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CLUSTERING OF CARDIOVASCULAR RISK FACTORS IN HYPERTENSIVE PATIENTS ADMITTED TO HOSPITAL

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ABSTRACT

Background: Hypertension remains the most common modifiable risk factor for cardiovascular morbidity and mortality worldwide. The clustering of several cardiovascular risk factors (dyslipidemia, diabetes mellitus, obesity and smoking) among hypertensive subjects further increases the risk of adverse cardiovascular events. In the Jordanian population, the prevalence of hypertension and associated risk factors is notably high. However, the pattern and extent of risk factor clustering among hypertensive patients admitted to King Hussein Medical Center have not been systematically characterized.

Objective: This retrospective study aimed to characterize the clustering patterns of major cardiovascular risk factors among hypertensive patients admitted to the internal medicine department at King Hussein Medical Center and to identify the most frequently associated comorbidities.

Methods: This retrospective cross-sectional study was conducted on 302 hypertensive patients (age ≥ 18 years) who were admitted to the internal medicine department at King Hussein Medical Center between January 2023 and August 2026. We reviewed the medical records. Data were extracted from electronic medical records (HAKEEM system) for demographic variables, anthropometric measurements, laboratory parameters and documented clinical history of comorbid conditions. Information on lifestyle factors including smoking status and physical activity was obtained from social history documentation. Risk factor clustering was defined as the presence of hypertension in combination with at least two other cardiovascular risk factors. Descriptive statistics and frequency analyzes were applied to assess the prevalence and the patterns of clustering. Subgroup analyses were performed based on age, gender, and the number of coexisting risk factors.

Results: Among 302 hypertensive patients (mean age 62.8 ± 12.4 years, 54.6% male), risk factor clustering was highly prevalent, with 78.5% ($n=237$) having at least two additional cardiovascular risk factors, and 42.7% ($n=129$) having three or more. The most common coexisting risk factors were dyslipidemia (68.2%, $n=206$), diabetes mellitus (48.7%, $n=147$), obesity (43.4%, $n=131$), and current smoking (32.5%, $n=98$). Physical inactivity was documented in 56.3% ($n=170$) of patients. Clustering was more common with increasing age, and patients aged ≥ 65 years had significantly higher mean number of risk factors (2.8 ± 1.1 vs. 2.3 ± 1.0 , $p<0.001$). Male patients were more likely to smoke (42.4% vs 20.4%, $p<0.001$) and had a higher mean number of risk factors (2.7 ± 1.1 vs 2.4 ± 1.0 , $p=0.016$), while female patients were more likely to be obese (52.9% vs 35.5%, $p=0.002$). Patients with ≥ 3 risk factors clustered together had

significantly higher rates of coronary artery disease (34.1% vs 18.2%, $p=0.003$), cerebrovascular disease (16.3% vs 7.5%, $p=0.024$) and chronic kidney disease (27.9% vs 14.0%, $p=0.006$). Multivariate logistic regression identified age ≥ 65 years (OR=2.14, 95% CI: 1.28–3.58, $p=0.004$), male gender (OR=1.68, 95% CI: 1.02–2.77, $p=0.041$), and obesity (OR=2.45, 95% CI: 1.48–4.06, $p<0.001$) as independent predictors of clustering of ≥ 3 risk factors.

Conclusion: Cardiovascular risk factor clustering is highly prevalent among hypertensive patients admitted to the internal medicine department at King Hussein Medical Center, with nearly 80% having at least two additional risk factors and over 40% having three or more. Clustering of ≥ 3 risk factors was significantly more common with coronary artery disease, cerebrovascular disease and chronic kidney disease. These results emphasize the necessity of a comprehensive assessment of cardiovascular risk, and the need for integrated management approaches addressing several risk factors at the same time.

Keywords: Hypertension; Cardiovascular risk factors; Risk factor clustering; Comorbidities

1 INTRODUCTION

Hypertension is the most common modifiable risk factor for cardiovascular morbidity and mortality worldwide, affecting >1.4 billion adults worldwide and accounting for ~ 10.4 million deaths annually [1]. In Jordan, the prevalence of hypertension is among the highest in the Middle East and North Africa region, estimated at 30–35% of the adult population, with a substantial proportion of patients remaining undiagnosed or inadequately controlled [2,3].

