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Daniela Andrén, Andrew E. Clark, Conchita D'Ambrosio, Sune Karlsson, Nicklas Pettersson

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Örebro University School of Business
701 82 Örebro
SWEDEN

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Daniela Andrén
Örebro University School of Business.
SE - 701 82 Örebro, Sweden.
Daniela.Andren@oru.se

Andrew E. Clark
Paris School of Economics - CNRS. 48 Boulevard Jourdan; 75014 Paris, France.
Andrew.Clark@ens.fr

Conchita D'Ambrosio,
Université du Luxembourg, Campus Belval. 11, Porte des Sciences, L-4366 Esch-sur-Alzette, Luxembourg.
conchita.dambrosio@uni.lu

Sune Karlsson
Örebro University School of Business.
SE - 701 82 Örebro, Sweden.
Sune.Karlsson@oru.se

Nicklas Pettersson
Örebro University School of Business.
SE - 701 82 Örebro, Sweden.
Nicklas.Pettersson@oru.se

Abstract

We use a rich longitudinal data set following a cohort of Swedish women from age 10 to 49 to analyse the effects of birth and early-life conditions on adulthood outcomes. These latter include both well-being and the stress hormone cortisol. Employment and marital status are important adult determinants of well-being. Log family income and absence from school also predict adult well-being, although their importance falls when controlling for adult and birth characteristics. Among the birth characteristics, we find that high birth weight (>4.3kg) affects adult well-being. We predict the level of adult cortisol only poorly, and suggest that the relationship between life satisfaction and cortisol is non-monotonic: both high and low cortisol are negatively correlated with life satisfaction. The results from an OLS life satisfaction regression and a multinomial logit of high or low cortisol (as compared to medium) are more similar to each other.

Keywords: life satisfaction; cortisol; birth-cohort data; adult, child and birth outcomes; multivariate imputation by chained equations.

JEL Classification Codes: A12; D60; I31.

1 Introduction

This paper considers the importance of personal characteristics from birth to middle-age for the well-being of women of women in their late forties. We do so using data from a unique cohort study following the life-course of children from a mid-sized Swedish town who were in Grade 3 in 1965. The dataset information is unique as it combines data from official registers (including criminal offences, mental health, employment, education, alcohol abuse, and birth records) collected during subjects' school years and beyond, child and family characteristics from child, parent and teacher questionnaires, and both individual physiological and behavioural variables and social environmental variables. Our main contribution here will be to compare subjective well-being (life satisfaction) at age 49 to stress hormone excretion (cortisol) measured at work and at home.

Sweden provides a 'window into the future' for women's well-being in that, together with the other Nordic countries, Sweden leads other countries in terms of female participation in work outside of the household (see https://data.oecd.org/emp/labour-force-participation-rate.htm). This rise largely took place during the adulthood of the Swedish women in the IDA study, so that they were to a large extent exposed to changing social norms and the challenges of achieving work-life balance. Even though in the 1960s, when women in the IDA study were attending school, it was very unusual for Swedish fathers to take part in childcare (only 1% of fathers took part in childcare when the children were small, and about 14% when the children were somewhat older), this had completely changed when the women analysed in this paper became mothers. Sweden was the first country in the world to grant fathers the right to paid parental leave in 1974. Since then policy reforms have comprehensively supported gender equality and work-life balance.

Over recent decades, an increasing amount of empirical evidence from different disciplines has traced the origins of life-cycle well-being to the early stages of life (see Almond and Currie, 2011, for an overview). Despite the variety of empirical methods and data sources across the different contributions, the results emphasise the long-lasting consequences of early-life conditions (see the review of the evidence on the link between early-childhood health and well-being and outcomes over the life course in Currie and Rossin-Slater, 2015).

Barker's 'fetal origins hypothesis' highlighted that early-life conditions can have lasting consequences on human well-being: adverse conditions in the prenatal period can produce metabolic characteristics associated with future diseases in the fetus (Barker, 1990). However, individuals may not experience these ill health effects until middle age. The 'life course'

framework goes beyond the fetal period and considers how biological, behavioural, and psychosocial processes from early life onwards can influence health and disease risk at older adult ages (Kuh *et al*., 2003; Kuh and Shlomo, 2004).

While long-term effects of earlier circumstances on quality of life and well-being have been observed, particularly in relation to childhood or mid-life social position (Niedzwiedz *et al*., 2012), life-course research on how individual life histories relate to adult well-being remains at an early stage of development (George, 2010).

Layard *et al*. (2014) is, to the best of our knowledge, the first contribution to estimate a recursive model of how adult life satisfaction is predicted by childhood influences, acting both directly and indirectly through adult circumstances (such as income, employment, education and physical and emotional health). In British Cohort Study (BCS) data, the most important factor among these adult circumstances is emotional health. Equally, the most powerful childhood predictor of adult life satisfaction is child emotional health, followed by the child behaviour, while child cognitive performance is among the least important childhood predictors of adult life satisfaction. These results are in line with those in Frijters *et al*. (2014), using another UK birth cohort, the National Child Development Study (NCDS), who analyse how well adult life satisfaction is predicted by childhood circumstances, including conventional measures of family social class, as well as health, personality, and cognitive and non-cognitive attributes. Their results show that around 2% of the variation in the average of adult life satisfaction (at ages 33, 42, 46 and 50) is predicted by characteristics observed at the time of birth, including birthweight, the gestation period and family economic status measured by parental education and father's occupational class. Adding extensive controls for child characteristics at ages 7, 11 and 16, including a wide range of child-specific traits and family characteristics, increases the predictive power to around 7%. Regardless of the model specification, child non-cognitive skills remain statistically significant predictors of adult life satisfaction, even after controlling for contemporaneous education, labour market and health outcomes.[1]

Earlier studies of well-being using Swedish data found that gender (being male), greater age, cohabitation, good childhood conditions, support from friends, a sound financial situation and the absence of negative life events were positively associated with well-being, and jointly explained about 20% of its variance. Hansson *et al*. (2005) conclude that the factors

[1] See Flèche *et al*. (2017) for a comparison of the life-course determinants of adult life satisfaction in the BCS and NCDS at all of the ages for which information on the latter is available.

associated with well-being in earlier analyses of Swedish data are fairly consistent across the different contributions, despite the different measurements, periods and sample sizes, but explain only a small part of the total variance,. It may therefore be argued that research on well-being needs to take a new approach, by placing less focus on external factors and more focus on internal factors, such as individual personality and coping strategies.

