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# Are happy people healthier? An instrumental variable approach using data from Greece

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## Abstract

**Background**

From a theoretical perspective, several studies indicate that happiness and health are –in some extent- interrelated. Despite the mechanisms explaining the relationship between happiness and health, there is still no consensus regarding this link. Using recently collected primary data, this study aims to examine the relationship between happiness and health, and identify potential heterogeneity in the association depending on socioeconomic status.

**Methods**

This study draws on data from a nationally representative cross-sectional survey, conducted by the Athens School of Public Health in 2015. We applied an instrumental variable approach to address the endogeneity, arising from the simultaneous determination of happiness and health. Controlling for several confounders (i.e. socioeconomic, demographic, lifestyle, social capital variables) we employed several IV models, including 2SLS, IV probit, and bivariate probit models.

**Results**

We report strong evidence of an association between happiness and health. This association remains strong after correcting for endogeneity, and is robust across different specifications. Further, we find a positive association between happiness and SRH for low-educated, but not for high-educated. Similarly, we find a strong relationship between happiness and health for the lower socioeconomic strata, but not for the higher ones.

**Conclusions**

Overall, we show that happiness is positively associated with health. Further, happiness significantly influences SRH in low-SES individuals, but this association wanes for the higher socioeconomic strata. This finding has significant implications for health promotion, prevention, and public health, and suggests that policy makers have a wider array of choices for improving health and tackling health inequalities.

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# BACKGROUND

For decades, most socioeconomic analyses focused on income as the key variable affecting individuals' utility and welfare[1]. Nevertheless, following the influence of welfarism and extra-welfarism in social research, the distribuendum -in terms of societal welfare- has shifted towards happiness and health. A wide array of literature corroborates that happiness and health are –in some extent- interrelated. Indeed, several studies suggest that those who are healthier are generally happier[2]. Although the link from health to happiness can be easily explained, the way through which positive emotions could affect health status is more complicated and requires further refinement and analysis, both from theoretical and empirical perspective.

From a theoretical perspective, an obvious question relates to the transmission channels through which happiness could affect health. Put another way, which are the underlying pathways that explain such a relationship and motivate research on this topic? According to medical, psychology and social science literature, there are several physiological, social and behavioural mechanisms, that potentially explain the link between positive emotions and health [3]. For example, happiness impacts specific physiological systems, including cardiovascular, endocrine and immune function[4]. In general, there are five potential transmission channels through which happiness affects health. First, a large body of literature indicates that the main transmission channel relates to the functioning of autonomic nervous system[5]. Second, happiness may affect health through some hormones released by the hypothalamic-pituitary-adrenal axis activation due to positive emotions. Third, positive affect appears to influence the functioning of the immune system, with profound implications on individual health. Fourth, happiness is associated with the

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intensity of social interactions and the quality of social ties, both of which are generally considered as predictors of health [6]. The last potential channel relates to the effects of happiness on the adoption of different health behaviours. In particular, happier people generally adopt a more health-promoting lifestyle, since they exercise more regularly, and are more likely to avoid smoking, drinking or unhealthy diet [7]. Diener et al. (2017) named the aforementioned as "mediators of this relationship" [8] (further details are presented in Figure A1 in Supplementary File).

Apart from the theoretical interest, the analysis of this relationship entails some empirical challenges. In particular, health is an important determinant of happiness [1], while higher levels of happiness may in turn be associated with better health. In this context, this relationship suffers from reverse causality, due to the simultaneous determination of health and happiness. Such a problem has serious implications on empirical analysis, since a simple correlational analysis would lead to biased estimates, due to the existence of simultaneity bias. There is, however, scant evidence regarding how happiness influences health, especially after having addressed the aforementioned empirical issue.

Although some studies do not report a statistically significant relationship between happiness and health [9,10], the majority of the evidence finds that positive emotions are associated with greater levels self-rated health (SRH) [7], lower risk of coronary heart disease [11], longevity and better health outcomes [12]. In general, most studies indicate that happiness is conducive for health and longevity and protects against the risk of illness, but it does not appear to cure diseases or improve individuals' chances to survive existing diseases among sick populations [2,12].

Additionally, according to a recent paper, there might exist some "effect moderators" in this relationship that essentially suggest that the relationship between happiness and health may vary across different population groups and conditions. Several studies have indeed found that age, sex and ethnicity might be moderators of this relationship [8]. There is, however, little and inadequate evidence about the potential moderating role of socioeconomic variables, which is rather focused on specific health conditions [13], or relies on aggregate data and cross-country comparisons [14].

Our analysis draws on data from Greece, a country that faced significant socioeconomic changes in the last years. During 2008-2015, the Gross Domestic Product decreased by more than a quarter, unemployment rapidly increased from 7.8% to 24.9% and a series of austerity measures (e.g. tax increases, salary cuts) were introduced in the context of a large-scale fiscal consolidation programme [15]. Evidence suggests that living conditions and health trends deteriorated [16,17], while patients face unmet needs and increased barriers to accessing health care [18]. These adverse developments had an impact on well-being and life satisfaction in Greece [19].