The presence of other risk factors (such as dyslipidemia, diabetes mellitus, obesity, smoking, and physical inactivity) greatly increases the cardiovascular risk associated with hypertension [4]. The clustering of multiple risk factors in the same individual has a multiplicative effect on cardiovascular risk rather than additive, greatly increasing the likelihood of myocardial infarction, stroke, heart failure and cardiovascular death [5,6]. This phenomenon, often referred to as "risk factor clustering" or "metabolic syndrome," is highly prevalent in hypertensive populations and represents a major public health challenge [7].

Several studies have shown that most of the hypertensive patients have one or more additional cardiovascular risk factors with clustering of three or more risk factors common in hospitalized cohorts [8,9]. The presence of clustering significantly complicates clinical management, as each additional risk factor requires specific therapeutic intervention, and the cumulative burden of polypharmacy and lifestyle modification can be challenging for patients and healthcare providers alike [10].

Clustering of risk factors is well recognized as clinically significant in hypertensive patients. However, there is a lack of comprehensive data regarding the prevalence and patterns of clustering in the Jordanian hospitalized population. It is essential to understand the degree of clustering and the most common comorbidity associations to develop targeted prevention and management strategies, optimize resource allocation and improve cardiovascular outcomes in this high-risk population. This study therefore aimed to characterize the clustering patterns of major cardiovascular risk factors among hypertensive patients admitted to the internal medicine department at King Hussein Medical Center and to identify the most frequently associated comorbidities.

2 METHODS

2.1 Study Design and Setting

A retrospective cross-sectional study was conducted at the Department of Internal Medicine, King Hussein Medical Center, Royal Medical Services, Amman, Jordan. The study protocol was reviewed and approved by the Institutional Review Board (IRB) of the Jordanian Royal Medical Services (registration number: 72_11/2026, approval date: 30 August 2026). The requirement for informed consent was waived due to the retrospective and anonymized nature of the data.

2.2 Subjects

We reviewed the medical records of all hypertensive patients (≥ 18 years) admitted to the internal medicine department between January 2023 and August 2026. A total of 302 patients fulfilled the inclusion criteria. Inclusion criteria were age ≥ 18 years, documented diagnosis of hypertension (ICD-10 code I10), complete medical records with all required variables, and length of stay ≥ 48 hours. Exclusion criteria included age < 18 years, secondary hypertension, pregnancy, incomplete medical records, transfer from another hospital, and length of stay < 48 hours.

2.3 Data Collection

Data were extracted from electronic medical records (HAKEEM system) using a standardized case report form. Demographic and clinical data collected were age, gender, nationality, body mass index, waist circumference and length of stay. Laboratory parameters were fasting blood glucose, HbA1c, lipid profile (total cholesterol, low density lipoprotein cholesterol, high density lipoprotein cholesterol, triglycerides), serum creatinine and estimated glomerular filtration rate (eGFR). Comorbidities recorded included diabetes mellitus, dyslipidemia, coronary artery disease, cerebrovascular disease, chronic kidney disease, and peripheral artery disease. Lifestyle factors including smoking status (current, former, never) and physical activity (active, sedentary) were obtained from social history documentation in physician and nursing admission assessments.

2.4 Definitions

Hypertension was defined as documented diagnosis or use of antihypertensive medications. Risk factor clustering was defined as the co-occurrence of hypertension with at least two additional cardiovascular risk factors. Additional risk factors included dyslipidemia (LDL ≥ 100 mg/dL or on lipid-lowering therapy), diabetes mellitus (fasting glucose ≥ 126 mg/dL or HbA1c $\geq 6.5\%$ or on antidiabetic therapy), obesity (BMI ≥ 30 kg/m²), current smoking, and physical inactivity. Dyslipidemia was defined as LDL cholesterol ≥ 100 mg/dL or documented use of lipid-lowering therapy. Diabetes mellitus was defined as fasting blood glucose ≥ 126 mg/dL, or HbA1c $\geq 6.5\%$, or reported use of antidiabetic medication. Obesity was defined as BMI ≥ 30 kg/m². Chronic kidney disease was defined as eGFR < 60 mL/min/1.73m² for ≥ 3 months.

