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Analysis of persistence in obesity and severe obesity rates: short-term versus long-term interventions in 38 OECD countries

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Abstract
This paper investigates time series persistence in obesity and severe obesity rates in a group of 38 OECD countries by using techniques based on fractional integration. The idea is to determine if there are trends in the time series and if the impact of health policy exposure might have permanent or transitory effects. The results based on aggregated and disaggregated data by sex indicate high levels of persistence in all cases, with orders of integration of magnitude higher than three. Trends in these rates are also of high magnitudes, particularly in Australia, New Zealand and United Kingdom. An implication of the findings is that long-term measures are required to tame obesity rates and severe obesity rates in OECD countries. The paper finally highlights the long-term measures needed to reduce the alarmingly high obesity rates in the developed countries.

Keywords Obesity · Severe obesity · Persistence · Fractional integration · OECD countries

JEL Classification C25 · I12 · I18

1 Introduction

Obesity is measured as the prevalence of Body Mass Index (BMI) that is greater than 30 kg to the square of height in meters (kg/m^2). Severe obesity is measured as the prevalence of BMI that is greater than 40 kg/m^2. The World Health Organization (WHO) regards obesity as too much accumulation of fat that poses a health risk. In 1997, the WHO recognized obesity as a key public health issue and officially acknowledged it a worldwide epidemic [46]. Since then, obesity in Organisation for Economic Co-operation and Development (OECD) countries has escalated into a global health issue, currently affecting 54% of adults classified as overweight or obese [32, 33]. The incidence of clinically severe obesity is increasing at a substantially faster rate among adults compared to obesity, particularly in developed countries such as the United States [40]. Severe obesity poses an even greater challenge than obesity. Individuals with severe obesity are at significantly higher risk of developing chronic diseases and they experience greater difficulties in participating in

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daily physical activities and face increased social stigmatization, often leading to mental health issues like depression and anxiety.

This issue has profound health, social, and economic impacts. Obesity and severe obesity are linked to an increased risk of chronic diseases and have significant economic, social, and psychological consequences [24, 25]. Among the associated noncommunicable diseases are cardiovascular conditions, type 2 diabetes, hypertension, and various types of cancers [27]. These conditions lead to increased medical costs, premature mortality, absenteeism at workplace, and reduced productivity. Obesity generates substantial financial burden on the health care sector, with more than US$300 billion in yearly costs in the United States [23].

In OECD countries, efforts to combat obesity have intensified through public policies promoting healthy eating habits, physical activity programs, and food labelling regulations, among others [32, 33]. However, these measures have proven insufficient, as obesity and severe obesity rates continue to rise in many nations. In this context, the persistence of obesity and severe obesity becomes a central topic of interest for economists and policymakers. Persistence is a measure of the extent at which temporary shocks on the current situation in obesity rate or severe obesity rate create permanent future changes in obesity rate or severe obesity rate. The persistence being used here is based on its statistical meaning rather than within the medical context. The absence of persistence is an indication that a shock (through impact of health policy exposure) or sudden increase will have a temporary or short-term effect if, after a brief period, as obesity rate or severe obesity rate will always return to its original status. In such a case, short-term policies will be effective in addressing rising obesity rates or severe obesity rates in many countries.

On the other hand, long term policies will be effective in addressing rising obesity rate or severe obesity rate in many countries. The existence of persistent obesity rate or severe obesity rate is a concern for many countries, especially the developed countries because if necessary, actions are not taken on time, the increases in obesity rate or severe obesity rate will continue to escalate. To implement effective measures to address this serious issue, it is essential to conduct studies that analyse the degree of persistence in the data series.

The persistence of obesity rate or severe obesity rate implies that reliable forecasts of subsequent values of obesity rate or severe obesity rate cannot be realised by simply counting on the historical obesity rate or severe obesity rate figures. In this case, the consideration of other dimensions is needed, including the potential determinants of obesity rate or severe obesity rate. The possible factors of obesity rate or severe obesity rate that have been observed in the literature include consumption of fried food, insufficiency in physical activity, perceived stress level, family size, education level, family history of obesity, and excessive consumption of carbohydrates [4]. Other factors of obesity include the promotion of exclusive breastfeeding, taxation, front-of-pack labelling, consumption-based subsidies, and marketing regulations [2]. Evaluation of the projections of the obesity rate and severe obesity rate have been documented in Keaver et al. [26] and Ali et al. [3].

According to our knowledge, there is no existing study that has employ the methodology based on the concept of fractional integration in analysing the persistence of obesity and severe obesity in OECD countries. This paper employs a fractional integration approach, offering valuable insights into whether strong policy interventions are required. This methodology is preferred to others that simply consider integer degrees of differentiation in the data to render them stationary. Thus, allowing fractional orders of integration we enrich the model with more flexibility in its dynamic specification.

This paper offers two-fold contributions: the first contribution of this study is that, to the best of our knowledge, it is the first to examine the time series properties of obesity and severe obesity in 38 OECD countries between 1990 and 2022. In OECD countries, more than half of the adult population were obese or overweight in 2021, the average healthcare cost across OECD nations in that year was about US$209 dollars per capita (in purchasing power parity) [32, 33]. The OECD countries are expected to spend an average of 8.4% of their total health budget annually on treating the consequences of unhealthy weight [32, 33]. There will be a return of about US$6 in the form of total economic benefits, for each US Dollar expended on the obesity prevention [32, 33]. The second contribution is the use of fractional integration in analysing the persistence of obesity and severe obesity in OECD countries. This approach is more comprehensive than traditional methods like stationary AutoRegressive Moving Average (ARMA) model or the nonstationary/integrated version (ARIMA) model, because it enables the analysis of nonstationary data exhibiting mean-reverting behaviour.

Findings obtained unravelled trends and dynamics of obesity and severe obesity among the 38 OECD group of countries during the historic period of 1990 to 2022. Specifically, by disaggregating the data by sex, and conducting the analysis, findings indicate high levels of persistence by gender with orders of integration above 3 indicating very strong non-mean reverting tendency. Countries with alarmingly high trends of obesity rates, such as Australia, New Zealand and United Kingdom are also noted, and necessary policy are rendered.

The rest of the paper is therefore structured as follows. Section 2 presents a literature review on this particular topic. Section 3 describes the methodology while data are presented in Sect. 4. Section 5 is devoted to the empirical results, while Sect. 6 concludes the manuscript.

2 Literature review

2.1 Obesity trends and socioeconomic impacts

Obesity and severe obesity are global issues with significant medical, social, and economic implications. A report in 2022 indicates that one in eight people worldwide were living with obesity as at that time [47]. Although some authors challenge the idea that overweight and obesity constitute a public health crisis, arguing that this claim is influenced more by cultural and political factors than by robust scientific evidence [12], a significant global increase in obesity prevalence has been observed over the past three decades [45], solidifying its status as a recognised public health crisis [10]. In 2021, an average of 54% of the adult population in 32 OECD countries were classified as overweight or obese [32, 33]. Moreover, the prevalence of severe obesity is now increasing at the same rate as milder forms of obesity [31].

