BMC Health Services Research

RESEARCH

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# The variations in health cost based on the traditional obesity parameters among patients with coronary artery diseases undergoing cardiac catheterization

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## Abstract

**Background** In the literature, obesity has been correlated with coronary artery diseases (CADs) and high health costs. This study aimed to investigate the relationships between obesity parameters and the health costs among patients with CADs undergoing cardiac catheterization.

**Method** A secondary data analysis was done for an original study. The original study was conducted among 220 hospitalized patients undergoing cardiac catheterization from two main hospitals located in the Middle and Northern regions of Jordan. Bivariate Pearson's correlation and forward linear regression analysis were calculated in this study.

**Results** The average health cost for the participants was 1,344 JOD (1,895.63 USD). A significant positive moderate correlation ($r=0.4$) was found between hip circumference (HC) and health cost. There were significant positive weak correlations between low-density lipoprotein (LDL), triglycerides, high-sensitivity C-reactive protein (HS-CRP), hemoglobin A1c (HbA1c), and depression, and the health cost (correlation coefficient 0.17, 0.3, 0.29, 0.22 and 0.17, respectively. HC, waist circumference (WC), waist-height ratio (WHtR), waist-hip ratio (WHR), and body adiposity index (BAI) were significantly associated with health costs among male participants. In contrast, among females, none of the obesity parameters was significantly associated with health costs. The forward regression analysis illustrated that an increase of HC by 3.9 cm (β (0.292) * SD (13.4)) will increase the health cost by 1 JOD (0.71 USD). The same analysis revealed that HS-CRP increased by 0.4 mg/dl (β (0.258)*SD (1.43)), or triglycerides increased by 8.3 mg/dl (β (0.241)* SD (34.3)), or depression score increased by 0.32 score (β (0.137)* SD (2.3)), or total cholesterol increased by 4 mg/dl (β (0.163)* SD (24.7)), the health cost will increase by one JOD (0.71 USD).

**Conclusion** Healthcare providers, including nurses, should significantly consider these factors to reduce the health costs for those at-risk patients by providing the appropriate healthcare on time.

**Keywords** Health cost, Obesity parameters, Body Anthropometrics, Coronary artery diseases, Cardiac catheterization

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## Introduction

On a global scale, coronary artery disease (CAD) is considered a main cause of mortality and disability. It was estimated that 8.9 million people died from ischemic heart disease in 2015 [1]. Nowadays, developing countries carry the huge financial burden of cardiovascular diseases. It is thought that the worldwide prevalence of unhealthy lifestyle choices, such as smoking, being overweight, and leading a sedentary lifestyle, have contributed to an increased incidence of CAD in recent years [2].

Obesity has been found to have nearly tripled since 1975, thus becoming a major concern worldwide [3]. More than 1.9 billion adults aged 18 years and older were identified as being overweight in 2016. Of these, over 650 million were obese [3]. Obesity and overweight were defined by the World Health Organization (WHO) in 2022 and the Obesity Society in 2013, as an abnormal excessive fat collection that affects health. In adults, if the body mass index (BMI) is equal to or greater than 25 kg/m$^2$, an individual is considered overweight, whereas a BMI greater than or equal to 30 kg/m$^2$ is considered obese. Obesity is associated with biological, psychosocial, socioeconomic, and environmental factors [4–7].

Furthermore, WHO [8] reported that, worldwide, between 74% and 86% of females and between 69% and 77% of males are overweight or obese. Correspondingly, obesity is considered a risk factor for coronary artery disease [9]. Numerous obesity parameters are used to measure and classify obesity into categories. These obesity parameters were addressed in terms of their relations with coronary artery disease and its related risk factors [10].

