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Clinical factors influencing intravenous thrombolysis in patients with cerebral infarction: a retrospective cohort study comparing private car and ambulance transport in Jiaxing, China

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ABSTRACT

Objectives This study aims to evaluate and compare the clinical differences in intravenous thrombolytic therapy among patients with cerebral infarction transported to the hospital by private cars versus ambulances in Jiaxing, a non-supersized city in China. It also sought to examine the impact of different transportation methods on emergency department arrival times, delays in initiating thrombolytic therapy and final clinical prognosis. The findings aim to provide a basis for optimising emergency treatment protocols and improving outcomes for patients with cerebral infarction.

Design Data on age, gender, height, weight, body mass index, season, time of day (day vs night), modified Rankin Scale scores, door-to-needle time (DNT) and onset-to-needle time (ONT) were retrospectively collected from 808 patients admitted to the emergency department of the Affiliated Hospital of Jiaxing University for intravenous thrombolysis between January 2019 and September 2022. The data were analysed and compared.

Setting A retrospective cohort study conducted in Jiaxing, China.

Outcome measures The primary outcomes were DNT and ONT.

Results Among the 808 eligible patients, 279 (34.53%) were transported by ambulance, and 529 (65.47%) arrived by private car. Patients in the private car group were younger on average than those in the ambulance group (aged 64.70 vs 68.41 years). Although ambulance transport resulted in shorter prehospital transportation times (113.89 vs 127.38 min), patients arriving by private car had shorter thrombolytic therapy initiation times (39.90 vs 36.30 min). At admission, the National Institutes of Health Stroke Scale scores were higher in the ambulance group (4 vs 2), indicating more severe conditions and a greater proportion of patients requiring bridging thrombectomy after thrombolysis (7.53% vs 3.02%).

Conclusion In non-supersized cities, private car transportation for acute patients with cerebral infarction may lead to shorter DNT and ONT compared with those in ambulance transport. However, patients transported by ambulance tended to have more severe conditions, highlighting the importance of tailored emergency response strategies.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ A diverse range of clinical data was retrospectively collected, enabling comprehensive analysis.
⇒ This retrospective cohort study analysed and compared the clinical characteristics and treatment delays of patients with cerebral infarction transported to hospitals by ambulance versus private cars in non-supersized cities.
⇒ The lack of longitudinal follow-up postdischarge limits the assessment of long-term outcomes.
⇒ The single-centre design may constrain the generalisability of the findings to other settings.
⇒ The exclusion of variables such as economic status and educational level may lead to potential bias.

INTRODUCTION

Stroke is a prevalent and often debilitating neurological condition, representing the leading cause of death and disability in China.[1 2] It is characterised by high incidence, mortality, disability and recurrence rates.[3 4] Ischaemic stroke, which constitutes the majority of stroke cases, requires the prompt administration of intravenous thrombolytic drugs for reperfusion therapy, which is currently the most effective treatment available.[5 6] Timely transfer from the site of the incident to the hospital's emergency department is critical for optimising outcomes.[7] The duration of this transfer varies depending on the mode of transportation, with ambulances and private cars being the most common options. However, limited research has explored the clinical patterns of hospital admission and related factors for patients with acute ischaemic stroke (AIS),

particularly in non-supersized cities with lower traffic congestion. To provide a basis for public health strategies, this study compares the differences between patients transported by ambulance and those transported by private car. Data from 808 patients with cerebral infarction who received intravenous thrombolysis in the emergency department between January 2019 and September 2022 were reviewed, and the findings are presented in this study.

METHODS

Study population

This study reviewed data from 974 patients diagnosed with cerebral infarction who visited the emergency stroke department of our hospital, as recorded in the stroke data registry, from January 2019 to September 2022. The inclusion and exclusion criteria are outlined below.

The inclusion criteria were as follows: (1) age ≥18 years; (2) diagnosis of cerebral infarction confirmed by head MRI or CT; (3) time from symptom onset to hospital admission must be within 6 hours and (4) receipt of complete conventional-dose intravenous thrombolysis.

