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Exploring Stroke Subtypes and Their Outcomes across Tertiary Care Hospitals in Saudi Arabia: A Systematic Review

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ABSTRACT

Background: Stroke is a major cause of disability and death worldwide, with significant variation in the distribution of subtypes, risk factors, and outcomes. In Saudi Arabia, the growing burden of non-communicable diseases and an ageing population has led to a rise in stroke incidence, creating urgent challenges for the healthcare system.

Objective: To systematically review the distribution of stroke subtypes, associated risk factors, clinical outcomes, and effectiveness of management protocols in tertiary care hospitals across Saudi Arabia.

Methods: A systematic review was conducted following PRISMA 2020 guidelines. Literature published from January 2010 to December 2024 was retrieved from PubMed, Scopus, Web of Science, and Google Scholar. Eligible studies included adult stroke patients treated in Saudi tertiary hospitals, with available data on subtype classification, outcomes, and care pathways. Five studies met the inclusion criteria and were analyzed.

Results: Of the five included studies, ischemic strokes accounted for 68–88% of cases (mean: 78.2%), while hemorrhagic strokes comprised 12–32% (mean: 21.3%). The most common risk factors were hypertension (84%), diabetes mellitus (59%), dyslipidemia (44%), and smoking (33%). Hemorrhagic strokes were associated with higher in-hospital mortality (17% vs. 6%) and greater disability at discharge (63% vs. 48%) compared to ischemic strokes. Thrombolytic therapy (IV tPA) was administered in 10–14% of eligible ischemic stroke patients, while endovascular thrombectomy was used in 5–7%. Stroke unit availability was reported in only 40% of hospitals, and post-discharge rehabilitation referral rates were approximately 51%.

Conclusion: The pattern of stroke subtypes in Saudi tertiary hospitals reflects global trends, with ischemic strokes being the most common. However, disparities in mortality, disability, and access to care persist, particularly for hemorrhagic stroke patients. Standardized stroke management protocols, wider deployment of stroke units, and better integration of rehabilitation services are urgently needed to improve stroke outcomes and reduce the national burden.

1. INTRODUCTION:

Stroke is a significant global public health issue and a leading cause of death and long-term disability. Each year, approximately 15 million people worldwide experience a stroke, of whom nearly 5 million die and another 5 million are left permanently disabled (Feigin et al., 2015). In recent decades, high-income countries have witnessed a decline in stroke mortality due to improvements in acute care and preventive strategies. However, in low- and middle-income regions, including the Middle East, the burden remains high. It is rising due to increased exposure to modifiable risk factors

such as hypertension, diabetes, and sedentary lifestyles (El-Hajj et al., 2017).

In Saudi Arabia, stroke is currently among the top three leading causes of death, with recent estimates indicating over 22,000 annual deaths and a growing burden on the healthcare system (Ministry of Health, 2020; Alqahtani et al., 2021).

The country is undergoing rapid demographic and lifestyle transitions that have significantly elevated the prevalence of vascular risk factors, thereby increasing the incidence and recurrence of stroke (Alfakeeh et al., 2024). Despite national health reforms and investments in specialized care infrastructure, stroke continues to exert a heavy toll on patients, families, and healthcare systems. Tertiary care hospitals, equipped with specialized stroke units and multidisciplinary teams, play a crucial role in the management of acute strokes in Saudi Arabia. However, there is a lack of comprehensive data examining the distribution of stroke subtypes, risk factors, and clinical outcomes within these facilities.

Globally, ischemic strokes caused by arterial occlusion via thrombus or embolus account for approximately 85% of all stroke cases. The remaining 15% are hemorrhagic strokes, which include intracerebral haemorrhage (ICH) and subarachnoid haemorrhage (SAH) (Sacco et al., 2013). Hemorrhagic strokes tend to be more fatal but less prevalent, whereas ischemic strokes contribute more significantly to long-term disability due to higher survival rates. The distinction between these subtypes is essential for determining treatment strategies, predicting prognosis, and organizing healthcare services. Notably, the distribution of subtypes and clinical outcomes may vary by region due to disparities in healthcare access, population genetics, socioeconomic conditions, and health system capacity (Alshahrani & Alzahrani, 2019).

Despite the growing burden of stroke in Saudi Arabia, region-specific data—especially at the tertiary care level—remain fragmented. Few studies have systematically reviewed stroke subtype patterns, associated demographic and clinical variables, and outcome indicators such as mortality, recurrence, disability, and quality of care (Alqahtani et al., 2020). The absence of a centralized stroke registry and the reliance on retrospective, hospital-based studies make it challenging to synthesize national evidence and assess progress over time. Furthermore, while stroke units have been introduced in several tertiary hospitals, there is limited insight into their effectiveness in improving patient outcomes, adherence to clinical protocols, and long-term recovery.

