Influence of off-hours admission on outcomes of ischemic stroke: a systematic review and meta-analysis of contemporary studies

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Abstract. – OBJECTIVE: The aim of this study was to document pooled evidence on the association between admission during off-hours and/or weekends and the risk of mortality and poor functional outcome in patients with ischemic stroke, as compared to admission during regular working hours and/or weekdays.

MATERIALS AND METHODS: We conducted a systematic search using PubMed, EMBASE, and Scopus databases. Observational studies published between 2013 and 2023 that investigated the association between weekend/off-hours admission and outcomes (mortality and functional outcomes) of ischemic stroke were considered for inclusion. A random effects model was used to conduct the analysis, and effect sizes were reported as pooled odds ratio (OR) or hazards ratio (HR) with corresponding 95% confidence intervals.

RESULTS: The analysis consisted of 31 studies and found that patients admitted during weekend/off-hours had a higher risk of in-hospital (OR 1.12, 95% CI: 1.06, 1.18), and 1-month post-admittance mortality (OR 1.13, 95% CI: 1.06, 1.20). However, the risk of mortality after 3, 6, and 12 months was not statistically different between the two patient groups. Patients admitted during weekends/off-hours had a slightly higher risk of poor functional outcomes (modified Rankin Scale score of ≥3) at 1-month post-admittance (OR 1.06, 95% CI: 1.00, 1.11). However, after 3, 6, and 12 months, the risk of poor functional outcomes was similar in both patient groups. Egger's test did not suggest the presence of publication bias for any of the outcomes.

CONCLUSIONS: Individuals who suffer from ischemic stroke and present outside of regular working hours or on weekends have a higher likelihood of experiencing short-term mortality and unfavorable functional outcomes.

Key Words:
Ischemic stroke, Off-hours, Weekend, Weekday, Working hours, Mortality, Functional outcome, Systematic review, Meta-analysis.

Introduction

Ischemic stroke is a prevalent and incapacitating medical condition that occurs due to the obstruction of blood flow to the brain, leading to neurological impairments and tissue injury[1]. Ischemic stroke is a leading cause of global mortality and morbidity, and its prevalence is expected to increase with the aging of the population and the subsequent escalating prevalence of risk factors like hypertension, diabetes, and obesity[1,2]. In 2019, the Global Burden of Disease Study[2] reported that ischemic stroke caused around 6.55 million deaths and 119 million disability-adjusted life years (DALYs). Compared to 2010, this represents a 16.8% increase in deaths and an 11.1% increase in DALYs[2]. Ischemic stroke incidence is influenced by age and sex, with men having a slightly higher incidence compared to women[3]. Additionally, the occurrence of ischemic stroke increases with age[4]. Optimal management of ischemic stroke necessitates prompt identification, diagnosis, and treatment, along with continuous monitoring and rehabilitation[5].

There is growing evidence[6,7] emphasizing the significance of providing timely and comprehensive care to enhance outcomes and reduce disability following ischemic stroke. The impact of off-hours admission to the hospital, which is defined as admission during weekends, evenings, or holidays, on the outcomes of ischemic stroke has been a topic of interest. This is because off-hours admission can result in delays in diagnosis, treatment, and transfer to specialized stroke units, in addition to reduced staffing levels and resource availability[8,9]. Moreover, off-hours admission may be linked to different patient populations, such as those with higher severity of illness or those who delay seeking care until off-hours.

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The impact of off-hours admission on ischemic stroke outcomes has been extensively studied, with varying and sometimes contradictory results. In a meta-analysis10 published about 10 years ago, 21 studies were included, which found that off-hour presentation at a health facility was associated with increased risk of short-term mortality [Odds ratio (OR) of 1.11] and poor functional outcome (OR 1.14) in patients with ischemic stroke. There have been no further attempts to update this investigation, even though a substantial number of studies have been published since then. The importance in understanding the impact of off-hours admission on ischemic stroke outcomes can aid in clinical decision-making and resource allocation, such as ensuring the provision of 24/7 stroke care services. This understanding can help identify possible disparities in quality and access to care for stroke patients. Finally, it can guide the development of interventions and policies intended to improve stroke outcomes.

This meta-analysis aimed to consolidate and evaluate the existing evidence of the impact of off-hours admission on mortality and functional outcomes in patients with ischemic stroke. Our systematic review and meta-analysis will offer a comprehensive and evidence-based appraisal of this issue, with the goal of enhancing stroke care and outcomes for patients globally.

Materials And Methods

Ethics and Search Strategy

As this study involved a systematic review and meta-analysis of previously published studies, ethical approval was not required. To ensure transparent and comprehensive reporting of our methods and results, we adhered to the PRISMA guidelines[11]. This paper is registered at PROSPERO with the number CRD42023420940.

