RESEARCH ARTICLE

Is low Weight Disorder (Anorexia Nervosa) Correlated with Gender, Socio Demographic and Psychological Features?

Authors:
Yuval Arbel[1,*], Chaim Fialkoff[2], Amichai Kerner[3], Miri Kerner[4]

Authors' affiliations:
[1] Western Galilee College, Israel.
[2] Hebrew University of Jerusalem, Israel.
[3] Netanya Academic College, Israel.
[4] Ruth and Bruce Rappaport Faculty of Medicine, Technion, Israel Institute of Technology

Corresponding author: Yuval Arbel
Western Galilee College, Israel.
Email: yuval.arbel@gmail.com

ABSTRACT

The objective of the current study is to examine the economics, socio-demographic and psychological determinants of the probability to suffer from low-weight disorder or anorexia nervosa. Unlike the vast literature on obesity, fewer studies have investigated the opposite phenomena, namely, low-weight disorder or anorexia. Given the extra difficulty to diagnose anorexia via Diagnostic and Statistical Manual of Mental Disorders (DSM) validated questionnaires, the advantage of our study lies in the simple quantitative measure we use of $BMI \leq 18$. This criterion might be a suitable measure to a western developed country like Israel, in which the probability that BMI<=18 reflects chronic energy deficiency due to circumstances of poverty and/or lack of access to food is small. We make use of an extensive set of questions concerning the economic and socio-demographic features, health and housing conditions of each respondent asked within the framework of the 2015-2016 longitudinal survey conducted by the Israeli Central Bureau of Statistics (CBS). The survey also includes information regarding the weight, height, gender and age of each household member. Results indicate a significant *decrease* in the projected probability of having BMI≤18 with age. Compared with the 21-67 year old cohorts, the relative frequency of BMI≤18 *rises* to 10.68%-16.83% for the 10-20 year-old cohorts. For the female (male) respondents, projected probability *drops* consistently from 50% (75%) at the 10-year-old cohort to about 0% at the 62- (67-) year-old cohort. These figures imply that low-weight disorder or anorexia is a typical

Copyright 2019 KEI Journals. All Rights Reserved

problem of the younger cohorts. Interestingly, there are gender differences in the spread around the projected probability of having BMI≤18. While this spread ranges between 30.67% and 68.64% for 10-year-old females (a range of 37.97%), the same spread ranges between 67.10% and 82.79% for 10-year-old males (a range of only 15.69%). For both gender, this spread around the projected probability drops with the age variable. For female respondents, projected probability of having BMI≤18 significantly *drops* with age, homeownership and European-American immigration status, and significantly *rises* with residence in a standard apartment in multi-story structure. For male respondents, projected probability of *BMI*≤18 *drops* significantly with age and with having a home library that includes at least one book, and rises significantly with the household size, and European-American immigration status. Interestingly, for female cohorts of 10-20 years, projected probability of *BMI*≤18 *rises* significantly from 4.4157% to 16.6627% with reported good health conditions. This outcome may be interpreted as self-denial of young female respondents regarding their realistic health conditions, and might support the definition of *BMI*≤18 as anorexia nervosa.

1. Introduction: The objective of the current study is to examine the economic, socio-demographic and psychological determinants of the probability to suffer from low weight disorder or become anorectic. Unlike the vast literature on obesity (e.g., Yoon et. al., 2015; Hermesch et. al., 2016; Gasse et. al.,2017; Shamritz et. al., 2017; Yan, et. al., 2017; The Authors, 2018; Nyberg et. al., 2018), fewer studies have investigated the opposite phenomena, namely, anorexia nervosa and other eating disorders (e.g., Brown *et. al.*, 2014; Mitchison *et. al.*, 2014; Mulders-Jones *et. al.*, 2017. For a review of studies on Asian countries, see, for example, Pike *et. al.*, 2014). Moreover, few studies investigated eating disorders among men in particular and gender differences in general (e.g., Striegel-Moore *et. al.*, 2009). Given the added difficulty of diagnosing anorexia by qualitative questionnaires (e.g., Pope et. al., 1987), the advantage of our study lies in the simple clincial measure we use of BMI≤18 (see the discussion in Brown *et. al.*, 2014 and further explanations below).

We make use of an extensive set of questions concerning the economic and socio-demographic features, health and housing conditions of each respondent asked within the framework of the 2015-2016 longitudinal survey conducted by the Israeli Central Bureau of Statistics (CBS). The survey also includes information regarding the weight, height, gender and age of each household member. Appendix S5 provides replication instructions for all the tables and figures.

Anorexia is defined as: "[a]n eating disorder characterized by markedly reduced appetite or total aversion to food." (Dryden-Edwards, Roxanne, MD; and Melissa Conrad Stöppler, MD: Anorexia Nervosa, at: https://www.medicinenet.com/anorexia_nervosa/article.htm). It is considered as a serious psychological disorder, where the

Copyright 2019 KEI Journals. All Rights Reserved

individual (mostly young girls and women) continues the endless cycle of restrictive eating, often to a point close to starvation. This becomes an obsession similar to drug addiction.

The clinical measure of anorexia is based on "Body Mass Index" (BMI) lower than or equal to 18 (see, for example, Brown *et. al.*, 2014, who states in the discussion section that: "[..]an operational definition for DSM-5 AN in research contexts should define low weight as BMI <18.5 kg/m^2 and require measurable rather than inferred weight phobia"). The BMI is calculated as $WEIGHT \div (HEIGHT^2)$ where *WEIGHT* is measured in kilograms and *HEIGHT* is measured in meters.

The concern about the use of this clinical definition (BMI≤18) without additional psychological tests lies on the possibility that low weight disorder might emanate from chronic energy deficiency due to circumstances of poverty and/or lack of access to food rather than psychological problems associated with anorexia. Yet, Israel is a western and fast growing economy (e.g., The Author(s), year, pages 340-343), and since 2010 the 32nd member of the Organization for Economic Cooperation and Development (OECD). According to 2016 IMF reports, in terms of nominal GDP per Capita, of the186 ranked countries, Israel is ranked 20 (close to the highest income decile). Moreover, the frequency of BMI<=18 in our representitive sample is rather low (6.15% for females and 2.44% for males). Consequently, the probability that BMI<=18 reflects chronic energy deficiency due to circumstances of poverty and/or lack of access to food is small.

Recent new DSM 5 definitions of anorexia nervosa extends the population that is defined as anorectic. According to Mustelin *et. al.* (2016) and referring to the Finnish population: "The lifetime prevalence of anorexia nervosa incr eased by 60% using the new DSM-5 definition". According to Estour *et. al.* (2017): "Removal of amenorrhea from the new DSM 5 definition of AN might result in misdiagnosis between these two populations."

In the United States, an estimated 0.5 to 3.7 percent of women suffer from anorexia nervosa at some point in their lifetime, and about 1 percent of female adolescents have anorexia (Spearing, 2001). According to eating disorders statistics estimated by the National Eating Disorder Association, in the US up to 30 million people suffer from an eating disorder such as anorexia nervosa, bulimia nervosa or binge eating disorder (Eating Disorders Statistics, at: https://www.mirror-mirror.org/eating-disorders-statistics.htm). Moreover, the weighted mortality rate from anorexia nervosa is 5.1 per 1,000 persons, the highest of any mental illness (Arcelus *et. al.*, 2011).

Results of our study expose a *decrease* in the projected probability of having BMI≤18 with age. Compared with the 21-67 year old cohorts, the relative frequency of BMI≤18 *rises* to 10.68%-16.83% for the 10-20 year-old cohorts. For the female (male) respondents, projected probability *drops* consistently from 50% (75%) at the 10-year-old cohort to about 0% at the 62- (67-)

Copyright 2019 KEI Journals. All Rights Reserved

year-old cohort. These figures imply that low-weight disorder or anorexia is a typical problem of the younger cohorts. Interestingly, there are gender differences in the spread around the projected probability of having *BMI*≤18. While this spread ranges between 30.67% and 68.64% for 10-year-old females (a range of 37.97%), the same spread range between 67.10% and 82.79% for 10-year-old males (a range of only 15.69%). For both gender, this spread around the projected probability drops with the age variable.

Regression outcomes for all cohorts above 10 years and below the retirement age of 62 years for female (67 years for male) indicate that for female respondents, projected probability of having BMI≤18 significantly *drops* with age, homeownership and European-American immigration status, and significantly *rises* with residence in a standard apartment in multi-story structure. For male respondents, projected probability of *BMI*≤18 *drops* significantly with age and with having a home library that includes at least one book, and *rises* significantly with the household size, and European-American immigration status.

Interestingly, for female cohort of 10-20 years, projected probability to suffer from *BMI*≤18 *rises* significantly from 4.4157% to 16.6627% with reported good health conditions. This outcome might be interpreted as self-denial of young female respondents regarding their realistic health conditions, which is closer to the definition of anorexia nervosa.

The rest of this paper is organized as follows. Section 2 provides descriptive statistics. Section 3 presents the empirical model and reports the research hypothese and results. Finally, Section 4 concludes and summarizes.

2. Descriptive Statistics: Table 1 presents the descriptive statistics of the variables stratified by gender. The table refers to 5,088 (5,539) females×years (males×years) belonging to 1,964 (2,113) households, where the age of female (male) members were restricted to between 10 and 62 (67) years old, participating in the 2015-2016 longitudinal survey carried out by the CBS. The upper age bound is based on the retirement age from the workforce, which is 62 (67) years old for females (males).