Being overweight or obese increases the individual's susceptibility to cardiac diseases, diabetes, stroke, and high blood pressure [11]. Maintaining a healthy weight is essential, not only for lowering the risk of developing these chronic conditions but also for helping a person to feel energetic and able to enjoy life [11]. Correspondingly, obesity is a significant risk factor for CAD, and it has been increasing progressively in the last decades [12, 13]. In this context, different obesity parameters were studied in relation to CAD and its risk factors. The parameters include waist-height ratio (WHtR), waist-hip ratio (WHR), body adiposity index (BAI), BMI, body shape index (BSI), waist circumference (WC), and hip circumference (HC) [12]. Each of these parameters offers a unique insight into fat distribution and body composition, which are considered key factors in cardiovascular health [12]. For example, HC and WC, whether applied individually or in combination, offer valuable information about metabolic risk and fat distribution [14, 15]. Understanding obesity parameters and their relation to cardiac diseases could help healthcare professionals identify individuals at risk of CAD and develop interventions to manage and prevent its progression and complications [12, 16, 17].

Patients with CAD could need to undergo coronary angiography, or it might be an elective procedure to identify the reason for abnormal stress test results or high-risk features on non-invasive imaging [18]. However, patients who experience chest pain or other symptoms indicative of a heart attack or unstable angina require urgent intervention to assess the severity of CAD and guide immediate treatment decisions [18]. Knowing the reason for angiography in the study population is vital to interpreting the results and identifying the different obesity parameters in relation to CAD based on the patient's clinical presentations [17].

Obesity is associated with numerous chronic diseases and health condition variables that necessitate advanced treatment. Each of these variables incurs increased direct medical expenditures for patients who are obese and overweight [19]. Cawley and colleagues [20] reported that obesity had caused elevated health costs in every class of care, such as inpatient, outpatient, and prescription drugs. Consequently, the medical care costs incurred as a result of an obese population amount to almost $173 billion per year in the United States [21], with the prediction that the figure might reach $48 to $66 billion per year in 2030 [22]. Su and colleagues [23] revealed a triple-fold increase in health expenditures for all obesity classes from 1 to 3. Specifically, for each kilogram of excess weight, the health costs rise by an average of $140 annually.

The overall medical costs have increased over time, influenced by a group of factors, such as the increase in the size of the adult population, rising healthcare charges, prevalence of obesity, an increase in the number and type of comorbidities, and the fact that obese individuals are being given more expensive treatments and services [20]. This study aimed to investigate the relationships between all traditional obesity parameters (WHtR, WHR, BAI, BMI, BSI, WC, and HC) and the health cost among patients with CADs undergoing cardiac catheterization.

## Methods

### Research design

A secondary data analysis was done for an original study [24]. The original study was conducted for 220 patients with symptomatic CAD, undergoing cardiac catheterization. Among the 220 patients, 175 participants had at least one severely stenotic coronary artery (≥60%), while the other participants (45) had mild to moderate stenotic arteries (<60%). This analysis was utilized to determine the potential variations in health costs based on the traditional obesity parameters among patients with CADs undergoing cardiac catheterization.

### Setting and sample

The original study [24] was conducted in the two main hospitals located in the Middle and Northern regions of Jordan. These two hospitals are considered major referral centers for the study target population. In the original study [24], a convenient sample of 220 patients with CADs was recruited as a sample size based on G power calculation. G*Power was used to calculate the required sample size, given the F test as a family test and linear hierarchical multiple regression with an effect size of 0.15, alpha error probability of 0.05, power of 0.8, and number of predictors of 25. Therefore, the calculated sample size was 181. However, to compensate for any possible attrition among the study participants, 25% of the sample size was added. Thus, a total of 220 participants were recruited as the study sample [24].

The inclusion criteria in the original study [24] meant that all participants were Jordanian citizens, minimum age of 18 years, diagnosed with CADs by a physician, and undergoing cardiac catheterization. Exclusion criteria in [24] ruled out participants diagnosed with severe organ impairment, such as renal failure and liver disease, pregnant women, patients having coronary artery bypass graft surgery, and those diagnosed with autoimmune disease, cancer, and/or immunosuppressed conditions.