An extensive search of three electronic databases, namely PubMed, Embase, and Scopus, from their inception to 31st March 2023, was carried out to identify relevant studies for our analysis. Our search strategy included a combination of medical subject headings (MeSH) and free-text terms relating to ischemic stroke, off-hours admission, and outcomes. The search query was: (off-hours admission OR weekend admission OR holiday admission) AND (ischemic stroke OR stroke OR cerebrovascular event) AND (clinical outcome OR mortality OR functional outcome OR death OR survival). Additionally, we screened the reference lists of relevant articles and systematic reviews to identify any additional studies that met our inclusion criteria.

Selection of Studies

To ensure the quality and reliability of our study, two independent reviewers conducted the screening process of all identified studies for inclusion based on predetermined eligibility criteria. We included observational studies that examined the association between off-hours admission and outcomes of ischemic stroke, which reported at least one of the following outcomes: mortality and functional outcomes (e.g., modified Rankin Scale), studies published in English, and conducted in adult human populations. To ensure that our analysis was based on current literature, we limited our inclusion criteria to studies published between 2013 and 2023.

We applied several exclusion criteria to the studies identified in our literature search. We excluded studies that were conducted in pediatric populations, focused on transient ischemic attacks (TIA) or intra-cerebral hemorrhage (ICH), or did not mention the stroke type. We also excluded studies that included subjects with documented neurological co-morbidities or had duplicate or overlapping data. Additionally, case reports, editorials, letters, and conference abstracts were excluded. Any disagreements between reviewers were resolved through discussion and consensus, and a third reviewer was consulted if necessary. Finally, we retrieved and assessed the full texts of potentially eligible studies for final inclusion.

Data Extraction and Risk of Bias Assessment

Two authors independently utilized a standardized data extraction form to collect information from the included studies. To assess the risk of bias, the Newcastle-Ottawa Scale was used[12]. If there were any disagreements in data extraction or risk of bias assessment, the two authors worked together to resolve the issue through discussion and consensus. If necessary, a third senior author was consulted to help reach an agreement.

Statistical Analysis

To determine the pooled effect sizes and corresponding 95% confidence intervals (CIs) for each outcome of interest, we used a random effects model. The overall effect estimate was computed by taking a weighted average of the effect sizes from each study, with weights proportional to the inverse of the variance of the effect size. To evaluate statistical heterogeneity, both the I-squared statistic and Cochran's Q test were utilized. Publication bias was evaluated using Egger's test[13]. A *p*-value lower than 0.05 was considered to denote statistical significance.

Results

We identified a total of 398 studies using our search strategy. After removing 88 duplicates, we were left with 310 studies that were unique. We then screened the studies based on their titles and abstracts, which led us to exclude 247 studies. We conducted a full-text review of the remaining 63 studies, resulting in the exclusion of an additional 32 studies. Ultimately, our meta-analysis comprised 31 studies[14-44], as illustrated in Figure 1.

Table I provides specific details of the studies included in the analysis. All studies were retrospective in design. The majority of studies were conducted in the USA[15,19,21,27,34,38,39] (n=7), Japan[24,25,41,43,44] (n=5), Taiwan[22,29,40] (n=3), Republic of Korea[26,30,32] (n=3), United Kingdom[28,33,42] (n=3), and Australia[17,20,23] (n=3). Additionally, two studies[16,36] were conducted in the Netherlands, and one study each was conducted in Brazil[14], Germany[18], China[31], Finland[37], and Austria[35]. Table I also includes the results of the quality assessment using the Newcastle Ottawa Scale, with scores ranging from 7 to 9 and a mean score of 8.

