run for both outcomes of interest to explore the contribution of TP profile to the explained variance in EQ VAS and EQ-5D-5L index score. In the first models ('without TP'), EQ VAS and EQ-5D-5L index were regressed on four socio-demographic variables (age, gender, education, income) and 12 chronic health condition groups. In the second models ('with TP'), the five ZTPI subscale scores were also added to the regression as independent variables in addition to respondents' socio-demographic characteristics and chronic conditions. To ease interpretation of the coefficients, ZTPI subscale scores were rescaled to range from 0 to 4 before the regression analyses. The presence of heteroscedasticity was confirmed by the Breusch-Pagan test [44]. Robust standard errors were used to correct for any heteroscedasticity. The 'without TP' and 'with TP' models were compared with regard to the explained variance (R^2 statistic). All analyses were performed in Stata 14 and p-values <0.05 were considered statistically significant.

Results

Characteristics of the study population

The study population showed an excellent representativeness for gender and age groups; however, there was a higher proportion of highly educated respondents compared to the adult general population in Hungary (Table 1). The majority reported overall good health status with mean EQ VAS of 78.03 and EQ-5D-5L index of 0.919 (Table 2). Overall, 72%, 93%, 80%, 53% and 67% had no problems with mobility, self-care, usual activities, pain/discomfort and anxiety/depression, and 38% of the sample reported to be in full health (11111).

The distribution of responses on each ZTPI item is presented in Figure 1. The item 'I meet my obligations to friends and authorities on time' received the highest proportion of affirmative responses (true or very true: 88%), while the disapproval rate (very untrue or untrue) was the highest for the statement 'I've taken my share of abuse and rejection in the past' (60%). With respect to TP subscales, the highest mean scores were found for the future subscale (3.89), followed by the past-positive (3.40), while the lowest were observed for the present-hedonistic subscale (2.65) (Table 2).

The association between EQ-5D-5L domain responses and TP

As hypothesized, after adjusting for socio-demographic characteristics and health status, respondents that scored higher on the past-negative and present-fatalistic and lower on the present-hedonistic and future subscales were more likely to report more health problems in at least one EQ-5D-5L domain (Table 3). Three EQ-5D-5L domains exhibited significant associations with various TP subscales (usual activities: present-fatalistic and future [range ORs: 0.60-1.26], pain/discomfort: past-negative and future [range of ORs: 0.69 to 1.47], anxiety/depression: past-negative, present-fatalistic, present-hedonistic and future [range of ORs: 0.42 to 2.05]). The mobility domain showed no association with TP profile.

Several TP subscales, socio-demographic and health status characteristics were found to be in a significant association with one or more EQ-5D-5L domains without evidence of cut-point shifting. For every one-year increase in age, the odds of reporting a one-level higher severity of problems was 1.03 (95%CI 1.02-1.04) for mobility and 0.97 (95%CI 0.96-0.98) for anxiety/depression. Women were 1.58 (95%CI 1.08-2.29) and 1.56 (95%CI 1.19-2.05) times more likely to report a one-level higher severity of problems with usual activities and pain/discomfort than men. Education was not associated with any EQ-5D-5L domain scores, but a higher level of income was related to a lower likelihood of reporting a one-level higher severity of problems with usual activities. The presence of different chronic conditions tended to increase the probability of reporting more problems in each EQ-5D-5L domain. Notably, the highest odds ratios were related to the association between having been diagnosed with anxiety and the anxiety/depression domain (OR 8.77, 95%CI 4.92-15.65) and having musculoskeletal disease and the mobility domain (OR 8.09, 95%CI 5.69-11.50).