Earlier work on Swedish well-being using IDA data mainly focused on women. Even when controlling for a number of internal factors, such as individual personality and coping strategies, the predictive power of sociodemographic factors remains low. Marital status and income were the strongest sociodemographic predictors, and personality factors tend to be the strongest and most consistent predictors of Subjective Well-Being (SWB) overall (Bergman and Daukantaite, 2006). In addition, the different ways in which women combined educational, occupational, and family involvement over time were to some extent reflected in mid-life health and well-being. For example, Johansson *et al*. (2007) found that working mothers with limited education, early full-time employment and fairly late childbirths reported slightly poorer adult health and lower satisfaction, while Huang and Sverke (2007) suggest no significant effect of different career patterns on life satisfaction. Daukantaite and Bergman (2005) report that optimism in adolescence has a positive effect on women's adult well-being.

Our major contribution here is to jointly analyse the early-life correlates of adult subjective well-being and cortisol. The relationship between well-being and stress hormones is not well understood, and there are conflicting results in the literature. The meta-analysis in Chida and Steptoe (2009) reports mixed results regarding the relationship between cortisol and well-being (and similar concepts). While Cacioppo (2008) found no significant relationship between a number of cortisol outcomes, including cortisol awakening response (CAR), and happiness, Smyth *et al*. (2015) instead highlight a negative relation between subjective well-being and one particular cortisol outcome (see Section 4 below for details). One potential explanation of the earlier reported mixed results could be the U-shaped relationship between negative affect and cortisol among middle-aged and older adults reported by, for example, Bremmer *et al*. (2007) and Penninx *et al*. (2007).

Our paper adds to this small literature by providing new empirical evidence on the relationship between birth conditions, school grades, behavioural scores, abilities and attitudes throughout the school years and adulthood to women's well-being and other outcomes (including cortisol) in their late forties. Our empirical strategy is exploratory and inspired by Layard *et al*. (2014): we build a recursive model of women's adult life satisfaction

to establish how this is affected by childhood influences both directly and indirectly through adult outcomes. In doing so we focus on women since the information collected for men and women is not the same, rendering any joint estimation difficult. Crucially, women underwent a medical examination in 1998 in which cortisol hormones measurements were taken. We use these measures to calculate a number of different cortisol functions that we then analyse in recursive models, in the same way as for life satisfaction.

The remainder of the paper is organised as follows. Section 2 sets out the details of the IDA data used in the paper. Section 3 then contains the empirical results on well-being while Section 4 focuses on the analysis of cortisol. Last, Section 5 concludes.

2 Data and institutional setting

Our data is extracted from The Swedish Individual Development and Adaptation (IDA) database,[2] which "*may be the single most important longitudinal study of this century*" (Lerner and Schwab, 1991). The first data collection was carried out in the spring of 1965. It involved pupils in three grades (the 3rd, 6th and 8th grades), their teachers and their parents in a medium-sized Swedish city, Örebro. In the Swedish school system at that time, children started school at the age of seven. Only pupils who were in the third grade in 1965 (519 boys and 510 girls) were subsequently followed up with extensive data collection. Children who moved into the region from 1965 to 1972 and were present in the school system during the years the data were collected were also included in the longitudinal population. In total, 710 boys and 683 girls appear in the dataset on at least one survey occasion. The same type of data (child and family characteristics collected via child, parent and teacher questionnaires, and from school records) was collected again when the participants were in grade 6 and during secondary school (grades 7-9), with the addition of age-relevant data concerning norm-breaking and norm groups as well as data on self-reported physical and psychological symptoms for teenage girls. During upper-secondary school (grades 10-12) the additional data collected mostly related to experiences at school and issues relating to vocational and educational behaviour. Ability-test data were also collected for those students attending the kind of secondary school that prepared them for university.

The participants continued to be followed during adulthood, with data covering a broad range of individual physiological and behavioural factors and environmental structural and social factors. Data from official registers (including information on criminal offences, mental

[2] This description of the data is heavily based on Magnusson (2012).

health, employment, education, alcohol abuse, and birth records) were collected during the subjects' school years and in adulthood.

For a number of reasons, the data for women and men was collected at different ages. Although they were mostly asked the same questions, there were also a number of different gender-related questions. In 1998, the year in which most of the IDA respondents turned 43, a new comprehensive survey wave of the women collected data on their work, health and education in a life-course perspective. Of the eligible women, 89% participated in this wave. In 2002, a follow up questionnaire focusing only on life style was administered to the women.

In 2004, all women who took part in the 1998 wave were contacted again and were asked to participate in a second follow-up study. The aim of this study was to collect information on the women's life situation, life satisfaction and health at age 49, using a subset of the questions from the 1998 wave. As such, some output variables that are relevant for our analysis are not available in 2004, but do appear in the 1998 detailed questionnaire.

After excluding four observations due to missing values for all variables and very extreme values on the variable cortisol (see the description in Section 2.1), we have 679 observations in our final sample.

The three following sub-sections present the definitions of all of the adult, childhood and birth variables used in our empirical analysis.

2.1 Adult Outcomes (AO)

Life satisfaction. Our main adult outcome is general life satisfaction (GLS). The question "*How happy, satisfied or content with your life were you during the last 12 months/year?*" 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 score given in 2002 and 2004. Approximately 70% of the respondents are "*mostly happy*" or "*mostly very happy*" (i.e. the scores of 5 and 6), with the third most-frequent answer "*sometimes happy*" (the score of 4) covering approximately 20% of respondents.

Working. Employment status is reported in 2004. This is coded as 1 if the individual is full- or part-time employed or self-employed, and 0 otherwise.

