

Mapping the Landscape of Metro Service Quality Research: A Comprehensive SPAR-based Systematic Review and Meta Analysis



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Abstract

Purpose: To systematically map the world's research on metro service quality to identify which service quality dimensions affect commuter satisfaction and which behavioral outcomes are affected by the latter.

Methodology: based on the SPAR-4-SLR protocol, which involved the retrieval of a total of 54 comprehensive studies that were published from 2015 to 2026 from the Scopus and TRIS databases for a systematic review and bibliometric mapping using the VOSviewer software. At the same time, a smaller sample of 22 primary empirical studies ($k=22$, $N=10,523$) focused on the 22 most critical factors was analyzed using a quantitative random-effects meta-analysis in Meta Essentials (v1.5).

Novelty: It offers the first empirical reconciliation of transit behavioral models by calculating a definitive global pooled correlation, mathematically incorporates a new RAILQUAL framework alongside traditional SERVQUAL metrics, and conceptualizes a new Input-Process-Output (IPO) framework.

Findings: Bibliometric co-occurrence shows that China leads the world in research footprint (2,728 citations), followed by Spain, the UK, and the USA. The meta-analysis reveals that the pooled effect size ($r = 0.61$, 95% CI: 0.48, 0.69) for service quality and satisfaction is very high and significant, and the trim-and-fill analysis does not indicate publication bias. Results indicate that local urban environments strongly influence transit perceptions, as evidenced by the high heterogeneity ($I^2 = 99.08\%$).

Implications: It establishes a key future research agenda by focusing on under-researched Tier-II cities, incorporating universal design for vulnerable passengers, and broadening dynamic, AI-powered predictive modeling.

Keywords: Metro rail, Service quality, Commuter satisfaction, Systematic literature review, Bibliometric analysis, RAILQUAL, Public transportation, Urban transit.

Introduction

Metro emerged not only as a major means of transport but also as a terminology to think about and experience the city differently. (Melissa Butcher, 2011). Indian cities are facing the crisis of urban transport. (Bharath et al., 2025) An efficient public transport system is the backbone of city development and the main driver of activity and trips within cities. (Aboul-Atta & Elmaraghy, 2022; He et al., 2023) Urban metro is increasingly becoming an indispensable means of transport (Chen et al., 2024). Metro systems have the potential to reduce road congestion and accidents, according to studies (Chen et al., 2021; Kumar, Das, and Vivek, 2026; Lin, Broere, and Cui, 2022; Mishra & Koner, 2022; Zheng et al., 2025). Public transport, especially metro rail, is a backbone of sustainable urban mobility that enables people to move around and helps reduce problems like environmental pollution and traffic congestion. The trend of urbanization has grown as the world's population has moved toward cities and the demand for efficient and reliable transportation has strengthened, making operators' emphasis on productivity more than ever a

focus on providing quality services. Perceived service quality is the basic definition of service quality as it stands in the eyes of the customer. It plays a crucial role in customer satisfaction and customer attrition, as well as in attracting customers away from private vehicles. Quality of metro has a variety of factors. They can be identified by models like SERVQUAL model which is based on five factors: assurance, reliability, responsiveness, tangibility, empathy. The same features have been expanded to rail travel via the RAILQUAL framework which includes elements of comfort, connectivity and convenience. Safety, security, travel costs and employee behaviour have also been found to be of significant importance in other areas in the region. A variety of sophisticated modelling tools are employed to study these factors. Structural Equation Modeling (SEM) is often utilized to disclose intricate relationships between the factors of services. In the meantime, Importance-Performance Analysis (IPA) is a strategic tool to prioritize gaps in service and put resources into them. Additionally, binary and multinomial logit models are widely used

for evaluating modal shift and predicting the probability that a commuter will switch to a new mode of travel (suburban rail or private modes) as an alternative. Finally, these models relate service quality to important behavioral outcomes, such as commuter satisfaction, loyalty, and the intent to use. But the role that satisfaction plays between service quality and loyalty is not agreed upon in literature. Some researchers found a full mediator model, whereas others proposed a partial mediator model, where service quality directly impacts future travel intentions in addition to the mediator role of satisfaction. Furthermore, there are significant differences in perceptions by demographic segments, and elderly or physically disabled passengers, as well as others in different age groups, may have different values for service attributes. This review systematically maps these determinants, models and behavioral outcomes to give a full picture of the current research field and future research priorities for transit interventions.

Research Question-

What is the publication trend related to Service Quality and Commuters' Satisfaction?

What are the key dimensions for service quality examined in Metro transit research?

What are the key research Gaps and promising future research directions?

Research Objectives -

- To assess publication trends and the intellectual structure of Metro Service Quality research.
- To identify and statistically synthesize the key dimensions of service quality that influence commuters' satisfaction.
- To evaluate the strength of the relationship between service quality and commuters' satisfaction through a meta-analytical approach.

