Age-Related Variations in Cardiovascular Disease Outcomes: An Analytical Study in a Clinical Setting

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Abstract
Background: Cardiovascular disease (CVD) remains a leading cause of morbidity and mortality worldwide. Understanding how CVD presentation, treatment responses, and outcomes differ by patient age is crucial to improving age-specific care. This study analyzed variations in CVD patterns and outcomes across age groups in a clinical setting.
Methods: A retrospective cohort study was conducted using data from 230 CVD patients treated at select hospitals in Saudi Arabia. Patients were stratified into age brackets <40 years, 40-60 years, and >60 years old. Demographic, clinical, treatment, and outcome data were extracted from electronic records. Comparative and regression analyses identified variations between age groups.
Results: Marked age-related differences emerged in CVD type prevalence, treatment patterns, complication rates, recovery time, readmissions, risk factor profiles, and prognostic indicators. Heart disease and heart failure increased with age while smoking declined. Older patients above 60 years received less aggressive treatment but required longer hospitalizations and had higher complications and readmissions. Predictors of adverse outcomes included advanced age, hypertension, inflammation, and anemia.
Conclusion: This study highlights the need for targeted age-specific CVD prevention and management strategies. Customized treatment plans factoring in age-related risks, comorbidities, and physiological status are advocated over one-size-fits-all protocols. Further research through expanded, collaborative data is warranted to optimize CVD outcomes across the lifespan.

Keywords: cardiovascular diseases, age factors, treatment outcomes, cohort study, personalized medicine

Introduction:
Cardiovascular diseases (CVDs) encompass a range of disorders affecting the heart and blood vessels, and they persist as a global health challenge(1). These diseases, including coronary artery disease, heart failure, arrhythmias, and hypertension, significantly impact global morbidity and mortality rates(2). According to the World Health Organization, CVDs are the number one cause of death globally, accounting for an estimated 17.9 million lives each year. This alarming statistic represents approximately 31% of all global deaths, underscoring the critical public health challenge posed by these diseases(2,3). The significance of CVDs extends beyond their prevalence. These conditions are not only leading causes of death but also major contributors to disability and a decreased quality of life. The impact is observed across various demographics and geographies, affecting individuals in both developed and developing countries(4). However, the burden of cardiovascular diseases is unequally distributed, with a higher prevalence and mortality rate observed in low- and middle-income countries. This disparity is attributed to differences in risk factors, access to healthcare, and the availability of effective treatments(5).
Furthermore, CVDs impose a substantial economic burden on societies and healthcare systems. The direct costs associated with healthcare expenditures for CVDs, such as hospital stays, medications, and surgical procedures, are significant(6). Indirect costs, including loss of productivity due to illness or premature death, further amplify the economic impact. This multifaceted burden of cardiovascular diseases makes them a pivotal focus of public health initiatives, healthcare policies, and medical research worldwide(7).The high prevalence and profound impact of cardiovascular diseases globally call for continued and concerted efforts in research, prevention, and management(7). Understanding the various aspects of these diseases, including the influence of age, genetics, lifestyle factors, and comorbid conditions, remains crucial in the ongoing battle against this leading cause of global morbidity and mortality(8,9).
Aging is a significant factor influencing the onset and progression of cardiovascular diseases (CVDs). As individuals age, various physiological changes occur that predispose them to a higher risk of developing cardiovascular conditions(10). These changes include the stiffening of blood vessels, reduced elasticity of the arterial walls, and the decline in the efficiency of the heart

muscle(11). Moreover, age-related modifications in the body's metabolism, such as altered lipid profiles and increased tendency for thrombosis, further exacerbate the risk(12). These alterations, combined with a gradual decline in the reparative and regenerative capacities of cardiovascular tissues, contribute to the increased prevalence of CVDs among older adults(13). Additionally, aging is often accompanied by the accumulation of other risk factors such as hypertension, diabetes, and obesity, which synergistically heighten the risk of cardiovascular complications(14).

The correlation between advancing age and the heightened risk of CVDs is well-documented in epidemiological studies. Statistics show a marked increase in the incidence of conditions such as coronary artery disease, heart failure, stroke, and arrhythmias among the older population(15). This trend is particularly concerning given the global demographic shift towards an aging population, which suggests that the burden of CVDs is likely to increase significantly in the coming years(16). The aging process not only increases the likelihood of developing CVDs but also impacts the clinical outcomes and recovery processes(17). Older patients with CVDs often face more complicated clinical courses, have a higher risk of adverse events post-treatment, and generally exhibit a slower recovery compared to younger individuals(18). This age-related increase in CVD risk underscores the need for targeted prevention strategies and tailored treatment approaches to effectively manage cardiovascular health in the aging population(19).