### Data collection

In [24], the basic data (weight, height, WC, and HC), used to calculate the parameters, were measured by skilled nurses. The nurses who collected the data underwent three training sessions. Upon admission, the data were gathered prior to undergoing a cardiac catheterization using flexible and rigid anthropometric tapes. Recruitment for [24] was completed between March 18, 2021 and July 18, 2021.

### Measurements

In [24], the socio-demographic variables were gathered from the patients themselves and their electronic health records. Serum levels of hemoglobin A1c (HbA1c), high-sensitivity C-reactive protein (HS-CRP), high-density lipoprotein cholesterol concentration (HDL), low-density lipoprotein cholesterol concentration (LDL), triglyceride, and random blood sugar (RBS) were assessed for all participants upon admission to the hospitals and before undergoing cardiac catheterization. Daily activity was measured using a valid pedometer after the participants had been discharged and allowed to resume normal daily activity by the primary healthcare provider.

In [24], a standard stadiometer and rigid measurement devices were used to measure height and weight, respectively. The HC was measured at the greatest protrusion of the gluteal muscles. The WHR and the WHtR were operationally defined as WC/HC and WC/height, respectively. The BSI, the BMI, and the BAI were calculated using the formulas reported in the original study [24]. In the current study, the health cost was measured by Jordanian dinar (JOD) (continuous variable). This data was collected from the Financial Department of each hospital. The total health cost was recorded before subtracting the values that were covered by health insurance or exemption. The analyzed health costs include the total expenses, from admission to undergoing cardiac catheterization through to discharge. This includes the cost of the cardiac catheterization procedure, medications during the hospitalization period, diagnostic tests, and discharge medication prescriptions.

### Statistical analysis

Multiple statistical analyses (correlation, regression, and analysis of variance) were carried out between all the predictors (sociodemographic and obesity parameters) and the dependent variable (health costs). However, each of these tests was conducted once without repetition, which did not necessitate a correction. The bivariate Pearson's correlation statistical analysis was measured for the strength of the relationship between the obesity parameters and the health cost. Forward linear regression was performed to examine the role of obesity parameters in predicting the variations in the health cost among patients with CADS undergoing cardiac catheterization. A significance regression level of 0.05 was considered in this study. The Statistical Package for Social Sciences (SPSS) software version 25 was used to do all required analyses.

### Ethical considerations

In the original study [24], the Institutional Review Board (IRB) approval was obtained from the Jordan University of Science and Technology (Ref#20210093). All methods were carried out in accordance with relevant guidelines and regulations. The aims and benefits of the study were clarified for all the participants. The participants had ample time to read and sign the written informed consent form, after having any questions fully addressed by the researchers. The participants were made aware of their right to proceed or withdraw from the study without prejudice. No minors took part in the study.

## Results

The mean age of the patients with CADS in [24] was 49.9 years old, while the overall age range was between 24 and 90 years old. Of the 220 participants in [24], 161 (73.2%) were male. Most of the participants in [24] were married (62.3%). Approximately half (49.1%) of the patients in [24] were employed. More than half (61.8%) were smokers. 43.6% of patients were classified as having hypertension stage I, 36.4% were classified as having pre-hypertension,

**Table 1** Health cost (JOD) for the participants ($N=220$)

| | *N* (%) | Mean (SD) | Median (Min, Max) |
|---|---|---|---|
| **Health Cost (JOD)** | | 1344 (583) | 1374 (290, 4211) |

and the remaining (20%) had normal blood pressure in the original study [24]. The health cost (JOD) for the current study participants is shown in Table 1.

As shown in Table 2, the following correlation model was built to evaluate and investigate the relationships between obesity parameters and health costs. A significant positive moderate correlation ($r=0.4$) was found between HC and health costs. Significant weak positive correlations were found between "WC, WHtR, and BAI" and health costs. While a significant negative correlation was found between WHR and health costs.