Methodology -

This study uses the SPAR-4-SLR (Scientific Procedures for Systematic Literature Review) protocol proposed by Paul et al. to map the landscape of metro service quality and commuter satisfaction. This structure provides three phases of the systematic review that are systematic, transparent, and reproducible: Assembling, Arranging, and Assessing (The 3-As). The execution of these phases follows a step-by-step manner, as shown below, integrated and elaborated.

The first was to define the research domain in Phase 1 - Assembling (Identification and Acquisition), focusing on "Metro Service Quality" and "Passenger Satisfaction". Structured Boolean operators were used in different databases, such as Scopus and TRIS, for data acquisition. Running the first time yielded 3563 records, of which 100 duplicates were removed, leaving 3463 mobilized for the next stage.

Phase 2 - Arranging (organization and Purification):

This phase included applying predetermined inclusion and exclusion criteria in order to purify the data set. Of 3,436 documents, 1,687 were removed as not relevant to the topic or not in English, and 476 were removed because they were published before 2015. For the systematic literature review (SLR), further screening of titles and abstracts reduced the number of documents to 54.

((TITLE-ABS-KEY ("Metro service quality" OR "Quality of Service" OR "Rail Qual")) AND (TITLE-ABS-KEY ("Customer Satisfaction" OR "Commuters Satisfaction" OR "Passenger Satisfaction")) OR (TITLE-ABS-KEY ("Public Transport" OR "Urban Transit")) AND NOT (TITLE-ABS-KEY ("Marine" OR "Airlines" OR "Bus Transport"))) AND (LIMIT-TO (PUBYEAR , > 2015) AND LIMIT-TO (PUBYEAR , < 2026)) AND (LIMIT-TO (SRCTYPE , "j"))) AND (LIMIT-TO (PUBSTAGE , "final"))) AND ((LIMIT-TO (SUBJAREA , "ENGI")) OR (LIMIT-TO (SUBJAREA , "BUSI"))) OR (LIMIT-TO (SUBJAREA ,

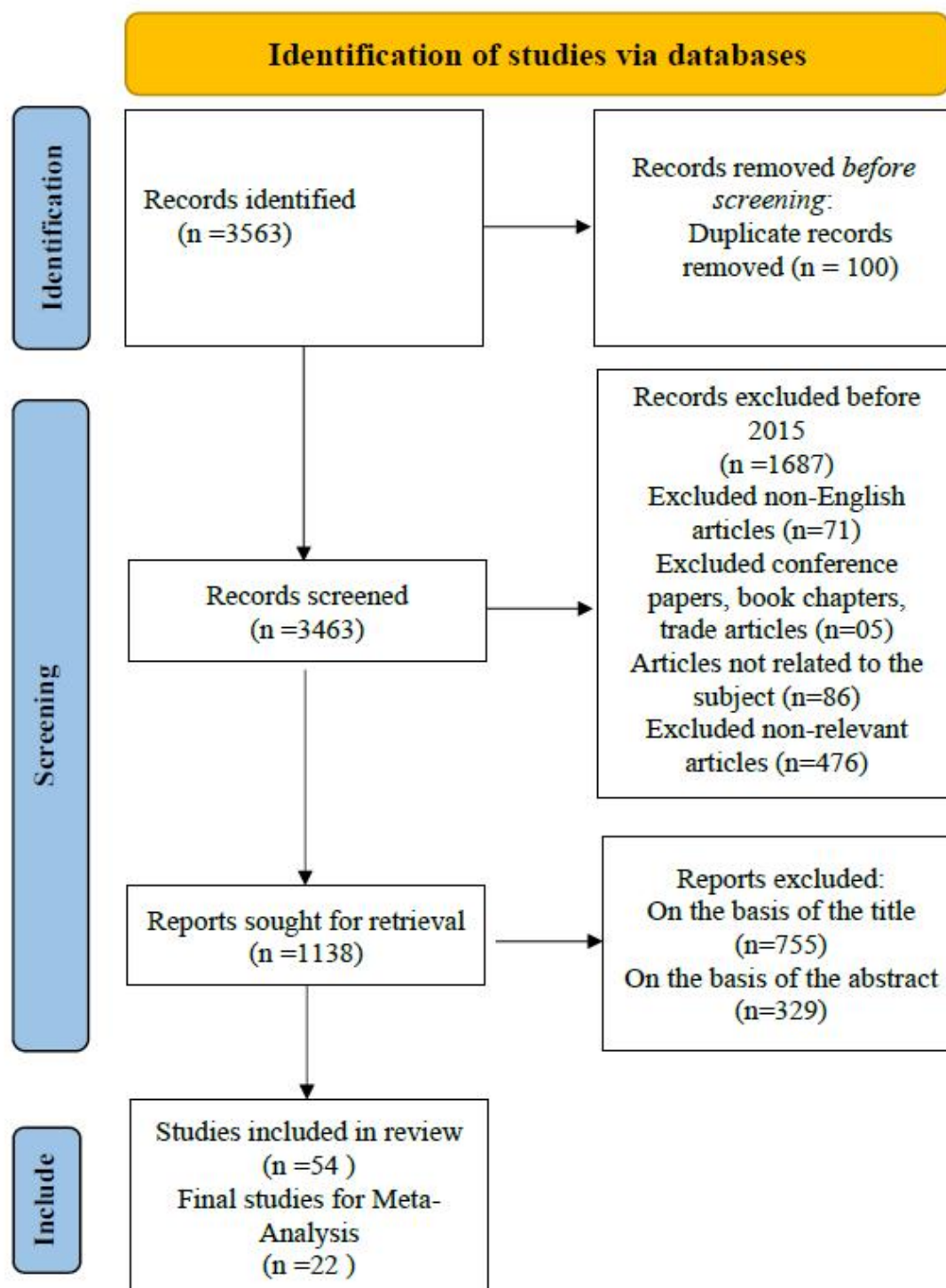
The final phase is Assessing (Evaluation & Reporting): a dual synthesis is used at this stage. To assess the intellectual structure and publication networks, the number of documents (54) was then analyzed through a bibliometric analysis using the software VOSviewer (v1.6.20). Second, a refined sub-criterion was used for the Quantitative Meta-Analysis synthesis – the final 54 studies included 22 core empirical studies (k=22, N=10,523) reporting the explicit correlation coefficient (r). Meta essentials (v1.5) was used to analyze these 22 studies using a random-effects model.

