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Obesity: Good and Bad News

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Abstract

Objective: To determine if obesity is a risk factor for COVID-19 death.

Methods: The COVID-19 data were taken from the John Hopkins records updated to February 17, 2021. The obesity prevalence in the 187 countries was that of 2016 (the only data available). LEEDELS (life expectancy, ecological, demographic and lifestyle) data for 2016 were also analyzed for all the countries. The countries were analyzed in two sets: the 49 countries whose death registries the WHO consider reliable (49 SCs) and the remaining 138 countries. The correlations between COVID-19 and obesity were calculated using Spearman's ρ. The same was done for the correlations between LEEDELS data and obesity.

Results: No correlation was found between obesity and COVID-19 deaths in the 49 SCs (good news) and in the other 138 countries the correlation was positive (bad news). Obesity seems to be independent of the LEEDELS data in the 49 SCs, apart from GDP1 (Gross Domestic Product type 1). A strong correlation was found in the remaining 138 countries with all the variables that reflect prosperity such as GDP, cars, mobile phones and internet connection.

Conclusions: Obesity cannot be considered a risk factor for COVID-19 deaths. Since obesity is linked to different LEEDELS data in the 49 SCs and the rest of the world, it is possible that every country shows a different pattern.

Keywords: Obesity; COVID-19 Deaths; Ecology; Lifestyle; Demography

Introduction

The link between obesity and COVID-19 has been the object of several investigations since it was shown to be the cause of poor immune response and outcomes during respiratory diseases [1].

Excess fatty mass in obesity is related to metabolic dysregulation and is considered a unifying risk factor for severe COVID-19 infections [2].

One of the first observations of the impact of obesity on the number of COVID-19 deaths was reported in a small study conducted in Seattle where a larger proportion of overweight diabetic patients died in comparison to those with normal weight [3,4].

In one Chinese region (Shenzhen), it was shown that obese patients were more likely to progress towards severe COVID-19 [5]. Similarly, in Italy, it was found that overweight and obese patients had a greater need for noninvasive ventilation during COVID-19 pneumonia [6].

Subjects with BMI > 35 kg/m^2 were highly prevalent among those requiring invasive mechanical ventilation in a study on 124 patients in France [7], and obesity was shown to be a risk factor for the worsening of COVID-19 and ICU admission [8].

After old age, BMI > 40 was the strongest predictor among 5279 patients suffering from COVID-19 in New York City [9], and the same was shown when considering the data from 10929 deaths in the UK [9], where the risk ratio

paralleled the increase in obesity class from I to III [10].

It has recently been stated that patients with obesity, diabetes type II, and cardiovascular diseases risk a poor outcome from COVID-19 infection [11].

From all these data, it seems that obesity is a risk factor for COVID-19 severity and deaths. However, the data reported refer to a few developed countries, and the correlation between obesity and COVID-19 might be different in countries characterized by different LEEDELS (life expectancy, ecological, demographic, and lifestyle) data. The aim of this research is to determine if obesity prevalence is correlated with the number of COVID-19 deaths in the world and which LEEDELS data determine this correlation.

Methods

The obesity prevalence data for 2016 were taken from the CIA Factbook [12] since this was the only source where data were available for every country. A total of 187 countries were considered. This figure was determined by the availability of obesity and LEEDELS variables (life expectancy, ecological, demographic and lifestyle) data for 2016, taken from the Atlante Geografico De Agostini [13].

The COVID-19 death figures were taken from the John Hopkins records updated to February 14, 2021 [14]. The data for all countries were considered. However, the evaluation of the relationship between obesity prevalence and obesity was mainly based on the data from the 49 countries considered by the WHO as having reliable death registries (49 selected countries or SC) [15]. These two sets of countries were also separated when considering the LEEDELS variables.

The LEEDELS data consist of:

- Life expectancy (years)
- Population density (inhabitants/Km^2)
- Urban population (% of inhabitants in cities)
- Unemployment (% of people not working compared with the total active population)
- GDP (Gross Domestic Product in USD)
- GDP1 (% of GDP from agriculture, animal husbandry, fishing and exploitation of forests)
- GDP3 (% of GDP from commerce, transport, communication, credit, insurance, and tourism)
- Education (% of GDP for education)
- Hospital beds (number of beds/1000 inhabitants)
- PM 2.5-10 (mg/m^3)
- Cars (number of cars/1000 inhabitants)
- Mobile phones (number of mobile phones/1000 inhabitants)
- Internet (number of connections/1000 inhabitants)

Statistical Evaluation

The mean values and standard deviations were calculated for all the LEEDELS data. The statistically significant differences between the 49 SCs and the other countries were calculated using the Mann–Whitney U test. Spearman's ρ was used for correlation. All the analysis was done using JMP14 Pro software produced by the SAS institute.

