***Health and Economic Burden of Insufficient Physical Activity in Saudi Arabia***

Short title: Burden of Physical Inactivity in Saudi Arabia

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# Abstract

**Background**

Insufficient physical activity (PA) was estimated to cause 4.8% of deaths and 2.6% of disability-adjusted life-years (DALYs) due to noncommunicable diseases in Saudi Arabia in 2019. While Saudi Arabia is already achieving great improvements, here, we predict the health and economic burden of insufficient PA up to 2040 to present a case for policy makers to invest more in the uptake of PA beyond baseline goals.

**Methods**

Using a population health model to estimate avoidable health loss, we identified four causes of health loss related to low PA—cardiovascular diseases, diabetes, breast cancer, and colorectal cancer—and estimated the deaths and DALYs from these causes. We projected the expected disease burden until 2040 under alternative assumptions about future PA levels and trends by using three health scenarios: baseline (no change in 2019 PA levels), intervention (81% of the population achieving sufficient PA levels), and ideal (65%: minimum 150 min/week moderate PA, 30%: high PA, and 5%: inactive). We applied an “intrinsic value” approach to estimate the economic impact of each scenario.

**Results**

Overall, we estimate that between 2023 and 2040, about 80,000 to 100,000 deaths from all causes and 2.5 million to 3.1 million DALYs could be avoided by increasing PA levels in Saudi Arabia. The average annual economic loss from insufficient PA is valued at 0.92% to 1.2% of the current gross domestic product, with an average of $6.5 billion to $8.8 billion annually till 2040. The most avoidable disease burden and economic losses are expected among males and because of ischemic heart disease.

**Conclusions**

This study highlights that low PA levels will have considerable health and economic impacts in Saudi Arabia if people remain inactive and do not start following interventions. There is an urgent need to develop innovative programs and policies to encourage PA among all age and sex groups.

# Introduction

Noncommunicable diseases (NCDs) are responsible for about two-thirds of deaths in Saudi Arabia [1] and represent a growing burden to healthcare systems and societies. Trends in NCDs are partly driven by population growth and aging but also by increased exposure to risk factors, such as unhealthy diet, tobacco use, and insufficient physical activity (PA), including sedentary behavior.

Globally, 7.2% and 7.6% of all-cause and cardiovascular disease deaths, respectively, are attributable to physical inactivity [2]. The proportions of NCDs attributable to physical inactivity vary by world region and level of income, with recent worldwide estimates showing that in Saudi Arabia, physical inactivity accounts for some of the highest risk for cardiovascular diseases, dementia, and cancer [2]. Insufficient PA contributes to nearly 5% of deaths in Saudi Arabia [3]. The country is currently undertaking significant transformation through Vision 2030 [4]. As part of this initiative, the Quality of Life Program aims at getting 40% of the adult population to meet PA recommendations by 2030, by engaging in PA at least 30 minutes a week [5]. According to the Saudi General Authority of Statistics (GASTAT), this goal has been achieved with 48.2% of the population now partaking in PA [6, 7]. Albeit meeting the Quality of Life Program target represents a clear progress, it remains below the standard recommendation provided by the World Health Organization and Centers for Disease Control and Prevention, which advocates for 150 minutes of moderate-intensity PA and 2 days of muscle-strengthening activity per week [8, 9]. Therefore, insufficient PA can be defined as not meeting the current recommended daily PA guidelines of doing at least 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity PA per week or any equivalent combination of the two [2]. Under this definition, over half of adults worldwide are not meeting the recommendations for PA [10].

The related concepts of the “economic burden of disease” and “cost of inaction” have been around for many years [12], but interest has been renewed due to the dramatic increase in sedentary lifestyles during the pandemic. As economic development continues to transform the labor force regionally towards more digital-based platforms, and enclosed environments, PA levels are expected to worsen - unless policy action is taken [11].

Studies examining the cost of inaction aim to quantify the cost of not addressing a particular disease, injury, or risk factor. These analyses often have counterfactual arguments, e.g., if disease X had been eliminated, there would have been Y economic benefits (usually valued in local or international currency). These estimates provide insight into the economic benefits of addressing health problems and are useful for agenda-setting, policy formulation and analysis, and advocacy purposes. Estimating the current losses due to physical inactivity will help set priorities to achieve more ambitious goals [4, 5] and help to design a framework to promote a balance between work commitments and PA.

