Can Obesity Prevalence Explain COVID-19 Indicators (Cases, Mortality and Recovery)? A Comparative Study in OECD Countries

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CAN OBESITY PREVALENCE EXPLAIN COVID-19 INDICATORS (CASES, MORTALITY AND RECOVERY)? A COMPARATIVE STUDY IN OECD COUNTRIES

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Abstract

Coronavirus disease 2019 (COVID-19) is a declared global pandemic with multiple risk factors. Obesity is considered by several researchers as one of the serious risk factors for coronavirus complications based on recent empirical studies. Yet, other scholars argue in favor of the existence of an obesity survival paradox, and criticize the former group of studies on the grounds that they lack controls for race, socioeconomic status, or quality of care. The objective of the current study is to analyze the potential relationships between different corona indicators and obesity on a state-wide level, based on an OECD report. In an attempt to test the counter-intuitive possibility of an obesity survival paradox, the proposed empirical model relaxes the assumption of monotonic change by applying the quadratic design and testing which one of the two competing models (i.e., quadratic or linear) better fits the data. Findings suggest more complex relationships between corona indices and obesity rates than previously thought. Consequently, ethical guidelines referring to priority in intubation and intensive care treatments should account for these complex relationships between obesity and corona. Indeed, there is a linear increase of mortality rate from corona with elevated prevalence of obesity. Yet, other indicators, such as the number of infected per 100,000 persons, rates of severe corona cases, rates of recovered corona patients and corona as the cause of death exhibit quadratic, rather than linear, patterns. The reasons for these non-linear patterns might be explained by several conditions such as increased metabolic reserves, more aggressive treatment, other non-corona complications for obese persons and unidentified factors that should be examined in future research.

Key Words: COVID-19; Body Mass Index; Obesity

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1. INTRODUCTION

Coronavirus disease 2019 (COVID-19) is a declared global pandemic with multiple risk factors (WHO report: coronavirus). Obesity is considered by several researchers as one of the serious risk factors causing coronavirus-related complications. Simonnet *et. al.* (2020) examined 124 COVID-19 hospitalized patients at a medical center in France and found that patients with a Body Mass Index $BMI > 35 \frac{kg}{meter^2}$ (severe obesity) were 7.36 times more likely to have been put on a mechanical ventilator compared to those with a $BMI < 25 \frac{kg}{meter^2}$ (normal weight). According to Garg et. al., (2020), from March 1 to March 30, nearly half (48.3%) of the patients in COVID-NET from selected US States had obesity ($BMI \geq 30$). Yet, other researchers argue in favor of the existence of an obesity survival paradox. Stefan *et al.* (2020) points out that: "Conversely, an obesity survival paradox has been observed in patients with pneumonia. That is, despite the increased risk of pneumonia and difficulties of intubation and mask ventilation, the risk of death in patients with obesity and pneumonia might be decreased". Harrison (2020) criticized these studies on the ground that: "none of these articles control for race, socioeconomic status, or quality of care—social determinants of health that we know explain the lion's share of health disparities between groups of people." (e.g., Park et. al., 2015).

There are several reasons that may support the former approach, according to which obesity is a risk factor associate with these complications. A summary of a report of more than 72 thousand cases from the Chinese Center for Disease Control and Prevention reported by Wu and McGoogan (2020) found that elderly persons (≥65 years) and the presence of comorbidities of cardiovascular disease and diabetes mellitus are associated with a more severe course and higher fatality rates of COVID-19 patients. As obesity is strongly associated with increased risk of cardiovascular disease and diabetes mellitus through direct effects (obesity induced structural and functional adaptions of

cardiovascular system to accommodate excess body weight, adipokine effects on inflammation and vascular homeostasis) and indirect effects (insulin resistance, hyperglycemia, hypertension and dyslipidemia), a high *BMI* might be an important risk factor for severe course of COVID-19 disease. According to Kakodkar, Kaka and Baig (2020): "COVID-19...clinical presentation can vary from asymptomatic to severe pneumonia" (page 5). As Jones and Nzekwu (2006) and Coply *et. al.* (2020) demonstrate, obesity may restrict the respiratory mechanism of expansion of the lungs, which, in turn, impairs the gas exchange. Indeed, Coply *et. al.* (2020) show that reducing obesity after bariatric surgery could improve lung functioning. There are also reasons to believe that obesity may influence the appropriate functioning of the immune system, and thus complicate the recovery from COVID-19 (e.g., Lee (2020)).

The objective of the current study is to analyze the potential relationships between different corona indicators and obesity on a state-wide level. The collected indicators are updated to April 28, 2020, and include: coronavirus as the cause of death (of the total number of deaths), number of corona infections, number of severe cases of illness from corona, the, number of deaths from corona, and the population of the country as of July 2019. The Organization for Economic Cooperation and Development (OECD) issued a report, which specifies for each country and year the prevalence of overweight and obesity in the population ($BMI \geq 25$) based on measured and self-reported height and weight. The report covers the years 1980-2020. Given the downward bias of self-reported indices, the current analysis uses only the former index.

In an attempt to test the counter-intuitive possibility of an obesity survival paradox, the empirical model in the study relaxes the assumption of monotonic change by applying the quadratic design and testing which one of the two competing models (i.e., quadratic or linear) better fits the data. Results of our study confirm the rise in the prevalence of obesity among 23

OECD countries. While in 1980, only 38 percent of the population suffers from overweight and obesity, this percent crosses the 50 percent benchmark (the majority of the population) in 2008, and reaches 55 percent in 2020.

Further results indicate more complex relationships between corona indices and obesity than previously considered. Consequently, ethical guidelines referring to priority in intubation and intensive care treatments should account for these complex relationships. Indeed, there is a linear increase of mortality rate from corona with the prevalence of obesity. Nevertheless, other indicators, such as the number of infected per 100,000 persons, rates of severe corona cases, rates of recovered corona patients, and corona as the cause of death exhibit quadratic, rather than linear patterns. The reasons for these non-linear patterns might be explained by several conditions such as, increased metabolic reserves, more aggressive treatment for obese persons, other non-corona complications, and unidentified factors that should be examined in future research.

The remainder of the article is organized as follows. Section 2 provides the descriptive statistics. Section 3 portrays the methodology and gives the results. Finally, section 4 concludes and summarizes.

2. DESCRIPTIVE STATISTICS

Overweight and obesity are known risk factors for long series of health problems, and the fourth leading risk factor for global mortality (Arbel, Fialkoff and Kerner, 2019). Figure 1 displays the percent of overweight in OECD countries, where $BMI = \frac{kg}{meter^2}$, overweight is defined (by WHO: Obesity and overweight, available at: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight) as: $25 \leq BMI < 30$ and obesity is defined as $BMI \geq 30$, $BMI = \frac{kg}{meter^2}$. According to the graph, the frequency of overweight stretches from a minimum of 25 percent in Indonesia to a maximum of 74.2 percent in Chile. However, based on measured,

rather than self- reported, *BMI*, Japan and South Korea seem to exhibit the lowest frequency of overweight and obesity (25.65 percent and 34.1 percent, respectively), and Mexico, USA and Chile exhibit the highest frequencies (71 percent, 72.5 percent, and 74.2 percent, respectively).

Figure 2 exhibits changes in overweight and obesity prevalence among 23 OECD countries between 1980-2020, based on measured *BMI*. Results show that the *YEAR* variable explains 60.9% of the dependent variable's variance. The baseline projected frequency in 1980 is 37.97 percent. This projected frequency steadily rises by 0.434 annually, crosses the 50 percent benchmark in 2008, and reaches the peak of 55.33 percent in 2020.

Table 1 reports the descriptive statistics of variables on a state-wide level. Reported variables include: number of identified corona cases until April 28, 2020 (CORONA_CASES); number of severe cases of corona (SEVERE_CASES); number of recovery cases of corona (RECOVERY_CASES); number of deaths from corona (DEATH_CASES); corona as the cause of death out of the total number of deaths in the country (CAUSE_OF_DEATH_CORONA); and frequency of overweight in the population in 1980-2020 based on measured BMI (OVERWEIGHT) and population of the country as of July 2019 (POPULATION);.

To permit appropriate cross-country comparisons, all the variables were transformed to percent according to population size. Table 1- 3 define the variables by percent and give their means, standard deviations and 95% confidence intervals.

The average number of infected people per 100,000 persons is approximately 127 and the standard deviation is 205 (INFECTED). The relative frequency of severe cases divided by total corona cases is 1.25 percent and the standard deviation is 0.77 percent (SEVERE). The relative frequency of recovered divided by total corona cases is 46.57 percent and the standard deviation is 30.02 percent (RECOVERED). The relative frequency of corona as the cause of death divided

by the total number of dead persons in the country is 8.73 percent and the standard deviation is 10.47 percent (CORONA). The relative frequency of mortality from corona divided by the total number of corona cases in the country is 5.15 percent and the standard deviation is 4.38 percent (MORTALITY). The 95% and 99% confidence intervals of all the corona indicators demonstrate that the sample means of all the variables across these 23 countries are different from zero. Finally, the relative frequency of overweight across these 23 countries and based on 1980-2020 measured *BMI* is 48.49 percent. The standard deviation is 16.87 percent (OVERWEIGHT). Based on the confidence intervals, one cannot reject the null hypothesis that the relative frequency equals the 50 percent benchmark, namely, a majority of the population suffers from obesity.