In light of the above, this study aims to further examine the relationship between happiness and health, controlling for a number of potential confounders, using appropriate empirical techniques to address the reverse causality between happiness and health. Apart from testing the relationship between happiness and health in the total sample, we stratify our sample by socioeconomic status (SES), and find heterogeneity in the relationship between happiness and health. In this context, the

remaining of the paper unfolds as follows. First, we present the dataset and the empirical strategy of our analysis. Second, we focus on the results of the empirical analysis. Third, we briefly discuss our results in comparison with the existing literature, while we also elaborate on potential public policy relevance and implications of the findings.

# METHODS

**Data and Variables**

This study draws on recently collected primary data from a nationally representative cross-sectional survey (the 'Health and Welfare Survey'), conducted by the Greek National School of Public Health in 2015. The sample consists of 2012 respondents, and is stratified by age, degree of urbanization, gender and region. Data were collected through strictly structured interviews that were conducted with the computer-assisted telephone (CATI) technique. The interviews were conducted by trained interviewers.

The dependent variable is self-rated health (SRH), and the independent variable of interest is happiness, and its measure is based on the so-called 'affect measures of well-being'[20]. In this context, the variable for capturing happiness is derived from the question: *'How often do you feel happy?'*, and the possible answers range from never/very rarely to very often/always. It is noteworthy that this variable is essentially one of the components of the so-called Scale of Positive and Negative Experience (SPANE)[21], and has been also used by several studies[9,22,23].

Apart from happiness, we also control for the following sets of regressors: (a) demographic factors (age, gender, nationality, marital status), (b) lifestyle characteristics (smoking, alcohol consumption, physical exercise), (c) SES (income, education, occupation), (d) objective health indicators (existence of chronic conditions, limitations in daily activities due to health problems) and (e) proxies for social capital at the individual level (e.g. size of social network, volunteering/hobbies, participation community activities). Regarding the latter set of regressors, our analysis considers some dimensions of social capital, as evidence suggests that these factors constitute strong predictors of health. It is noteworthy that these variables generally capture the main dimensions of the four interpretations of social capital, as proposed by OECD (i.e. personal relationhsip, social network support, civic engagement and trust and cooperative norms) [24]. Last, we control for region fixed effects. Table A1 in the Supplementary File presents a detailed description of the independent variables. Summary statistics can be found in Table 1.

## Table 1: Descriptive statistics

| Variable | n | Percentage |
|---|---|---|
| **SRH: very poor** | 46 | 2.29 |
| **SRH: poor** | 108 | 5.37 |
| **SRH: fair** | 458 | 22.79 |
| **SRH: good** | 818 | 40.70 |
| **SRH: very good** | 580 | 28.86 |
| **Happiness: never** | 118 | 5.91 |
| **Happiness: rarely** | 340 | 17.03 |
| **Happiness: sometimes** | 282 | 14.13 |
| **Happiness: quite often** | 553 | 27.71 |
| **Happiness: very often** | 585 | 29.31 |
| **Happiness: always** | 118 | 5.91 |
| **Age group: 18-24** | 189 | 9.39 |
| **Age group: 25-39** | 521 | 25.89 |
| **Age group: 40-54** | 531 | 26.39 |
| **Age group: 55-64** | 310 | 15.41 |
| **Age group: over 65** | 461 | 22.91 |