Given the high burden caused by physical inactivity in Saudi Arabia, our study investigated the economic impact of health outcomes related to insufficient PA. We developed three hypothetical future health scenarios, based on alternative projections of PA levels in the population, and estimated number of deaths, and disability-adjusted life-years (DALYs) that could be avoided as a result of adequate PA. These health gains were then translated into economic returns using standard cost-benefit analysis methods, which could inform policy-making decisions at multi-sectorial level in Saudi Arabia.

# Methods

## Overview

Based on the consensus of the 2019 Global Burden of Disease (GBD) Risk Factors Collaborators (3), and on a previous related dose-response meta-analysis [13], four major causes of health loss were identified, with solid evidence for a causal association with insufficient PA: cardiovascular diseases(), diabetes, breast cancer, and colorectal cancer [14]. The association is stronger for cardiovascular diseases and diabetes [15] but weaker for cancers [16]. Fig 1 provides a conceptual overview of our analysis.

**Fig 1: Conceptual overview of the analysis**

Common to all approaches that estimate the health and economic impact of diseases and risk factors are two components: (i) estimated “avoidable” disease burden (left side of Fig 1) and then (ii) calculated economic value of that avoidable burden (right side of Fig 1).

To understand the relative importance of PA, population-attributable fractions (PAFs) measured disease burden as it is associated with chosen risk factors, with a scale ranging from 0 (no attribution of a risk factor to the cause of death) to 1 (cause of death is fully attributable to the risk factor). PAFs communicate the relative importance of the risk factor—in this case, insufficient PA—to various causes of death and between sexes. The PAFs in this analysis were calculated as the potential impact fraction for a theoretical population in which 100% of people participate in high levels of PA. The population distribution of PA would shift from 83% low, 10% moderate, and 7% high to 0% low, 0% moderate, and 100% high PA, respectively. While this is a theoretical and unattainable set-up, it is useful to see the distribution of risk more clearly.

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## Estimating Avoidable Health Loss

This study employed a population health model previously developed for NCD interventions in different countries [17] to project the expected disease burden in Saudi Arabia under alternative assumptions about future PA levels and trends.

Risk categories for the population were defined, as the 2019 GBD study reported the adjusted relative risk (RR) estimates for each of the four cause groups in increments of 600 metabolic equivalents (MET) min/week (e.g., 0, 600, 1200, 1800, etc.). The minimum theoretical health risk is associated with 3000 MET min/week to 4500 MET min/week (11); this is the minimum required MET min/week to be considered “healthy” and not at risk due to physical inactivity. For simplicity, we defined the population distribution of PA using three discrete categories that correlate well with the dose-response relationship that has been reported in the literature [13]:

1. **Low:** Below 600 MET min/week. To get a proxy risk level for this group, we averaged the RR values for 0 MET min/week and 600 MET min/week for each age and sex group.
2. **Moderate:** Between 600 MET min/week to 1800 MET min/week. We used age- and sex-specific RR values for 1200 MET min/week as the proxy risk level for this group.
3. **High:** Over 1800 MET min/week. As a conservative measure, we used age- and sex-specific RR values for 1800 MET min/week as the proxy risk level for this group.

Population distributions of current PA uptake in Saudi Arabia were obtained from the 2019 GASTAT Household Sports Survey [18].