As shown in Table 3, the correlation model was built to evaluate and investigate the relationships between health variables and health costs. Moreover, the analysis of variance (ANOVA) test was employed to test mean group differences between categories of blood pressure and health costs. There were significant positive weak correlations between (LDL, triglycerides, HS-CRP, HbA1c, and depression) and health costs (correlation coefficient 0.17, 0.3, 0.29, 0.22, and 0.17, respectively).

As shown in Table 4, the correlation model was built to evaluate and investigate the relationships between sociodemographic variables and health costs. The ANOVA test was employed to test the differences between categories of education, marital status, and employment, and health costs. There were statistical differences between education levels in relation to health costs ($F=2.39$, $P=0.04$). Illiterate participants had higher health costs (Mean=43.2, SD=5.2) than participants who had completed primary school (Mean=34.7, SD=8.4) ($P=0.04$). There were statistical differences between marital status categories in relation to health costs ($F=3.1$, $P=0.03$). Accordingly, single patients (Mean=1523, SD=661) had higher health costs than married (Mean=1261, SD=510), while no difference was detected with other categories (widowers and divorced).

To test the relationship and the prediction role between the model of obesity parameters and health costs, statistical analysis was carried out using forward regression analysis, as shown in Table 5. Model (1), which had the sole predictor of hip circumference (HC), explained 12.9% of the variation of health costs ($P<0.001$), while model (5) which had five predictors, explained 29.2% of the variation of health costs ($P=0.03$). Model (5) illustrated that an increase of HC by 3.9 cm (β (0.292) * SD (13.4)) will increase health costs by 1 JOD. Model (5)

**Table 2** Pearson's correlations (r) between obesity parameters and health costs ($N=220$)

| | | | Health Cost | |
|---|---|---|---|---|
| | **Mean (SD)** | **Median (Min, Max)** | ***r*** | ***P* value** |
| Weight kg | 80.02 (14.42) | 80.00 (50, 126) | 0.03 | 0.61 |
| Waist Circumference | 102.72 (13.26) | 102.00 (65, 140) | 0.27 | **<0.001** |
| Hip Circumference | 110.59 (13.42) | 110.50 (68, 151) | **0.4** | **<0.001** |
| Waist Height Ratio | 0.64 (0.10) | 0.63 (0.37, 0.98) | 0.25 | **<0.001** |
| Waist Hip Ratio | 0.92 (0.07) | 0.92 (0.45, 1.20) | -0.16 | **0.02** |
| Body Adiposity Index | 0.35 (0.10) | 0.35 (0.05, 0.67) | 0.33 | **<0.001** |
| Body Mass Index | 32.2 (4.59) | 32.3 (23.0, 42.1) | 0.05 | 0.50 |
| Body Shape Index | 0.09 (0.08) | 0.09 (0.01, 0.90) | -0.04 | 0.58 |

**Table 3** The bivariate analysis between health variables and health costs ($N=220$)

| **Health Variable** | **Health Cost** | **Statistic Test** | ***P* value** |
|---|---|---|---|
| Blood Pressure | F=2.90 | ANOVA (F) | 0.06 |
| Smoking | *r*= -0.09 | Pearson's Correlation (r) | 0.22 |
| Daily Activity | *r*= -0.09 | r | 0.2 |
| LDL | *r*=0.17 | r | **0.01** |
| HDL | *r*= -0.13 | r | 0.052 |
| Triglycerides | *r*=0.30 | r | **< 0.001** |
| Total Cholesterol | *r*= -0.09 | r | 0.21 |
| HS-CRP | *r*=0.29 | r | **< 0.001** |
| RBS | *r*=0.02 | r | 0.94 |
| HbA1c | *r*=0.22 | r | **0.002** |
| Anxiety | *r*=0.04 | r | 0.57 |
| Depression | *r*=0.17 | r | **0.02** |

Note: HDL: High-density lipoprotein, RBS: Random blood sugar, LDL: Low-density lipoprotein, HS-CRP: High-sensitivity C-reactive protein, HbA1c: Hemoglobin A1c