| | | |
|---|---|---|
| **Married** | 1275 | 63.37 |
| **Unmarried** | 504 | 25.05 |
| **Widowed** | 171 | 8.50 |
| **Separated/divorced** | 62 | 3.08 |
| **Male** | 958 | 47.61 |
| **Female** | 1054 | 52.39 |
| **Greek** | 1893 | 94.18 |
| **Non-Greek** | 117 | 5.82 |
| **Up to Primary education** | 276 | 13.76 |
| **Secondary education** | 934 | 46.56 |
| **Tertiary education** | 796 | 39.68 |
| **Employer** | 263 | 13.08 |
| **Employee** | 539 | 26.82 |
| **Unemployed** | 243 | 12.09 |
| **Pensioner** | 603 | 30.00 |
| **Home caring** | 229 | 11.39 |
| **Student** | 133 | 6.62 |
| **Low income** | 801 | 44.23 |
| **Middle income** | 752 | 41.52 |
| **High income** | 258 | 14.25 |
| **Smoker** | 668 | 33.22 |
| **Non-smoker** | 1343 | 66.78 |
| **Drinking: never/almost never** | 1172 | 58.28 |
| **Drinking: 1-4 times/week** | 641 | 31.87 |
| **Drinking: 5-6 times/week** | 198 | 9.85 |
| **Physical exercise: 0 times/week** | 534 | 27.58 |
| **Physical exercise: 1-2 times/week** | 464 | 23.97 |
| **Physical exercise: 3-5 times/week** | 425 | 21.95 |
| **Physical exercise: more than 6 times/week** | 513 | 26.50 |
| **Chronic condition: yes** | 847 | 42.10 |
| **Chronic conditions: no** | 1165 | 57.90 |
| **Limitations in daily activities: yes** | 620 | 30.82 |
| **Limitations in daily activities: no** | 1392 | 69.18 |
| **Having a hobby** | 520 | 25.86 |
| **Not having a hobby** | 1491 | 74.14 |
| **Participating in community activities** | 278 | 13.82 |
| **Not participation in community activities** | 1734 | 86.18 |
| **Number of people he/she can rely on: 0** | 69 | 3.43 |
| **Number of people he/she can rely on: 1-2** | 577 | 28.72 |
| **Number of people he/she can rely on: 3-5** | 937 | 46.64 |
| **Number of people he/she can rely on: over 6** | 426 | 21.20 |
| **Having children under 18** | 561 | 27.91 |
| **Not having children under 18** | 1,449 | 72.09 |
| **Number of household members: 1** | 270 | 13.46 |
| **Number of household members: 2** | 594 | 29.61 |
| **Number of household members: 3** | 445 | 22.18 |
| **Number of household members: 4** | 473 | 23.58 |
| **Number of household members: 5 or more** | 224 | 11.17 |

**Empirical strategy**

Our empirical analysis is based on the following econometric specification:

$$HS_i^* = \beta_0 + HA_i\beta_1 + C_i\beta_2 + \varepsilon_i = X_i\beta + \varepsilon_i$$

where $HS^*$ is a latent variable for health status, $HA$ is happiness, and $C$ is a vector of the independent variables.

The empirical strategy of this paper goes beyond a simple correlational analysis between happiness and SRH, since their relationship is spurious for two reasons. First, this relationship is characterized by reverse causality, which occurs due to the simultaneous determination of these variables. Second, although we have controlled for many potential confounders, there might be unobserved heterogeneity due to omitted variables. We will thus use an instrumental variable (IV) approach to address these problems.

We start our analysis using a linear probability model for the first stage and a plain 2SLS, ignoring the categorical nature of the treatment and of the outcome variable. In general, 2SLS modeling is often used in these cases [25]. In particular, a *'garden variety 2SLS'* is preferable compared to other approaches, since OLS estimation in the first stage guarantees that first-stage residuals are uncorrelated with the fitted values and the other regressors[26]. This is not necessarily the case for the residuals derived from non-linear models, such as probit or logit. We then employ an IV probit, and – last- we run an IV ordered probit in order to exploit the additional information captured by the ordinal measure of SRH. Some additional robustness checks/models and details on the IV diagnostics are presented in the Supplementary File

**A note on the choice of instrumental variables**

IV should be correlated with the endogenous variable (i.e. happiness), and uncorrelated with the error term. In this context, we use two instruments for happiness: (a) mattering, and (b) social trust.

The first of our instruments reflects the quality of relationships, and particularly focuses on the concept of mattering. The literature suggests that there is a strong positive relationship between mattering and happiness or other measures of well-being[27,28]. In this context, our instrument satisfies the relevance condition. It also appears to satisfy the orthogonality condition, since mattering could relate to physical health, but only through the happiness-related link.

In addition, we use social trust as a second instrument following the approach by Sabatini (2014) [7]. In particular, several studies have documented a positive association between social trust and happiness [29,30], and the relevance condition is thus satisfied. What about the orthogonality condition? Although there are some studies that document a positive relationship between social trust and health[31], they do not include happiness as a potential confounder. Therefore, the reported association between trust and health may reflect the positive relationship between social trust and happiness, if an analysis has not controlled for the latter [7]. Indeed, Durlauf (2002) found that the reported effect of social trust on several socioeconomic outcomes (such as health) may be confounded by omitted variables [32]. Additionally, another strand of the literature finds little or no evidence of an association between social trust and health [33,34]. In this context, the empirical findings from correlational studies are quite conflicting. Further, it appears that there is still no evidence of a causal link or mechanism between social trust and health

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either from from empirical or from a theoretical perspective [7,35]. From an empirical perspective, we do not find a statistically significant relationship between social trust and SRH in our sample, as shown in Table A2 (Supplementary File). Furthermore, the relevant statistical and diagnostic tests suggest that the aforementioned instruments perform well (more details are presented in the Supplementary File). Based on the aforementioned theoretical and empirical arguments, it is fairly plausible and reasonable to claim that social trust is a suitable instrument in this case, given that it appears that there is no causal or direct link between social trust and SRH in the sample we examine.