2.5 Statistical Analysis

Data were analyzed using SPSS version 27 (IBM Corp., Armonk, NY, USA). Descriptive statistics were presented as means $\pm$ standard deviations for continuous variables and frequencies with percentages for categorical variables. Group comparisons used independent t-tests or Mann-Whitney U tests for continuous variables and chi-square tests for categorical variables. Multivariate logistic regression identified independent predictors of clustering of ≥ 3 risk factors. Variables with $p < 0.1$ in univariate analysis were included in the multivariate model. Results were reported as adjusted odds ratios (aOR) with 95% confidence intervals. A p-value < 0.05 was considered statistically significant.

3 RESULTS

3.1 Participant Characteristics

A total of 302 hypertensive patients were included in the final analysis, with a mean age of 62.8 ± 12.4 years (range 18–96 years) and a male predominance of 54.6% (n=165). The mean BMI was 29.8 ± 5.6 kg/m², and 43.4% (n=131) were obese (BMI ≥ 30 kg/m²). The mean length of stay was 9.6 ± 5.2 days.

3.2 Prevalence of Cardiovascular Risk Factors

The most common coexisting risk factors were dyslipidemia, affecting 68.2% (n=206) of patients, followed by diabetes mellitus in 48.7% (n=147), obesity in 43.4% (n=131), and current smoking in 32.5% (n=98). Physical inactivity was documented in 56.3% (n=170) of patients.

3.3 Patterns of Risk Factor Clustering

Risk factor clustering was highly prevalent in this cohort. In total, 78.5% (n=237) of patients had ≥ 2 and 42.7% (n=129) had ≥ 3 additional cardiovascular risk factors. Patients were distributed according to the number of additional risk factors as follows: 22 patients (7.3%) had no extra risk factor, 43 patients (14.2%) had one extra risk factor, 108 patients (35.8%) had two extra risk factors, 89 patients (29.5%) had three extra risk factors, 32 patients (10.6%) had four extra risk factors, 8 patients (2.6%) had five extra risk factors. The most common combinations of risk factors were hypertension with dyslipidemia and diabetes (n=58, 19.2%), hypertension with dyslipidemia and obesity (n=46, 15.2%), hypertension with dyslipidemia and smoking (n=38, 12.6%), and hypertension with diabetes and obesity (n=34, 11.3%).

3.4 Risk Factors by Age Group

The prevalence of clustering increased with age. Patients aged ≥ 65 years had a significantly higher mean number of risk factors compared to younger patients (2.8 ± 1.1 vs. 2.3 ± 1.0 , $p < 0.001$) and a higher prevalence of clustering of ≥ 3 risk factors (52.4% vs. 35.6%, $p = 0.003$). Individual risk factor prevalence by age group showed that dyslipidemia was present in 72.0% of patients aged ≥ 65 years compared to 64.5% of younger patients ($p = 0.161$), diabetes mellitus in 52.7% versus 44.7% ($p = 0.163$), obesity in 43.3% versus 43.4% ($p = 0.987$), and current smoking in 29.3% versus 35.5% ($p = 0.250$).

3.5 Risk Factors by Gender

Current smoking was more prevalent among male patients (42.4% vs 20.4%, $p < 0.001$), as was a higher mean number of risk factors (2.7 ± 1.1 vs 2.4 ± 1.0 , $p = 0.016$). Female patients were more likely to have obesity (52.9% vs. 35.5%, $p = 0.002$). Clustering of ≥ 3 risk factors was present in 47.3% of males and 37.2% of females ($p = 0.075$). Dyslipidemia was present in 67.9% of males and 68.6% of females ($p = 0.891$), while diabetes mellitus was present in 49.7% of males and 47.4% of females ($p = 0.692$).

3.6 Clustering and Comorbidities

Patients with clustering of ≥ 3 risk factors had significantly higher rates of comorbid conditions compared to those with 0–2 risk factors. Coronary artery disease was present in 34.1% of patients with ≥ 3 risk factors compared to 18.2% of those with 0–2 risk factors ($p = 0.003$). Cerebrovascular disease was documented in 16.3% versus 7.5% respectively ($p = 0.024$). Chronic kidney disease was present in 27.9% versus 14.0% ($p = 0.006$). Peripheral artery disease showed a trend toward higher prevalence in the clustering group (9.3% vs. 4.6%, $p = 0.112$), though this did not reach statistical significance.