The exclusion criteria for patients were as follows: (1) age <18 years; (2) arrival by means other than an ambulance or private car; (3) contraindications to intravenous thrombolysis; (4) severely incomplete clinical or laboratory data; (5) discontinuation of intravenous thrombolysis and (6) unknown onset time, onset time >6 hours or onset occurring after awakening.

Based on these criteria, 166 patients were excluded, resulting in a total of 808 patients included for comprehensive analysis. Clinical data were compared and analysed between patients transported by ambulance and those transported by private cars.

Conventional drug therapy

Patients with AIS were treated according to current guidelines.[8 9] Those presenting within 4.5 hours of symptom onset received recombinant tissue plasminogen activator (rt-PA, Boehringer Ingelheim, SJ20160054), while those presenting between 4.5 and 6 hours of onset were treated with urokinase (Nanjing Nanda Pharmaceutical Co., H32023295). Rt-PA was administered intravenously at a total dose of 0.9 mg/kg. The initial 10% of the dose was given as a 1 min intravenous bolus, with the remaining dose diluted in normal saline and infused intravenously over 60 min. Urokinase was administered at a dose of 100–150 U, diluted in normal saline and infused intravenously over 30 min.

On admission, two neurologists assessed the patients, and a specialised stroke treatment team promptly initiated therapy. Following 24 hours of thrombolytic therapy, patients without cerebral haemorrhage, as confirmed by CT/MRI, were prescribed neuroprotective and antiplatelet therapies. Standard medications included antiplatelet agents such as aspirin and/or clopidogrel and lipid-regulating agents like atorvastatin calcium, as drugs aimed at enhancing blood circulation and scavenging oxygen free radicals.

Data collection and clinical assessment

Clinical data were collected for all included patients, covering parameters such as age, gender, height, weight, body mass index (BMI), the season of admission, time of admission (day or night), the modified Rankin Scale (mRS) score before symptom onset, National Institutes of Health Stroke Scale (NIHSS) score at the time of onset, smoking history, hypertension history, diabetes history, atrial fibrillation history, ischaemic heart disease history, stroke history, allergy history, previous use of antiplatelet drugs, previous use of anticoagulants, previous statin usage, blood pressure, body temperature, door-to-needle time (DNT), onset-to-needle time (ONT), time from symptom onset to emergency room arrival, type of reperfusion drug (rt-PA or urokinase), NIHSS scores at 24 hours, 7 days and discharge, the occurrence of haemorrhage after thrombolysis, length of hospital stay, discharge condition and mRS score at discharge.

Specifically, ONT refers to the time from symptom onset to thrombolysis, while DNT refers to the time from arrival at the emergency department to thrombolysis. Symptom onset time was determined based on patient/family reports, emergency department entry time and the thrombolysis time as recorded by the nursing staff in the original medical records. ONT and DNT were calculated by nursing personnel and documented in the medical records for submission to the national stroke registry. The time required for the patient's journey (ONT–DNT) was derived through statistical analysis conducted during data collection. Patients were classified into ambulance or private car groups for further analysis.

Statistical analysis

Data analysis was performed using SPSS V.25.0 and R V.4.4.2. Categorical variables were compared using the χ^2 test. Independent samples t-tests were used for intergroup comparisons of continuous variables that followed a normal distribution. The Mann-Whitney U test was applied for non-normally distributed continuous data, with results presented as medians and IQRs. To adjust for potential baseline differences between the private car group and the ambulance group, propensity score matching (PSM) was conducted using the R package MatchIt (V.4.6.0). PS were derived from logistic regression analysis. A 1:1 nearest neighbour matching method with a calliper of 0.05 was used, and unmatched data were excluded. Standardised mean differences (SMDs) were calculated to assess the balance of confounding variables, with an SMD <0.1 indicating an ideal balance between groups. Statistical significance was set at $p<0.05$.