Copyright 2019 KEI Journals. All Rights Reserved

Table 1: Descriptive Statistics Stratified by Age and Gender 2015-2016 Panel

A. Females

VARIABLES	Description	Obs.	Mean	STD	Min	Max
WEIGHT	Weight in kg.	5,088	64.160	13.3163	44	120
HEIGHT	Height in Meters	5,088	1.6308	0.0656	1.49	1.9
BMI	$Body\ Mass = \frac{WEIGHT}{HEIGHT^2}$	5,088	24.115	4.7937	12.188	48.684
BMI18	1=BMI≤18; 0=BMI>18	5,088	0.0615	0.2403	0	1
OWNER	1=own an apartment; 0=otherwise	5,088	0.6836	0.4651	0	1
MULTI_STORIES	1=A conventional apartment in a multy-stories structure; 0=otherwise	5,088	0.5623	0.4962	0	1
BOOKS	1=At least one book at home; 0=no home library	5,088	0.9762	0.1524	0	1
OVER_200_BOOKS	1=over 200 books at home library; 0=otherwise	5,088	0.2496	0.4328	0	1
CAR	1=own a car; 0=otherwise	5,088	0.7750	0.4176	0	1
AGE	Age in years	5,088	35.874	14.9816	10	62
HHSIZE	Number of persons in household	5,088	4.2901	2.0326	1	27
SINGLE	1=single; 0=otherwise	5,088	0.3443	0.4752	0	1
MARRIED	1=married; 0=otherwise	5,088	0.5523	0.4973	0	1
DIVORCED	1=divorced; 0=otherwise	5,088	0.0810	0.2728	0	1
WIDOW	1=widow; 0=otherwise	5,088	0.0224	0.1480	0	1
IMMIGRANT	1=immigrant; 0=otherwise	5,088	0.1966	0.3974	0	1
IMM_EUROPE_AMERICA	1=immigrant from European or American countries; 0=otherwise	5,088	0.1655	0.3717	0	1
IMM_ASIA_AFRICA	1=immigrant from Asian or African countries; 0=otherwise	5,088	0.0311	0.1735	0	1
IMM_EUROPE_AMERICA _PER	1=immigrant from European or American countries only among the immigrant population; 0=otherwise	1,000	0.842		0	1
IMM_ASIA_AFRICA_PER	1=immigrant from Asia or African countries only among the immigrant population; 0=otherwise	1,000	0.158		0	1
OVERALL_HEALTH	1=report of good overall health; 0=otherwise	5,088	0.8931	0.3090	0	1

B. Males

VARIABLES	Description	Obs.	Mean	STD	Min	Max
WEIGHT	Weight in kg.	5,539	78.123	15.7820	44	120
HEIGHT	Height in Meters	5,539	1.7472	0.0840	1.49	1.9
BMI	$Body\ Mass = \frac{WEIGHT}{HEIGHT^2}$	5,539	25.479	4.3490	14.045	54.052
BMI18	1=BMI≤18; 0=BMI>18	5,539	0.0244	0.15422	0	1
OWNER	1=own an apartment; 0=otherwise	5,539	0.6606	0.47355	0	1
MULTI_STORIES	1=A conventional apartment in a multy-stories structure; 0=otherwise	5,539	0.5512	0.49742	0	1
BOOKS	1=At least one book at home; 0=no home library	5,539	0.9821	0.1325	0	1
OVER_200_BOOKS	1=over 200 books at home	5,539	0.2542	0.4354	0	1

Copyright 2019 KEI Journals. All Rights Reserved

VARIABLES	Description	Obs.	Mean	STD	Min	Max
	library; 0=otherwise					
CAR	1=own a car; 0=otherwise	5,539	0.8052	0.39608	0	1
AGE	Age in years	5,539	37.142	16.3691	10	67
HHSIZE	Number of persons in household	5,539	4.193	2.20528	1	27
SINGLE	1=single; 0=otherwise	5,539	0.3864	0.4870	0	1
MARRIED	1=married; 0=otherwise	5,539	0.5499	0.49755	0	1
DIVORCED	1=divorced; 0=otherwise	5,539	0.0581	0.23402	0	1
WIDOW	1=widow; 0=otherwise	5,539	0.0056	0.07461	0	1
IMMIGRANT	1=immigrant; 0=otherwise	5,539	0.1955	0.3966	0	1
IMM_EUROPE_AMERICA	1=immigrant from European or American countries; 0=otherwise	5,539	0.1518	0.35889	0	1
IMM_ASIA_AFRICA	1=immigrant from Asian or African countries; 0=otherwise	5,539	0.0437	0.20442	0	1
IMM_EUROPE_AMERICA_PER	1=immigrant from European or American countries only among the immigrant population; 0=otherwise	1,083	0.7765	0.4168	0	1
IMM_ASIA_AFRICA_PER	1=immigrant from Asia or African countries only among the immigrant population; 0=otherwise	1,083	0.2235	0.4168	0	1
OVERALL_HEALTH	1=report of good overall health; 0=otherwise	5,539	0.8913	0.31127	0	1

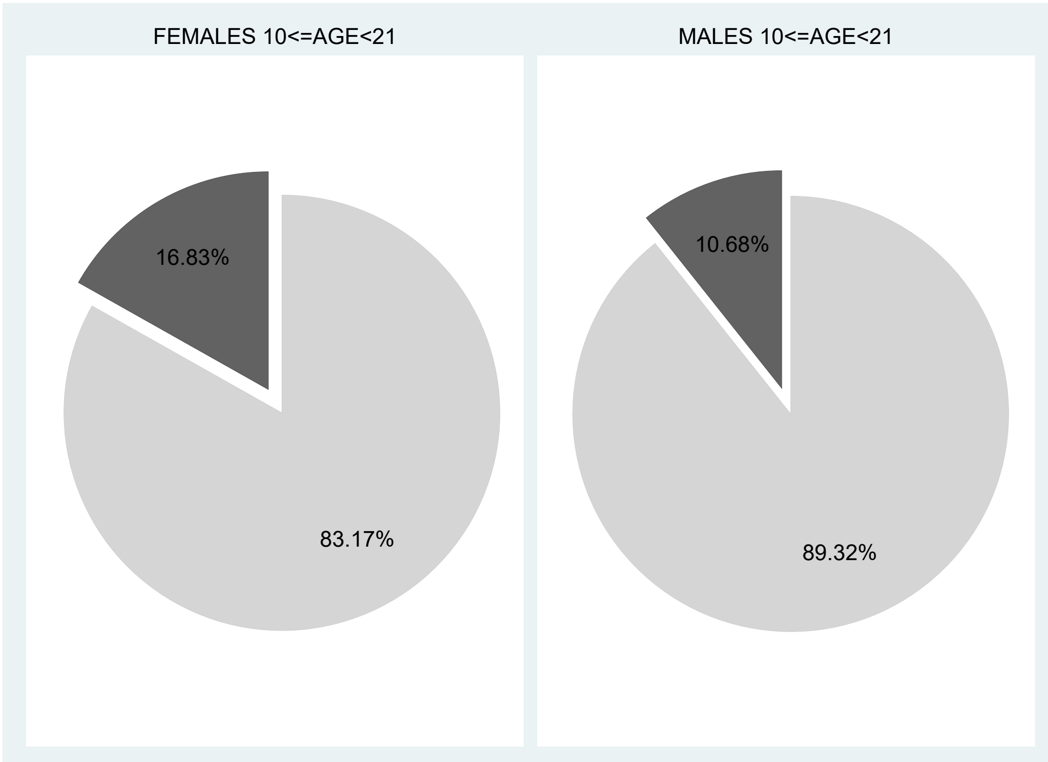
Notes: The sample includes panel of 5,088 (5,539) females×years (males×years) belonging to 1,964 (2,113) households, where the age of female (male) members were restricted to between 10 and 62 (67) years old. The upper age bound is based on the retirement age from the workforce, which is 62 (67) years old for females (males).

An acceptable measure of low weight disorder (anorexia nervosa) is $BMI \leq 18$. As previously noted, BMI is $WEIGHT \div (HEIGHT^2)$ where $WEIGHT$ is measured in kilograms and $HEIGHT$ is measured in meters. The respective sample mean BMI of females and males is 24.115 and 25.479 (BMI). The minimum BMI of females (12.188) seems to be lower than that of males (14.045). Of the 5,088 (5,539) females×years (males×years), the frequency of $BMI \leq 18$ is 6.152% (2.437%). Given that the calculated *t*-value is 9.3916 and Satterthwaite's degrees of freedom are 8,541.27, the 3.715% female-male difference is statistically significant at the 1% significance level (BMI18).

Figure 1 compares the frequency of $BMI \leq 18$ in the female-male samples among teenagers from the 10-20-year cohort. The dark (bright) segment of the pie chart is the proportion of female×year and male×year with $BMI \leq 18$ ($BMI > 18$).

Copyright 2019 KEI Journals. All Rights Reserved

Figure 1: Precent of Young Participants with Anorexia Stratified by Gender



Notes: The Figure compares the frequency of Anorexia in the female-male samples among teenagers from the 10-20 year cohort.The dark (bright) segment of the pie charts is the proportion of female×year and male×year with *BMI*≤18 (*BMI*>18).

The figure demonstrates that low weight disorder or anorexia becomes a salient problem particularly for women at young cohorts. Among the group of 10-21 year-old females (males), the frequency of anorexia is 16.83% (10.68%). The 6.15% difference across gender is statistically significant at the 1% significance level, where the calculated *t*-value with 1,996.44 degrees of freedom is 4.12252. By comparison, and as previously noted, the sample mean of all cohorts is 6.152% for women and 2.437% for men. Among the adult 21-62 (21-67) cohorts of females (males), the frequency of anorexia drops to 3.448% (0.362%). The 3.086% difference across gender is statistically significant at the 1% significance level, where the calculated *t*-value with 4,861.03 degrees of freedom is 10.2794. Finally, Given that the calculated *t*-value is 11.1315 (11.0943) and Satterthwaite's degrees of freedom are 1,153.28 (1,134.22), the 13.38% (10.32%) difference across young-adult cohorts of females (males) is statistically significant at the 1% significance level.

Referring to the variables related to wealth in Table 1, of the 5,088 (5,539) females×years (males×years), 68.36% (66.06%) live in a housing unit owned by the household (*HOMEOWNER*). By comparison, the national Israeli 2016 average shows that 67.6% are homeowners (Israeli Central Bureau of Statistics Press

Copyright 2019 KEI Journals. All Rights Reserved

Release, 2016). 56.23% (66.06%) live in a multi-family apartment building (MULTI_STORIES). 77.50% (80.52%) own a car (CAR). By comparison, the national 2015 average shows that 69.7% of the 2.4139 million households own at least one car and 24.4% own two cars or more (CBS, http://www.cbs.gov.il/publications17/1677/pdf/t14.pdf). Finally, 97.62% (98.21%) of the female (male) participants declared to have at least one book at the home library (*BOOKS*). 24.96% (25.42%) of the female (male) participants declared to have over 200 books at the home library (*OVER_200_BOOKS*). The latter variables might be considered as proxies for wealth or education level.

