The use of electronic health records to examine the association between obesity and chronic conditions: Results from a population-based sample in Saudi Arabia

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Research

Keywords: Obesity, diabetes, hypertension, Saudi Arabia

Posted Date: October 1st, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-84058/v1>

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Abstract

Background

Obesity is a growing public health problem worldwide. Over the past few decades, the prevalence of obesity has increased significantly in Saudi Arabia, putting population health at an increased risk of mortality and morbidity. Because of the wide variation in previous local estimates, this study used electronic records of a population-based sample to estimate the prevalence of obesity and its association with diabetes and hypertension.

Methods

This study used records from five hospitals in the National Guard Health Affairs, which provides medical service to about a million beneficiaries. We included individuals aged 17 years or older who visited any outpatient clinic in the past four years (2016-2019). Body mass index (BMI) was measured before the doctor's encounter. Patients were classified as diabetic or hypertensive if they had any visit during the four years, where the primary diagnosis was one of those conditions or if the patient was taking medications. The associations between obesity (BMI>30) and diabetes and hypertension were evaluated using a multiple logistic regression model adjusting for age, gender, nationality, and region.

Results

A total of 616,092 individuals were included. Of them, 55.0% were females, and the majority were Saudi nationals (93.1%). Approximately 68% of the population were either obese (38.9%) or overweight (29.30%). Obesity was more prevalent among Saudi nationals (39.8% vs. 26.7%, $p<0.01$) and females (45.3% vs. 31.2%, $p<0.01$). Compared to those younger than 26 years of age, those older than 65 years were over 27 times more likely to have diabetes (OR= 27.3, $p<0.01$). In addition, obesity was independently associated with diabetes mellitus (OR= 2.24, $p<0.01$) and hypertension (OR= 2.15, $p<0.01$).

Conclusions

The prevalence of obesity in the study population was high, and more pronounced among women. Our findings call for efforts to intensify preventive measures to reduce obesity and associated conditions. Using electronic records to examine the impact of interventions to reduce obesity and chronic conditions may help monitor and improve population health.

Background

Obesity is a growing public health problem worldwide and has become an epidemic in many countries. Statistics of the World Health Organization (WHO) suggest that obesity rates have nearly tripled since 1975 [1]. In 2016, it was estimated that there were more than 1.9 billion overweight adults worldwide (39%). Of these adults, over 650 million were obese, representing 13% of all adults worldwide. [1, 2] Over the past few decades, the prevalence of obesity has increased significantly in the Gulf Cooperation

Council (GCC) countries (Kuwait, Saudi Arabia, Oman, United Arab Emirates, Qatar, and Bahrain). This increase paralleled the rapid economic growth and prosperity following oil discovery in the region [2].

Factors such as urbanization, limited access to walkable areas, sedentary lifestyle, hot weather, changes in dietary habits, and car-dependent cities have shifted the leading causes of death from infectious to non-communicable diseases (NCDs) in the GCC countries, including Saudi Arabia (SA) [3]. These factors also constitute significant drivers of obesity in SA. Previously published nationwide surveys showed an increase of about 74% in the prevalence of obesity in SA [4]. This progressive increase led to obesity, rising from 22% in 1990 to 36% in 2005 [5, 6]. However, according to the WHO, adult obesity decreased slightly to 33.7% in 2016 [7]. This minimal decrease does not change the ongoing war against the obesity epidemic in SA, especially with the existent gender disparity in obesity prevalence; 39.5% vs. 29.5% among women than men, respectively [7].

High body mass index (BMI) can put someone at an increased risk of mortality and multiple morbidities, including diabetes mellitus, hypertension, dyslipidemia, cardiovascular diseases (CVD), and cancer [8–10]. Having a higher BMI is associated with an increased risk of death from all-cause mortality and CVD compared to people in the healthy weight range [11]. Notably, high BMI tops the list of the risk factors associated with disease burden in SA [12]. Nowadays, NCDs account for about 73% of SA's deaths.