Patient and public involvement

As this study was retrospective, patients and the public were not involved in the design, conduct, reporting or dissemination of the research.

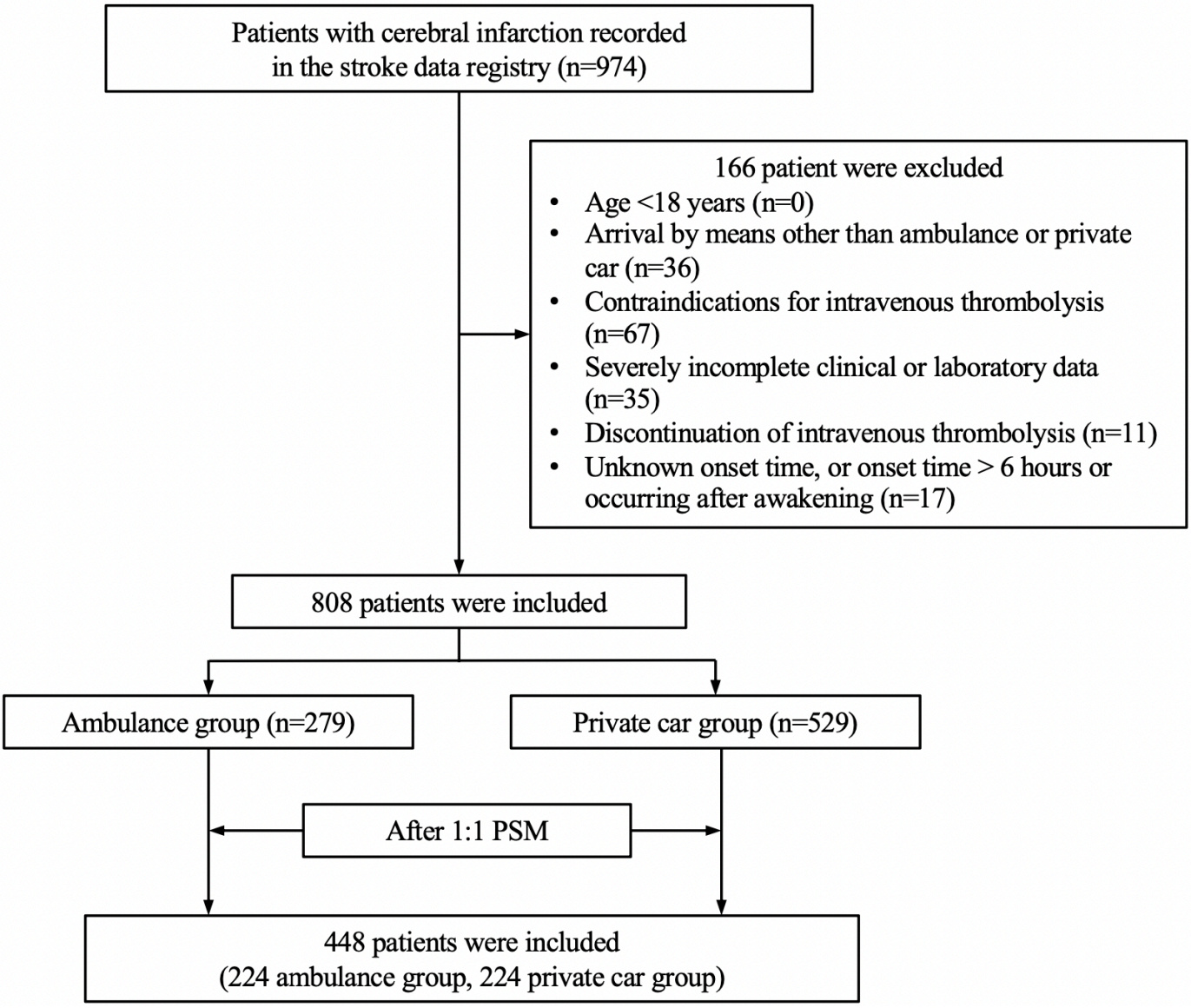

Figure 1 Flow chart of patient selection. PSM, propensity score matching.

