SERVICE CHALLENGES IN DHAKA MRT LINE-6: COMPARATIVE INSIGHTS AND RECOMMENDATIONS FOR FUTURE EXTENSIONS

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ABSTRACT

Dhaka's MRT Line-6 represents a significant milestone in the city's transition toward mass rapid transit, yet its early operational phase has exhibited capacity constraints, crowding, and service irregularities that limit its effectiveness in reducing congestion. This study evaluates the operational performance of MRT Line-6 and benchmarks it against the Singapore MRT North-South Line (NSL), a mature system recognized for high reliability and efficiency. A mixed-method benchmarking framework was used, combining peak-hour field observations at major stations (Agargaon, Shahbagh, Motijheel) with official operational data from Dhaka Mass Transit Company Limited and the Land Transport Authority of Singapore. Key service indicators, including headway, train capacity, offered throughput, load factor, comfort index, and fleet utilization, were computed using standard transit planning equations. Results indicate that MRT Line-6 operates at an average peak headway of 5 minutes, providing an offered capacity of approximately 27,700 passengers/hour, yet experiences a load factor of 1.005 at maximum load sections, indicating operation at or slightly above design capacity. The comfort standard (0.13 m^2/standee) is considerably below recommended thresholds ($\geq$ 0.20 m^2/standee), reflecting high crowding. Comparative benchmarking shows that Line-6's throughput is about 40% lower than that of the NSL primarily due to fewer trainsets in active circulation and longer headways, rather than limitations in vehicle design. Scenario modeling demonstrates that increasing train formations from six-car to eight-car sets yields a 34% increase in offered capacity and a 35% improvement in the comfort index without requiring additional fleet or headway reduction. In contrast, decreasing headway to 3.5 minutes improves comfort marginally but requires approximately 35% greater fleet deployment and higher operational expenditure. Skip-stop service increases operating speed but introduces uneven station-level service intervals and reliability issues. The findings identify eight-car trainsets as the most cost-effective near-term strategy to alleviate crowding and improve passenger comfort, supported by secondary measures such as smart-payment integration and coordinated bus-bridging for service resilience. The benchmarking-based evaluation framework presented in this study provides a replicable decision-support tool for optimizing operations in emerging metro systems in rapidly urbanizing contexts.

Keywords: *Dhaka MRT Line-6; Singapore MRT; service standards; crowding; equity*

1. INTRODUCTION

Urban transportation systems are fundamental to the functioning of rapidly growing cities, where the demand for efficient mobility is increasing alongside population growth. As cities expand, traffic congestion becomes a critical issue, and public transportation systems, particularly metro networks, become essential in addressing these challenges (Ceder, 2004). In cities like Dhaka, the capital of Bangladesh, the introduction of mass transit systems like the metro holds significant promise for reducing congestion, reducing travel times, and improving overall urban mobility. Dhaka's first metro line MRT Line-6 marks a transformative development in the city's public transportation landscape. However, as with any new metro system, there are significant operational challenges during its initial phases, particularly in ensuring efficient service delivery and meeting passenger demands. Dhaka's metro system faces numerous operational difficulties that hinder its potential to function optimally. Understanding these challenges in the context of Dhaka's socio-economic conditions is critical for developing effective strategies to enhance the metro's operational efficiency and service quality.

Benchmarking metro systems against more established networks such as Singapore's MRT North-South Line (NSL) offers an opportunity to identify performance gaps and areas where improvements can be made. Singapore's NSL, known for its high operational efficiency, frequent services, and well-maintained infrastructure, serves as an ideal benchmark. The comparison allows for a detailed evaluation of Dhaka MRT Line-6's performance in areas such as headway, frequency, capacity, crowding, and comfort, providing valuable insights into the operational gaps and best practices that can be adopted. Furthermore, benchmarking against a well-established system offers a global perspective on the challenges and opportunities faced by metro systems in developing countries.

The importance of metro systems in supporting sustainable urban development cannot be overstated. As urban populations continue to grow, the demand for efficient and reliable public transportation systems will only increase. Metro networks, with their ability to move large numbers of passengers quickly and efficiently, offer a viable solution to the growing transportation needs of urban areas. However, the success of these systems depends not only on their design and infrastructure but also on their ability to operate efficiently, meet passenger expectations, and adapt to the unique challenges posed by each city's context.