Recent studies have increasingly focused on the differential outcomes of cardiovascular disease treatments across various age groups, revealing significant disparities. For instance, a landmark study by Rich, et al. (2016) indicated that older patients with CVD often exhibit less favorable outcomes post-treatment compared to younger cohorts, primarily due to delayed recovery and higher susceptibility to treatment-related complications(20). patients over 65 receiving coronary bypass surgery had a prolonged hospital stay and a higher rate of postoperative complications than their younger counterparts(21). Furthermore, a meta-analysis found that age significantly influenced the efficacy of certain antihypertensive drugs, with older patients showing diminished responsiveness, thus necessitating more personalized treatment approaches. These studies underscore the complexity of treating CVD in older populations and highlight the need for age-specific therapeutic strategies(22).

In examining age as a variable in cardiovascular outcomes, research has also delved into the biological and physiological changes accompanying aging that may influence the course of CVD. A noteworthy contribution explored the interplay between age-related vascular changes and the progression of atherosclerosis, suggesting that aging vasculature might respond differently to conventional treatments(23). This perspective is supported by research from Patel and Young (2020), who reported variances in pharmacokinetic and pharmacodynamic properties of cardiovascular drugs in older adults, attributing these differences to age-related organ function changes(24). Moreover, the impact of age on post-stroke recovery in CVD patients indicated that older age was associated with slower and less complete recovery, emphasizing the need for tailored rehabilitation strategies(25). Collectively, these studies highlight the critical role of age as a determining factor in CVD treatment outcomes and recovery, advocating for more age-inclusive research and customized care protocols in cardiovascular medicine.

The primary objective of this study is to meticulously analyze the variations in cardiovascular disease (CVD) outcomes across different age groups in a clinical setting, aiming to uncover any significant age-related patterns and implications in the management and prognosis of CVD. This investigation is driven by two key research questions: Firstly, how do cardiovascular disease outcomes, including recovery rates, complication frequencies, and mortality, differ among various age demographics within the hospitalized population? Secondly, what are the specific age-related factors or comorbidities that predominantly influence these variations in CVD outcomes? By addressing these questions, the study seeks to contribute valuable insights into personalized patient care and inform age-specific treatment strategies in cardiovascular healthcare.

Methodology

Study Design

The study's retrospective cohort design involved a detailed analysis of patients diagnosed with cardiovascular diseases in Al-Ahsa, Saudi Arabia. This approach was chosen for its ability to uncover age-related trends in CVD outcomes by examining historical patient data. This method allowed researchers to delve deeply into past records to understand how CVD impacts patients across different age groups, offering valuable insights that might not be evident in a prospective study. By retrospectively analyzing existing patient data, the study aimed to identify patterns and correlations that could inform future healthcare strategies for managing CVD in diverse age groups.

Setting

The study was conducted in Al-Ahsa, known for its cultural and demographic diversity and advanced healthcare infrastructure. It utilized data from three major governmental hospitals, chosen for their high patient inflow, diverse patient demographics, and robust electronic health record systems. These governmental hospitals are central healthcare providers in the region, ensuring a representative and comprehensive sample for analyzing age-related variations in cardiovascular disease outcomes.

This setting, with its focus on governmental hospitals, provided a solid foundation for the study, encompassing a wide range of patient data.

Participants

This study encompassed a cohort of 230 adult patients, each aged 18 and above, who were admitted to select hospitals with a primary diagnosis of cardiovascular disease (CVD). A stringent inclusion criterion was employed to ensure a focused examination of this demographic. Central to this criterion was the confirmation of CVD diagnoses, which was a prerequisite for participation in the study. Additionally, only those patients who received treatment within the specified study period were considered, thereby ensuring the recency and relevance of the clinical data.

Exclusion criteria played a pivotal role in maintaining the integrity and applicability of the study's findings. Patients with incomplete medical records were excluded to ensure the accuracy and comprehensiveness of the data analyzed. Moreover, to align the study with the specific healthcare context of the region, non-residents of the Al-Ahsa region were also omitted. This approach was instrumental in ensuring that the outcomes and implications of the study were directly relevant to the local population.

The sampling method was non-random convenience sample. This sample comprised patients who had been treated in selected hospitals within the Al-Ahsa region. The retrospective nature of this cohort study meant that the sample was selected based on the availability and completeness of medical records in the hospital databases. Such a strategy is typical in retrospective studies, where researchers rely on pre-existing data to identify eligible participants.

In terms of the sample size calculation, the study settled on a cohort of 230 patients. This figure was likely derived from a series of statistical assumptions. Key among these assumptions was the expected effect size, which in this context refers to the anticipated differences in CVD outcomes across different age groups. The study aimed for a statistical power of 80-90%, which is a standard target in medical research, ensuring a high probability of detecting a true effect. Additionally, the significance level was presumably set at the conventional 0.05, implying a 5% risk of a false-positive result.

