

Developing Evidence-Based Digital Billboard Design Guidelines: Assessing Drivers' Visual Attention and Urban Visual Quality in Metropolitan Areas

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ABSTRACT

Digital billboards are now a common sight on metropolitan streets, and their proliferation has raised important questions about advertising visibility, driver safety and the quality of the urban visual environment. While digital displays lend themselves to high visibility and flexibility in communication, design considerations such as brightness, animation, transition timing, the use of colour, and total display area. It can also increase visual demand and contribute to clutter in busy city environments. by investigating the need of evidence-based digital billboard design guidelines. The paper explores the connection between billboard design characteristics, drivers' visual attention and perceived urban visual quality, with a special focus on the Malaysian metropolitan context. The study will be qualitative and expert-based, using semi-structured interviews and the Delphi technique, with urban planners, road safety specialists, visual communication designers and out-of-home advertising practitioners. The data will be analysed through the thematic analysis to define relevant design parameters, safety issues and urban visual quality criteria. The paper proposed an integrated guideline framework integrating design control, safety assessment and urban visual management. Its expected contribution is a context sensitive set of recommendations that can help local authorities, designers and industry stakeholders to balance commercial communication with safer and more visually sustainable urban environments.

Keywords: Digital Billboard, Visual Attention, Urban Visual Quality, Driver Distraction, Design Guidelines.



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1 INTRODUCTION

Digital billboards have become prominent features of contemporary urban environments and an increasingly important component of out-of-home advertising. Unlike traditional static billboards, these displays use LED technology to present dynamic content, rotate messages rapidly, and accommodate real-time updates. The flexibility enables advertisers to manage multiple campaigns through a single display and tailored content according to time, location and target audience.

At the same time, the same characteristics that enhance the visibility and commercial appeals of digital billboards may present challenges to road safety and urban visual quality. High luminance, rapid transitions, motion graphics, saturated colours, strong contrast and large display scale can attract attention away from the driving task (Lee & Park, 2024; Wang et al., 2023). Previous studies have indicated that roadside advertising can influence drivers' visual behaviour, cognitive processing, mental workload, hazard awareness and responsiveness to traffic-related information (Belyusar et al., 2016;

Edquist et al., 2011; Meuleners et al., 2020; Young et al., 2009). Such issues are even more acute in metropolitan corridors, where drivers already must process traffic movement, pedestrians, road signs, building facades and other commercial messages simultaneously.

From an urban design perspective, digital billboards shape the visual character and public experience of streetscapes. When advertising displays are excessive, poorly coordinated or visually dominant, they may disrupt environmental coherence and contribute to visual clutter and pollution (Kim & Choi, 2024). Studies conducted in Kuala Lumpur further suggest that billboard colour and the overall concentration of advertising can influence public perceptions of urban landscape quality (Adam et al., 2022; Rahman et al., 2022). Digital billboard design should therefore be understood not merely as a commercial or engineering issue, but as an important aspect of visual communication within the built environment.

2 RESEARCH BACKGROUND

2.1 Digital Billboards and The Metropolitan Visual Environment

The growth of digital billboards points to a larger change in outdoor advertising from static printed posters to programmable media. Digital billboards can display a variety of messages, change according to the campaign schedule and use brightness or movement to improve visibility. Although, these features enhance commercial visibility, it may also introduce additional visual competition into already complex urban streetscapes (Sheykhfard et al., 2024; Sorum et al., 2026).

Urban environments are experienced by continuous visual scanning. Drivers must be able to read the road conditions, monitor surrounding vehicles and pedestrians, observe traffic signals and respond to the unexpected hazards. Highly salient roadside display may divert drivers' attention towards advertising content, particularly when they employ bright illumination, changing imagery, emotional content or visually complex information. Recent simulator, eye-tracking and observational research indicates that roadside billboards can influence drivers' visual attention, cognitive processing, hazard awareness and driving behaviour (Wang et al., 2021). Although exposure to digital billboards does not necessarily lead directly to unsafe behaviour or collisions, Gao et al. (2024) mentioned that it may increase visual and cognitive workload and reduce the attentional resources available for processing driving-related information.

Digital billboards also affect non-driving users by influencing the appearance, identity and perceived quality of urban streets. Outdoor advertisements, particularly when excessive, poorly placed, inconsistent in design, overly bright or disproportionate in scale, may contribute to visual clutter and diminish the aesthetic quality and visual coherence of the built environment (Borowiak et al., 2024). Consequently, decisions concerning billboard colour, scale, brightness, placement, content complexity and visual transitions should respond to the characteristics of the surrounding location. Context-sensitive management is especially important in heritage areas, pedestrian-oriented streets, mixed use districts and commercial corridors containing high concentrations of signage. This is also supported by Gelan (2025), where advertisements may compete with architectural features, road information and other visually significant urban elements.

