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# Financial Burden of Weight Gain: A Secondary Analysis Study on MNGHA's Employees, Saudi Arabia

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**ABSTRACT**

**Introduction:** Obesity and related chronic health conditions pose significant financial and healthcare implications in workplace settings worldwide. The objective of this study is to examine the economic impact of weight gain among full-time employees working at the Ministry of National Guard Health Affairs (MNGHA) in Alhasa and Dammam, Saudi Arabia.
**Methods:** In order to achieve the research objective a drawing from cross-sectional datasets, the research was done to estimate the healthcare costs associated with each additional kilogram of weight gain and to explore its link to the occurrence of chronic illnesses such as Type 2 Diabetes, Hypertension, Asthma, and Depression. Traditional and machine learning models were used to estimate the approximate cost of weight gain per kilogram. The models include Linear, KNN, Random Forest, Decision Tree, Linear SVM, and RBF SVM applied on both SAS 9.4 and Python. Models were evaluated to select the most suitable model.
**Results:** Hypothesis testing and correlation showed a significant difference between work schedules, age, and year of experience. The model estimated that with every one-kilogram gain in weight, the total burden increases by 676 SAR.
**Conclusion:** This study clearly showed that incremental weight gain among MNGHA employees contributes to a significant financial burden on healthcare costs.

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## INTRODUCTION

The rise in obesity is a growing public health problem, creating major financial challenges for healthcare systems, particularly in Saudi Arabia. Numerous research studies have examined the impact of obesity on productivity at work and its potential to raise direct medical costs [1].

Particularly, studies have focused on the relationship between weight gain after employment and the financial impact of chronic diseases linked to this change in physiology. Accordingly, it becomes evident that obesity is not only a health concern but also an economic phenomenon [1]. As the country undergoes rapid economic growth and a decrease in unemployment rates, many people are witnessing changes in physical activity and eating habits, which may increase their risk of obesity [2]. Beyond its health implications, obesity imposes a substantial economic burden on healthcare systems and employers globally. Previous studies have emphasized the significant financial costs of obesity, ranging from increased medical expenses

to reduced workplace productivity According to a recent research conducted in 2022, healthcare costs associated with obesity in Saudi Arabia reach nearly 3.8 billion SAR annually [3,4].

## LITERATURE REVIEW

A substantial body of research has examined the economic and health impacts of obesity globally, but there is limited work quantifying the costs associated with incremental weight gain, particularly in specific populations such as employees.

Globally, obesity accounts for a significant portion of healthcare expenditures. Studies have highlighted that medical costs attributed to obesity in the USA alone exceed $190 billion annually, with the majority of expenses related to treating obesity-related comorbidities, this results was concluded using cost-effect approach [5]. Similarly, in Europe, a study using simulation model revealed that obesity has been linked to an increase in workplace absenteeism and healthcare resource utilization, leading to billions in indirect costs [6].

Research has shown that obesity increases direct healthcare costs and impacts employee productivity. Meta-Analysis Studies from Australia have demonstrated that overweight employees incur higher absenteeism and presentism rates, translating into significant economic losses for employers [7]. Furthermore, shift work and irregular schedules have been linked to a higher risk of weight gain, suggesting the need for targeted interventions in occupational health [8].

In Saudi Arabia, the economic burden of obesity is exacerbated by cultural and environmental factors, such as reliance on high-calorie diets and limited opportunities for physical activity. Recent studies have emphasized the financial strain obesity places on the country's healthcare system, with costs expected to rise as obesity prevalence increases [9]. Workplace interventions, such as wellness programs and dietary counseling, have shown promise in addressing this issue in similar populations, but their effectiveness in Saudi Arabia remains underexplored [10].

This study focuses on understanding the financial impact of incremental weight gain among MNGHA's employees. Using existing data, quantifying the additional healthcare costs incurred for each kilogram of weight gained, highlighting the direct economic consequences of weight gain at a granular scale will be conducted.