The Quantitative Synthesis (Meta-Analysis Protocol) will be used to analyze the findings.

A multi-stage screening protocol was used to ensure methodological rigor and to ensure a smooth transition from quantitative to qualitative synthesis. Initially, the comprehensive

In addition to bibliographic mapping, a meta-analysis was conducted within the 'assessing' phases of the SPAR framework to complement the mapping and provide a scientific statistical assessment of the situation. The quantitative synthesis specifically examines the strength and generalizability of the relationship between service quality dimensions in a metro system and passenger satisfaction across a range of empirical contexts. In total, 22 core empirical studies (k=22) were extracted from the finalized databases, each with explicit Pearson correlation coefficients (r) and sample sizes (N). Meta Essentials (v1.5) was used to carry out the statistical calculations. The differences in geographical context, economic fabric, and scale of operations across the world's metro areas made it inappropriate to use a fixed-effects model. This means that intra-study and inter-study variability is addressed, so that a single large-sample size study will not overly influence the overall effect size. Also, Cochran's Q and I² are used to assess statistical heterogeneity. The procedures were carried out systematically to ensure the validity of the

analysis.



Inclusion and exclusion criteria for the literature review

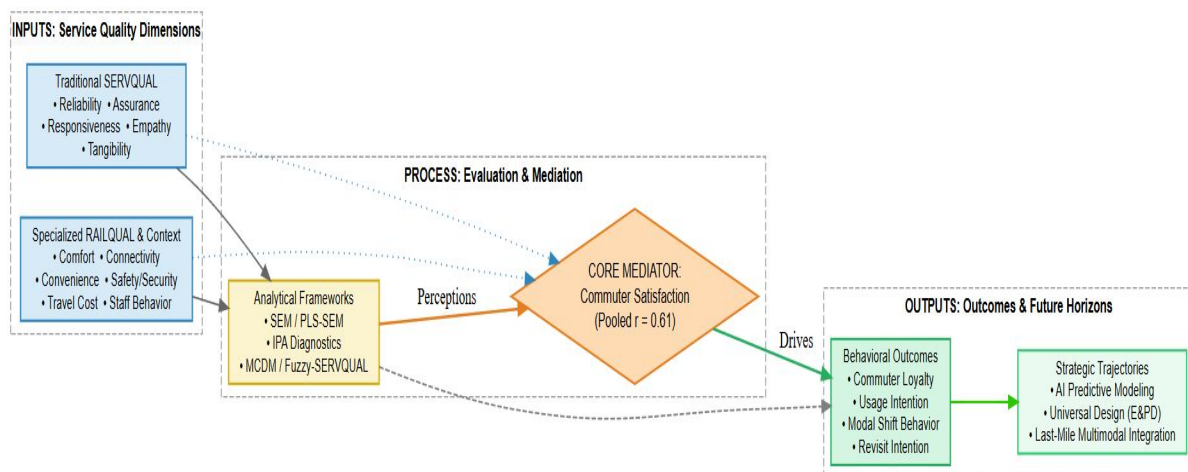
Inclusion	Exclusion
Article Consider which are published between 2015 and 2026 (n= 2304)	The article does not consider those that are not related to the timeline n=1687
Article published in English (n= 2233)	Article not consider in which are not in publish in English language (n=71)
Include only the article document (n=1123)	Exclude conference, book chapter, trade article (n=05)
Include articles that are in the final stage (n=	Exclude articles that are in the Work in Progress