Integral to estimating avoidable disease burden is to specify the health scenarios that define the bounds of “avoidable” accounting for the different risk categories. We modeled three such scenarios for Saudi Arabia:

1. **Baseline:** Assuming that PA levels reported in the 2019 GASTAT Household Sports Practice Survey [18] remain constant until 2040, with no further progress on increasing PA in the coming years. This served as the reference scenario for the other two scenarios.
2. **Intervention:** Assuming that PA levels could shift in 2023 to those observed in a high-performing (benchmark) country, reflecting ambitious but realistic changes in population behaviors due to PA interventions and maintained until 2040. In this analysis, we defined Sweden as the benchmark country, as being one of the better countries to implement these interventions and having the lowest levels of inactive populations [19-21]. The assumption used for this scenario, based on data from Sweden, was that 81% of the population would achieve sufficient levels of PA, defined as the recommended minimum of 150 min/week of moderate PA [9, 10, 22].
3. **Ideal:** Assuming that PA could shift in 2023 to “ideal levels,” reflecting the maximum possible health impact of improved PA and maintained until 2040. We defined “ideal” as 65% participating in at least 150 min/week of moderate PA, another 30% of the population participating in more intense and/or frequent levels of PA above the minimum recommended, and the remaining 5% of the population assumed to be inactive for health or aging-related reasons (e.g., spinal cord injury, severe dementia) and unable to achieve at least the 150-minute recommendation.

To calculate avoidable health loss due to insufficient PA, the potential impact fraction (PIF) [23] was calculated for each of the four causes of death linked to inadequate PA, as well as by age group and sex. Potential impact fraction values are based on the population distribution (P) of PA and relative risk (RR) in each risk category (i):

where is the baseline risk distribution (i.e., the proportion of the population participating in each level of PA according to the 2019 GASTAT Household Sports Practice survey data) [18], and is the alternative risk distribution in the intervention and ideal scenarios. Relative risk estimates for colorectal cancer, breast cancer, ischemic heart disease, ischemic stroke, and type 2 diabetes mellitus for males and females aged 25-79 years were taken from other GBD studies [3, 13]. For each risk factor, a Bayesian hierarchical model was applied to predict risk factor levels [23, 24]. The potential impact fraction was applied to the baseline projection of deaths as previously developed in another modeling study [17], yielding alternative estimates of age-, sex-, and cause-specific deaths. We then translated these deaths into DALYs using the ratios of deaths to DALYs in Saudi Arabia, as reported in the 2019 GBD study [1]. High body mass index is an intermediary risk factor for these disease outcomes. Still, the literature suggests that insufficient PA is a risk factor for diseases independent of high body mass index [15], so our analysis used these RRs for inadequate PA [13] of the former.

## Estimating Economic Impact

In our analysis, we followed the intrinsic value approach based on the three general approaches to conduct the economic valuation of improved health [25]. Specifically, this involves converting the value of a statistical life for a given country into the value of a statistical life-year and then multiplying the latter quantity by the number of DALYs averted in the intervention and ideal scenarios relative to the baseline scenario [20, 23].

## Results

## Population-Attributable Fractions

We performed a PAFs analysis to understand the relative importance of physical inactivity in the Saudi Arabia population. Fig 2 plots the range of PAF values across the different five-year age groups in the 25-79 years range (y-axis), disaggregated by sex and cause of death (x-axis). It reveals three main findings. First, age-specific PAFs are relatively consistent, differing at most by about 0.035 units. Second, PAFs are generally higher for females than males regardless of the cause of death or age group, reflecting the lower level of PA among females in most age groups. Third, PAFs are the highest for cardiovascular causes, followed by diabetes, which influences the projections of avoidable deaths by cause at the population level.

**Fig 2: Population-attributable fractions derived from this analysis**

## Avoidable Mortality and Disability

By applying the three categories to develop different scenarios, at baseline, the average population distribution of MET-min/week in Saudi Arabia across age groups was 83% low, 10% moderate, and 7% high. In the intervention scenario, the low, moderate, and high groups would change to 19%, 74%, and 7%, respectively. In the ideal scenario, the low, moderate, and high groups would change to 5%, 65%, and 30%, respectively.

Overall, it is estimated that between 2023 and 2040, about 80,000 (intervention scenario) to 100,000 (ideal scenario) deaths from all causes could be avoided by increasing PA levels in Saudi Arabia. Fig 3 shows the annual number of deaths that could be avoided. This number would increase by about one-third between 2023 and 2040 due to population growth and aging (as would the total number of deaths in the baseline scenario).