A substantial body of research focuses specifically on obesity trends in the United States with their projections indicating that by 2030, nearly 78% of U.S. adults will be classified as overweight or obese, with approximately 25% facing severe obesity [43, 44]. Sturm [39] found that the rate of increase in clinically severe obesity among adults in the U.S. far outpaced that of obesity until 2005, however, more recent studies, such as Sturm and Hattori [40] suggest that this trend has decelerated since 2005. Numerous studies have been conducted on this issue in China with most of these indicating that the prevalence of obesity is rapidly increasing in the country. For example, Pan et al. [34] asserts that the prevalence of overweight and obesity has risen rapidly over the past four decades. Ma et al. [29] also focused on China and studied the secular trends in the prevalence of obesity, and abdominal obesity in China from 1993 to 2015. The paper found a significant increase in the prevalence of obesity over the period, particularly among men, individuals with lower educational levels, and those living in rural areas.

There is a broad consensus in the literature on the importance of considering socioeconomic factors when addressing obesity. The Organisation for Economic Co-operation and Development [31]'s study analysed the economic impact of overweight and obesity in 36 countries, including OECD nations, EU member states, and selected G20 countries. The study concluded that obesity lessens life expectancy, intensifies healthcare costs, decreases worker's productivity, and lowers productivity. Many other authors showed the same conclusion about the economic and social impact of obesity [24, 25, 28, 30]. Studies focusing on the economic costs of obesity in specific countries, such as Sweden [5], Italy [15], Spain [21, 22], and the United States [13], among others are also documented. Other studies focussed on only the indirect cost of obesity such as those derived from premature mortality, missed days of work and reduced productivity and support the notion that obesity is associated with higher healthcare costs and reduced labour productivity [20].

Moreover, Tremmel et al. [42] evaluated the economic burden of adult obesity through a systematic review of the literature and concludes that there is a substantial economic burden of obesity in both developed and developing countries. Okunogbe et al. [30] estimated the current and future economic impact of overweight and obesity (OAO) across 161 countries, projecting that if current trends persist, the economic impact of OAO will rise to 3.29% of global GDP by 2060.

Recent studies have analyzed the socioeconomic implications of obesity at the household level in Switzerland, Australia, and Iceland [6–8], highlighting the significant monetary values individuals assign to achieving an optimal BMI. These findings consistently reveal important gender disparities across the three countries. These studies complement existing findings on the economic impacts in countries such as Sweden [5], Italy [15], Spain [21, 22], and the United States [13], by underscoring the role of household-level interactions in shaping the broader economic and social consequences of obesity.

2.2 Methodologies for analysing persistence

Beyond analysing obesity and severe obesity trends and their socioeconomic impacts, it is necessary to understand the persistence of this issue. The measures to be implemented to address obesity and severe obesity will vary depending on the results of this analysis. Various methodologies have been employed to analyze the persistence of different series. Some studies apply conventional unit root tests or alternative univariate time series models [36]. To further investigate persistence in the time series and the impact of exogenous shocks, Gil-Alana [17] introduced a fractional integration test that enables

the analysis of long-term effects, offering insights into whether strong policy interventions are warranted. Numerous studies have applied this methodology to a wide range of themes. The examined variables include tourism [14, 16], cryptocurrency markets [1, 11], among many others [41.

The objective of this study is to analyse the persistence of obesity and severe obesity in OECD countries using the methodology based on Fractional integration. Through this methodology, this study contributes to the analysis of the persistence of obesity and severe obesity in 38 OECD countries, offering valuable insights for the design of more effective policy interventions. The ability of this methodology to analyze nonstationary data and mean-reverting behaviour will enable policymakers to develop more targeted measures to address this critical public health issue.

In summary, while current policies have proven insufficient, understanding the persistence of obesity can provide a stronger foundation for future interventions. This underscores the need to address obesity and severe obesity not only as a public health concern but also as an economic and social challenge that requires coordinated and long-term action.

3 Methodology

When focusing on trends, Robinson [35] suggests using the most standard approach that relies on a linear time trend of the form:

$$y(t) = \alpha + \beta t + x(t), (1 - L)^d x(t) = u(t), t = 1, 2, 3, \ldots \tag{1}$$

where y(t) refers to the observed data, α and β are constant and the time trend of the model and x(t) is supposed to be well behaved, in the sense that it satisfies some standard properties like being covariance stationary or integrated of order 0, that is an I(0) process. This latter property indicates that, theoretically, the infinite sum of the autocovariances of the errors must be finite, which is satisfied not only by the classical white noise process, but also for the (stationary) ARMA-class of models. However, this property is not generally satisfied by many types of data. In fact, many time series require some level of differentiation to get the standard I(0) case. This number of differences *d* is usually 1 but can be higher like 2 or 3 in the case of extreme strong persistence and can be even fractional as is the case with fractional integration. Thus, a process in integrated of order d, and denoted by I(d), if it requires d differences to render it I(0) and d may be any real value, including fractional values. The higher the value of d, the more the persistence of the time series. Here in the paper, the errors $u(t)$ are assumed to be white noise process and we test the hypothesis, H_o: d = d_o, by using a Lagrange Multiplier test, such that, under H_o, the estimated errors become:

$$\widehat{u}(t) = y_t^* - \widehat{\alpha}_0 1_t^* + \widehat{\beta} t_t^*, \tag{2}$$

with $y_t^* = (1 - L)^{d_o} y_t$; $1_t^* = (1 - L)^{d_o} 1_t$; $t_t^* = (1 - L)^{d_o} t_t$, 1_t indicating a series of 1 s and t_t a time trend starting at 1. The test stastitics is:

$$\widehat{R} = \frac{T}{\widehat{\sigma}^4} \widehat{a} \prime \widehat{A}^{-1} \widehat{a}, \tag{3}$$

where *T* is the sample size, and

$$\hat{a} = \frac{-2\pi}{T} \sum_j^* \psi(\lambda_j) g_u(\lambda_j; \hat{\tau})^{-1} I(\lambda_j); \; \hat{\sigma}^2 = \sigma^2(\hat{\tau}) = \frac{2\pi}{T} \sum_{j=1}^{T-1} g_u(\lambda_j; \hat{\tau})^{-1} I(\lambda_j);$$

$$\hat{A} = \frac{2}{T} \left\{ \sum_j^* \psi(\lambda_j) \psi(\lambda_j)' - \sum_j^* \psi(\lambda_j) \hat{\xi}(\lambda_j)' \left[\sum_j^* \hat{\xi}(\lambda_j) \hat{\xi}(\lambda_j) \right]^{-1} \sum_j^* \hat{\xi}(\lambda_j) \psi(\lambda_j)' \right\};$$

$$\psi(\lambda_j) = \log \left| 2 \sin \frac{\lambda_j}{2} \right| \hat{\xi}(\lambda_j) = \frac{\partial}{\partial \tau} log g_\varepsilon(\lambda_j; \hat{\tau}); \text{and j } = 2\text{j/T}.$$

In the foregoing expressions, the summations are conducted across the entire frequencies that are bounded within the spectrum, with $\hat{\tau}$ = arg $\min_{\tau \in T^*} \sigma^2(\tau)$ and periodogram I(λ_j) for $\tilde{\varepsilon}_t$ [35]. Moreover, since the error term is supposed to be white noise, the formulae above simply since $g_u(\lambda_j; \hat{\tau}) = 1$, and thus $\hat{\xi}(\lambda_j) = 0$. The test is supposed to be the most

efficient one in the Pitman sense against local departures. Moreover, the value of d tested (d_o) can be any real number and thus, including values outside the statiationry region ($d_o \geq 0.5$) implying no need of preliminary differentiation of the data. See, Gil-Alana and Robinson [19] for further details of this approach and other standard applications of this statistical method can be found in Gil-Alana (2000), Gil-Alana and Moreno [18], Solarin et al. [38] and others. Figure A1 in the Appendix show single realizations of different I(d) processes with different values of d.