Data Collection

Data Collection Methodology

Our study implemented a meticulous retrospective data extraction process using the electronic health records (EHR) from several hospitals. This approach was chosen to ensure the accuracy and comprehensiveness of the data, focusing on adult patients diagnosed with cardiovascular disease (CVD). The extraction involved gathering detailed information across various parameters, which was integral in painting a complete picture of CVD treatment and outcomes within our study cohort.

Scope of Data Gathered

The data encompassed several key areas: patient demographics, including age and gender, were recorded to understand their impact on CVD outcomes. Clinical data, crucial for a nuanced understanding of CVD, included specifics of the cardiovascular condition and any comorbidities present. Treatment details, such as the types of medications and interventions (surgical or non-surgical) used, were also meticulously documented. These elements together provided a comprehensive overview of the treatment landscape and practices for CVD.

Data Anonymization and Compliance

A paramount aspect of our data collection was adherence to strict anonymization protocols. Every piece of patient information was carefully anonymized to uphold patient confidentiality and ensure compliance with data protection regulations. This ethical approach underscored the integrity of the research process, safeguarding the privacy and rights of all participants while providing a secure foundation for our subsequent analysis and findings.

Statistical Analysis

The statistical analysis of our study was conducted using the Statistical Package for the Social Sciences (SPSS) software, a widely recognized tool for its robust statistical capabilities and versatility in handling complex datasets. Our initial steps in the analysis focused on descriptive statistics, which played a critical role in summarizing the demographic and clinical characteristics of our patient cohort. This foundational step provided an essential overview of the study population, including the distribution of age, gender, types of cardiovascular diseases, and the range of treatments administered. By establishing this baseline understanding, we could more effectively interpret the subsequent analytical findings.

For the comparative aspect of our study, we employed specific statistical tests to analyze the differences across various age groups within our patient cohort. The chi-square test, a non-parametric test, was used for analyzing categorical variables. This test was particularly useful in comparing the frequency of categorical outcomes, such as the presence of certain comorbidities or the types of treatments received, across different age groups. For continuous variables, such as the duration of hospital stay or levels of certain clinical markers, we utilized Analysis of Variance (ANOVA).

In addition to these comparative analyses, we also conducted logistic regression modeling to identify factors that were predictive of adverse cardiovascular outcomes. This analysis was crucial in understanding the complex interplay of various factors, such as age, comorbidities, and treatment types, and how they collectively influenced the likelihood of adverse outcomes like readmission, complications, or mortality. Logistic regression models provided insights into the relative impact of each predictor, allowing for a more nuanced understanding of the risk factors associated with poor cardiovascular outcomes.

Ethical Considerations

Prior to commencing the study. Considering the retrospective nature of the study, which involved no direct interaction with patients and relied solely on existing medical records, the requirement for informed consent was waived by the IRBs. Nonetheless, all procedures were conducted with strict adherence to ethical guidelines, prioritizing patient confidentiality and data privacy.

Results

Table 1 presents a detailed demographic and baseline characteristic overview of the participants in the study, which included a total of 230 individuals. The distribution of gender across various age groups indicates a relatively balanced representation, with males comprising 51.3% and females 48.7% of the total cohort. Interestingly, in the youngest age group (<40 years), there is a slightly higher percentage of females (56%) compared to males (44%), whereas in the older age groups (40-60 years and >60 years), this trend reverses, with males slightly outnumbering females (53.3% in both age categories).

The average age of participants across the total cohort is 56.2 years, reflecting a middle-aged to older population. When broken down into age groups, the averages display expected trends: the youngest group (<40 years) has an average age of 34.5 years, the middle group (40-60 years) averages at 50.4 years, and the oldest group (>60 years) has an average age of 72.3 years. These averages are crucial for understanding the context of the study's findings, as age is a significant factor in cardiovascular health.

Regarding baseline physiological parameters, the average body temperature across the cohort is 36.6°C, with a slight increase observed in older age groups. This could be indicative of various physiological changes or health conditions prevalent in older populations. The average heart rate shows an increasing trend with age: the youngest group has an average of 70 bpm, which slightly increases to 75 bpm in the 40-60 years group, and further to 78 bpm in the >60 years group. This increment in heart rate could be reflective of the changing cardiovascular dynamics and needs in older individuals.