3. METHODOLOGY AND RESULTS

(3a) Methodology

Consider the following two competing empirical models:

$$Y_j = \alpha_{1j} OVERWEIGHT^2 + \alpha_{2j} OVERWEIGHT + \alpha_{3j} + u_{1j} \quad (1)$$

$$Y_j = \beta_{1j} OVERWEIGHT + \beta_{2j} + u_{2j} \quad (2)$$

where j=1,2,3,4,5; $Y_1 = INFECTED = 100{,}000 \cdot \frac{CORONA\_CASES}{POPULATION}$; $Y_2 = SEVERE = 100 \cdot \frac{SEVERE\_CASES}{CORONA\_CASES}$; $Y_3 = RECOVERED = \frac{RECOVERY\_CASES}{CORONA\_CASES}$; Y_4=*CORONA* (as the cause of death from the total number of dead persons); $Y_5 = MORTALITY = 100 \cdot \frac{DEATH\_CASES}{CORONA\_CASES}$; $\alpha_{1j}, \alpha_{2j}, \alpha_{3j}$ and β_{1j}, β_{2j} are parameters; and u_{1j}, u_{2j} are the stochastic random disturbance terms. Unlike equation (2), equation (1) permits non-monotonic change of the corona indicator with the OVERWEIGHT variable.

To test which of these two models better fits the data for each indicator, the Ramsey RESET test is employed (e.g., Ramanathan, 2002: 270-271). The test is based on estimating the models:

$Y_j = a_j + b_j X + c_j \hat{Y}_j^2 + \mu_j$ where $\hat{Y}_j = \hat{d}_j + \hat{e}_j X$; j=1,2,3,4,5; X=OVERWEIGHT; H_0: $c_j = 0$, and H_1: $c_j \neq 0$. Rejection of the null hypothesis suggests that compared to the linear model, the quadratic model fits the data better.

(3b) Results

Figures 3-7 plot the results based on the regression analysis given at the bottom of each figure. The vertical axis in these graphs includes the following corona indicators: projected rate of: 1) infections by corona per 100,000 persons; 2) severe corona case; 3) recovered corona patients; 4) mortality from corona (rather than other reasons); and 5) mortality from corona of the total corona cases. The horizontal axis describes the prevalence of overweight and obesity within the range of 25 percent to 70 percent.

Figure 3 reports the relationships between corona cases per 100,000 persons and the prevalence of overweight and obesity. The Ramsey RESET test supports the quadratic in favor of the linear model (calculated $F(1,177)=90.23$; $p=0.0027$). Projected corona cases begin with approximately 29 per 100,000 persons in a country, such as Japan, which exhibits the lowest obesity prevalence of 25 percent. Projected corona cases steadily rise with prevalence of obesity until peaking at approximately 195 per 100,000 persons in countries such as Israel and the Czech Republic, which exhibit overweight and obesity prevalence of 52.05 percent. At this range of 25-52.05 prevalence of overweight and obesity, upward changes seem to exacerbate the situation and increase the number of corona infected per 100,000 persons. Yet, referring to an upward change above obesity prevalence of 52.05 percent, this corona indicator has a beneficial effect, dropping to approximately 122 per 100,000 persons for 70 percent obesity prevalence, in countries such as the United States, Mexico and Chile.

Figure 4 reports the relationships between the rate of severe corona cases of the total number of corona cases and the prevalence of overweight and obesity. The Ramsey RESET test supports the quadratic model in favor of the linear model (calculated $F(1,177)=76.75$; $p<0.0001$). Projected rate of severe corona cases begins with 1.78 percent in a country, such as Japan. Projected rate of severe corona cases steadily *drops* with prevalence of obesity until it reaches its nadir with 0.67 percent of severe cases in countries such as Israel and the Czech Republic, which exhibit overweight and obesity prevalence of 48.32 percent. At this range of 25-48.32 prevalence of overweight and obesity, upward changes seem to have a beneficial effect. Yet, referring to an upward change above obesity prevalence of 48.32 percent, this corona indicator has a worsening effect. It rises to approximately 1.63 percent of severe corona cases, in countries such as the United States, Mexico and Chile.

Figure 5 reports the relationships between the rate of recovered corona patients and the prevalence of overweight and obesity. Again, the Ramsey RESET test supports the quadratic model in favor of the linear model (calculated $F(1,148)=34.32$; $p<0.0001$). Our findings suggest a beneficial effect in the 25-49.33 percent prevalence of obesity range with an elevated prevalence of obesity, and a worsening effect within the 49.33-70 percent range. Projected rate of recovered corona patients starts with approximately 30.05 percent in a country, such as Japan. The projected rate of recovered corona patients steadily rises with prevalence of obesity, peaking at approximately 65.57 percent in countries such as Israel and the Czech Republic, which exhibit overweight and obesity prevalence of 49.33 percent. Referring to an upward change above obesity prevalence of 49.33 percent , this corona indicator drops to approximately 39.93 recovery rate for 70 percent obesity prevalence, in countries such as the United States, Mexico and Chile.

Figure 6 reports the relationships between corona as the cause of death of the total number of dead persons and the prevalence of overweight and obesity. As noted previously, the Ramsey RESET test supports the quadratic model in favor of the linear model (calculated $F(1,162)=38.13$; $p<0.0001$). Projected corona cases begin with approximately 1.66 percent in Japan, the OECD country with the lowest obesity prevalence. Projected rate of corona as the cause of death steadily rises with prevalence of obesity until it reaches its peak of approximately 15.08 percent in countries such as Israel and the Czech Republic, which exhibit overweight and obesity prevalence of 50.09 percent. At this range of 25-50.09 prevalence of overweight and obesity, upward changes seem to inflate corona as the cause of death. Yet, referring to an upward change above obesity prevalence of 50.09 percent, the frequency of corona as the reason of death *drops* to approximately 6.63 percent for 70 percent obesity prevalence, in the United States, Mexico and Chile.

Finally, Figure 7 reports the relationships between mortality rate from corona and the prevalence of overweight and obesity. Consistent with the previous analyses, the Ramsey RESET test supports the linear model in favor of the quadratic model (calculated $F(1,177)=1.49$; $p=0.2238$). For the lowest obesity prevalence of 25 percent, projected mortality rate is 3.06. This projected corona indicator steadily rises with prevalence of obesity until it reaches a peak of projected mortality rate of 7.07 percent for 70 percent obesity prevalence, in countries such as the United States, Mexico and Chile.

4. SUMMARY AND CONCLUSION

The objective of the current study is to analyze the potential relationships between different corona indicators and obesity on a state-wide level, using the OECD countries as the basis for the comparison. The dependent variables in our model are the following: 1) infections by corona per 100,000 persons; 2) rate of severe corona case; 3) rate of recovered corona patients; 4) rate of mortality from corona (rather than other reasons); and 5) mortality from corona of the total corona cases. The independent variable includes overweight and obesity prevalence on a scale of between 25 percent (Japan) and approximately 70 percent (USA, Mexico and Chile). Given the counter-intuitive possibility of an obesity survival paradox (Stefan et. al., 2020), the current study relaxes the assumption of monotonic change by applying the quadratic design and testing which of the two competing models (i.e., quadratic or linear) better fit the data.

Findings suggest that relationships between corona indices and obesity rates is more complex than previously thought. Consequently, ethical guidelines referring to priority in intubation and intensive care treatments should account for these complex relationships between obesity and corona. Indeed, there is a linear increase of mortality rate from corona with prevalence of obesity. Nevertheless, other indicators, such as the number of infected per 100,000 persons, rates of severe corona cases, rates of recovered corona patients, and corona as the cause of death exhibit quadratic, rather than linear patterns. The reasons for these non-linear patterns might be explained by several conditions such as, increased metabolic reserves, more aggressive treatment for obese persons, other non-corona complications, and unidentified factors that should be examined in future research.

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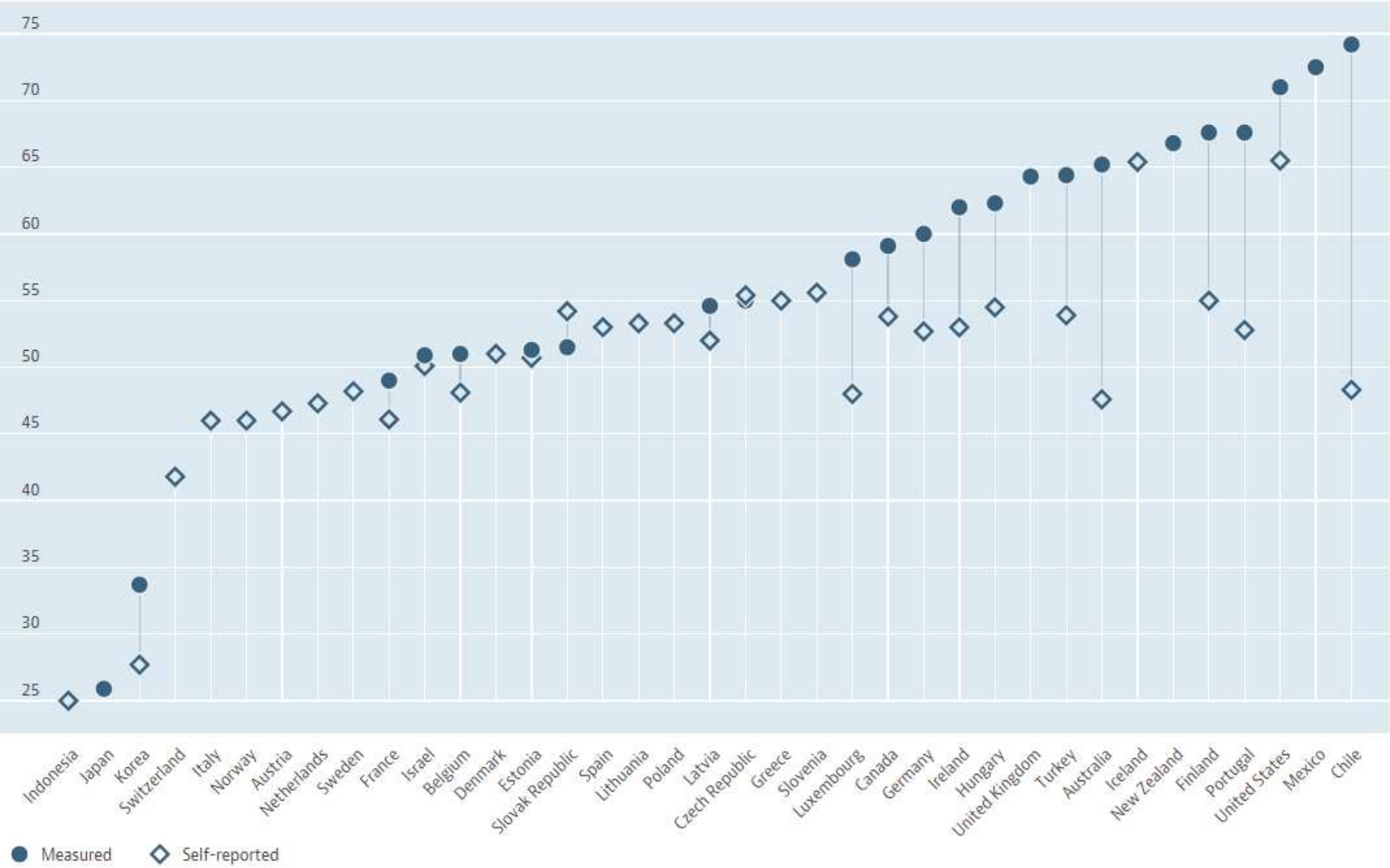
Declarations:

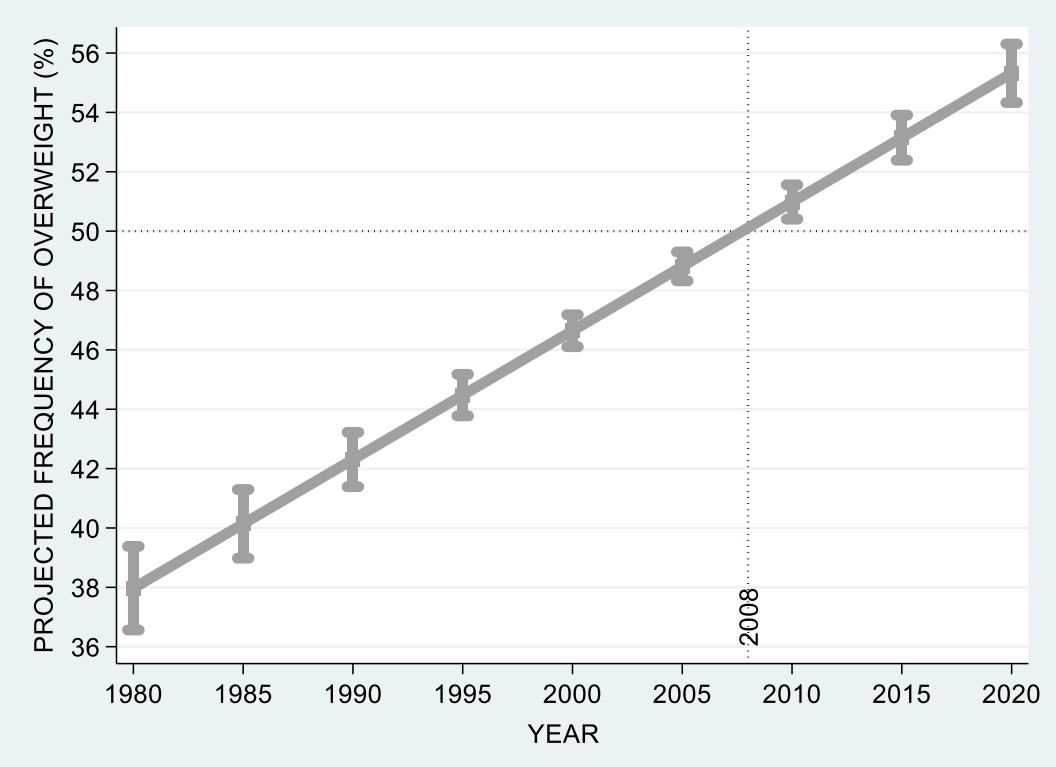
The authors declare that they have no relevant or material financial interests that relate to the research described in this paper.

Figure 1: Overweight or Obese Population (Measured/Self Reported, % of Population Aged 15+, 2018 or Latest Available)



Source : OECD Report available at: https://data.oecd.org/pinboard-editor/ (Last accessed on April 28, 2020). Overweight is defined as: $25 \leq BMI < 30$ and obesity is defined as $BMI \geq 30$, where $BMI = \frac{kg}{meter^2}$.

Figure 2: Changes in Overweight and Obesity Prevalence in 23 OECD Countries, 1980-2020



Notes: The vertical axis measures the projected relative frequency of overweight and obesity ($BMI \geq 25$ where $BMI = \frac{kg}{meter^2}$) in the population of 23 OECD countries based on measured height and weight. The horizontal axis measures the year in which the measurement took place. The figure is based on the following fixed-effect regression outcomes given in column (2):

VARIABLES	(1) OVERWEIGHT	(2) OVERWEIGHT
$(YEAR-1980)^2$	-0.00392*	–
	(0.0960)	–
(YEAR−1980)	0.589***	0.434***
	(9.00e-09)	(<0.0001)
Constant	36.91***	37.97***
	(<0.0001)	(<0.0001)
Observations	180	180
Countries	23	23
R-squared	0.616	0.609

P-values are given in parentheses. *p<0.1; **p<0.05; ***p<0.01

Table 1: Descriptive Statistics

Countries	CORONA CASES	POPULATION	SEVERE CASES	RECOVERY CASES	CAUSE OF DEATH: CORONA (%)	DEATHS CASES	OVERWEIGHT (%)
AUS	6,731	25,203,198	42	5,626	0.50	84	54.05
BEL	47,334	11,539,328	876	10,943	43	7,331	51.00
CAN	48,500	37,411,047	557	18,268	3.50	2,707	59.51
CHL	13,813	18,952,038	426	7,327	0.90	198	67.00
CZE	7,449	10,689,209	73	2,842	1.50	223	52.00
DEU	158,758	83,517,045	2,409	117,400	4.00	6,126	59.85
EST	1,660	1,325,648	9	240	2.20	50	51.30
FIN	4,740	5,532,156	56	2,500	1.30	193	61.56
FRA	165,842	65,129,728	4,608	45,513	30.00	23,293	49.00
GBR	157,149	675,301,372	1,559	–	23.00	21,092	57.73
HUN	2,649	9,684,679	49	516	1.00	291	56.53
IRL	19,648	4,882,495	146	9,233	15.00	1,102	61.33
ISR	15,589	8,519,377	117	7,375	3.10	208	56.55
JPN	13,614	126,860,301	300	1,899	0.10	385	22.76
KOR	10,752	51,225,308	55	8,854	0.90	244	30.89
LUX	3,729	615,729	20	3,123	23.00	88	54.10
LVA	836	1,906,743	4	267	2.20	13	54.60
MEX	15,529	127,575,529	378	9,086	0.50	1,434	67.94
NZL	1,472	4,783,063	1	1,214	–	19	62.20
PRT	24,322	1,906,743	172	1,389	5.80	948	67.60
SVK	1,384	5,457,013	6	423	–	20	51.07
TUR	112,261	83,429,615	1,736	33,791	3.70	2,900	59.90
USA	1,010,507	329,064,917	14,186	139,162	10.00	56,803	64.82

Notes: The table reports the sample mean for 23 OECD countries. Information on frequency of overweight in different countries is available at: https://data.oecd.org/pinboard-editor/ (Lastly Accessed on April 28, 2020). Information regarding the corona is updated to April 28, 2020. The population data is updated to July 2019.