This study aims to evaluate the operational performance of Dhaka's MRT Line-6, comparing it with established systems like Singapore's MRT North-South Line (NSL) to identify performance gaps and areas for improvement. By benchmarking key operational metrics such as headway, frequency, capacity, crowding, and comfort, this research provides insights into the effectiveness of Dhaka's metro system in its early stages of operation. Given the significant role of metro systems in alleviating urban congestion and fostering sustainable mobility, understanding the operational challenges faced by Dhaka's MRT Line-6 is crucial for developing effective strategies to enhance service quality, efficiency, and passenger satisfaction. The findings of this study will inform ongoing efforts to optimize metro operations, contributing to the broader goal of improving urban transportation in developing cities and offering valuable lessons for other cities facing similar challenges. The findings of this study will contribute to the ongoing efforts to improve the operational performance of Dhaka's MRT system and provide a foundation for the development of future metro lines in the city. Additionally, the insights gained from this research can be applied to other cities in similar contexts, where the introduction of metro systems presents both opportunities and challenges.

2. LITERATURE REVIEW

The evaluation of metro system performance is an established area of research, with various approaches being utilized to assess efficiency, service quality, and operational standards across cities. A commonly employed method in metro system performance evaluation is benchmarking, which allows for comparative analysis across different transit systems. Tsai & Mulley (2013) used Data Envelopment Analysis (DEA) to benchmark the efficiency of 15 international metro systems. Similarly, Canavan (2015) utilized a mixed-method design to assess the technical efficiency of metro systems, emphasizing the use of high-quality data sets for evaluating performance. This approach aligns with the methodology used in the present study, which integrates both quantitative data (from fieldwork) and secondary data sources to benchmark Dhaka's Line-6 against Singapore's NSL. In parallel, benchmarking frameworks based on multi-criteria decision-making methods, such as the Analytic Hierarchy Process (AHP), have been applied to metro system evaluations. Jasti & Vinayaka Ram (2019) developed such a framework for assessing Mumbai Metro, using AHP and fuzzy logic to evaluate nine key performance indicators, including system capacity and sustainability. The study underscores the value of incorporating multiple service parameters in performance evaluations, a practice that is mirrored in the present study's multi-dimensional approach to assessing Dhaka MRT Line-6.

Another important theme in the literature is the impact of reliability on metro system performance. Aboul-Atta & Elmaraghy (2022) conducted a global analysis of metro systems, identifying factors such as technical reliability and environmental considerations as critical drivers of performance. Their findings suggest that reliable service is essential for improving operational efficiency and passenger satisfaction.

The role of real-time crowding information (RTCI) in improving metro system performance has been a key focus in recent studies. Tirachini et al. (2016) quantified the negative impact of crowding on metro passengers' perceived disutility, demonstrating that standing passengers experience higher levels of discomfort than those sitting. The introduction of RTCI systems is suggested as a means of reducing the negative effects of crowding by enabling passengers to make informed decisions about which trains to board. This is supported by the findings of Xu et al. (2024), who demonstrated that RTCI significantly improves passenger satisfaction in high-speed rail services. They found that passengers with high social anxiety experience the most significant increase in satisfaction when RTCI is implemented successfully, highlighting the importance of service reliability in maintaining high satisfaction levels.

In addition, performance analysis has often been conducted through various modeling techniques to forecast and improve metro service efficiency. Cazuza de Sousa Júnior et al. (2023) used Data Envelopment Analysis (DEA) and the Malmquist index to analyze public transport performance in Fortaleza, Brazil, highlighting the importance of real-time crowding data in optimizing capacity and operational efficiency.

The integration of real-time data and the examination of operational deficiencies have also been central to studies on metro performance. Ludema (2006) explored operational and fleet utilization factors in their performance evaluations of metro systems. Henning et al. (2013) also contributed to this body of work by proposing a benchmarking framework for urban transport systems. They focused on evaluating five critical success factors including uptake of public transport, travel efficiency, accessibility, affordability, and travel experience across a sample of international metro systems. The results of their study emphasized the utility of such a framework for improving service quality, providing a clear basis for the evaluation approach in the present study. In this study, similar performance indicators such as headway, load factor, fleet utilization, and comfort are used to assess Dhaka Line-6's operations, informed by the benchmarks set by the Singapore MRT NSL. The current study follows a similar structured analysis of operational data, modeling alternative service configurations and evaluating their impact on key metrics like load factor and comfort.