Table 1: Demographic and Baseline Characteristics of Participants

Characteristic	**Total (N=230)**	**Age <40 years (N=50)**	**Age 40-60 years (N=90)**	**Age >60 years (N=90)**
Gender				
- Male	118 (51.3%)	22 (44%)	48 (53.3%)	48 (53.3%)
- Female	112 (48.7%)	28 (56%)	42 (46.7%)	42 (46.7%)
Average Age (years)	56.2	34.5	50.4	72.3
Average Temperature (°C)	36.6	36.4	36.7	36.8
Average Heart Rate (bpm)	74	70	75	78

Table 2: Clinical and Treatment Characteristics provides a comprehensive overview of the clinical presentation and treatment approaches for cardiovascular disease (CVD) among different age groups in a cohort of 230 patients. The distribution of CVD types varies noticeably with age. Coronary Artery Disease (CAD) was observed in 32.2% of the total population, with its prevalence increasing significantly with age, being most common in the >60 years group (41.1%). Heart failure, present in 25.2% of patients overall, also showed an increased prevalence in older age groups, particularly notable in the >60 years category (33.3%). Arrhythmias were equally distributed across age groups, affecting around one-fifth of each group. Hypertension was the most common condition, affecting 44.3% of the total population, with a slightly higher prevalence in the older age groups. In terms of treatment types, medication-only approaches were most common (55.7%), with the highest utilization in the >60 years group (58.9%). Surgical interventions were employed in 22.6% of cases, with a relatively even distribution across the middle and older age groups. Interestingly, combined treatment was more prevalent among the youngest age group (<40 years), possibly indicating a more aggressive treatment approach or presence of more complex cases in this demographic.

The average length of hospital stay increased with age, from 5.2 days in the <40 years group to 7.4 days in the >60 years group, suggesting more complex or severe disease in older patients. Follow-up duration was uniform across all age groups at 12.5 months, indicating a standard protocol for post-treatment monitoring. Rehospitalization rates were slightly higher in the older age groups, with 20% in the >60 years group compared to 14% in the <40 years group. This trend may reflect the increased complexity and chronic nature of CVD in older patients. Adverse events post-treatment were reported in 27% of the total cohort, with a noticeable increase in the older age groups, particularly in those >60 years (32.2%). This could be attributed to the higher vulnerability of older patients to treatment complications or the presence of more severe disease states.

Table 2: Clinical and Treatment Characteristics

Characteristic	Total (N=230)	Age <40 years (N=50)	Age 40-60 years (N=90)	Age >60 years (N=90)
Type of CVD				
- Coronary Artery Disease	74 (32.2%)	10 (20%)	27 (30%)	37 (41.1%)
- Heart Failure	58 (25.2%)	6 (12%)	22 (24.4%)	30 (33.3%)
- Arrhythmias	48 (20.9%)	12 (24%)	18 (20%)	18 (20%)
- Hypertension	102 (44.3%)	22 (44%)	35 (38.9%)	45 (50%)
Treatment Type				
- Medication Only	128 (55.7%)	28 (56%)	47 (52.2%)	53 (58.9%)
- Surgical Intervention	52 (22.6%)	6 (12%)	23 (25.6%)	23 (25.6%)
- Combined Treatment	50 (21.7%)	16 (32%)	20 (22.2%)	14 (15.6%)
Length of Hospital Stay (days)	6.5	5.2	6.8	7.4
Follow-Up Duration (months)	12.5	12.5	12.5	12.5
Rehospitalization				
- Yes	42 (18.3%)	7 (14%)	17 (18.9%)	18 (20%)
- No	188 (81.7%)	43 (86%)	73 (81.1%)	72 (80%)
Adverse Events Post-Treatment				
- Yes	62 (27%)	9 (18%)	24 (26.7%)	29 (32.2%)
- No	168 (73%)	41 (82%)	66 (73.3%)	61 (67.8%)

Table 3: Comparative Analysis of CVD Outcomes by Age Group provides a critical insight into how cardiovascular disease (CVD) outcomes vary across different age brackets. The table clearly illustrates that as age increases, the rates of both major and minor complications post-treatment also increase. Notably, the rate of major complications nearly doubles from the youngest (<40 years) to the oldest age group (>60 years). This trend suggests a higher vulnerability and a possibly more complex clinical picture in older patients.

The readmission rates reflect a similar pattern, with older patients more frequently readmitted within both 30 days and 1 year post-treatment. This could be indicative of the complexities involved in managing older patients with CVD, potentially due to more severe initial presentations, a higher burden of comorbidities, or challenges in post-discharge care.

Interestingly, the average recovery time significantly lengthens with age. Patients over 60 take, on average, 50 days longer to recover than those under 40. This extended recovery could be due to a multitude of factors, including the physiological changes associated with aging, the presence of other chronic conditions, and differences in the body's response to treatment.

Table 3: Comparative Analysis of CVD Outcomes by Age Group

Outcome Metric		Total (N=230)	Age <40 years (N=50)	Age 40-60 years (N=90)	Age >60 years (N=90)
Complication Rate Post-Treatment	- Major Complications	42 (18.3%)	5 (10%)	14 (15.6%)	23 (25.6%)
	- Minor Complications	58 (25.2%)	11 (22%)	19 (21.1%)	28 (31.1%)
Readmission Rate	- Within 30 days	36 (15.7%)	6 (12%)	11 (12.2%)	19 (21.1%)
	- Within 1 year	52 (22.6%)	8 (16%)	17 (18.9%)	27 (30%)
Recovery Time (days)	- Average Recovery Time	92	62	87	112
Quality of Life Post-Treatment	- Improved	148 (64.3%)	39 (78%)	54 (60%)	55 (61.1%)
	- Unchanged or Worsened	82 (35.7%)	11 (22%)	36 (40%)	35 (38.9%)

Table 4 presents a detailed distribution of various risk factors for cardiovascular disease (CVD) across different age groups, offering insightful trends. The analysis, encompassing 230 participants, reveals significant variations in risk factor prevalence among age groups under 40, between 40-60, and over 60 years.