Referring to the quantitative socio-demographic variables, the sample mean of the age variable is 35.874 for females and 37.142 for males (AGE). According to 2018 Statistical Abstract of Israel, (http://www.cbs.gov.il/shnaton69/st02_19x.pdf), the median age of the overall population is 31.0 years (29.8 years) for females (males). The sample mean of household size is about four for both genders (*HHSIZE*)

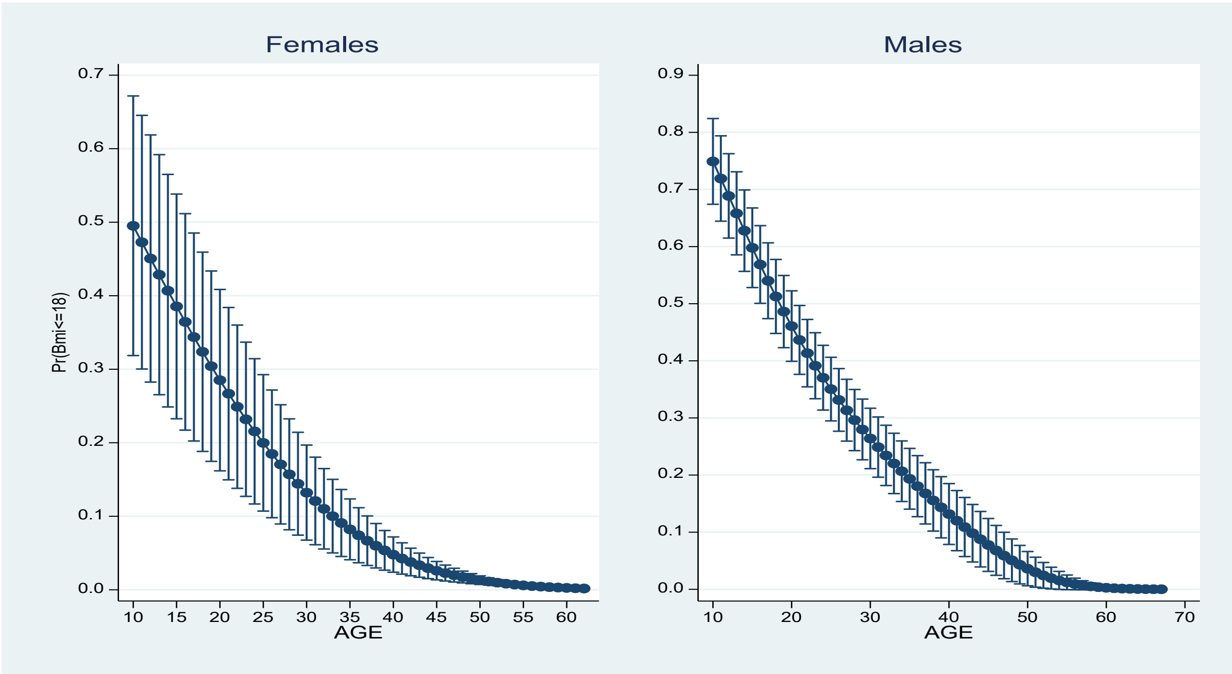
Following Williams (2012), Figure 2 displays the projections and their 95% confidence intervals obtained from the following probit model run separately for women and men: $\emptyset(BMI18) = \alpha_0 + \alpha_1(AGE) + \alpha_2(AGE)^2 + HFE \cdot \vec{\alpha}_3 + u$, where the dependent variable is $\emptyset(BMI18)$, the cuumulative normal distribution function of *BMI*18, a dummy variable that equals 1 for low weight disorder or anorexia (*BMI*≤18) and zero otherwise. $\alpha_0, \alpha_1, \alpha_2$ are parameters; HFE is a matrix of household effect dummies; $\vec{\alpha}_3$ is a column vector of parameters; and u is the random disturbance term. The $(AGE)^2$ terms permits non-monotonic variation of the AGE variable with respect to the dependent variable (e.g., Greene, 2012: 156-157). Regression outcomes are reported in Appendix S1. The model enables testing the following research hypothesis:

Hypothesis 1: *Projected Probability of Low Weight Disorder (Anorexia Nervosa) is expected to drop with age for both gender.*

As demonstrated in Table 1 and Figure 1, for both gender the relative frequency of low weight disorder (anorexia) indeed *rises* significantly to 10.68%-16.83% for the 10-20 year-old cohorts. This information indicates that low-weight disorder or anorexia is a typical problem of the younger cohorts.

Copyright 2019 KEI Journals. All Rights Reserved

Figure 2: Projected Probability of Low Weight Disorder (Anorexia) Stratified by Age and Gender



Notes: The figure displays the projections and their 95% confidence intervals obtained from the following probit model run separately for women and men: $\emptyset(BMI18) = \alpha_0 + \alpha_1(AGE) + \alpha_2(AGE)^2 + HFE \cdot \vec{\alpha}_3 + u$, where where the dependent variable is $\emptyset(BMI18)$, the cuumulative normal distribution function of $BMI18$, a dummy variable that equals 1 for low weight disorder or anorexia ($BMI \leq 18$) and zero otherwise. $\alpha_0, \alpha_1, \alpha_2$ are parameters; HFE is a matrix of household effect dummies; $\vec{\alpha}_3$ is a vector of parameters; and u is the random disturbance term. Regression outcomes are reported in Appendix S1.

Figure 2 shows that on the one hand, compared with males, as the cohort becomes younger, projected probability of females to suffer from low weight disorder or anorexia is lower (50% compared with 75% at the 10-year-old cohort) . On the other hand, the 95% spread of projected probability among females is higher. While this spread ranges between 30.67% and 68.64% for 10-year-old females (a range of 37.97%), the same spread range between 67.10% and 82.79% for 10-year-old males (a range of only 15.69%). For both gender, this spread around the projected probability drops with the age variable.

Referring to the binary socio-demographic variables in Table 1, for the overall cohort, 34.43% (38.64%) of the female (male) participants are single (*SINGLE*), 55.23% (54.99%) are married (*MARRIED*), 8.10% (5.81%) are divorced (*DIVORCED*), and 2.24% (0.56%) are widowed (*WIDOW*). By comparison, according to the 2018 Statistical Abstract of Israel (http://www.cbs.gov.il/reader/shnaton/templ_shnaton_e.html?num_tab=st02_04x&CYear=2018) the total Israeli population in 2016 includes 3.1317 (2.9987) million females (males), of whom 28.1% (35.0%) are single, who were never married. Returning once again to the sample mean, among the young cohort of 10-20 years in our sample, 96.30% (99.64%) of the adolescent females (males) are single and 3.70% (0.36%) are married.

Copyright 2019 KEI Journals. All Rights Reserved

Finally, 19.66% (19.55%) are female (male) immigrants (IMMIGRANTS), of whom 16.55% (15.18%) are from European-American countries (IMM_EUROPE_AMERICA), and 3.11% (4.37%) from Asian-African countries (IMM_ASIA_AFRICA). These figures imply that of the 1,000 (1,083) female (male) immigrants, 84.20% (77.65%) are from European-American countries (IMM_EUROPE_AMERICA_PER) and the remainder are from Asian_African countries (IMM_EUROPE_ASIA_AFRICA_PER). By comparison, according to the 2018 Statistical Abstract of Israel, the proportion for the entire population of immigrants emigrated to Israel in 1948-2017 in favor of European-American Immigrants is 70.1%.

An interesting psychological feature in our sample is the self-assessement of overall health. Of the 5,088 (5,539) females×years (males×years), 89.31% (89.13%) reported on good overall health. Stratification by cohorts show that compared with adults, the report on good health among young respondents rises significantly by 10.57%-10.60%.

3. Methodology and Results:

3.1 The Empirical Model: Consider the following empirical model estimated separately for female and male respondents for the pooled sample:

(1)

$$\begin{aligned}\emptyset(BMI18) &= \beta_0 + \beta_1 OWNER + \beta_2 MULTI\_STORY \\ &+ \beta_3 BOOKS + \beta_4 OVER\_200\_BOOKS \\ &+ \beta_5 CAR + \beta_6 AGE + \beta_7 AGE\_SQ \\ &+ \beta_8 HHSIZE + \beta_9 MARRIED \\ &+ \beta_{10} DIVORCED + \beta_{11} WIDOW \\ &+ \beta_{12} IMM\_EUROPE\_AMERICA \\ &+ \beta_{13} IMM\_ASIA\_AFRICA \\ &+ \beta_{14} OVERALL\_HEALTH + HFE \cdot \vec{\delta}_1 \\ &+ \mu_1\end{aligned}$$

Where The dependent variable is $\emptyset(BMI18)$, the cuumulative normal distribution function of $BMI18$, a dummy variable that equals 1 for low weight disorder or anorexia ($BMI \leq 18$) and zero otherwise. The independent variables include 1) wealth and education proxies: *OWNER*, *MULTI_STORY*, *BOOKS*, *OVER_200_BOOKS*; *CAR*; 2); Socio-demographic characteristics: *AGE*, *AGE_SQ* and *HHSIZE*; 3); family-status variables: *MARRIED*, *DIVORCED*, and *WIDOW* (base category of *SINGLE*); 4) immigration variables: *IMM_EUROPE_AMERICA*, *IMM_ASIA_AFRICA* (base category of Native Israeli); and 5) self-assessement of overall health *OVERALL_HEALTH*. $\beta_0, \beta_1, \ldots, \beta_{14}$ are parameters, *HFE* is a matrix of household fixed effect dummies, δ_1 is a column vector of parameters, and μ_1 is the stochastic random disturbance term.

When the pooled sample is stratified by adult and adolescent cohorts, equation (1) remains the same for the adult cohort. However, given that 96.30%-99.64% of the young cohorts aged 10-20 years old are single, to prevent perfect multicollinearity,

Copyright 2019 KEI Journals. All Rights Reserved

the marital status variables have to be removed. Consequently, for the adolescent cohort the model becomes:

(2)

$$\emptyset(BMI18) = \gamma_0 + \gamma_1 OWNER + \gamma_2 MULTI\_STORY + \gamma_3 BOOKS + \gamma_4 OVER\_200\_BOOKS + \gamma_5 CAR + \gamma_6 AGE + \gamma_7 AGE\_SQ + \gamma_8 HHSIZE + \gamma_9 IMM\_EUROPE\_AMERICA + \gamma_{10} IMM\_ASIA\_AFRICA + \gamma_{11} OVERALL\_HEALTH + HFE \cdot \vec{\delta}_2 + \mu_2$$

Where γ_0, γ_1,..., γ_{11} are parameters, *HFE* is a matrix of individual effect dummies, δ_2 is a column vector of parameters, and μ_2 is the stochastic random disturbance term.