CVD, which hypertension is a major risk factor for, account for about 37% of deaths, making CVD the leading cause of death in SA [13]. Diabetes, on the other hand, places high among the top 10 causes of death (5% of total deaths) and disability (years lived with disability or YLDs). This makes it a significant contributor to the disease burden in SA [7, 14]. The increasing burden of NCDs is not limited to population health; it also creates an enormous economic burden on the health system [10].

In 2017, SA had adopted a unified excise tax on sugar-sweetened beverages [15]. Moreover, to create greater public awareness of food choices, the government recently mandated that all food establishments label menus show meals' calorie content [16]. Some studies showed an increasing trend of obesity prevalence in SA [6, 17]. But the WHO estimates tell a different story [7]. This discrepancy emphasizes the need for more updated and comprehensive data than what is already published. Furthermore, in light of the recent obesity preventive interventions, there is a need for an effective tracking system to measure the impact of these interventions and monitor local progress. Most of the previous studies were based on convenience samples using traditional data sources, such as community surveys. An emerging, more comprehensive surveillance source of chronic diseases and other population health-related data is electronic medical records (EMR). The use of EMR data for chronic disease surveillance has been encouraged as it can provide timely, geographically specific, and high-quality information [18, 19]. Additionally, it has been reported that once the EMR system is in place, the time and cost commitment for data extraction is minimal [20]. Therefore, the EMR system is a potentially cost-effective tool that can be used to bridge the current gap in knowledge and represent a promising tool in population health improvement.

A good understanding of the obesity epidemic in SA and its association with cardiometabolic diseases, including diabetes and hypertension, is needed. Awareness of the magnitude of the target population's problem and characteristics is critical in targeting at-risk groups and designing effective population-based interventions. SA covers a wide geographic area, and its residents come from various cultural backgrounds. This study aims to estimate the prevalence of overweight and obesity and their association with sociodemographic factors and morbidities in the central, eastern, and western provinces of the Kingdom.

Methods

This population-based study used the EMR system from the National Guard Health Affairs (NGHA) in SA. NGHA is a government entity that serves all employees of the national guard and their dependents. In addition, individuals with health insurance may also be seen privately through the business center. This network of five hospitals is located in three regions of the Kingdom: central, western, and eastern regions. The network is estimated to serve around one million beneficiaries. Care is coordinated via a single EMR system known as BestCare. This system was implemented in January of 2016. The main medical city is located in the capital of Riyadh, which is also the home for a large university for health sciences and a research center with branches in the eastern and western regions. In addition, there are several outpatient clinics distributed around the Kingdom that serves patients.

In this study, we included individuals ages 17 years or older who visited any outpatient clinic in the past four years (2016-2019) and had at least one reading of BMI. Measuring BMI is a standard part of clinical care during outpatient visits. Data were captured from five locations: King Abdul-Aziz Medical City in Riyadh, King Abdul-Aziz Medical City in Jeddah, King Abdul-Aziz Hospital in Al Ahsa, Al-Imam Abdulrahman bin Faisal Hospital in Dammam, and Prince Mohammad Bin Abdul-Aziz Hospital in Al-Madinah. Patients from Jeddah and Prince Mohammad Bin Abdul-Aziz Hospital in Al Madinah were combined to represent the western region while cases from King Abdul-Aziz Hospital in Al Ahsa and from Al-Imam Abdulrahman bin Faisal Hospital in Dammam were combined to represent the eastern region.

BMI was calculated automatically in the system using weight (in kg) divided by height (in meters squared). Subjects were then categorized as underweight (BMI <18.5), normal (BMI=18.5-24.9), or overweight (BMI=25-29.9) or obese (≥ 30) [4]. The following variables were obtained from the BestCare system; age, gender, nationality, BMI, diabetes, hypertension, and cancer. If the patient attended an outpatient appointment or was hospitalized for any reason, a primary diagnosis is documented. Patients were classified as diabetic if the discharge diagnosis was diabetes. The same was true for hypertensive patients. This study was reviewed and approved by the Institutional Review Board (IRB) of King Abdulah International Medical Research Center (KAIMRC).