Results

On February 17 2021 the total deaths for COVID-19 in the world were about 2,24 million and for the 68.7 % they were recorded in the 49 SC. The average values of the LEEDELS data in the two sets of countries are shown in table 1.

Country	COVID-19 2021 Feb 17	Obesity 2016	Country	COVID-19 2021 Feb 17	Obesity 2016	Country	COVID-19 2021 Feb 17	Obesity 2016
Afganistan	0.093	5.5	Gibuti	0.072	10.9	Oman	0.402	27.0
Albania	0.567	21.7	Greece	0.561	13.5	Pakistan	0.068	8.6
Algeria	0.075	27.4	Grenada	0.009	24.9	Palau	0.000	55.3
Andorra	1.391	25.6	Guatemala	0.390	21.3	Panama	1.469	22.7
Angola	0.020	8.2	Guinea	0.080	21.2	Papua New Guinea	0.001	21.3
Antigua	0.111	18.9	Guinea Bissau	0,030	7.7	Paraguay	0.438	20.3
Argentina	1.182	28.3	Guinea Equatorial	0.115	9.5	Peru	1.430	19.7
Armenia	1.046	20.2	Guyana	0.235	8.0	Philippines	0.114	6.4
Australia	0.039	29.0	Haiti	0.024	20.2	Poland	1.073	23.1
Austria	0.974	20.1	Honduras	0.448	22.7	Portugal	1.508	20.8
Azerbaigian	0.336	19.9	Hungary	1.410	21.4	Qatar	0.116	35.1

Bahamas	0.486	31.6	Iceland	0.088	24.1	Romania	0.982	22.5
Bahrein	0.312	29.8	India	0.125	21.9	Russia	0.549	23.1
Bangladesh	0.053	3.6	Indonesia	0.134	3.9	Rwanda	0.020	5.8
Barbados	0.098	23.1	Iran	0.778	6.9	Saint Kitts and Nevis	0.000	22.9
Belgium	1.951	22.1	Iraq	0.395	25.8	San Marino	2.169	nr
Belize	0.872	24.1	Ireland	0.863	30.4	Santa Lucia	0.128	19.7
Benin	0.007	9.6	Israel	0.656	25.3	Saint Vincent Grenadinas	0.055	23.7
Bhutan	0.001	6.4	Italy	1.549	26.1	Samoa	0.000	22.5
Belarus	0.198	24.5	Jamaica	0.140	19.9	Sao Tomè and Principe	0.098	12.4
Bolivia	1.056	20.2	Japan	0.057	24.7	Saudi Arabia	0.209	35.4
Bosnia	1.283	17.9	Jordan	0.688	4.3	Senegal	0.057	8.8
Bostwana	0.112	18.9	Kazakhstan	0.180	35.5	Serbia	0.598	21.5
Brazil	1.188	22.1	Kenia	0.041	21.0	Seychelles	0.111	14.0
Brunei	0.007	14.1	Kiribati	0.000	7.1	Sierra Leone	0.013	8.7
Bulgaria	1.347	25.0	Korea North	nr	46.0	Singapore	0.007	6.1
Burkina Faso	0.008	5.6	Korea South	0.031	6.8	Slovakia	1.138	20.5
Burundi	0.000	5.4	Kuwait	0.294	4.7	Slovenia	1.815	20.2
Cambogia	0.000	3.9	Kyrgyzstan	0.245	37.9	Solomon Islands	0.000	22.5
Camerun	0.023	11.4	Laos	0.000	16.6	Somalia	0.016	8.3
Canada	0.599	29.4	Latvia	0.753	5.3	South Africa	0.895	28.3
Cabo Verde	0.270	11.8	Lebanon	0.916	23.6	Spain	1.424	23.8
Centr. Afr. Republic	0.014	7.5	Lesotho	0.122	32.0	Sri Lanka	0.020	5.2
Chiad	0.010	6.1	Liberia	0.020	16.6	Sudan	0.050	6.6
Chile	1.102	28.0	Libya	0.332	9.9	Suriname	0.310	26.4
China	0.004	6.2	Liechtenstein	1.427	32.5	Sweden	1.327	20.6
Colombia	1.216	22.3	Lithuania	1.508	nr	Swaziland	0.507	nr
Comoros	0.174	7.8	Luxembourg	1.113	26.3	Switzerland	1.194	19.5
Congo	0.028	9.6	Madagascar	0.013	22.6	Syria	0.043	27.8
Congo D.R.	0.010	6.7	Malawi	0.061	5.3	TaJikistan	0.011	14.2
Core D'Ivore	0.008	10.3	Malaysia	0.033	5.8	Tanzania	0.000	8.4
Costa Rica	0.573	25.7	Maldives	0.170	15.6	Taywan	0.000	nr
Croatia	1.263	24.4	Mali	0.021	8.6	Thailand	0.001	10.0
Czechia	1.765	26.0	Malta	0.701	8.6	Timor Leste	0.000	3.8
Cuba	0.024	24.6	Marshall	0.000	28.9	Togo	0.012	8.4
Cyprus	0.262	21.8	Mauritania	0.122	52.9	Tongo	0.000	48.2