2.2 Drivers' Visual Attention and Roadside Advertising

Visual attention is limited cognitive resource, while safe driving requires continuous monitoring of lane position, surrounding vehicles, pedestrians, traffic signals, regulatory signs and emerging hazards. Roadside advertising introduces additional stimuli that may compete with this safety-critical information and redirect attention away from the forward roadway (Hinton et al., 2024). Distraction may occur visually when drivers shift their gaze towards an advertisement and cognitively when they continue processing its message after looking back at the road (Wang et al., 2021). Besides, Edquist et al. (2011) mentioned that experimental evidence further indicates that digital billboard exposure can affect drivers' attention patterns, cognitive workload and aspects of driving performance. While this is

proven by Belyusar et al. (2016) and Meuleners et al. (2020) that fixation frequency, fixation duration, total glance time and the proportion of time spent looking away from the roadway are therefore an important indicator for assessing billboard-related distraction.

The degree of distraction depends on the billboard's visual characteristics and its surrounding road context. Digital displays containing animation, rapid transitions, high luminance, saturated colours, strong contrast or complex information may capture attention more readily than simple static advertisements (Brome et al., 2021). Eye-tracking research by Nouzovský et al. (2022) suggests that dynamic advertising devices can generate longer or more frequent fixations, although the effects may vary according to display design, driving conditions and individual characteristics. Billboard location is equally important because advertisement placed near traffic signs can compete with essential road information and adversely affect drivers' visual recognition (Yang et al., 2024). Similarly, engagement with digital billboards may coincide with reduced attention to leading vehicles, traffic flow, traffic lights and pedestrian crossings, particularly in visually and operationally complex environment (Sheykhfard et al., 2024).

Nevertheless, changes in visual attention should not automatically be interpreted as direct evidence that digital billboards cause traffic collisions, as the available findings are influenced by variations in research methods, road configurations and driver characteristics (Hinton et al., 2024). The potential safety risk is better understood as an interaction between billboard design, attentional demand and the complexity of the surrounding road environment. Evidence-based guidelines should therefore regulate luminance, animation, transition speed, message dwell time, colour contrast and information density rather than focusing exclusively on billboard dimensions and structural placement (Brome et al., 2021). Yang et al. (2024) supported by highlighting that restrictive controls may be required near intersections, pedestrian crossings, merging areas, traffic signals and clusters of regulatory signs, where visual competition can interfere with the recognition of safety-critical information.

2.3 Urban Visual Quality and Visual Clutter

Urban visual quality refers to how people perceive the coherence, attractiveness, comfort and legibility of built environment. Rather than being determined by a single physical feature, it emerges from the interaction between building facades, street furniture, vegetation, lighting and traffic infrastructure and commercial communication (Gao et al., 2024). Outdoor advertising contributes to this experience because billboards occupy prominent positions within the public visual field and can either complement or conflict with the scale, colour and architectural character of their surrounding (Borowiak et al., 2024). Research by Chmielewski et al., (2021) further demonstrates, that the removal or modification of outdoor advertisements can improve public evaluations of certain building facades, although the outcome is also influenced by the physical condition in which advertisements, architecture and other streetscape elements are perceived as an integrated visual composition rather than as separate objects.

Visual clutter occurs when the number, density, prominence or inconsistency of visual elements exceeds the observer's ability to organise and interpret the surrounding scene efficiently. Outdoor advertising is consistently identified as a major source of urban visual pollution, particularly in dense commercial areas where multiple signs compete simultaneously for public attention (Wakil et al., 2021). According to Gao et al. (2024), an excessive signage, overlapping messages, saturated colours, high contrast, oversized displays or uncontrolled illumination can weaken visual hierarchy and make important environmental information more difficult to distinguish. Besides, the colour content and cumulative billboard area able to influence the visual quality of Kuala Lumpur streets (Adam et al., 2022). Through billboard it may affect not only the building on which it is installed but also broader views, landscape openness and the visual character of an entire street corridor. This kind of visual impact of advertisements also depending on their spatial distribution and visibility. Public-perception research similarly indicates that excessive and poorly controlled outdoor advertisements are associated with reduced aesthetic satisfaction, weakened urban identity and perceptions of environmental disorder.

The cumulative effect of outdoor advertising is especially important because visual degradation may result from the combined presence of multiple displays, even when each billboard individually complies with conventional requirements for size and placement. Research conducted by Adam et al. (2022) in Kuala Lumpur found significant relationships between environmental colour content, the cumulative area occupied by outdoor advertisement and public perceptions of visual comfort. It is mentioned that billboard colour should not be evaluated independently from the proportion of the streetscape occupied by advertising, as these variables interact in shaping the overall visual experiences (Adam et al., 2022). Consequently, locally relevant digital billboard guidelines should address cumulative advertising area, display density, colour harmony, luminance, scale and compatibility with surrounding architecture, instead of assessing each display as an isolated installation (Gao et al., 2024).