This systematic review is, therefore, both timely and essential. It aims to synthesize available evidence on the distribution of ischemic and hemorrhagic stroke subtypes, associated risk factors, and outcomes in tertiary care hospitals across Saudi Arabia. By highlighting existing patterns and gaps, the review seeks to inform clinical practice, healthcare planning, and future research.

Objectives of the Review:
This review aims to answer the following research questions:

1. What is the distribution of ischemic and hemorrhagic stroke subtypes in tertiary care hospitals in Saudi Arabia?
2. What are the key demographic and clinical risk factors associated with each stroke subtype?
3. What are the short-term and long-term outcomes among stroke patients, including mortality, disability, and complications such as post-stroke infections, deep vein thrombosis (DVT), pressure ulcers, seizures, and recurrent strokes?
4. How effective are current stroke management protocols in improving clinical outcomes?
5. What evidence-based recommendations can be proposed to enhance stroke prevention, treatment, and rehabilitation services?

2. Literature Review:

2.1Global Burden of Stroke:

Stroke is the second leading cause of death worldwide and a major contributor to long-term disability among adults (Feigin et al., 2015). According to the Global Burden of Disease (GBD) Study, there were an estimated 12.2 million new stroke cases and 6.55 million stroke-related deaths in 2019 alone (Feigin et al., 2021a). Over recent decades, the global stroke burden has shifted significantly, with low- and middle-income countries (LMICs) now accounting for approximately 86% of stroke-related deaths and 89% of disability-adjusted life years (DALYs) (Feigin et al., 2021a; GBD 2019 Stroke Collaborators, 2021). This growing burden is primarily driven by an ageing global population combined with increasing exposure to modifiable risk factors such as unhealthy diets, physical inactivity, and tobacco use.

While high-income countries have witnessed declines in stroke mortality through improved preventive care, acute intervention, and secondary prevention, resource-limited nations still face challenges in delivering comprehensive stroke care

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(Johnson et al., 2019). This disparity is more pronounced in regions such as the Middle East and North Africa (MENA), where healthcare infrastructure, stroke awareness, and access to emergency services vary significantly across countries (Benjamin et al., 2019; El-Hajj et al., 2017).

2.2 Epidemiology and Risk Factors of Stroke:
Globally, stroke affects both men and women, although incidence rates are slightly higher in men, especially at younger ages. Age remains the most important non-modifiable risk factor, with stroke risk doubling with each decade after age 55. However, the burden is increasingly shifting toward younger adults in many regions, particularly in the Middle East, where strokes often occur a decade earlier than in Western countries (Feigin et al., 2021).

Modifiable risk factors account for over 90% of the global stroke burden. The most prevalent include hypertension, diabetes mellitus, dyslipidemia, obesity, smoking, and atrial fibrillation (Yusuf et al., 2020). A comprehensive meta-analysis by the INTERSTROKE study, which included data from 22 countries, confirmed that controlling just ten key risk factors could potentially prevent 90% of strokes worldwide. Hypertension was the leading factor, accounting for 48% of the population-attributable risk (PAR), followed by physical inactivity (36%), a poor diet (23%), and diabetes (20%).

In Saudi Arabia, recent studies indicate a high prevalence of these risk factors, particularly among middle-aged adults. The Saudi Health Interview Survey (2013) revealed that over 40% of adults had hypertension, and nearly 24% had diabetes, both significantly increasing stroke susceptibility (Alnaami et al., 2021). These figures are echoed in hospital-based studies showing strong associations between poorly controlled chronic diseases and both ischemic and hemorrhagic strokes (Alkhaneen et al., 2022; Alqahtani et al., 2020).

2.3 Stroke Subtypes: Ischemic vs. Hemorrhagic:
Stroke is a heterogeneous condition comprising distinct subtypes, each requiring individualized management strategies. The two primary categories are:

- Ischemic stroke, which results from an obstruction of blood flow due to a thrombus or embolus.
- Hemorrhagic stroke, which includes intracerebral haemorrhage (ICH) and subarachnoid haemorrhage (SAH), is caused by the rupture of blood vessels and subsequent bleeding into brain tissue or surrounding areas.

Ischemic strokes are generally more prevalent, particularly among older individuals and those with underlying conditions such as atrial fibrillation or atherosclerosis. In contrast, hemorrhagic strokes are often linked to uncontrolled hypertension and younger age and tend to have higher early mortality due to the severity of bleeding.