**Table 4** The bivariate analysis between socio-demographics and the health cost ($N=220$)

| Socio-demographic Variable | Health Cost | Statistic Test | *P* value |
|---|---|---|---|
| Age | $r=0.04$ | Pearson's Correlation (r) | 0.58 |
| Income | $r=-0.04$ | Pearson's Correlation (r) | 0.61 |
| Gender | t = 0.12 | t Test | 0.91 |
| | Mean (SD) | | |
| Males [Ref] | 1347 (568) | | |
| Females | 1337 (622) | | |
| Education | F = 2.39 | ANOVA | **0.04** |
| | Mean (SD) | Post hoc Tukey test | |
| Primary School & Illiterate | 34.7 (8.4)<br>43.2 (5.2) | | **0.04** |
| Marital Status | F = 3.1 | ANOVA (F) | **0.03** |
| | Mean (SD) | Post hoc Tukey test | |
| Single [Ref] | 1523 (661) | | **0.03** |
| Married | 1261 (510) | | |
| Employment | F = 0.33 | ANOVA (F) | 0.72 |

Note: Ref: Reference group

**Table 5** Forward regression analysis between obesity parameters and health variables, and health costs (JOD) ($N=220$)

| Model | | R2 for the Model (*P*) | Standardized Coefficients (β) | *P* | CI 95% LL | UL |
|---|---|---|---|---|---|---|
| 1 | HC (m) | 0.129 (< 0.001) | 0.359 | **< 0.001** | 202 | 442 |
| 2 | HC (m) | 0.199 | 0.352 | **< 0.001** | 199 | 431 |
| | HS-CRP (mg/dl) | (< 0.001) | 0.265 | **< 0.001** | 254 | 736 |
| 3 | HC (m) | 0.248 | 0.323 | **< 0.001** | 176 | 402 |
| | HS-CRP (mg/dl) | (0.001) | 0.246 | **< 0.001** | 225 | 696 |
| | Triglycerides (mg/dl) | | 0.223 | **0.001** | 46 | 166 |
| 4 | HC (m) | 0.273 | 0.3194 | **< 0.001** | 156 | 382 |
| | HS-CRP (mg/dl) | (0.011) | 0.256 | **< 0.001** | 246 | 710 |
| | Triglycerides (mg/dl) | | 0.255 | **< 0.001** | 60 | 181 |
| | Total Cholesterol (mg/dl) | | 0.164 | **0.011** | -194 | -25 |
| 5 | HC (m) | 0.292 | 0.292 | **< 0.001** | 150 | 373 |
| | HS-CRP (mg/dl) | (0.03) | 0.258 | **< 0.001** | 253 | 712 |
| | Triglycerides (mg/dl) | | 0.241 | **< 0.001** | 54 | 174 |
| | Total Cholesterol (mg/dl) | | 0.163 | **0.011** | -192 | -25 |
| | Depression (score) | | 0.137 | **0.013** | 21 | 413 |

Note: The last model explained 29.2% of the variation of total health cost ($P=0.03$). JOD: Jordanian Dinar, HC: Hip circumference, HS-CRP: High-sensitivity C-reactive protein

showed that if HS-CRP increased by 0.4 mg/dl (β (0.258)* SD (1.43)), or triglycerides increased by 8.3 mg/dl (β (0.241)* SD (34.3)), or depression score increased by 0.32 score (β (0.137)* SD (2.3)), or total cholesterol increased by 4 mg/dl (β (0.163)* SD (24.7)), health costs would increase by 1 JOD.

To test the relationship and the prediction role between obesity parameters and health costs in males and females separately, statistical analysis was carried out using regression analysis, as shown in Table 6. Accordingly, among males, five obesity parameters were significantly associated with health costs. Among them, four (WC, HC, WHtR, and BAI) are positively associated with health costs, while WHR is inversely associated with health costs. On the other hand, among females, none of the obesity parameters were significantly associated with health costs.