Table 2: Definition of Indicators for COVID-19 and Obesity

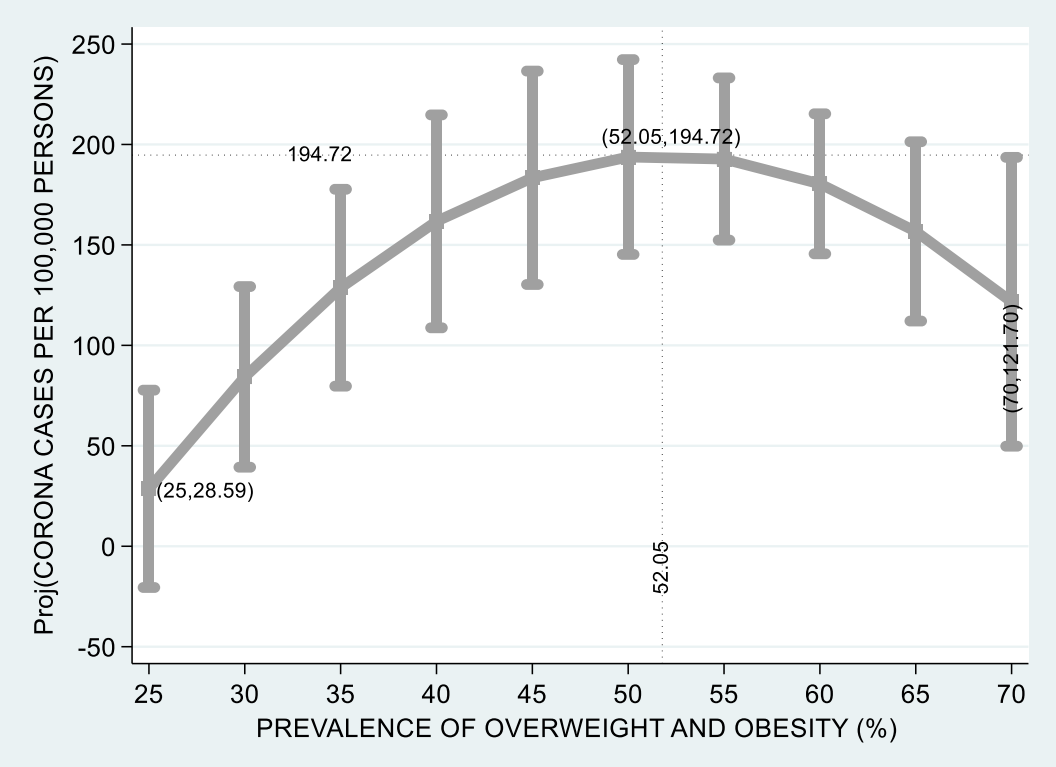
Variable	Formula	Definiton
INFECTED	$100{,}000 \cdot \left[\frac{CORONA\_CASES}{POPULATION}\right]$	Number of corona cases per 100,00 persons.
SEVERE	$100 \cdot \left[\frac{SEVERE\_CASES}{CORONA\_CASES}\right]$	Relative frequency of severe corona cases (%).
RECOVERED	$100 \cdot \left[\frac{RECOVERY\_CASES}{CORONA\_CASES}\right]$	Relative frequency of recovery (%).
CORONA	Already defined in %	Corona as the cause of death from the total number of dead persons (%).
MORTALITY	$100 \cdot \left[\frac{DEATH\_CASES}{CORONA\_CASES}\right]$	Relative frequency of death from corona (%).
OVERWEIGHT	Already defined in %	Relative frequency (%) of overweight in the country (BMI≥25).
YEAR	Irrelevant	The year in which the measuremnt took place.

Table 3: Descriptive Statistics

Variable	Mean	(SD)
INFECTED	127.60*** [97.30, 157.81] {87.73, 167.46}	(205.42)
SEVERE	1.25*** [1.14, 1.37] {1.10, 1.40}	(0.77)
RECOVERED	46.57*** [41.75, 51.40] {40.20, 52.95}	(30.02)
CORONA	8.73*** [7.12, 10.34] {6.60, 10.85}	(10.47)
MORTALITY	5.15*** [4.51, 5.80] {4.30, 6.00}	(4.38)
OVERWEIGHT	48.49*** [46.01, 50.97] {45.22, 51.76}	(16.87)
YEAR	2004.26 [2002.75, 2005.76] {6.60, 10.85}	(10.21)

Notes: The YEAR variable spans from 1978 to 2018. The OVERWEIGHT variable is based on measured height and weight. For the variables: INFECTED, SEVERE, and CORONA, N=180 and refers to 23 OECD countries. For the variable RECOVERED, N=151 and refers to 22 OECD countries. For the variable MORTALITY, N=165 and refers to 21 OECD countries.Standard deviations are given in parentheses. [95%] {99%} confidence intervals are given in [square] {curly} brackets. ***p<0.01 for rejection of the null hypothesis of equality to zero.

Figure 3: Corona Cases Per 100,000 Persons vs. Prevalence of Overweight and Obesity

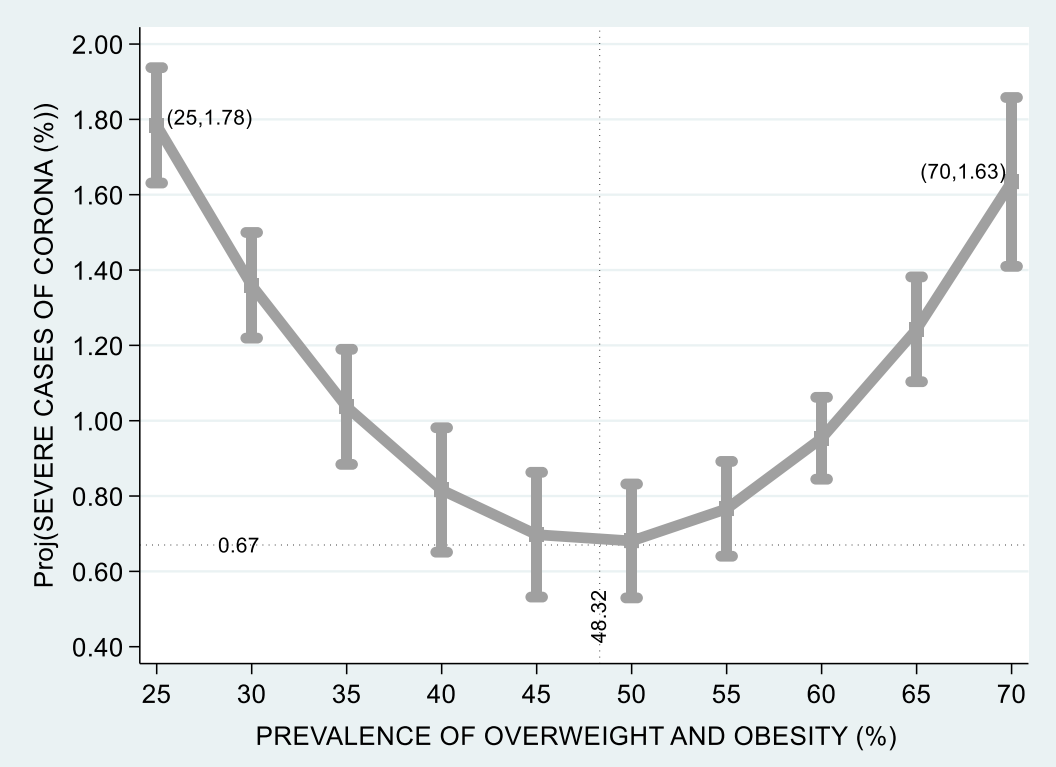


Notes: The vertical axis measures the projected probability of corona cases per 100,000 persons based on the formula: $100{,}000 \cdot (CORONA\_CASES \div POPULATION)$ applied separately to 23 OECD countries. The horizontal axis measures the frequency of overweight and obesity ($BMI \geq 25$ where $BMI = \frac{kg}{meter^2}$) in the population of OECD countries based on measured height and weight. The figure is based on the following regression outcomes given in column (1):

VARIABLES	(1) INFECTED	(2) INFECTED
OVERWEIGHT^2	-0.227***	–
	(0.00274)	–
OVERWEIGHT	23.62***	3.692***
	(0.000457)	$(3.51 \cdot 10^{-5})$
Constant	-420.2***	-51.41
	(0.00134)	(0.251)
Observations	180	180
OECD Countries	23	23
R-squared	0.137	0.092

P-values are given in parentheses. *p<0.1; **p<0.05; ***p<0.01. The Ramsey RESET test is based on estimating the model: $Y_1 = a_1 + b_1 X + c_1 \hat{Y}_1^2 + \mu_1$ where $\hat{Y}_1 = \hat{d}_1 + \hat{e}_1 X$; Y_1=RECOVERED, X=OVERWEIGHT, H_0: $c_1 = 0$, and H_1: $c_1 \neq 0$. The test supports the hypothesis that the quadratic model better fit the data (calculated $F(1,177)=9.23$; $p=0.0027$).

Figure 4: Rate of Severe Corona Cases vs. Prevalence of Overweight and Obesity

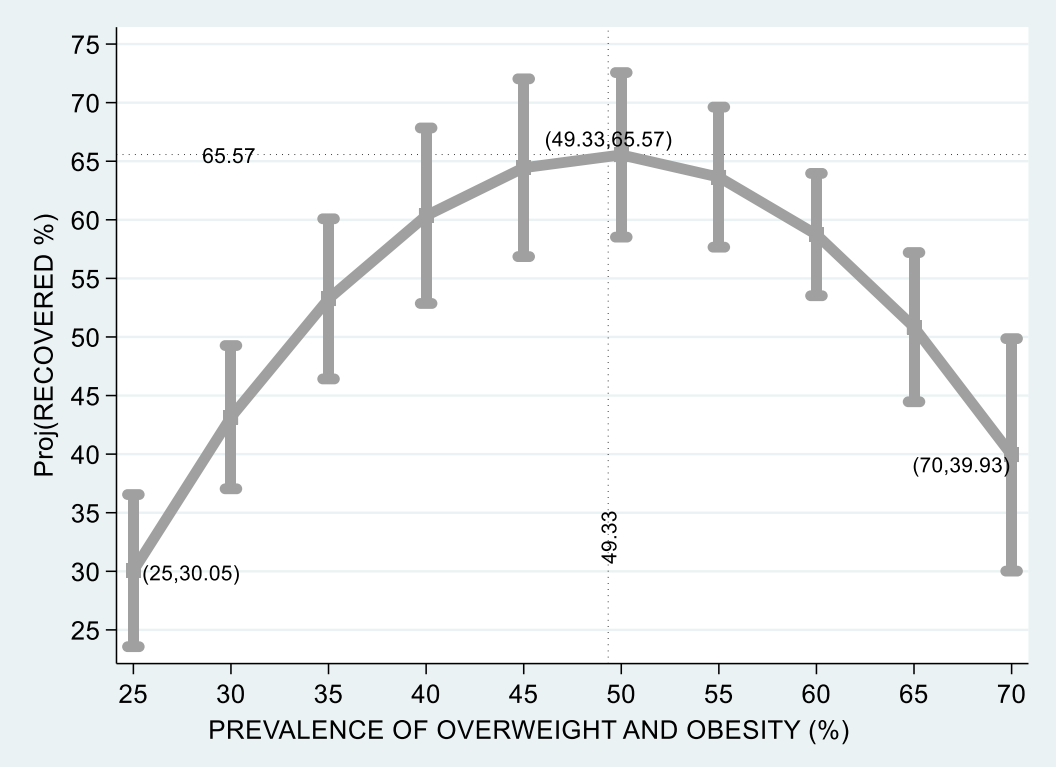


Notes: The vertical axis measures the projected probability of severe cases of corona divided by total cases of corona in percentage points. The horizontal axis measures the prevalence of overweight and obesity ($BMI \geq 25$ where $BMI = \frac{kg}{meter^2}$) in the population of OECD countries based on measured (rather than self-reported) height and weight. The Figure is based on the following regression outcomes given in column (1):