**Fig 3: Deaths from selected causes that could be avoided between 2023 and 2040 in two scenarios of increased physical activity in Saudi Arabia**

The total number of DALYs that could be avoided ranged from 2.5 million (intervention scenario) to 3.1 million (ideal scenario). Over time, trends in avoided DALYs would be similar to those in deaths avoided shown in Fig 3, increasing by about one-third between 2023 and 2040.

Fig 4 illustrates the cumulative avoidable deaths and DALYs in the two scenarios and disaggregates these deaths by cause. The overwhelming majority of deaths and DALYs would be due to ischemic heart disease, as this cause has the highest PAFs (Fig 2). Conversely, the burden of breast cancer and colorectal cancer would not be significantly reduced with increased PA because these conditions are less common and may involve other factors, such as genetics, and their PAFs are lower than those of cardiovascular diseases and diabetes.

**Fig 4. Cumulative cause-specific deaths and DALYs avoidable between 2023 and 2040 in two scenarios of increased physical activity in Saudi Arabia**

## Economic Impact

Based on the estimates of avoidable deaths and DALYs, we calculated the economic cost of avoidable disease burden using the intrinsic value approach. The implied economic value of an avoidable DALY in Saudi Arabia is 2.3 times the gross domestic product (GDP) per capita (20). Table 1 presents the economic impact of insufficient PA, with results disaggregated by sex and scenario. The cumulative impact would range from $110 billion (intervention scenario) to $150 billion (ideal scenario), an average of $6.5 billion to $8.8 billion annually over the next 17 years, or 0.92% to 1.3% of the current GDP.

Most of the economic impact of insufficient PA would be from individuals with ischemic heart disease, and males would be disproportionately affected, accounting for 66% of health and economic losses. Under the intervention scenario, approximately $75 billion would be saved from insufficient PA in males, approximately 60% of which can be attributed to ischemic heart disease. Under the ideal scenario, $97 billion would be saved from insufficient PA in males, approximately $58 billion of which would be saved due to ischemic heart disease (Table 1).

**Table 1.** Economic impact of insufficient PA in Saudi Arabia (2023 – 2040)

|  |  |  |  |
| --- | --- | --- | --- |
| **Scenario** | **Males** | **Females** | **Both sexes** |
| **Intervention** | $75 billion | $38 billion | $110 billion |
| **Ideal** | $97 billion | $48 billion | $150 billion |

Note: Costs are given in 2020 United States dollars.

# Discussion

Overall, we estimate that between 2023 and 2040, 80,000 (intervention scenario) to 100,000 (ideal scenario) deaths from all causes could be avoided by increasing PA levels in Saudi Arabia. If these scenarios are not implemented, the economic value of this excess mortality and disability would be between $110 billion and $150 billion, respectively. Results show that most of the economic impact of insufficient PA would be from individuals with ischemic heart disease, and males would be disproportionately affected.

In the literature, three general approaches are available to conduct the economic valuation of improved health [7]. In brief, health losses can be valued purely in instrumental terms, where the loss implies a reduction in macroeconomic output related to decreased labor-force participation and capital formation/deployment (i.e., the “human capital” approach). They can also be valued according to the excess medical and non-medical costs incurred because of excess disease burden (i.e., the “cost-of-illness” approach). Finally, they can be valued in welfare terms, reflecting the intrinsic preferences individuals have for health over income (i.e., the “intrinsic value” approach). The latter approach is mostly used in cost-benefit analysis. It employs a “value of a statistical life” parameter estimated from stated and revealed preference studies among individuals engaged in hazardous work, most of which have come from the United States of America. The Lancet Commission on Investing in Health (19) synthesized this literature and generated estimates of the value of a life-year gain that could be applied worldwide, including in low- and middle-income countries. The intervention scenario used in the study is intended to be a more realistic level that Saudi Arabia could achieve through governmental policies. The reason for choosing a high PA level for the ideal scenario was to provide an “upper bound” on the health and economic burden of insufficient PA.