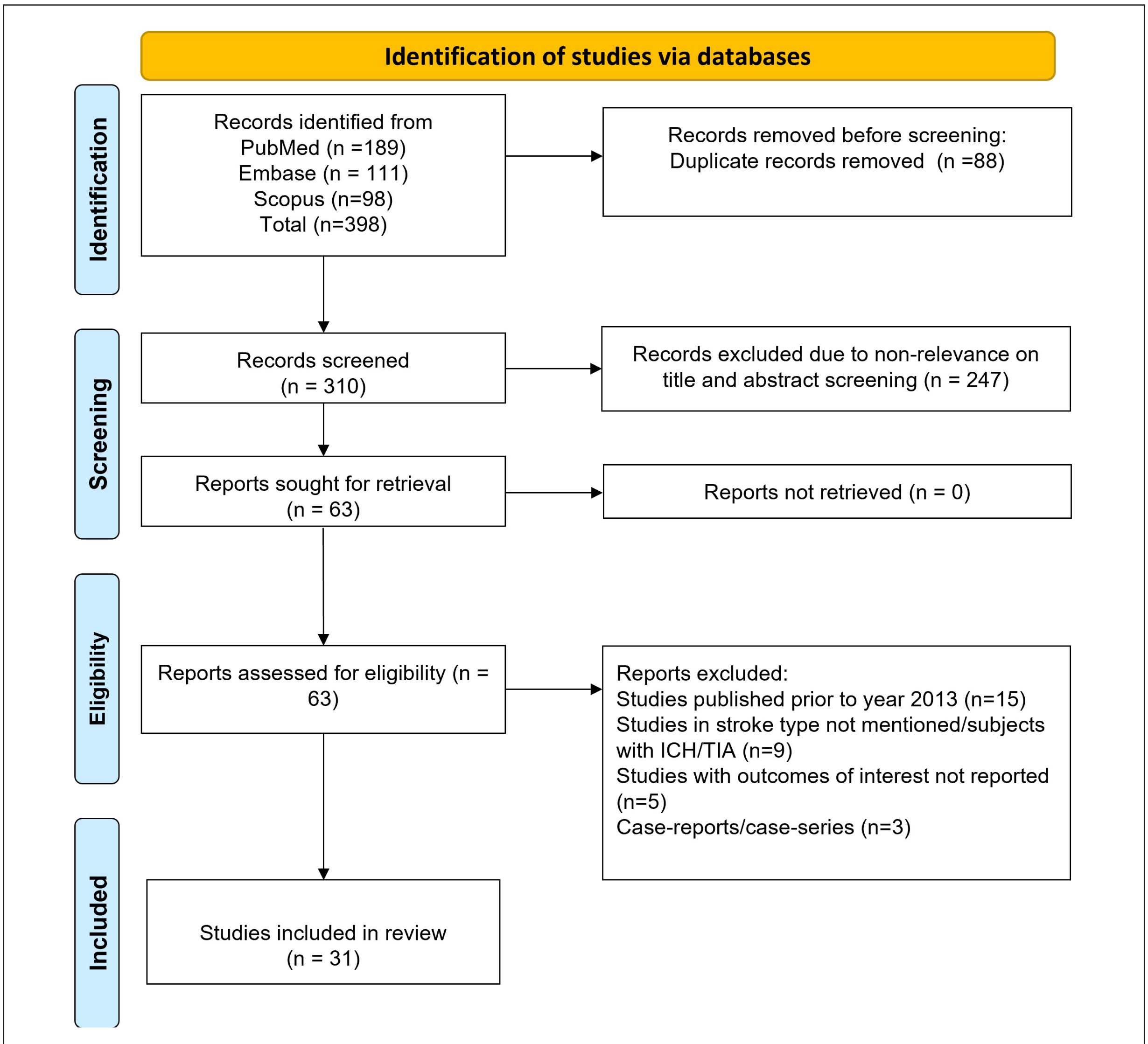

Figure 1. Selection process of studies included in the review.

Table I. Key characteristics of the studies included in the meta-analysis.