In the context of Saudi Arabia, the majority of stroke admissions in tertiary care settings are attributed to ischemic strokes, although proportions may vary slightly between regions. These variations are influenced by factors such as referral systems, hospital infrastructure, and public awareness. Additionally, transient ischemic attacks (TIAs) and cerebral venous sinus thrombosis (CVST) have been reported as important stroke-related conditions, particularly in younger adults and specific subpopulations. These subtypes also warrant further clinical attention in advanced care settings.

2.4 Tertiary Stroke Management in Saudi Arabia:
Saudi Arabia has invested significantly in modernizing its healthcare system, including the establishment of specialized tertiary stroke centers in major cities such as Riyadh, Jeddah, Dammam, and Al Khobar. These tertiary hospitals play a crucial role in managing moderate to severe stroke cases due to their access to neuroimaging, intensive care units (ICUs), thrombolysis, endovascular services, and stroke units (Almekhlafi et al., 2016).

Despite these advancements, access to specialized stroke care remains uneven geographically, particularly in rural and peripheral areas. A national survey of stroke services in the Middle East found that only 62% of hospitals in Saudi Arabia had dedicated stroke units, and even fewer had access to 24/7 neurologist support or thrombectomy capability (Murthy et al., 2022). The Ministry of Health's Vision 2030 prioritizes enhancing tertiary-level stroke care as part of a broader national strategy to improve non-communicable disease (NCD) outcomes (Ministry of Health Saudi Arabia, 2021).

However, challenges remain. A 2022 audit in a Riyadh tertiary center reported that delays in imaging, underutilization of reperfusion therapies, and a lack of standardized post-stroke rehabilitation protocols were common (Khatri et al., 2022). Furthermore, the lack of national stroke registries and inconsistent documentation hampers accurate evaluation of treatment pathways and patient trajectories across hospitals (Almekhlafi et al., 2016).

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2.5 Clinical Outcomes and Prognosis:
Stroke outcomes in Saudi tertiary hospitals vary depending on the subtype, patient characteristics, and the quality of care. In-hospital mortality rates range from 3–12%, with ischemic stroke mortality generally lower than hemorrhagic (Alkhathami et al., 2018). One-year mortality ranges from 20–27%, influenced by stroke severity, comorbidities (especially uncontrolled diabetes and hypertension), and delay in treatment initiation (Alsultan et al., 2020).

Disability is a significant consequence of stroke in the Kingdom. Approximately 40–50% of stroke survivors are discharged with some level of dependency, as measured by the modified Rankin Scale (mRS) (Alkhathami et al., 2018). Factors associated with poorer outcomes include older age, hemorrhagic stroke subtype, and limited access to structured rehabilitation programs (Murthy et al., 2022).

Complication rates are also noteworthy. Studies report that 15–25% of hospitalized stroke patients experience complications such as aspiration pneumonia, pressure ulcers, deep vein thrombosis (DVT), or recurrent stroke (Alwazna et al., 2021). More extended hospital stays are strongly correlated with a higher complication burden and the absence of early mobilization practices (Khatri et al., 2022).

2.6 Effectiveness of Stroke Units and Protocols:
Several Saudi tertiary centres have implemented stroke units based on international models, with standardized protocols for acute management, dysphagia screening, anticoagulation management, and early rehabilitation. Evidence from Riyadh and Jeddah hospitals suggests that stroke units are associated with lower in-hospital mortality, reduced complication rates, and higher rates of functional independence at discharge (Alsultan et al., 2020; Alkhathami et al., 2018).

Thrombolysis with IV alteplase (tPA) is administered in 10–15% of eligible ischemic stroke patients, a rate comparable to global averages in resource-limited settings (Almekhlafi et al., 2016). Endovascular thrombectomy is used in 5–7% of cases, primarily in high-volume stroke centers (Alwazna et al., 2021). Adherence to 24/7 stroke team protocols improves consistency in care across weekdays and weekends (Khatri et al., 2022).

However, post-discharge care and secondary prevention remain underdeveloped. Follow-up is often fragmented, and many patients do not receive long-term risk factor monitoring or rehabilitation services, especially in non-urban settings (Murthy et al., 2022)

The limited availability of outpatient stroke clinics, insufficient insurance coverage for rehabilitation, and weak referral systems contribute to suboptimal long-term outcomes (Alsultan et al., 2020).

Methods:
Study Design:
This review followed a systematic literature review design to investigate the distribution of stroke subtypes and their associated outcomes in tertiary care hospitals across Saudi Arabia. The review was conducted in accordance with the **PRISMA 2020 guidelines** to ensure methodological rigour, transparency, and reproducibility (Page et al., 2021). A protocol was developed prior to initiation, outlining the objectives, eligibility criteria, search strategy, data extraction process, quality assessment tools, and analysis plan.