3.2 Research Hypotheses: The methodology of regression analysis permits testing multiple research hypotheses, which include the following:

Hypothesis 1: (tested previously): *Projected Probability of Low Weight Disorder (Anorexia) is expected to drop with age for both gender.*

Hypothesis 2: *Projected Probability of Low Weight Disorder or Anorexia is Expected to Drop with Home-ownership.*

Hypothesis 3: *Projected Probability of Low Weight Disorder or Anorexia is Expected to Rise with Residence in Multi-Storey Buildings.*

Hypothesis 4: *Projected Probability of Low Weight Disorder or Anorexia is Expected to Rise with Immigrant Status from European or American countries.*

Hypothesis 5: *Projected Probability of Low Weight Disorder or Anorexia is Expected to Drop with Self-Ranking of Good Health Stature.*

3.3 Results: Appendix S2 reports the estimation results of the random effect probit regressions given by equation (1) among females and males for the pooled sample of all cohorts. The dependent variable is $\emptyset(BMI18)$, the cuumulative normal distribution function of *BMI*18, a dummy variable that equals 1 for low weight disorder or anorexia (*BMI*≤18) and zero otherwise. Following the LR test, which reject the null hypothesis that the coefficients of household effect dummies are equal, all the regressions include dummies Fixed-Effects, otherwise the coefficients might be inefficient (for a discussion see Johnston and Dinardo, 1997: 391-395; Greene, 2012: 386-387).

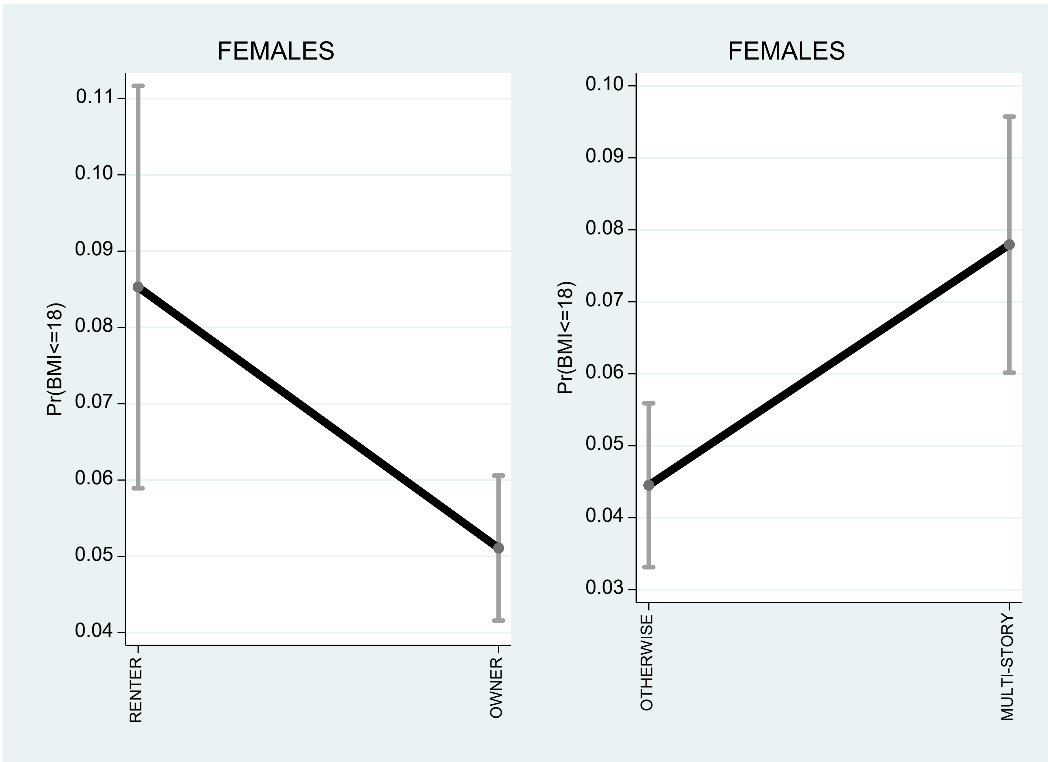
Following Williams (2012), and based on the projections obtained from regression outcomes in Appendix S2, Figures 3-5 show projected probabilities of 10-62 (10-67) year-old females (males) to suffer from low weight disorder (anorexia) with respect to variables with statistically significant coefficients and their 95% confidence intervals.

Results reported in Figure 3 demonstrate that projected probability of *BMI*≤18 *drops* significantly (at the 5% significance level) from 8.53% for female renters to 5.11% for female homeowner. Projected probability of low weight disorder *rises* significantly (at the 1% significance level) from 4.45% for female who reside in single-family units to 7.79% for female who reside in an

Copyright 2019 KEI Journals. All Rights Reserved

apartment located in a conventional multi-story structure:

Figure 3: Projected Probability of Low Weight Disorder (Anorexia) of 10-62 Year-Old Females Stratified by Homeownership and Residence in Multistory Apartment



Notes: The figure displays the projections and their 95% confidence intervals obtained from the regression outcomes reported in Appendix S2. Projected probability of low weight disorder *drops* from 8.53% for female renters to 5.11% for female homeowner. Projected probability of low weight disorder *rises* from 4.45% for female who reside in a single-family unit to 7.79% for female who reside in an apartment located in a multi-story structure.

Results reported in Figure 4 demonstrate that projected probability of $BMI \leq 18$ *drops* significantly (at the 5% significance level) from 7.28% for male who declared to have no books at the home library to 2.48% for male who declared to have at least one book. The 95% projected probability spread for the former case is wider (1.45%-13.12% compared with 2.00%-2.96%). Projected probability of $BMI \leq 18$ *rises* significantly (at the 1% significance level) from 1.67% for a single male to 3.79% for a male whose household size includes 10 persons:

Copyright 2019 KEI Journals. All Rights Reserved

Figure 4: Projected Probability of Low Weight Disorder for 10-67 Year-Old Males Stratified by Books and Household Size

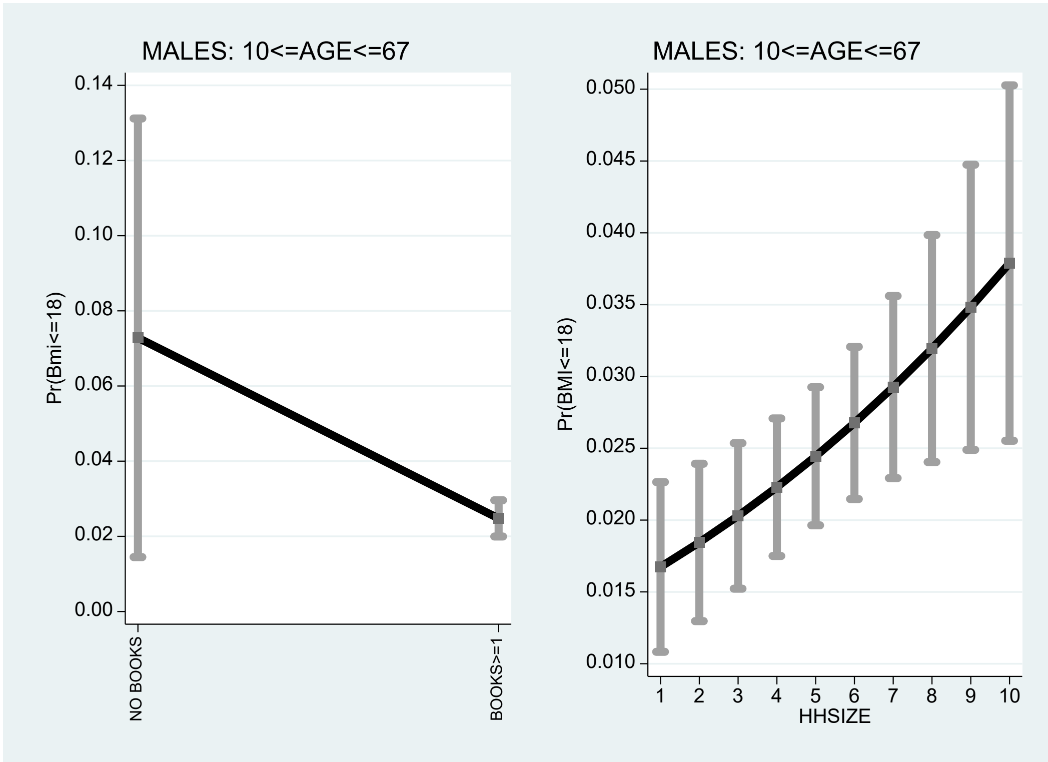
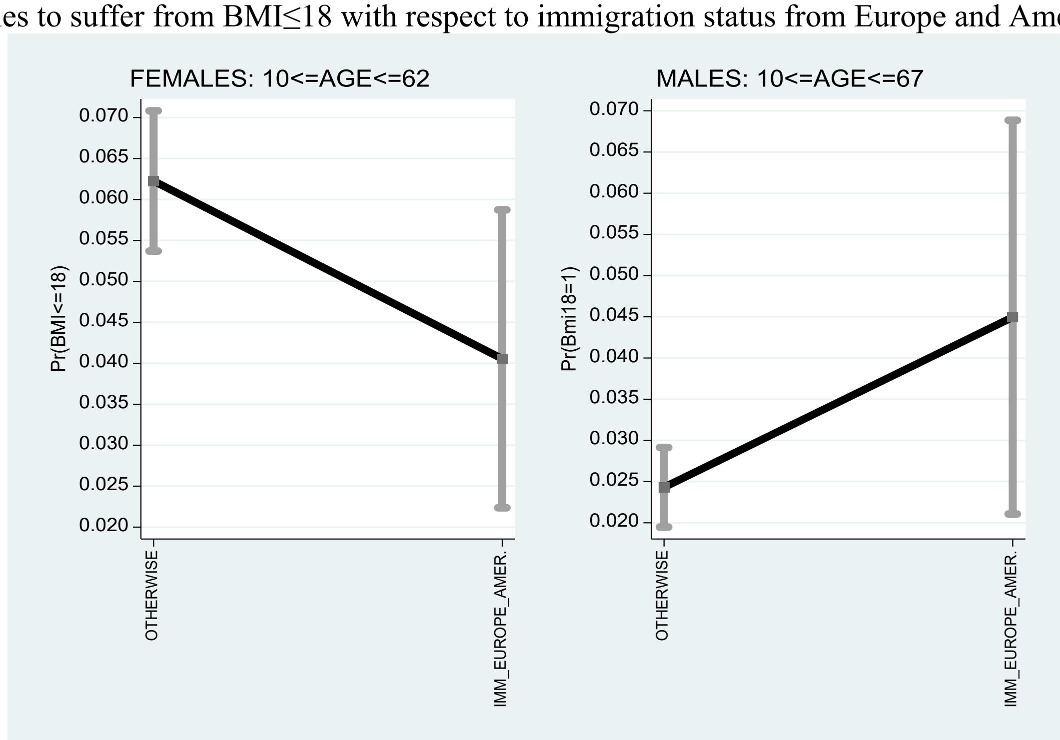