Response heterogeneity

The anxiety/depression domain showed evidence of cut-point shift (Table 3). Individuals with higher present-hedonistic or future TP subscale scores were less likely to report moderate-to-extreme problems vs. no or slight problems (present-hedonistic: OR 0.58, 95%CI 0.40-0.86 and future: OR 0.42, 95%CI 0.26-0.69) relative to slight-to-extreme problems vs. no problems (present-hedonistic: OR 0.90, 95%CI 0.73-1.10 and future: OR 0.75, 95%CI 0.57-0.99). Age, gender and education showed no evidence of cut-point shift. One of the income quintiles demonstrated cut-point shift for mobility; however, both separate coefficients were insignificant. An array of chronic condition categories indicated cut-point shift (mobility: cardiovascular diseases, usual activities: anxiety and depression, pain/discomfort: allergy, anxiety/depression: cancer, diabetes, skin disease). Note that only four of these seven chronic condition groups had a statistically significant association with the respective EQ-5D-5L domains.

The association between TP and EQ VAS and EQ-5D-5L index scores

In the first EQ VAS model ('without TP'), respondents with higher income had slightly higher EQ VAS scores and eight of 12 chronic health conditions were associated with a significant decrease in EQ VAS scores ranging from hypertension (2.55) to depression (10.42) (Table 4). In the second model ('with TP'), after including respondents' TP subscale scores in addition to their socio-demographic characteristics and health status, four of the five TP subscales had a significant effect on EQ VAS scores. A one-point increase in the past-negative and present-fatalist subscale scores, all else equal, decreased the EQ VAS score by 2.70 and 2.58 ($p<0.05$). By contrast, a one-point increase in the future and present-hedonistic subscale scores, all else equal, resulted in a 3.00 and 1.25 increase in EQ VAS score ($p<0.05$). Respondents' TP profile (including all five TP subscale scores) increased the explained variance in EQ VAS score from 26.6% ('without TP') to 30.2% ('with TP').

In the first EQ-5D-5L index model ('without TP'), no socio-demographic characteristics were associated with index scores; however, five of 12 chronic health conditions were resulted in a significant decrease in index scores ranging from hypertension (0.026) to depression (0.101) (Table 4). In the second model ('with TP'), after including respondents' TP subscale scores in addition to their socio-demographic characteristics and health status, two TP subscales had a significant effect on EQ-5D-5L index scores. A one-point increase in the present-fatalistic and future TP subscale scores, was associated with a decrease of 0.015 and an increase of 0.016 in EQ-5D-5L index, all else equal ($p<0.05$). Respondents' TP profile increased the explained variance in EQ-5D-5L index from 30.9% ('without TP') to 32.6% ('with TP').

Discussion

This study contributes to the growing literature on the link between psychological dispositions and self-reported health on the EQ-5D. Using a large general population sample from Hungary, it affords an insight into the association between individuals' TP profiles and self-reported health on the EQ-5D. Three EQ-5D domains (usual activities, pain/discomfort and anxiety/depression) as well as the EQ VAS and EQ-5D index scores were associated with respondents' TP profile. Furthermore, we proved the existence of response heterogeneity in the anxiety/depression domain; the probability of reporting more problems in this domain decreased with having more future and present-hedonistic characteristics. As such, this is the first study that identified response heterogeneity on the EQ-5D arising from individual psychological factors. Other authors have used item response theory, Rasch-analysis, Mantel-Haenszel statistics and ordinal logistic regressions, and reported response heterogeneity on the EQ-5D mainly across countries, regions, demographics and clinical characteristics [25-31].

Respondents' TP profile and a few chronic condition groups seem to display cut-point shift, a form of response heterogeneity. It is important to stress that for variables not producing any cut-point shift, but being significantly related to self-reported health (e.g. future TP to usual activities and pain/discomfort), an index shift may still occur. In our analytical framework, we accounted for 'true' health by controlling for respondents' chronic health conditions; however, response heterogeneity may also affect these variables through false reporting [45]. As we could not rely on more objective health indicators (e.g. blood pressure, grip strength, gait speed, lung capacity, vision tests, blood samples), it leaves open the possibility that we did not sufficiently capture variation in 'true' health. Future research is recommended to use different approaches (e.g. anchoring vignettes, performance measurements, objective clinical variables and item response theory) to isolate index shift as a reporting behaviour from variations in underlying health status [46-51].