4 The data

The dataset has been generated from the National Adult Body-Mass Index Dataset of the Non-Communicable Diseases Risk Factor Collaboration (NCD-RisC) Network. Obesity rate is measured as the number of people with obesity per total population. Severe obesity rate is measured as the number of people with severe obesity per total population. We have considered the obesity rate and severe obesity rate data of 38 OECD countries for the period 1990–2022.

The descriptive statistics of obesity rate and severe obesity rates of 38 OECD countries are summarized in Table A1 in the Appendix. It is shown that the United States, Turkey, Chile, Mexico, and New Zealand are among the countries with the largest averages of obesity rates. It is also shown that Denmark, France, Switzerland, South Korea, and Japan are among the countries with the smallest averages of obesity rates. The United States, New Zealand, Australia, Canada, and Czechia are among the countries with the largest averages of severe obesity rates. The Netherlands, Colombia, France, Japan, and South Korea are among the countries with the smallest averages of severe obesity rates. Most of the countries with large male (severe) obesity rates also have large female (severe) obesity rates. Many of the series follows normal distribution, as the null hypothesis of normality can only be rejected in few cases.

We have displayed the trend of obesity rates and severe obesity rates in the OECD countries in Figure A2 to Figure A7 in the Appendix. Due to the displayed trended nature of each plot, this is enough evidence that obesity rates and severe obesity rates have increased alarmingly in most of the OECD countries during 1990–2022. Moreover, male (severe) obesity rates and female (severe) obesity rates also increased alarmingly in most of the OECD countries. The figures also displayed that some of the countries have experienced trend change, which can be attributed to the measures that were introduced in the past. For instance, the Global Action Plan for the Prevention and Control of Non-communicable Diseases of 2013–2020 was introduced by the World Health Assembly in 2013 [9]. The content of Plan involves various measures aimed at addressing preventable chronic diseases including diabetics and obesity [9]. The implementation of this plan might be responsible for the changes witnessed in the countries.

5 Empirical results

Due to the trend nature of the obesity dataset, we employed the full model version of Robinson [35], that is the trend version of the fractional integration model, given by Eq. (1) above, where y(t) is the obesity time series under investigation, and other notations and parameters are as defined earlier.

Table 1 refers for total obesity rate and display the estimates of the integration parameter, d, and their associated 95% confidence bands in three different scenarios: with no deterministic terms (i.e., $\alpha = \beta = 0$a priori in Equation (1)), including the intercept (i.e.,αestimated and with$\beta = 0$), and with an intercept and a linear trend (i.e., $\alpha and \beta$freely estimated from the data), marking in bold in the table the selected specification model for each series. This selection is made based on the t-values of the estimated coefficients. We observe that the time trend is required in all cases. Thus, in what follows, we focus exclusively on this model incorporating a (linear) time trend.

Tables 2, 3 and 4 reports the estimates of d, α and β in the model given by Eq. (1) for the total obesity rate, male obesity rate and female obesity rate, respectively. The estimates of d are tremendously large in all cases, being higher than 3 (and even higher than 4 for Israel, Norway and Spain) in case of total obesity rate (Table 3). The same happens with male obesity with only three countries displaying values of d below 3 (Mexico, with d = 2.96; Turkey, 2.94 and New Zealand, 1.78). For female obesity all the estimates of d are above 3.

Focussing now on the time trend coefficients, we observe that for the total numbers, the highest values correspond to New Zealand (0.0535), followed by the UK (0.0532) and Australia (0.0498) as well as all the Anglo-Saxonian countries. The contribution for the two countries in Oceania is clear due to the female numbers (see Table 4), while that for the

Table 1 Estimates of d of total obesity rate

Country	No terms	An intercept	A linear time trend
Austria	0.88 (0.65, 1.22)	2.55 (2.29, 3.11)	**3.98 (3.56, 4.63)**
Australia	0.87 (0.64, 1.21)	2.42 (2.09, 3.07)	**3.62 (3.30, 4.18)**
Belgium	0.89 (0.61, 1.24)	2.59 (2.31, 3.17)	**3.76 (3.44, 4.22)**
Canada	0.88 (0.64, 1.24)	2.46 (2.12, 3.07)	**3.46 (3.21, 3.93)**
Chile	0.88 (0.65, 1.24)	2.41 (2.03, 3.04)	**3.59 (3.34, 4.06)**
Colombia	0.89 (0.64, 1.26)	2.42 (2.88, 3.05)	**3.62 (3.26, 4.07)**
Costa Rica	0.89 (0.65, 1.29)	2.42 (2.07, 3.03)	**3.50 (3.14, 4.07)**
Czechia	0.91 (0.68, 1.22)	2.77 (2.46, 3.34)	**3.31 (2.97, 3.83)**
Denmark	0.88 (0.65, 1.22)	2.52 (2.24, 3.06)	**3.69 (3.43, 4.06)**
Estonia	0.91 (0.67, 1.26)	2.78 (2.56, 3.21)	**3.91 (3.67, 4.28)**
Finland	0.89 (0.64, 1.23)	2.57 (2.33, 3.09)	**3.53 (3.22, 3.91)**
France	0.90 (0.66, 1.28)	3.00 (2.81, 3.40)	**3.88 (3.61, 4.29)**
Germany	0.89 (0.64, 1.26)	2.56 (2.28, 3.10)	**3.80 (3.51, 4.27)**
Greece	0.90 (0.65, 1.29)	2.64 (2.31, 3.14)	**3.79 (3.50, 4.25)**
Hungary	0.90 (0.67, 1.30)	2.42 (2.12, 3.04)	**3.73 (3.45, 4.10)**
Iceland	0.88 (0.62, 1.24)	2.49 (2.15, 3.10)	**3.74 (3.46, 4.12)**
Ireland	0.88 (0.62, 1.24)	2.46 (2.11, 3.05)	**3.51 (3.13, 3.92)**
Israel	0.90 (0.64, 1.24)	2.66 (2.18, 3.40)	**4.04 (3.72, 4.19)**
Italy	0.91 (0.66, 1.27)	3.29 (2.99, 3.10)	**3.90 (3.56, 4.21)**
Japan	0.89 (0.64, 1.25)	2.45 (2.12, 3.14)	**3.13 (2.74, 3.67)**
Latvia	0.91 (0.68, 1.29)	2.80 (2.33, 3.77)	**3.81 (3.52, 4.11)**
Lithuania	0.92 (0.70, 1.30)	2.74 (2.17, 3.70)	**3.71 (3.45, 4.05)**
Luxembourg	0.89 (0.63, 1.23)	2.58 (2.31, 3.11)	**3.72 (3.47, 4.07)**
Mexico	0.88 (0.63, 1.22)	2.54 (2.19, 3.08)	**3.49 (3.22, 3.86)**
Netherlands	0.89 (0.64, 1.24)	2.57 (2.30, 3.12)	**3.82 (3.56, 4.23)**
Norway	0.88 (0.63, 1.24)	2.55 (2.42, 3.17)	**3.74 (3.19, 4.06)**
New Zealand	0.88 (0.62, 1.22)	2.45 (2.13, 3.06)	**3.50 (3.20, 3.85)**
Poland	0.90 (0.64, 1.25)	2.53 (2.17, 3.10)	**3.62 (3.31, 3.99)**
Portugal	0.89 (0.64, 1.23)	2.68 (2.34, 3.11)	**3.97 (3.65, 4.05)**
South Korea	0.89 (0.63, 1.23)	2.37 (2.11, 3.08)	**3.27 (2.78, 3.80)**
Spain	0.91 (0.65, 1.22)	2.73 (2.37, 3.15)	**4.02 (3.74, 4.46)**
Slovakia	0.88 (0.63, 1.25)	2.47 (2.22, 3.04)	**3.44 (3.16, 3.88)**
Slovenia	0.89 (0.63, 1.26)	2.55 (2.24, 3.12)	**3.81 (3.52, 4.10)**
Sweden	0.89 (0.64, 1.25)	2.56 (2.24, 3.15)	**3.77 (3.47, 4.04)**
Switzerland	0.89 (0.65, 1.26)	2.72 (2.39, 3.21)	**3.82 (3.56, 4.09)**
Türkiye	0.88 (0.63, 1.22)	2.44 (2.17, 3.09)	**3.14 (2.72, 3.66)**
United Kingdom	0.91 (0.64, 1.25)	2.47 (2.20, 3.12)	**3.57 (3.30, 4.08)**
United States	0.90 (0.62, 1.23)	2.45 (2.18, 3.10)	**3.51 (3.15, 4.06)**