Household income. Household income was assessed in 1998 (at age 43) from the question "*How large is the income of your entire household **after** tax deduction?*". We use the

logarithm of household income equivalised using the OECD equivalent scale in the empirical analysis.

Years of education. Education was self-reported in 1998 in seven categories: 1) compulsory schooling (grade 9); 2) two-year vocational upper-secondary school; 3) incomplete two-year theoretical upper-secondary school; 4) completed two-year theoretical upper-secondary school; 5) three-four year upper-secondary school; 6) incomplete university; and 7) university degree. A few women did not complete their education and were assigned to the nearest lower level of education. The variable is then converted to the corresponding number of years of schooling.

Married/cohabiting. Marital status was recorded in 2004, and is here coded as 1 if married or cohabiting and 0 otherwise.

Cortisol. Section 4 presents a short description of the stress hormone cortisol and findings in the earlier literature about its association with well-being. As part of the 1998 medical examination, four self-administrated saliva samples (s1-s4) were taken in the morning at 0 (s1), 15 (s2), 30 (s3) and 45 (s4) minutes after waking, and were analysed for the cortisol hormone (see Lundberg and Hellström, 2002, for a detailed description). In addition to the average cortisol figure (over the four measurement points), we constructed, following Preussner *et al*. (2003), indices for total (AUCg) and increase in (AUCi) cortisol secretion from awakening ground level: AUCg=(s1+s2)/2 + (s2+s3)/2 + (s3+s4)/2 and AUCi=AUCg-3*s1. An alternative measure of increase was also calculated: the change in cortisol in the first 30 minutes after awakening: INC=s3-s1. All five measures were also trichotomised as follows: s1 = < 7, 7-14 (ref), > 14; mean cortisol = < 10, 10-20 (ref), > 20; AUCg = < 30, 30-60 (ref), > 60; AUCi = < 0, 0-30 (ref), > 30; and INC = < 0, 0-15 (ref), > 15. The negative relationship between s1 and both AUCi (the Pearson correlation is -0.30) and INC (-0.33) is in line with the findings in the review by Stalder *et al*. (2016).

2.2 Child Outcomes (CO)

Father's years of education. This is obtained from the parents' questionnaire when the child was in Grade 3. The reported educational level is converted to the corresponding number of years of schooling.

Mother's years of education. This is measured analogously to father's education above.

Family income. This is the sum of the mother's and father's pre-tax income, obtained from the parents' questionnaire when the child was in Grade 3. The response is banded in the

questionnaire and we use the mid-interval values except for the open-ended top category, where we use the average income for married couples in Sweden with a combined income above 50 000 Kronor (Table 377, SCB, 1967). The logarithm of household income is equivalised using the OECD equivalent scale.

Mother works. This is a dummy variable for the mother having full- or part-time employment or being self-employed when the child was in Grade 3.

Absence from school. The average of hours absent from school in Grades 3, 6 and 8, obtained from school records.

Aptitude. This is a comprehensive measure constructed as the first principal component of school grades and scores on standardised national tests in years 3, 6 and 8, intelligence tests in years 3, 6 and 8 and teacher's scores of child behaviour over seven dimensions in years 3 and 6. The first component explains 57% of the variation in the variables and loads negatively on the teacher's scores (where a higher score indicates worse behaviour) and positively on the other variables.

2.3 Birth Outcomes (BO)

Starting in December 1983 and up to January 1985, birth outcomes were collected from the delivery records of the local hospitals. Records were obtained for 450 of the 683 girls, with all but a few of the remainder being born outside the region.

Birth weight. Weight at birth in kilograms. This is recoded into three groups: low (< 2.5), medium (2.5-4.3), and high (> 4.3).

Mother's age. Age of the mother at birth. Recoded as: young (< 21), medium (21-35), and high (> 35).

Previous pregnancies. Number of previous pregnancies, including miscarriages.

Mother's diagnoses. Number of diagnosed illnesses or conditions during pregnancy.

2.4 Representativeness

Given that the IDA data cover all individuals in the third grade of school in 1965 in Örebro, we may wonder how representative they are of the corresponding national Swedish birth cohort. Table 1 presents some descriptive statistics regarding the Swedish population of women, the sub-population of women living in Örebro and the samples when the empirical analysis uses only adult outcomes (AO; N = 368) and all of adult, child and birth outcomes (AO+CO+BO; N = 152). The women in both samples have, on average, a slightly higher

wage in 1998 than Swedish women overall or women living in Örebro. Marital status does appear to differ markedly from the national or local pattern, with more married and cohabiting women. This probably reflects that Swedish official statistics do not reliably record cohabitation, and so only include married women: some women who are officially recorded as single or widows are in fact cohabiting. The women in our samples are better educated than their age-peers, with the main difference being that a greater proportion completed university.

While there are some differences compared to the country and/or city they are, with the potential exception of education, relatively small and should not affect the validity of the analysis. We note, in particular, that the sample composition is not greatly affected by the loss of observations when moving from an analysis with adult outcomes only to one with adult, childhood and birth outcomes.

Table 1 The comparison of the IDA Sample to Örebro and Sweden

	Sweden age 40-44	Örebro age 40-44	Sample AO	Sample AO+BO+CO
Yearly wages in 1998 for women (age 43), thousand Kronor				
Median	168.0	172.0	180.0	184.8
Average	168.8	168.7	186.4	187.5
Marital status in 2004 for women (age 49), percentage				
Single	21.2	22.5	10.7	11.3
Married/cohabitation	57.3	54.5	76.1	72.3
Divorced	20.0	21.2	9.5	9.9
Widow	1.6	1.8	0.8	0.9
Other	-	-	2.9	5.6
Education in 2004 for women (age 49), percentage				
Compulsory school (9 years)	16.0	13.2	16.7	15.5
2-year secondary school	35.7	33.9	28.8	31.5
3 year secondary school	11.9	9.7	7.2	5.6
Attended university	17.6	21.3	7.8	9.5
University degree	18.7	21.8	39.5	38.0

2.5 Imputation

Of the 679 observations, on average 26% are missing for the different variables, with 33% missing values for life satisfaction and 67% for Cortisol. Depending on the estimated model, few complete cases are available.