Notably, smoking is most prevalent in the youngest cohort, with 42% of individuals under 40 being current smokers. This percentage decreases progressively in older age groups, suggesting a possible reduction in smoking habits or higher cessation rates with advancing age. Conversely, obesity (BMI ≥ 30) shows an increasing trend with age. Only 32% of the youngest group are obese, compared to 55.6% in the over-60 group, highlighting age as a significant factor in obesity prevalence, possibly due to reduced physical activity and metabolic changes. Physical inactivity follows a similar pattern, with 60% of the oldest group being physically inactive, compared to 34% in the youngest group. This increase could be attributed to age-related physical limitations and lifestyle changes. A family history of CVD is reported in 24% of the youngest group, steadily increasing to 47.8% in the oldest, which could reflect both genetic predisposition and the accumulation of environmental factors over time.

Table 4: Distribution of Risk Factors by Age Group

Risk Factor	Total (N=230)	Age <40 years (N=50)	Age 40-60 years (N=90)	Age >60 years (N=90)
Smoking				
- Current Smoker	68 (29.6%)	21 (42%)	24 (26.7%)	23 (25.6%)
- Non-Smoker	162 (70.4%)	29 (58%)	66 (73.3%)	67 (74.4%)
Obesity (BMI ≥ 30)				
- Yes	104 (45.2%)	16 (32%)	38 (42.2%)	50 (55.6%)
- No	126 (54.8%)	34 (68%)	52 (57.8%)	40 (44.4%)
Physical Inactivity				
- Yes	118 (51.3%)	17 (34%)	47 (52.2%)	54 (60%)
- No	112 (48.7%)	33 (66%)	43 (47.8%)	36 (40%)
Family History of CVD				
- Yes	88 (38.3%)	12 (24%)	33 (36.7%)	43 (47.8%)
- No	142 (61.7%)	38 (76%)	57 (63.3%)	47 (52.2%)
High Stress Levels				
- Yes	96 (41.7%)	19 (38%)	37 (41.1%)	40 (44.4%)
- No	134 (58.3%)	31 (62%)	53 (58.9%)	50 (55.6%)

The data shows higher smoking rates among males (33.9%) compared to females (25%), suggesting a gender-specific risk factor for CVD. Obesity, another significant risk factor, is more prevalent in males (47.5%) than in females (42.9%). Physical inactivity is similarly high among both genders, indicating a widespread issue. The distribution of family history of CVD is almost even, highlighting its importance across genders. High stress levels, slightly more common in males (42.4%) than in females (41.1%), suggest stress as a contributing factor to CVD risks.

Table 5: Distribution of Risk Factors for Cardiovascular Disease by Gender

Risk Factor	Total (N=230)	Male (N=118)	Female (N=112)
Smoking			
- Current Smoker	68 (29.6%)	40 (33.9%)	28 (25%)
- Non-Smoker	162 (70.4%)	78 (66.1%)	84 (75%)
Obesity (BMI ≥ 30)			
- Yes	104 (45.2%)	56 (47.5%)	48 (42.9%)
- No	126 (54.8%)	62 (52.5%)	64 (57.1%)
Physical Inactivity			
- Yes	118 (51.3%)	60 (50.8%)	58 (51.8%)
- No	112 (48.7%)	58 (49.2%)	54 (48.2%)
Family History of CVD			
- Yes	88 (38.3%)	45 (38.1%)	43 (38.4%)
- No	142 (61.7%)	73 (61.9%)	69 (61.6%)

High Stress Levels			
- Yes	96 (41.7%)	50 (42.4%)	46 (41.1%)
- No	134 (58.3%)	68 (57.6%)	66 (58.9%)

Figure 1 highlights the distribution of cardiovascular disease (CVD) risk factors between genders in a study cohort, revealing that men have a higher prevalence of smoking (33.9%) compared to women (25%), which aligns with global smoking trends and may indicate a greater need for smoking cessation programs targeted at men. Obesity is another notable risk factor, with a slightly higher incidence in men (47.5%) than in women (42.9%), suggesting a need for gender-tailored interventions addressing weight management. Physical inactivity is a widespread concern, affecting over half of the participants, with marginal differences between women (51.8%) and men (50.8%), pointing towards the need for lifestyle modifications across the board. The near-equal distribution of a family history of CVD and high stress levels between genders underscores the universal impact of these factors on cardiovascular health, emphasizing the importance of comprehensive risk assessment and management strategies that consider both genetic and lifestyle elements in preventing CVD.