Author (year of publication)	Study design	Country	Subject characteristics	Sample size	Newcastle Ottawa quality score
Barros et al[14] (2013)	Retrospective	Brazil	No difference in baseline characteristics between those admitted on weekdays and weekends. Mean age 68 yrs; male (53%); with hypertension (83%), diabetes (27%), current smoker (38%)	365	8
Asaithambi et al[15] (2020)	Retrospective	USA	No difference in baseline characteristics between study groups; mean age of 71 yrs; male (52%)	89	7
Groot et al[16] (2021)	Retrospective	Netherlands	No significant difference in baseline characteristics between study groups; mean age of 70 yrs; male (51%); associated diabetes (16%), hypertension (43%)	4,161	9
Kilkenny et al[17] (2018)	Retrospective	Australia	No significant difference in baseline characteristics between study groups; median age of 75 yrs; male (55%)	30,649	8
Ghiani et al[18] (2022)	Retrospective	Germany	Patients hospitalized on the weekend, on average, older (77 *vs.* 76 yrs) and more likely to be females; mean age of sample studied (77 yrs) and 55% females	32,311	8
Taylor et al[19] (2022)	Retrospective	USA	Majority in the age range of 50-79 yrs (60%); females (51%); hypertension (84%), smoker (36%), diabetes (37%)	12,86,501	9
Baldwin et al[20] (2018)	Retrospective	Australia	Mean age of ~75 yrs; males (55%)	14,354	9
Shi et al[21] (2016)	Retrospective	USA	Mean age of ~72 yrs; males (around 52%)	20,187	7
Lin et al[22] (2022)	Retrospective	Taiwan	No significant difference in baseline characteristics between study groups; Mean age of 68 yrs; females (42%); hypertension (76%), diabetes (47%)	297	7
Lillicrap et al[23] (2020)	Retrospective	Australia	No significant difference in baseline characteristics between study groups; Mean age of 69 yrs; males (58%)	539	8
Nakajima et al[24] (2015)	Retrospective	Japan	No significant difference in baseline characteristics between study groups; Mean age of 75 yrs; males (56%); hypertension (73%), diabetes (25%); current smoker (18%)	5625	8
Inoue and Fushimi[25] (2015)	Retrospective	Japan	Mean age of 74 yrs; males (57%)	35,382	7
Cho et al[26] (2016)	Retrospective	Republic of Korea	Majority in the age group of ≥60 years; males (>50%); majority of urban population;	8,957	7
Cossey et al[27] (2019)	Retrospective	USA	No significant difference in baseline characteristics between study groups; Mean age of 63 yrs; males (50%); hypertension (69%), diabetes (30%); tobacco use (39%)	424	8
Turner et al[28] (2016)	Retrospective	UK	Mean age of 73 yrs; males (49%)	52,276	9
Hsieh et al[29] (2016)	Retrospective	Taiwan	Mean age of ~69 yrs; males (60%)	46,007	9
Kim and Jwa[30] (2021)	Retrospective	Republic of Korea	No significant difference in baseline characteristics between study groups; Mean age of ~68 yrs; male (56%); diabetes (24%); hypertension (58%)	7,144	7
Wang et al[31] (2015)	Retrospective	China	No significant difference in baseline characteristics between study groups; Mean age of ~67 yrs; male (60%); current smoker (26%); hypertension (65%)	4,493	9
Kim et al[32] (2014)	Retrospective	Republic of Korea	No significant difference in baseline characteristics between study groups; Mean age of ~67 yrs; male (59%); diabetes (33%); hypertension (70%)	7,075	8

Table continued

Table I ***(continued).*** Key characteristics of the studies included in the meta-analysis.

Author (year of publication)	Study design	Country	Subject characteristics	Sample size	Newcastle Ottawa quality score
Bray et al[33] (2014)	Retrospective	UK	Mean age of ~77 yrs; female (50%)	56,211	8
Adil et al[34] (2016)	Retrospective	USA	Mean age and sex distribution between weekday and weekend groups were statistically similar; comorbid conditions were also similar between groups	8,467	7
Bachner and Zuba[35] (2022)	Retrospective	Austria	Mean age of ~74 yrs; male (50%); 13% with previous stroke	86,399	8
Tuinman et al[36] (2019)	Retrospective	Netherlands	No significant difference in baseline characteristics between study groups; Mean age of ~71 yrs; male (52%); diabetes (24%); hypertension (66%)	5,378	8
Räty et al[37] (2021)	Retrospective	Finland	Mean age of 69 yrs; males (57%); hypertension (59%); diabetes (15%)	3,980	7
Mekonnen et al[38] (2020)	Retrospective	USA	Majority more than 75 yrs old; male (50%); majority with associated comorbidities	603,125	9
Witrick et al[39] (2020)	Retrospective	USA	Mean age of ~68 yrs; male (48%); diabetes (40%); hypertension (84%)	19,759	9
Huang et al[40] (2019)	Retrospective	Taiwan	Majority in the age range of 40-79 yrs; male (61%); diabetes (30%); hypertension (55%)	49,104	8
Kamitani et al[41] (2014)	Retrospective	Japan	Mean age of 74 yrs; males (57%); hypertension (68%); diabetes (27%); current smoker (30%)	20,758	8
Balinskaite et al[42] (2018)	Retrospective	UK	Mean age of 76 yrs; males (53%); majority white population (88%)	1,51,557	8
Nishimura et al[43] (2013)	Retrospective	Japan	Mean age of ~72 yrs; males (51%)	68,718	7
Lee et al[44] (2013)	Retrospective	Japan	Mean age of 74 yrs; females (42%); hypertension (49%); dyslipidaemia (22%)	21,445	8

Risk of Mortality

Patients with an ischemic stroke that were admitted on a weekend/off-hours had a higher risk of in-hospital mortality (OR 1.12, 95% CI: 1.06, 1.18, N=21, I^2=83.0%) and mortality at 1 month of follow up (OR 1.13, 95% CI: 1.06, 1.20, N=13, I^2=74.4%), compared to those admitted on a weekday/regular working hours (Figures 2-3). The risk of mortality at 3 months (HR 1.09, 95% CI: 0.92, 1.30, N=8, I^2=52.4%), 6 months (HR 1.11, 95% CI: 0.89, 1.38, N=2, I^2=58.3%) and 12 months (HR 0.95, 95% CI: 0.90, 1.01, N=3, I^2=0.0%) of follow up was statistically similar in both patient groups i.e., with or without weekend/off-hours admission (Figure 4). Egger's test did not suggest the presence of publication bias for mortality outcome at any of the above-mentioned time points (p>0.05).