RESULTS

A total of 808 patients with ischaemic stroke who met the inclusion criteria were analysed (figure 1). Among them, 279 (34.53%) were transported to the hospital by emergency vehicles, while 529 (65.47%) arrived via private cars. Patients in the private car group were younger compared with those in the emergency vehicle group (mean age: 64.70 vs 68.41 years, p<0.001). No significant differences were observed between the two groups in terms of gender, height, weight, BMI, season of presentation or time of arrival (day or night) (p>0.05).

In terms of transportation dynamics, the median onset-to-treatment time was not significantly different between the private car and emergency vehicle groups (153.79 vs 163.68 min, p>0.05). However, the emergency vehicle group demonstrated a shorter prehospital transport time relative to the private car group (113.89 vs 127.38 min, p<0.05). Conversely, DNT was shorter in the private car group (36.30 vs 39.90 min, p<0.05). The choice of thrombolytic agent (rt-PA or urokinase) was similar between the groups, with no statistically significant difference.

On arrival at the hospital, the emergency vehicle group presented with higher median NIHSS scores (4 vs 2, p<0.001), indicating greater stroke severity. A significantly higher proportion of these patients underwent bridging thrombectomy following thrombolysis (7.53% vs 3.02%, p<0.01). No significant differences were noted between the groups concerning admission blood pressure or body temperature (p>0.05).

Clinical outcomes demonstrated that the emergency vehicle group exhibited persistently higher NIHSS scores at 24 hours, 7 days and discharge compared with the private car group (p<0.001). This group also experienced higher mRS scores at discharge (p<0.001), an increased incidence of haemorrhagic transformation post-thrombolysis (9.32% vs 5.10%, p<0.001) and poorer prognoses (8.24% vs 1.32%, p<0.001). Furthermore,

patients transported by emergency vehicles had significantly longer hospital stays compared with those in the private car group (p<0.01).

Patients transported by emergency vehicles demonstrated a significantly higher prevalence of atrial fibrillation (12.90% vs 5.48%, p<0.001) and allergies (23.30% vs 14.37%, p<0.01) compared with those in the private car group. However, no significant differences were identified between the two groups concerning prestroke mRS scores, histories of hypertension, diabetes, prior stroke and myocardial infarction or previous use of medications such as antiplatelet agents, anticoagulants and statins (p>0.05). A detailed summary of these findings is presented in online supplemental material 1.

Logistic regression analysis was performed to match the two groups based on age, history of atrial fibrillation and NIHSS scores on admission (details provided in online supplemental material 2). The analysis revealed that the DNT for patients in the private car group was significantly shorter compared with the ambulance group (33.81 vs 39.73 min, p<0.001). In contrast, there were no significant differences between the two groups in terms of ONT, time from symptom onset to emergency room arrival, discharge NIHSS scores or changes in NIHSS scores. These findings indicate that the private car group demonstrated comparable performance to the ambulance group, with no observed inferiority. Although the shorter DNT in the private car group suggests greater efficiency, it did not translate into a significant improvement in the final discharge NIHSS scores. A detailed summary of these results is provided in table 1.

DISCUSSION

This retrospective study analysed the impact of transportation modes on the clinical characteristics and treatment outcomes of patients with acute cerebral infarction in Jiaxing, China. The findings revealed that patients transported by private vehicles were generally younger, had lower NIHSS scores on admission and experienced shorter DNT compared with those transported by ambulance.