A model was therefore set up to multiply impute the missing values in 250 datasets under a missing at random assumption (Rubin, 1976) using multivariate imputation by chained equations (van Buuren and Groothuis-Oudshoorn, 2011). After an initial screening for key variables, the predictor-selection procedure in van Buuren *et al*. (1999) was applied to select

predictor variables that were correlated with the response indicators of the model variables, and with the model variables themselves. In addition to the model variables, at most 15 other variables were included in the prediction model for each variable. The final results we report are pooled from all imputed data sets.

3 Empirical Framework and Results

We use the same empirical framework as Layard *et al*. (2014), taking adult life satisfaction as the measure of a successful life. Life satisfaction is determined partly by 'adult outcomes', *AO*, (e.g., income, education, employment, family status), and partly by family background and childhood characteristics, *CO* (e.g., family's economic status, parents' education, performance in school, intelligence scores and abilities and attitudes throughout the school years). We also add individual characteristics at birth and mother's characteristics during pregnancy and during delivery, *BO* (e.g., weight, mother's age, number of previous pregnancies and diagnosed complications during a pregnancy).

We model both subjective well-being (Table 2) and an objective measure of well-being, the stress hormone cortisol, (Table 3) as a function of the *AO* variables to see how current life outcomes affects well-being, then as a function of *CO* variables to assess the role of early life events, and last as a function of *BO* to evaluate the role of 'initial conditions'. Second we model both well-being variables as a function of all of *AO, CO* and *BO*. This will reveal how much of the effect of childhood and birth characteristics is mediated by current life outcomes. We last directly model the adult outcomes *AO* as a function of *CO* and *BO*. This shows how adult income, education etc. are determined by the childhood and birth characteristics (Table 4).

We standardise all variables in the regressions, with the exception of the dummies: the resulting coefficient estimates are thus beta-coefficients, and should be interpreted in terms of standard deviations.[3] A beta-coefficient of 0.5, for example, means that a one standard-deviation rise in the explanatory variable increases the dependent variable by one half of its standard deviation. We standardise as many variables lack a natural scale, making normal estimated regression coefficients difficult to interpret, and to allow the simple evaluation of the relative importance of the explanatory variables.

Column 1 of Table 2 shows that the adult outcomes of employment and marital status are statistically-significant predictors of life satisfaction, while the estimated coefficients on the

[3] See Layard *et al*. (2014) for more details regarding beta-coefficients.

other adult outcomes (income and education) are small and insignificant. Turning to the role of childhood outcomes (Column 2) we find that these are much less important as predictors of life satisfaction, and explain a smaller proportion of the variation in life satisfaction. Even so, family income and absence from school do significantly predict adult life satisfaction. Of the birth outcomes (in column 4), only high birth weight is significantly correlated with adult life satisfaction.

Column 3 of Table 2 combines the adult and childhood outcomes. The coefficients of the *CO* variables are now all insignificant, while the explanatory power of the two significant *AO* variables, employment and marital status, is unaffected.

The final column of Table 2 presents the results using all of the adult, childhood and birth outcomes. Perhaps unsurprisingly, the pattern in column 3 is repeated with respect to the adult and childhood outcomes. The significant adult outcomes there remain so, with the coefficient estimates being largely unaffected by the inclusion of birth outcomes. For the birth outcomes themselves, the positive life-satisfaction effect of high birth weight found in column 4 continues to hold.

Table 2 Mean Adult Life Satisfaction as a Function of Adult, Child and Birth Characteristics. Linear Regressions (679 multiply-imputed observations).

	(1) AO	(2) CO	(3) AO+CO	(4) BO	(5) AO+CO+BO
Adult outcomes					
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					
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					
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-squared	0.098	0.020	0.114	0.029	0.137

*** p<0.01, ** p<0.05, * p<0.1; robust standard errors; # indicates a dummy variable that is not standardised. The figures in parentheses following the variable names indicate the year at which the adult outcome is measured or the age(s) at which the childhood outcome is measured.

Table 3 Average Cortisol (98) Equations as a Function of Adult, Child and Birth Characteristics. Linear Regressions (679 multiply-imputed observations).

	(1) AO	(2) CO	(3) AO+CO	(4) BO	(5) AO+CO+BO
Adult outcomes					
Log family income (98)	0.006		0.004		0.005
Working (04)#	0.013		0.022		0.018
Years of education (04)	-0.065		-0.063		-0.068
Married/cohabiting (04)#	0.016		0.015		0.017
Childhood outcomes					
Father's education (3)		0.030	0.036		0.051
Mother's education (3)		-0.064	-0.056		-0.024
Log family income (3)		-0.025	-0.015		-0.020
Mother works (3)#		0.079	0.073		0.061
School absence (3, 6, 8)		0.014	0.009		0.007
Aptitude (3, 6, 8)		0.023	0.037		0.030
Birth outcomes					
Birth weight (2.5-4.3kg)#				-0.001	0.004
High birth weight (> 4.3kg)#				0.116	0.146
Young mother (< 21 years)#				0.040	0.026
Old mother (> 35 years)#				-0.305**	-0.287*
Previous pregnancies				-0.036	-0.049
Mother's diagnoses				-0.022	-0.018
Constant	-0.022	-0.033	-0.060	0.048	-0.013
R-squared	0.014	0.014	0.027	0.031	0.055

*** p<0.01, ** p<0.05, * p<0.1; robust standard errors; # indicates a dummy variable that is not standardised. The figures in parentheses following the variable names indicate the year at which the adult outcome is measured or the age(s) at which the childhood outcome is measured.