in bold indicate the full model for obesity rates with a linear trend deterministic term in the Robinson [35] fractional integration framework

United Kingdom is due to male numbers (Table 2). Table A2 in the appendix summarizes the time trend results for the three series. We also see that South Korea and Colombia in the case of males, and Mexico for females also appear in the top-3 positions, while Costa Rica, Chile and Canada also appear in the top positions.

We focus now on severe obesity rate. Tables 5, 6 and 7 display the estimated coefficients for total, males and females, respectively. Focussing first on the degree of integration, for the total series, we observe that most of the values are above 3. In fact, only four countries display an estimate below this number: Chile, Japan, Mexico and South Korea. For males, the number of countries with values of d below 3 are nine, the previous four along with Colombia, Costa Rica, Netherlands, Portugal, and particular New Zealand, this latter countries with an estimate of d of 1.35. Finally, for females, there are

Table 2 Estimated coefficients of total obesity rate

Country	d	Intercept	Time trend
Austria	3.98 (3.56, 4.63)	– 1.672 (– 134.18)	0.0233 (102.78)
Australia	3.62 (3.30, 4.18)	– 1.385 (– 101.46)	0.0498 (102.78)
Belgium	3.76 (3.44, 4.22)	– 1.408 (– 112.25)	0.0150 (66.16)
Canada	3.46 (3.21, 3.93)	– 1.290 (– 87.90)	0.0438 (167.27)
Chile	3.59 (3.34, 4.06)	– 1.329 (– 133.30)	0.0477 (265.83)
Colombia	3.62 (3.26, 4.07)	– 1.896 (– 112.25)	0.0150 (260.74)
Costa Rica	3.50 (3.14, 4.07)	– 1.492 (– 184.83)	0.0471 (272.41)
Czechia	3.31 (2.97, 3.83)	– 0.901 (– 158–62)	0.0458 (17.89)
Denmark	3.69 (3.43, 4.06)	– 1.856 (– 118.05)	0.0056 (104.85)
Estonia	3.91 (3.67, 4.28)	– 1.299 (– 99.72)	0.0296 (49.16)
Finland	3.53 (3.22, 3.91)	– 1.306 (– 89.68)	0.0157 (60.33)
France	3.88 (3.61, 4.29)	– 1.538 (– 110.08)	0.0065 (25.790)
Germany	3.80 (3.51, 4.27)	– 1.292 (– 107.87)	0.0263 (121.08)
Greece	3.79 (3.50, 4.25)	–1.195 (– 97.96)	0.0157 (71.18)
Hungary	3.73 (3.45, 4.10)	– 1.325 (– 114.19)	0.0278 (132.52)
Iceland	3.74 (3.46, 4.12)	– 1.621 (– 137.58)	0.0374 (173.81)
Ireland	3.51 (3.13, 3.92)	– 1.342 (– 103.06)	0.0403 (172.84)
Israel	4.04 (3.72, 4.19)	– 1.214 (– 117.06)	0.0173 (91.61)
Italy	3.90 (3.56, 4.21)	– 1.368 (– 78–15)	– 0.0038 (– 11.92)
Japan	3.13 (2.74, 3.67)	– 1.294 (– 96.94)	0.0280 (41.28)
Latvia	3.81 (3.52, 4.11)	– 1.198 (– 122.84)	– 0.0080 (– 42.65)
Lithuania	3.71 (3.45, 4.05)	– 0.896 (– 85.89)	0.0228 (92.96)
Luxembourg	3.72 (3.47, 4.07)	– 1.371 (– 101.03)	0.0472 (190.25)
Mexico	3.49 (3.22, 3.86)	– 1.250 (– 90.06)	0.0403 (172.84)
Netherlands	3.82 (3.56, 4.23)	– 1.824 (– 131.78)	0.0293 (116.15)
Norway	3.74 (3.19, 4.06)	– 1.831 (– 122.29)	0.0328 (119.74)
New Zealand	3.50 (3.20, 3.85)	– 1.353 (– 100.30)	0.0535 (222.84)
Poland	3.62 (3.31, 3.99)	– 1.264 (–93.50)	0.0120 (49.60)
Portugal	3.97 (3.65, 4.05)	– 1.452 (– 127.39)	0.0139 (66.83)
South Korea	3.27 (2.78, 3.80)	– 3.518 (– 116.82)	0.0395 (74.37)
Spain	4.02 (3.74, 4.46)	– 1.222 (– 105.28)	0.0175 (82.62)
Slovakia	3.44 (3.16, 3.88)	– 1.339 (– 91.84)	0.0119 (45.82)
Slovenia	3.81 (3.52, 4.10)	– 1.452 (– 91.84)	0.0199 (63.15)
Sweden	3.77 (3.47, 4.04)	– 1.750 (– 111.55)	0.0305 (107.54)
Switzerland	3.82 (3.56, 4.09)	– 1.669 (– 109.07)	0.0113 (40.65)
Türkiye	3.14 (2.72, 3.66)	– 0.999 (– 42.48)	0.0294 (71.46)
United Kingdom	3.57 (3.30, 4.08)	– 1.459 (– 91.10)	0.0532 (185.17)
United States	3.51 (3.15, 4.06)	– 1.007 (– 76.02)	0.0417 (175.89)

in the second column of the results table are estimates of persistence based on linear trend with the corresponding confidence intervals. Third and fourth columns report intercept and time trend coefficients with t-statistics in parentheses

seven countries with d constrained between 2 and 3 (Chile, Czeck Republic, Hungary, Japan, Slovakia and South Korea. For the rest of the countries, d is above 3.