Another noteworthy finding from this study is that the EQ-5D showed no evidence of cut-point shift by age, gender and education. Notwithstanding, some domains exhibited significant associations with age or gender that may signal a possible index shift. These results are difficult to reconcile with the existing literature due to differences in study populations (e.g. general population vs. patients) and methods used (e.g. proportional odds model vs. item response theory). However, in line with prior work on response heterogeneity on the EQ-5D, older respondents were more likely to report problems with mobility and less likely with anxiety/depression [27,31]. Even though we cannot rule out the possibility of having more mobility problems with age after controlling for specific chronic health conditions, it may also be possible that these findings are attributable to an index shift. Similarly, our findings suggest a possible index shift on the usual activities and pain/discomfort domains by gender, whereby women were more inclined to report problems than men. In a previous study with cancer patients, the mobility and usual activities domains showed large- and medium-size response heterogeneity by gender [27]. Among the two forms of response heterogeneity distinguished in our analytical framework, index shift is less concerning than cut-point shift due to its linear nature [22]. When one can properly control for the covariates that possibly lie at the root of index shift, then the measurement of health and the comparisons across different socio-demographic groups within the population will not be biased.

Possessing more future and present-hedonistic traits may be seen as desirable qualities leading to less health problems, whereas individuals with more past-negative and present-fatalistic characteristics appear to report more health problems. These results are broadly consistent with those of previous studies that identified an association between TP profile and self-reported health measured by various instruments [18-21]. As argued above, these associations must be treated with caution as they are presumably a result of both response heterogeneity and true health effects. A possible explanation for the latter is that TP profile has been found to be related to a number of health behaviours, such as exercising, alcohol, tobacco and substance use, attendance at health screenings and adherence to medications [52-56]. The association between health outcomes and TP profiles is further supported by evidence of the effectiveness of TP-based psychological interventions, such as 'Time Perspective Therapy', which have successfully improved mental health in patients with posttraumatic stress disorder [57]. Other authors reported that TP-based interventions increased physical activity or helped to develop a career planning attitude [58,59].

Our findings have wider implications for patient management, clinical trials, population health surveys and economic evaluations. It seems that non-health factors, such as TP profile may affect one's 'true' health as well as response behaviour on the EQ-5D. Understanding the relationship between TP and health status may help to identify barriers in treatment adherence and to improve patient self-management. On the other hand, psychological characteristics, such as TP profile, may be considered a source of bias in clinical trials; for example, if there were considerable differences in individual TP profiles between the treatment and control groups. Moreover, given the widespread use of the EQ-5D in monitoring population health status, our findings also present an issue for population norm development, decomposing health inequality and cross-country comparability and transferability of EQ-5D scores. At a broader level, personality characteristics may not be evenly distributed across geographical regions and cultures which could invalidate cross-country health comparisons [60]. However, a recent large-scale study described only small variations in the occurrence of 30 personality traits across 22 countries [61]. It may be an alternative to the use of anchoring vignettes in health surveys to include questions on psychological characteristics, such as TP or personality type to accommodate at least a part of the existing response heterogeneity. Lastly, considering that the EQ-5D index scores are used to estimate quality-adjusted life years, individual TP may also represent an uncertainty on the results of cost-effectiveness analyses and healthcare decisions based thereon.