VARIABLES	(1) SEVERE	(2) SEVERE
OVERWEIGHT^2	0.00204***	–
	(<0.0001)	–
OVERWEIGHT	-0.197***	-0.0179***
	(<0.0001)	$(5.86 \cdot 10^{-8})$
Constant	5.437***	2.122***
	(<0.0001)	(<0.0001)
Observations	180	180
OECD Countries	23	23
R-squared	0.409	0.153

P-values are given in parentheses. *p<0.1; **p<0.05; ***p<0.01. The Ramsey RESET test is based on estimating the model: $Y_2 = a_2 + b_2X + c_2\hat{Y}_2^2 + \mu_2$ where $\hat{Y}_2 = \hat{d}_2 + \hat{e}_2X$; Y_2=SEVERE, X=OVERWEIGHT, H_0: $c_2 = 0$, and H_1: $c_2 \neq 0$. The test supports the hypothesis that the quadratic model better fit the data (calculated $F(1,177)=76.75$; $p<0.0001$)

Figure 5: Rate of Recovered Corona Patients vs. Prevalence of Overweight and Obesity

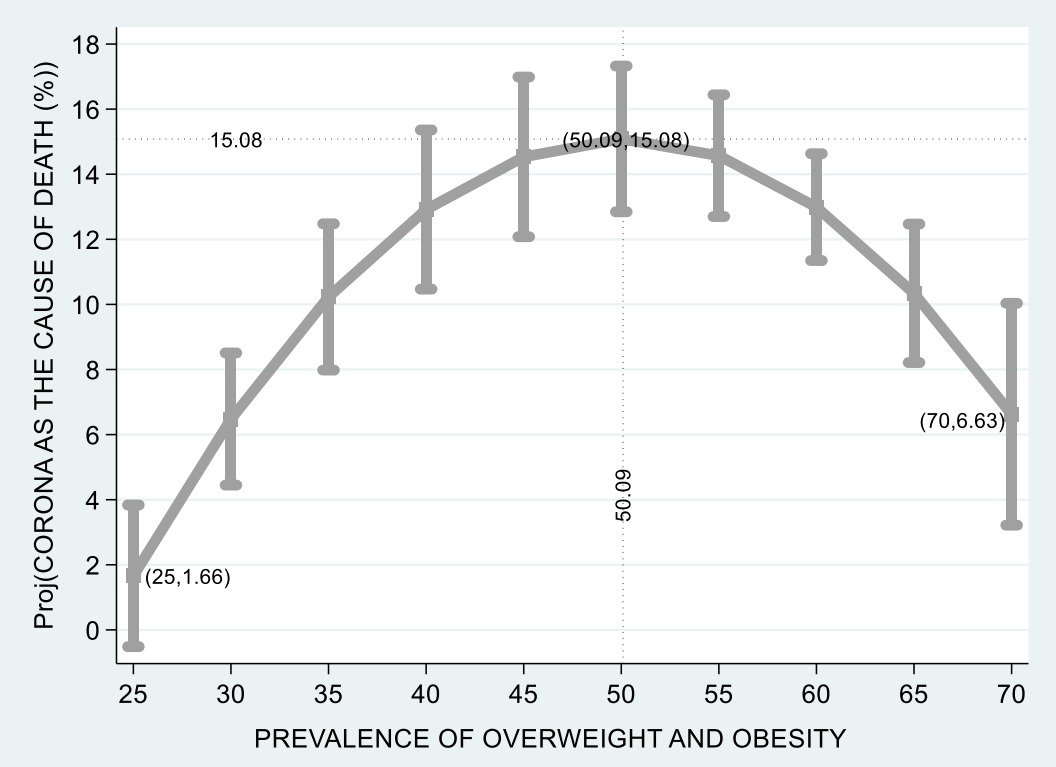


Notes: The vertical axis measures the projected probability of recovery divided by total cases of corona in percentage points. The horizontal axis measures the prevalence of overweight and obesity ($BMI \geq 25$ where $BMI = \frac{kg}{meter^2}$) in the population of OECD countries based on measured height and weight. The figure is based on the following regression outcomes given in column (1):

VARIABLES	(1) RECOVERED	(2) RECOVERED
OVERWEIGHT^2	-0.0600***	–
	$(2.91 \cdot 10^{-8})$	–
OVERWEIGHT	5.919***	0.644***
	$(1.05 \cdot 10^{-9})$	$(1.62 \cdot 10^{-6})$
Constant	-80.42***	16.49**
	$(9.55 \cdot 10^{-6})$	(0.0114)
Observations	151	151
OECD Countries	22	22
R-squared	0.305	0.143

P-values are given in parentheses. *p<0.1; **p<0.05; ***p<0.01. The Ramsey RESET test is based on estimating the model: $Y_3 = a_3 + b_3X + c_3\hat{Y}_3^2 + \mu_3$ where $\hat{Y}_3 = \hat{d}_3 + \hat{e}_3X$; Y_3=RECOVERED, X=OVERWEIGHT, H_0: $c_3 = 0$, and H_1: $c_3 \neq 0$. The test supports the hypothesis that the quadratic model better fit the data (calculated $F(1,148)=34.32$; $p<0.0001$)

Figure 6: Corona as the Cause of Death vs. Prevalence of Overweight and Obesity

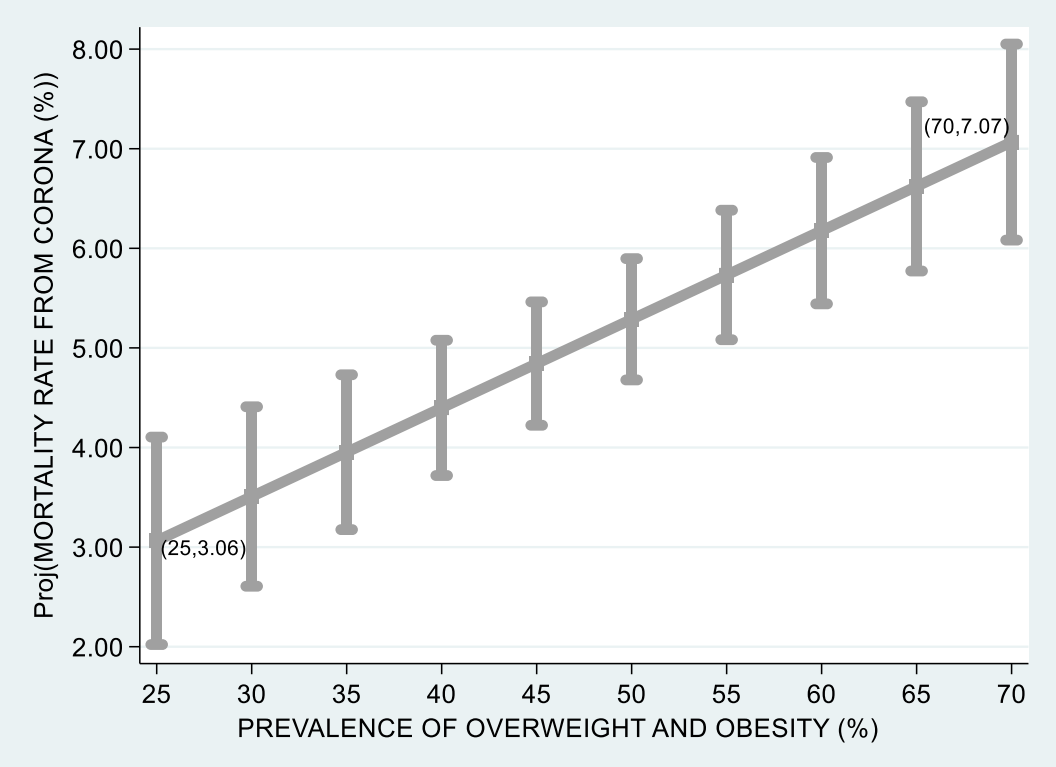


Notes: The vertical axis measures the projected probability of corona virus as the cause of death rather than other reasons. The horizontal axis measures the prevalence of overweight and obesity ($BMI \geq 25$ where $BMI = \frac{kg}{meter^2}$) in the population of OECD countries based on measured height and weight. The figure is based on the following regression outcomes given in column (1):

VARIABLES	(1) CORONA	(2) CORONA
OVERWEIGHT^2	-0.0213***	–
	$(5.14 \cdot 10^{-9})$	–
OVERWEIGHT	2.137***	0.272***
	$(5.79 \cdot 10^{-11})$	$(2.05 \cdot 10^{-9})$
Constant	-38.43***	-4.199*
	$(7.72 \cdot 10^{-10})$	(0.0539)
Observations	165	165
OECD Countries	21	21
R-squared	0.351	0.198

P-values are given in parentheses. *p<0.1; **p<0.05; ***p<0.01. The Ramsey RESET test is based on estimating the model: $Y_4 = a_4 + b_4X + c_4\hat{Y}_4^2 + \mu_4$ where $\hat{Y}_4 = \hat{d}_4 + \hat{e}_4X$; Y_4=CORONA, X=OVERWEIGHT, H_0: $c_4 = 0$, and H_1: $c_4 \neq 0$. The test supports the hypothesis that quadratic model better fit the data (calculated $F(1,162)=38.13$; $p<0.0001$).