Denmark	0.409	19.7	Mauritius	0.008	12.7	Trinidad Tobago	0.124	18.6
Dominica	0.000	27.9	Mexico	1.469	10.8	Tunisia	0.694	29.9
Dominican R.	0.306	27.6	Micronesia	0.000	28.9	Turkey	0.356	32.1
Equador	0.960	19.9	Moldova	0.905	45.8	Turkmenistan	0.000	18.6
Egypt	0.115	32.0	Mongolia	0.001	18.9	Tuvalu	0.000	51.6
El Salvador	0.276	24.6	Montenegro	1.465	20.6	Uganda	0.009	5.3
Equatorial Guinea	0.115	8.0	Morocco	0.255	23.3	Ukraina	0.607	24.1
Eritrea	0.001	5.0	Mozambique	0.022	26.1	United Arab Emirates	0.187	31.7
Estonia	0.388	21.2	Myammar	0.062	7.2	United Kingdom	1.831	27.8
Ethiopia	0.025	4.5	Namibia	0.175	nr	United States	1.531	36.2
Fiji	0.002	30.2	Nepal	0.074	17.2	Uruguay	0.159	27.9
Finland	0.132	22.2	Netherland	0.900	4.1	Uzbekistan	0.020	16.6
France	1.298	21.6	New Zealand	0.006	20.4	Vanautu	0.000	25.2
Gabon	0.043	15.0	Nicaragua	0.028	30.8	Venezuela	0.043	25.6
Gambia	0.073	10.3	Niger	0.009	23.7	Vietnam	0.000	2.1
Georgia	0.909	21.7	Nigeria	0.010	8.9	Yemen	0.024	17.1
Germany	0.820	22.3	North Macedonia	1.452	22.4	Zambia	0.065	8.1
Ghana	0.021	5.5	Norway	0.118	23.1	Zimbawe	0.100	15.5
						ρ Spearman = 0.3729 p< 0.001		

Table 1: COVID-19 Deaths x 10^3 at February 17 2021 and obesity prevalence 2016 in all the 187 world countries with available data.
nr = not reported; The correlation between obesity and deaths due to COVID-19 is significantly positive.

The data concerning the 49 SC are reported in Table 2.

Country	COVID-19 Death x 10^3 Feb-17	Obesity Prevalence 2016	Country	COVID-19 Death x 10^3 Feb-17	Obesity Prevalence 2016
Armenia	1.046	20.2	Kyrgyzstan	0.245	16.6
Australia	0.039	29.0	Latvia	0.753	23.6
Austria	0.974	20.1	Lithuania	1.058	26.3
Bahamas	0.486	31.6	Luxembourg	1.113	22.6
Belgium	1.951	22.1	Malta	0.701	28.9
Brazil	1.188	22.1	Mauritius	0.008	10.8
Brunei	0.007	14.1	Mexico	1.469	28.9
Canada	0.599	29.4	Netherlands	0.900	20.4
Chile	1.102	28.0	New Zealand	0.006	30.6