This study has a number of limitations. First, we used a general population sample, and therefore, there was less variability in respondents' health status that motivated us in collapsing response levels and excluding self-care from the domain-specific analyses. Further research is encouraged to replicate our study in patient populations with more frequent and severe health problems. Emerging from the findings of our study, different mental conditions (e.g. anxiety and depression) appear to be of particular interest for future studies. Secondly, more abundant information about the clinical status of respondents (e.g. severity/stage, symptoms, limitations in functioning) could have been useful to more adequately adjust our models for 'true' health. Thirdly, selection bias may have occurred not only because of the online mode of administration that excluded people without internet access or sufficient computer literacy, but also due to the study design. During the DCE tasks, 255 respondents were excluded based on quality control criteria, such as providing inconsistent responses on the dominant pairs. As these tasks may be viewed as some kind of logical or cognitive test, it is likely that respondents with somewhat higher cognitive abilities accomplished them and therefore were selected to the final sample. Fourthly, the original 56-item ZTPI questionnaire has been subject to some criticisms with regard to its construct validity and dimensionality [15,62]. In our study, we used a 17-item short version of this scale that performed well in most psychometric tests in an earlier study in Hungary [40]. However, its face validity may still be questioned; for example, some of the items may rather capture beliefs, values or preferences that do not directly relate to TP and therefore may represent alternative psychological constructs [15,63,64]. Finally, possible measurement biases are not solely confined to the EQ-5D, the ZTPI as a self-reported questionnaire may itself be prone to response heterogeneity [65,66].

In conclusion, this is the first study to explore the association between individuals' TP and self-reported health on the EQ-5D and also the first to identify response heterogeneity (cut-point shift) stemming from psychological characteristics on the EQ-5D. It seems that psychological factors may play a double role in self-reported health, firstly as affecting underlying health and secondly as a factor influencing one's response behavior. These findings increase our understanding of the non-health-related factors that affect self-reported health and the potential sources of bias in population health surveys, clinical trials and cost-effectiveness outcomes. Future research is warranted to provide a comprehensive overview of the psychological characteristics that potentially bias self-reporting health on the EQ-5D and to develop strategies to overcome these.

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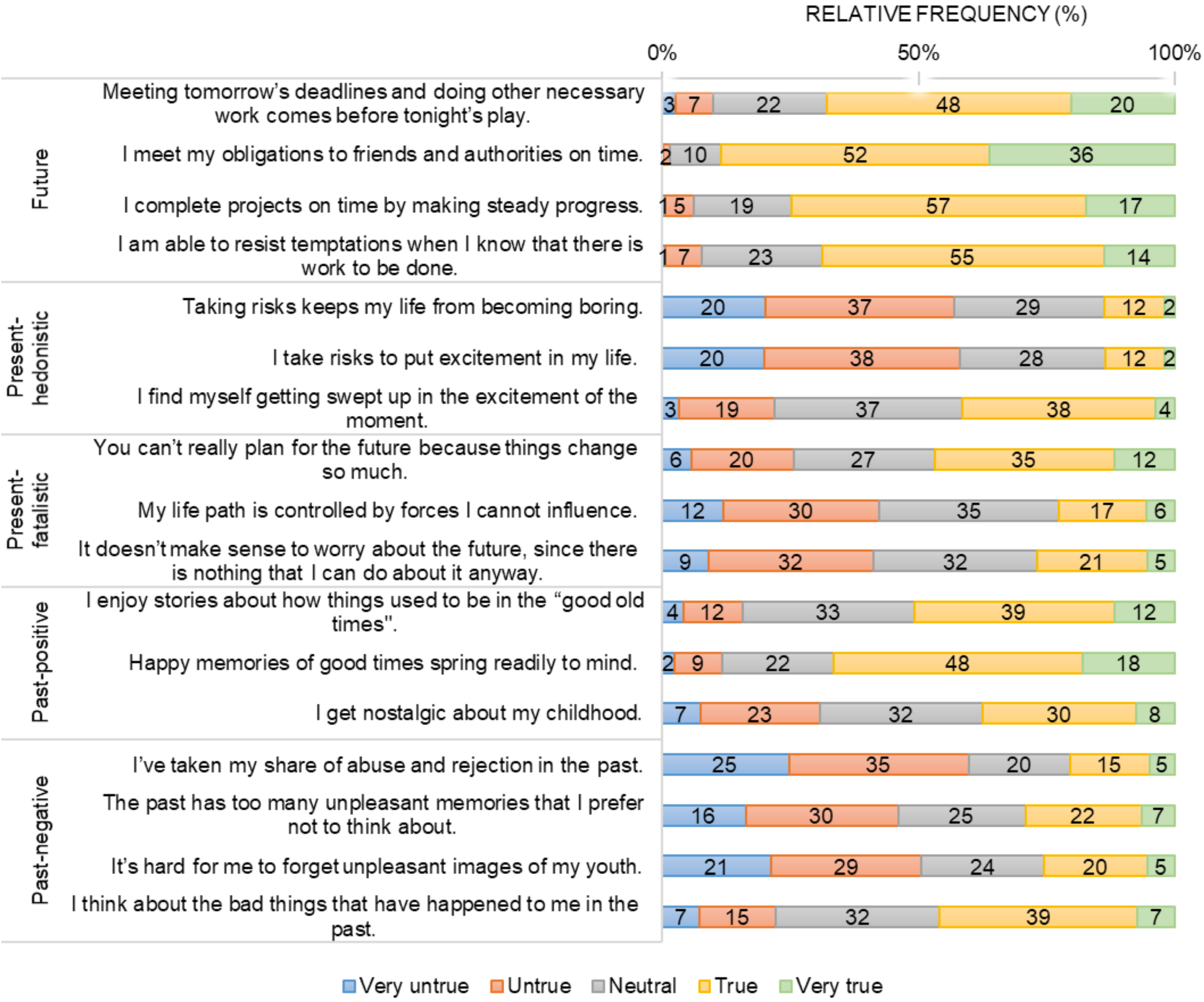
Figure 1 Distribution of responses on the 17-item Zimbardo Time Perspective Scale