3.7 Multivariate Predictors of Clustering

Multivariate logistic regression identified independent predictors of clustering of ≥ 3 risk factors. Age ≥ 65 years was associated with an adjusted odds ratio of 2.14 (95% CI: 1.28–3.58, $p = 0.004$). Male gender was associated with an adjusted odds ratio of 1.68 (95% CI: 1.02–2.77, $p = 0.041$). Obesity (BMI ≥ 30 kg/m²) was the strongest independent predictor [adjusted odds ratio = 2.45 (95% CI = 1.48–4.06, $p < 0.001$)].

Table 1: Prevalence of Cardiovascular Risk Factors (N=302)

Risk Factor	Definition	n (%)
Dyslipidemia	LDL ≥ 100 mg/dL or on lipid-lowering therapy	206 (68.2)
Diabetes Mellitus	Fasting glucose ≥ 126 mg/dL, HbA1c $\geq 6.5\%$, or on antidiabetic therapy	147 (48.7)
Obesity	BMI ≥ 30 kg/m ²	131 (43.4)
Current Smoking	Active smoker at admission	98 (32.5)
Physical Inactivity	Sedentary lifestyle documented	170 (56.3)

Legend: Prevalence of individual cardiovascular risk factors among 302 hypertensive patients. *Abbreviations:* LDL, Low-Density Lipoprotein; BMI, Body Mass Index; HbA1c, Glycated Hemoglobin.

Table 2: Distribution of Patients by Number of Additional Risk Factors (N=302)

Number of Additional Risk Factors	n (%)
0	22 (7.3)
1	43 (14.2)
2	108 (35.8)
3	89 (29.5)
4	32 (10.6)
5	8 (2.6)
≥ 2 risk factors	237 (78.5)
≥ 3 risk factors	129 (42.7)

Legend: Distribution of hypertensive patients by the number of coexisting cardiovascular risk factors.

Table 3: Risk Factor Clustering by Age Group

Parameter	Age <65 years (n=152)	Age ≥65 years (n=150)	p-value
Mean number of risk factors	2.3 ± 1.0	2.8 ± 1.1	<0.001
≥3 risk factors, n (%)	54 (35.6)	75 (52.4)	0.003
Dyslipidemia, n (%)	98 (64.5)	108 (72.0)	0.161
Diabetes Mellitus, n (%)	68 (44.7)	79 (52.7)	0.163
Obesity, n (%)	66 (43.4)	65 (43.3)	0.987
Current Smoking, n (%)	54 (35.5)	44 (29.3)	0.250

Legend: Comparison of risk factor clustering by age group. Abbreviations: SD, Standard Deviation.

Table 4: Risk Factor Clustering by Gender

Parameter	Male (n=165)	Female (n=137)	p-value
Mean number of risk factors	2.7 ± 1.1	2.4 ± 1.0	0.016
≥3 risk factors, n (%)	78 (47.3)	51 (37.2)	0.075
Dyslipidemia, n (%)	112 (67.9)	94 (68.6)	0.891
Diabetes Mellitus, n (%)	82 (49.7)	65 (47.4)	0.692
Obesity, n (%)	58 (35.5)	73 (52.9)	0.002
Current Smoking, n (%)	70 (42.4)	28 (20.4)	<0.001

Legend: Comparison of risk factor clustering by gender. Abbreviations: SD, Standard Deviation.

Table 5: Comorbidities by Clustering Status

Comorbidity	0–2 Risk Factors (n=173)	≥3 Risk Factors (n=129)	p-value
Coronary Artery Disease, n (%)	31 (18.2)	44 (34.1)	0.003
Cerebrovascular Disease, n (%)	13 (7.5)	21 (16.3)	0.024
Chronic Kidney Disease, n (%)	24 (14.0)	36 (27.9)	0.006
Peripheral Artery Disease, n (%)	8 (4.6)	12 (9.3)	0.112

Legend: Comparison of comorbid conditions between patients with 0–2 versus ≥3 risk factors.

Table 6: Multivariate Predictors of Clustering of ≥3 Risk Factors

Predictor	Adjusted OR	95% CI	p-value
Age ≥65 years	2.14	1.28–3.58	0.004
Male gender	1.68	1.02–2.77	0.041
Obesity (BMI ≥30 kg/m ²)	2.45	1.48–4.06	<0.001

Legend: Multivariate logistic regression analysis identifying independent predictors of clustering of ≥3 cardiovascular risk factors. Abbreviations: OR, Odds Ratio; CI, Confidence Interval; BMI, Body Mass Index.

