New ways to measure well-being?

A first joint analysis of subjective and objective measures

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Abstract

Our study is, to our knowledge, the first joint analysis of subjective and objective measures of well-being. Using a rich longitudinal data from the mothers pregnancy until adulthood for a birth cohort of children who attended school in Örebro during the 1960s, we analyse in a first step how subjective (self-assessed) and objective (cortisol-based) measures of well-being are related to each other. In a second step, life-course models for these two measures are estimated and compared with each other. Despite the fact that our analysis is largely exploratory, our results suggest interesting possibilities to use objective measures to measure well-being, even though this may imply a greater degree of complexity.

Keywords: subjective and objective well-being; general life satisfaction; cortisol; birth-cohort data; adult, child and birth outcomes; multivariate imputation.

JEL Classification Codes: A12; D60; I31.

1 Introduction

Individual well-being and the prerequisites for a good life have attracted increasing attention in recent years. Several large international organizations (OECD, EU and UN) have expressed the need for new and improved statistical measures of people's lives and well-being to supplement common macroeconomic statistics.

Most of the earlier literature that have studied individual well-being and its determinants have been based on subjective measures of well-being, i.e., the individuals' assessment (see for example Di Tella and MacCulloch 2006; Frey and Stutzer 2002; Stutzer and Frey 2010). Subjective well-being is a broad concept that includes both affective states (pleasure and discomfort) and satisfaction with life as a whole or with a certain part of life (Diener et al. 1999). However, subjective measures of well-being have been criticized on the basis that they constitute individual assessments and that the same objective circumstances can be perceived differently by different individuals and what is measured is thus not well-defined. One may, on the other hand, in many cases argue, not at least in terms of well-being, that it is the individual's own experience that is essential. As part of this debate, we investigate to what extent well-known determinants of subjective well-being can also explain the variation in the stress hormone cortisol, which is commonly seen as an objective measure of well-being.

Cortisol is a steroid hormone that is produced as a reaction to stress. It is important for the metabolism and contributes to the regulation of a number of bodily functions. The cortisol level varies over the day and is usually at its lowest level just before waking up, after which it rises rapidly and reaches a peak about half an hour later. Although the variation between the cortisol levels of different individuals may be significant, systematic variations were reported, for example, for Addison's disease as well as for psychological conditions such as post-traumatic stress disorder and depression.

The few earlier studies that have analyzed cortisol and well-being have used cortisol as an explanatory variable for subjective well-being, and reported mixed results. Steptoe et al. (2005) find a negative correlation between the cortisol level during the day and subjective well-being, while Sjögren et al.. (2006) find a positive correlation between well-being and the difference between the cortisol level at waking and the level in the evening. In a meta-analysis, Chida and Steptoe (2009) find no clear correlation between the rapid increase in cortisol levels after waking up and well-being, similarly Cacioppo et al. (2008) find no significant correlation between several cortisol-related measures and happiness. On the other hand, Smyth et al. (2015) find a negative correlation for the total cortisol level after waking up.

With Layard et al. (2014) as a starting point, we model both a subjective measure of well-being, i.e., the self-assessed general life satisfaction and an objective measure of well-being, i.e., the stress hormone cortisol, as a function of individual

characteristics in adulthood, childhood and at birth and during the mother's pregnancy. We do this with a unique longitudinal data material that follows a cohort of school children, who attended third grade in 1965, from birth to adulthood.

Our main contribution, however, is that, in addition to studying subjective well-being in an established empirical paradigm (Layard et al. 2014), we show that the determinants of the subjective well-being are important when explaining the variation in the stress hormone cortisol, an objective measure of well-being. This is, to our knowledge, the first study that establishes a link between subjective and objective measures of well-being, suggesting a framework for the validation of subjective measures of well-being.[1]

2 Data

We use data from a long-term project, the IDA program (*Individual Development and Adaptation*), which is a major ongoing longitudinal research program in which a cohort of about 1500 children who attended third grade in 1965 are followed from birth to their late forties.[2] The overall purpose of the IDA program is to understand people's adaptation processes in a life-course perspective, and aims to contribute to knowledge about the mechanisms that govern the development of individuals for, among other things, different career paths and adaptation patterns in adulthood. For various reasons, for a few years, the data were collected only for either women or men. In 1998, when most subjects turned 43, a comprehensive study of women's work, health and education was conducted in a lifelong perspective. In 2002 and 2004, a follow-up that focused solely on women's lifestyle was conducted. In addition, sex differences are documented regarding the variation in the stress hormone cortisol. Therefore, this study only analyzes the 679 women in the data.