Statistical analysis

STATA 15 and Excel for Mac were used in all the analyses. Descriptive statistics by BMI category were calculated for various variables, and differences by demographic characteristics were evaluated using

Chi-2 tests. A p-value of <0.05 was declared as statistically significant. In addition, differences in BMI categories were depicted across genders, regions, and nationalities.

To evaluate the association between obesity and diabetes or hypertension controlling for multiple factors, we constructed logistic regression models to calculate the odds ratios (ORs) and associated 95% confidence intervals. Normal weight individuals (BMI=18.5-24.9) were used as the reference category. Age was categorized into (17-25 as the reference, 26-45, 46-64, and 65 and older). Females and the central region were used as the reference group for gender and region, respectively.

Results

The study initially identified 876,602 individuals. After excluding those younger than 17 years old, the remaining were 616,092 individuals. Most of the study population were Saudi nationals 573,698 (93.1%), and 338,724 (55%) of the overall population were females. The distribution of individuals in each BMI category was underweight=33,332 (5.41%), normal weight=162,100 (26.32%), overweight=180,431 (29.30%) and obese=239,913 (38.96%). Approximately 68% of the study population were either obese or overweight. Comorbidities like diabetes and hypertension were found in 18.42% and 16.23% of individuals, respectively (Table 1).

Notably, a higher prevalence of obesity was observed among Saudi nationals than non-Saudis (39.9% vs. 26.7%, $p<0.01$). On the other hand, most non-Saudis fell in the overweight category (36.6%, Figure 1). Obesity was more prevalent among older patients (56.6% in 46-64 and 45.9% in ≥ 65 age groups, vs. 17.7% among <26 years old, $p<0.01$, Table 2). Females were more likely to be obese than males (45.3% vs. 31.2%, $p<0.01$). This result was equally seen in Saudi and non-Saudi, as depicted in Figures 2 and 3.

In the multivariable logistic analysis, BMI was independently associated with diabetes mellitus. Obese individuals were significantly more likely to have diabetes than those with normal weight (OR=2.24; 95% CI=2.19, 2.28, $p<0.01$). Age was also a predictor of diabetes. Compared to those younger than 26 years old, those older than 65 years were approximately 27 times more likely to have diabetes (OR= 27.36; 95% CI=26.32, 28.45, $p<0.01$). Males were 6% more likely to be diagnosed with diabetes than females (OR=1.07; 95% CI=1.05, 1.08, $p<0.01$). Compared to the central region, western and eastern regions were associated with 26% lower odds of diabetes (western: OR=0.74; 95% CI=0.72, 0.75, $p<0.01$, and eastern: OR=0.90; 95% CI=0.89, 0.92, $p<0.01$, Table 3).

An independent association also observed between obesity and hypertension; obese patients were 2.1 times more likely to have hypertension (p-value <0.01). Gender was also a significant predictor of hypertension. Males were 18% more likely to be diagnosed with hypertension than females (OR=1.18; 95% CI=1.16, 1.20, $p<0.01$). When comparing Saudi regions to the central region, western and eastern areas were associated with reduced likelihood of hypertension (western: OR=0.62; 95% CI=0.61, 0.63, $p<0.01$, and eastern: OR=0.89; 95% CI=0.87, 0.92, $p<0.01$, Table 3).

Discussion

This study found a significant association between higher BMI and being diagnosed with diabetes or hypertension. Our results revealed that around 45% of women in our sample were obese, and 26% were overweight. Obesity prevalence was projected to rapidly increase between 1992 -2022 from 12% to 41% among men, and 21% to 78% among women [17]. Our finding underlines the major impact that obesity plays on NCDs and healthcare utilization and on population health. NCDs are currently responsible for around 73% of all death in the Kingdom [12, 21]. If this burden continues, it will likely play a devastating impact on population health in the next decade in the Kingdom. Using electronic records to examine the impact of interventions to reduce obesity and chronic conditions may help monitor and improve population health. Other countries, such as the United States, have explored using EMR to evaluate conditions like diabetes, hyperlipidemia, hypertension, smoking, obesity, and depression to better understand population health [22].