Note that the original order of items was reorganised according to subscales for this figure.
Figures may not add up to 100% due to rounding.

Table 1 Characteristics of the study population

Variables	Reference population[a]	Total sample (n=996)		Variables	Reference population[a]	Total sample (n=996)	
	%	n	%		%	n	%
Age (years)				**Gender**			
18-24	10	103	10	Female	53	522	52
25-34	15	157	16	Male	47	474	48
35-44	20	195	20	**Education**			
45-54	16	167	17	Primary school or less	45	219	22
55-64	17	172	17	Secondary school	33	366	37
65-74	13	134	13	College/university degree	31	411	41
75+	10	68	7	**EQ-5D-5L domain scores**			
Household's per capita net monthly income (HUF)				**Mobility**			
Quintile 1 (<= 87500.50)	n/a	161	16	No problems	n/a	721	72
Quintile 2 (87500.51 – 131250.25)	n/a	154	15	Slight problems	n/a	198	20
Quintile 3 (131250.26 – 175000.33)	n/a	145	15	Moderate problems - unable to	n/a	77	8
Quintile 4 (175000.34 – 225000.33)	n/a	165	17	**Self-care**			
Quintile 5 (225000.34+)	n/a	162	16	No problems	n/a	930	93
Don't know/refused to answer	n/a	209	21	Slight problems	n/a	44	4
Chronic health conditions[b,c]				Moderate problems - unable to	n/a	22	2
None	52	461	46	**Usual activities**			
Allergy	15	160	16	No problems	n/a	800	80
Anxiety	n/a	78	8	Slight problems	n/a	146	15
Asthma	5	56	6	Moderate - extreme problems	n/a	50	5
Cancer	2	33	3	**Pain/discomfort**			
Cardiovascular disease	>8	120	12	No problems	n/a	526	53
Depression	8	53	5	Slight problems	n/a	380	38
Diabetes	9	103	10	Moderate - extreme problems	n/a	90	9
Gastrointestinal disease	n/a	75	8	**Anxiety/depression**			
Hypertension	31	305	31	No problems	n/a	664	67
Musculoskeletal disease	>20	239	24	Slight problems	n/a	250	25
Osteoporosis	6	30	3	Moderate - extreme problems	n/a	82	8
Skin disease	n/a	78	8	**11111 (full health)**	n/a	378	38

a: Reference values: Hungarian Central Statistical Office: Microcensus 2016

b: Reference values: Hungarian Central Statistical Office: Health at a glance, 2019

c: n=19 don't know/refused to answer

Figures may not add up 100% due to rounding. n/a = not available

Table 2 Descriptive statistics of EQ VAS, EQ-5D-5L index and ZTPI subscale scores