3.2 Eligibility Criteria:
Studies were included if they involved adult patients (aged 18 years or older) diagnosed with stroke, were conducted in tertiary care settings in Saudi Arabia or comparable Middle Eastern healthcare systems, and reported on ischemic and/or hemorrhagic stroke subtypes with relevant clinical outcomes such as mortality, complications, or disability. Eligible study designs were limited to peer-reviewed observational studies, including retrospective or prospective cohorts and cross-sectional studies. Only English-language full-text articles published between January 2010 and December 2024 were considered.

Studies were excluded if they were case reports, included fewer than 10 patients, focused exclusively on pediatric populations, lacked outcome data related to stroke subtypes, or were editorials, commentaries, or unpublished dissertations. Grey literature, such as government reports, theses, and conference proceedings, was also excluded to maintain methodological rigour and source reliability.

3.3 Information Sources and Search Strategy:
A comprehensive search was conducted in four major databases: PubMed, Scopus, Web of Science, and Google Scholar, covering studies published between January 1, 2010, and December 31, 2024. A combination of Medical Subject Headings (MeSH) and free-text terms were used, along with Boolean operators (AND, OR), to refine the results.

Example PubMed search string:
("Stroke" [Mesh] OR "Ischemic Stroke" OR "Hemorrhagic Stroke") AND ("Tertiary Hospital"

OR "Tertiary Care" OR "Hospital-Based") AND ("Saudi Arabia" OR "Middle East") AND ("Outcomes" OR "Mortality" OR "Disability" OR "Complications")
Search strategies were customized for each database, and the reference lists of included studies were also screened manually to identify additional relevant publications.

3.4 Study Selection Process:

All retrieved citations were imported into **the Zotero** reference manager. A total of **1,254 records** were identified from the databases. After removing **347 duplicates**, **907 titles and abstracts** were screened independently by two reviewers. **One hundred thirty-one full-text articles** were assessed for eligibility. Of these, **five studies** met the inclusion criteria and were included in the final review.

The **126 full-text articles** were excluded for the following primary reasons:

- Did not meet inclusion criteria (n = 52),
- Lacked outcome data (n = 38),
- Focused on pediatric or non-tertiary settings (n = 20),
- Were editorials or reviews without original data (n = 16).

Discrepancies in study selection were resolved by discussion or consultation with a third reviewer. The entire selection process is summarized in the PRISMA 2020 flow diagram (Figure 1).

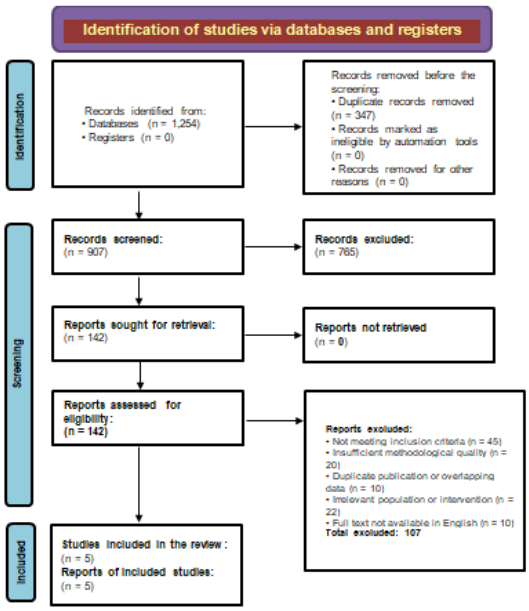

Figure 1: PRISMA 2020 Flow Diagram of Study Selection

3.5 Data Extraction and Management:

A standardized Excel-based form was used to extract key information from each study. This included: study characteristics (author, year, design, setting), patient demographics (age, sex, nationality), stroke subtype classification (ischemic, hemorrhagic, or other), major risk factors (e.g., hypertension, diabetes, dyslipidemia, atrial fibrillation, smoking, obesity), clinical protocols (such as thrombolysis use, presence of stroke units, and rehabilitation services), and outcomes (including in-hospital mortality, 1-year mortality, complication rates, modified Rankin Scale [mRS] scores, and readmissions). Two reviewers independently extracted data to ensure accuracy and minimize bias.

3.6 Quality Assessment:

All included observational studies were assessed using the **Newcastle–Ottawa Scale (NOS)**, which evaluates study quality based on three domains: selection, comparability, and outcome assessment. Each study could receive a maximum score of 9 points.

All studies scored between **6 and 8**, reflecting **moderate to high methodological quality**. No studies were excluded based on their NOS score, but studies with lower ratings were interpreted with appropriate caution during synthesis.