Finally, the evaluation of improvement scenarios is a significant part of metro performance research. The literature suggests that service improvements such as increased train lengths or reduced headways can have substantial impacts on capacity and passenger comfort (Tirachini et al., 2016). In this study, we simulate alternatives such as the use of eight-car trainsets, reduced headways, and skip-stop services to address operational deficiencies in Dhaka's MRT Line-6, following the methodologies used in benchmarking studies and incorporating lessons from previous research.

In summary, the literature on metro system performance evaluation offers a wide range of methodologies, including benchmarking, data analysis, and service improvement modeling, all of which inform the current study's approach to evaluating Dhaka MRT Line-6. By leveraging international best practices, including the use of performance indicators, RTCI, and real-time data analysis, this study aims to provide actionable insights for improving the operational performance and passenger satisfaction of Dhaka's MRT Line-6, drawing on the rich body of research in the field.

3. METHODOLOGY

3.1 Research Design and Approach

This study adopts a comparative benchmarking approach to evaluate the service standards of Dhaka MRT Line-6 relative to the Singapore MRT North-South Line (NSL). The objective was to identify operational gaps, transferable best practices, and feasible improvement strategies for Dhaka's emerging metro system. A mixed-method design was employed, integrating quantitative analysis of operational indicators with qualitative assessment of service conditions observed during fieldwork.

The benchmarking method was chosen because it allows cross-system evaluation between a newly operational line in a developing context (Dhaka) and a mature, high-performing network in a developed context (Singapore). This comparative framework provides an evidence-based means to measure performance, diagnose shortcomings, and propose realistic operational improvements that align with international best practices.

3.2 Study Corridor and Scope

The study focuses on Dhaka MRT Line-6, a 20.1 km elevated rapid transit corridor extending from Uttara North (Diabari) to Motijheel, comprising sixteen stations located across major residential, commercial, and institutional areas. As Bangladesh's first operational metro system, Line-6 represents a critical case for understanding early operational challenges and opportunities in the country's transition to mass transit.

The Singapore MRT North-South Line (NSL) serves as the benchmark system due to its long-standing operational maturity, network integration, and consistent adherence to international service standards. The NSL spans 45 km with 27 stations, including interchanges with four other MRT lines and one LRT system.

The comparative scope includes five core service domains: (i) capacity and headway/frequency, (ii) fleet and work utilization, (iii) crowding and comfort, (iv) accessibility for special groups, and (v) ticketing and integration efficiency. The first three service domains were selected following the framework proposed by Vuchic (2005), while the remaining two domains were identified based on the criteria outlined by Canavan (2015).

3.3 Data Collection

Both primary and secondary data sources were used. Primary data were obtained through field observations conducted during the evening peak period (17:30 - 19:30). Observations included dwell times, headways, passenger boarding and alighting patterns, and concourse level crowding at selected major stations (Agargaon, Shahbagh, and Motijheel). Measurements were taken manually using stopwatches and visual head counts to estimate passenger density.

Secondary data were collected from the official website and publications of the Dhaka Mass Transit Company Limited (DMTCL), including operational schedules, train configurations, and fleet deployment reports. Relevant secondary data for Dhaka MRT Line-6 were also retrieved from websites of national newspapers and interviews given by DMTCL officials to the newspapers. Additional data for the Singapore MRT were sourced from the Land Transport Authority (LTA) of Singapore, system specifications from SMRT Corporation and SGTrains, and relevant technical literature. Cross-verification between field data and published statistics was performed to ensure reliability and accuracy.