## Discussion

The world has witnessed a dramatic rise in the prevalence of obesity in recent decades. Since obesity is considered a risk factor and an associated variable for CADs, there is an urgent need to take stock of the healthcare costs of obesity [12]. This study aimed to investigate the relationships between obesity parameters and health costs among patients with CADs undergoing cardiac catheterization.

In the current study, the average expenditure for the participants was 1,344 JOD (1,895.63 USD). Numerous previous studies consistently reported that patients diagnosed with obesity have higher healthcare costs

**Table 6** The linear regression analysis between obesity parameters and health costs in males and females (*N* = 220)

| Obesity Parameter | B | *P* value |
|---|---|---|
| **Weight kg** | | |
| Male | − 0.002 | 0.61 |
| Female | 0.008 | 0.09 |
| **Waist Circumference** | | |
| Male | 0.009 | **< 0.001** |
| Female | 0.006 | 0.14 |
| **Hip Circumference** | | |
| Male | 0.015 | **< 0.001** |
| Female | 0.004 | 0.35 |
| **Waist Height Ratio** | | |
| Male | 1.45 | **< 0.001** |
| Female | 0.67 | 0.23 |
| **Waist Hip Ratio** | | |
| Male | -2.81 | **< 0.001** |
| Female | 0.74 | 0.37 |
| **Body Adiposity Index** | | |
| Male | 2.02 | **< 0.001** |
| Female | 0.98 | 0.19 |
| **Body Mass Index** | | |
| Male | − 0.001 | 0.89 |
| Female | 0.02 | 0.13 |
| **Body Shape Index** | | |
| Male | − 0.39 | 0.59 |
| Female | -4.3 | 0.50 |

compared to those who are not obese. Another study revealed a total annual cost of $1250 per obese participant. Consequently, obesity can be reliably associated with higher costs of care for patients with cardiovascular disease [25]. This might be due to the higher risk of severe health complications and hospitalization among patients who are overweight and/or obese [26]. Moreover, the additional incurred health costs of obesity-related diseases and complications place an economic burden on patients, their families, and governments [27, 28]. As a result, determining these specific possible predictors for health costs using the obesity parameters among patients with CADs undergoing cardiac catheterization provides scientific indications as to how these parameters could be related to the high health costs of treating these at-risk patients.

Regarding predictors of health costs, this study revealed that hip circumference was significantly correlated with increased health costs among patients with CAD undergoing cardiac catheterization during hospitalization. Consistently, Wang and colleagues found that HC is positively associated with increased cardiovascular events [29]. However, this positive association between HC and cardiovascular disease events is considered unusual and needs further investigation. Hip circumference is not commonly used as a marker of cardiovascular risk or obesity compared to other parameters like waist circumference or body mass index (BMI) [30].

Indeed, larger hip circumferences are considered a protective factor against specific health risks, known as the “obesity paradox” or “lipid paradox [14]. However, hip circumference could be used to measure adiposity, which reflects overall body fat distribution and adipose tissue deposition, leading to metabolic abnormalities and CVD risk factors [14, 15]. Furthermore, individuals with larger hip circumferences may have a lower risk of metabolic syndrome and lower visceral adiposity. However, they are still at higher risk of other obesity-related conditions, such as sleep apnea and musculoskeletal disorders, which could necessitate additional treatment and associated costs [14, 15]. More research is needed to explain the mechanism linking health costs and hip circumference among patients with CAD, which could be used in clinical practice and managing obesity-related conditions. Although it is widely known that health costs can be affected by the general health condition of the patient, there is limited research on the relationship between various obesity parameters and health costs in patients with CAD undergoing cardiac catheterization.