While numerous studies have examined the overall economic cost of obesity, there remains a significant gap in research concerning the financial implications of each incremental kilogram of weight gain on healthcare costs. This study aims to address this gap by estimating the healthcare costs linked specifically to weight gain among employees of the MNGHA. Through a granular analysis, this research will quantify the financial burden associated with weight gain, providing a unique perspective on obesity-related healthcare costs in the workplace. The primary research question is: What is the estimated healthcare costs incurred for each kilogram of weight gained by MNGHA employees after employment?

The paper aims to estimate the incremental increase in direct medical costs associated with each kilogram of weight gained among full-time MNGHA employees. In Addition, it aims to analyze the relationship between weight gain, years of employment, and the cost development of chronic diseases, and to implement traditional linear model and machine learning models to select the best suitable model to the data.

## METHODOLOGY

This study conducted a secondary analysis of existing cross-sectional data from 380 full-time MNGHA employees [11]. The dataset includes demographic and job-related variables, such as age, gender, marital status, occupation, and work schedule, as well as health indicators, such as weight before and after employment and the development of chronic diseases post-employment. The financial burden of obesity was calculated by multiplying the years of experience by the cost of each disease a single employee developed. For example, asthma costs 7,121 SAR per patient/year, and hypertension costs 8,437 SAR per patient/year [12]. Suppose an employee developed asthma and hypertension with 5 years of experience. In that case, the total cost of treating these diseases -which are assumed to have developed once someone gains weight or becomes obese- is (8,437×5) + (7,121×5) = 77,790 SAR for this single employee over a period of 5 years.

### Data Analysis Plan

Descriptive statistics were employed to summarize demographic characteristics. For numerical variables, the mean and standard deviation were calculated for normally distributed data, while the median and interquartile range were used for non-normal distributions. For categorical variables, frequencies and percentages were reported.

Hypothesis tests were conducted to examine the relationship between demographic variables and the burden cost of weight gain. For numerical variables, correlations were analyzed in relation to the total cost of weight gain. The Mann-Whitney U test or t-test was applied for categorical variables depending on the data distribution.

A multivariate linear regression model was applied to evaluate the association between weight gain and total healthcare costs, incorporating relevant variables. Adjustments on the linear model will be used if any assumption is violated such as log transformations or a robust variance estimator were considered to ensure the model's validity. Machine learning models which include Random Forest, KNN, SVM, and Decision Tree will be use and compared with linear model in term of R-square, Akaika Information Criterion (AICC), and Root Mean Square Error (RMSE) [17]. Selection will be made on a model that performs the best. The analysis was done using SAS 9.4 and Python.

## RESULTS

The study included a total of 380 employees. A significant proportion of the participants were female (50.7%), and most reported not having undergone weight-loss surgery (87.11%). Additionally, most participants noticed weight gain prior to their recruitment (75.53%). In terms of marital status, the majority were single (66.84%), and a significant number occupied administrative or faculty positions (60%). Regarding the nature of work, nearly half of the participants (45.53%) reported engaging in roles that involved physical movement, and a large majority had a regular work schedule (76.32%). Interestingly, most participants (78.16%) indicated they had not developed any chronic illnesses [Table 1].

**Table1.** Descriptive Statistics Table

| | Frequency (%) |
|---|---|
| Q2: Have you undergone any weight loss surgery? | |
| 1) Yes | 49 (12.89%) |
| 2) No | 331 (87.11%) |
| Q4: Have you noticed any weight gain before and after joining MNGHA? | |
| Yes | 287 (75.53%) |
| No | 93 (24.47%) |
| Q8: Gender | |
| Male | 187 (49.21%) |
| Female | 193 (50.79%) |
| Q9: Status | |
| Single | 254 (66.84%) |
| Married | 126 (33.16%) |
| Q10: Occupation | |
| 1) Health care staff | 152 (40%) |
| 2) Admin and faculty staff | 228 (60%) |
| Q11: Does your work nature include physical movement? | |
| 1) Yes | 173 (45.53%) |
| 2) No | 133 (35%) |
| 3) Sometimes | 74 (19.47%) |
| Q13: Work schedule | |
| 1) Regular | 290 (76.32%) |
| 2) Shifts | 90 (23.68%) |
| Q14: Living with chronic illness. Specify if yes | |
| 1) Yes | 83 (21.84%) |
| 2) No | 297 (78.16%) |

The median age of participants was 36 years, with a median weight gain of 9 kg reported after a median of 8 years of work experience. The total estimated cost attributed to the burden of weight gain—stemming from the development of chronic diseases—amounted to approximately 7.6 million SAR. Among the chronic conditions, high cholesterol represented the highest financial burden (2.9 million SAR), followed by diabetes, hypertension, and depression [Table 2].