Table 4 Adult Outcomes as a Function of Child and Birth Characteristics. Linear Regressions (679 multiply-imputed observations)

	(1) Log family income (98)	(2) Working (04) #	(3) Years of education (04)	(4) Married/cohabiting (04) #
Childhood outcomes				
Father's education (3)	0.049	0.008	0.104**	0.035
Mother's education (3)	-0.044	0.039*	0.138***	-0.005
Log family income (3)	0.128**	0.002	0.147***	0.028
Mother works (3)#	0.137	-0.068*	-0.111	0.010
School absence (3, 6, 8)	-0.010	-0.039*	-0.074*	-0.004
Aptitude (3, 6, 8)	0.036	0.020	0.217***	-0.009
Birth outcomes				
Birth weight (2.5-4.3kg)#	0.059	0.074	0.283*	-0.062
High birth weight (> 4.3kg)#	0.190	-0.017	0.443**	-0.173
Young mother (< 21 years)#	-0.187	-0.036	-0.104	-0.078
Old mother (> 35 years)#	-0.008	-0.006	0.029	-0.054
Previous pregnancies	0.013	-0.009	-0.054	0.022
Mother's diagnoses	-0.023	-0.009	0.024	-0.042*
Constant	-0.088	1.827***	-0.208	1.830***
R-squared	0.053	0.076	0.227	0.042

*** p<0.01, ** p<0.05, * p<0.1; robust standard errors; # indicates a dummy variable that is not standardised. The figures in parentheses following the variable names indicate the year at which the adult outcome is measured or the age(s) at which the childhood outcome is measured.

Table 3 carries out the analogous analysis for the average of the stress hormone cortisol. Contrary to the life-satisfaction results in Table 2, there is only one parameter estimate which is statistically significant: the mother being over 35 at birth, both when only the birth outcomes variables are included and when all of the adult, childhood and birth outcomes appear. We will see in the following section that the analysis of cortisol requires a more elaborate approach than a standard linear model due to its non-linear relation to life-satisfaction.

Table 4 addresses the issue of mediation: the extent to which childhood and birth outcomes indirectly affect life satisfaction via the adult outcomes. Overall the R^2 is low in these estimated equations, with childhood and birth outcomes explaining under 8% of the variation in the adult outcomes (except for years of education which is relatively well predicted with an R^2 statistic of 0.2: the same distinction is found in Layard *et al*., 2014). The only significant predictor of adult household equivalent income is the same variable during childhood. Mother's education, absence from school and mother works significantly predict that the respondent works at age 49, and both parents' education, as well as absence from school, aptitude and both normal and high birth weight significantly predict adult education. Mother's diagnoses during pregnancy is the only significant variable in the adult marital-status equation.

4 Cortisol

The steroid hormone cortisol is related to a number of physiological functions and is released in response to stress. Cortisol typically has a diurnal pattern: the lowest level is at night, with a steep rise to its peak at about half an hour (somewhat later for women and more attenuated with age) after awakening and then a gradual decline during the rest of the day. Abnormal cortisol levels are associated with various conditions, such as Addison's disease (low), Cushin's syndrome (high), or Post Traumatic Stress Disorder (low and high). An overview of cortisol outcomes and related key findings in naturalistic studies appears in Saxbe (2008), and of the relation between cortisol and positive affect in Steptoe *et al*. (2009). A negative relationship between SWB and the diurnal level of cortisol (Lindfors and Lundberg, 2002;

Steptoe *et al*., 2005) is commonly found, and Sjögren *et al*. (2006) also report a positive association between well-being and the awakening minus evening levels of cortisol.

The early morning cortisol peak is also known as the cortisol awakening response (CAR), often measured by area under curve indices for total (AUCg) and increase in (AUCi) cortisol secretion from the awakening ground level (Preussner *et al*., 2003). A recent review has however underlined that the CAR is a relatively distinct (superimposed awakening response) period, and noted the importance of the starting point (that is the level at awakening) of the CAR, which often is inversely related to the increase (Stalder *et al*., 2015).

A meta-analysis (Chida and Steptoe, 2009) reveals mixed results regarding the relation between CAR and well-being (and similar concepts). While Cacioppo *et al*. (2008) found no significant relation between several cortisol outcomes (including CAR) and happiness, a recent contribution finds that AUCg (but not AUCi) is correlated with daily cortisol secretion and a negative relation between SWB and post-awakening total (but not increase in) cortisol secretion (Smyth *et al*., 2015). Some work in the last decade has identified a U-shaped relationship between negative affect and cortisol (Bremmer *et al*., 2007; Penninx *et al*., 2007), including AUC-indices (Power *et al*., 2011; Wardenaar *et al*., 2011) among middle-aged and older adults, and suggests a role for imbalances in stress homeostasis, which could explain the earlier mixed results.

The preliminary results in Table 3 referred to average cortisol measured at four points during the first 45 minutes after waking. It is, however, not clear that this simple average is the best way to capture the information in the cortisol measurements. The first panel of Figure 1 plots life satisfaction against mean cortisol, and suggests something of a non-linear relationship with a peak in life satisfaction at an average cortisol level of around 15. The remaining four panels carry out a similar exercise for the other four other cortisol functions described at the end of Section 2.1, which again produces a non-linear relationship.[4]

In line with some recent findings in the literature, we thus find that both high and low levels of cortisol are associated with lower life satisfaction. In the empirical analysis below

[4] Plotting cortisol against self-assessed health produces more exaggerated versions of the shapes in Figure 1.

we will thus consider trichotomised versions of the five cortisol measures as the dependent variables. The middle category, which is associated with higher well-being, will be the reference category. This categorisation produces sparser observations, and due to empty-cell problems affecting the robustness of the parameter estimates, we use continuous birth weight and mother's age variables instead of the trichotomised versions.