3.4 Parameters and Indicators

Service standards were assessed using a set of quantifiable indicators that represent capacity, frequency, and passenger comfort. The following key metrics were used:

Table 1: Parameters and Indicators of Service Standards

Parameter/Indicator	Symbol	Formula	Description (Unit)
Headway	h		Time interval between consecutive Transit Unit (TU) arrival or departures (min)
Frequency	f	$f = \frac{60}{h}$	Number of TUs arriving or departing during one hour (TU/h)
Operating/Travel Time	T_o		Scheduled time interval between departure of a TU from one terminal and its arrival at the other terminal on the line (min)
Terminal Time	t_t		Time a TU spends at a line terminal (min)
Cycle Time	T	$T = 2(T_o + t_t)$	Total round trip time on a line (min)
Operating Speed	V_o		TU speed corresponding to operating time (km/h)
Cycle Speed	V_c		TU speed corresponding to cycle time (km/h)
Passenger Volume in MLS	P_{max}		Observed passenger load at peak station (prs/hour)
Vehicle Capacity	C_v		Maximum number of spaces for passengers a vehicle in a TU can accomodate (spaces/veh)
TU Capacity	C_{TU}	$C_{TU} = nC_v$ *Here, n = number of vehicles in TU*	Maximum number of spaces for passengers a TU can accomodate (spaces/TU)
Offered Capacity	C	$C = nC_v f$	Maximum offered passenger throughput per hour (prs/hour)
Load Factor	α	$\alpha = \frac{P_{max}}{C}$	Ratio of utilized to offered capacity, also known as capacity utilization coefficient
Comfort Standard	σ		Floor area per standee, a measure of comfort for the standing passengers (m^2/standee)
Fleet Size	N_f	$N_f = N + N_r + N_m$ *Here, N = fleet in service* N_r = *fleet in reserve* N_m = *fleet in maintenance*	Total number of vehicles needed for operation of a line
Fleet Utilization Factor	ϕ	$\phi = \frac{N + N_r}{N_f}$	Percent of fleet available for service
Work Utilization Factor	α_{avg}	$\alpha_{avg} = \frac{w_p}{w_o}$ *Here,* w_p = *utilized work* W_o = *offered work*	Average value of the load factor weighted by the passenger volume along the line

These indicators were computed using standard transit planning equations (Vuchic, 2005).

3.5 Analytical Framework

The analysis followed a structured five-step process:

1. Performance Evaluation: Computing current operational metrics for Dhaka MRT Line-6 using observed and official data.
2. Benchmarking: Compiling equivalent performance data for the Singapore NSL to serve as the reference standard.
3. Gap Identification: Determining percentage deviations between the two systems for each performance indicator.
4. Improvement Scenario Modeling: Simulating alternative service configurations for Line-6, including (i) increasing train length from six to eight cars, (ii) reducing peak headway from 5.0 min to 3.5 min, and (iii) introducing skip-stop service instead of local/all-stop service.
5. Impact Evaluation: Assessing each alternative in terms of its effect on load factor, crowding index, and fleet utilization, supported by both quantitative results and qualitative feasibility assessments.

This structured framework enables systematic comparison and ensures analytical transparency, allowing replication by other researchers or policymakers.

3.6 Evaluation Method

Each improvement scenario was evaluated based on operational, economic, and user-comfort criteria. The operational evaluation included recalculating offered capacity, load factor, comfort standard, fleet and work utilization factor for modified service regimes. Economic implications were assessed qualitatively by considering changes in required fleet size. Passenger comfort and accessibility impacts were analyzed in relation to reduced congestion and improved boarding efficiency.

Scenario outcomes were summarized through comparative tables and interpreted with respect to international service benchmarks (Singapore MRT NSL).

In summary, the study applied a comparative benchmarking methodology combining empirical field data and secondary operational statistics to assess the service quality of Dhaka MRT Line-6. Through quantitative evaluation of performance indicators and simulation of feasible alternatives, the approach enables a rigorous and scalable framework for guiding operational improvements across Dhaka's expanding MRT network.

4. DATA ANALYSIS AND RESULT

4.1 Overview

This section quantifies the operational performance of Dhaka MRT Line-6 using both field and secondary data, compares it with Singapore's North–South Line (NSL) and evaluates feasible improvement scenarios. All computations were performed using the July 2025 field log and official statistics from DMTCL.

4.2 Current Operational Characteristics of MRT Line-6

4.2.1 Headway and Speed

During the evening peak (17:30 - 18:30 h), the observed mean headway was 5 min, corresponding to a frequency of 12 TU/h. Average run time between adjacent stations was 2 min, while average dwell time was 0.6 min. The measured end-to-end travel time (Uttara North to Motijheel) was 33.3 min, giving an operating speed (V_o) of 36.2 km/h. The cycle time (T), including terminal times of 7 min per direction is 80.7 min, and the cycle speed (V_c) is 29.9 km/h.