1102)	stage (n=21)
The article includes those related to business, Management & Accounting, Social Science, Economics, Engineering, Finance (n=924)	The article is excluded because it is not within the subject range.
Focus on Metro rail, Quality of Service, Rail Qual, Public Transport, Urban Transit (n = 838)	Exclude article focuses on Marine, airlines, bus transport (n=86)
Include after screening of title (n=383)	Exclude articles that are not relevant to my topic (n=455)
Include the article after screening of the abstract (n= 54)	Exclude the article after screening of the abstract (n= 329)

Discussion and Finding-



Conceptual Framework



Authors' own work

Explanation of Conceptual Framework

1. The proposed framework, developed in RStudio, outlines the relationship between the quality of the metro service and the behaviour of the passengers within an Input-Process-Output framework. The input (Service Quality Dimensions) block includes the operational factor that the passenger is evaluating. These encompass the traditional Servqual metrics as well as the Rail Qual Factors (comfort, connectivity, convenience, safety and travel cost).

convenience, safety and travel cost).

2. Process (Evaluation & Mediation): This is an analytical layer core to it. It takes commuters satisfaction as the key indicator, corroborated by a meta analysis of a high pooled correlation ($r = 0.61$). It also contains various statistical models including SEM and IPA models for measuring this relationship.

3. Output (Outcome & Future Gaps): Outcome layer is the result of the passenger satisfaction including

commuter satisfaction, commuter loyalty, revisit intention, and modal shift behavior from private vehicles.

Top Countries

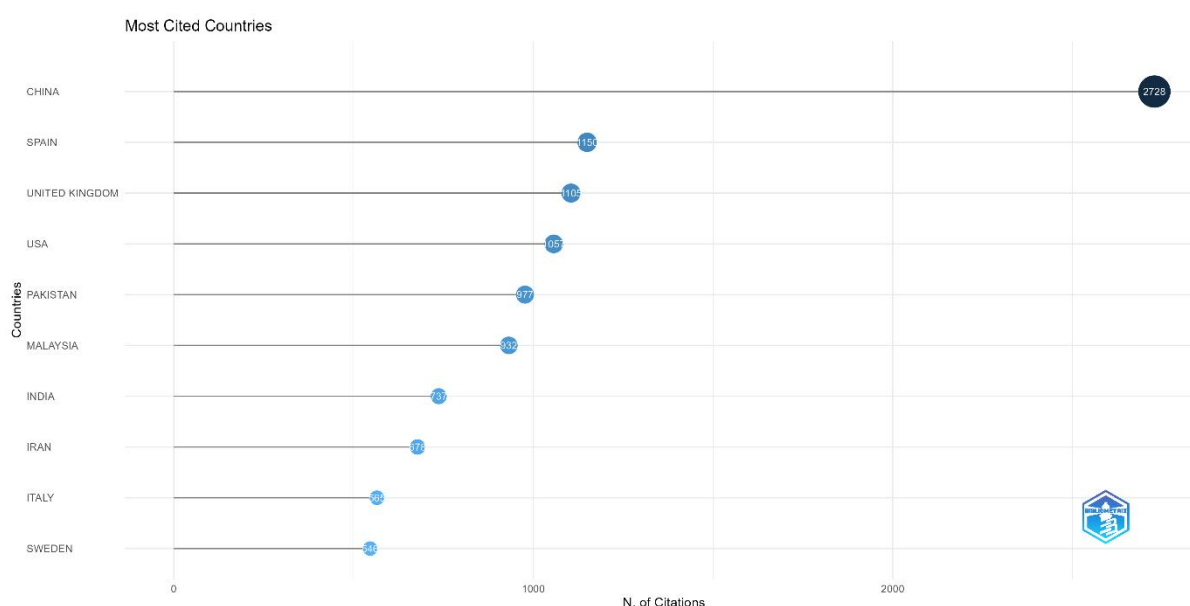
Research in this field is international, but some countries excel in the number of contributions. A citation analysis of research contributing countries was carried out to understand the global academic impact and intellectual influence of the research on the service quality of metro services, using the Bibliometrix tool. The figure depicts the list of top 10 most cited countries in this research domain. This is a significant amount of citations. China is by far in the lead for citations in global research as it gets 2,728 citations. This is a bold underscore with a large number of citations. Rapid urbanization and the extensive academic literature produced about urban transportation in China are fueled by the country's large investment. In second place, after China, a group

of European and North American countries are well represented academically: Spain (1,150 citations), United Kingdom (1,105 citations) and the United States (1,057 citations) were all intellectual powerhouses. At the same time, developing economies and Asian countries are showing an increasing trend towards the study of transport. Pakistan with 977 citations is fifth, and Malaysia is just behind with 932 citations. There is also a significant Indian presence, particularly of the metropolises which are fast growing. The lower tier of the top 10 is occupied by Iran (678), Italy (565), and Sweden (546).