Poor Functional Outcomes

Patients admitted during weekend/off-hours had a slightly higher risk of having poor functional outcomes (modified Rankin Scale score of ≥3) at 1 month of follow-up (OR 1.06, 95% CI: 1.00, 1.11, N=4, I^2=0.0%) (Figure 5). However, at 3 months (OR 1.01, 95% CI: 0.94, 1.09, N=9, I^2=0.0%), 6 months (OR 1.06, 95% CI: 0.90, 1.25, N=2, I^2=0.0%) and 12 months (OR 1.00, 95% CI: 0.84, 1.19, N=1) of follow up, those with weekend/off-hours admission had similar risk of poor functional outcomes compared to those admitted on a weekday/regular working hours (Figure 5). Egger's test did not suggest the presence of publication bias (p>0.05).

Discussion

The study findings indicate that patients who experience ischemic stroke and are admitted to the hospital during the weekend have poorer short-term outcomes in comparison to those admitted on weekdays. Specifically, these patients

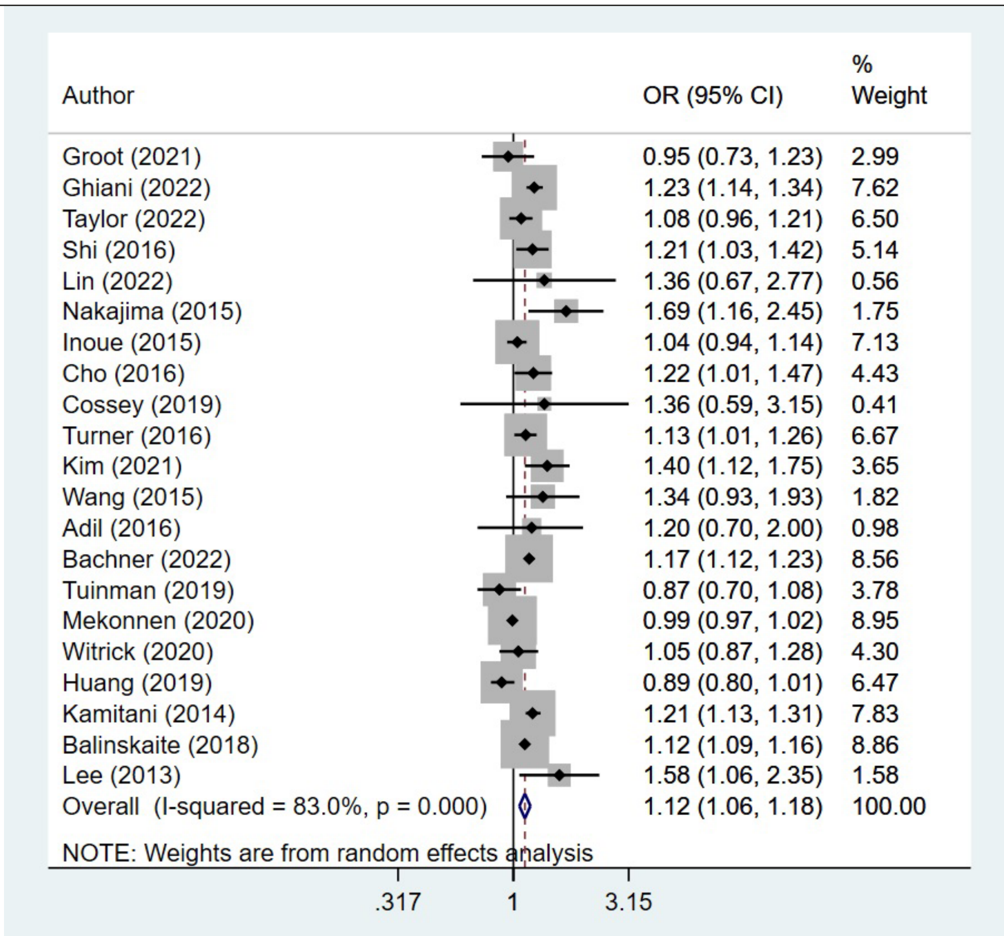

Figure 2. Risk of in-hospital mortality in patients with weekend/off-hours admission compared to patients admitted on a weekday/regular working hours.