# RESULTS

**OLS, probit and ordered probit estimates**

Based on the aforementioned methodology, Table 2 present the OLS, probit and ordered probit estimates, without considering the endogeneity issues. We indeed find a strong positive association between happiness and SRH at the 1% significance level. As expected, the data reveal a negative association between age and SRH. Last, we find some evidence of a significant relationship between some key lifestyle factors and health, while our findings also document the so-called socioeconomic gradient in health. In particular, we find evidence of a strong association between educational level and health, since higher education is positively associated with SRH. We also report similar results for the relationship between income and SRH.

**Table 2: OLS, Probit and Ordered Probit estimates**

|  | (1) | (2) | (3) |
|---|---|---|---|
|  | SRH | SRH | SRH |
|  | OLS | Probit | Ordered probit |
| **Happiness** | 0.114*** | 0.170*** | 0.164*** |

| | | | |
|---|---|---|---|
| | (0.0168) | (0.0293) | (0.0233) |
| **Age group (ref 18-24)** | | | |
| 25-39 | 0.213** | 0.538*** | 0.340** |
| | (0.0978) | (0.202) | (0.160) |
| 40-54 | 0.125 | 0.317 | 0.188 |
| | (0.106) | (0.214) | (0.169) |
| 55-64 | 0.0859 | 0.299 | 0.129 |
| | (0.126) | (0.241) | (0.191) |
| More than 65 | -0.00377 | 0.156 | 0.00536 |
| | (0.140) | (0.262) | (0.208) |
| **Male** | -0.120*** | -0.182** | -0.178*** |
| | (0.0429) | (0.0864) | (0.0634) |
| **Greek** | -0.0344 | -0.107 | -0.0478 |
| | (0.0776) | (0.151) | (0.114) |
| **Marital status (ref: married)** | | | |
| Unmarried | 0.261*** | 0.420*** | 0.404*** |
| | (0.0694) | (0.145) | (0.107) |
| Widowed | 0.170* | 0.164 | 0.247** |
| | (0.0879) | (0.165) | (0.120) |
| Separated/Divorced | -0.0320 | 0.0268 | 0.0169 |
| | (0.129) | (0.188) | (0.170) |
| **Education (ref: primary education)** | | | |
| Secondary education | 0.159** | 0.226* | 0.176* |
| | (0.0737) | (0.119) | (0.0933) |
| Tertiary education | 0.201** | 0.373*** | 0.239** |
| | (0.0785) | (0.131) | (0.102) |
| **Occupation (ref: employer)** | | | |
| Employee | 0.0387 | 0.211 | 0.0638 |
| | (0.0587) | (0.132) | (0.0932) |
| Unemployed | -0.0680 | -0.00841 | -0.114 |
| | (0.0753) | (0.151) | (0.112) |
| Pensioner | -0.0136 | 0.181 | -0.00969 |
| | (0.0903) | (0.158) | (0.125) |
| Home caring | -0.153* | -0.0350 | -0.185 |
| | (0.0889) | (0.164) | (0.125) |
| Student | 0.0981 | 0.314 | 0.161 |
| | (0.121) | (0.259) | (0.197) |
| **Income (ref: low income)** | | | |
| Middle income | 0.129*** | 0.229*** | 0.194*** |
| | (0.0460) | (0.0851) | (0.0647) |
| High income | 0.299*** | 0.384*** | 0.463*** |
| | (0.0631) | (0.129) | (0.0965) |
| **Smoking** | -0.0562 | -0.148* | -0.0875 |
| | (0.0417) | (0.0805) | (0.0603) |
| **Physical exercise (ref: 0)** | | | |
| 1-2 times | 0.0616 | -0.0116 | 0.0536 |
| | (0.0524) | (0.100) | (0.0745) |
| 3-4 times | 0.0954* | 0.209* | 0.120 |
| | (0.0574) | (0.107) | (0.0813) |
| 5-6 times | 0.101* | 0.152 | 0.123 |
| | (0.0544) | (0.101) | (0.0765) |
| **Drinking (ref: never/almost never)** | | | |
| 1-4 times | 0.0559 | 0.0644 | 0.0884 |
| | (0.0424) | (0.0850) | (0.0631) |
| 5-6 times | 0.0387 | 0.154 | 0.0699 |
| | (0.0860) | (0.139) | (0.117) |
| **Size of social network (ref: 1-2 individuals)** | | | |
| 0 | -0.0850 | 0.0621 | -0.0548 |
| | (0.119) | (0.174) | (0.148) |
| 3-5 | 0.0930** | 0.139 | 0.144** |
| | (0.0443) | (0.0870) | (0.0627) |