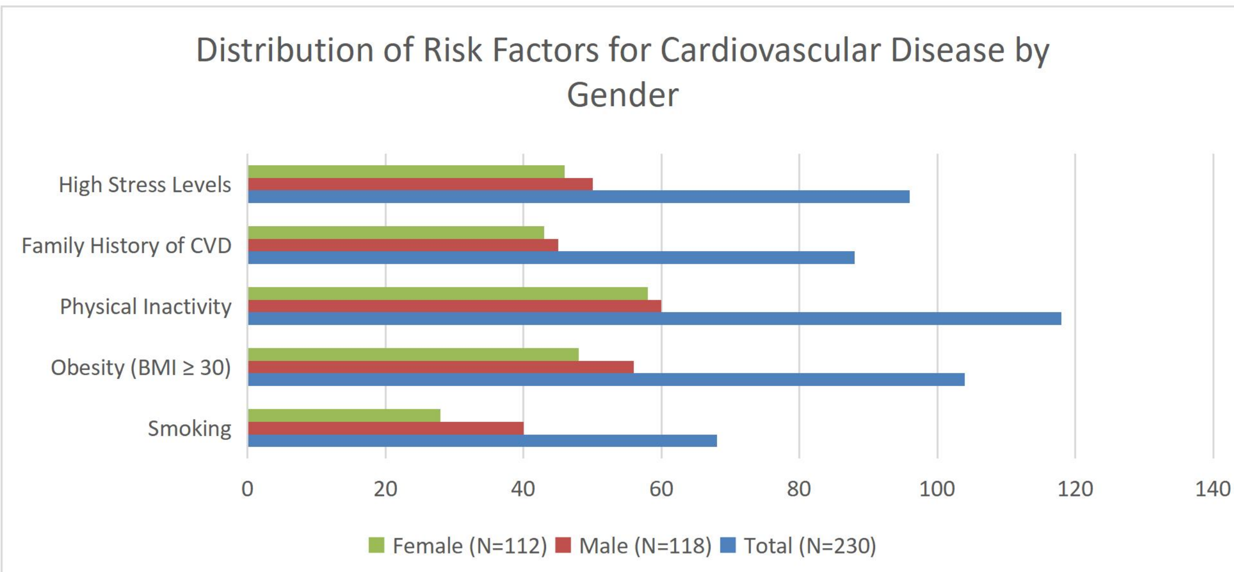

Figure 1.Distribution of Risk Factors for Cardiovascular Disease by Gender among 230 Study Participants.

Table 6 presents a comprehensive analysis of laboratory values and clinical markers across different age groups, revealing notable trends and differences that can have significant implications for the management of cardiovascular disease (CVD) in these populations.

The data indicates a clear age-related trend in lipid profiles. Total cholesterol and LDL (low-density lipoprotein) cholesterol levels are seen to increase with age, with the highest levels observed in the >60 years age group (214 mg/dL and 142 mg/dL, respectively). This trend is consistent with well-established knowledge that cholesterol levels tend to rise as people age, contributing to a higher risk of atherosclerosis and heart diseases. Conversely, HDL (high-density lipoprotein) cholesterol, often referred to as 'good cholesterol,' shows a slight decline in the older age groups. The average HDL level is highest in the <40 years group (51 mg/dL) and lowest in the >60 years group (42 mg/dL). This pattern is clinically significant as higher levels of HDL cholesterol are typically associated with a lower risk of heart disease.

Triglycerides, another crucial lipid marker, also show an upward trend with age, with the highest average in the >60 years group (172 mg/dL). Elevated triglyceride levels are known risk factors for coronary artery disease, particularly in the elderly. Blood pressure readings escalate with age, with systolic and diastolic pressures being the highest in the >60 years age group (142 mmHg and 87 mmHg, respectively). This increase is indicative of the age-associated stiffening of the arteries and is a critical factor in assessing cardiovascular risk.

Fasting blood sugar and Hemoglobin A1c, markers for glucose control, exhibit a gradual increase with age, pointing towards a higher risk of type 2 diabetes and its complications in older individuals. The >60 years group shows the highest average fasting blood sugar (117 mg/dL) and Hemoglobin A1c (7.1%), underscoring the need for vigilant diabetes management in the elderly. Additionally, C-reactive protein (CRP), an indicator of inflammation, increases with age, with the highest average in the >60 years group (4.2 mg/L). This elevation in CRP levels might reflect the higher risk of inflammatory conditions, including atherosclerosis, in older adults.