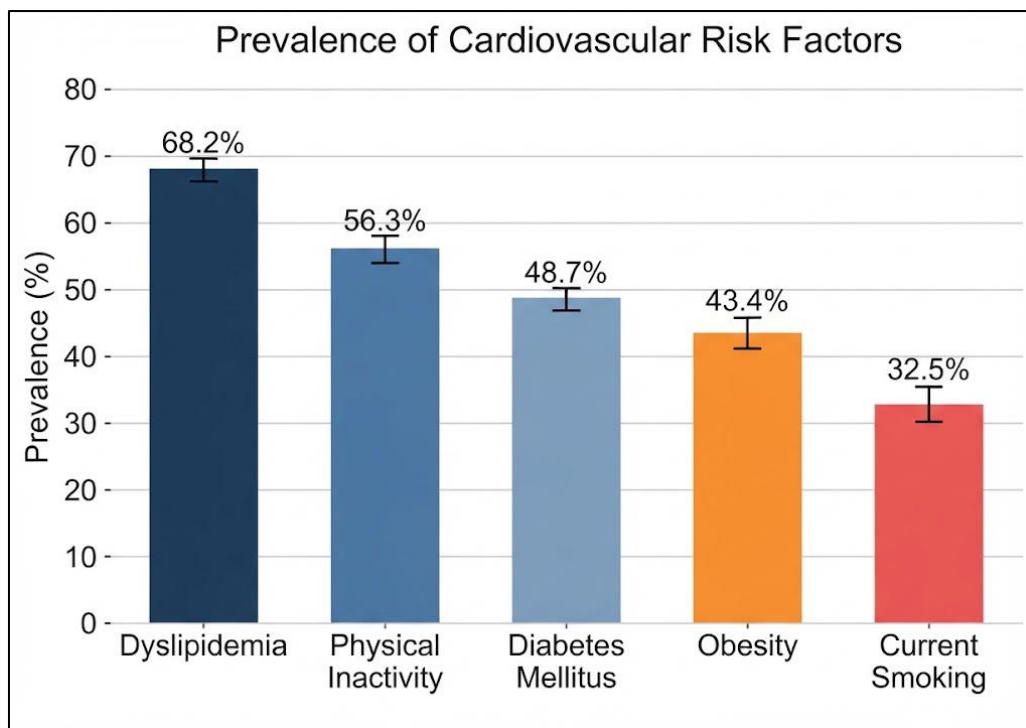


Figure 1: Prevalence of Cardiovascular Risk Factors

Legend: Bar chart showing the prevalence of individual cardiovascular risk factors among 302 hypertensive patients. Dyslipidemia: 68.2%; Physical Inactivity: 56.3%; Diabetes Mellitus: 48.7%; Obesity: 43.4%; Current Smoking: 32.5%. Error bars represent 95% confidence intervals.