Figure 5: comparison between projected probabilities of 10-62 year-old females and 10-67 year old males to suffer from BMI≤18 with respect to immigration status from Europe and America:



Copyright 2019 KEI Journals. All Rights Reserved

Results reported in Figure 5 demonstrate opposite effects for women and men with respect to immigration status from Europe and America. Projected probability of women *drops* significantly (at the 10% significance level) from 6.23% among Native Israelis and immigrants from Asian-African countries to 4.05% for immigrants from European-American countries. The 95% projected probability spread for the latter case is wider (5.37%-7.08% compared with 2.33%-5.87%). Projected probability of men *rises* significantly (at the 10% significance level) from 2.43% among Native Israelis and immigrants from Asian-African countries to 4.50% for immigrants from European-American countries. The 95% projected probability spread for the latter case is wider (1.95%-2.91% compared with 2.11%-6.89%).

Appendix S3 and S4 report the estimation results of the random effect panel regressions given by equations (1) and (2) and stratified by gender for older respondents (21-62; 21-67 year old female and male, respectively) and young adolescents (10-20 year old respondents) separately.

All the regressions were estimated via the log-likelihood procedure and based on the random-effect probit model. The dependent variable is $\emptyset(BMI18)$, the cuumulative normal distribution function of $BMI18$, a dummy variable that equals 1 for low weight disorder or anorexia ($BMI \leq 18$) and zero otherwise. $\ln(\hat{\sigma}^2)$ is the estimated natural logarithm of the random distrubance term variance. The LR tests of Rho reject the null hypothesis that the coefficients of household-effects dummies are equal. The odd (even) columns reflect the full (step-wise) model for females and males given by equation (1). The step-wise procedure gradually omits variables with insignificant coefficient, where the threshold is a significance level of 10%.

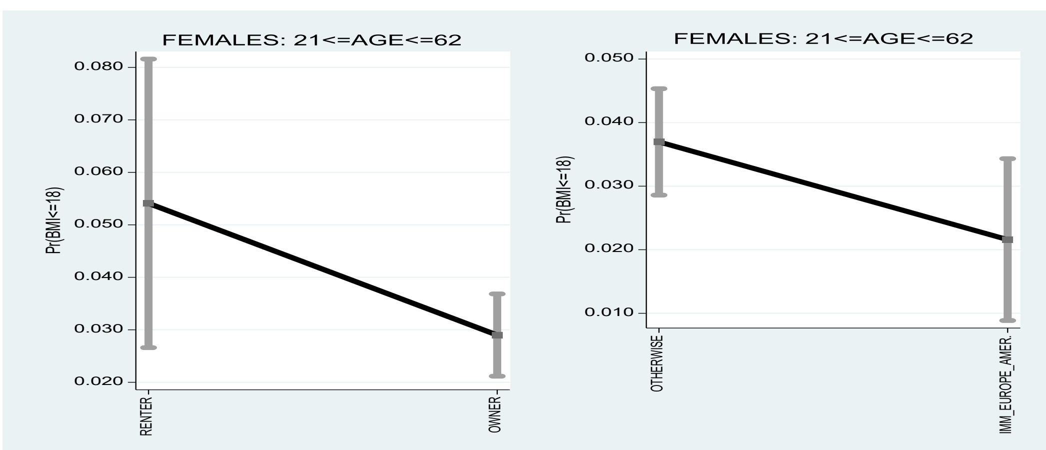
Once again, we follow Williams (2012), and based on the projections obtained from regression outcomes in Appendix S3, We calculate projected probabilities of 21-62 year-old females to suffer from low weight disorder (anorexia) with respect to variables with statistically significant coefficients and their 95% confidence intervals. These are given in Figures 6-7. Unfortunately, no statistical significant coefficients were found among male respondents:

Copyright 2019 KEI Journals. All Rights Reserved

Figure 6: Projected Probability of Low Weight Disorder (Anorexia) of 21-62 Year-Old Females Stratified by Residence in Apartment at Multi-Story Structures

Notes: The figure is based on the results reported in column (1) of Appendix S3. Projected probabilities are converted from $\emptyset(BMI18)$, the cuumulative normal distribution function of *BMI*18, a dummy variable that equals 1 for low weight disorder or anorexia (*BMI*≤18) and zero otherwise. Projected probability of low-weight-disorder or anorexia rises significantly from 4.4157% to 16.6627% with self report of good health. The 95% confidence interval is [0.6598%-8.1716%] for no self-report of good health, compared with [14.0407%-19.2846%] for self-report of good health

Figure 7: Projected Probability of Low Weight Disorder (Anorexia) of 21-62 Year-Old Females Stratified by Ownership Status and Immigration from European-American Countries



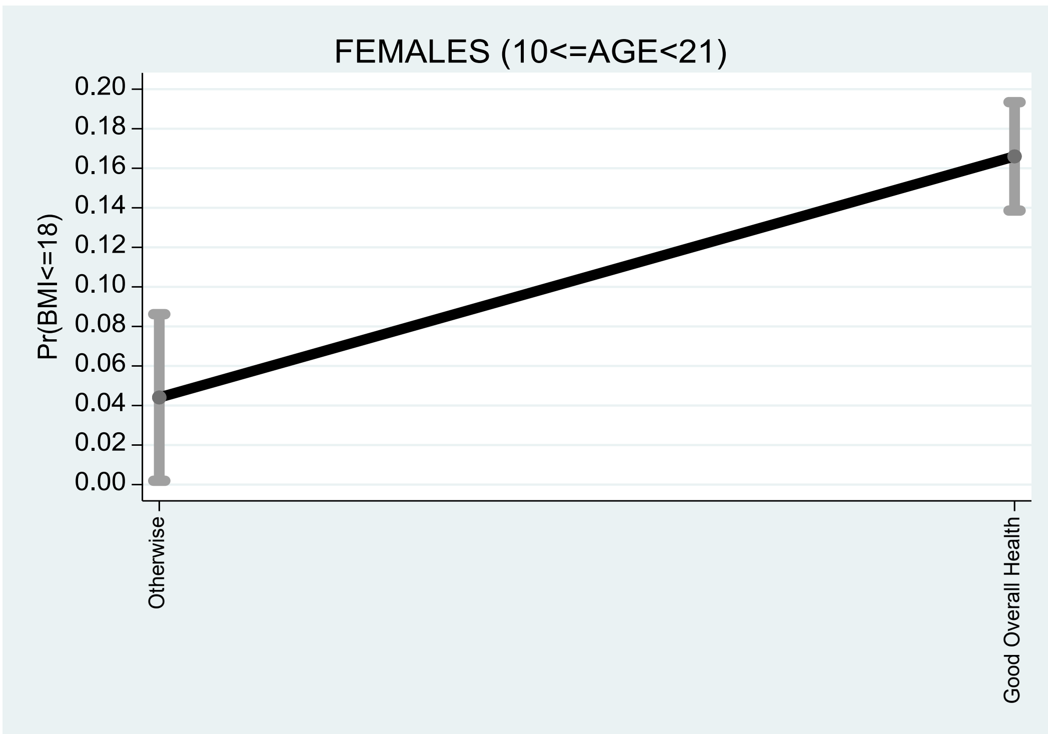
Notes: The figure is based on the results reported in column (1) of Appendix S3. Projected probabilities are converted from $\emptyset(BMI18)$, the cuumulative normal distribution function of *BMI*18, a dummy variable that equals 1 for low weight disorder or anorexia (*BMI*≤18) and zero otherwise. Projected probability of low-weight-disorder or anorexia *drops* significantly (at the 10% significance level) from 5.41% to 2.90% with homeownership status. The 95% confidence interval is [2.66%-8.16%] for renters, compared with [2.12%-3.68%] for owners. Projected probability of low-weight-disorder or anorexia *drops* significantly (at the 10% significance level) from 3.70% to 2.16% with immigrant status from European-American countries. The 95% confidence interval is [2.86%-4.53%] for Native Israelis and immigrant from Asian-African countries, compared with [0.89%-3.43%] for immigrants from European-American countries.

Copyright 2019 KEI Journals. All Rights Reserved

The outcomes of Figures 6-7 are reported at the notes below each figure. For the female respondents, results are robust to those obtained for the pooled sample of 10-62 year-old cohort.

Finally, based on the projections obtained from regression outcomes in Appendix S4, we calculate projected probabilities of 10-21 year-old females to suffer from low weight disorder (anorexia) with respect to variables with statistically significant coefficients and their 95% confidence intervals. These are given in Figures 8-9.