Our results concur with several studies that assessed the burden of obesity, diabetes, and hypertension in Saudi Arabia. Memish et al. showed in their 2013 national survey that only enrolled Saudis (ages 15 years or older) an increase in the obesity burden among women (33% women vs. 24% men) [10]. Our large sample included both Saudi and non-Saudi populations and showed a wider extent of obesity prevalence (45% women vs. 31% men). Our findings are also consistent with the Almajwal et al. study that showed an increased risk of diabetes and hypertension among the Saudi population relative to their BMI [21, 23].

In addition, several previous regional cross-sectional studies have indicated variations in obesity prevalence in the Kingdom [21, 24, 25]. Although these rates varied between regions due to limited sample size and differences in age groups, their findings consistently align with our findings on the higher obesity prevalence among women. Furthermore, our result on the obesity prevalence being higher among women was also similar to findings from a recently published study (PURE-Saudi) [26]. While our findings indicate that 16% of our study participants have hypertension and 18% have diabetes, the PURE-Saudi study showed a prevalence of 30% hypertension and 25% diabetes among participants. This might be explained by the older cohort in the PURE study or its limited representativeness.

Lifestyle has become more westernized and sedentary in the Kingdom during the last three decades, leading to an increased obesity prevalence among both men and women [27]. In particular, women have been shown in our study and other previous research to have a higher prevalence of obesity than men. [12, 21, 24]. A combination of social and policy factors may be leading to this inequality. These factors include that women are more prone to stay home, have limited access to culturally acceptable exercise activities, and the high cost of female gyms relative to those for men [4, 12, 21].

Our findings have implications for both healthcare policies and population health initiatives and research funding. On the national level, these findings call for strengthening preventive care to reduce obesity in the Kingdom and to address inequality between men and women in terms of obesity burden and chronic disease management. Our findings can also be used to inform the modelling of future obesity burden and

inform targeted-awareness initiatives in the Kingdom. Finally, this study adds to the growing evidence that obesity and NCDs are increasing threats in the Kingdom.

The Saudi Vision 2030 is a strategic plan to effectively transform numerous sectors in the Kingdom, including healthcare [28]. Multiple initiatives, under the Vision 2030, have been recently implemented to reduce the burden of NCDs in the Kingdom and its risk factors, including obesity. For example, the Kingdom recently introduced a tax on carbonated drinks (50%), which has been shown to be effective in lowering the consumption of carbonated beverages [15]. In addition, there is a new model of care being developed for the Saudi healthcare system as part of the Saudi Vision 2030. This model prioritizes NCDs prevention and emphasizes the public health role in healthcare [29]. Addressing the inequalities between women and men is a critical indicator in Vision 2030. This comes alongside other public health initiatives to improve the quality of life in SA and promote women's access to exercise facilities that are safe, affordable, and culturally acceptable [28]. Further studies need to assess the trend in women's physical activity in the light of the recent policies aimed to promote physical activity among women and evaluate the acceptability and efficacy of promoting home gyms in the Kingdom.

Since 2016, the Kingdom has experienced rapid growth in food home delivery via smartphone applications. Moreover, the Kingdom has also experienced complete and partial lockdown between March and June 2020 to mitigate the coronavirus disease 2019 (COVID-19) pandemic. Consequently, this inevitably limited physical activity. These two factors are expected to contribute to the pre-existing obesity endemic in Saudi Arabia.

Epidemiological research remains vital to assess the current landscape of population health in the Kingdom. Although Saudi Arabia's research output on NCDs has massively improved in the last decade, it still lags behind several countries in the region [30]. Our findings add to the existing body of literature and are expected to support the need to allocate funding to population health research from the recently established Saudi National Institute of Health [31].