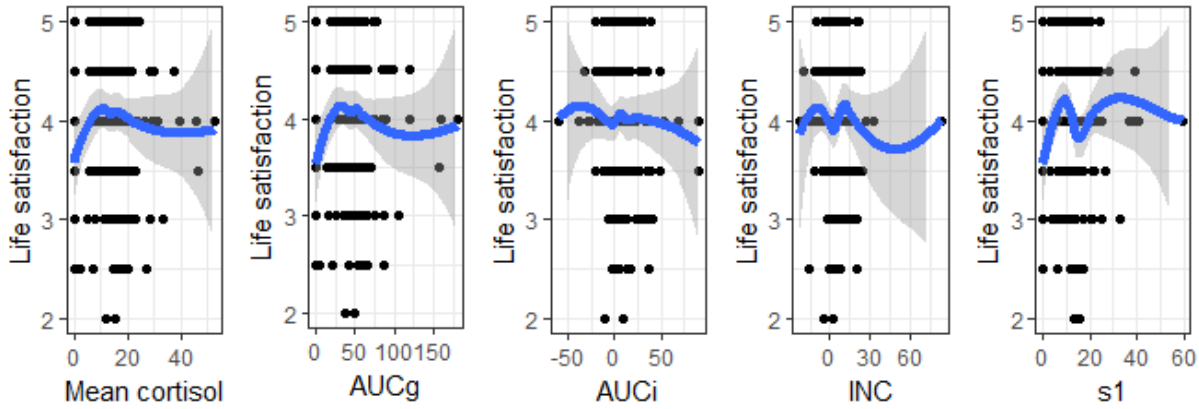

Figure 1 LOESS fit (with 95% confidence intervals) of life satisfaction as a function of five different transformations of the cortisol measurements.

4.1 Results for overall cortisol: mean cortisol and AUCg

The parameter estimates for the low and high (relative to the middle) categories of average cortisol (Table 5) and AUCg (Table 6) are very similar. The McFadden R-squared shows that all three sets of outcome explanatory variables contribute to the total. Considered separately, birth outcomes (column 4) are the most important and adult outcomes (column 1) the least important determinants of cortisol, with childhood outcomes (column 2) coming in between.

Years of education (column 1) is the only significant adult predictor of low (relative to middle) mean cortisol and AUCg. The estimated parameter is larger when childhood (column 3) and birth outcomes (column 5) are accounted for. Although insignificant, the estimated parameter on log household income behaves in the same way as education. While the estimated parameter on working is negative for low and positive for high (relative to middle) cortisol, the estimates for married/cohabiting are both negative.

Among the childhood outcomes, the estimated parameter on father's education is negative for low and positive for high cortisol, with the coefficient on low always being significant except for the childhood outcomes separately for AUCg (column 2 of Table 6). The estimate on mother's education, on the contrary, is positive for both low and high cortisol, and is always significant for low except for the specification with both adult and childhood outcomes for AUCg (column 3 of Table 6). Aptitude attracts a negative estimated coefficient for both low and high average cortisol and AUCg, but of these only low is significant when adult outcomes are included (column 3), or for adult and birth outcomes of AUCg (column 5 of Table 6). While log family income has only a small coefficient, both absence from school and having had a working mother attract positive estimated coefficients for both low and high cortisol, although none is significant.

For the birth outcomes (column 4), birth weight is strongly predictive of high average cortisol and AUCg. The estimates increase slightly when adult and childhood outcomes are included (column 5). The estimated birth-weight coefficients for low are also positive, but insignificant. Mother's age is protective against both low and high cortisol, with the latter coefficients being significant. Previous pregnancies protect against low cortisol, but mother's diagnoses do attract a significant estimated coefficient.

4.2 Results for increases in cortisol - AUCi and INC

The results from the incremental measures of CAR, AUCi in Table 7 and INC in Table 8, generally match. Childhood outcomes are the strongest and adult outcomes the weakest predictors, with the highest and lowest McFadden R-squareds respectively. Compared to the models for average cortisol (Table 5) and AUCg (Table 6), the McFadden R-squareds here are generally smaller.

None of the adult outcomes are significant here, either when they are introduced on their own (column 1), together with childhood outcomes (column 3) or both childhood and birth outcomes (column 5). Working attracts negative (insignificant) estimated coefficients in both tables, whilst the estimated parameters of married/cohabiting are negative for low and positive for high cortisol increase. The estimated effects of the other adult outcomes (log household income and years of education) are only small in size for all models.

When considered on their own, all of the estimated childhood outcome coefficients are insignificant except for father's years of education for INC in column 2 of Table 8, which is reduces the incidence of the low category, although this becomes insignificant when both adult and birth outcomes are taken into account (column 5 of Table 8). In this latter specification, mother's education and log family increase the probability of high cortisol.

The greatest difference between the AUCi and INC models is found for the birth outcomes (columns 4 and 5) for the birth weight estimates. Birth weight predicts the high category of AUCi, but not of INC. Equally, mother's age at birth reduces the high category of AUCi, but not of INC.

4.3 Results for ground level of cortisol at awakening (s1)

Last, the estimates of the trichotomised awakening ground level (s1) of CAR appear in Table 9. The McFadden R-squared is highest for childhood outcomes, and smallest for birth outcomes. Compared to the results for overall (Table 5 and 6) and change in (Table 7 and 8) cortisol, the adult outcomes seems to be more important for the awakening ground level (Table 9).

Among the adult outcomes, working is a strong negative correlate of both low and high awakening cortisol across all specifications. Similarly, both log household income and education are positively associated with low cortisol. The same is true for mother's education and log family income in the childhood outcomes.

For the birth outcomes, birth weight (positive) and mother's age (negative) predict high levels of s1, and previous pregnancies predicts low s1.

Table 5 Average Cortisol (98) equations as a function of Adult, Child and Birth Characteristics. Multinomial logistic regression results (679 multiply-imputed observations) with middle as the reference category.