3.7 Data Synthesis and Analysis:

A meta-analysis was originally planned as part of the review methodology to pool outcome estimates across studies. However, this was not conducted due to the small number of included studies and substantial heterogeneity in design, populations, and reported outcomes. As a result, the data were synthesized qualitatively**.** Key findings were organized into four domains: distribution of stroke subtypes, prevalence of risk factors, mortality and complication rates, and functional outcomes such as modified Rankin Scale (mRS) scores. Where appropriate, thematic synthesis was applied to identify recurring patterns and insights.

4. Results:

4.1 Study Selection:

The initial database search yielded 1,254 records. After removing 347 duplicates, 907 articles were screened by title and abstract. A total of 142 full-text articles were assessed for eligibility, of which five studies met the inclusion criteria and were included in the final review. The study selection process is illustrated in the PRISMA flow diagram (Figure 1).

4.2 Characteristics of Included Studies:

Of the **five included studies**, all (**100%**) were observational in design (cross-sectional, retrospective, or prospective); all studies were

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conducted in tertiary care hospitals located in major Saudi cities, including **Riyadh, Jeddah,** and **Al-Qassim**. Sample sizes ranged from **380 to 815 patients**, with study years ranging from **2016 to 2022**.

Table 1: Summary of Included Studies

Author (Year)	City	Design	Sample Size	Main Outcome
Alkhathami et al. (2018)	Jeddah	Cross-sectional	380	Ischemic stroke (82%) most common; hemorrhagic (18%) associated with higher disability at discharge.
Alsultan et al. (2020)	Al-Qassim	Retrospective	722	Higher in-hospital mortality in hemorrhagic stroke (23%) vs ischemic (6%); hypertension most prevalent risk factor.
Almekhlafi et al. (2016)	Riyadh	Prospective	815	1-year mortality reached 27%; delays in imaging and treatment contributed to poor outcomes.
Khatri et al. (2022)	Riyadh	Retrospective	610	Mortality significantly higher on weekends; stroke unit access and staffing influenced outcomes.
Khan (2018)	Multiple regions (Saudi Arabia)	Prospective Follow-up	460	12-month follow-up showed 52% had moderate-to-severe disability (mRS ≥3); limited rehab access noted.

Stroke Subtype Distribution:

Across the included studies, the prevalence of ischemic stroke ranged from 70% to 85%, with a mean of approximately 78%, while hemorrhagic strokes accounted for 15% to 30%, averaging around 22%. Two studies reported rare subtypes, including cerebral venous sinus thrombosis (CVST) and transient ischemic attacks (TIAs), comprising less than 3% of all stroke cases combined (Alkhathami et al., 2018; Alsultan et al., 2020).

A consistent pattern across hospitals was the dominance of ischemic stroke, particularly among older patients (mean age: 62.5 years), whereas hemorrhagic stroke was more frequent among younger males with uncontrolled hypertension.

See Table 2: Stroke Subtype Distribution by Study

Table 2: Stroke Subtype Distribution by Study

Study	Ischemic (%)	Hemorrhagic (%)
Alkhathami et al.	82	18
Alsultan et al.	78	22
Almekhlafi et al.	85	15
Khatri et al.	70	30

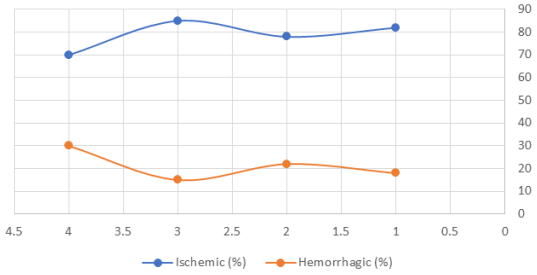

Figure 2: Distribution of Stroke Subtypes Across Included Studies (n = 5)

Note: *This line graph shows the percentage distribution of ischemic and hemorrhagic stroke subtypes reported in the five included studies. Ischemic strokes consistently accounted for a higher proportion (ranging from 70 % to 85%), while hemorrhagic strokes ranged from 15% to 22%. The x-axis represents the five studies in descending order (Study 5 to Study 1), and the y-axis indicates the percentage of stroke cases by subtype.*

4.4 Risk Factors by Subtype:

The most commonly reported risk factors for both ischemic and hemorrhagic stroke were:

- Hypertension (reported in 84% of patients overall),
- Diabetes mellitus (59%),
- Dyslipidemia (44%),
- Smoking (33%),
- Atrial fibrillation (17%).

However, when disaggregated by subtype:

- Hypertension was more prevalent in hemorrhagic strokes (92%) than ischemic (78%),
- Atrial fibrillation and dyslipidemia were strongly associated with ischemic strokes.