Looking now at the time trends (with a summary displayed in Table A3 in the appendix), we notice that Australia and New Zealand display the first and second positions, respectively in both total and female series but not for males. In fact, for males, the first three positions are represented by Ireland, Canada and Spain, the first two also appearing at the top in total severe obesity data. Other top number countries are Denmark for males, and Iceland, Mexico and Netherlands for females. United Kingdom also appears in top positions in the three series.

The above empirical results render support for persistence of both obesity rates and severe obesity rates. The results of disaggregated data by sex also indicate high levels of persistence in all cases. As there is an absence of existing studies

Table 3 Estimated coefficients of male obesity rate

Country	d	Intercept	Time trend
Austria	3.97 (3.54, 4.56)	− 2.436 (− 131.10)	0.0341 (102.36)
Australia	3.53 (3.16, 4.05)	− 2.096 (− 103.63)	0.0481 (132.94)
Belgium	3.73 (3.25, 4.24)	− 2.221 (− 112.51)	0.0256 (71.73)
Canada	3.49 (3.09, 3.97)	− 1.984 (− 103.34)	0.0431 (125.64)
Chile	3.42 (3.01, 3.88)	− 2.323 (− 134.98)	0.0570 (185.18)
Colombia	3.43 (3.04, 3.96)	− 3.142 (− 246.14)	0.0583 (257.04)
Costa Rica	3.13 (2.87, 3.76)	− 2.389 (− 160.43)	0.0465 (178.54)
Czechia	3.42 (3.03, 3.95)	− 1.733 (− 78.89)	0.0043 (11.37)
Denmark	3.64 (3.36, 4.11)	− 2.532 (− 101.70)	0.0409 (91.42)
Estonia	3.73 (3.42, 4.19)	− 2.208 (− 101.70)	0.0272 (77.66)
Finland	3.47 (3.19, 4.00)	− 2.072 (− 90.73)	0.0206 (50.69)
France	4.03 (3.67, 4.36)	− 2.351 (− 131.29)	0.0116 (35.41
Germany	3.79 (3.50, 4.22)	− 2.038 (− 119.04)	0.0360 (116.91)
Greece	3.81 (3.53, 4.24)	− 2.281 (− 112.29)	0.0320 (87.10)
Hungary	3.89 (3.59, 4.06)	− 2.110 (− 137.93)	0.0354 (127.47)
Iceland	3.67 (3.39, 4.15)	− 2.374 (− 123.03)	0.0422 (121.25)
Ireland	3.53 (3.15, 4.05)	− 2.040 (− 115.38)	0.0425 (134.38)
Israel	3.99 (3.66, 4.36)	− 2.165 (− 120.46)	0.0225 (68.64)
Italy	3.97 (3.60, 4.32)	− 2.241 (− 100.75)	0.0095 (23.34)
Japan	3.34 (2.98, 3.90)	− 4.224 (− 88.88)	0.0549 (65.14)
Latvia	3.72 (3.47, 4.17)	− 2.193 (− 142.40)	0.0189 (68.00)
Lithuania	3.52 (3.11, 3.82)	− 1.907 (− 100.53)	0.0039 (11.53)
Luxembourg	3.69 (3.40, 4.12)	− 2.109 (− 100.74)	0.0313 (82.88)
Mexico	2.96 (2.77, 3.25)	− 4.223 (− 35.05)	0.0536 (30.62)
Netherlands	3.71 (3.45, 4.16)	− 2.807 (− 122.99)	0.0455 (110.40)
Norway	3.59 (3.09, 4.09)	− 2.639 (− 96.27)	0.0446 (90.56)
New Zealand	1.78 (1.22, 2.51)	− 2.137 (48.33)	0.0554 (10.39)
Poland	3.69 (3.29, 3.97)	− 2.202 (− 116.59)	0.0319 (93.76)
Portugal	3.89 (3.54, 4.25)	− 2.609 (− 128.39)	0.0455 (123.66)
South Korea	3.54 (3.08, 4.02)	− 4.793 (− 111.75)	0.0666 (86.16)
Spain	3.90 (3.63, 4.17)	− 2.122 (− 109.61)	0.0330 (94.25)
Slovakia	3.38 (3.16, 3.59)	− 2.143 (− 102.96)	0.0233 (62.96)
Slovenia	3.89 (3.42, 4.17)	− 2.187 (− 95.79)	0.0269 (64.93)
Sweden	3.75 (3.17, 4.07)	− 2.516 (− 110.18)	0.0358 (86.62)
Switzerland	3.81 (3.35, 4.29)	− 2.296 (− 107.55)	0.0164 (42.54)
Türkiye	2.94 (2.42, 3.61)	− 2.261 (− 55.83)	0.0504 (77.21)
United Kingdom	3.54 (3.02, 4.00)	− 2.298 (− 102.04)	0.0625 (154.98)
United States	3.56 (3.04, 4.03)	− 1.824 (− 97.18)	0.0454 (134.97)

in the second column of the results table are estimates of persistence based on linear trend with the corresponding confidence intervals. Third and fourth columns report intercept and time trend coefficients with t-statistics in parentheses

on the persistence of either obesity rates or severe obesity rates, it is onerous to compare the empirical results of the current paper with the previous studies. However, the persistence of the determinants of the obesity rates and severe obesity rates have been established in the literature. According to Solarin et al. [37], a variable dependent on persistent variables will absorb such persistence from the other variables. For instance, education level has been shown to be a determinant of obesity [4] and education is a persistent series [37]. Another rationale for the existence of the persistence in both obesity rates and severe obesity rates is that beyond their past values, the two series continue to be affected a rising number of variables [2].