Interestingly, among males, five obesity parameters (WC, HC, WHtR, WHR, and BAI) were significantly associated with health costs. On the contrary, no significant relationship between any of the obesity parameters and health costs among females was found. This difference could be explained as females having a lower risk for coronary artery disease due to hormonal protection effects, which could affect the significance of the relationship between obesity parameters and healthcare costs among females [31]. Also, in Jordan, females tend to have lower smoking percentages than males, which makes males more susceptible to CAD complications [32]. Consistently, in our study, the mean smoking cigarette among males is 30 cigarettes/day, while among females is 19 cigarettes/day. Consequently, females have two alleviating factors (hormonal protection and a lower smoking percentage) that could reduce the impact of obesity on the participant’s health condition and thus, on health costs.

Additionally, our study found that depression had a significant positive association with participants’ health costs during hospitalization. Having consistent results, Nigatu and colleagues [33] found a positive association between abdominal obesity (WC of ≥102 cm for males and ≥88 cm for females), depression, and health costs. They explained their results by emphasizing that obesity is associated causally with serious medical conditions aggravated by an increase in serum lipids and insulin resistance. They also illustrated that depression was associated with decreased quality of life and higher comorbidity of medical conditions. These findings could be attributed to poor compliance with treatment plans that result in higher health costs.

Our study found that triglycerides and total cholesterol had a significant positive association with health costs. The results of the current study were consistent with those of Bahia and colleagues [34], who found a positive correlation between the level of triglyceride and total cholesterol, and an increase in health costs among patients with CADs. They illustrated their results by stating that either hypertriglyceridemia or hypercholesterolemia is a considered contributing factor for CAD, and both increase the need for an advanced level of medical care. This higher medical care involved conducting more serology tests, radiology diagnostic tests, and pharmacological treatment, all of which are considered costly.

The current results showed that there was a weak positive correlation between “WHR and BAI” and health costs. These results are consistent with those reported by Cawley [35], Au [36], and Withrow and Alter [37]. Their results supported the positive association between adiposity and added financial burden on the healthcare system.

The study also revealed that there is a positive weak relationship between “LDL and triglycerides” and health costs. This was supported by Zhao and colleagues [38] who studied CVD healthcare costs concerning Lipoprotein (a) (Lp(a)). This study revealed that increased levels of Lp (a) are leading to higher risk for patients with CVD, particularly for patients with LDL-C > 70 mg/dL, and in turn, higher health costs. This is also consistent with Toth and colleagues [39] who used a retrospective observational analytic method to evaluate cardiovascular outcomes, healthcare utilization, and health costs among patients with high triglycerides and high risk of cardiovascular complications. Their study revealed that the high risk of cardiovascular complications and high triglycerides (2.26–5.64 mmol/L [200–499 mg/dL]) among Statin-treated patients had negative cardiovascular outcomes, more healthcare utilization, and higher health costs compared to those who had triglycerides below 1.69 mmol/L (< 150 mg/dL) and HDL-C more than 1.04 mmol/L (> 40 mg/dL).

Furthermore, this study reported a positive weak correlation between HbA1c and depression and health costs, a finding that was previously reported by Langberg and colleagues [40]. During an 8-year study based on the Medical Expenditures Panel Survey (MEPS), they addressed the cost of diabetes and depression. They revealed that health costs were significantly higher in patients with both diabetes and depression, in which the incremental cost was above $6000/participant/year.

Our study found that HS-CRP had a significant positive association with health costs, a finding that corresponded with the results of Schnell-Inderst and colleagues [41]. They affirmed that HS-CRP is considered a predictor for heart disease severity and, consequently, increased CAD severity that requires additional medical care, including more medical interventions, serology tests, and radiology tests which all increase health costs. Another analysis, conducted by Lee and colleagues [42] among patients with intermediate and low cardiovascular risk, revealed that an increase in HS-CRP indicates an increased risk for cardiac patients. However, this was not found to be a cost-effective screening tool. A recent study supported that HS-CRP could be a predictor of the incidence of CAD, but HS-CRP was not used previously in many studies because of its elevated cost [43].