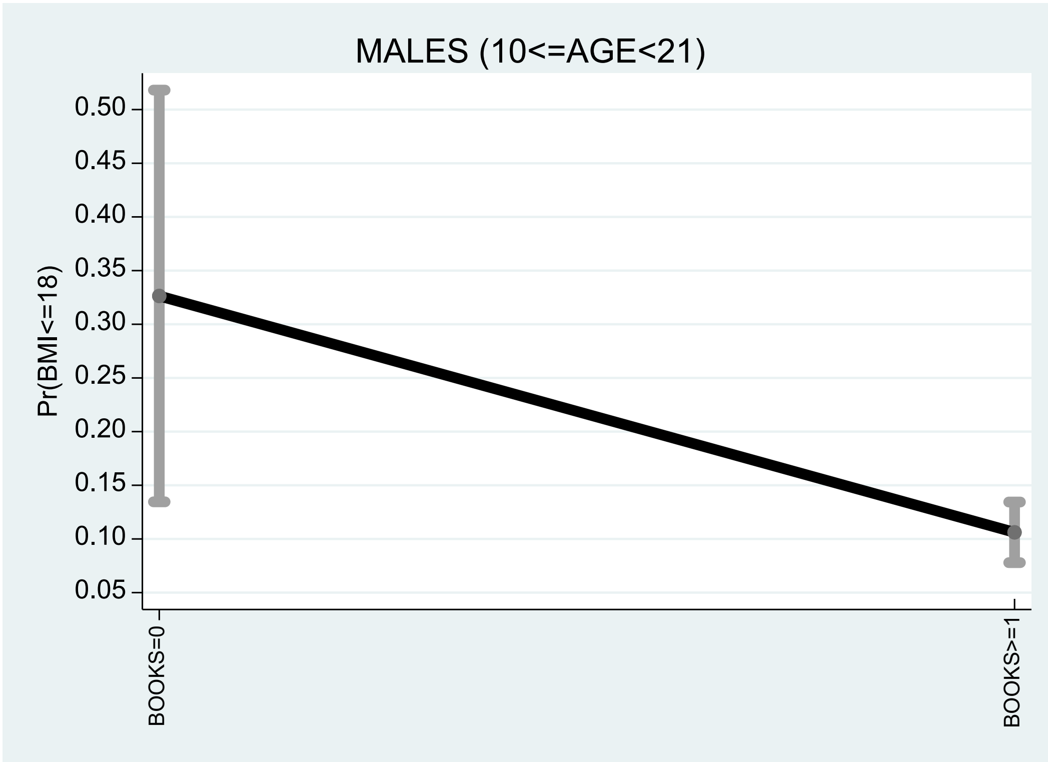
Figure 8: Projected Probability of Low Weight Disorder (Anorexia) of 10-20 Year-Old Females Stratified by Self-Reported Health Conditions



Notes: The figure is based on the results reported in column (2) of Appendix S4. Projected probabilities are converted from $\emptyset(BMI18)$, the cuumulative normal distribution function of $BMI18$, a dummy variable that equals 1 for low weight disorder or anorexia ($BMI \leq 18$) and zero otherwise. Projected probability of low-weight-disorder or anorexia rises significantly from 4.4157% to 16.6627% with self report of good health. The 95% confidence interval is [0.6598%-8.1716%] for no self-report of good health, compared with [14.0407%-19.2846%] for self-report of good health

Copyright 2019 KEI Journals. All Rights Reserved

Figure 9: Projected Probability of Low Weight Disorder (Anorexia) of 10-20 Year-Old Males Stratified by Self-Reported Number of Books at the Home Library



Notes: The figure is based on the results reported in column (3) of Appendix S4. Projected probabilities are converted from $\emptyset(BMI18)$, the cuumulative normal distribution function of *BMI*18, a dummy variable that equals 1 for low weight disorder or anorexia (*BMI*≤18) and zero otherwise. Projected probability of low-weight-disorder or anorexia *drops* significantly from 32.64% to 10.62% with self report of at least one book at the home library. The 95% confidence interval is [10.85%-54.43%] for no books, compared with [8.44%-12.80%] for self-report of at least one book at the home library.

For male respondents, projected probability of *BMI*≤18 *drops* significantly with age and with having a home library that includes at least one book.

Interestingly, for female cohort of 10-20 years, projected probability to suffer from *BMI*≤18 *rises* significantly from 4.4157% to 16.6627% with reported good health conditions. This outcome might be interpreted as self-denial of young female respondents regarding their realistic health conditions, which might support the psychological definition of anorexia nervosa.

4. Discussion:

The objective of the current study is to examine the economic, socio-demographic and psychological determinants of the probability to suffer from low weight disorder or anorexia nervosa. Given the extra difficulty of diagnosing anorexia by DSM questionnaires consisting of large number of questions (e.g., Pope *et. al*., 1987) , the advantage of our study lies in the simple quantitative measure we use of *BMI*≤18. Given that Israel is a western developed country and a fast growing economy, the probability that BMI<=18 reflects chronic energy deficiency due to circumstances of

Copyright 2019 KEI Journals. All Rights Reserved

poverty and/or lack of access to food rather than anorexia is small. Moreover, for the female group, we provide evidence supporting the possibility of anorexia nervosa.

We make use of an extensive set of questions concerning the economic and socio-demographic features, health and housing conditions of each respondent asked within the framework of the 2015-2016 longitudinal survey conducted by the CBS. The survey also includes information regarding the weight, height, gender and age of each household member.

Results of our study expose a *decrease* in the projected probability of having BMI≤18 with age. Compared with the 21-67 year old cohorts, the relative frequency of BMI≤18 *rises* to 10.68%-16.83% for the 10-20 year-old cohorts. For the female (male) respondents, projected probability *drops* consistently from 50% (75%) at the 10-year-old cohort to about 0% at the 62- (67-) year-old cohort. These figures imply that low-weight disorder or anorexia is a typical problem of the younger cohorts. Interestingly, there are gender differences in the spread around the projected probability of having *BMI*≤18. While this spread ranges between 30.67% and 68.64% for 10-year-old females (a range of 37.97%), the same spread range between 67.10% and 82.79% for 10-year-old males (a range of only 15.69%). For both gender, this spread around the projected probability drops with the age variable.

Regression outcomes for all cohorts above 10 years and below the retirement age of 62 years for female (67 years for male) indicate that for female respondents, projected probability of having BMI≤18 significantly *drops* with age, homeownership and European-American immigration status, and significantly *rises* with residence in a standard apartment in multi-story structure. For male respondents, projected probability of *BMI*≤18 *drops* significantly with age and with having a home library that includes at least one book, and *rises* significantly with the household size, and European-American immigration status.

Interestingly, for female cohort of 10-20 years, projected probability to suffer from *BMI*≤18 *rises* significantly from 4.4157% to 16.6627% with reported good health conditions. This outcome might be interpreted as self-denial of young female respondents regarding their realistic health conditions, which is closer to the definition of anorexia nervosa.

5. Data Availability Statement: All the data will be made fully available upon request. Instructions for Replication of the Tables and Figures via Stata software package are given in Appendix S5.

6. Funding Statement: None of the authors received any direct or indirect funding for this article.

References:

1. Arbel, Yuval; Fialkoff, Chaim and Amichai Kerner. Negative Externalities and Implicit Non-linear Prices: Capitalization of Highway Noise into Housing Values. *Journal of Real Estate Literature*, 25(2) (2017): 335-364.

Copyright 2019 KEI Journals. All Rights Reserved

2. Arbel, Yuval; Fialkoff, Chaim, and Amichai, Kerner. What is the optimal housing choice for a minimal BMI? *Economics Bulletin* (2018), 38(3): 1313-1337.
3. Arcelus J, Mitchell AJ, Wales J, Nielsen S. Mortality Rates in Patients with Anorexia Nervosa and Other Eating Disorders: A Meta-analysis of 36 Studies. *Arch General Psychiatry*. July, 2011 68(7):724-731. At: https://jamanetwork.com/journals/jamapsychiatry/fullarticle/1107207
4. Brown, Tiffany A., Lauren A. Holland, and Pamela K. Keel. Comparing operational definitions of DSM-5 anorexia nervosa for research contexts. *International journal of eating disorders* 47.1 (2014): 76-84.
5. Dryden-Edwards, Roxanne, MD; and Melissa Conrad Stöppler, MD: Anorexia Nervosa, at: https://www.medicinenet.com/anorexia_nervosa/article.htm
6. Estour, Bruno, Nesrine Marouani, Torrance Sigaud, François Lang, Eric Fakra, Yiin Ling, Aurélie Diamondé, James S. Minnion, Bogdan Galusca, and Natacha Germain. "Differentiating constitutional thinness from anorexia nervosa in DSM 5 era." *Psychoneuroendocrinology* 84 (2017): 94-100.
7. Gasse, Cédric; Boutin, Amélie; Demers, Suzanne; Chaillet, Nils; and Emmanuel Bujold. Body mass index and the risk of hypertensive disorders of pregnancy: the great obstetrical syndromes (GOS) study. *The Journal of Maternal-Fetal & Neonatal Medicine* (2017) Forthcoming: 1-21.
8. Greene, William H.*Econometric* Analysis, Seventh Edition. Pearson Education Limited., 2012.
9. Hermesch Amy C.; Allshouse Amanda A.; and Kent D. Heyborne. Body Mass Index and the Spontaneous Onset of Parturition. *Obstetrics & Gynecology* (2016), 128(5):1033–1038.
10. International Monetary Fund, World Economic Outlook Database, October 2017.
11. Israeli Central Bureau of Statistics. Table 14: Ownership of durable Goods in Deciles of Households by Net Income per Standard Person, 2015. At: http://www.cbs.gov.il/publications17/1677/pdf/t14.pdf
12. Israeli Central Bureau of Statistics. 2018 Statistical Abstract of Israel: Population Aged 15 and Over by Religion, Marital Statuse, Sex and Age, Average 2016, At:
13. http://www.cbs.gov.il/reader/shnaton/templ_shnaton_e.html?num_tab=st02_04x&CYear=2018
14. Israeli Central Bureau of Statistics. 2018 Statistical Abstract of Israel: Immigrants by Period of Immigration and Last Continent of Residence. At: http://www.cbs.gov.il/reader/shnaton/templ_shnaton_e.html?num_tab=st04_02&CYear=2018
15. Israeli Central Bureau of Statistics. 2018 Statistical Abstract of Israel: Population, by Population Group, Religion, Age and Sex, District and Sub-District. At: http://www.cbs.gov.il/shnaton69/st02_19x.pdf
16. Israeli Central Bureau of Statistics Press Release.Dwelling in Israel - Findings

from the Household Expenditure Survey, 2016 (Hebrew). Published in December 6, 2016: http://www.cbs.gov.il/www/hodaot2017n/15_17_358b.docx