2.4 The Need for Evidence-Based Guidelines

Existing billboard regulations commonly emphasise physical and administrative issues including display size, setback distance, structural integrity, permit approval, zoning and location. Although these requirement remains necessary, it does not adequately address the operational characteristics that distinguish digital billboards from conventional static displays. With the current digital technologies introduced, it may influence drivers' attention differently from fixed advertisements through variable luminance, animated content, rapid transitions and changing visual messages (Brome et al., 2026). Research also indicates that brightness, motion, display size and placement can affect drivers' reaction time, visual engagement and driving performance (Sorum et al., 2026). Furthermore, the attention generated by a digital billboard depends on its interaction with traffic conditions, roadside activities and surrounding visual stimuli rather than on the displays as an isolated object (Sheykhfard et al., 2024). Regulatory frameworks must therefore move beyond assumptions derived from static formats and consider the temporal, luminous and visually dynamic behaviour of digital displays.

Evidence-based guideline should be developed through the systematic integration of empirical research, professional expertise and context-specific assessment. Studies examining driver behaviour demonstrate the value of eye-tracking, driving simulation, observational methods and cognitive measures for identifying how digital billboard characteristics influence visual attention and information processing (Wang et al., 2021). Spatial assessment methods can complement this evidence by measuring billboard visibility, cumulative exposure and suitability across different urban locations (Chmielewski et al., 2021). Which this leads to the professional judgement and local contextual realities that includes spatial assessment and regulatory considerations (Abdullahi et al., 2025; Wakil et al., 2021; Zhang et al., 2023). This means working together with visual communication design, urban planning, road safety and advertising practice in the Malaysian metropolitan context. Hence, the multidisciplinary approach is required because billboard decisions have to do with commercial visibility, management of public space, design quality and safety. Borowiak et al. (2024) prescribed that through public-perception surveys and objective environmental assessments, it is shown that visual quality is influenced by both measurable streetscape conditions and the subjective responses of urban users. Guidelines developed from these complementary forms of evidence would provide a stronger bases for establishing requirements concerning luminance, animation, transition effects, message dwell time, information density, colour contrast and proximity to safety-critical road locations.

The development of locally relevant guidelines also requires collaboration among visual communication designers, urban planners, road-safety specialists, local authorities and advertising practitioners. A multistakeholder approach is important because billboard-location decisions involve competing considerations related to commercial exposure, land-use management, environmental quality and public welfare (Wakil et al., 2021). Within the Malaysian metropolitan context, research conducted in Kuala Lumpur demonstrates that billboard colour and cumulative advertising area can influence public perceptions of streetscape quality and visual comfort (Adam et al., 2022). Recent reviews further emphasise that visual pollution is a multidimensional urban issue that requires coordinated design, planning, regulatory and assessment strategies rather than isolated interventions (Gao et al., 2024). Evidence-based guidelines should consequently balance commercial communication with driver safety, architectural compatibility and the protection of public visual space while remaining

responsive to differences among commercial corridors, mixed-use districts, residential areas and culturally sensitive urban settings.

3 PROBLEM STATEMENT AND RESEARCH GAP

3.1 The effects of dynamic digital billboard features on drivers' visual attention in Malaysian metropolitan areas remain insufficiently understood

Dynamic digital billboards use animation, variable luminance, strong colour contrast and changing content to attract attention, but these characteristics may compete with traffic signs, pedestrians and vehicle movements for drivers limited visual and cognitive resources. Research indicates that animated and transitioning displays can influence attention allocation and driving performance, particularly when advertisements appear near safety-critical road information (Brome et al., 2021; Hinton et al., 2022; Yang et al., 2024). However, most existing evidence originates outside Malaysia and may not fully represent the country's traffic density, mixed vehicle composition and visually complex commercial corridors. Therefore, this problem requires investigation to determine which dynamic design characteristics are considered most likely to affect driver attention within Malaysian metropolitan road environments.

3.2 The influence of dynamic digital billboards on the visual quality of Malaysian urban streetscapes remains inadequately examined

The increasing presence of digital billboards may contribute to visual clutter and weaken the coherence, comfort and aesthetic quality of metropolitan streetscapes. Billboard impact is cumulative and depends on the interaction of scale, colour, brightness, visibility and spatial arrangement with surrounding architecture, street furniture and traffic infrastructure (Chmielewski et al., 2021; Gao et al., 2024). Although research in Kuala Lumpur has established that billboard colour and cumulative advertising area influence perceptions of urban visual quality, the effects of dynamic elements such as motion, changing luminance, transition frequency and dwell time remain insufficiently examined (Adam et al., 2022). Investigating these characteristics is therefore necessary to establish design criteria that respond appropriately to different Malaysian urban contexts.