Previous studies have asserted that the use of statin treatment for patients with CVDs is a cost-effective treatment [44, 45]. CVDs are associated with elevated triglyceride levels within the context of statin treatment in addition to its parallel association with higher medical costs [46, 47]. High triglyceride (TG) levels are associated with cardiovascular disease risk. It is categorized as mild to moderate when fasting levels are ≥ 150 mg/dl, nonfasting levels are ≥ 175 mg/dl to < 500 mg/dl, and severe when levels are ≥ 500 mg/dl, especially ≥ 1000 mg/dl. Further, hypertriglyceridemia is defined as levels ≥ 175 mg/dl after lifestyle intervention and management of secondary causes [48, 49].

Recent studies have reported that high TG levels (200–499 mg/dL) are associated with increased CV events, cost, and healthcare usage [39, 49, 50]. Patients with hypertriglyceridemia with levels at or above 500 mg/dL had a higher rate of cardiovascular events (HR 1.19; 95% CI 1.10–1.28), diabetes-related events (HR 1.42; 95% CI 1.27–1.59), and kidney disease (HR 1.13; 95% CI 1.04–1.22) compared to those with triglyceride levels below 500 mg/dL. These associations remained significant after adjusting for important confounders [51].

Toth et al.'s [39] study revealed that the total healthcare cost for patients with high triglyceride levels was 15% higher than for patients with normal levels, which increased the cost to around $183$ per month per patient with high triglycerides. In addition, according to heart disease and stroke statistics [52], the direct and indirect costs of cardiovascular disease and stroke are around $330 billion per year.

## Limitations

Among the limitations of the current study is the fact that it is considered a secondary analysis of a previous cross-sectional study, in which the cross-sectional research design does not provide causal relationships between the variables. Moreover, the sample size needs to be larger in order to support a more robust methodology, and in turn, more accurate results. The current study needs to be replicated with more years of follow-up of the healthcare cost of the utilization of numerous obesity parameters among patients with CAD undergoing cardiac catheterization.

## Conclusion

The significant variations in health costs based on the traditional obesity parameters among patients with coronary artery diseases undergoing cardiac catheterization were associated with an increase in HC, HS-CRP, total cholesterol, triglycerides, and depression. Interestingly, among males, five obesity parameters (WC, HC, WHtR, WHR, and BAI) were significantly associated with health costs. In contrast, among females, no significant relationship between any of the obesity parameters and health costs was found. Healthcare providers, including nurses, should significantly consider these factors to reduce health costs for those at-risk patients by providing the appropriate healthcare on time.

**Acknowledgements**
The authors would like to thank the Jordan University of Science and Technology for funding this study.

**Author contributions**
We hereby confirm that all listed authors meet the authorship criteria and that all authors are in agreement with the content of the manuscript. Study conception & design: IA, AH, MR; data collection and analysis: IA, AH, MR; data interpretation: IA, AH, MR; and manuscript preparation: IA, AH, MR, RT, EA A, KA, SA A, SM A, ES A; final approval of the manuscript version to be published: IA, AH, MR, RT, EA A, KA, SA A, SM A, ES A.

**Funding**
This work was funded by the Jordan University of Science and Technology. [Grant number:20210093].

**Data availability**
Data can be requested from the first author upon a reasonable request.

## Declarations

**Ethics approval and consent to participate**
The institutional review board (IRB) approval was obtained from the Jordan University of Science and Technology (Ref#20210093). All methods were carried out in accordance with relevant guidelines and regulations. Informed consent was obtained from all subjects and/or their legal guardian(s). The aims of the study and the benefits of the study were clarified for all the participants. The participants had ample time to read and sign the written informed consent. The questions from the participants about the study were completely answered. The participants had the right to make the decision to participate in or withdraw from the study. The study had no minors.

**Consent for publication**
Not applicable.

**Competing interests**
The authors declare no competing interests.

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Received: 18 August 2023 / Accepted: 23 August 2024
Published online: 16 September 2024

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