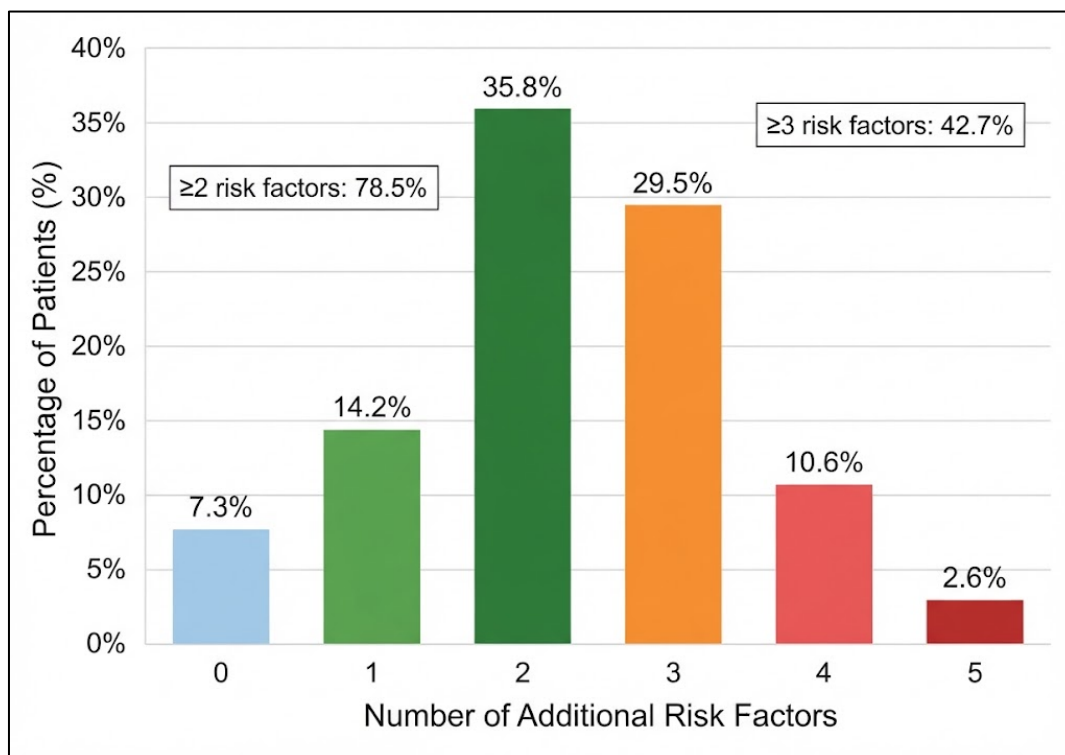


Figure 2: Distribution of Patients by Number of Additional Risk Factors

Legend: Bar chart showing the distribution of patients by the number of additional cardiovascular risk factors. 0 risk factors: 7.3%; 1 risk factor: 14.2%; 2 risk factors: 35.8%; 3 risk factors: 29.5%; 4 risk factors: 10.6%; 5 risk factors: 2.6%.

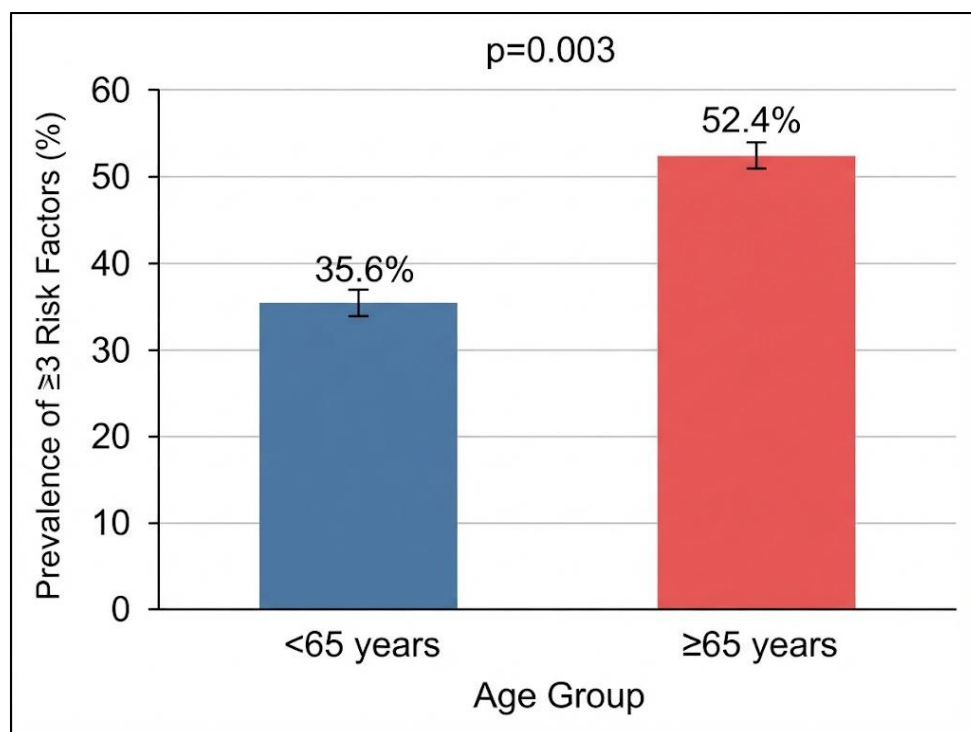


Figure 3: Risk Factor Clustering by Age Group

Legend: Bar chart comparing the prevalence of clustering of ≥ 3 risk factors between patients aged <65 years (35.6%) and ≥ 65 years (52.4%) ($p=0.003$). Error bars represent 95% confidence intervals.