Given the purpose of establishing a link between subjective and objective measures of well-being, we present these two variables in detail. The subjective measure focuses on the pleasure-based part of well-being, such as satisfaction and happiness, and comes from answers to the question "How happy, satisfied or content with your life were you during the last 12 months/year?" which was included in the 1998, 2002 and 2004 waves. The question was answered on a 6-point scale, ranging from 1 (very dissatisfied, unhappy most of the time) to 6 (extremely happy, could not have been more satisfied or pleased). Our empirical analysis uses the average of the scores given in 2002 and 2004. Figure 1 shows that almost 40% of women are "almost satisfied" (the score of 4) and about 40% are "very happy" (i.e. the scores of 5 and 6).

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[1] This working paper is complementary to Andrén et al (2017) that contains detailed information about data, descriptive statistics, method and all results.

[2] Detailed information about the IDA program, its design and results is available at www.oru.se/ida-programmet.
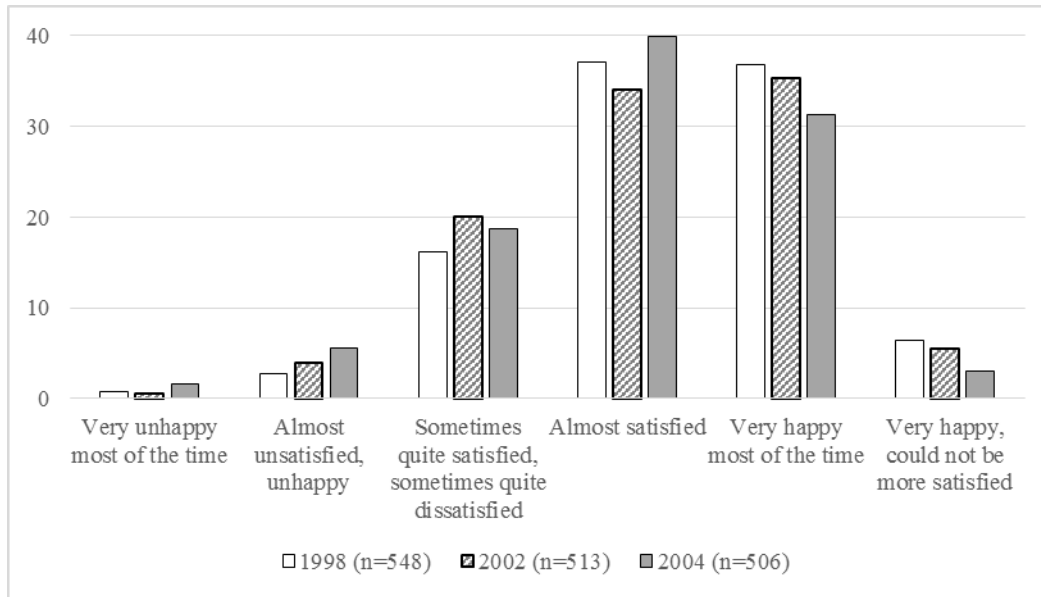
Figure 1 Subjective well-being 1998, 2002, 2004 (percent)

Source: own computations using IDA-data.

Given the complex mechanisms underlying the functions of and secretion of (morning) cortisol, where much research still remains, our approach is explorative and investigates several proposed measures. Self-administered saliva samples were taken by the women at and just after waking up. Based on this, we use three different measures that reflect different aspects of the cortisol profile: base level, total cortisol and the rate of increase.