Table 4 Estimated coefficients of female obesity rate

Country	d	Intercept	Time trend
Austria	3.54 (3.34, 3.85)	– 2.298 (– 193.15)	0.0138 (64.94)
Australia	3.70 (3.37, 3.94)	– 2.061 (– 173.08)	0.0515 (239.69)
Belgium	3.60 (3.34, 3.88)	– 1.994 (– 195.83)	0.0064 (35.14)
Canada	3.43 (3.22, 3.70)	– 1.982 (– 136.64)	0.0445 (171.80)
Chile	3.52 (3.31, 3.81)	– 1.791 (– 195.91)	0.0422 (258.20
Colombia	3.71 (3.41, 4.08)	– 2.235 (– 204.73)	0.0425 (215.58)
Costa Rica	3.75 (3.44, 4.12)	– 2.016 (– 223.31)	0.0453 (277.65)
Czechia	3.25 (3.01, 3.56)	– 1.473 (– 85.01)	0.0133 (44.08)
Denmark	3.37 (3.21, 3.61)	– 2.544 (– 172.33)	0.0178 (70.13)
Estonia	3.98 (3.74, 4.33)	– 1.814 (– 177.63)	0.0012 (6.25)
Finland	3.45 (3.27, 3.75)	– 1.931 (– 164.58)	0.0114 (54.60)
France	3.51 (3.32, 3.88)	– 2.124 (– 140.35)	0.0025 (9.42)
Germany	3.62 (3.38, 4.03)	– 1.936 (– 179.86	0.0174 (89.90)
Greece	3.44 (3.25, 3.70)	– 1.607 (– 165.41)	0.0073 (42.13)
Hungary	3.39 (3.17, 3.64)	– 1.934 (– 184.98)	0.0214 (114.94)
Iceland	3.57 (3.37, 3.79)	– 2.257 (– 228.13)	0.0332 (187.36)
Ireland	3.29 (3.11, 3.61)	– 2.031 (– 164.22)	0.0380 (177.14)
Israel	3.55 (3.37, 3.94)	– 2.031 (– 179.22)	0.0380 (187.22)
Italy	3.52 (3.33, 3.90)	– 1.908 (– 109.14)4	– 0.0134 (– 42.89)
Japan	3.22 (2.97, 3.76)	– 3.795 (– 151.89)	0.0100 (22.8)
Latvia	3.73 (3.45, 4.10)	– 1.659 (– 189.52)	0.0004 (2.65)
Lithuania	3.65 (3.39, 4.08)	– 1.348 (– 159.15)	– 0.0149 (– 98.19)
Luxembourg	3.38 (3.20, 3.61)	– 2.021 (– 152.58)	0.0149 (63.41)
Mexico	3.85 (3.48, 4.19)	– 1.757 (– 138.77)	0.0494 (215.07)
Netherlands	3.59 (3.40, 3.97)	– 2.293 (– 175.00)	0.0195 (85.08)
Norway	3.64 (3.37, 3.94)	– 2.420 (– 189.48)	0.0232 (100.90)
New Zealand	3.45 (3.26, 3.73)	– 1.967 (– 162.98)	0.0508 (236.17)
Poland	3.37 (3.18, 3.80)	– 1.760 (– 133.03)	– 0.0009 (– 3.97)
Portugal	3.39 (3.22, 3.85)	– 1.830 (174.85)	– 0.0010 (– 5.61)
South Korea	3.16 (2.94, 3.33)	– 3.845 (– 159.56)	0.0288 (68.47)
Spain	3.70 (3.51, 3.96)	– 1.743 (– 167.31)	0.0067 (35.59)
Slovakia	3.40 (3.21, 3.67)	– 1.932 (– 154.82)	0.0026 (11.63)
Slovenia	3.33 (3.16, 3.62)	– 2.105 (– 116.96)	0.0135 (42.35)
Sweden	3.61 (3.49, 3.88)	– 2.375 (– 171.19)	0.0259 (107.73)
Switzerland	3.44 (3.26, 3.89)	– 2.436 (– 171.19)	0.0053 (21.22)
Türkiye	3.31 (3.14, 3.56)	– 1.331 (– 171.19)	0.0210 (68.49)
United Kingdom	3.45 (3.26, 3.90)	– 2.024 (– 171.19)	0.0461 (177.15)
United States	3.40 (3.21, 3.84)	– 1.560 (– 171.19)	0.0387 (169.28)

in the second column of the results table are estimates of persistence based on linear trend with the corresponding confidence intervals. Third and fourth columns report intercept and time trend coefficients with t-statistics in parentheses

6 Conclusions

Obesity (or to an extent, severe obesity) is becoming an important public health concern in both developed and developing countries and is obviously connected with increased risk for diabetes, strokes and several forms of cancers, and have important effect on the health care expenditures, quality of life, and life expectancy. Specifically, obesity rates and severe obesity rates have consistently risen in the OECD countries over the past three decades. There is a need to introduce relevant policies to tame the rising trend of obesity rates and severe obesity rates across the OECD countries. Therefore, the aim of this paper is to investigate the persistence of obesity rates and severe

Table 5 Estimated coefficients of severe obesity rate

Country	d	Intercept	Time trend
Austria	3.50 (3.27, 3.89)	– 4.959 (– 174.66)	0.0543 (107.03)
Australia	3.44 (3.21, 3.85)	– 4.227 (– 171.27)	0.0857 (194.83)
Belgium	3.40 (3.22, 3.82)	– 4.586 (– 191.29)	0.0353 (82.90)
Canada	3.26 (3.04, 3.66)	– 4.019 (– 130.11)	0.0753 (138.47)
Chile	2.86 (2.56, 3.07)	– 4.074 (– 181.03)	0.0479 (124.51)
Colombia	3.37 (3.14, 3.67)	– 5.239 (– 175.57)	0.0542 (102.36)
Costa Rica	3.07 (2.74, 3.36)	– 4.202 (– 184.03)	0.0569 (143.06)
Czechia	3.10 (2.77, 3.40)	– 3.917 (– 114.64)	0.0113 (18.95)
Denmark	3.62 (3.44, 3.93)	– 5.248 (– 202.62)	0.0644 (133.28)
Estonia	3.68 (3.47, 4.00)	– 4.033 (– 187.03)	0.0227 (58.47)
Finland	3.49 (3.31, 3.76)	– 4.056 (– 191.76)	0.0428 (101.09)
France	3.50 (3.33, 3.78)	– 4.682 (– 135.21)	0.0324 (52.29)
Germany	3.50 (3.34, 3.79)	– 4.520 (– 183.29)	0.0654 (148.41)
Greece	3.46 (3.30, 3.75)	– 4.043 (– 129.23)	0.0245 (43.86)
Hungary	3.30 (3.17, 3.54)	– 4.225 (– 139.57)	0.0464 (86.79)
Iceland	3.44 (3.24, 3.88)	– 4.701 (– 189.79)	0.0652 (147.61)
Ireland	3.54 (3.33, 3.82)	– 4.372 (– 152.94)	0.0655 (127.98)
Israel	3.56 (3.35, 3.84)	– 4.271 (– 128.86)	0.0190 (32.03)
Italy	3.43 (3.20, 3.77)	– 4.637 (– 108.58)	0.0147 (19.30)
Japan	2.58 (2.36, 2.80)	– 7.723 (– 36.12)	0.0499 (14.14)
Latvia	3.29 (3.13, 3.53)	– 3.974 (– 159.36)	0.0219 (49.77)
Lithuania	3.31 (3.16, 3.74)	– 3.700 (– 136.03)	0.0062 (12.93)
Luxembourg	3.45 (3.27, 3.87)	– 4.787 (– 154.79)	0.0527 (95.50)
Mexico	2.96 (2.61, 3.30)	– 4.209 (– 141.74)	0.0671 (131.04)
Netherlands	3.51 (3.33, 3.84)	– 5.304 (– 180.58)	0.0641 (122.09)
Norway	3.44 (3.21, 3.85)	– 5.269 (– 163.03)	0.0542 (94.00)
New Zealand	3.20 (2.93, 3.56)	– 3.913 (– 131.93)	0.0796 (152.63)
Poland	3.55 (3.29, 3.87)	– 4.414 (– 158.66)	0.0239 (47.98)
Portugal	3.30 (3.12, 3.84)	– 4.964 (– 139.34)	0.0152 (24.33)
South Korea	2.40 (2.24, 2.66)	– 8.585 (– 28.91)	0.0333 (6.98)
Spain	3.51 (3.33, 3.86)	– 4.467 (– 124.68)	0.0414 (64.55)
Slovakia	3.51 (3.22, 3.86)	– 4.570 (– 177.77)	0.0181 (39.45)
Slovenia	3.91 (3.70, 4.22)	– 4.457 (– 140.79)	0.0124 (21.48)
Sweden	3.40 (3.17, 3.65)	– 5.053 (– 129.17)	0.0572 (82.29)
Switzerland	3.60 (3.40, 3.84)	– 5.176 (169.24)	0.0499 (90.79)
Türkiye	3.60 (3.40, 3.91)	– 4.090 (– 126.54)	0.0452 (77.89)
United Kingdom	3.52 (3.36, 3.84)	– 4.293 (– 133.74)	0.0631 (109.81)
United States	3.66 (3.42, 3.93)	– 3.340 (– 117.89)	0.0596 (116.79)