Figure 7: Mortality Rate from Corona vs. Prevalence of Overweight and Obesity

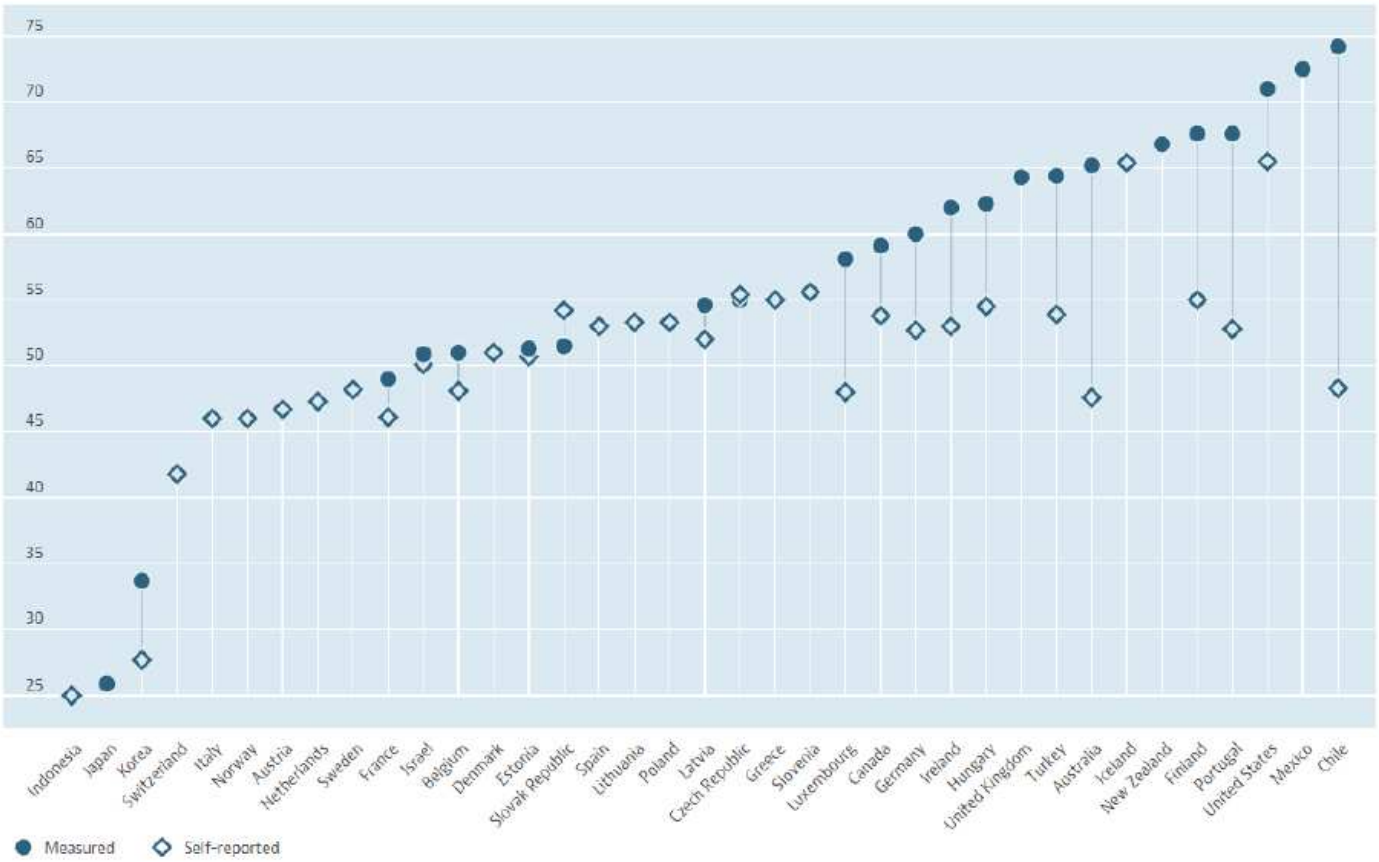


Notes: The vertical axis measures the projected probability of mortality from corona, based on the formula for each OECD country: $100 \cdot (NUMBER\ OF\ DEATHS\ FROM\ CORONA \div TOTAL\ NUMBER\ OF\ CORONA\ PATIENTS)$. The horizontal axis measures the prevalence of overweight and obesity ($BMI \geq 25$ where $BMI = \frac{kg}{meter^2}$) in the population of 23 OECD countries based on measured height and weight. The figure is based on the following regression outcomes given in column (2):

VARIABLES	(1) MORTALITY	(2) MORTALITY
OVERWEIGHT^2	-0.00196	–
	(0.224)	–
OVERWEIGHT	0.261*	0.0890***
	(0.0678)	(2.45e-06)
Constant	-2.340	0.839
	(0.399)	(0.372)
Observations	180	180
OECD Countries	23	23
R-squared	0.125	0.118

P-values are given in parentheses. *p<0.1; **p<0.05; ***p<0.01. The Ramsey RESET test is based on estimating the model: $Y_5 = a_5 + b_5X + c_5\hat{Y}_5^2 + \mu_5$ where $\hat{Y}_5 = \hat{a}_5 + \hat{b}_5X$; Y_5=MORTALITY, X=OVERWEIGHT, H_0: $c_2 = 0$, and H_1: $c_2 \neq 0$. The test supports the hypothesis that linear model better fit the data (calculated $F(1,177)=1.49$; $p=0.2238$).

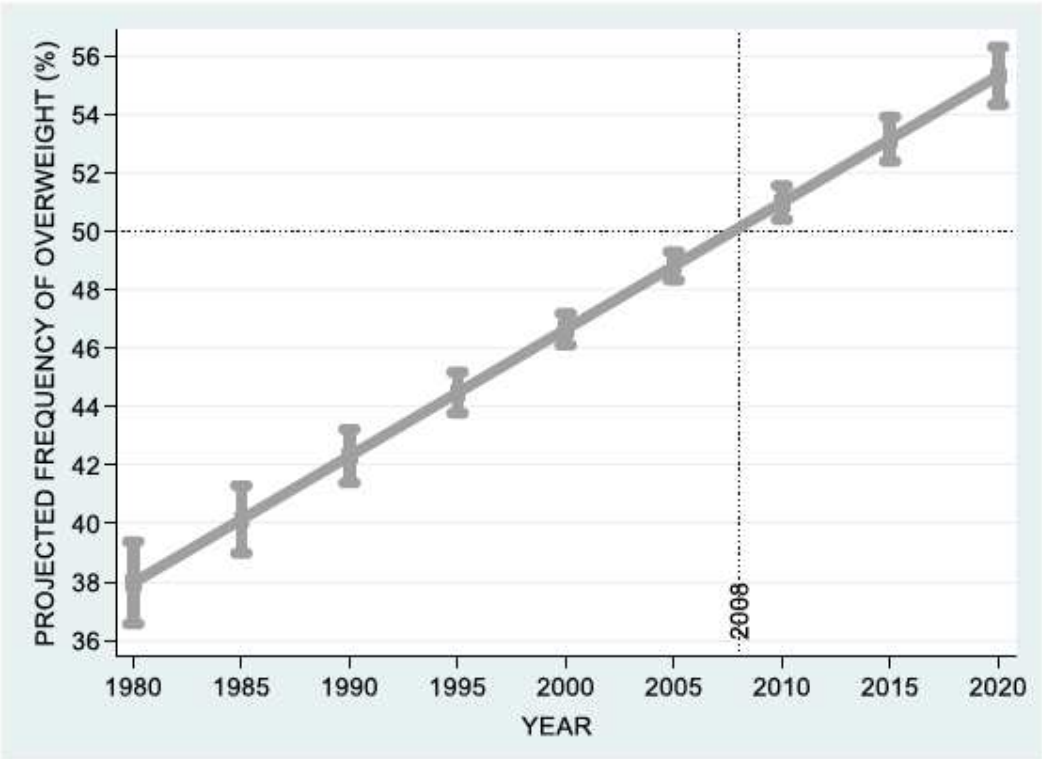
Figures



Source : OECD Report available at: https://data.oecd.org/pinboard-editor/ (Last accessed on April 28, 2020). Overweight is defined as: $25 \leq BMI < 30$ and obesity is defined as $BMI \geq 30$, where $BMI = \frac{kg}{meter^2}$.