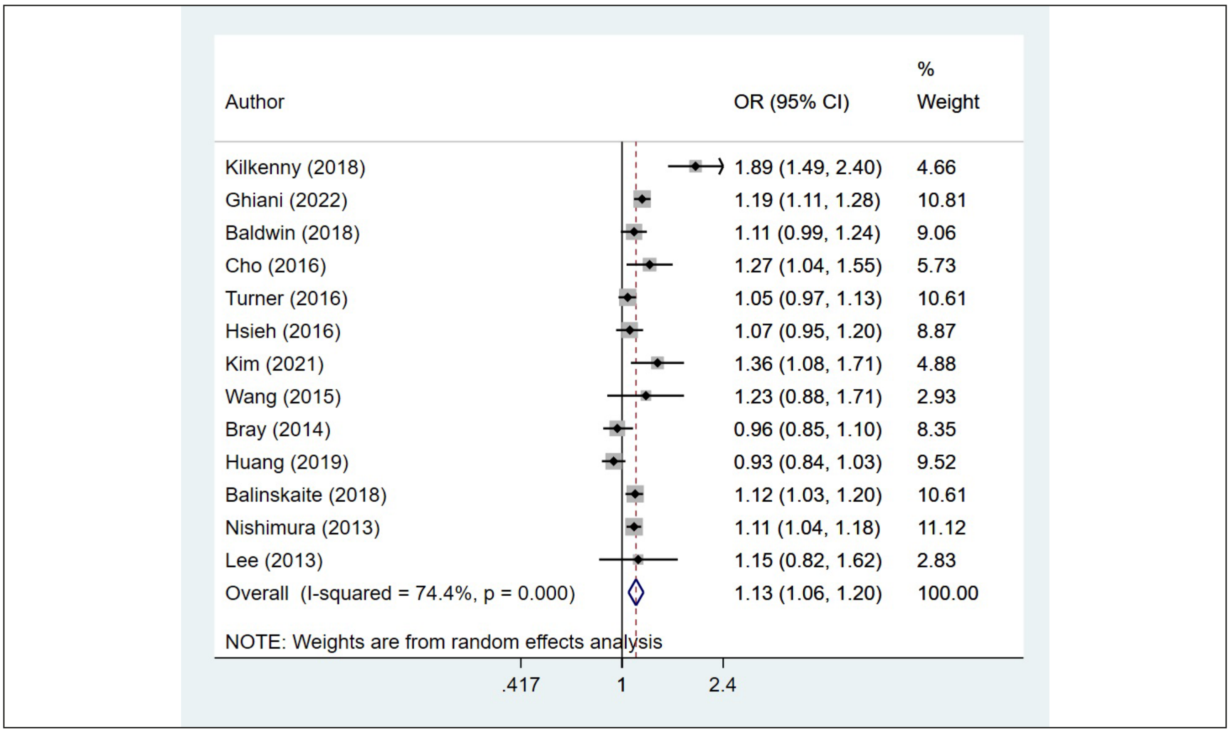

Figure 3. Risk of mortality at one-month follow-up in patients with weekend/off-hours admission compared to patients admitted on a weekday/regular working hours.