**Table 2.** Numerical Descriptive Statistics

| | Mean ± STD / Median (IQR) |
|---|---|
| Age | 36 (10) |
| Weight Before Recruitment | 68 (21) |
| Weight After Recruitments | 75 (24) |
| Estimate Weight gain after Recruitment | 9 (10) |
| Years of Experience | 8 (10) |
| Total Cost Estimated | Total: 7619689.2 Average: 245796.4258 |
| Cost of Hypertension | Total: 2252679 Average: 225267.9 |
| Cost of Diabetes | Total: 2375962.2 Average: 182766.3231 |
| Cost of High Cholesterol | Total: 2988448 Average: 373556 |
| Cost of Depression | Total: 2600 Average: 1300 |

**Bivariate Analysis**

Hypothesis testing revealed notable relationships between the financial burden of weight gain and various factors. Employees with regular work schedules exhibited a significantly higher financial burden than those working in shifts, with total costs of 168,740 SAR (mean: 104,261) versus 126,555 SAR (mean: 75,933; P = 0.0214). Additionally, single employees experienced a higher financial burden compared to their married counterparts, with a close-to-significant p-value. Specifically, the financial burden was 158,960 SAR (mean: 95,989) for single employees and 101,244 SAR (mean: 144,375) for married employees. Further analysis demonstrated positive correlations between financial burden and several factors, including age, years of experience, and total weight gain. The correlation coefficients were 0.39 (P = 0.0072) for age, 0.78 (P < 0.0001) for years of experience, and 0.28 (P = 0.059) for total weight gain. These findings emphasize the interplay between professional and personal factors and the economic implications of weight gain [Table 3].

**Table3.** Bivariate Analysis Table

| Bivariate Analysis (Hypothesis Testing) | Median (IQR) of Financial Burden | P-Value |
|---|---|---|
| Q2: Have you undergone any weight loss surgery? | | |
| 3) Yes | 168740 (31427) | 0.9549 |
| 4) No | 151057 (138223) | |
| Q4: Have you noticed any weight gain before and after joining MNGHA? | | |

| | | |
|---|---|---|
| Yes | 158960 (100982) | 0.5938 |
| No | 134002 (188631) | |
| Q8: Gender | | |
| Male | 158960 (95989) | 0.4908 |
| Female | 158960 (144260) | |
| Q9: Status | | |
| Single | 158960 (95989) | 0.0571 |
| Married | 101244 (144375) | |
| Q10: Occupation | | |
| 3) Health care staff | 126861.5 (48305) | 0.5592 |
| 4) Admin and faculty staff | 158960 (146611) | |
| Q11: Does your work nature include physical movement? | | |
| 4) Yes | 143429 (42185) | 0.9838 |
| 5) No | 158960 (100982) | |
| 6) Sometimes | - | |
| Q13: Work schedule | | |
| 3) Regular | 168740 (104261) | 0.0214 |
| 4) Shifts | 126555(75933) | |
| Q14: Living with chronic illness. Specify if yes | | |
| 3) Yes | 158823 (115408) | - |
| 4) No | - | |
| Q3:Age | Corr Cof:0.3955 | 0.0072 |
| Q12: Years of Experience | Corr Cof: 0.78379 | <0.0001 |
| Total Weight Gained | Corr Cof: 0.28274 | 0.05969 |

**Model Selection and Outcome**

After applying all suitable models for the data outcome, both the linear regression model and K-NN had the best performance. To serve our explainability aim, a linear model with a robust estimator will be selected with a high R-Square, lower AICc, and a slightly higher RMSE than K-NN [Table 4].