Measure	Theoretical range	Observed range	Mean	SD	Median	Q1-Q3
EQ VAS	0 to 100	1 to 100	78.03	17.22	81	70 to 90
EQ-5D-5L index	-0.848 to 1	-0.393 to 1	0.919	0.130	0.957	0.907 to 1
ZTPI future	1 to 5	1.75 to 5	3.89	0.55	4.00	3.50 to 4.25
ZTPI present-fatalistic	1 to 5	1 to 5	2.94	0.83	3.00	2.33 to 3.58
ZTPI present-hedonistic	1 to 5	1 to 5	2.65	0.78	2.67	2.00 to 3.00
ZTPI past-positive	1 to 5	1 to 5	3.40	0.81	3.33	3.00 to 4.00
ZTPI past-negative	1 to 5	1.5 to 4.5	2.88	0.50	3.00	2.50 to 3.25

EQ VAS = EuroQol visual analogue scale; ZTPI = 17-item Zimbardo Time Perspective Inventory

Table 3 Partial proportional odds models of the association between time perspective and EQ-5D-5L domains (odds ratio and 95%CI)

	Mobility	Usual activities	Pain/discomfort	Anxiety/depression
Intercept	0.05 (0.01-0.31)**	0.24 (0.03-1.79)	0.44 (0.09-2.01)	0.20 (0.04-1.12)
Time perspective (ZTPI subscales)				
Future				
Level 1 vs. Levels 2-5	0.76 (0.56-1.02)	0.60 (0.43-0.84)**	0.69 (0.54-0.89)**	0.75 (0.57-0.99)*
Levels 1-2 vs. Levels 3-5				0.42 (0.26-0.69)**
Present-hedonistic				
Level 1 vs. Levels 2-5	0.98 (0.79-1.22)	1.00 (0.79-1.28)	0.96 (0.8-1.15)	0.90 (0.73-1.10)
Levels 1-2 vs. Levels 3-5				0.58 (0.40-0.86)**
Present-fatalistic	1.14 (0.93-1.4)	1.26 (1.00-1.58)*	1.14 (0.96-1.35)	1.59 (1.31-1.92)***
Past-positive	1.11 (0.89-1.39)	1.09 (0.85-1.39)	1.05 (0.88-1.25)	0.96 (0.80-1.16)
Past-negative	1.07 (0.76-1.49)	0.89 (0.62-1.29)	1.47 (1.12-1.94)**	2.05 (1.51-2.78)***
Age *(years)*	1.03 (1.02-1.04)***	1.01 (0.99-1.02)	0.99 (0.98-1.00)	0.97 (0.96-0.98)***
Gender (ref: male)	0.95 (0.68-1.33)	1.58 (1.08-2.29)*	1.56 (1.19-2.05)**	1.27 (0.94-1.71)
Education (ref: primary)				
Secondary	1.00 (0.66-1.52)	0.89 (0.56-1.40)	0.76 (0.53-1.09)	0.92 (0.61-1.39)
Tertiary	1.00 (0.64-1.56)	0.84 (0.52-1.38)	0.79 (0.54-1.16)	1.02 (0.67-1.57)
Income (ref: quintile 1)				
Quintile 2	0.98 (0.58-1.65)	0.94 (0.54-1.63)	1.35 (0.85-2.15)	0.93 (0.56-1.56)
Quintile 3				
Level 1 vs. Levels 2-5	0.83 (0.46-1.50)	0.91 (0.50-1.68)	1.60 (0.99-2.60)	1.19 (0.70-2.01)
Levels 1-2 vs. Levels 3-5	1.58 (0.72-3.47)			
Quintile 4	0.83 (0.47-1.45)	0.44 (0.23-0.85)*	1.01 (0.63-1.64)	0.75 (0.44-1.28)
Quintile 5	0.71 (0.39-1.30)	0.60 (0.31-1.16)	1.31 (0.80-2.16)	1.24 (0.72-2.11)
Don't know/refused to answer	0.72 (0.42-1.25)	0.58 (0.33-1.05)	1.03 (0.66-1.62)	0.81 (0.50-1.33)
Chronic conditions (ref: none)				
Allergy				
Level 1 vs. Levels 2-5	1.47 (0.95-2.28)	2.09 (1.33-3.27)**	0.80 (0.54-1.19)	0.90 (0.60-1.36)
Levels 1-2 vs. Levels 3-5			1.53 (0.86-2.72)	
Anxiety				
Level 1 vs. Levels 2-5	1.75 (0.92-3.32)	1.48 (0.73-2.99)	2.18 (1.23-3.87)**	8.77 (4.92-15.65)***
Levels 1-2 vs. Levels 3-5		0.46 (0.15-1.40)		
Asthma	0.94 (0.49-1.78)	1.83 (0.96-3.46)	1.58 (0.88-2.83)	0.79 (0.4-1.57)
Cancer				
Level 1 vs. Levels 2-5	1.52 (0.72-3.20)	1.35 (0.60-3.03)	1.62 (0.79-3.31)	0.99 (0.41-2.40)
Levels 1-2 vs. Levels 3-5				3.24 (1.01-10.39)*
Cardiovascular disease				
Level 1 vs. Levels 2-5	1.39 (0.85-2.27)	2.26 (1.43-3.58)**	2.24 (1.48-3.38)***	1.30 (0.81-2.10)
Levels 1-2 vs. Levels 3-5	2.92 (1.63-5.24)***			
Depression				
Level 1 vs. Levels 2-5	1.55 (0.73-3.29)	3.25 (1.49-7.09)**	2.7 (1.34-5.44)**	4.83 (2.38-9.80)***
Levels 1-2 vs. Levels 3-5		8.67 (3.26-23.07)***		
Diabetes				