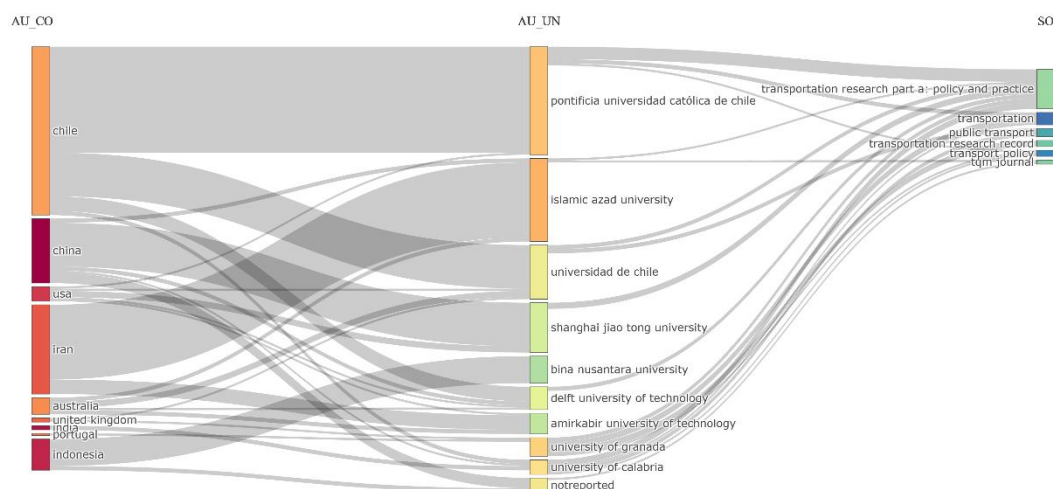
To sum up, although the academic influence is clearly dominated by the east Asian and western countries, the inclusion of global south countries (such as the Indian Union) and publications validating a changing research focus in transit infrastructure strongly suggest the North-South paradigm has shifted.

S.No	Country	Number of Citations
1	China	2728
2	Spain	1150
3	United Kingdom	1105
4	USA	1057
5	Pakistan	977
6	Malaysia	932
7	India	737
8	Iran	678
9	Italy	565
10	Sweden	546

Authors own work



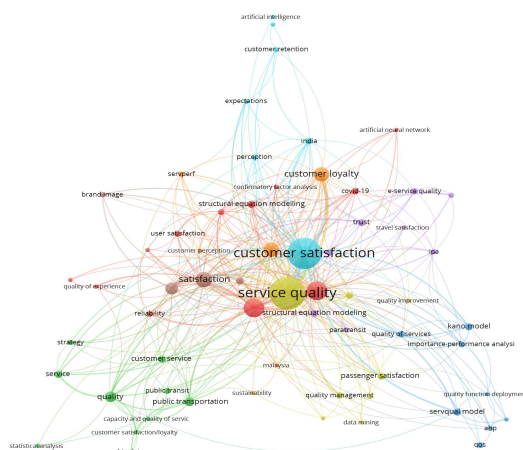
Top Institutions



The top institutions clearly have the top cited authors and strong research groups.

A multi-relational analysis was conducted by linking together the author's country (AU_CO), the author's affiliation (AU_UN) and the publication source (SO) in a three field plot to reveal the institutional landscape and show how research routes flow between the institutions. The Sankey flow diagram shows a very focused intellectual corridor. One observation is that Chile is a big contributor in this particular dataset, particularly the Pontificia Universidad Catolica de Chile and Universidad de Chile. Their research reveals a significantly higher, dense traffic to the highest quality journals of the Transportation and Transport Research Part A: Policy and Practice disciplines, dominated by the very large number of publications of those top journals. At the same time, China's research output, as embodied in its leading institutions, Shanghai Jiao Tong University, shows a diversified Publishing strategy, publishing the results in various

reputable journals, including Public Transport, Transportation Research Record, and Transport Policy. Another notable workflow is identified from Iran, anchored by Islamic Azad University and Amirkabir University of Technology. Their research output is similar to other journals like Transport Policy and TQM Journal, which focus on the operational and quality management aspects of urban transportation systems. The countries that are emerging into participation are also drawn to India, the USA and Indonesia, where they form nodes to these global institutions. This integrated flow illustrates the geographic distribution of the institutional origins and the strong connection to core Elsevier, Springer and Sage transportation Journals where the final dissemination of the service quality literature from the institutions occurs. Keywords: co-occurrence and intellectual structure



The author's work

To analyze the conceptual structure and trace the thematic dimensions of the metro service quality literature, a keyword co-occurrence analysis was conducted in VOSviewer using a minimum-occurrence threshold. The network visualizes a highly centralized topology in which “service quality” and “customer satisfaction” serve as the primary structural anchors. Chronologically and methodologically, the clusters are split into different strategic sub-themes:-

The analytical core (Red and Orange Clusters: Central to the domain is “structural equation modeling” (SEM), closely linked with “customer perception”). This indicates a strong academic consensus that viewing satisfaction should not be viewed merely as a final metric, but as a critical mediator influencing long-term commuter retention and loyalty.