Figure 2 shows, in line with previous studies (Bremmer et al. 2007; Penninx et al. 2007), tendencies to an inverse U-shaped relationship between subjective well-being and the different cortisol-based measures. Due to few observations, the uncertainty of this relationship is much higher for high levels of cortisol.
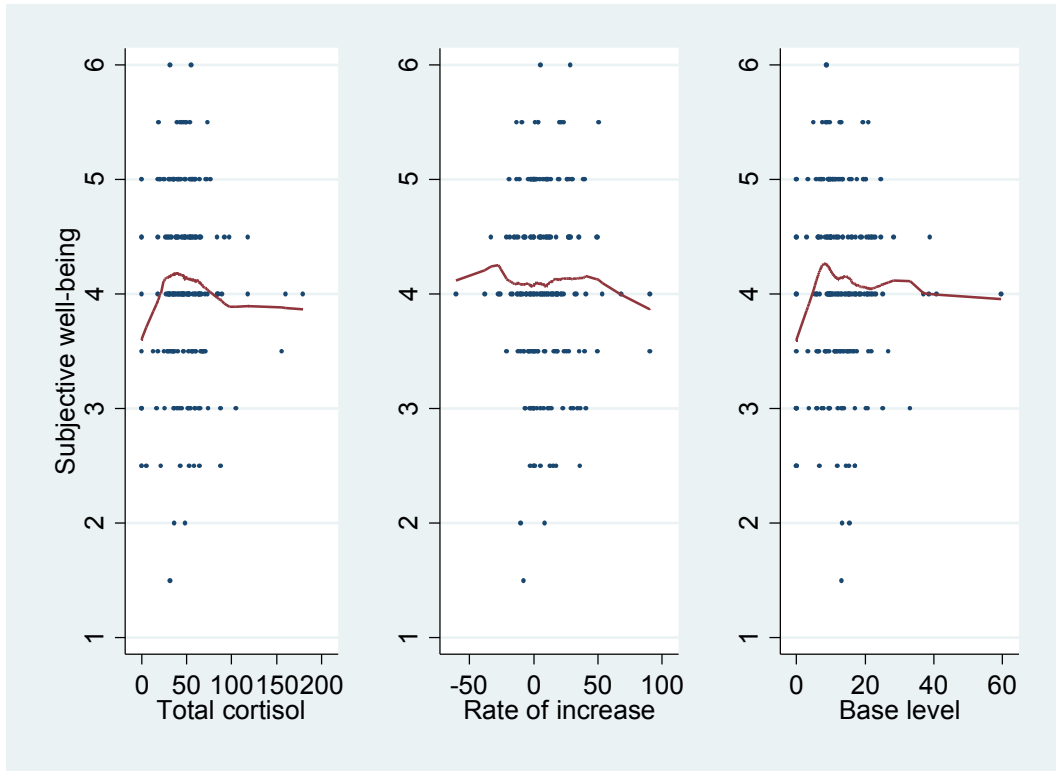
Figure 2. Three different measures of cortisol and subjective well-being

Note: Each graph is a locally weighted estimate (LOWESS) of subjective well-being as a
function of the current measure of cortisol.

Source: own computations using IDA-data.

3 Explanatory factors for subjective and objective well-being

Based on the empirical framework in Layard et al. (2014) we examine how well-
being, measured based on either self-assessment or cortisol, can be explained by
outcomes in adulthood (income, education, employment, family socio-economic
status, etc.), outcomes during adolescence (the family's financial status, parents'
education, results in school, as well as tests about abilities and attitudes) and
factors related to birth and the mother's characteristics during pregnancy (birth
weight, maternal age, pregnancy complications and number of previous
pregnancies).

First, we study to what extent well-being is separately explained by outcomes in
adulthood, outcomes in adolescence and at birth and during the pregnancy. Then,
how these characteristics influence the individual's well-being from a life-course
perspective. All variables (except the dummy variables) in the regressions are

standardized, so that the estimated so-called beta coefficients are interpreted in terms of standard deviations.

Table 1 shows that the subjective well-being is higher among women who are married/cohabiting or are employed compared to women who are single or non-employed, corresponding to half a standard deviation each in terms of self-assessed well-being. This relationship remains when more factors are taken into account (see column 5). For outcomes during childhood, the connection is weaker. The results indicate that subjective well-being increases with family income and with increased school attendance, but when all factors are taken into account, these relationships are no longer statistically significant. Birth weight shows a positive correlation, while mother's low and high age and health problems during pregnancy show a negative (but not significant) relationship with subjective well-being.

Table 2 shows the relations for the objective (cortisol-based) measure of well-being, categorized in low, medium and high values (where medium is the reference category). Total cortisol, the rate of increase and the base level of cortisol are modeled here as functions of outcome during adulthood, childhood and at birth and during mother's pregnancy. A negative sign of the coefficient indicates that the variable is to a lesser extent associated with the category low (or high) cortisol relative to the category medium.

The likelihood of a low value of total cortisol increases with both the woman's and the mother's educational level, but decreases with the father's level of education. Both the father's and the mother's length of education (as well as being self-employed or that the mother has worked) are also associated with high total cortisol, although not statistically significant. Being married/cohabiting makes it more likely to belong to the middle category. Higher aptitude is related to not having a low value of total cortisol. The birth weight is positively associated with high values of total cortisol, and the maternal age at birth is negatively associated with both low and high values of total cortisol, the latter statistically significant. While the mother's previous pregnancies are positively associated with low values, many diagnoses in pregnancy are negatively associated with high values of total cortisol.

Being married/cohabiting in adulthood is linked (albeit not statistically significant) with a higher rate of increase in cortisol. The mother's level of education is significantly associated with a high rate of increase of cortisol's value and family income is linked both to high and low rate of increase, the latter however not statistically significant. Finally, both high birth weight and low age of the mother are linked to a high rate of increase of cortisol.