17. Johnston, Jack; and John Dinardo, 1997.*Econometric Methods*, Fourth Edition. McGraw-Hill International Edition.
18. Mitchison, Deborah ; Hay, Phillipa ; Slewa-Younan, Shameran and Jonathan Mond. The changing demographic profile of eating disorder behaviors in the community. BMC Public Health 14 (2014): 943-
19. Mulders-Jones, Brittany; Mitchison, Deborah; Girosi, Federico; and Phillipa Hay. Socioeconomic Correlates of Eating Disorder Symptoms in an Australian Population-Based Sample. *PLOS-ONE*, (2017), 12(1): e0170603.
20. Mustelin, Linda, Yasmina Silén, Anu Raevuori, Hans W. Hoek, Jaakko Kaprio, and Anna Keski-Rahkonen. “The DSM-5 Diagnostic Criteria for Anorexia Nervosa May Change Its Population Prevalence and Prognostic Value.” Journal of Psychiatric Research 77: (June, 2016): 85–91.
21. Nyberg, Solja T., G. David Batty, Jaana Pentti, Marianna Virtanen, Lars Alfredsson, Eleonor I. Fransson, Marcel Goldberg et al. "Obesity and loss of disease-free years owing to major non-communicable diseases: a multicohort study." The Lancet Public Health (2018).
22. Pike, Kathleen M., and Patricia E. Dunne. "The rise of eating disorders in Asia: a review." *Journal of eating disorders* 3.1 (2015): 33: 1-14.
23. Pope, Harrison G.; Champoux, Richard F.; and James I. Hudson. "Eating disorder and socioeconomic class: Anorexia nervosa and bulimia in nine communities." *Journal of Nervous and Mental Disease* 175(10), (1987): 620-623.
24. Shamriz, Oded., Leiba, Merav; Levine, Hagai; Derazne, Estela; Keinan-Boker, Lital ; and Jeremy D. Kark. Higher body mass index in 16-19 year-old Jewish Adolescents of North African, Middle Eastern and European Origins is a Predictor of Acute Myeloid Leukemia: a cohort of 2.3 million Israelis. *Cancer Causes Control*, 28 (2017): 331.
25. Spearing, Melissa. Eating Disorders: Facts about Eating Disorders and the Search for Solutions. National Institute of Mental Health (DHHS), Report NIH-01-4901 (2001): 1-13. Available at: https://eric.ed.gov/?id=ED457455
26. Striegel-Moore, Ruth H., Francine Rosselli, Nancy Perrin, Lynn DeBar, G. Terence Wilson, Alexis May, and Helena C. Kraemer. "Gender difference in the prevalence of eating disorder symptoms." *International Journal of Eating Disorders*, 42, no. 5 (2009): 471-474.
27. Williams, Richard. “Using the margins command to estimate and interpret adjusted predictions and marginal effects.” *The Stata Journal* 12(2) (2012):308-331.
28. Yan, Yinkun; Hou, Dongqing; Liu, Junting; Zhao, Xiaoyuan; Cheng, Hong; Xi, Bo; Jie Mi. Childhood body mass index and blood pressure in prediction of subclinical vascular damage in

Copyright 2019 KEI Journals. All Rights Reserved

adulthood: Beijing blood pressure cohort. *Journal of Hypertension*, 35(1) (2017) :47–54.

29. Yoon, Sook Hee; Han, Kyu-Tae; Kim, Sun Jung; Sohn, Tae Yong; Jeon, Byungyool; Kim, Woorim; and Eun-Cheol Park. Combined effect of body mass index and body size perception on metabolic syndrome in South Korea: results of the fifth Korea National Health and Nutrition Examination Surveys (2010-2012). *BMC Public Health*, 15 (2015): 554-569.

S1. Random Effect 2015-2016 Probit Regressions: Cohort Effect on Projected Probability of Low BMI Among Females and Males

VARIABLES	(1) Φ(BMI18)	(3) Φ(BMI18)
AGE_SQ	0.0009***	0.0025***
	(0.0003)	(0.0004)
AGE	-0.1052***	-0.2482***
	(0.0188)	(0.0299)
Constant	-0.2246	1.0816***
	(0.2782)	(0.3568)
$\ln(\hat{\sigma}^2)$	0.4311**	0.4573*
	(0.1888)	(0.2710)
Gender	FEMALES	MALES
Cohort	10≤AGE≤62	10≤AGE≤67
Observations	5,088	5,539
Number of households	1,964	2,113
log-likelihood	-958	-435.4
Wald-chi2	119.2***	96.65***
LR-TEST of Rho	182.9***	69.52***

Notes: All the regressions were estimated via the log-likelihood procedure and based on the random-effect probit model. $\Phi(\cdot)$ is the cumulative normal distribution function of of *BMI*18, a dummy variable that equals 1 for low weight disorder or anorexia (*BMI*≤18) and zero otherwise. $\ln(\hat{\sigma}^2)$ is the estimated natural logarithm of the random distrubance term variance. The LR tests of Rho reject the null hypothesis that the coefficients of household effect dummies are equal. Robust standard errors are given in parentheses. * significant at the 10% significance level. ** significant at the the 5% significance level. *** significant at the 1% significance level.

Copyright 2019 KEI Journals. All Rights Reserved http://journals.ke-i.org/index.php/mra

S2. Projected Probability of Low BMI Among Females and Males for All Cohorts Above or Equal to 10 Years and Below the Retirement Age

	(1)	(2)	(3)	(4)
VARIABLES	full Φ(BMI18)	Step-wise Φ(BMI18)	full Φ(BMI18)	Step-wise Φ(BMI18)
Constant	-1.0077*	-0.1704	2.0604***	1.8019***
	(0.5723)	(0.2830)	(0.7627)	(0.6507)
OWNER	-0.4668**	-0.4705**	0.1337	–
	(0.1964)	(0.1934)	(0.2810)	–
MULTI_STORY	0.5022***	0.4840***	-0.2557	–
	(0.1905)	(0.1851)	(0.2772)	–
BOOKS	0.3149	–	-1.1152**	-1.2008**
	(0.3912)	–	(0.4994)	(0.4786)
OVER_200_BOOKS	0.0294	–	-0.1274	–
	(0.1183)	–	(0.1777)	–
CAR	0.0190	–	-0.0076	–
	(0.1403)	–	(0.2007)	–
AGE	-0.0878***	-0.1033***	-0.2553***	-0.2541***
	(0.0219)	(0.0188)	(0.0344)	(0.0314)
AGE_SQ	0.0007**	0.0008***	0.0025***	0.0026***
	(0.0003)	(0.0003)	(0.0004)	(0.0004)
HHSIZE	-0.0022	–	0.0818***	0.0842***
	(0.0289)	–	(0.0290)	(0.0294)
MARRIED	-0.2697*	–	0.0872	–
	(0.1609)	–	(0.3186)	–
DIVORCED	-0.4219	–	–	–
	(0.3035)	–	–	–
WIDOWED	-0.1536	–	–	–
	(0.4870)	–	–	–
IMM_EUROPE_AMERICA	-0.3486*	-0.3612*	0.6070*	0.5768*
	(0.2014)	(0.1943)	(0.3108)	(0.3066)
IMM_ASIA_AFRICA	0.3044	–	-0.1019	–
	(0.3548)	–	(0.7777)	–
OVERALL_HEALTH	0.3148	–	-0.2188	–
	(0.2520)	–	(0.3473)	–
$\ln(\hat{\sigma}^2)$	0.4176**	0.3990**	0.5283**	0.5537**
	(0.1830)	(0.1890)	(0.2527)	(0.2690)
Gender	FEMALES	FEMALES	MALES	MALES
Cohort	10≤AGE≤62	10≤AGE≤62	10≤AGE≤67	10≤AGE≤67
Observations	5,088	5,088	5,539	5,539
Number of households	1,964	1,964	2,113	2,113
log-likelihood	-948.8	-952.5	-428.5	-429.4
Wald-chi2	156.7***	132.6***	111.8***	99.45***
LR-TEST of Rho	172.9***	174.4***	70.32***	74.02***

Notes: All the regressions were estimated via the log-likelihood procedure and based on the random-effect probit model. $\Phi(\cdot)$ is the cumulative normal distribution function. $\ln(\hat{\sigma}^2)$ is the estimated natural logarithm of the random distrubance term variance. The LR tests of Rho reject the null hypothesis that the coefficients of household-effects dummies are equal. The odd (even) columns reflect the full (step-wise) model for females and males given by equation (1). The step-wise procedure gradually omits variables with insignificant coefficient, where the threshold is a significance level of 10%. Robust standard errors are given in parentheses. * significant at the 10% significance level. ** significant at the the 5% significance level. *** significant at the 1% significance level.

Copyright 2019 KEI Journals. All Rights Reserved

S3. Projected Probability of Low BMI Among Females and Males for Adult Cohorts Above or Equal to 21 Years and Below the Retirement Age

	(1)	(2)	(3)	(4)
VARIABLES	full Φ(BMI18)	step-wise Φ(BMI18)	full Φ(BMI18)	step-wise Φ(BMI18)
Constant	-2.7047**	-2.8863***	-2.9908	-12.7358
	(1.2816)	(0.3299)	(7.3764)	0.1112
OWNER	-0.6367*	-0.6445*	1.3285	–
	(0.3465)	(0.3426)	(1.2873)	–
MULTI_STOREY	0.7211**	0.7083**	-0.7277	–
	(0.3268)	(0.3241)	(0.6964)	–
BOOKS	0.2748	–	-1.1180	–
	(0.5745)	–	(2.2047)	–
OVER_200_BOOKS	0.1135	–	-0.8325	–
	(0.1996)	–	(0.7633)	–
CAR	-0.0309	–	0.3132	–
	(0.2264)	–	(1.2677)	–
AGE	-0.0115	–	-0.1091	–
	(0.0585)	–	(0.1427)	–
AGE_SQ	-0.0003	-0.0005***	0.0009	–
	(0.0007)	(0.0001)	(0.0016)	–
HHSIZE	-0.0290	–	0.0195	–
	(0.0532)	–	(0.0785)	–
MARRIED	-0.3303	–	-0.0768	–
	(0.2333)	–	(0.6547)	–
DIVORCED	-0.5402	–	–	–
	(0.3826)	–	–	–
WIDOWED	-0.3194	–	–	–
	(0.5614)	–	–	–
IMM_EUROPE_AMERICA	-0.5106*	-0.5147*	0.0880	–
	(0.3027)	(0.2911)	(0.5841)	–
IMM_ASIA_AFRICA	0.2234	–	–	–
	(0.4437)	–	–	–
OVERALL_HEALTH	0.0263	–	-0.7010	–
	(0.3140)	–	(0.5269)	–
$\ln(\hat{\sigma}^2)$	1.2269***	1.2305***	1.6165	4.905
	(0.2241)	(0.2268)	(2.6044)	
Gender	FEMALES	FEMALES	MALES	MALES
Cohort	21≤AGE≤62	21≤AGE≤62	21≤AGE≤67	21≤AGE≤67
Observations	4,060	4,060	4,425	4,425
Number of households	1,911	1,911	2,033	2,033
log-likelihood	-500.7	-503.2	-85.20	-89.1
Wald-chi2	40.08***	27.63***	13.09	–
LR-TEST of Rho	154.8***	155.5***	25.68	–

Notes: All the regressions were estimated via the log-likelihood procedure and based on the random-effect probit model. $\Phi(\cdot)$ is the cumulative normal distribution function. $\ln(\hat{\sigma}^2)$ is the estimated natural logarithm of the random distrubance term variance. The LR tests of Rho reject the null hypothesis that the coefficients of household-effects dummies are equal. The odd (even) columns reflect the full (step-wise) model for females and males given by equation (1). The step-wise procedure gradually omits variables with insignificant coefficient, where the threshold is a significance level of 10%. Robust standard errors are given in parentheses. * significant at the 10% significance level. ** significant at the the 5% significance level. *** significant at the 1% significance level.