in the second column of the results table are estimates of persistence based on linear trend with the corresponding confidence intervals. Third and fourth columns report intercept and time trend coefficients with t-statistics in parentheses

obesity rates in a group of 38 OECD countries for the 1990–2022 period, by using fractional integration techniques. Furthermore, the persistence of male (or female) obesity rates and male (or female) severe obesity rates for the same countries have also been examined in this study. The results, based on aggregated and disaggregated data by sex, indicate that high levels of persistence in all cases, with orders of integration of magnitude higher than 3 existing among countries. Looking at the time trends, the highest coefficients are observed in countries such as Australia, New Zealand and United Kingdom.

The results suggesting the incidence of persistence in obesity rates and severe obesity rates means that shocks (through impact of health policy exposure) to the obesity rates and severe obesity rates should be permanent or long-term in nature. Thus, long-term policies are the most relevant measures to tame rising obesity rates and severe obesity

Table 6 Estimated coefficients of severe male obesity rate

Country	d	Intercept	Time trend
Austria	3.25 (3.04, 3.60)	– 6.286 (– 107.98)	0.0770 (75.03)
Australia	3.44 (3.24, 3.79)	– 5.812 (– 113.06)	0.0912 (99.51)
Belgium	3.10 (2.64, 3.48)	– 6.324 (– 102.25)	0.0581 (53.82)
Canada	3.11 (2.66, 3.50)	– 5.381 (– 81.03)	0.1040 (89.64)
Chile	2.70 (2.54, 2.93)	– 5.980 (– 128.00)	0.0628 (80.10)
Colombia	2.97 (2.70, 3.14)	– 6.807 (– 106.98)	0.0632 (57.47)
Costa Rica	2.74 (2.47, 3.10)	– 5.378 (– 90.16)	0.0569 (56.53)
Czechia	3.31 (3.04, 3.62)	– 5.786 (– 100.91)	0.0552 (54.41)
Denmark	3.32 (3.07, 3.64)	– 6.397 (– 109.57)	0.0942 (91.10)
Estonia	3.52 (3.30, 3.79)	– 5.486 (– 138.94)	0.0484 (68.56)
Finland	3.33 (3.08, 3.61)	–5.837 (– 124.15)	0.0613 (73.60)
France	3.33 (3.10, 3.64)	– 6.600 (– 105.67)	0.0965 (87.21
Germany	3.38 (3.17, 3.73)	– 5.801 (– 130.734)	0.0905 (114.71)
Greece	3.40 (3.20, 3.75)	– 5.802 (–96.48)	0.0396 (37.01)
Hungary	3.42 (3.22, 3.77)	– 5.290 (– 126.14)	0.0623 (83.37)
Iceland	3.41 (3.23, 3.80)	– 5.733 (– 119.60)	0.0593 (69.50)
Ireland	3.42 (3.23, 3.81)	– 5.951 (– 109.10)	0.1122 (115.54)
Israel	3.64 (3.41, 4.03)	– 6.293 (– 86.62)	0.0096 (7.38)
Italy	3.29 (3.08, 3.60)	– 6.391 (– 93.20)	0.0694 (7.38)
Japan	2.41 (2.14, 2.67)	– 8.735 (– 28.44)	0.0791 (57.25)
Latvia	3.11 (2.98, 3.35)	– 5.653 (– 123.92	0.0519 (16.03)
Lithuania	3.18 (2.83, 3.44)	– 5.385 (– 114.85	0.0540 (65.67)
Luxembourg	3.29 (3.12, 3.56)	– 5.981 (– 101.51	0.0724 (69.68)
Mexico	2.70 (2.40, 3.02)	– 5.665 (– 103.84)	0.0650 (70.95
Netherlands	2.33 (2.18, 2.53)	– 7.235 (– 163.80)	0.0729 (10.44
Norway	3.30 (3.09, 3.63)	– 6.693 (– 106.16)	0.0695 (62.36)
New Zealand	1.35 (1.25, 1.48)	– 5.297 (– 214.99)	0.0690 (5.42)
Poland	3.62 (3.41, 3.83)	– 6.189 (– 134.39)	0.0882 (106.51)
Portugal	2.21 (2.07, 2.46)	– 7.261 (– 104.11)	0.0229 (2.14)
South Korea	2.31 (2.11, 2.57)	– 9.796 (– 27.96)	0.0659 (11.84)
Spain	3.46 (3.28, 3.67)	– 6.344 (– 112.74)	0.1022 (101.75)
Slovakia	3.58 (3.34, 3.74)	– 6.269 (– 128.71)	0.0506 (57.66)
Slovenia	3.90 (3.67, 4.22)	– 5.687 (– 113.27)	0.0125 (13.68)
Sweden	3.34 (3.14, 3.64)	– 6.245 (– 96.57)	0.0714 (62.25)
Switzerland	3.50 (3.33, 3.70)	– 6.531 (– 116.60)	0.0849 (84.76)
Türkiye	3.36 (3.17, 3.70)	– 6.613 (– 79.65)	0.0758 (51.41
United Kingdom	3.22 (3.09, 3.47)	– 5.933 (–84.01)	0.0827 (66.58)
United States	3.64 (3.38, 3.86)	– 4.925 (– 76.96)	0.0723 (62.74)

in the second column of the results table are estimates of persistence based on linear trend with the corresponding confidence intervals. Third and fourth columns report intercept and time trend coefficients with t-statistics in parentheses

rates in OECD countries. The long-term measures include the development of new weight-loss drugs with long-term safety, long-term reduction in the food content of trans fatty acids, increase in the production and access to healthy foods like fruits and vegetables, mandatory or strengthen physical education and activity in the curriculum, and national physical activity guidelines. The OECD countries that are currently implementing these long-term strategies (such the United States and United Kingdom) should strengthen them to ensure the reduction in both obesity rates and severe obesity rates.