The Diagnostic Framework (Dark Blue Cluster): Positioned on the lower right flank, keywords such as “servqual model”, “importance performance analysis” (IPA), “kano model,” and “quality function deployment” cluster tightly together. This maps the transition from pure theoretical quality modeling to

strategically resource-allocation diagnostic tools frequently deployed by metro operators.

Contextual and Operational Attributes (Green and Yellow Clusters): Keywords like “public transit, “sustainability, “reliability,” and “quality management” highlight the operational indicators that directly determine transit equity and ecological value.

Emerging technological frontiers (Light Blue Cluster): Anchored at the absolute top of the map, an isolated yet rapidly developing cluster captures “artificial intelligence”, “customer retention,” and “expectations”. This represents the critical research gap and future trajectory identified in this review, shifting from static, cross-sectional surveys to dynamic, AI- driven predictive modeling of passenger experience.

Statistically Synthesis and Meta-Analysis Results

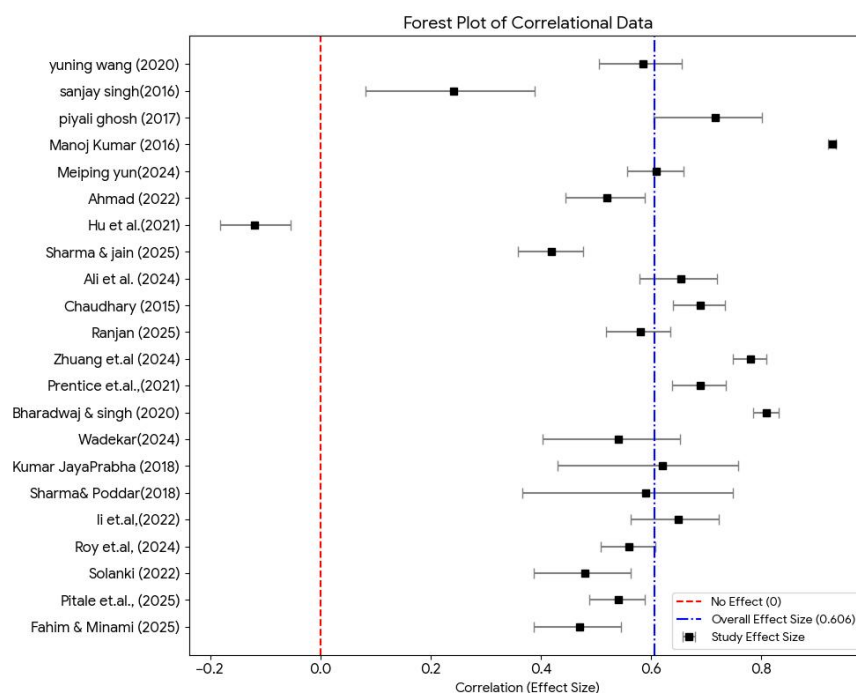
To statistically validate the dimensions mapped via VOS viewer, a meta-analysis of 22 empirical studies (k=22) was conducted to estimate the pooled effect size of metro service quality on commuters' satisfaction.

Table 1- Meta-Analysis Summary of Service Quality and Passenger -

S.no	Study Name (Year)	Correlation (r)	Number of Subjects (n)	Lower limit (95% CI)	Upper Limit (95% CI)	Weight %
1	Yuning wang (2020)	0.59	300	0.51	0.66	4.57
2	sanjay singh(2016)	0.24	148	0.08	0.39	4.50
3	(Ghosh et al., 2017)	0.72	100	0.60	0.80	4.44
4	Manoj Kumar (2016)	0.93	1500	0.92	0.94	4.62
5	(Yun et al., 2024)	0.61	583	0.56	0.66	4.60
6	(Ibrahim et al., 2020)	0.52	400	0.44	0.59	4.58
7	Hu et al.(2021)	-0.12	918	-0.18	-0.05	4.61
8	(Sharma & Jain, 2025)	0.42	752	0.36	0.48	4.61
9	(Ali et al., 2024)	0.66	258	0.58	0.72	4.56
10	Chaudhary (2015)	0.69	491	0.64	0.73	4.59
11	(Ranjan & Sinha, 2025)	0.58	500	0.52	0.64	4.60
12	Zhuang et al.	0.78	628	0.75	0.81	4.59

	(2024)					
13	Prentice et.al.,(2021)	0.69	451	0.64	0.74	4.61
14	Bharadwaj & Singh (2020)	0.81	850	0.52	0.83	4.48
15	Wadekar(2024)	0.54	128	0.40	0.65	4.43
16	Kumar JayaPrabha (2018)	0.62	60	0.43	0.76	4.24
17	Sharma& Poddar(2018)	0.59	50	0.37	0.75	4.54
18	li et.al,(2022)	0.65	208	0.56	0.72	4.61
19	Roy et al., (2024)	0.56	735	0.51	0.61	4.57
20	Solanki (2022)	0.48	300	0.39	0.56	4.61
21	Pitale etal (2025)	0.54	781	0.49	0.59	4.61
22	Fahim & Minami (2025)	0.47	382	0.39	0.54	4.58
	Combine (Pooled)Effects	0.61	10,523	0.48	0.69	100