**Table4.** Model Selection Criteria

| Model | R-Square | RMSE | AICc |
|---|---|---|---|
| Linear Regression | 0.003288 | 89794.744328 | 376.605379 |
| Random Forest | -0.106017 | 94590.393561 | 378.270322 |
| K-NN | 0.171937 | 81846.060097 | 373.639418 |
| Decision Tree | -0.809372 | 120984.603770 | 386.145758 |
| SVM (linear) | 0.001174 | 89889.960288 | 376.639293 |

| | | | |
|---|---|---|---|
| SVM (RBF) | -0.000390 | 89960.307026 | 376.664326 |
| Linear with Robust estimator | 0.1833 | 96405 | 92.3701 |

A multivariate model was employed, with adjustments made using the Sandwich Variance Estimator to account for variability. The model's R-square was 0.18, indicating that the included predictors explained approximately 18% of the variation in financial burden. The analysis revealed that each additional kilogram of weight gain was associated with an approximate cost of 676 SAR for MNGHA. Based on prior studies, the average weight gain over an average duration of work experience was estimated at 10 kg. For single employees with regular work schedules, the financial burden was calculated to be approximately 187,246 SAR [Table 5].

**Table 5.** Linear Regression Model outcome

| Multivariate Linear Regression Model | | | | |
|---|---|---|---|---|
| Parameter | | Estimate | Standard Error | P-Value |
| Intercept | | 47759.72 | 30994.24 | 0.1233 |
| Weigh Gained | | 676.7357 | 659.8317 | 0.3051 |
| Work Schedule | Regular vs. Shift | 62272.24 | 28485.71 | 0.0288 |
| Status | Single Vs. Married | 69905.78 | 26955.51 | 0.0095 |

## DISCUSSION

The data reveals a positive correlation between financial burden and age (correlation coefficient = 0.39; $p = 0.0072$), and a stronger correlation with years of experience (correlation coefficient = 0.78; $p < 0.0001$). The strong relationship between years of experience and financial burden could indicate that the longer an employee remains in a sedentary or high-stress job, the more likely they are to experience weight gain and related health issues. Similarly, the age-related increase in financial burden may reflect age-associated health risks contributing to chronic disease. This finding highlights the importance of implementing early intervention wellness programs for employees with fewer years of experience to help prevent the cumulative effects of weight gain and chronic diseases over time. A proactive approach could lower healthcare costs associated with aging employees.

In the multivariate linear regression model, single employees and those with a regular schedule face a higher financial burden. Specifically, the model estimates that with each kilogram of weight gain, the financial burden increases by approximately SAR 676, holding other factors constant. This analysis suggests that marital status and work schedule independently contribute to financial burden, even when controlling for other variables. The model's R-square (0.18) indicates that while these variables are predictive, other unmeasured factors likely also impact financial burden. This result supports the need for diverse intervention strategies that consider physical health, social factors, and work-life balance, with adjustments for individual weight gain patterns.

The total financial burden attributable to high cholesterol, diabetes, hypertension, and depression shows that high cholesterol is the costliest condition, followed by diabetes, hypertension, and then depression. This hierarchy suggests that certain chronic conditions associated with obesity carry a disproportionate financial burden. High cholesterol's leading position indicates a need to focus on dietary interventions and cholesterol management within wellness programs. By identifying which conditions contribute most to the healthcare costs, MNGHA can prioritize resources to target high-cost conditions, potentially reducing overall financial burden through focused health screenings and preventive care programs.

The results found in this study align with some previous research which were performed to assess the economic burden associated with obesity. All these studies have supported the role of wellness programs in reducing the healthcare costs associated with weight gain. However, the specific correlation of variables, such as the impact of marital status and work schedules, differ in terms of correlation in the previous studies.

While similar studies conducted in the United States and Europe, highlight substantial healthcare costs associated with obesity, this study provides a unique perspective within a Saudi healthcare setting, emphasizing the cultural and organizational factors influencing weight gain and chronic disease prevalence.