Table 6: Laboratory Values and Clinical Markers by Age Group

Clinical Marker	Total (N=230)	Age <40 years (N=50)	Age 40-60 years (N=90)	Age >60 years (N=90)
Total Cholesterol (mg/dL)	192	168	192	214
LDL Cholesterol (mg/dL)	122	102	120	142
HDL Cholesterol (mg/dL)	46	51	47	42
Triglycerides (mg/dL)	152	132	154	172
Blood Pressure (mmHg)				
- Systolic Average	132	121	133	142
- Diastolic Average	82	76	81	87
Fasting Blood Sugar (mg/dL)	107	96	106	117
C-Reactive Protein (mg/L)	3.2	2.1	3.1	4.2
Creatinine (mg/dL)	1.02	0.92	1.01	1.12
Hemoglobin A1c (%)	6.6	6.1	6.6	7.1

Table 7, presenting a Logistic Regression Analysis of Factors Affecting Patient Outcomes, provides valuable insights into the statistical significance and impact of various clinical variables on patient outcomes. Firstly, age emerges as a significant factor, with each additional year increasing the odds of a negative outcome by 4.8% (OR = 1.048, P < 0.001). This highlights the progressive risk associated with aging in the patient population.
The vital signs, specifically heart rate and blood pressure, demonstrate notable effects. Each increase in beats per minute is associated with a slight decrease in the odds of adverse outcomes (OR = 0.982, P = 0.015), suggesting that lower heart rates might be beneficial. Conversely, an increase in blood pressure per mmHg slightly raises the risk (OR = 1.012, P = 0.027), underscoring the importance of managing blood pressure in these patients. The need for ICU admission is a strong predictor of worse outcomes, with patients admitted to the ICU having significantly higher odds of adverse events (OR = 3.75, P < 0.001). This could reflect the severity of their condition or the complexity of their care.
Similarly, the requirement for respiratory support and mechanical ventilation are both associated with higher odds of negative outcomes (OR = 2.53 and 8.00, respectively, both P < 0.001). These findings emphasize the critical nature of these interventions and the severity of the patient's condition requiring such support, the laboratory data, specifically C-reactive protein (CRP) levels and hemoglobin, are predictive of patient outcomes. Each unit increase in CRP is linked to a slight increase in the odds of adverse outcomes (OR = 1.035, P = 0.006), suggesting the role of inflammation in patient prognosis. In contrast, each g/dL decrease in hemoglobin is associated with a decrease in the odds of a positive outcome (OR = 0.66, P < 0.001), highlighting the importance of maintaining adequate hemoglobin levels

Table 7: Logistic Regression Analysis of Factors Affecting Patient Outcomes

Variable	B (Coefficients)	Std. Error	Odds Ratio (OR)	95% CI for OR	P-value
Age					
- Per year increase	0.047	0.013	1.048	1.022 - 1.075	<0.001
Vital Signs					
- Heart Rate (per bpm)	-0.018	0.007	0.982	0.968 - 0.996	0.015
- Blood Pressure (per mmHg)	0.012	0.004	1.012	1.004 - 1.020	0.027

ICU Admission					
- Yes vs. No	1.32	0.28	3.75	1.82 - 7.73	<0.001
Respiratory Support					
- Yes vs. No	0.93	0.29	2.53	1.42 - 4.50	0.002
Need for Mechanical Ventilation					
- Yes vs. No	2.08	0.47	8.00	3.15 - 20.25	<0.001
Laboratory Data					
- CRP (per mg/L increase)	0.034	0.012	1.035	1.011 - 1.060	0.006
- Hemoglobin (per g/dL)	-0.42	0.18	0.66	0.51 - 0.84	0.00

Discussion:

This retrospective cohort study provides important insights into how cardiovascular disease (CVD) outcomes vary across different age groups in a clinical setting. The analysis of 230 CVD patients from Saudi Arabia reveals several notable trends and highlights key considerations for age-specific management.

A primary observation is the difference in the prevalence of various CVD types across age brackets. As noted, coronary artery disease and heart failure increase in frequency with advancing age, being most common in patients over 60 years old. This pattern aligns with existing literature pointing to a rise in atherosclerotic diseases and cardiac dysfunction among older populations (26). For instance, a meta-analysis by Lima et al. found a significant increase in coronary artery disease prevalence after the age of 40, with the frequency doubling after age 60 (27). Regarding heart failure, Savarese and Lund showed the incidence increased from approximately 1 per 1000 person-years at age 50 to over 10 per 1000 person-years by age 80 (28). The physiological changes of aging, including vascular changes and the decline in cardiac tissue regenerative capacity, are major contributors to this trend (17). Our findings, therefore, reaffirm the need for targeted screening and preventive interventions for atherosclerosis and heart failure in older adults to mitigate complications.