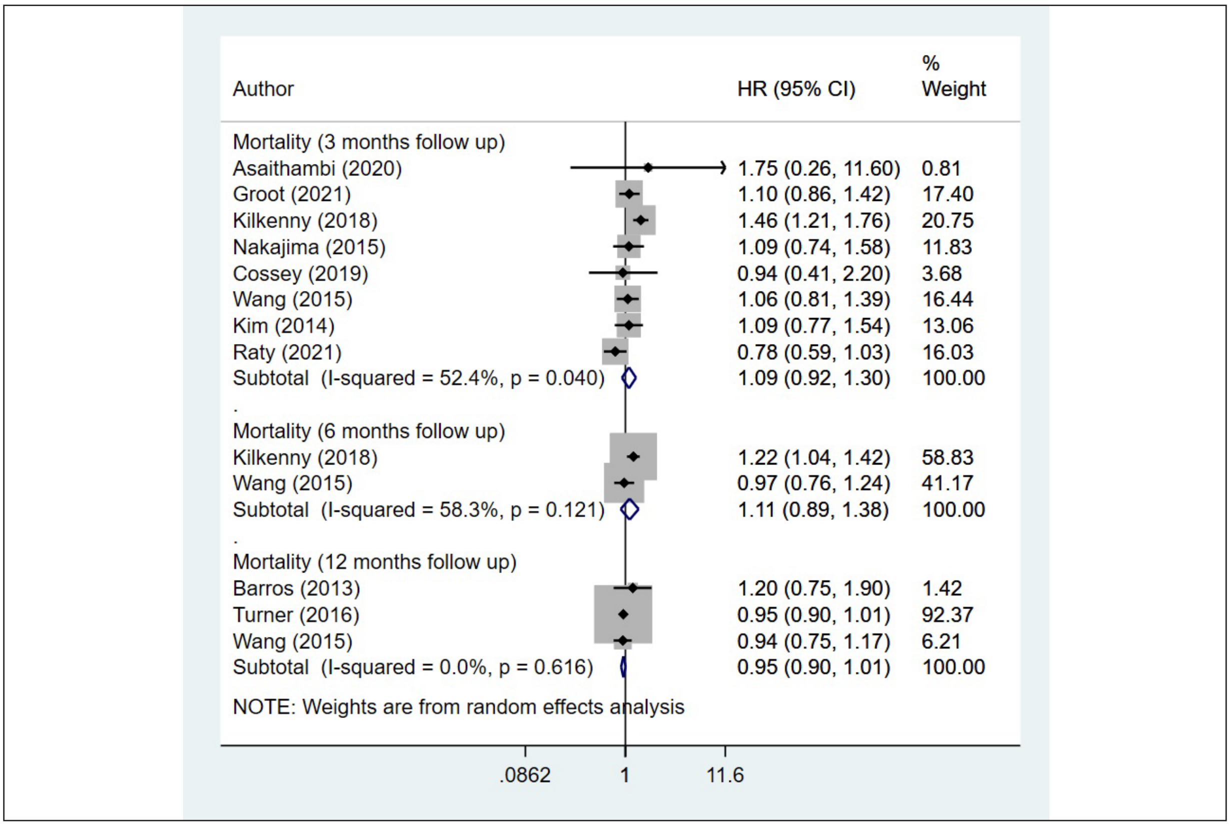

Figure 4. Risk of mortality at 3, 6, and 12 months of follow-up in patients with weekend/off-hours admission compared to patients admitted on a weekday/regular working hours.

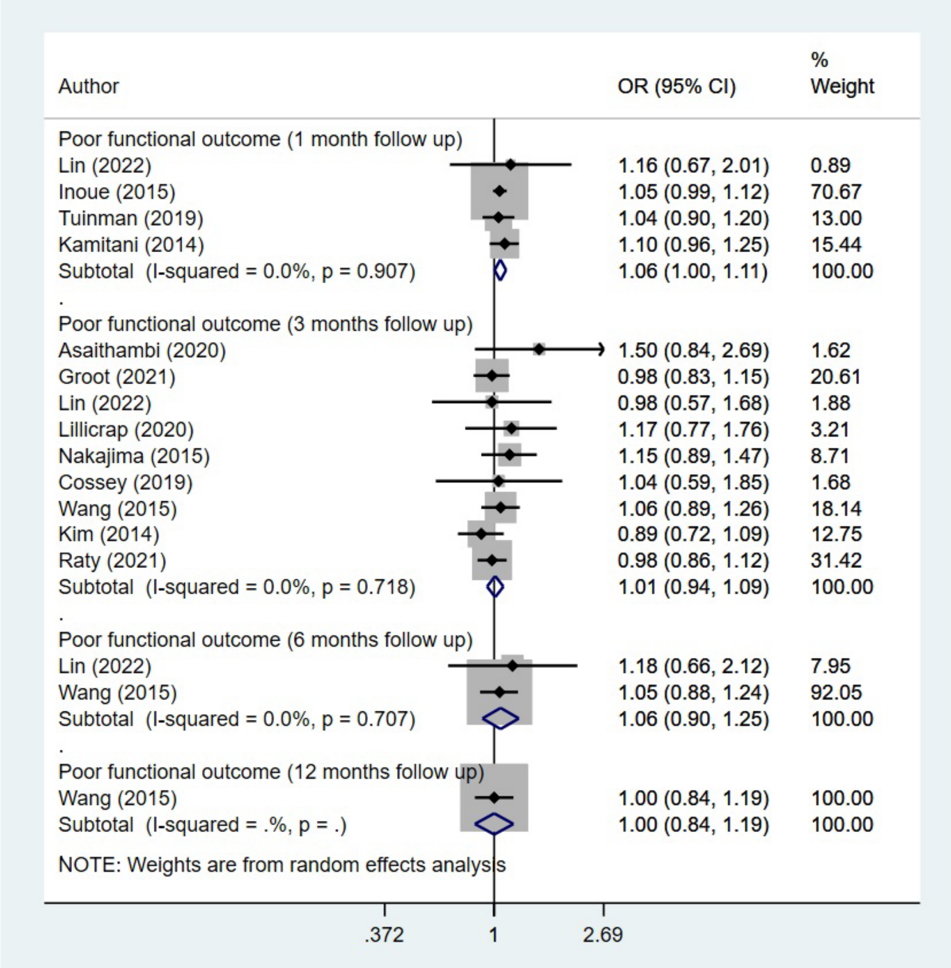

Figure 5. Risk of poor functional outcomes (mRS≥3) in patients with weekend/off-hours admission compared to patients admitted on a weekday/regular working hours.