Croatia	1.263	24.4	Norway	0.118	23.1
Cuba	0.024	24.6	Republic of Chorea	0.031	4.7
Czechia	1.765	26.0	Moldova	0.905	18.9
Denmark	0.409	19.7	Romania	0.982	22.5
Estonia	0.388	21.2	Saint Vincent & Grenadinas	0.055	23.7
Finland	0.132	22.2	Slovakia	1.138	20.5
France	1.298	21.6	Slovenia	1.815	20.2
Germany	0.820	22.3	Spain	1.424	23.8
Grenada	0.009	21.3	Sweden	1.327	20.6
Guatemala	0.390	21.2	Switzerland	1.194	19.5
Hungary	1.410	24.1	Macedonia	1.452	22.4
Iceland	0.088	21.9	Trinidad and Tobago	0.124	18.6
Ireland	0.863	25.3	United Kingdom	1.831	27.8
Israel	0.656	26.1	USA	1.531	36.2
Italy	1.549	19.9	Uzbekistan	0.020	16.6
Japan	0.057	4.3	ρ Spearman	-0.1730 p > 0.05	

Table 2: COVID-19 Deaths x 10^3 at February 17 2021 and obesity prevalence 2016 in the 49 SC.

There was no correlation between obesity and risk of death from COVID-19.

We tried to understand this discrepancy on the correlations between the two sets of counties, and the possible determinants of obesity in relation to the LEEDELS were analyzed (Table 3).

Vaiable	Measure	49 SC	138 countries	P[a]
Life expectancy	Years	79.5 ± 3.97	68.4 ± 8.89	< 0.05
Density	inhabitants/Km^2	165.7 ± 222.35	289 ± 16174,1	< 0.05
Urban population	% of inhabitants	70.7 ± 19.22	51.7 ± 22.31	< 0.05
Unemployment	% of inhabitants	8.4 ± 9.94	10.3 ± 8.58	< 0.05
GDP total	USD/inhabitant	32254 ± 25339.2	8738 ± 18422.6	< 0.05
GDP 1[a]	% of the total	8.4± 9.34	31.9 ± 24.83	< 0.05
GDP 3[b]	% of the total	68.3 ± 11.53	47.9 ± 21.50	< 0.05
Instruction	% GDP total	5.3 ± 1.71	4.5 ± 2.53	< 0.05
Hospital beds	N/1000 inhabitants	4.7 ± 2.28	2.5 ± 2.31	< 0.05
PM 2.5-10.0	mg/m^3	29.1 ± 16.12	48.6 ± 39.44	< 0.05
Cars	N/1000 inhabitants	361.7 ± 187.98	98.3. ± 160.34	< 0.05
Cell Phone	N/1000 inhabitants	1173.2 ± 239.51	992.4 ± 429.89	< 0.05
Internet	Connections/1000 inhabitants	722.2 ± 198.77	335.4 ± 252.2	< 0.05
Covid-19 deaths		1537839	700843	
Total population	N x 10^3	1436486	5792701	

Table 3: LEEDELS variables in the 49 SCs compared to the other 138 countries with available data: mean values ± SD.
a = Mann–Whitney U test p values.

All the variables in the 49 SC were significantly different from those in the remaining 138 countries.

As regards the LEEDELS data, obesity showed a statistically significant negative correlation only with GDP1 (Table 4), which measures GDP from agriculture, animal husbandry, fishing, and forest exploitation. Total GDP and GDP3 (GDP from transport, communications, credit, insurance and tourism) were not correlated, and neither were all the other LEEDELS variables.

Variable	Measure	49 SC by WHO Spearman ρ	p	138 countries Spearman ρ	p
Life expectancy	Years	0.0059	> 0.05	0.1618	> 0.05
Density	inhabitants/Km^2	0.2114	> 0.05	-0.0482	> 0.05
Urban population	% of inhabitants	-0.0270	> 0.05	0.5793	**< 0.001**
Unemployment	% in relation to the workers	0.1235	> 0.05	0.2635	**< 0.001**
GP total	USD/inhabitant	0.0054	> 0.05	0.5789	**< 0.001**
GP 1[a]	% of the total	-0,3055	**< 0.05**	-0.6195	**< 0.001**
GP 3[b]	% of the total	0.0864	> 0.05	0.5580	**< 0.001**
Instruction	% GDP total	-0.2384	> 0.05	0.2036	**< 0.001**
Hospital beds	N/1000 inhabitants	0.2577	> 0.05	0.3303	**< 0.001**
PM 2.5-10.0	mg/m^3	0.0968	> 0.05	-0.2309	**< 0.001**
Cars	N/1000 inhabitants	0.1751	> 0.05	0.5419	**< 0.001**
Cell Phone	N/1000 inhabitants	0.2469	> 0.05	0.3342	**< 0.001**
Internet	Connections/1000 inhabitants	0.1401	> 0.05	0.5364	< 0.001