| | | | |
|---|---|---|---|
| More than 6 | 0.0811 | 0.0756 | 0.141* |
| | (0.0573) | (0.109) | (0.0819) |
| **Number of household members (ref: 1)** | | | |
| 2 | -0.0325 | -0.249* | -0.0327 |
| | (0.0730) | (0.145) | (0.106) |
| 3 | -0.0678 | -0.125 | -0.0837 |
| | (0.0777) | (0.162) | (0.115) |
| 4 | -0.0444 | -0.205 | -0.0320 |
| | (0.0817) | (0.174) | (0.123) |
| 5 or more | -0.138 | -0.479** | -0.187 |
| | (0.0917) | (0.186) | (0.136) |
| **Hobby and/or** | 0.155*** | 0.342*** | 0.228*** |
| | (0.0429) | (0.0894) | (0.0647) |
| **Community activities** | 0.0913 | 0.103 | 0.135 |
| | (0.0562) | (0.110) | (0.0834) |
| **Having children** | 0.0729 | 0.258** | 0.0966 |
| | (0.0576) | (0.114) | (0.0829) |
| **Chronic conditions** | -0.508*** | -0.785*** | -0.741*** |
| | (0.0456) | (0.0805) | (0.0651) |
| **ADL** | -0.511*** | -0.719*** | -0.643*** |
| | (0.0614) | (0.0987) | (0.0784) |
| **Region FE** | Yes | Yes | Yes |
| | | | |
| **Constant cut1** | | | -1.740*** |
| | | | (0.310) |
| **Constant cut2** | | | -1.017*** |
| | | | (0.303) |
| **Constant cut3** | | | 0.241 |
| | | | (0.302) |
| **Constant cut4** | | | 1.624*** |
| | | | (0.303) |
| **Constant** | 3.279*** | -0.368 | |
| | (0.202) | (0.392) | |
| | | | |
| Observations | 1,717 | 1,717 | 1,717 |
| R-squared | 0.358 | | |

*Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

**IV estimates**

As pointed above, the results of the previous analysis may be biased, since they suffer from endogeneity. Simply put, the empirical problem arises from the following: healthier people are happier, but –at the same time- happier people might be healthier. Using an IV approach, we address this problem and present the IV estimates in Table 3. Following the approach by Angrist and Pischke[26] and controlling for several potential confounders, we employ a 2SLS and find strong effects of happiness on SRH at the 1% significance level. It should be noted that after accounting for endogeneity, the magnitude of the coefficient is 0.295, and more than twice as high

relative to the plain OLS estimate. It is noteworthy that the magnitude of the 2SLS estimate of the coefficient of happiness is similar to the ones of the IV Probit and IV ordered probit estimates, which were found to be 0.348 and 0.222. In order to have a better understanding of the impact of happiness on the probability of reporting good/very good health, we also estimated the relevant marginal effects of happiness. In particular, we find that being happy increases the probability of having good/very good health by 10.4 percentage points. This figure is substantial, especially if one compares it with the relevant marginal effects of other variables. For instance, having a chronic condition decreases the probability of good/very good health by 20.2 percentage points, while being high-income increases the corresponding probability by 7.4 percentage points.

We estimated the models in Table 3, treating the happiness variable as continuous, and we thus employed some models without considering the categorical nature of the endogenous variable. Although this is a consistent and widely used approach in the econometrics literature, we also present a series of robustness checks, using a binary endogenous treatment (see Table A3 in Supplementary File). Similar to the models presented in Table 3, we find strong positive effects of happiness on SRH in all the cases we examined. Apart from the IV estimates, the last column in Table A3 presents a bivariate probit model, which is essentially a robustness check. The estimates of the bivariate probit model also confirm our base estimates, since we find strong positive effects of happiness on health at the 1% significance level. Furthermore, we also present some additional robustness checks in Tables A4 and A5 (Supplementary File), using only mattering as instrument for happiness. Our results remain strong and

robust across different scenarios, regardless the changes and checks we employed, and further support our main findings.