have a higher risk of mortality and poor functional outcomes at the time of hospital discharge and within one month of post-discharge follow-up. However, the study also found that the association between weekend admission and poor outcomes disappears beyond the one-month follow-up period. These findings are similar to a previous meta-analysis by Sorita et al[10]. In their study, Sorita et al[10] examined the association between off-hour presentation and patient outcomes in cases of acute ischemic stroke. Using a meta-analysis[10] of 21 cohort studies, they found that off-hours presentation to the health facility was more likely to be associated with short-term mortality and poor functional outcomes. This meta-analysis was conducted using studies published prior to the year 2013. The results presented here focused on studies of 2013 or after so that more contemporary evidence could be produced. Another meta-analysis by Zhou et al[45] documented the association of off-hour admission with different disease conditions. They[45] noted that increased mortality for 28 diseases was found to be associated with off-hour admission. A large retrospective observational study involving 1987 subjects with COVID-19 also found longer survival in those admitted during weekday[46].

Several potential reasons could explain the inferior short-term outcomes associated with weekend admission. Patients who are admitted on weekends may have more severe strokes or pre-existing health conditions that contribute to their unfavorable outcomes[47]. Another possibility is that individuals admitted on weekdays may have easier access to healthcare resources, which may contribute to better outcomes. A potential reason for the inferior outcomes associated with weekend admission could be the reduced staffing levels and hospital resources during the weekends[48,49]. This situation could lead to delays in the diagnosis and treatment of patients, ultimately resulting in poorer outcomes for those suffering from strokes.

Another possible reason for the poorer outcomes associated with weekend admission could be related to stroke patients receiving care from less experienced or less specialized healthcare providers. This situation could result in less effective overall care. However, some evidence[50,51] suggests that the impact of healthcare provider experience and specialization on stroke outcomes may not be as substantial as previously believed. It is also possible that stroke patients who are admitted on weekends may experience delays in diagnosis and treatment due to factors such as difficulties in obtaining imaging studies. Furthermore, these patients may be less likely to receive certain types of rehabilitation care counseling, which could contribute to better outcomes.

In summary, several possible explanations could account for the inferior short-term outcomes observed among patients with ischemic stroke admitted on weekends. The finding that this association disappears beyond the one-month follow-up period suggests improvements in follow-up stroke care practices. The current method of follow-up care for ischemic stroke patients involves a multidisciplinary approach that incorporates telemedicine, early rehabilitation, patient-centered care, remote monitoring, and lifestyle modifications[52,53]. Early rehabilitation is critical to promote functional recovery and prevent complications and focus on physical, occupational, and speech therapy to improve mobility, strength, and speech[52]. The ultimate goal is to restore patients' independence and ability to perform daily activities. Patient-centered care is a fundamental aspect of follow-up care for ischemic stroke patients and involves tailoring their care to meet their individual needs and preferences. Patient education is crucial in empowering patients to take an active role in their recovery and manage their health[52,54]. Nursing personnel are integral members of the interdisciplinary stroke care team and play a critical role in ensuring that patients receive safe, high-quality care[55]. They are often the frontline caregivers who provide initial assessments and ongoing care to patients throughout their hospital stay. It is, therefore, important that they are thoroughly trained in providing basic stroke care so that patients admitted on a weekend or during off-hours are stabilized before the physician arrives.

Limitations

Interpretation of our study findings should consider several limitations. The included studies were mainly observational and thus vulnerable to potential bias. There was considerable heterogeneity among the included studies in terms of study design, patient characteristics, and off-hours definitions, which could limit the generalizability of our findings. There was significant variation in the time points at which the outcomes were evaluated across the included studies, potentially impeding the comparability of results. Unpublished or non-English language studies were not included, introducing the possibility of publication and language bias. Finally, our study was unable to determine the mechanisms underlying the observed association between off-hours admission and ischemic stroke outcomes.

Conclusions

Patients who present with ischemic stroke outside of regular hours or on weekends tend to have higher mortality rates and poor functional outcomes compared to those who present during regular hours or on weekdays. This may be due to differences in staffing expertise, availability of appropriate technologies and therapies, and other administrative factors between off-hours/weekends and regular hours/weekdays. Ultimately, efforts to enhance systems of care should aim to achieve comparable patient outcomes regardless of the time of presentation. This study offers updated evidence regarding the impact of off-hours admission on ischemic stroke outcomes. The implications of these findings are substantial for healthcare policy and clinical practice, suggesting that optimizing stroke care beyond regular working hours could lead to better patient outcomes.

Authors' Contributions

MW conceived and designed the study, LC, YW and WZ collected data and performed data analysis. MW wrote the draft of this manuscript. WZ edited the manuscript.

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None.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethics Approval and Informed Consent

Not applicable.

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