4.2.2 Capacity and Utilization

Each six-car train accommodates 2,308 passengers. With a frequency of 12 TU/h, the offered capacity (C) equals 27,696 prs/h.

The maximum load section (MLS) was observed at Agargaon, carrying 27,840 prs/h, yielding a load factor of 1.005, indicating operation at or slightly above design capacity. The fleet utilization factor (φ) is 0.71, as 14 trains are in service out of a total fleet of 24 (plus 3 in reserve).

The work-utilization coefficient (α_{avg} = 0.75) suggests that 75% of offered capacity is effectively consumed.

4.2.3 Crowding and Comfort

At the critical doorway zone, the measured floor area per standee was 0.13 m², lower than the 0.15 m² comfort threshold for developing-country metros, indicating crush-load conditions during peak periods (Vuchic, 2005). Such density implies forced movements and elevated risk of passenger discomfort or minor injury.

4.2.4 Accessibility and Ticketing Observations

All escalators and lifts were functioning during the survey; however, boarding and alighting bottlenecks still emerged at the doorways due to weak queue discipline. In addition, nearly every station exhibited at least one malfunctioning ticket vending machine, and all service counters relied exclusively on cash transactions, creating further congestion at the concourse level.

4.3 Benchmarking Comparison with NSL

Table 2: Comparison of Service Standards of Dhaka MRT Line-6 with Singapore MRT NSL

Parameter/Indicator	Dhaka MRT Line-6	Singapore MRT NSL	% Gap = $\frac{NSL-(Line-6)}{NSL} X\ 100$	Interpretation for Dhaka MRT Line-6
Peak Headway (min)	5	2.5	-100%	Half the service frequency of NSL
Offered Capacity (prs/h)	27,696	46,080	+40%	Lower throughput due to longer headway
Load Factor	1.005	0.93	-8.6%	Operates above sustainable comfort level
Comfort Standard	0.13	0.25	+48%	Excessive density in Dhaka
Fleet Utilization Coefficient	0.71	0.83	+14%	Under-deployment of rolling stock

Dhaka's effective capacity is roughly 40% lower, largely due to longer headways and a limited number of active trainsets, rather than any deficiency in vehicle capacity. Although each train offers slightly greater available space, the system regularly operates above its sustainable load factor. This outcome indicates that service frequency - rather than vehicle design - remains the critical limiting factor.

4.4 Scenario Evaluation

Three operational alternatives were simulated to address the observed deficiencies:

1. increasing train length from six to eight cars,
2. reducing peak headway from 5.0 min to 3.5 min, and
3. introducing skip-stop service instead of local/all-stop service.

4.4.1 Alternative 1: Eight-Car Trainsets

Increasing each train from 6 to 8 cars raises the TU capacity to 3,088 passengers. At the existing 5-min headway, offered capacity becomes 37,056 pphpd, a 34 % increase, while the comfort standard improves from 0.13 to 0.20 m²/standee (+35 % comfort). Since fleet size and frequency remain unchanged, operating costs are nearly constant, limited to the capital outlay for additional cars. The work-utilization coefficient decreases to 0.56, which reflects increased reserve capacity and reduced congestion.

4.4.2 Alternative 2: Reduced Peak Headway (3.5 min)

Shortening the headway to 3.5 min increases service frequency to 17 TU/h. Offered capacity rises to 39 236 prs/h (+42 %), and load factor declines to 0.70. However, the required fleet expands from 14 to 23 active trainsets (+35 %), implying significant operating and maintenance cost growth. Comfort standard improves marginally to 0.21 m²/standee and fleet utilization (φ) improves to 0.96, which indicates near-maximum resource use.

4.4.3 Alternative 3: Skip-Stop Service

Skip-stop operation divides trains into two patterns (A and B) serving alternate stations. For Train A, operating speed increases to 40.7 km/h and α = 0.90; for Train B, speed = 41.4 km/h and α = 0.98. Although cycle speed improves by 10-12 %, headways at individual stations lengthen (7.5 and 12 min), reducing reliability and creating uneven platform occupancy. Fleet utilization modestly rises to 0.79 but at the cost of passenger confusion and minimal comfort gain.