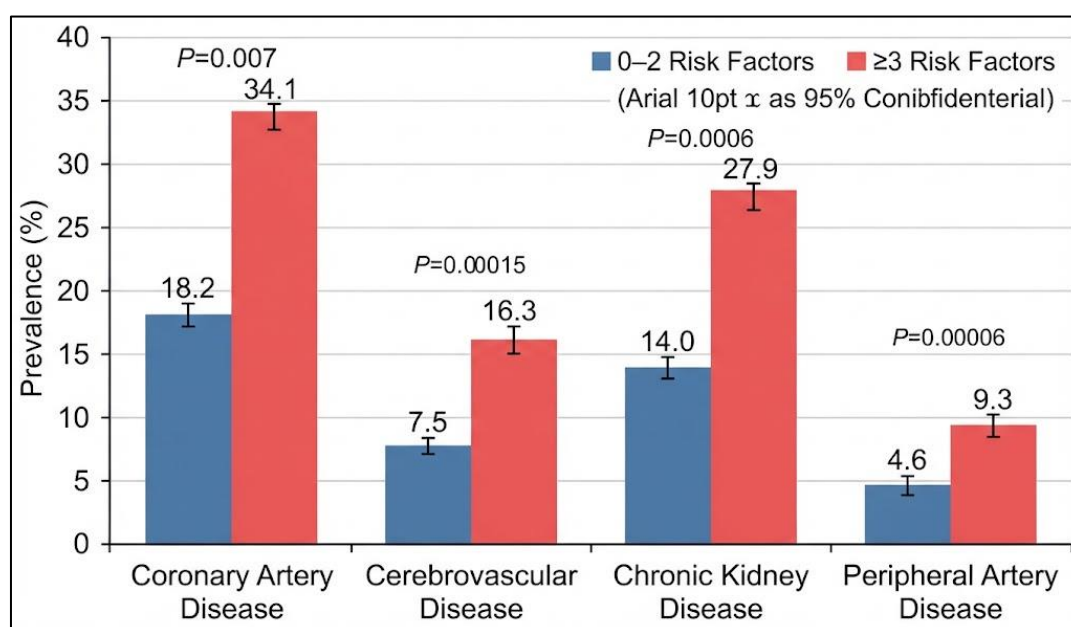


Figure 4: Comorbidities by Clustering Status

Legend: Bar chart comparing the prevalence of comorbidities between patients with 0–2 risk factors (blue bars) and ≥ 3 risk factors (red bars). Coronary artery disease: 18.2% vs. 34.1% ($p=0.003$); Cerebrovascular disease: 7.5% vs. 16.3% ($p=0.024$); Chronic kidney disease: 14.0% vs. 27.9% ($p=0.006$).

4 DISCUSSION

A retrospective cross-sectional study was conducted on 302 hypertensive patients admitted to the internal medicine department at King Hussein Medical Center. Our study shows that cardiovascular risk factor clustering is highly prevalent in this population, 78.5% had at least two additional risk factors, and 42.7% had three or more risk factors.

Dyslipidemia, diabetes mellitus, obesity, and smoking were the most common coexisting risk factors, and clustering of ≥ 3 risk factors was associated with significantly higher rates of coronary artery disease, cerebrovascular disease, and chronic kidney disease.

The high clustering rate (78.5% with ≥ 2 additional risk factors) is comparable to the previous studies in hypertensive populations [10,12,13]. Mancia et al. reported that in a European hypertensive population, 80.4% of patients had at least one other risk factor and 45.2% had 3 or more [8]. In their study, Williams et al. found that 75% of hypertensive patients had at least two risk factors, most commonly dyslipidemia, obesity and diabetes [9]. Our finding of 42.7% with ≥ 3 risk factors is comparable to the 45.2% reported by Mancia et al., suggesting that clustering patterns in our Jordanian cohort are similar to those observed in Western populations [8].

Prevalence of dyslipidemia 68.2% and diabetes mellitus 48.7% in our cohort is in line with the literature. Dyslipidemia and diabetes are highly prevalent in the Jordanian population. The rates in hypertensive patients have been previously reported to be 60–70 % and 40–50 % [2,3]. The high prevalence of obesity (43.4%) reflects the increasing epidemic of obesity in Jordan, where the prevalence of obesity has increased dramatically in the last two decades [11]. The finding that physical inactivity was documented in 56.3% of patients is also concerning, as sedentary lifestyle is a well-established modifiable risk factor for cardiovascular disease [4].