Copyright 2019 KEI Journals. All Rights Reserved

S4. Projected Probability of Low BMI Among Females and Males for Young Cohorts Above or Equal 10 Years and Below 21 Years

	(1)	(2)	(3)	(4)
VARIABLES	full Φ(BMI18)	step-wise Φ(BMI18)	full Φ(BMI18)	step-wise Φ(BMI18)
Constant	-7.4325**	-7.5336***	-11.3148**	-10.6679**
	(3.2134)	(2.8961)	(4.4114)	(5.0992)
OWNER	-0.4686*	–	-0.1837	–
	(0.2524)	–	(0.3126)	–
MULTI_STOREY	0.4014	–	0.0588	–
	(0.2552)	–	(0.3278)	–
BOOKS	0.2159	–	-1.4164**	-1.2697*
	(0.3294)	–	(0.7013)	(0.6827)
OVER_200_BOOKS	0.0012	–	-0.0364	–
	(0.1950)	–	(0.1829)	–
CAR	0.0269	–	0.0360	–
	(0.1733)	–	(0.2495)	–
AGE	0.7978*	0.7968**	1.5945**	1.5821**
	(0.4329)	(0.3979)	(0.6717)	(0.7702)
AGE_SQ	-0.0297**	-0.0297**	-0.0598**	-0.0594**
	(0.0151)	(0.0137)	(0.0243)	(0.0277)
HHSIZE	-0.0465	–	0.0665	–
	(0.0457)	–	(0.0407)	–
MARRIED	-0.2505	–	–	–
	(0.4681)	–	–	–
IMM_EUROPE_AMERICA	-0.2451	–	1.2666**	1.1284*
	(0.4449)	–	(0.5072)	(0.6755)
OVERALL_HEALTH	1.1165***	1.0904***	0.3716	–
	(0.3005)	(0.3482)	(0.4704)	–
$\ln(\hat{\sigma}^2)$	0.0002	0.0838	0.1756	0.1107
	(0.3177)	(0.2328)	(0.3496)	(0.3901)
Gender	FEMALES	FEMALES	MALES	MALES
Cohort	10≤AGE<21	10≤AGE<21	10≤AGE<21	10≤AGE<21
Observations	1,028	1,028	1,114	1,114
Number of households	447	447	470	470
log-likelihood	-421.4	-424.2	-322.5	-324.4
Wald-chi2	37.44	14.78	22.82	8.993
LR-TEST of Rho	48.29	53.88	35.72	34.78

Notes: All the regressions were estimated via the log-likelihood procedure and based on the random-effect probit model. $\Phi(\cdot)$ is the cumulative normal distribution function. $\ln(\hat{\sigma}^2)$ is the estimated natural logarithm of the random distrubance term variance. The LR tests of Rho reject the null hypothesis that the coefficients of household-effects dummies are equal. The odd (even) columns reflect the full (step-wise) model for females and males given by equation (1). The step-wise procedure gradually omits variables with insignificant coefficient, where the threshold is a significance level of 10%. Bootstrap standard errors with 50 replications are given in parentheses. * significant at the 10% significance level. ** significant at the the 5% significance level. *** significant at the 1% significance level.

Copyright 2019 KEI Journals. All Rights Reserved

S5. Instructions for Replication of the Tables and Figures

For replication objectives, we are attaching the following Stata and PDF files:

1. Raw Data Files:

Number	Year of Interview	File Name	Description
(1)	2016	"f805fam.dta"	Raw household level data file obtained from a representative sample of the same households interviewed in 2014-2015
(2)	2016	"f805ind.dta"	Raw individual level data file obtained from a representative sample of the same households interviewed in 2014-2015
(3)	2014-2015	"n799fam.dta"	Raw household level data file obtained from a representative sample of households whose members were interviewed in 2014-2015
(4)	2014-2015	"n799ind.dta"	Raw individual level data file obtained from a representative sample of households whose members were interviewed in 2014-2015

2. Other files

Number	Type of File	File Name	Description
(5)	Batch File	"For_journal_of_obesity_20190124.do"	A batch file designed to replicate the outcomes (after updating the change directory "cd" command in the second row so as to fit the PC directory, where the raw files are stored and downloaded).
(6)	Output File	"For_ journal_of_obesity_20190124.smcl"	An output file, which exhibits all the outputs obtained by running the batch file.
(7)	Output File	"For_ journal_of_obesity_20190124.pdf"	An output file, which exhibits all the outputs obtained by running the batch file in pdf. format.
(8)	Figures1-9	"Figure1.gph","Figure2.gph", "Figure3.gph","Figure4.gph", "Figure5.gph","Figure6.gph", "Figure7.gph","Figure8.gph", "Figure9.gph",	All the figures that appear in the articles after additional editing.

Copyright 2019 KEI Journals. All Rights Reserved

Replication is possible by running the batch file "For_PLOS_One_20181209.do" after updating the change directory "cd" command in the first row so as to fit the user PC directory, where the raw files are stored and downloaded. Row numbers described below may be tracked in the do, smcl, and pdf files.

After each of the raw files, the commands "describe" in rows 7, 203, 341, 509 provide the full original list of variables and their descriptions.

Based on the raw dataset file "f805fam.dta", uploaded in row 6, we define the following numeric or dummy variables: *OWNER*2016 (rows 331); *MULTI_STORY*2016 (rows 57); *BOOKS*2016 (rows 19-20); *OVER_200_BOOKS*2016 (rows 21-22); *CAR*2016 (row 14). Another variable at the household level includes: *HHSIZE*2016 (row 62). As can be seen from the variables definition, dummy variables include only "yes" or "no" categories encoded as one and zero, respectively. All blank spaces or other categories were excluded.

Having defined the 2016 variables at the household level, we now save the file as "longtitudal_family_2016.dta" (row 201).

Based on the raw dataset file "f805ind.dta", uploaded in row 202, we define the following individual level variables: *FEMALE*2016 (row 228); *AGE*2016 (row 229); *HEIGHT*2016 (rows 235-245); *INDWEIGHT*2016 (rows 252-269); *BMI*2016 $=\frac{INDWEIGH2016}{(HEIGHT2016)^2}$ (row 271); *MARRIED*2016 (row 275); *DIVORCED*2016 (row 276); *WIDOW*2016 (row 277); *SINGLE*2016 (row 278); *IMMIGRANT_EUROPE_AMERICA*2016 (row 286); *IMMIGRANT_ASIA_AFRICA*2016 (row 287); *OVERALL_HEALTH*2016 (row 216)

In order to combine the individual and household variables of 2016, the program matchs between the raw files (1)-(2), after some definitions of variables and arrangement, (the "merge" command in row 309 where *HHID* is the key variable for merging) and stores the matched files as "longtitutudal_2016.dta" (row 336).

Based on the raw dataset file "n799fam.dta", uploaded in row 340, we define the following numeric or dummy variables: *OWNER*2015 (rows 628); *MULTI_STORY*2015 (row 400); *BOOKS*2015 (rows 353-354); *OVER_200_BOOKS*2015 (rows 355-356); *CAR*2015 (row 348). Another variable at the household level includes: *HHSIZE*2015 (row 410). As can be seen from the variables definition, dummy variables include only "yes" or "no" categories encoded as one and zero, respectively. All blank spaces or other categories were excluded.

Having defined the 2015 variables at the households level, we now save the file as "longtitudal_family_2015.dta" (row 507).

Based on the raw dataset file "n799ind.dta", uploaded in row 508, we define the following individual level variables: *FEMALE*2015 (row 529); *AGE*2015 (row 536); *HEIGHT*2015 (rows 542-552); *INDWEIGH*2015 (rows 559-576); *BMI*2015 $=\frac{INDWEIGH2015}{(HEIGHT2015)^2}$ (row 578) *MARRIED*2015 (row 586); *DIVORCED*2015 (row 587); *WIDOW*2015 (row 588); *SINGLE*2015 (row 589); *IMMIGRANT_EUROPE_AMERICA*2015 (row 597); *IMMIGRANT_ASIA_AFRICA*2015 (row 598); *OVERALL_HEALTH*2015 (row 521)

Copyright 2019 KEI Journals. All Rights Reserved

In order to combine the individual and household variables of 2015, the program matches between the raw files (3)-(4), after some definitions of variables and arrangement, (the "merge" command in row 602 where *HHID* is the key variable for merging).

To generate a standard structure of panel dataset, we merge the 2015 and 2016 files (row 608) and use the "reshape" command (row 638).

The dependent variable BMI18 is defined in rows 649-650. The outputs of Figure 1 is generated by the "graph" commands in rows 649-651. The output of Table 1 (Descriptive Statistics Stratified by Age and Gender 2015-2016 Panel) is generated by the "outreg" and "sum" commands in rows 687-691 for females and rows 718-725 for males.

The output of Appendix S1 is generated by the "xtprobit" command in rows 674 and 678. The output of Figure 2 is generated by the "margins" and "marginsplot" command in rows 676-677 for females and rows 680-681 for males.

The output of Appendix S2 is generated by the "xtprobit" command in rows 692, and 712 for females and 726 and 742 for males. The output of Figures 3-5 is generated by the "margins" and "marginsplot" command in rows 696-699 and rows 728-733 for males.

The output of Appendix S3 is generated by the "xtprobit" command in rows 748, and 768 for females and 771 and 786 for males. The output of Figure 6-7 is generated by the "margins" and "marginsplot" command in rows 751-756 for females.

The output of Appendix S4 is generated by the "xtprobit" command in rows 748, and 803 for females and 808 and 818 for males. The output of Figure 8-9 is generated by the "margins" and "marginsplot" command in rows 805-806 for females and rows 820-821 for males.

Copyright 2019 KEI Journals. All Rights Reserved