## Table 3: IV estimates

| | (1) SRH 2SLS[1] | (2) SRH IV Probit[1] | (3) SRH IV Ordered Probit[1,2] |
|---|---|---|---|
| **Happiness** | 0.295*** | 0.348** | 0.222** |
| | (0.0833) | (0.152) | (0.0968) |
| **Age group (ref 18-24)** | | | |
| 25-39 | 0.260** | 0.584*** | 0.349** |
| | (0.108) | (0.218) | (0.154) |
| 40-54 | 0.225* | 0.424* | 0.218 |
| | (0.122) | (0.237) | (0.170) |
| 55-64 | 0.186 | 0.396 | 0.163 |
| | (0.140) | (0.267) | (0.194) |
| More than 65 | 0.0157 | 0.185 | 0.0181 |
| | (0.144) | (0.273) | (0.201) |
| **Male** | -0.137*** | -0.198** | -0.184*** |
| | (0.0465) | (0.0886) | (0.0644) |
| **Greek** | -0.00269 | -0.0815 | -0.0395 |
| | (0.0846) | (0.165) | (0.117) |
| **Marital status (ref:** | | | |
| Unmarried | 0.333*** | 0.486*** | 0.425*** |
| | (0.0833) | (0.159) | (0.113) |
| Widowed | 0.241** | 0.211 | 0.270** |
| | (0.0957) | (0.172) | (0.129) |
| Separated/Divorced | 0.00247 | 0.0641 | 0.0344 |
| | (0.117) | (0.216) | (0.160) |
| **Education (ref: primary** | | | |
| Secondary education | 0.163** | 0.217* | 0.179* |
| | (0.0688) | (0.119) | (0.0924) |
| Tertiary education | 0.189** | 0.335** | 0.240** |
| | (0.0749) | (0.132) | (0.101) |
| **Occupation (ref: employer)** | | | |
| Employee | 0.0498 | 0.217 | 0.0614 |
| | (0.0670) | (0.134) | (0.0952) |
| Unemployed | -0.0348 | 0.0310 | -0.104 |
| | (0.0833) | (0.158) | (0.115) |
| Pensioner | 0.0539 | 0.262 | 0.00235 |
| | (0.0886) | (0.160) | (0.121) |
| Home caring | -0.0928 | 0.0321 | -0.173 |
| | (0.0913) | (0.171) | (0.126) |
| Student | 0.0493 | 0.251 | 0.143 |
| | (0.136) | (0.277) | (0.194) |
| **Income (ref: low income)** | | | |
| Middle income | 0.101** | 0.207** | 0.184*** |
| | (0.0492) | (0.0946) | (0.0671) |
| High income | 0.267*** | 0.348** | 0.451*** |
| | (0.0697) | (0.141) | (0.0989) |
| **Smoking** | -0.00783 | -0.0842 | -0.0735 |
| | (0.0469) | (0.0906) | (0.0641) |
| **Physical exercise (ref: 0)** | | | |
| 1-2 times | 0.0777 | 0.00977 | 0.0601 |
| | (0.0565) | (0.105) | (0.0780) |

| | | | |
|---|---|---|---|
| 3-4 times | 0.0995* | 0.208* | 0.123 |
| | (0.0579) | (0.109) | (0.0805) |
| 5-6 times | 0.0877 | 0.128 | 0.117 |
| | (0.0548) | (0.102) | (0.0756) |
| **Drinking (ref: never/almost** | | | |
| 1-4 times | 0.0405 | 0.0406 | 0.0865 |
| | (0.0457) | (0.0881) | (0.0640) |
| 5-6 times | 0.0118 | 0.116 | 0.0614 |
| | (0.0743) | (0.136) | (0.103) |
| **Size of social network (ref:** | | | |
| 0 | -0.00836 | 0.128 | -0.0154 |
| | (0.127) | (0.232) | (0.165) |
| 3-5 | 0.0146 | 0.0631 | 0.119 |
| | (0.0585) | (0.113) | (0.0774) |
| More than 6 | -0.0625 | -0.0700 | 0.0971 |
| | (0.0846) | (0.162) | (0.108) |
| **Number of household** | | | |
| 2 | -0.0256 | -0.238 | -0.0313 |
| | (0.0758) | (0.148) | (0.106) |
| 3 | -0.0687 | -0.141 | -0.0820 |
| | (0.0823) | (0.162) | (0.115) |
| 4 | -0.0327 | -0.183 | -0.0298 |
| | (0.0864) | (0.169) | (0.121) |
| 5 or more | -0.122 | -0.459** | -0.179 |
| | (0.0970) | (0.188) | (0.135) |
| **Hobby and/or volunteering** | 0.132*** | 0.309*** | 0.220*** |
| | (0.0473) | (0.0975) | (0.0665) |
| **Community activities** | 0.0923 | 0.0922 | 0.134 |
| | (0.0584) | (0.112) | (0.0820) |
| **Having children under 18** | 0.0581 | 0.237** | 0.0942 |
| | (0.0624) | (0.118) | (0.0864) |
| **Chronic condition** | -0.486*** | -0.757*** | -0.731*** |
| | (0.0463) | (0.0958) | (0.0660) |
| **ADL** | -0.424*** | -0.607*** | -0.616*** |
| | (0.0685) | (0.141) | (0.0915) |
| **Region FE** | Yes | Yes | Yes |
| **Constant** | 2.518*** | -1.120 | |
| | (0.395) | (0.746) | |
| | | | |
| Observations | 1,687 | 1,687 | 1,687 |
| R-squared | 0.310 | | |

*Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

[1] In these models, we employ a linear first stage, ignoring the categorical treatment variable. This is the main approach proposed by Angrist and Pischke (2009).

[2] For estimating model 3, we rely on conditional mixed-process models. The econometrics of this method can be found in Roodman (2011).