A Meta-analysis of k=22 empirical studies (N=10,523) was conducted to statistically synthesize the effect of metro service quality on commuters' satisfaction. Using a random-effect model, the overall pooled correlation was $r = 0.61$, with a 95% confidence interval of 0.50 to 0.69. The absence of zero within this interval confirms a highly significant positive relationship. High heterogeneity was observed across the literature, indicated by a I^2 of 99.08% and a cohorn's Q of 2274.14 ($p < 0.001$), which underscores that systematic differences across global transit networks heavily dictate passenger perceptions. This variation is illustrated in a forest plot, where individual study outcomes range from strong positive alignment (Manoj Kumar, 2016; $r=0.93$) to distinct negative exceptions (Hu et al., 2021; $r=-0.12$) -



Publication Bias Analysis –

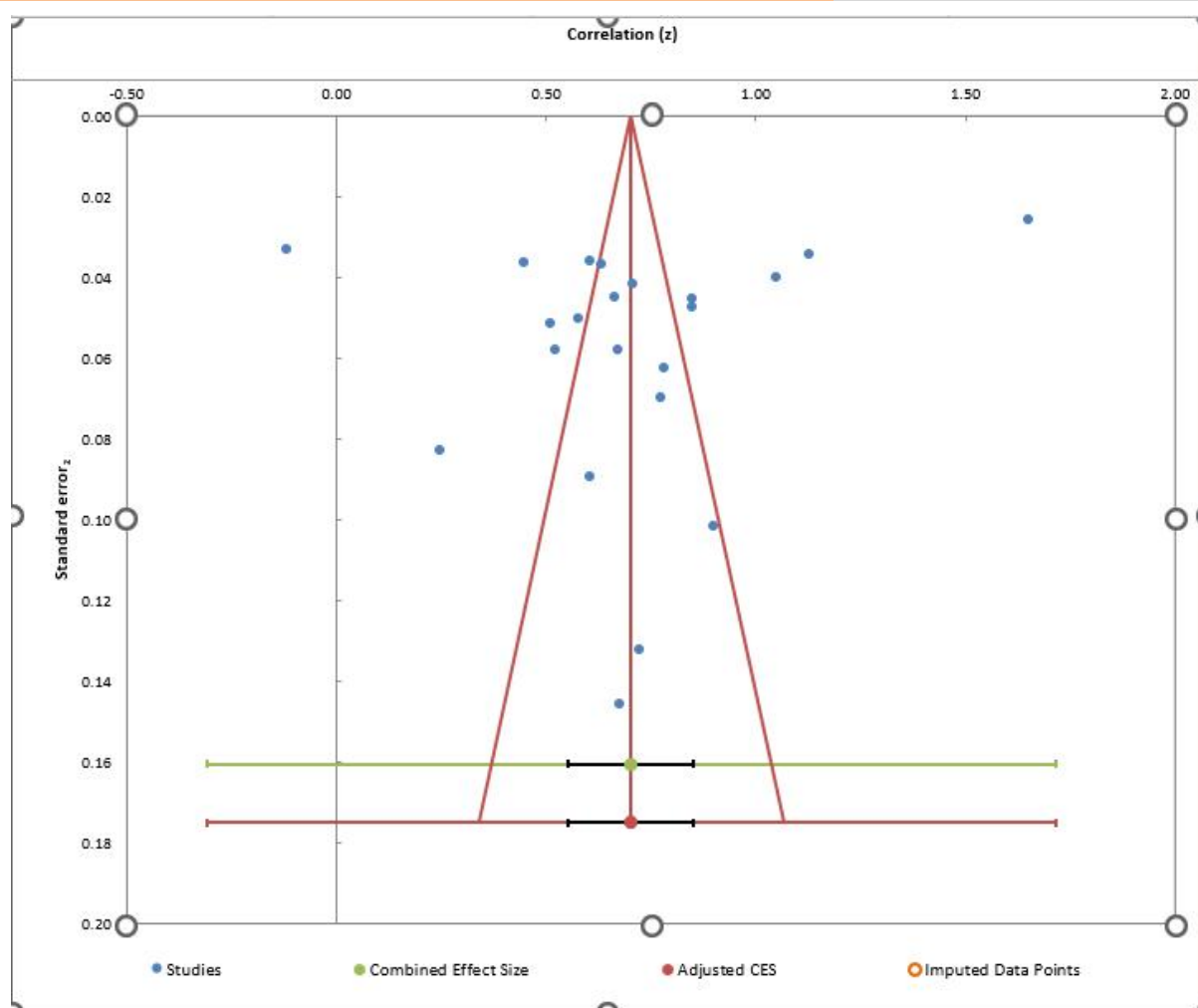
To ensure the reliability of the meta-analysis, Funnel plot analysis was conducted for the 22 included studies ($N=10,523$) using Meta-Essentials. This plot helps check whether our sample is affected by publication bias or by extreme differences across studies. The horizontal axis (X-axis) represents the calculated effect size (Fisher's z), while the vertical axis (Y-axis) shows the standard error. In an ideal scenario with no publication bias, the studies should be distributed symmetrically inside the inverted triangular funnel. High- Precision studies: - A strong cluster of studies is near the top of the funnel. These represent larger sample sizes with lower standard errors, closely matching our overall pooled effect size ($z=0.70$)