Regarding the base level of cortisol during waking up, the probability of belonging to the medium category is higher among women who have a job, while long education is associated with a low base level. A high family income is linked to low values of the base level of cortisol. The mother's educational level is

strongly positively associated with a low base level while the father's educational level is negatively associated, although not statistically significant. Birth weight is positively associated with both low and high baseline, the latter statistically significant. Having an older mother increases the likelihood of belonging to the middle category. The number of previous pregnancies for the mother are significantly associated with a low base level.

Table 1 Subjective well-being as a function of adult outcomes, during childhood, at birth and during the mother's pregnancy

	(1) AO	(2) CO	(3) AO+CO	(4) BO	(5) AO+CO+ BO
Adult outcomes AO					
Log family income (98)	0.058		0.054		0.046
Working (04)	0.514***		0.512***		0.502***
Years of education (04)	-0.017		-0.010		-0.025
Married/cohabiting (04)	0.520***		0.519***		0.522***
Childhood outcomes CO					
Father's education (3)		-0.001	-0.022		-0.018
Mother's education (3)		-0.067	-0.077		-0.058
Log family income (3)		0.085*	0.069		0.072
Mother works (3)		-0.059	-0.042		-0.058
School absence (3, 6, 8)		-0.084*	-0.062		-0.055
Aptitude (3, 6, 8)		-0.025	-0.037		-0.045
Birth outcomes & during mother's pregnancy BO					
Birth weight (2.5-4.3kg)				0.228	0.228
High birth weight (> 4.3kg)				0.427*	0.491**
Young mother (< 21 years)				-0.237	-0.146
Old mother (> 35 years)				-0.145	-0.136
Previous pregnancies				-0.005	0.007
Mother's diagnoses				-0.036	-0.014
Constant	-0.826***	0.025	-0.806***	-0.151	-0.965***
R^2	0.098	0.020	0.114	0.029	0.137

Note: Linear regression (679 multiple imputed observations). Figures in brackets after variable names indicate the year (adults), or the yearly grade in the school (upbringing) when the outcome was measured. ***, ** and * indicate statistical significance at one, five and ten percent levels, respectively, based on robust standard errors.

Table 2 Cortisol measurement as a function of outcomes in adulthood, childhood, at birth and during the mother's pregnancy

	Total cortisol		Rate of increase		Base level	
	Low	High	Low	High	Low	High
Adult outcomes						
Log family income (98)	0.201	0.041	-0.072	0.092	0.290*	0.205
Working (04)	-0.208	0.376	-0.178	-0.247	-1.162**	-1.143**
Years of education (04)	0.619***	0.023	0.088	0.011	0.307**	-0.131
Married/cohabiting (04)	-0.399	-0.416	-0.048	0.479	0.028	-0.023
Childhood outcomes						
Father's education (3)	-0.458**	0.328	-0.245	0.080	-0.327	-0.052
Mother's education (3)	0.363*	0.301	0.018	0.353*	0.488**	0.123
Log family income (3)	-0.036	0.001	0.305	0.378*	0.375*	0.113
Mother works (3)	0.041	0.245	-0.113	0.152	-0.032	-0.207
School absence (3, 6, 8)	0.168	0.095	-0.095	0.238	0.168	-0.065
Aptitude (3, 6, 8)	-0.261*	-0.135	0.041	0.190	-0.070	0.060
Birth outcomes & during mother's pregnancy						
Birth weight (2.5-4.3kg)	0.192	0.571***	0.166	0.511***	0.236	0.386**
High birth weight (> 4.3kg)	-0.292	-0.594***	-0.135	-0.371*	-0.388*	-0.343**
Young mother (< 21 years)	0.491**	0.047	0.079	0.184	0.360*	0.165
Old mother (> 35 years)	0.148	-0.322	-0.224	-0.237	-0.119	-0.217
Constant	-0.230*	-0.754	0.095	-0.754**	1.515***	1.605***
McFadden R²		0.142		0.093		0.094

Note: Multinomial logit model with medium as reference category (679 multiple imputed observations). Figures in brackets after variable names indicate the year (adults), or grade (upbringing) when the outcome is measured. ***, ** and * indicate statistical significance at one, five and ten percent levels, respectively, based on robust standard errors.

4 Discussion and conclusions

We have used a rich longitudinal data material, where girls are followed from third grade until the end of their forties, supplemented with data at their birth and characteristics related to their mother's pregnancies. We estimate models for well-being based on subjective self-assessment and, as far as we know, for the first time in the literature also based on an objective measure (i.e., the stress hormone cortisol), as a function of outcomes during adulthood, childhood, at birth and during mother's pregnancy. In line with the previous studies, an inverse U-shaped relationship is found between cortisol measures and subjective well-being.