The data underscore a trend seen in international studies, reinforcing the need for workplace health interventions worldwide, though cultural and contextual factors may influence specific outcomes [13].Another study identified a direct association between obesity and increased healthcare costs. Their research indicated that individuals with higher BMI incurred significantly higher medical expenditures than those of normal weight [14].One additional research also supports the findings of the study on the impact of work schedules on weight gain and associated healthcare costs. Their study demonstrated that employees working regular schedules were more prone to weight gain and related health issues due to sedentary work patterns and limited physical activity [15].

**Strength**

This study has several important strengths that make its findings impactful and relevant. It provides a well-rounded analysis that connects weight gain among employees to financial burdens, particularly the costs associated with chronic conditions like high cholesterol, diabetes, and hypertension. By using robust statistical model and several machine learning models, the study ensures reliable and meaningful insights into how factors such as age, marital status, work schedules, and years of experience influence health-related expenses. What sets this study apart is its focus on the cultural and organizational aspects of the Saudi healthcare setting, offering a unique perspective that complements similar international studies. Additionally, by emphasizing the economic implications of weight gain and the role of workplace variables, the study highlights practical opportunities for targeted wellness programs and policy interventions to support employees' health while reducing costs. These findings make a strong case for proactive, culturally tailored approaches to managing weight and chronic diseases in healthcare organizations.

**Limitation**

This study was applied only in two branches of MNGHA, which limits the generalization of the study. The majority of the study participants did not report their developed chronic diseases, and the total cost was only calculated for those who were willing to share their disease. MNGHA is a government hospital that provides medical care to employees and their dependents, such as wives/husbands, children, mothers, and fathers. This study did not account for the weight gain from dependence. For further study, data should be collected from the MNGHA healthcare system to reduce the effect of recall bias.

Accordingly, unmeasured variables, such as family history, personal income, and lifestyle choices outside of work, may contribute to weight gain and healthcare costs but are not fully accounted for in this study. Future research should consider these variables to provide a more comprehensive understanding of factors affecting employee health costs. Moreover, the focus on MNGHA limits generalization across different sectors, though this study offers valuable insights for similar healthcare organizations

## CONCLUSION

This study clearly showed that incremental weight gain among MNGHA employees contributes to a significant financial burden on healthcare costs. Each kilogram of weight gained has a noticeable impact on healthcare expenses, especially for chronic diseases such as high cholesterol and diabetes.

The results support the need for targeted workplace wellness programs and policy interventions to manage weight and prevent chronic diseases in healthcare settings.

In addition, it is recommended that a further study could be carried out to extend this analysis to track weight and health outcomes over longer periods, allowing for a more comprehensive view of the long-term financial impacts.

**Competing Interests**

The authors have no competing interests as defined by BMC, or other interests that might be perceived to influence the results and/or discussion reported in this paper.

**Ethical Approval and Consent to Participate**

All participates in the study provided their consent before participation. In Addition, This study was approved by the Institutional Review Board of King Abdullah International Medical Research Center, which align with international guidelines and the 'Law of Ethics of Research on Living Creatures' established by the National Committee of Bioethics (NCBE) in Saudi Arabia. The study has a protocol number of NRA24/003/11.

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**Data availability and Materials**

The dataset supporting the conclusions of this article is available upon requesting from King Abdullah International Research Center IRB unit.

**Consent for publication**

All participants signed a consent form approved by the KAIMRC IRB. Additionally, the anonymity of all participants was maintained throughout the study.

**Authors' Contributions**

S.K: conceptualization, interpretation and writing, revision, editing, analysis, validation and writing, proposal writing, and ethics review process for IRB approval. R.A: original manuscript draft wring, critical review, feedback, revision, editing and writing of proposal, critical review of manuscript, preparation of the presentation and feedback. A.H: validation, critical review of the manuscript, feedback, revision, editing and writing of proposal and preparation of the presentation. A.A: validation, critical review of the manuscript, feedback, revision, editing and writing of proposal, preparation of the presentation.

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**Conflict of Interest:**

The authors declare that this study was completed without any financial assistant that could be a possible conflict of interest.

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