Asymmetry and outliers: Most of the studies lie

outside the triangular lines on both the left and right sides. The scattering is not a sign of bias; rather, it visually confirms the high statistical heterogeneity ($I^2=99.08\%$) in metro research. This happens because passenger satisfaction varies significantly across cities and transit networks worldwide.

Trim-and-fill analysis: The software applied a trim-and-fill test to detect missing data. As shown at the bottom of the plot, the original combined effect size (Green nodes) and adjusted effect size (Red node) are exactly at the same point. Furthermore, no missing or imputed data points (orange circles) were added by the software.

In conclusion, we mathematically demonstrate that our dataset is complete and free of hidden publication bias. Therefore, the final pooled correlation of $r = 0.61$ is stable.



Authors' own work

1. Key Research Gaps

There is an imbalance in the study of Tier-II and mid-sized cities (Patna, Bhopal, Jaipur etc) compared to the study concentrated in well-resourced cities like Delhi, Mumbai, London and New York.

Vulnerable User Groups: Elderly and physically disabled (E&PD) passenger needs and perception is largely under researched, especially in developing countries, and the implementation of "universal design" standards.

The Access and Egress Environments: Little investigation is undertaken of the access trip to urban rail; most studies are concerned with operations within the metro itself, overlooking the urban context (either enabling or inhibiting) to passengers entering stations.

Non-User Perspectives: The research has been conducted mostly from the perspective of current transit users, with little focus on understanding the reasons for discontinuing transit service or why they continue to drive when metros are available.

Satisfaction as a full and/or partial mediator between service quality and loyalty/usage intentions: There is a consensus regarding this gap, as the exact nature of the relationships between service quality and satisfaction, and between satisfaction and loyalty/usage intentions remains unclear.

Promising future directions for research.

The subjective perception surveys and the objective operational data (such as actual delay frequencies, crowding indices and real-time vehicle location) should be combined in future research to get a more complete picture of the service quality.

A key and emerging area is Post-Pandemic "New Normal": Understanding the long-term effect of post-pandemic concerns (e.g., hygiene, COVID-19 safety measures, ventilation, changed travel habits etc.) on usage intention.

Sentiment analysis using user-generated content from social media and data mining sites such as Twitter or Google Maps is a cost-effective and dynamic alternative to traditional survey techniques.

Incorporating new techniques such as machine learning (ML), hybrid choice models, and Bayesian networks, which hold promise for capturing more complex, non-linear relationships and for dealing with the inherent vagueness of human perception, are promising areas of development.

Transition from cross sectional "snapshots" to longitudinal studies: This will enable researchers to see how satisfaction changes as a result of incremental policy changes over time.

• **Multidimensional Quality of Life (QoL) Frameworks:** Future models should integrate emotional,

psychological, and social well-being alongside traditional mobility and accessibility measures to better evaluate the holistic impact of metro systems (Verma & Rastogi, 2025).

• **Last-Mile and Multimodal Integration:** Investigating the challenges of first-mile and last-mile connectivity, particularly for female commuters and vulnerable groups, is critical for enhancing overall system patronage (Jasti & Ram, 2024).

Conclusion

This research offers a statistically robust and comprehensive assessment of the global metro transit literature, combining the SPAR-4-SLR protocol and a quantitative meta-analysis of 22 key empirical studies with 10,523 passengers. The empirical analysis reveals a very strong, significant pooled effect size ($r = 0.61$) between metro service quality and commuters' satisfaction. Concurrently, the very high statistical heterogeneity ($I^2 = 99.08\%$) clearly indicates that the influences on passenger expectations are strongly shaped by the unique urban settings, and thus cannot be generalized by a "one-size-fits-all" approach. The study's original Input-Process-Output (IPO) continuum ultimately suggests a broader adoption of new transit policies and scholarly research to promote sustainable urban mobility, by focusing on under-researched Tier-II cities, advocating for universal design for elderly and physically disabled (E&PD) passengers, and introducing flexible, AI-based predictive modeling of the commuter experience.

Declarations

Conflict of Interest Statement: The authors declare that they have no potential or perceived conflicts of interest associated with this manuscript.

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