## Heterogeneous effects of happiness on health

Apart from the overall effect, our analysis further aims to uncover potential heterogeneity in the association between happiness and health across different population groups. First, we examine potential heterogeneity between low- and high-

educated individuals. Second, we repeat this exercise for the low- and high-SES individuals, relying on stratification by subjective social status. The results of this analysis are presented in Table 4. We find a strong positive association between happiness and SRH for low-educated, but not for high-educated individuals. Similarly, we report a strong association between happiness and health for the lower socioeconomic strata, whereas there is no statistically significant relationship for those in higher SES.

## Table 4: Heterogeneous effects of happiness on health

| | SRH | |
|---|---|---|
| | **Low-educated[1]** | **High-educated[1]** |
| **Happiness** | 0.445** | 0.185 |
| | (0.186) | (0.249) |
| **Number of observations** | N=1,002 | N=685 |
| | | |
| | **Low SES[2]** | **High SES[2]** |
| **Happiness** | 0.388*** | 0.216 |
| | (0.149) | (0.680) |
| **Number of observations** | N=1,381 | N=232 |
| | | |
| | **Low SES[3]** | **High SES[3]** |
| **Happiness** | 0.507*** | -0.235 |
| | (0.142) | (0.338) |
| **Number of observations** | N=1,072 | N=545 |
| | | |
| | **Low SES[4]** | **High SES[4]** |
| **Happiness** | 0.584*** | -0.022 |
| | (0.132) | (0.367) |
| **Number of observations** | N=801 | N=816 |

Note: In these models, we have controlled for the independent variables we mentioned in the Methods section.
[1] High educated are defined as those who have a university degree. Low educated are those without a university degree
[2] High-SES individuals are defined as who rated their social status between 8 and 10 in a 10-level subjective scale. Low-SES are defined as those who rated their social status between 1 and 7
[3] High-SES individuals are defined as who rated their social status between 7 and 10 in a 10-level subjective scale. Low-SES are defined as those who rated their social status between 1 and 6
[4] High-SES individuals are defined as who rated their social status between 6 and 10 in a 10-level subjective scale. Low-SES are defined as those who rated their social status between 1 and 5

# DISCUSSION

Using recently collected primary data, our analysis shows that happiness is strongly associated with health. In other words, happiness appears to be a crucial part of the 'production function' of health. Such a finding is generally consistent with the broader WHO definition of health, which incorporates a strong psychosocial element. To specifically address the endogeneity issue, we have employed an IV approach using novel instruments. In addition, following different approaches and a series of robustness checks, this relationship remains strong and statistically significant.

Our findings suggest that the effect of happiness on health is even stronger after addressing the endogeneity issue, and are generally in line with several studies. For instance, a strand of the literature has found evidence of a relationship between happiness and mortality or longevity[36], while other studies have reported that happiness and emotional well-being are associated with several conditions, such as the incidence of stroke[37], antibody response to vaccination[38], coronary heart disease[11], and SRH, long-term conditions or self-reported symptoms[7]. As pointed above, this strong association can be explained on the basis of several transmission channels. First, there are physiological mechanisms, which indicate that happiness is beneficial for several systems of the human body, such as cardiovascular, immune and endocrine system[8]. Second, happy individuals tend to adopt healthy behaviours, and avoid unhealthy lifestyle.

A rather interesting finding relates to the heterogeneous effects of happiness on health. After stratifying the sample by educational level or SES, we find that happiness significantly influences SRH in low-SES individuals, but this association

wanes for the higher socioeconomic strata. A recent review noted that research findings might be moderated by the population that is studied, and there may thus be differences in the relationship between happiness and health across different population groups [8]. For instance, a study found that anger is linked with subclinical atherosclerosis in low-SES individuals, but this is not the case for high-SES ones [13]. In the same vein, another study showed that the link between emotions and health is much stronger and critical in poorer areas [14]. However, the present one is the first study that examines the relationship between happiness and general health status depending on individuals' SES.

A potential explanation for this heterogeneity might relate to the link between happiness and healthy behaviours. In particular, this relationship can be attenuated in population groups that –in general- avoid unhealthy behaviours, such as the high-educated who have generally a more healthy lifestyle relative to low-educated [39]. Therefore the nexus between happiness and health might not be significant for high-SES individuals, since most of them tend to adopt a healthy lifestyle and the association between happiness and health behaviours is thus weak.

Another explanation could be based on the broad strokes of the 'capability approach', introduced by Amartya Sen [40] and his later work on health and perceptions [41], especially when these theoretical concepts are applied in a socioeconomic environment with extreme hardships, such as the current setting in Greece. In particular, personal valuations of well-being are heavily influenced by the socioeconomic context, within which individuals live. In this context, 'normal' is what individuals in a community (or, ad extenso, a social group) usually experience.