Figure 1

Overweight or Obese Population (Measured/Self Reported, % of Population Aged 15+, 2018 or Latest Available)



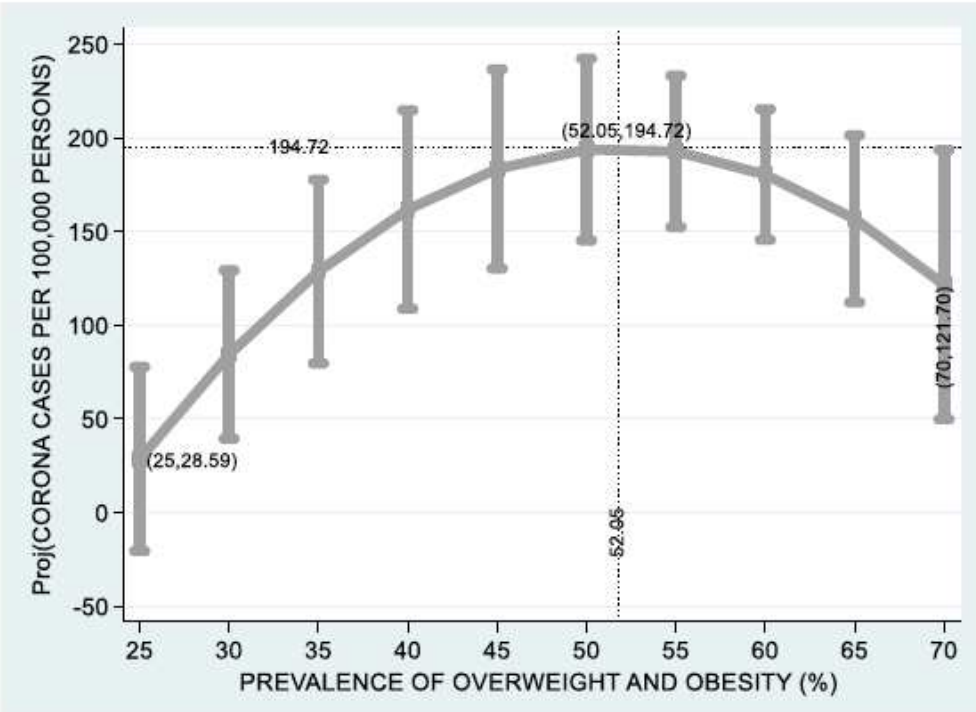
Notes: The vertical axis measures the projected relative frequency of overweight and obesity ($BMI \geq 25$ where $BMI = \frac{kg}{meter^2}$) in the population of 23 OECD countries based on measured height and weight. The horizontal axis measures the year in which the measurement took place. The figure is based on the following fixed-effect regression outcomes given in column (2):

VARIABLES	(1) OVERWEIGHT	(2) OVERWEIGHT
$(YEAR-1980)^2$	-0.00392*	–
	(0.0960)	–
(YEAR–1980)	0.589***	0.434***
	(9.00e-09)	(<0.0001)
Constant	36.91***	37.97***
	(<0.0001)	(<0.0001)
Observations	180	180
Countries	23	23
R-squared	0.616	0.609

P-values are given in parentheses. *p<0.1; **p<0.05; ***p<0.01

Figure 2

Changes in Overweight and Obesity Prevalence in 23 OECD Countries, 1980-2020



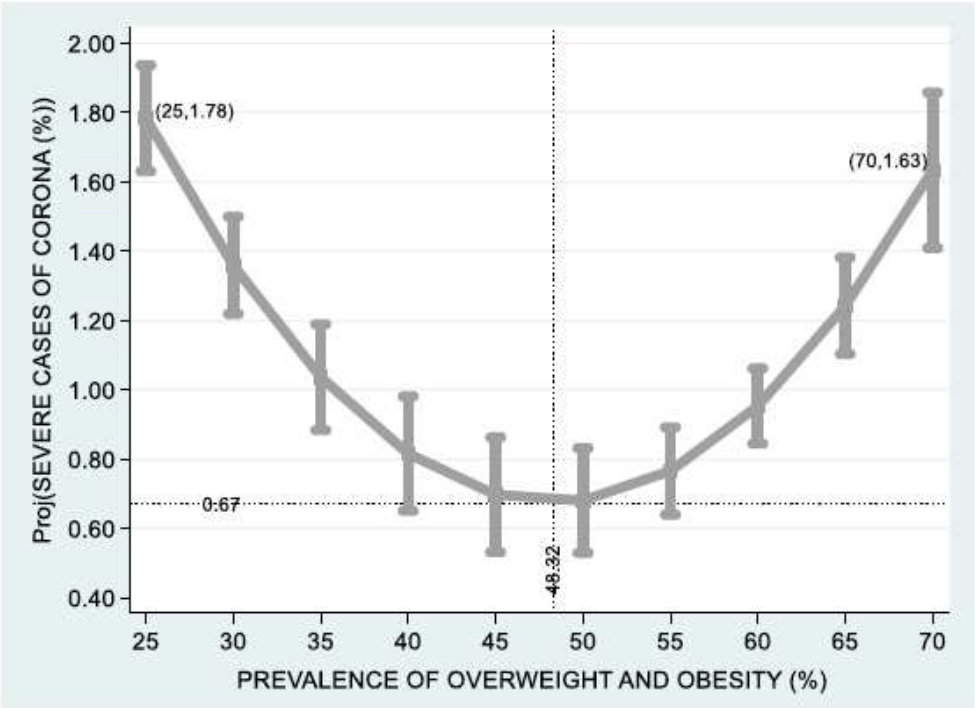
Notes: The vertical axis measures the projected probability of corona cases per 100,000 persons based on the formula: $100{,}000 \cdot (CORONA\_CASES \div POPULATION)$ applied separately to 23 OECD countries. The horizontal axis measures the frequency of overweight and obesity ($BMI \geq 25$ where $BMI = \frac{kg}{meter^2}$) in the population of OECD countries based on measured height and weight. The figure is based on the following regression outcomes given in column (1):

VARIABLES	(1) INFECTED	(2) INFECTED
OVERWEIGHT^2	-0.227***	–
	(0.00274)	–
OVERWEIGHT	23.62***	3.692***
	(0.000457)	$(3.51 \cdot 10^{-5})$
Constant	-420.2***	-51.41
	(0.00134)	(0.251)
Observations	180	180
OECD Countries	23	23
R-squared	0.137	0.092

P-values are given in parentheses. *p<0.1; **p<0.05; ***p<0.01. The Ramsey RESET test is based on estimating the model: $Y_1 = a_1 + b_1 X + c_1 \hat{Y}_1^2 + \mu_1$ where $\hat{Y}_1 = \hat{d}_1 + \hat{e}_1 X$; Y_1=RECOVERED, X=OVERWEIGHT, H_0: $c_1 = 0$, and H_1: $c_1 \neq 0$. The test supports the hypothesis that the quadratic model better fit the data (calculated $F(1,177)=9.23$; $p=0.0027$).

Figure 3

Corona Cases Per 100,000 Persons vs. Prevalence of Overweight and Obesity



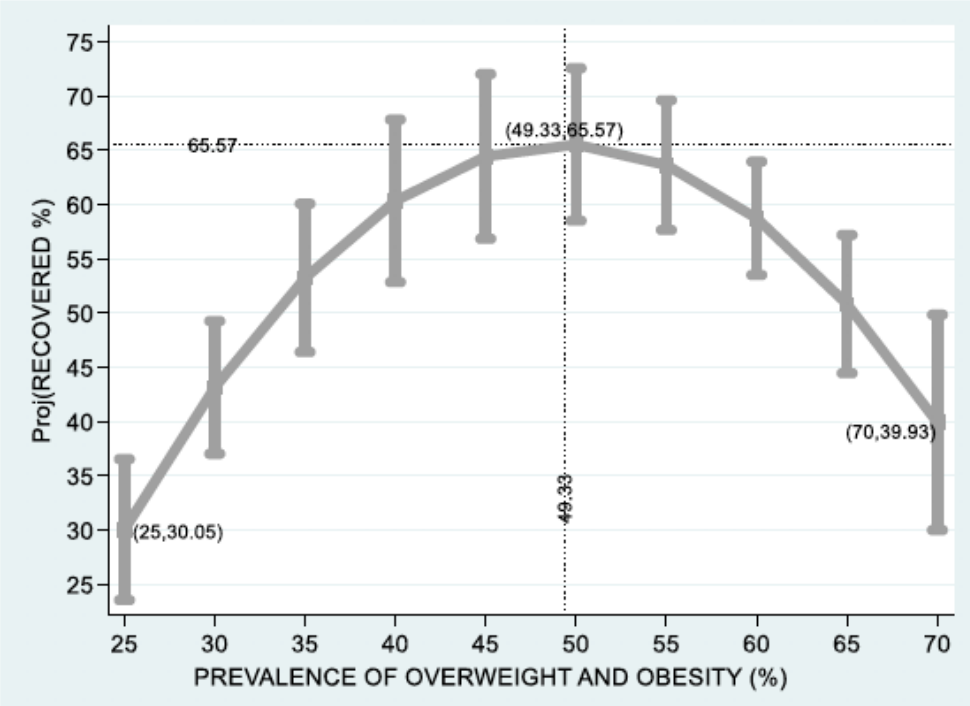
Notes: The vertical axis measures the projected probability of severe cases of corona divided by total cases of corona in percentage points. The horizontal axis measures the prevalence of overweight and obesity ($BMI \geq 25$ where $BMI = \frac{kg}{meter^2}$) in the population of OECD countries based on measured (rather than self-reported) height and weight. The Figure is based on the following regression outcomes given in column (1):

VARIABLES	(1) SEVERE	(2) SEVERE
OVERWEIGHT^2	0.00204***	–
	(<0.0001)	–
OVERWEIGHT	-0.197***	-0.0179***
	(<0.0001)	$(5.86 \cdot 10^{-8})$
Constant	5.437***	2.122***
	(<0.0001)	(<0.0001)
Observations	180	180
OECD Countries	23	23
R-squared	0.409	0.153