In numerous countries, including China, large-scale public health campaigns, such as the 'BE FAST' initiative and China's '120' stroke identification method, have significantly improved public awareness of early stroke recognition. This heightened awareness is crucial for ensuring timely hospital arrival, a critical factor in stroke management.[10–12] However, despite these educational efforts, less than 35% of patients with ischaemic stroke in this study were transported to the hospital via ambulance. While this figure represents an improvement over the 2019 China Stroke Center Alliance survey (which reported an ambulance usage rate of less than 13%),[13] it remains substantially lower than the rates reported in other studies, where approximately 60% of patients with stroke used ambulance services.[14 15] In Jiaxing, ambulances play a primary role in the emergency medical services (EMSs), with healthcare providers focusing

Table 1 Comparison of PSM between the ambulance and private car groups for patients with intravenous thrombolysis

Project	Ambulance group (n=224)	Private car group (n=224)	χ^2/t/u value	P value
Age (years)	66.96±13.25	68.17±12.40	0.998	0.319
Gender				
Male, n (%)	148 (66.07)	138 (61.60)	0.783	0.376
Female, n (%)	76 (33.93)	86 (38.39)		
History of atrial fibrillation, n (%)	17 (7.59)	23 (10.27)	0.686	0.407
DNT	39.73±20.36	33.81±13.09	−3.657	0.000***
ONT	151.88±70.31	143.58±13.09	−1.210	0.227
Time from onset to emergency (min)	112.81±70.17	109.75±70.96	−0.449	0.654
NIHSS score on emergency department arrival	3 (1, 8)	3 (1, 8)	−0.595	0.552
NIHSS score at discharge	1 (0, 2)	1 (0, 2)	0.721	0.471
NIHSS score changes	2 (0, 4)	1 (0, 4)	−0.679	0.497
mRS score at discharge	1 (0, 3)	1 (0, 3)	−0.043	0.966

***$p < 0.001$

DNT, door-to-needle time; mRS, modified Rankin Scale; NIHSS, National Institutes of Health Stroke Scale; ONT, onset-to-needle time; PSM, propensity score matching.

on patient assessment and the rapid transportation of patients to the nearest medical facility for treatment.[16] However, ambulance crews are typically unable to administer specific stroke therapies en route, limiting their role to stabilisation and transport. Moreover, the absence of a standardised stroke screening scale in the emergency systems of some Chinese cities prevents effective grading of stroke severity, thereby constraining the overall efficacy of the emergency response system.[17–19]

To address the significant proportion of patients arriving at hospitals via non-emergency transportation services, it is crucial to develop supplementary transport options and enhance treatment workflows. In China, cities with a permanent population of fewer than 5 million are classified as 'non-supersized cities,' while approximately 30 cities exceeded this threshold. Jiaxing, categorised as a non-supersized city, spans 4275.05 square kilometres and has a permanent population of approximately 4.86 million. The city's urban road network efficiently manages traffic flow with minimal congestion, unlike larger metropolitan areas. This characteristic may explain why transportation times for private cars in Jiaxing are comparable to those for ambulances, even during emergency situations.[20 21]

In this retrospective study, all suspected patients with stroke were admitted to the hospital through the established green channel and assessed in the emergency room. Within the Chinese healthcare system, clinicians must provide patients and their families with comprehensive information on thrombolytic therapy, including its risks, potential benefits, financial implications, medical insurance coverage and prognosis before proceeding with treatment.[22] The final decision regarding thrombolytic treatment rests with the patient or their legal representatives in cases where the patient lacks decision-making capacity.[23] While essential, this shared decision-making process extends the DNT to include not only hospital admission but also the period required for patients or their representatives to consent to thrombolytic therapy.[24]

Patients and their families who opt to use private cars for hospital transport tend to respond more proactively to the onset of illness,[25] potentially influenced by their economic status. Those with greater financial resources are more likely to access medical care directly, bypassing potential delays associated with EMS.[26 27] Additionally, a higher economic status is often associated with greater health literacy, enabling faster decision-making regarding thrombolytic therapy given an improved understanding of its benefits and risks.[28]