Level 1 vs. Levels 2-5	1.20 (0.74-1.96)	1.59 (0.93-2.72)	1.13 (0.71-1.79)	1.66 (0.97-2.84)
Levels 1-2 vs. Levels 3-5				4.24 (1.95-9.21)***
Gastrointestinal disease	0.61 (0.33-1.13)	0.90 (0.47-1.72)	1.32 (0.79-2.19)	2.52 (1.48-4.29)**
Hypertension	1.72 (1.20-2.48)**	1.64 (1.09-2.47)*	1.61 (1.17-2.23)**	1.17 (0.81-1.71)
Musculoskeletal disease	8.09 (5.69-11.50)***	4.23 (2.88-6.22)***	4.40 (3.17-6.13)***	1.12 (0.77-1.63)
Osteoporosis	1.11 (0.50-2.44)	1.29 (0.55-3.04)	1.64 (0.78-3.45)	0.92 (0.39-2.18)
Skin disease				
Level 1 vs. Levels 2-5	0.78 (0.44-1.39)	0.67 (0.35-1.28)	1.10 (0.67-1.8)	0.58 (0.31-1.08)
Levels 1-2 vs. Levels 3-5				1.89 (0.83-4.34)
Model fit	$\chi^2(28)=348.86$, $p<0.001$, Pseudo $R^2=0.2326$	$\chi^2(28)=242.15$, $p<0.001$, Pseudo $R^2=0.2000$	$\chi^2(27)=273.02$, $p<0.001$, Pseudo $R^2=0.1486$	$\chi^2(31)=329.07$, $p<0.001$, Pseudo $R^2=0.2008$

Note that modelling was not possible for the self-care dimension due to limited variability in responses.
ZTPI = 17-item Zimbardo Time Perspective Inventory
Level 1 = no problems, level 2 = slight problems, level 3-5 = moderate-to-extreme problems.
* p<0.05; ** p<0.01; *** p<0.001

Table 4 OLS regression of the association between time perspective and EQ VAS and EQ-5D-5L index scores (regression coefficients and standard errors)