Table 4: Correlation between LEEDELS data and obesity in the 49 SCs and in the remaining 138 countries in the world with available data.
a = % of GDP from agriculture, animal husbandry, fishing, and forest exploitation.
b = % of GDP from transport, communications, credit, insurance and tourism.

The patterns of the two sets of countries are extremely different. In particular, apart from life expectancy and population density, all the variables were directly or indirectly correlated with obesity in the group of 138 countries.

The variables which may be considered typical of developed countries were all correlated: in a negative way for GPD1, and PM; and in a positive way for all the others (education, hospital beds, cars, mobile phones, and internet). Urban population and unemployment were also correlated.

Discussion

The main limitation of this study is that the data relating to obesity prevalence are those of 2016, while the number of COVID-19 deaths refers to 2021. In a previous study [16], it was shown that there is a strong correlation between years for any disease. Therefore, if we compare data from 2016 with data from 2021 we still obtain reliable information.

The results of this analysis indicate that obesity cannot be considered a risk factor for COVID-19 deaths in the developed countries, despite the extensive literature reporting a correlation between obesity and COVID-19 [2-11]. A part of the studies done in China [5], all the other was conducted in developed countries (e.g. USA, Italy, France).

However, we should consider that obesity prevalence does not consider the severity of the condition. It has been shown that the risk of COVID-19 death doubles when BMI is > 40 kg/m^2 (class III) and due to aging. [10]. According to the many studies carried out on COVID-19, severe disease and aging are risk factors, but this falls a long way short of considering overweight young or adult people < 30 kg/m^2 at risk. Furthermore, obesity is an important medical condition to take care of, and plenty of resources are devoted to improving all aspects of this condition. All these efforts may also help counteract COVID-19 infection, giving obese people the same possibility to tackle the viral spread as the healthier population has.

Despite the difference in the reliability of the death registries in the two sets of countries (49 SC and other 138 countries), the correlation with obesity was different. It was shown that obesity has a very different pattern in relation to the LEEDELS variables in the more developed countries (49 SC) than it has in the other 138 countries.

In the 49 SC, only GPD 1 was negatively correlated with obesity, while in the rest of the world all the variables reflecting wealth were significantly involved. Increase in obesity was directly correlated with number of cars, internet connections, and mobile phones, which all reflect the prosperity of a country, and the negative correlation with PM can also be considered to be connected with the tentative to reach prosperity increasing the industrial activity (which is bound to pollution).

There is a sort of "ceiling effect" in the 49 SC: the relatively high LEEDELS values (Table 3) do not allow obesity to be determined, while in developing countries, the same variables have much greater weight in determining obesity prevalence.

The different LEEDELS/obesity and the obesity/COVID-19 patterns indicates that the number of deaths from the infection in the 49 SC is relatively independent of the LEEDLEs data. This was confirmed by the lack of correlation between the number of COVID-19 deaths and any of the LEEDELS values apart from GDP1.

However, this is not the first time the conclusions are not in line with common findings once the bigger picture is considered. For instance, considering the diabetes type II values in the 49 SC no correlation was found [17-20], at the opposite a protection was shown (not statistically significant) that become statistically significant considering all the world countries (data not reported but available). However, we cannot rule out that each country may have peculiarities, and therefore specific outcomes cannot be considered general rules even if they are found in important or large countries.

Conclusion

On the basis of the analysis of obesity prevalence in 187 an increase in the number of deaths due to COVID-19 seems to be evident (the bad news), while in the 49 SC more developed countries this correlation is absent (the good news). Obesity shows different patterns with different LEEDELS variables. In the poorest countries, the variables linked to prosperity are positively correlated with the condition. However, studies carried out in one country, no matter how important it is in the world, cannot be considered valid for all other countries.

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Author Contributions

UC conceived the trial; GB and UC retrieved all the data; MR carried out the statistical evaluation; UC wrote the text.

Conflict of Interest

There are no conflicts of interest.

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