Thus, individuals probably value how well-off they are (in terms of material possessions or emotional status) in reference or in comparison to others (i.e. the current social norm). Low-SES individuals, especially in austerity-inflicted Greece, experience substantial deprivation but, also, intense negative feelings. Comparing their personal emotional state against the social norm of peers in same social class, individuals who (for any reason) experience happiness, are by contrast in a better state than others (who are, by the standard norm, unhappy). This could, in turn, be translated into better health, mainly through the psychosocial dimensions of health (e.g. healthy behaviours, strength of social ties). As individuals become more affluent, the magnitude of 'differential happiness' is, logically, smaller and, thus, other things than happiness (e.g. more 'objective' determinants, such as aspects related to medical care) contribute to good health. In this context, happiness matters more at lower socioeconomic levels, and its role –as a determinant of health- appears to diminish for higher socioeconomic groups.  In the end, could this mean that there are 'diminishing returns of happiness on health'? In any case, further research is needed in order to examine and corroborate similar findings.

Arguably, the finding that happiness impacts health has significant policy implications for health promotion, prevention, and public health. Simply put, our findings suggest that policies that can make people happier can also make them healthier. These findings thus provide a better and wider ideological framework for health promotion. In particular, they imply that the WHO programming goal 'Health for all' is closely related to the utilitarian imperative of 'greater happiness for greater number'.

In practical terms, policy makers have a wider array of choices in terms of designing long-term policies for improving health. One could thus argue that policies for improving health are not merely the ones focusing on health system. More than this, several public policies could affect health through their potential impact on happiness and quality of life. There are two main types of policy interventions, and focusing on them could potentially generate health gains through happiness improvements: (a) micro-level interventions in order to help people to be happier, (b) macro-level interventions to improve the livability of society and institutions [2]. The first set of policies can assist individuals to improve their quality of life and live happier and includes: (a) evidence-based advice and information for making fully informed decisions about life choices and lifestyle decisions, (b) training for art-of-living in order to develop essential skills for happy living (i.e. realism, social competence, resilience) [42], and (c) professional guidance and life-counseling for a happier life. These individual-level interventions are particularly important, especially for the lower socioeconomic groups, who have worse information and access to such services and practices. The latter set of interventions focuses on interventions on some macro-level characteristics that are particularly relevant for happiness, such as good material living standards, existence of democratic institutions, freedom, a well-functioning welfare-state and high-quality governance [43].

In this context, designing a "happiness policy" in Greece is particularly relevant, especially in the current socioeconomic environment that has largely affected life satisfaction and well-being. In particular, Greece has experienced the largest decline in happiness levels among OECD countries during the last years [44]. The aforementioned individual-level intervention could increase happiness of the Greek

population, and –based on our findings- could be also beneficial for health, especially for the lower socioeconomic groups. In addition, emphasis on the macro-social interventions is also instrumental and policy relevant, especially in a period of economic stability, generalized mistrust towards institutions, increased pessimism and reduced material wealth [45].

**Strengths and limitations**

This study has some limitations. First, a richer dataset could allow us to experiment with other potential instruments. In any case, our instruments perform well, and the diagnostic tests reveal that they satisfy the required conditions. Second, our findings should be interpreted with caution due to the cross-sectional design of the survey, and one should be thus careful with potential interpretation of associations as causal relationships.

Using recently collected primary data, this study contributes to the literature through several ways. First –contrary to the existing literature on this topic- we adequately address the endogeneity issue between happiness and health, using an IV approach and a novel set of instruments. To our knowledge, there is only one study using advanced IV modeling to uncover the nexus between happiness and health [7]. Second, this is the first study that finds robust heterogeneous effects of happiness on health, depending on individuals' SES. Last, we provide evidence using Greek data, during a period of an unprecedented economic downturn and severe socioeconomic changes in Greece. Given that the adverse socioeconomic changes have affected happiness, well-being, the core components of social capital, and its role as a

protective factor for health [46] our findings could be useful in terms of health policy, prevention and public health.

**Authors' contributions:** All authors meet the ICMJE authorship criteria. IK, KA and JK contributed to the conception and the design of the study. IK contributed to the analysis and the interpretation of the data. IK and KA drafted the manuscript. JK contributed to the critical revision of the manuscript for important intellectual content. All authors read and approved the final manuscript.

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**What is already known on this topic**

-Several physiological and psychosocial mechanisms could potentially explain that happiness is associated with better health status.

-This relationship suffers from reverse causality, since happiness and health are simultaneously determined (i.e. healthier tend to be happier, and happier might be healthier).

**What this study adds**

-Using an IV approach to address reverse causality, we find strong and robust evidence of a relationship between happiness and health.

-Happiness significantly influences health in low-SES individuals, but this association wanes for the higher socioeconomic strata.

-We provide some potential explanations for the heterogeneity in the association between happiness and health across socioeconomi groups.

-These findings have significant implications for prevention and public health, and suggest that policy makers have a wider array of choices for improving health and tackling health inequalities.

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