Table 3 summarizes all of the alternatives:

Table 3: Analysis of Alternatives for Improving Service Standards in Dhaka MRT Line-6

Regime		**Local**		**Skip-Stop**	
Train Type	**Current Service**	**n = 8 from 6**	**h = 3.5 min from 5 min**	**A**	**B**
L (km)		20.1		20.1	
T_o (min)		33.33		29.66	29.1
V_o (km/h)		36.2		40.7	41.4
P_{max} (prs/h)		27840		16680	11280
f (TU/h)	12	12	17	8	5
N	6	8	6	6	6
h (min)	5	5	3.5	7.5	12
T (min)		80.66		75	72
V_c (km/h)		29.9		32.2	33.5
N_f	14	14	23	10	6
$\sum N_f$	14	14	23	16	
$n*N_f$	84	14	23	60	36
$\sum(n*N_f)$	84	112	138	96	
α	1.005	0.75	0.7	0.9	0.98
α_{avg}	0.75	0.56	0.53	0.64	0.76

Regime	**Local**			**Skip-Stop**	
Train Type	**Current Service**	**n = 8 from 6**	**h = 3.5 min from 5 min**	**A**	**B**
α_{avg} (service)	0.75	0.56	0.53	0.75	
σ (m^2/standee)	0.13	0.2	0.21	0.16	0.15
Φ	0.71	0.71	0.96	0.79	

4.5 Impact Evaluation

Impacts are evaluated under two criteria:

1. Equity and Accessibility Implications
2. Ticketing and Service-Resilience Insights

4.5.1 Equity and Accessibility Implications

Reducing crush levels from 0.13 to 0.20 m² per standee in the eight-car scenario directly lowers doorway interference, thereby facilitating smoother boarding for elderly and mobility-impaired passengers. The resulting decline in passenger density also reduces dwell-time variability, which strengthens service reliability and enhances system inclusiveness, all without requiring significant capital expansion of depots or track infrastructure.

4.5.2 Ticketing and Service-Resilience Insights

Integrating mobile financial platforms (bKash, Nagad etc.) into ticketing would shorten average purchase time per passenger.

The implementation of bus-bridging provisions would benefit significantly from the ongoing electric bus pilot in Dhaka. Leveraging electric fleets for such contingency operations would not only enhance system resilience and service reliability but also advance national sustainability objectives.

4.6 Synthesis of Finding

Quantitative evaluation indicates that expanding capacity via 8-car trainsets provides the most favorable ratio of comfort gain to cost. This approach reduces the load factor by 25% and crowding by 35% without requiring additional rolling stock or increasing energy consumption.

In contrast, further reducing headways to 3.5 minutes offers only marginal improvements in comfort while raising operating expenditures by approximately 35%. Similarly, while skip-stop services enhance running speed, they compromise service regularity and fail to mitigate congestion at key stations.

Consequently, the optimal near-term strategy for the DMTCL involves the deployment of 8-car formations, supported by smart-payment integration and bus-bridging provisions for service disruptions.

5. CONCLUSIONS

This study provides a comprehensive evaluation of the operational performance of Dhaka's MRT Line-6, benchmarking it against Singapore's MRT North-South Line to identify critical performance gaps and improvement opportunities. The analysis highlights key operational challenges, such as extended headways, capacity constraints, and overcrowding, which hinder the metro system's effectiveness in meeting the growing demand for urban mobility in Dhaka. By simulating improvement scenarios, including increasing train length and reducing headways, the study offers actionable strategies to optimize service delivery, enhance passenger comfort, and improve fleet utilization. Furthermore, the comparison with a mature system like the NSL underscores the importance of operational efficiency, reliability, and frequent services in ensuring the success of metro systems in developing cities. The findings of this study are crucial for informing future operational strategies for Dhaka's MRT Line-6 and other emerging metro systems in similar socio-economic contexts. By addressing the identified challenges, Dhaka can realize the full potential of its metro network, contributing to sustainable urban development and improving the quality of life for its residents. This research provides a valuable framework for policymakers and transit authorities aiming to enhance the performance of mass transit systems in rapidly urbanizing regions.

DECLARATION OF USE OF AI

Artificial intelligence tools, specifically ChatGPT, were used only to refine grammar, improve clarity and strengthen the overall cohesion of the text. All suggestions provided by the tool were carefully reviewed and adjusted by the author. No AI assistance was involved in analyzing data, developing methods, interpreting results or supporting any other part of the research process.

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