The study findings suggest a larger economic impact of physical inactivity than that implied by previous modeling studies in the country. For example, a 2018 World Health Organization’s study estimated that economic losses from all NCDs—irrespective of the attribution to physical inactivity—were about 2.8% of GDP in Saudi Arabia [26]. An update of this research on direct medical costs and worker productivity found that NCD-related losses were approximately 4.5% of GDP [27]. We found that the economic impact of physical inactivity-related NCDs alone—about 5% of the NCD burden—would be valued at 0.92-1.3% of GDP. A reason our estimates are higher than those of previous studies is that we used an intrinsic value approach, which typically gives estimates substantially larger than estimates using the “human capital” or “cost-of-illness” approaches [25]. For example, applying the intrinsic value approach to all NCD deaths in 2019 would yield a value of around 25% of GDP globally and approximately 10% of GDP in Saudi Arabia [18], as compared to the 3-10% of GDP found in various country-level NCD investment cases [26]. These figures and approaches best correspond to reality and remain a contested issue in the literature; we note that our estimates are higher than others but are consistent with a welfare perspective that includes non-market losses [12].

This study’s findings underscore an urgent need to develop innovative programs and policies to encourage PA, specifically to tackle cardiovascular diseases and diabetes. The main challenge with tackling insufficient PA, dietary risks, or both is the paucity of evidence-informed policy options. The Disease Control Priorities project recently provided recommendations for intersectoral policy action to reduce health-related risks [20]. Large-scale built-environment interventions to promote PA are more likely to succeed than small-scale community-based health promotion interventions, but neither has a particularly robust evidence base. The situation in Saudi Arabia is not unique; as it ranked the 3rd among 172 countries with the greatest cardiovascular disease mortality risk attributed to PA [2],other developed countries face similar policy challenges. Governmental agencies should consider “experimenting” with different urban planning, transportation, and infrastructure-related policies that can incentivize PA. They should prospectively evaluate these policies using rigorous scientific methods. Ambitious policy experimentation could allow these governments to become international examples in obesity and NCD prevention.

It must also be emphasized the distinction between insufficient PA and high body mass index (i.e., overweight and obesity) as risk factors for NCDs. Obesity is responsible for a greater share of deaths than insufficient PA (22% vs. 4.8%, respectively) [3]. Hence, while inadequate PA is a risk factor for obesity, dietary risks appear to be much more important drivers of obesity-related disease burden in Saudi Arabia [28]. Efforts by the government and other stakeholders to tackle obesity should take a comprehensive approach, with a relatively greater emphasis on dietary risks. Unfortunately, there are no simple policy solutions to dietary risks; most Wordl Health Organization-recommended “cost-effective” interventions have a small impact and are cost-effective merely because they are cheap [29]. Further research is needed to understand the dietary drivers of obesity and the policy interventions that can most effectively promote a healthy weight.

This analysis has some important limitations. First, as implied previously in the discussion, the “costs” that we report here are economic costs (based on estimates of welfare losses) rather than financial outlays. Excess healthcare costs can be a more relevant measure to some stakeholders and represent “costs” borne by payers. It was beyond the scope of this article to compare multiple approaches to evaluating health losses, but future projects with sufficient data could allow for these analyses. Second, our model used population-level data and average values based on triangulating surveys and other data sources. We could not account for joint distributions of various risks (e.g., low PA, tobacco use, and high cholesterol) concentrated in the same high-risk individuals. An individual-level simulation model could incorporate these factors, but high-quality, individual-level data in Saudi Arabia is lacking. Population-based cohort studies of NCD risk factors and long-term outcomes would enhance local understanding of trends in major diseases and improve the accuracy and precision of modeling analyses like this study.

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# Conclusions

If no additional action is taken, insufficient PA could lead to an excess of 80,000 to 100,000 deaths and 2.5 million to 3.1 million DALYs in Saudi Arabia between 2023 and 2040. The economic value of these health losses could be as high as 0.92% to 1.2% of the GDP. Tackling physical inactivity in the country will require multisectoral approaches that include redesigning transportation systems, strengthening school-based PA programs, behavioral and social approaches, including community clubs and classes, and effective urban planning. Given the lack of robust evidence on interventions to improve PA, there is an opportunity for governmental agencies to experiment with policies and rigorously evaluate their effectiveness and costs, significantly contributing to the international evidence base.

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