P-values are given in parentheses. *p<0.1; **p<0.05; ***p<0.01. The Ramsey RESET test is based on estimating the model: $Y_2 = a_2 + b_2X + c_2\hat{Y}_2^2 + \mu_2$ where $\hat{Y}_2 = \hat{d}_2 + \hat{e}_2X$; Y_2=SEVERE, X=OVERWEIGHT, H_0: $c_2 = 0$, and H_1: $c_2 \neq 0$. The test supports the hypothesis that the quadratic model better fit the data (calculated $F(1,177)=76.75$; $p<0.0001$)

Figure 4

Rate of Severe Corona Cases vs. Prevalence of Overweight and Obesity



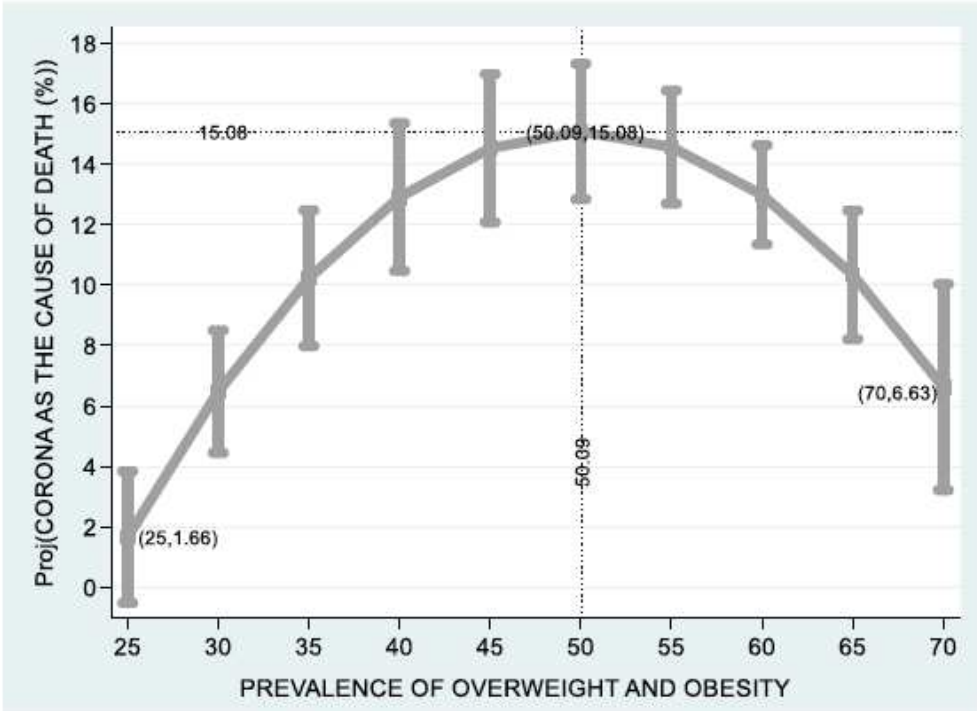
Notes: The vertical axis measures the projected probability of recovery divided by total cases of corona in percentage points. The horizontal axis measures the prevalence of overweight and obesity ($BMI \geq 25$ where $BMI = \frac{kg}{meter^2}$) in the population of OECD countries based on measured height and weight. The figure is based on the following regression outcomes given in column (1):

VARIABLES	(1) RECOVERED	(2) RECOVERED
OVERWEIGHT^2	-0.0600***	–
	$(2.91 \cdot 10^{-8})$	–
OVERWEIGHT	5.919***	0.644***
	$(1.05 \cdot 10^{-9})$	$(1.62 \cdot 10^{-6})$
Constant	-80.42***	16.49**
	$(9.55 \cdot 10^{-6})$	(0.0114)
Observations	151	151
OECD Countries	22	22
R-squared	0.305	0.143

P-values are given in parentheses. *p<0.1; **p<0.05; ***p<0.01. The Ramsey RESET test is based on estimating the model: $Y_3 = a_3 + b_3X + c_3\hat{Y}_3^2 + \mu_3$ where $\hat{Y}_3 = \hat{d}_3 + \hat{e}_3X$; Y_3=RECOVERED, X=OVERWEIGHT, H_0: $c_3 = 0$, and H_1: $c_3 \neq 0$. The test supports the hypothesis that the quadratic model better fit the data (calculated $F(1,148)=34.32$; $p<0.0001$)

Figure 5

Rate of Recovered Corona Patients vs. Prevalence of Overweight and Obesity



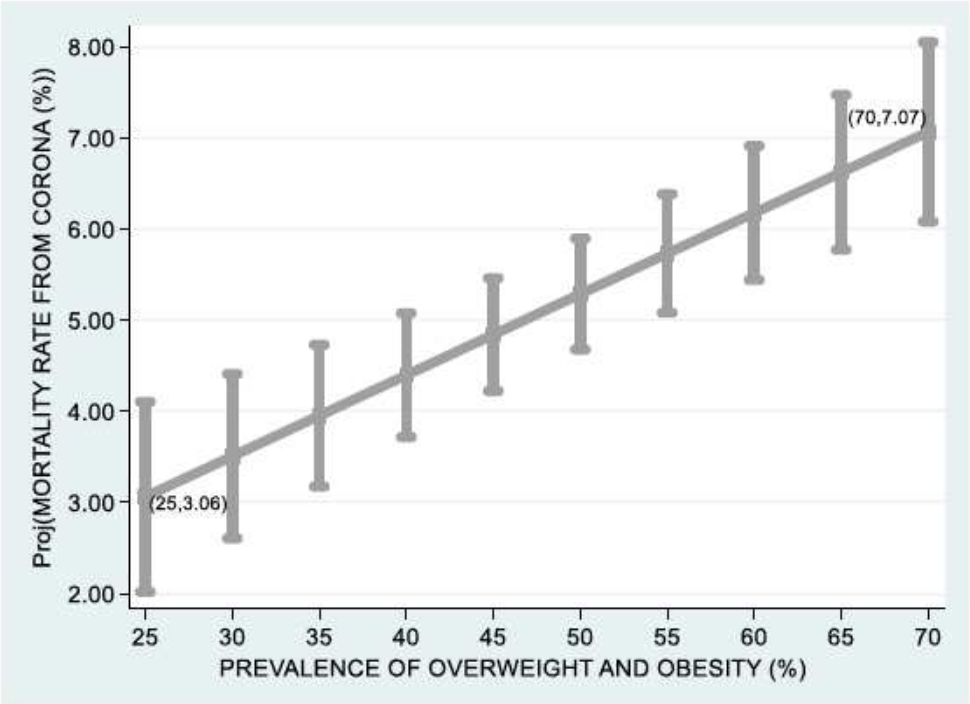
Notes: The vertical axis measures the projected probability of corona virus as the cause of death rather than other reasons. The horizontal axis measures the prevalence of overweight and obesity ($BMI \geq 25$ where $BMI = \frac{kg}{meter^2}$) in the population of OECD countries based on measured height and weight. The figure is based on the following regression outcomes given in column (1):

VARIABLES	(1) CORONA	(2) CORONA
OVERWEIGHT^2	-0.0213***	–
	$(5.14 \cdot 10^{-9})$	–
OVERWEIGHT	2.137***	0.272***
	$(5.79 \cdot 10^{-11})$	$(2.05 \cdot 10^{-9})$
Constant	-38.43***	-4.199*
	$(7.72 \cdot 10^{-10})$	(0.0539)
Observations	165	165
OECD Countries	21	21
R-squared	0.351	0.198

P-values are given in parentheses. *p<0.1; **p<0.05; ***p<0.01. The Ramsey RESET test is based on estimating the model: $Y_4 = a_4 + b_4X + c_4\hat{Y}_4^2 + \mu_4$ where $\hat{Y}_4 = \hat{d}_4 + \hat{e}_4X$; Y_4=CORONA, X=OVERWEIGHT, H_0: $c_4 = 0$, and H_1: $c_4 \neq 0$. The test supports the hypothesis that quadratic model better fit the data (calculated $F(1,162)$=38.13; p<0.0001).

Figure 6

Corona as the Cause of Death vs. Prevalence of Overweight and Obesity



Notes: The vertical axis measures the projected probability of mortality from corona, based on the formula for each OECD country: $100 \cdot (NUMBER\ OF\ DEATHS\ FROM\ CORONA \div TOTAL\ NUMBER\ OF\ CORONA\ PATIENTS)$. The horizontal axis measures the prevalence of overweight and obesity ($BMI \geq 25$ where $BMI = \frac{kg}{meter^2}$) in the population of 23 OECD countries based on measured height and weight. The figure is based on the following regression outcomes given in column (2):

VARIABLES	(1) MORTALITY	(2) MORTALITY
OVERWEIGHT^2	-0.00196	–
	(0.224)	–
OVERWEIGHT	0.261*	0.0890***
	(0.0678)	(2.45e-06)
Constant	-2.340	0.839
	(0.399)	(0.372)
Observations	180	180
OECD Countries	23	23
R-squared	0.125	0.118

P-values are given in parentheses. *p<0.1; **p<0.05; ***p<0.01. The Ramsey RESET test is based on estimating the model: $Y_5 = a_5 + b_5X + c_5\hat{Y}_5^2 + \mu_5$ where $\hat{Y}_5 = \hat{a}_5 + \hat{b}_5X$; Y_5=MORTALITY, X=OVERWEIGHT, H_0: $c_2 = 0$, and H_1: $c_2 \neq 0$. The test supports the hypothesis that linear model better fit the data (calculated $F(1,177)$=1.49; p=0.2238).

Figure 7

Mortality Rate from Corona vs. Prevalence of Overweight and Obesity

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- OECDData.xlsx