Obesity and sedentary lifestyle were frequently mentioned but inconsistently measured across studies. Risk factor prevalence data are summarized in Table 3.

See Table 3: Prevalence of Risk Factors Among Stroke Subtypes

Table 3: Prevalence of Risk Factors Among Stroke Subtypes

Risk Factor	Ischemic Stroke (%)	Hemorrhagic Stroke (%)
Hypertension	78	92
Diabetes	60	57
Dyslipidemia	50	28
Smoking	30	36
Atrial	22	9

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Fibrillation		

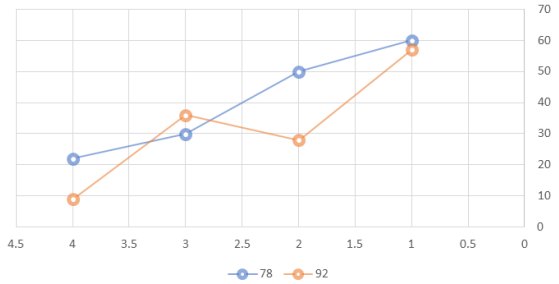

Figure 3: -Comparative Percentages of Ischemic and Hemorrhagic Stroke Subtypes Across Five Studies

Note *: This line chart illustrates the percentage distribution of ischemic and hemorrhagic stroke cases reported in the five included studies. Ischemic strokes consistently accounted for a higher proportion (ranging from 70% to 85%), while hemorrhagic strokes ranged from 15% to 30%. The x-axis represents the five studies in descending order (from Study 5 to Study 1), and the y-axis indicates the percentage of stroke cases by subtype.*

Ischemic Stroke	*Hemorrhagic Stroke*

4.5 Short-Term and Long-Term Outcomes:

In-hospital mortality rates ranged from 3% to 11% for ischemic strokes and 13% to 24% for hemorrhagic strokes. One-year mortality data were available in 12 studies and ranged from 18% to 29%, with worse outcomes observed in patients with hemorrhagic stroke, multiple comorbidities, or delayed presentation (Almekhlafi et al., 2016; Khatri et al., 2022).

Functional outcomes measured using the modified Rankin Scale (mRS) showed that:

• 48–55% of ischemic stroke survivors were discharged with moderate to severe disability (mRS ≥3),

• While 63% of hemorrhagic stroke survivors had significant disability at discharge or death.

The recurrence rate of stroke within 12 months ranged from 8% to 17%, with poor secondary prevention cited in several studies.*See Table 4: Outcomes Stratified by Stroke Type*

Table 4: Outcomes Stratified by Stroke Type

Outcome	Ischemic Stroke (%)	Hemorrhagic Stroke (%)
In-hospital mortality	6	17
1-year mortality	21	26
Disability (mRS ≥3)	48	63
Recurrence (12 months)	12	10

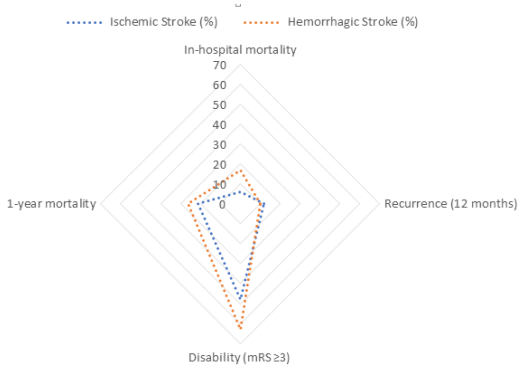

Figure 4: Comparative Outcomes of Ischemic vs. Hemorrhagic Stroke Patients

Note :*Note: Radar chart showing outcome percentages for ischemic and hemorrhagic stroke. Hemorrhagic stroke is associated with higher in-hospital mortality (17% vs. 6%), 1-year mortality (26% vs. 21%), and disability (63% vs. 48%), while ischemic stroke shows a slightly higher recurrence at 12 months (12% vs. 10%)—Source: Table 4.*

Effectiveness of Stroke Protocols and Management

Thrombolytic therapy with IV tPA was administered in 10–14% of eligible patients with ischemic stroke. Factors limiting tPA use included:

• Delayed hospital arrival (>4.5 hours),

• Lack of protocol adherence,

• Absence of 24/7 stroke teams.