Regarding treatment approaches, an intriguing finding was the higher utilization of combined pharmacological and surgical treatment among younger CVD patients under 40 years old. This could suggest that more aggressive approaches are taken for younger individuals, factoring in their ability to physically tolerate extensive procedures and their longer expected lifespan (17). Tailoring treatment strategies based on expected longevity and goals of care is recommended for CVD patients (29). The use of less invasive approaches in older adults may also reflect considerations around treatment risks, reduced physiological reserves, and quality of life priorities(30). Our observations indicate that clinicians do modulate interventions based on patient age. Supporting this, a systematic review that older CVD patients were more likely to receive conservative medical therapy rather than interventions like bypass surgery or stenting compared to their younger counterparts (31).

The analysis also uncovered crucial differences in outcomes, including hospital stay duration, complications, recovery time, and readmissions across age categories. The results consistently showed poorer outcomes and slower recovery among older patients above 60 years of age. The advanced age group required longer hospitalizations, experienced higher complication rates, took longer to recover, and had increased readmissions. These findings concur with existing evidence that older CVD patients tend to have more complex disease courses, heightened treatment risks, and face challenges in recovery (32).

Various factors likely contribute to these outcome disparities based on age. The physiological changes of aging can make older patients more vulnerable to stressors like surgery, medications, and infections, thereby heightening risks (33). Pre-existing comorbidities and frailty status, more common in the elderly, are associated with poorer surgical outcomes and prolonged recovery in CVD patients (34). Post-discharge support limitations and medication/treatment compliance challenges among older adults may also play a role in readmission rates (35). Our study reinforces the importance of considering age and its physiological implications while managing expectations and tailoring follow-up care.

When analyzing risk factors, smoking was more prevalent among younger CVD patients, while obesity, inactivity, and family history increased with age. This distribution coincides with literature indicating that smoking peaks at younger ages, while other risks accumulate with aging (36). An interesting intervention could be to leverage the higher smoking cessation motivation observed in older former smokers to promote quitting in younger cohorts (37). The rise in metabolic risks like obesity with age, compounded by physical inactivity, highlights the need to encourage healthy lifestyle changes earlier in life rather than waiting for old age.

Our examination of laboratory and clinical parameters also revealed important age-related patterns. The progressive rise in cholesterol levels and blood pressure in older groups is well-established in previous studies and contributes to higher CVD risk (38). An alarming observation was the low average HDL or "good" cholesterol among those over 60 years old. This makes routine screening and medication to improve HDL crucial in older patients (39). We also noted increases in inflammatory marker CRP and hemoglobin A1c in the elderly, indicating heightened inflammation and poorer glucose control in this group. Tailoring treatment plans based on these age-specific laboratory findings can optimize outcomes.

The multivariate regression analysis enriched our understanding further by elucidating the statistically significant predictors of adverse outcomes. Advanced age, high blood pressure, need for intensive interventions like ventilation, and elevated CRP levels were all associated with poorer prognosis. The positive contribution of hemoglobin levels highlights the importance of nutrition and preventing anemia. These findings can guide clinicians in identifying high-risk patients needing greater support and individualized management. Similar conclusions were reached in a review by Pretorius et al. which identified age over 60, hypertension, ventilation, and elevated inflammatory markers as independent risk factors for poor in-hospital outcomes in CVD patients (40).

Our study provides a framework for designing optimal age-specific CVD care, but certain limitations should be acknowledged. The reliance on retrospective data from a single healthcare system constrains generalizability. Prospective cohort studies can establish stronger causal inferences. Our sample had a higher mean age and uneven age group distributions that may skew results. Larger samples with balanced age group representations could improve precision. We were also unable to account for differences in socioeconomic status, insurance coverage, and outpatient health behaviors that may affect outcomes. Incorporating contextual patient data could enrich insights further. Finally, the focus on inpatient care provides a limited snapshot - evaluating outpatient treatment responses and long-term outcomes would also be valuable.

this study highlights the clinical importance of considering age-related variations in CVD risk factors, presentation, treatment response, and outcomes. Key differences were observed across age groups in the prevalence of CVD types, optimal treatment approaches, complication rates, and predictors of adverse events. These findings underline the need for targeted strategies across the lifespan, with aggressive prevention and screening for atherosclerotic disease and heart failure among older adults. Individualized treatment plans factoring in physiological age, life expectancy, comorbidities, and laboratory findings are recommended over one-size-fits-all protocols. Older patients may need extended hospital care, modified interventions, expanded post-discharge support, and closer follow-up to optimize recovery outcomes.

Supporting this, studies have shown improved outcomes when tailored rehabilitation programs, patient education, and transition-of-care models are implemented for elderly CVD patients (18-20). Continued research through prospective studies, expanded community-based data, and long-term tracking of age-diverse cohorts can further advance age-specific CVD care and ultimately improve patient outcomes across all demographics. A multicenter, international collaborative approach would be particularly impactful, as emphasized by Bernal et al., to account for regional variations in age demographics, healthcare access, and CVD patterns . With rising life expectancy and aging populations worldwide, optimizing CVD management across the lifespan will only grow in importance.

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