Our results for subjective well-being are in line with previous studies with Swedish data, where work and marital status are important determinants. Apart from birth weight, however, there are no other statistically significant relationships for factors earlier in life.

We use several measures of cortisol: total cortisol, the rate of increase and the base level of cortisol. Total cortisol is best predicted. The dynamics of the cortisol secretion during waking up can be divided into the awakening level (base) and the change afterwards (the rate of increase). Although these two measures are negatively correlated, they are largely predicted by the same factors. For some outcomes, such as having a job, a stronger relationship is also seen than for total cortisol. Family income in adulthood, having a work, and education level are important. For outcomes during childhood, parents' education, family income and the child's aptitude contribute to explaining cortisol. From outcomes at birth and during mother's pregnancy, the birth weight, the age of the mother and the number of previous pregnancies are linked to the different cortisol measures.

Low values of cortisol measures are more often than high values associated with factors that usually predict low subjective well-being. The importance of having a job is a clear determinant for both subjective and objective measures. Similar patterns are observed for married/cohabitation, but are not statistically significant for the objective measures. In addition to birth weight, several outcomes prior to adult life are statistically significant for objective measures.

Our results are exploratory and limited to a cohort of Swedish women, but they point to the potential of being able to make use of both subjective and objective measures of well-being. Our contribution is hopefully a step in the right direction in meeting the need for development regarding the measurement and analysis of well-being.

References

Andrén D, A Clark, C D'Ambrosio, S Karlsson & N Pettersson (2017), "Subjective and Physiological Measures of Well-being: An Exploratory Analysis Using Birth-cohort Data", Working Papers No 2017:8, Handelshögskolan, Örebro universitet.

Bremmer M, D Deeg, A Beekman, B Penninx B, P Lips & W Hoogendijk (2007), "Major Depression in Late Life is Associated with Both Hypo-and Hypercortisolemia", *Biological psychiatry*, vol 62, s 479–486.

Cacioppo J, L Hawkley, A Kalil, M Hughes, L Waite & R Thisted (2008), "Happiness and the Invisible Threads of Social Connection, The Chicago Health, Aging, and Social Relations Study", i Eid, M & R Larsen (red), *Science of Subjective Well-Being*, The Guilford Press, New York.

Chida, Y & A Steptoe (2009), "Cortisol Awakening Response and Psychosocial Factors: A Systematic Review and Meta-analysis", *Biological Psychology*, vol 80, s 265–278.

Di Tella, R & R MacCulloch (2006), "Some Uses of Happiness Data in Economics", *Journal of Economic Perspectives*, vol 20, s 25–46.

Diener, E, E M Suh, R E Lucas & H L Smith (1999), "Subjective well-being: Three decades of progress", *Psychological Bulletin*, vol 125, s 276–302.

Frey B & A Stutzer (2002), "What Can Economists Learn from Happiness Research?", *Journal of Economic Literature*, vol 40, s 402–435.

Layard R, A Clark, F Cornaglia, N Powdthavee & J Vernoit (2014), "What Predicts a Successful Life? A Life-course Model of Well-being", *Economic Journal*, vol 124, F720–F738.

Penninx B, A Beekman, S Bandinelli, A Corsi, M Bremmer M, W Hoogendijk, J Guralnik & L Ferrucci (2007), "Late-life Depressive Symptoms are Associated with both Hyperactivity and Hypoactivity of the Hypothalamo-pituitary-adrenal Axis", *American Journal of Geriatric Psychiatry*, vol 15, s 522–529.

Sjögren E, P Leanderson & M Kristenson (2006), "Diurnal Saliva Cortisol Levels and Relations to Psychosocial Factors in a Population Sample of Middle-Aged Swedish Men and Women", *International Journal of Behavioral Medicine*, vol 13, s 193–200.

Smyth N, L Thorn, F Hucklebridge, P Evans & A Clow (2015), "Post Awakening Salivary Cortisol Secretion and Trait Well-being: The Importance of Sample Timing Accuracy", *Psychoneuroendocrinology*, vol 58, s 141–151.

Steptoe A, J Wardle & M Marmot (2005), "Positive Affect and Health-Related Neuroendocrine, Cardiovascular, and Inflammatory Processes", *Proceedings of the National academy of Sciences of the United States of America*, vol 102, s 6508–6512.

Stutzer A & B Frey (2010), "Recent Advances in the Economics of Individual Subjective Well-Being", *Social research: An International Quarterly*, vol 77, s 679–714.