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## Original Research

# Trends and determinants of weight gains among OECD countries: an ecological study

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## ABSTRACT

**Objectives:** Obesity has become a global issue with abundant evidence to indicate that the prevalence of obesity in many nations has increased over time. The literature also reports a strong association between obesity and economic development, but the trend that obesity growth rates may converge over time has not been examined. We propose a conceptual framework and conduct an ecological analysis on the relationship between economic development and weight gain. We also test the hypothesis that weight gain converges among countries over time and examine determinants of weight gains.

**Study design:** This is a longitudinal study of 34 Organisation for Economic Cooperation and Development (OECD) countries in the years 1980–2008 using publicly available data.

**Methods:** We apply a dynamic economic growth model to test the hypothesis that the rate of weight gains across countries may converge over time. We also investigate the determinants of weight gains using a longitudinal regression tree analysis.

**Results:** We do not find evidence that the growth rates of body weight across countries converged for all countries. However, there were groups of countries in which the growth rates of body weight converge, with five groups for males and seven groups for females. The predicted growth rates of body weight peak when gross domestic product (GDP) per capita reaches US\$47,000 for males and US\$37,000 for females in OECD countries. National levels of consumption of sugar, fat and alcohol were the most important contributors to national weight gains.

**Conclusion:** National weight gains follow an inverse U-shape curve with economic development. Excessive calorie intake is the main contributor to weight gains.

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## Introduction

There is substantial evidence to indicate that obesity has a strong historical association with economic development.<sup>1</sup>

Body mass index (BMI) has increased rapidly in 200 countries across the world during the past three decades.<sup>2</sup> However, the rate of increase has not been linear. A cross-sectional study of more than 100 countries found that BMI increases

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rapidly with income per capita and reaches a peak at an income of \$12,500 for females and \$17,000 for males<sup>3</sup> (the US dollars are used in this article). Despite slower recent growth in BMI, obesity continues to increase in developed countries.<sup>4</sup> We argue that BMI growth rates may converge over time, especially in countries with a similar level of economic development. The convergence of BMI growth rates provides important policy applications as lessons from developed countries can help developing countries to avoid or reduce the growth and hence reduce the high costs associated with unhealthy weight gains during the economic development process.

The prevalence of obesity has increased in recent decades across the world.<sup>2</sup> Global mean BMI increased at a yearly rate of 0.4 kg/m<sup>2</sup> per decade for men and 0.5 kg/m<sup>2</sup> for women in 199 countries over the years 1980–2008. In 2008, an estimated 1.47 billion adults worldwide were overweight (BMI  $\geq$  25 kg/m<sup>2</sup>), of which 205 million men and 297 million women were obese (BMI  $\geq$  30 kg/m<sup>2</sup>).

The literature has found a positive but non-linear relationship between economic development and body weight.<sup>6–8</sup> However, these studies did not provide any theoretical foundation to explain the relationship between weight gains and economic development. Factors associated with weight gains include urbanisation,<sup>7</sup> economic transition from socialism to capitalism,<sup>8</sup> trade liberalisation<sup>10</sup> and technological progress.<sup>7,11,12,14</sup>

Only one study<sup>9</sup> has examined the convergence of weight gains among states of the USA. However, the study applied the traditional economic growth model and found that BMI grew faster in poorer states and the dispersion of BMI growth rates among states reduced over time. The main disadvantage of this method is that it did not allow an individual transition path of weight gain for each state.

This study contributes to the literature by applying a dynamic economic growth model by Phillips and Sul<sup>5</sup> and panel data analysis to investigate if BMI growth rates of Organisation for Economic Cooperation and Development (OECD) countries converge over time. Country-level factors associated with weight gains are also examined in an ecological analysis to provide ideas for public health policy applications.

## Methods

### Conceptual framework

In this study, a simple conceptual framework of energy balance<sup>15</sup> is used to analyse the trends and determinants of weight gains. A healthy weight is maintained when energy intake from foods and drinks equals the energy expenditure in activities and metabolism. Weight gain occurs when energy intake is greater than energy expenditure, and conversely, weight loss occurs when the energy intake is less than energy expenditure. This simple conceptual framework has been widely used in the literature.<sup>10,16–18</sup>

We argue that in the early stage of economic development, machinery replaces most manual labour, while technological progress in agricultural and food-processing industries results in cheap and abundant food. Therefore, economic

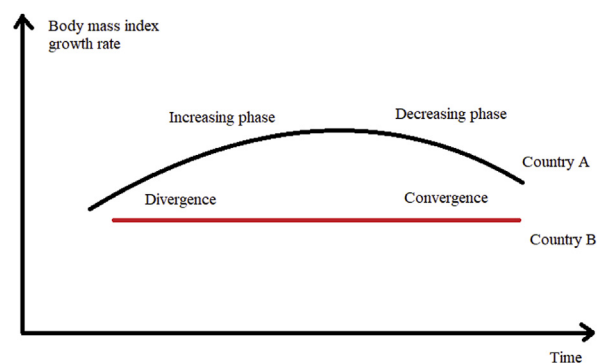
development can lead to increased obesity, due to a more sedentary lifestyle and an abundance of cheap high-calorie foods.<sup>19–21</sup> Many studies have provided evidence of the positive relationship between economic development and obesity.<sup>22,23</sup> The obesity prevalence increases in poorer countries as they develop.<sup>24</sup> However, as economic development continues, higher incomes allow people to buy healthier food and have more time for exercise.<sup>13,25</sup> Technology is also a key factor in reducing the growth rate of obesity at the mature stage of economic development. For example, marine biotechnology can result in increased productivity in the production of healthy food,<sup>26</sup> while the increasing use of robots in the workplace<sup>27</sup> allows people to work less and hence have more time for exercise.

The relationship between economic development and obesity may follow an ‘Obesity Kuznets curve’, named after the famous ‘environmental Kuznets curve’ to depict an inverted U-shape relationship between economic development and obesity.<sup>25,39,40</sup> Empirical studies show that the level of income per capita in which BMI reaches its peak varies from \$12,500 for females and \$17,000 for males.<sup>3</sup> A US study also found that the incidence of obesity (BMI  $\geq$  30 kg/m<sup>2</sup>) and morbidly obesity (BMI  $\geq$  40 kg/m<sup>2</sup>) for white women peaks when annual income per capita reaches \$30,000 and \$36,000, respectively<sup>25</sup> (the relationship was insignificant for white men).

We propose that BMI growth rates at first increase with economic development and then peak before gradually decreasing (see Fig. 1). Therefore, BMI growth rates among countries may converge in the long run, although a divergence is possible in the short run due to differences in economic development. We argue that the convergence of weight gains is more likely to occur among countries with a similar level of economic development. Thus, in this study, we focus on testing the convergence of BMI growth among OECD countries.

### Statistical analysis

The BMI growth rates of countries can be grouped into two main factors: the common factor (e.g. technology shared by all countries) and the individual factor (e.g. culture and environment of each country). The common factor is represented by the marginal average of BMI growth rates among countries,



**Fig. 1 – Stylized graph: BMI growth rates and economic development.**

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