The finding of increased clustering with age is in line with previous studies. With age, the cumulative exposure to cardiovascular risk factors increases and the probability of multiple risk factors increases [10]. The prevalence of smoking was higher among males (42.4%) than females (20.4%) which is consistent with the smoking pattern in Jordan where smoking is more prevalent among males [2]. The higher prevalence of obesity among females (52.9% versus 35.5%) in this study reflects the high prevalence of obesity among women in Jordan and other Middle Eastern countries in general [11]. These gender-specific patterns of risk factor distribution have important implications for targeted prevention strategies.

The clinical relevance of clustering was highlighted by the strong association of clustering of ≥ 3 risk factors with comorbid conditions including cerebrovascular disease, chronic kidney disease and coronary artery disease. These findings are compatible with the hypothesis of an additive load of risk factors accelerating atherosclerotic cardiovascular disease and end-organ damage [5, 6]. Interestingly, clustered patients had a 3-fold higher prevalence of CKD, suggesting a possible association between clustering and cardiovascular and renal morbidity. This association may be mediated through shared pathophysiological mechanisms, including endothelial dysfunction, inflammation, and activation of the renin-angiotensin-aldosterone system [7].

The high prevalence of clustering among hypertensive patients admitted to hospital has a number of important clinical implications. First, it emphasizes the importance of total cardiovascular risk assessment beyond blood pressure control alone. Each additional risk factor demands specific therapeutic interventions, lipid lowering for dyslipidemia, glucose lowering for diabetes, weight management for obesity and smoking cessation for smokers. Second, the high prevalence of clustering highlights the need for integrated management strategies that simultaneously address multiple risk factors such as single-pill combinations for hypertension and dyslipidemia and comprehensive cardiovascular risk reduction programs [10]. Third, the identification of age, male gender, and obesity as independent predictors of clustering can help clinicians identify high-risk patients who may benefit from more intensive risk factor modification.

There are some limitations to be recognized. The retrospective cross-sectional design limits causal inference because we cannot determine the temporal relationship between the clustering of risk factors and development of comorbidities. The study was a single center study and results may not be generalizable to other health care settings in Jordan. Physical activity assessment was based on documentation in medical records, which may be incomplete or subject to reporting bias. The clustering definition used here is based on well established criteria but may not be able to capture all aspects of cardiovascular risk including emerging risk factors such as inflammatory markers and genetic predisposition. Residual confounding from unmeasured factors such as socioeconomic status, dietary habits, and medication adherence cannot be entirely excluded.

Future studies should prospectively validate these findings in larger multicenter cohorts to confirm the generalizability of our results. Evaluation of the effectiveness of integrated risk factor management interventions to reduce cardiovascular events in this population is warranted. Exploring barriers to attaining multiple risk factor control in the Jordanian health care context, including patient-related, provider-related and system-related factors, would guide the creation of specific measures. Finally, the development of culturally appropriate lifestyle modification programs for high-risk hypertensive patients in Jordan should be a priority for public health initiatives.

5 CONCLUSION

Clustering of cardiovascular risk factors is very common among hypertensive patients admitted to the internal medicine department at King Hussein Medical Center, where nearly 80% of these patients had at least two other risk factors and more than 40% had three or more. Dyslipidemia, diabetes mellitus, obesity and smoking were the most common coexisting risk factors. ≥ 3 risk factors were associated with significantly higher rates of coronary artery disease, cerebrovascular disease, and chronic kidney disease. Age ≥ 65 years, male gender and obesity were independent predictors of clustering of ≥ 3 risk factors. The results emphasize the need for a thorough evaluation of cardiovascular risk and the use of integrated management strategies that address several risk factors at once in this high-risk population.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare no conflicts of interest regarding the publication of this manuscript. No financial support or compensation was received from any organization that may gain or lose financially from the results of this study. The authors have no relevant financial or non-financial interests to disclose.

Statement of ethical approval

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of the Royal Medical Services, Jordan, on **16 September 2026** under registration number **34_13/2026**. Final institutional approval was obtained from the Educational and Technical Directorate on **20 October 2026**.

Statement of informed consent

The IRB waived the requirement for written informed consent because the data analysis was retrospective and the data were de-identified. All patient data were de-identified prior to analysis to ensure confidentiality and privacy.

AI Statement

This manuscript was prepared with the help of AI tools, which were used by the authors for initial draft structuring, language refinement, and formatting assistance. All content produced by AI was reviewed carefully, fact-checked against source data, and substantially edited by the authors. The final manuscript represents the authors' own intellectual work, analysis, and conclusions.

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