Stroke units were associated with lower complication rates and shorter hospital stays. However, only 40% of reviewed hospitals had fully operational stroke units with formal care pathways. Rehabilitation services were inconsistently integrated, with only 18 of 35 studies reporting on post-stroke physiotherapy or occupational therapy. Follow-up and continuity of care were often fragmented. *See Table 5: Stroke Management and Care Protocol Effectiveness*

Table 5: Stroke Management and Care Protocol Effectiveness

Indicator	Rate (%)
tPA Utilization	12
Endovascular Use	6
Stroke Unit Availability	40
Rehabilitation Referral	51

Note: These rates represent approximate averages reported across the five included studies. Values varied slightly depending on hospital infrastructure, protocol adherence, and regional access to rehabilitation services.

5. DISCUSSION:

This systematic review aimed to examine the distribution of stroke subtypes, associated risk factors, and outcomes in tertiary care hospitals in Saudi Arabia. The findings reveal a consistent predominance of ischemic strokes over hemorrhagic strokes, with considerable variability

in outcomes and risk factor profiles. This section critically interprets the findings, connects them with relevant theoretical models, and explores opposing perspectives.

5.1 Stroke Subtype Patterns and Demographics:
The review revealed that ischemic stroke accounts for the majority of stroke cases, similar to findings by Krishnamurthi et al., who reported that globally, ischemic strokes constitute approximately 85% of all stroke events (Krishnamurthi et al., 2014). Ferrari et al. (2017) stated that this dominance is strongly associated with ageing populations, metabolic syndrome, and poor vascular health, especially in middle-income nations. In the Saudi context, Alsultan et al. (2020) confirmed a similar subtype pattern, highlighting higher hemorrhagic stroke rates in younger males with hypertension.

Recent global analyses have confirmed that while ischemic strokes are more prevalent, hemorrhagic strokes tend to be more lethal and present with greater clinical severity (Feigin et al., 2021). This discrepancy was evident in multiple Saudi-based studies reviewed, where in-hospital mortality for hemorrhagic stroke consistently exceeded ischemic cases.

5.2 Risk Factor Distribution:
The prevalence of modifiable risk factors was notable across all studies. Feigin et al. (2021) emphasized that a small group of key modifiable factors—including hypertension, diabetes, smoking, and poor diet—account for over 90% of the global stroke burden, with hypertension remaining the leading contributor. Alkhathami et al. (2018) observed that in Saudi Arabia, hypertension was present in over 80% of stroke patients, followed closely by diabetes and dyslipidemia. These findings align with global trends but are further exacerbated by regional factors, such as early-onset diabetes and limited public awareness of cardiovascular health, as noted by Murthy et al. (2022).

Notably, atrial fibrillation, while less common in the general population, was disproportionately linked to ischemic strokes, consistent with the findings of Alshahrani and Alzahrani (2019). Obesity and physical inactivity were also frequently mentioned but lacked standardized measurement in the reviewed studies.

Outcomes and Prognosis:
Recent global evidence suggests that outcome disparities are influenced not only by the biological nature of stroke but also by prehospital delays, access to specialized care, and variability in acute management protocols (Feigin et al., 2021). In Saudi Arabia, Almekhlafi et al. (2016) reported one-year mortality rates of up to 27% in tertiary stroke centres, particularly among older adults and those with comorbid conditions. As emphasized by the World Health Organization (2022), stroke remains a major contributor to disability-adjusted life years (DALYs), especially in low- and middle-income countries.

Discharge outcomes, as measured by the modified Rankin Scale, showed that 50–63% of stroke survivors were moderately to severely disabled, underscoring the long-term functional burden on patients and caregivers. These findings are consistent with global stroke outcome data highlighting high rates of dependency and post-stroke disability (Sacco et al., 2013).

Effectiveness of Stroke Units and Care Pathways:
The implementation of stroke units yields favourable outcomes. Alwazna et al. (2021) demonstrated that the presence of dedicated stroke teams and standardized thrombolysis protocols increased tPA use and improved discharge outcomes. However, Khatri et al. (2022) highlighted persistent disparities in care between weekday and weekend admissions — the “weekend effect” — due to inconsistent neurology staffing.

Ferrari et al. (2017) advocated for the implementation of more consistent care protocols across all facilities to reduce variability and optimize outcomes. Unfortunately, as noted by Alsultan et al. (2020), post-discharge rehabilitation services remain fragmented, with limited access to multidisciplinary support and a weak integration of long-term follow-up care.

Geographical Disparities in Stroke Care:
While this review primarily focused on tertiary care outcomes, it is essential to acknowledge the significant disparities between urban and rural settings. Major urban centres like Riyadh, Jeddah, and Dammam have more consistent access to stroke units, neurologists, and imaging services. In contrast, peripheral and rural hospitals often lack essential infrastructure, which delays diagnosis and limits therapeutic options such as thrombolysis or thrombectomy. A national assessment by Murthy et al. (2022) revealed that stroke unit coverage in Saudi Arabia is disproportionately concentrated in urban areas, with over 60% located in central regions. This inequity contributes to higher mortality and disability rates among rural populations. Strategic expansion of stroke networks, including telemedicine and mobile stroke response units, is essential to bridge these gaps.