Our study has several strengths. First, the study included a large sample of diverse populations. To our knowledge, this is the largest cohort that aimed to determine the extent of the burden of obesity in Saudi Arabia. In fact, we do not know of any other study that used a population-based sample capturing over half a million individuals in the Kingdom. Previous similar research was limited either to the Saudi population, small sample size, or to a specific region. In addition, BMI measurements were recorded during hospital visits by trained nurses, which improves the reliability of BMI measurements in our data. Finally, the use of a unified electronic system captured the latest data measured in terms of BMI or disease diagnosis for all patients. This will help future studies in terms of identifying targeted groups for prevention or intervention.

However, our present study has a few limitations. The data are based on visits to the healthcare facility, raising the possibility that the prevalence of obesity is overestimated compared with the general population. This is because those who did not visit the hospital in a period of four years are not represented in our sample and likely to be healthier than those who visited the hospital or clinic. Still, even

if that had occurred, it is expected that the magnitude of the bias is minimal as NGHA provides healthcare to all military personnel, staff, and students who may have shown up at the clinic for a regular check-up. Second, some patients may have had a change in their BMI since their last visit due to nutritional programs, exercise, or other means of weight reduction. However, it is unlikely that a drastic change had occurred without any visit to our facility in which BMI would have been captured. Therefore, it is doubtful that this would affect our findings. Finally, the study did not discriminate between type 1 and type 2 diabetes. Because the latter is the one known to be associated with obesity, the potential underestimation of association is possible.

Conclusion

In summary, this large sample population-based study showed a significant association between BMI, diabetes, and hypertension. The extent of obesity prevalence in the study population was high, and more pronounced among women. These findings support the ongoing efforts to increase preventive measures and population health research. Future work is needed to continuously monitor the obesity trend and evaluate the efficacy of Vision 2030 obesity-related policies and initiatives. Using electronic records to examine the impact of interventions to reduce obesity and chronic conditions may help monitor and improve population health.

Abbreviations

EMR Electronic medical records

BMI Body mass index

CVD Cardiovascular diseases

GCC Gulf cooperation council

KAIMRC King Abdulah International Medical Research Center

NCDs Non-communicable diseases

NGHA National Guards health affairs

OR Odds ratio

SA Saudi Arabia

WHO World health organization

YLD Years lived with disability

Declarations

Ethics approval and consent to participate

This study was reviewed and approved by the Institutional Review Board (IRB) of King Abdulah International Medical Research Center (KAIMRC).

Consent to publication

Not applicable.

Availability of data and material

All data are available from the corresponding author upon reasonable request.

Competing interests

None.

Funding

None.

Contributions

SA, MA, RA designed the study. SAZ, SAE, MB, AA, MAD, and IA reviewed the literature and interpreted the findings. SA analysed the data and wrote the introduction and methods. SAZ wrote the result section. SAE wrote part of the discussion section. All authors contributed to the revision of the manuscript.

Acknowledgements

The authors would like to acknowledge Bien Paras and Aljowhara Alsahan for their help obtaining and preparing the dataset.

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Tables

Table 1: Baseline characteristics of the patients treated in National Guard Hospitals from 5 regions (n= 616,092)

Characteristics variables	n (%)
Age categories	
17-25	116,656 (18.94)
26-45	264,892 (43)
46-64	152,672 (24.79)
>=65	81,580 (13.25)
Gender	
Male	277,336(45)
Female	338,724 (55)
BMI/ Kg m⁻²categories	
underweight	33,324 (5.41)
normal	162,100 (26.32)
overweight	180,431 (29.30)
obese	239,913 (38.96)
Nationality	
Saudi	573,698 (93.12)
Non-Saudi	42,102 (6.83)
Region	
Central	338,027 (54.89)
Western	178,204 (28.94)
Eastern	99,569 (16.17)
Diabetes mellitus	
Yes	113,409 (18.42)
No	502,391 (81.58)
Hypertension	
Yes	99,934 (16.23)
No	515,866 (83.77)

BMI, body mass index.