	(1) AO		(2) CO		(3) AO+CO		(4) BO		(5) AO+CO+BO	
	Low	High	Low	High	Low	High	Low	High	Low	High
Adult outcomes										
Log family income (98)	0.214	0.102			0.276	0.086			0.287	0.089
Working (04)#	-0.279	0.371			-0.154	0.417			-0.149	0.353
Years of education (04)	0.316**	-0.016			0.524***	-0.096			0.564***	-0.087
Married/cohabit (04)#	-0.360	-0.300			-0.331	-0.375			-0.329	-0.378
Childhood outcomes										
Father's education (3)			-0.362*	0.222	-0.440**	0.244			-0.533**	0.290
Mother's education (3)			0.429**	0.195	0.399*	0.193			0.448**	0.322
Log family income (3)			-0.041	-0.080	-0.159	-0.068			-0.022	0.044
Mother works (3)#			0.125	0.358	0.145	0.375			0.036	0.229
School absence (3, 6, 8)			0.168	0.081	0.223	0.091			0.215	0.081
Aptitude (3, 6, 8)			-0.155	-0.059	-0.306**	-0.056			-0.241	-0.030
Birth outcomes										
Birth weight							0.234	0.500***	0.214	0.550***
Mother's age							-0.195	-0.453***	-0.275	-0.603**
Previous pregnancies							0.396***	0.127	0.485**	0.136
Mother's diagnoses							0.118	-0.248	0.115	-0.317
Constant	-0.066	-0.681	-0.627***	-0.750***	-0.334	-0.851*	-0.545***	-0.663***	-0.309*	-0.853*
McFadden R-squared		0.025		0.038		0.075		0.056		0.141

*** p<0.01, ** p<0.05, * p<0.1; robust standard errors; # indicates a dummy variable that is not standardized.

Table 6 Cortisol-AUCg (98) equations as a function of Adult, Child and Birth Characteristics. Multinomial logistic regression results (679 multiply-imputed observations) with middle as the reference category.

	(1) AO		(2) CO		(3) AO+CO		(4) BO		(5) AO+CO+BO	
	Low	High	Low	High	Low	High	Low	High	Low	High
Adult outcomes										
Log family income (98)	0.139	0.053			0.195	0.040			0.201	0.041
Working (04)#	-0.339	0.369			-0.212	0.441			-0.208	0.376
Years of education (04)	0.363***	0.050			0.571***	0.011			0.619***	0.023
Married/cohabit (04)#	-0.423	-0.336			-0.402	-0.414			-0.399	-0.416
Childhood outcomes										
Father's education (3)			-0.290	0.249	-0.362*	0.260			-0.458**	0.328
Mother's education (3)			0.363*	0.190	0.320	0.172			0.363*	0.301
Log family income (3)			-0.059	-0.094	-0.174	-0.093			-0.036	0.001
Mother works (3)#			0.111	0.348	0.146	0.383			0.041	0.245
School absence (3, 6, 8)			0.130	0.082	0.181	0.100			0.168	0.095
Aptitude (3, 6, 8)			-0.172	-0.120	-0.328**	-0.142			-0.261*	-0.135
Birth outcomes										
Birth weight							0.221	0.522***	0.192	0.571***
Mother's age							-0.212	-0.457***	-0.292	-0.594***
Previous pregnancies							0.399***	0.064	0.491**	0.047
Mother's diagnoses							0.154	-0.249	0.148	-0.322
Constant	0.006	-0.558	-0.635***	-0.654***	-0.244	-0.743	-0.574***	-0.578**	-0.230*	-0.754
McFadden R-squared		0.025		0.035		0.071		0.061		0.142

*** p<0.01, ** p<0.05, * p<0.1; robust standard errors; # indicates a dummy variable that is not standardised.

Table 7 Cortisol-AUCi (98) equations as a function of Adult, Child and Birth Characteristics. Multinomial logistic regression results (679 multiply-imputed observations) with middle as the reference category.

	(1) AO		(2) CO		(3) AO+CO		(4) BO		(5) AO+CO+BO	
	Low	High	Low	High	Low	High	Low	High	Low	High
Adult outcomes										
Log family income (98)	-0.051	0.139			-0.069	0.093			-0.072	0.092
Working (04)#	-0.110	-0.153			-0.129	-0.149			-0.178	-0.247
Years of education (04)	0.106	0.173			0.083	0.002			0.088	0.011
Married/cohabit (04)#	-0.033	0.474			-0.034	0.417			-0.048	0.479
Childhood outcomes										
Father's education (3)			-0.240	0.093	-0.247	0.077			-0.245	0.080
Mother's education (3)			-0.017	0.237	-0.029	0.254			0.018	0.353*
Log family income (3)			0.248	0.268	0.246	0.248			0.305	0.378*
Mother works (3)#			-0.067	0.329	-0.059	0.302			-0.113	0.152
School absence (3, 6, 8)			-0.094	0.233	-0.096	0.233			-0.095	0.238
Aptitude (3, 6, 8)			0.047	0.148	0.032	0.152			0.041	0.190
Birth outcomes										
Birth weight							0.176	0.438***	0.166	0.511***
Mother's age							-0.042	-0.115	-0.135	-0.371*
Previous pregnancies							-0.042	0.044	0.079	0.184
Mother's diagnoses							-0.198	-0.191	-0.224	-0.237
Constant	-0.026	-0.656	-0.135	-0.613**	-0.010	-0.804	-0.132	-0.432**	0.095	-0.754**
McFadden R-squared		0.014		0.047		0.057		0.027		0.093

*** p<0.01, ** p<0.05, * p<0.1; robust standard errors; # indicates a dummy variable that is not standardised.

Table 8 Cortisol-INC (98) equations as a function of Adult, Child and Birth Characteristics. Multinomial logistic regression results (679 multiply-imputed observations) with middle as the reference category.

	(1) AO		(2) CO		(3) AO+CO		(4) BO		(5) AO+CO+BO	
	Low	High	Low	High	Low	High	Low	High	Low	High
Adult outcomes										
Log family income (98)	-0.163	0.073			-0.180	0.032			-0.183	0.028
Working (04)#	-0.255	-0.331			-0.264	-0.365			-0.308	-0.453
Years of education (04)	0.057	0.202			0.060	0.036			0.060	0.058
Married/cohabit (04)#	-0.209	0.216			-0.204	0.159			-0.210	0.166
Childhood outcomes										
Father's education (3)			-0.321*	0.144	-0.318*	0.135			-0.306	0.152
Mother's education (3)			-0.179	0.152	-0.190	0.165			-0.161	0.252
Log family income (3)			0.234	0.154	0.253	0.140			0.267	0.220
Mother works (3)#			-0.155	0.356	-0.144	0.333			-0.180	0.221
School absence (3, 6, 8)			-0.053	0.173	-0.066	0.163			-0.063	0.228
Aptitude (3, 6, 8)			0.082	0.219	0.080	0.222			0.072	0.157
Birth outcomes										
Birth weight							0.133	0.255	0.116	0.283
Mother's age							-0.024	-0.118	-0.051	-0.337
Previous pregnancies							-0.128	-0.042	-0.033	0.074
Mother's diagnoses							-0.111	-0.256	-0.122	-0.310
Constant	0.227	-0.300	-0.128	-0.622**	0.234	-0.430	-0.131	-0.420**	0.302	-0.360
McFadden R-squared		0.016		0.049		0.061		0.019		0.086