Private vehicles also allow for the presence of multiple family members, including drivers and individuals with decision-making authority, facilitating quicker consent to treatment and expediting the emergency care process.[29 30] Conversely, economically disadvantaged patients may depend more on ambulance services due to their reliance on public resources. Although emergency systems are equipped to identify strokes and alert hospitals, ambulance availability is often constrained by limited resources. Delays may arise due to occupied vehicles, extended response times or the need for round trips, which double travel duration. Moreover, ambulances typically accommodate only one or two family members, necessitating additional time to contact or wait for individuals with decision-making capacity.[31] The observed delay in DNT for ambulance patients likely stems from patient-side decision-making processes rather than hospital procedures. Economic disparities contribute to unequal access to timely, high-quality medical care, placing low-income patients at a disadvantage.[32] This study could not include specific socioeconomic data, such as income or education levels, which future research should incorporate to comprehensively explore factors influencing transportation and treatment decisions for patients with stroke.

Despite increased reliance on the EMS following public awareness campaigns, a significant proportion of patients continue to arrive at hospitals via non-emergency means. Consequently, optimising in-hospital emergency procedures is essential to minimise disparities in the diagnostic and treatment processes between patients transported by emergency vehicles and those arriving by private cars. On arrival, patients are initially assessed by trained triage nurses. If identified as suspected stroke cases within 24 hours of symptom onset, they are immediately directed to the emergency room. Emergency physicians promptly conduct essential haematological examinations, including head CT scans and routine blood tests and consult neurologists. This efficient triage system and immediate diagnostic approach ensure that patients arriving by private cars receive care comparable to those transported by ambulances. Moreover, the neurology department operates 24/7, enabling timely evaluation for thrombolysis and thrombectomy. These measures effectively address the limitations associated with private car transport, ensuring that treatment outcomes for such patients are not inferior to those of patients arriving via emergency services.

Studies have indicated that patients transported by ambulance typically present with more severe conditions than those arriving by private car.[33 34] This disparity may be attributed to the fact that critically ill patients are often reliant on ambulance services due to the severity of their illness, whereas those with milder conditions have the flexibility to choose alternative transportation methods.

While private cars demonstrated advantages in this study, ambulance services remain essential in emergency medical care. Consistent with previous findings, patients transported by ambulance generally presented with more severe stroke symptoms and higher baseline NIHSS scores, which contributed to greater post-treatment improvement.[35] The baseline differences between the two groups significantly influenced changes in NIHSS scores. After adjusting for factors such as admission NIHSS score, age and atrial fibrillation through PSM, the NIHSS score differences before and after treatment were comparable between the two groups. This similarity may be attributed

to the milder conditions and lower baseline scores of patients in the matched group. Additionally, the short hospital stays and lack of long-term follow-up data could explain the observed differences between the groups.

These findings highlight that ambulance services are crucial for patients in critical condition or requiring immediate medical intervention. Thus, this research does not seek to undermine the importance of ambulance services but to emphasise that private cars can serve as an effective supplement in non-supersized cities, particularly when ambulance resources are limited or response times are prolonged. A notable limitation of this study is the absence of mRS scores at admission, which restricts the ability to assess the functional prognosis comprehensively. Future research should incorporate mRS scores to provide a more comprehensive evaluation of functional recovery and quality of life of patients.

CONCLUSION

In summary, this study demonstrated that in non-supersized and less congested cities, private cars demonstrated comparable performance to ambulances. Additionally, patients transported by private cars experienced shorter DNT. These findings provide valuable insights into optimising clinical pathways and public health strategies for stroke prevention and treatment.

Contributors JH is the guarantor of this work. JH designed and developed this study. DM, XZ and JH drafted and edited the manuscript. YL, XZ and YG performed the analysis. XL and TJ contributed to the conception of the study. JH, DM, YL, YG and XZ collected the data. DM and YG performed the interpretation. All authors contributed to the manuscript and approved the submitted version.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This was a retrospective study. The study was approved by the Bioethics Committee of the Affiliated Hospital of Jiaxing University, Jiaxing City (2024-KY-015). As this study was retrospective and did not contain any identifiable patient information or images, the Ethics Committee of the Affiliated Hospital of Jiaxing University waived the need for participants' written informed consent.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

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