Table 2: Descriptive characteristics of the study population by BMI category

Variables	Underweight n (%)	Normal n (%)	Overweight n(%)	Obese n (%)	p value
Age categories					<0.01 *
17-25	20,114(17.24)	51,716 (44.33)	24,098 (20.66)	20,728 (17.77)	
26-45	9,713 (3.7)	74,762 (28.22)	85,091 (32.12)	95,326 (35.99)	
46-64	1,422 (0.93)	19,262 (12.62)	45,564 (29.84)	86,424 (56.61)	
>=65	2,083 (2.55)	16,370 (20.07)	25,689 (31.49)	37,438 (45.89)	
Gender					<0.01 *
Male	18,742 (6.76)	81,624 (29.45)	90,342 (32.59)	86,488 (31.20)	
Female	14,582 (4.31)	80,476 (23.77)	90,089 (26.61)	153,425 (45.32)	
Nationality					<0.01 *
Saudi	32,140 (5.6)	147,836(25.77)	165,048 (28.77)	228,674 (39.86)	
Non-Saudi	1,192 (2.83)	14,274 (33.90)	15,394 (36.56)	11,242 (26.70)	
Region					<0.01 *
Central	17,489 (5.17)	88,254 (26.11)	99,079 (29.31)	133,205(39.41)	
Western	11,215 (6.29)	48,950 (27.47)	53,012 (29.75)	65,027 (36.49)	
Eastern	4,628 (4.65)	24,906 (25.01)	28,351 (28.47)	41,684 (41.86)	
Diabetes mellitus					<0.01 *
Yes	1,570 (1.38)	14,736 (12.99)	32,734 (28.86)	64,369 (56.76)	
No	31,762 (6.32)	147,374(29.33)	147,708 (29.40)	175,547(34.94)	
Hypertension					<0.01 *
Yes	1,359 (1.36)	12,927 (12.94)	28,483 (28.50)	57,165 (57.20)	
No	31,973 (6.20)	149,183(28.92)	151,959 (29.46)	182,751(35.43)	

*Statistically significant ($P<0.05$)

Table 3: Logistic regression of the association between BMI and the likelihood of diabetes and hypertension

Variables	Adjusted DM			Adjusted HTN		
	Odds Ratio (OR)	95% CI	P-value	Odds Ratio (OR)	95% CI	P-value
Age Category						
17 - 25	Reference					
26 - 45	2.34	2.26 - 2.43	<0.01*	3.96	3.70 - 4.23	<0.01*
46 - 64	13.37	12.87 - 13.89	<0.01*	37.71	35.37 - 40.21	<0.01*
>= 65	27.37	26.32 - 28.45	<0.01*	106.189	99.57 - 113.25	<0.01*
Gender						
Female	Reference					
Male	1.06	1.05 - 1.08	<0.01*	1.18	1.16 - 1.20	<0.01*
BMI						
Normal weight	Reference					
Underweight	0.78	0.74 - 0.83	<0.01*	0.86	0.81 - 0.92	<0.01*
Overweight	1.56	1.52 - 1.59	<0.01*	1.45	1.41 - 1.49	<0.01*
Obese	2.24	2.19 - 2.29	<0.01*	2.15	2.09 - 2.19	<0.01*
Region						
Central	Reference					
Western	0.74	0.72 - 0.75	<0.01*	0.62	0.61 - 0.63	<0.01*
Eastern	0.90	0.88 - 0.92	<0.01*	0.89	0.87 - 0.92	<0.01*

*Statistically significant ($P<0.05$)

Figures

Figure 1

The distribution of BMI categories for Saudi and non-Saudi

Figure 2

prevalence of obesity and overweight by gender: Saudis

Figure 3
prevalence of obesity and overweight by gender: Non-Saudis