*** p<0.01, ** p<0.05, * p<0.1; robust standard errors; # indicates a dummy variable that is not standardised.

Table 9 Cortisol (s1) at awakening (98) equations as a function of Adult, Child and Birth Characteristics. Multinomial logistic regression results (679 multiply imputed observations) with middle as the reference category.

	(1) AO		(2) CO		(3) AO+CO		(4) BO		(5) AO+CO+BO	
	Low	High	Low	High	Low	High	Low	High	Low	High
Adult outcomes										
Log family income (98)	0.286*	0.197			0.279*	0.196			0.290*	0.205
Working (04)#	-1.060**	-0.929**			-1.033**	-0.973**			-1.162**	-1.143**
Years of education (04)	0.289**	-0.106			0.277*	-0.133			0.307**	-0.131
Married/cohabit (04)#	0.019	-0.058			0.004	-0.051			0.028	-0.023
Childhood outcomes										
Father's education (3)			-0.229	-0.051	-0.276	-0.042			-0.327	-0.052
Mother's education (3)			0.396*	-0.004	0.415*	0.049			0.488**	0.123
Log family income (3)			0.312*	0.014	0.241	0.020			0.375*	0.113
Mother works (3)#			0.155	0.027	0.108	-0.053			-0.032	-0.207
School absence (3, 6, 8)			0.189	-0.015	0.190	-0.056			0.168	-0.065
Aptitude (3, 6, 8)			-0.068	-0.014	-0.116	0.039			-0.070	0.060
Birth outcomes										
Birth weight							0.217	0.332*	0.236	0.386**
Mother's age							-0.175	-0.295*	-0.388*	-0.343**
Previous pregnancies							0.211	0.148	0.0360*	0.165
Mother's diagnoses							-0.068	-0.190	-0.119	-0.217
Constant	1.372***	1.306***	0.384**	0.431**	1.301**	1.364***	0.509***	0.465***	1.515***	1.605***
McFadden R-squared		0.032		0.035		0.064		0.024		0.094

*** p<0.01, ** p<0.05, * p<0.1; robust standard errors; # indicates a dummy variable that is not standardised.

5 Discussion and Conclusions

We have here used a rich longitudinal dataset that follows girls from third grade of school up to the end of their forties. We estimate models of adult life satisfaction and cortisol as a function of adult, childhood and birth circumstances. Most of the effect of birth characteristics on the various measures of adult well-being are mediated via the adult outcomes. In line with earlier work on Swedish data, adult employment and marital status are by far the most important predictors of adult life satisfaction.

At first sight, the amount of stress these women experience, as measured by their average level of the cortisol stress hormone in the first 45 minutes after waking is less predictable than life satisfaction. The R-squared statistics in Table 3 are notably lower than those in Table 2. However, we suggest that cortisol is actually not a monotonic physiological measure of well-being: both low and high levels of cortisol are detrimental. When we split average cortisol up into three categories, that are modelled via a multinomial logit as a function of adult outcomes and childhood and birth characteristics, we obtain R-squared statistics that are comparable to those of life satisfaction.

There are many ways in which we can treat the four cortisol measures other than taking their average. The regression results show that we can predict average growth in cortisol as well as its level, but the other three measures (AUC_i, INC and s1) less well. Some physiological well-being measures may then be as amenable to life-course econometric analysis as are subjective measures of well-being.

In terms of our initial research question, we are interested in whether the same characteristics predict life satisfaction and cortisol. A simple summary measure of this similarity is obtained by correlating the estimated regression coefficients across the life satisfaction regressions in Table 2 and the cortisol regressions in Tables 3 and 5 through 9 (as in Clark, 2016, for measures of hedonic and eudaimonic well-being). As mother's age at birth and birth weight are not treated consistently across these tables, we do not consider their associated coefficients in this analysis. Table 3 concerns average cortisol, while Tables 5 through 9 have separate regressions for low and high cortisol (as compared to the middle cortisol level). We thus have one correlation coefficient for the comparison of life satisfaction to average cortisol, and two correlation coefficients for the comparison of life satisfaction to the other cortisol measures.

The correlation coefficient between the estimated coefficients for life satisfaction in Table 2 and those for average cortisol in Table 3 is only just over 0.1, reinforcing that these

are not the same measure of well-being. The analogous coefficients for the cortisol coefficients in Tables 5 through 9 are in general much higher, underscoring that cortisol is not a monotonic well-being measure.

Without listing all of those coefficients in detail, two points stand out. The first is that in general the correlation between the low-cortisol and life-satisfaction coefficients is higher than that with the high-cortisol coefficients. In that sense, low cortisol seems to be more similar to subjective well-being. Second, overall life satisfaction seems to be somewhat more similar to the increase s3-s1 and the waking cortisol level (s1) than to the other cortisol variables, which is notable since the increase and awakening level represent two (negatively correlated) components of the cortisol awakening response.

While our findings here are exploratory, and are of course limited to this cohort of Swedish women, we believe that there is potential for the joint analysis of subjective and physiological measures of well-being. In line with existing work on the life-course determinants of life satisfaction, we find significant correlates in both childhood and adulthood. We cannot give a definitive answer here to the question of the best measure of individual well-being: do we want to live a satisfying life, or one with low stress, or even one with high income or greater levels of meaning and purpose? However, the joint analysis of different well-being measures will bring new information on the various correlates of these measures of success, and in addition allow us to evaluate how similar they are to each other.

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