Variables	EQ VAS 'without TP'	EQ VAS 'with TP'	EQ-5D-5L index 'without TP'	EQ-5D-5L index 'with TP'
Intercept	79.478 (2.43)***	78.979 (4.166)***	0.934 (0.019)***	0.938 (0.031)***
Time perspective *(ZTPI subscale score -1)*				
Future	-	2.996 (0.935)**	-	0.016 (0.006)**
Present-hedonistic	-	1.246 (0.619)*	-	0.003 (0.005)
Present-fatalistic	-	-2.575 (0.639)***	-	-0.015 (0.005)**
Past-positive	-	0.259 (0.647)	-	-0.001 (0.004)
Past-negative	-	-2.700 (0.98)**	-	-0.009 (0.007)
Age *(years)*	0.013 (0.033)	0.011 (0.033)	0.000 (0.000)	0.000 (0.000)
Gender (ref: male)	0.426 (0.982)	0.635 (0.968)	-0.006 (0.008)	-0.005 (0.008)
Education (ref: primary)				
Secondary	2.363 (1.454)	2.058 (1.407)	0.008 (0.011)	0.006 (0.011)
Tertiary	0.915 (1.459)	0.216 (1.419)	0.014 (0.01)	0.009 (0.01)
Income (ref: quintile 1)				
Quintile 2	1.343 (2.002)	1.116 (1.954)	0.013 (0.015)	0.011 (0.015)
Quintile 3	1.781 (1.938)	0.989 (1.877)	0.014 (0.015)	0.009 (0.014)
Quintile 4	4.736 (1.864)*	3.966 (1.798)*	0.027 (0.014)	0.023 (0.014)
Quintile 5	4.042 (1.883)*	2.742 (1.832)	0.020 (0.014)	0.012 (0.013)
Don't know/refused to answer	4.353 (1.765)*	3.683 (1.704)*	0.025 (0.013)	0.021 (0.013)
Chronic conditions (ref: none)				
Allergy	0.144 (1.347)	0.111 (1.353)	-0.004 (0.01)	-0.005 (0.01)
Anxiety	-7.949 (2.129)***	-7.140 (2.141)**	-0.081 (0.019)***	-0.078 (0.019)***
Asthma	-4.411 (2.138)*	-3.726 (2.189)	-0.018 (0.02)	-0.015 (0.02)
Cancer	-9.753 (4.185)*	-8.918 (4.123)*	-0.014 (0.025)	-0.009 (0.024)
Cardiovascular disease	-8.388 (1.831)***	-8.673 (1.781)***	-0.070 (0.019)***	-0.071 (0.018)***
Depression	-10.416 (2.643)***	-9.385 (2.642)***	-0.101 (0.028)***	-0.095 (0.027)**
Diabetes	-6.190 (1.74)***	-6.293 (1.686)***	-0.031 (0.017)	-0.032 (0.017)
Gastrointestinal disease	-2.527 (1.932)	-2.184 (1.877)	-0.013 (0.017)	-0.011 (0.017)
Hypertension	-2.548 (1.208)*	-2.600 (1.202)*	-0.026 (0.009)**	-0.026 (0.009)**
Musculoskeletal disease	-7.316 (1.339)***	-7.039 (1.337)***	-0.075 (0.01)***	-0.074 (0.01)***
Osteoporosis	-7.123 (3.686)	-6.844 (3.639)	-0.004 (0.024)	-0.003 (0.023)
Skin disease	-0.567 (1.738)	-0.341 (1.786)	0.004 (0.014)	0.006 (0.014)
Model fit	F(21, 974)=12.04 (p<0.001), R^2=0.266	F(26, 969)=12.51 (p<0.001), R^2=0.302	F(21, 974)=8.25 (p<0.001), R^2=0.309	F(26, 969)=7.66 (p<0.001), R^2=0.326

EQ VAS = EuroQol visual analogue scale; TP = time perspective; ZTPI =17-item Zimbardo Time Perspective Inventory
* p<0.05; ** p<0.01; *** p<0.001