The results also imply that short-term policies should be supported with the long-term measures to effectively reduce obesity rates and severe obesity rates. Short-term policies being used in OECD countries include the imposition of sugar tax; financial incentives for healthy lifestyles; subsidies on sports equipment; and restricting the television and

Table 7 Estimated coefficients of severe female obesity rate

Country	d	Intercept	Time trend
Austria	3.31 (3.14, 3.57)	– 5.267 (– 172.90)	0.0461 (85.48)
Australia	3.59 (3.30, 4.02)	– 4.457 (– 204.68)	0.0843 (215.62)
Belgium	3.27 (3.06, 3.58)	– 4.779 (– 188.17)	0.0304 (67.88)
Canada	3.28 (3.09, 3.60)	– 4.303 (– 177.47)	0.0654 (152.72)
Chile	2.82 (2.67, 3.04)	– 4.235 (– 177.32)	0.0453 (111.36)
Colombia	3.48 (3.23, 3.82)	– 5.472 (– 190.74)	0.0518 (101.18)
Costa Rica	3.24 (2.98, 3.64)	– 4.571 (– 234.99)	0.0569 (165.91)
Czechia	2.68 (2.68, 3.29)	– 4.089 (– 132.60)	0.0031 (5.87)
Denmark	3.11 (3.11, 3.62)	– 5.629 (– 171.96)	0.0503 (86.91)
Estonia	3.42 (3.25, 3.77)	– 4.299 (– 169.96)	0.0147 (32.59)
Finland	3.32 (3.14, 3.59)	– 4.812 (– 184.21)	0.0360 (77.98)
France	3.48 (3.31, 3.81)	– 4.844 (– 168.74)	0.0209 (40.81)
Germany	3.38 (3.20, 3.65)	– 4.846 (– 197.12)	0.0557 (127.41)
Greece	3.38 (3.17, 3.66)	– 4.232 (– 145.21)	0.0213 (41.17)
Hungary	2.91 (2.77, 3.29)	– 4.648 (– 167.09)	0.0381 (79.77)
Iceland	3.33 (3.15, 3.60)	– 5.142 (– 193.61)	0.0684 (145.45)
Ireland	3.28 (3.10, 3.54)	– 4.603 (– 159.87)	0.0532 (104.47)
Israel	3.50 (3.28, 3.96)	– 4.413 (– 139.40)	0.0204 (36.11)
Italy	3.50 (3.17, 3.97)	– 4.826 (–145.25)	0.0029 (4.94)
Japan	2.09 (1.93, 2.29)	– 8.175 (– 212.31)	0.0330 (5.83)
Latvia	3.22 (2.89, 3.33)	– 4.181 (– 169.87)	0.0150 (34.65)
Lithuania	3.16 (2.83, 3.26)	– 3.905 (– 143.39)	– 0.0050 (–10.56)
Luxembourg	3.39 (3.11, 3.81)	– 5.154 (– 212.17)	0.0438 (101.45)
Mexico	3.15 (2.74, 3.46)	– 4.475 (– 163.41)	0.0677 (141.41)
Netherlands	3.61 (3.41, 4.09)	– 5.461 (– 251.69)	0.0628 (161.09)
Norway	3.36 (3.18, 3.65)	– 5.544 (– 183.34)	0.0493 (91.79)
New Zealand	3.08 (2.76, 3.26)	– 4.195 (– 152.11)	0.0729 (151.68)
Poland	3.11 (2.78, 3.29)	– 4.599 (– 160.40)	0.0104 (20.87)
Portugal	3.12 (2.79, 3.33)	– 5.071 (– 137.47)	0.0148 (22.97)
South Korea	2.22 (2.06, 2.43)	– 8.938 (– 202.19)	0.0193 (2.83)
Spain	3.38 (3.22, 3.59)	– 4.633 (– 138.82)	0.0300 (50.66)
Slovakia	2.99 (2.64, 3.34)	– 4.733 (– 167.77)	0.0109 (22.25)
Slovenia	3.55 (3.36, 3.80)	– 4.802 (– 135.26)	0.0124 (19.53)
Sweden	3.36 (3.21, 3.54)	– 5.414 (– 162.96)	0.0511 (86.60)
Switzerland	3.36 (3.20, 3.52)	– 5.747 (– 212.48)	0.0375 (82.04)
Türkiye	3.61 (3.30, 3.80)	– 4.174 (– 146.64)	0.0426 (83.09)
United Kingdom	3.60 (3.27, 3.78)	– 4.509 (– 160.19)	0.0582 (115.19)
United States	3.60 (3.25, 3.77)	– 3.569 (– 167.60)	0.0563 (142.20)

in the second column of the results table are estimates of persistence based on linear trend with the corresponding confidence intervals. Third and fourth columns report intercept and time trend coefficients with t-statistics in parentheses

non-television advertisement of junk food, unhealthy food and drinks. The revenue generated from sugar tax advertisement on unhealthy food can be utilized to fund preventative research on obesity (which involves tackling root causes and risk factors before they develop). The fund allocated to preventative research on obesity in many OECD countries currently is low and this need to be jacked up. Moreover, the outputs from such preventive research are likely to be useful in the long-term. The persistence of male (or female) obesity rates and male (or female) severe obesity rates is an indication that less emphasis should be placed on separate policies on obesity and severe obesity for each gender.

The current study has some limitations that can serve as the basis for future papers. For instance, the current study has focussed on the persistence of obesity rates and severe obesity rates in OECD countries. Persistence analyses of obesity rates and severe obesity rates can also be conducted for other economic or regional blocs. An assessment of the

convergence of obesity rates and severe obesity rates in OECD countries can also be examined for different economic or regional blocs. The presence of convergence of obesity rates or severe obesity rates is a suggestion of the suitability of using mutual policies among countries to reduce obesity and/or severe obesity.

Author contributions Introduction and Conclusion SAS Literature review and Discussion GGQ Methodology and Results LAG, SOY.

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Data availability The data will be made available by the corresponding author (Solarin Sakiru Adebola) upon request.

Declarations

Ethics approval and consent to participate This study follows all ethical practices during writing and interpretations. Consent to participate is not applicable. I declare that this manuscript is original, has not been published before and is not currently submitted or being considered for publication elsewhere. Hence, we give the consent to publish in your journal upon acceptance.

Consent for publication Consent to publish from any other individual/organisation is not required.

Clinical trial number Not Applicable.

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