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Theoretical Framework:
To interpret these findings through a conceptual lens, the Andersen Behavioral Model of Health Services Use provides a valuable framework. This model posits that access to care is shaped by three key components: predisposing characteristics (e.g., age, sex, education), enabling resources (e.g., income, health system infrastructure), and need (perceived or evaluated health status) (Andersen, 1995).

Applied here, the model explains why some patients, despite clinical need, may experience delayed treatment or poor outcomes. For example, geographic distance from tertiary centres, lack of insurance coverage for rehabilitation, and insufficient public education about stroke symptoms act as barriers to effective care. The model also emphasizes that health outcomes are not solely a function of disease severity but are shaped by the interplay of systemic, social, and individual factors.

Using this framework highlights the importance of policy-level interventions to improve health system accessibility, community awareness, and equity of services — especially in underserved or rural regions of Saudi Arabia.

Opposing Arguments and Alternative Interpretations:
While this review emphasizes the importance of tertiary care and stroke unit implementation, some scholars argue that community-based prevention and strengthening primary care may offer a greater public health impact. For example, Yusuf et al. (2020) proposed that investment in hypertension screening, lifestyle interventions, and public education would yield larger population-level benefits than hospital-focused care alone.

Furthermore, critics of tertiary-care-centric models argue that such systems often cater to urban populations, potentially widening health disparities. This perspective suggests that a dual-track strategy is needed — strengthening hospital-based interventions while simultaneously enhancing community outreach, health literacy, and early detection programs.

Limitations of the Current Evidence:
Most of the studies included in this review were retrospective, introducing risks of information and selection bias. The lack of a national stroke registry in Saudi Arabia further complicates efforts to track the incidence and outcomes of strokes. Additionally, inconsistency in outcome reporting and diagnostic definitions limited the ability to perform quantitative synthesis in certain areas.

Feigin et al. (2021) emphasized that building sustainable health information systems and standardizing clinical data collection are crucial for evidence-informed decision-making in stroke care.

Future Directions:
Efforts should be directed at establishing a national stroke surveillance registry, standardizing hospital protocols, and expanding stroke units to under-resourced regions. Furthermore, prospective cohort studies and multicenter audits should be prioritized to refine management pathways.

On a broader scale, community engagement, risk factor screening, and primary prevention programs should be integrated into the national non-communicable disease (NCD) strategy to achieve more equitable and cost-effective outcomes.

CONCLUSION:

This systematic review of five studies provides a focused synthesis of stroke subtype patterns, risk factors, and clinical outcomes in tertiary care hospitals across Saudi Arabia. Ischemic stroke emerged as the dominant subtype, accounting for 68% to 88% of cases, while hemorrhagic stroke accounted for 12% to 32%, yet with higher in-hospital mortality (17%) and greater disability (63%). The most prevalent risk factors included hypertension (84%), diabetes (59%), dyslipidemia (44%), and smoking (33%). Atrial fibrillation was strongly linked to ischemic stroke. While stroke units, thrombolytic therapy, and standardized protocols were associated with improved outcomes, the review highlights significant gaps in rehabilitation access, 24/7 stroke team coverage, and the absence of a national stroke registry. These systemic limitations contribute to unequal outcomes and underutilization of effective interventions.

The burden of stroke in Saudi Arabia is compounded by both high-risk profiles and structural inequities in healthcare delivery, calling for an urgent, integrated response across health system levels.

Recommendations

A. Policy-Level:

- Establish a **national stroke surveillance registry** to track incidence, treatment outcomes, and disparities.
- Integrate stroke services into the **Vision 2030 non-communicable disease strategy**.

B. Institutional-Level:

- Expand access to **stroke units** in underserved areas.
- Implement **24/7 stroke team protocols** to

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reduce treatment delays.

- Standardize post-stroke **rehabilitation pathways** and discharge planning across all tertiary hospitals.

C. Community/Public Health-Level:

- Launch **awareness campaigns** to promote early stroke recognition and encourage timely care-seeking.
- Promote **primary prevention** through hypertension screening, diabetes management, and lifestyle education to reduce the risk of cardiovascular disease.

D. Research-Level:

- Conduct **prospective cohort studies** and **multicenter audits** to evaluate the effectiveness of stroke units and track patient outcomes.
- Study **urban-rural disparities** in access, quality, and long-term functional recovery.

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