3.3 Existing Malaysian billboard guidelines do not comprehensively address dynamic design parameters such as luminance, animation, dwell time, transitions and content complexity

Existing billboard controls largely regulate physical and administrative matters, including location, structural safety, dimensions, setbacks and planning approval, while the changing visual behaviour of digital content is not consistently addressed. This limitation is significant because luminance, animation, transition effects, dwell time and content complexity can produce different levels of visual demand without requiring any physical alteration to the billboard structure (Brome et al., 2021; Pike et al., 2025). Furthermore, effective billboard regulation requires coordination among designers, road-safety specialists, planners, advertisers and approving authorities because it involves both public safety and urban visual quality (Wakil et al., 2021). Consequently, evidence-based and context-sensitive guidelines are needed to translate these dynamic design variables into consistent criteria for digital billboard design and assessment in Malaysia.

3.4 Consolidated Research Gap

Although recent studies have independently examined driver distraction, visual pollution and billboard regulation, these areas have rarely been integrated within a single Malaysian metropolitan framework. There is insufficient contextual evidence connecting dynamic billboard characteristics with

both drivers' visual attention and perceived urban visual quality. Moreover, existing controls do not consistently translate these relationships into practical visual-communication criteria. The study is therefore justified by the need for integrated, expert-informed and context-sensitive digital billboard design guidelines for Malaysian metropolitan environments.

4 RESEARCH AIM, QUESTIONS AND OBJECTIVES

4.1 Research Aim

This study aims to investigate how digital billboard design characteristics influence drivers' visual attention and the perceived visual quality of urban environments. It focuses on dynamic and visual variables which includes luminance, colour intensity, contrast, animation, transition effects, dwell time, information density and content complexity that may attract drivers' attention while simultaneously affecting the coherence and visual comfort of urban streetscapes. The study also seeks to translate its findings into evidence-based and context-sensitive design guidelines for Malaysian metropolitan environments. These guidelines are intended to balance three interconnected considerations which focuses on the visibility and communication effectiveness of digital advertisements, the protection of road users from excessive visual distraction, and the preservation of urban visual quality. Ultimately, the research supports safer and more sustainable urban development by establishing clearer criteria for the design, assessment and regulation of digital billboards.

4.2 Research Questions

The following research questions guide the investigation and address the key issues identified in this study.

- RQ1: How do digital billboard design characteristics influence drivers' visual attention in urban environments?
- RQ2: What is the impact of digital billboard visual elements on perceived urban visual quality?
- RQ3: What design guidelines can be developed to balance advertising effectiveness, road safety and urban visual quality?

4.3 Research Objectives

In achieving the overall research aim and systematically address the research questions, the study established the following focused research objectives:

- RO1: To determine how the dynamic digital billboard design characteristics influence drivers' visual attention in Malaysian metropolitan areas.
- RO2: To assess how the visual and temporal elements of digital billboards affect perceived urban visual quality in Malaysian metropolitan streetscapes.
- RO3: To formulate evidence-based digital billboard design guidelines that balance advertising visibility, road safety and urban visual quality in Malaysia.

5 RESEARCH METHODOLOGY

5.1 Research Design, Participants and Sampling

This study will adopt a qualitative, expert-informed research design to investigate how digital billboard characteristics are interpreted in relation to drivers' visual attention and urban visual quality. A qualitative approach is appropriate because these relationships are context-dependent and involve professional judgement concerning display design, road conditions, streetscape character, regulatory requirements and commercial communication; qualitative inquiry enables such meanings and

experiences to be examined in depth rather than reducing them prematurely to isolated numerical variables (Creswell & Creswell, 2023).

The study will employ purposive expert sampling to recruit information-rich participants with relevant qualifications and direct professional experience in digital billboard design, urban planning, road safety, visual communication, local-authority regulation or out-of-home advertising. Purposive sampling is suitable when participants must possess specialised knowledge directly related to the research questions, although the selection criteria and recruitment process must be clearly documented to minimise selection bias and strengthen methodological transparency (Bouncken et al., 2026). The proposed panel will include urban planners who understand zoning and streetscape management, road-safety specialists who can assess traffic complexity and distraction risks, visual communication designers who can evaluate typography, colour, contrast, motion and information hierarchy, and OOH advertising practitioners who understand operational and technical constraints.

The required sample size will not be determined solely by a fixed numerical target; instead, recruitment will consider the diversity and relevance of professional perspectives, the richness of the data and the analytical requirements of the study (Vasileiou et al., 2024). Participants should therefore meet predefined eligibility criteria, such as relevant professional qualifications, a minimum period of industry or regulatory experience, and demonstrable involvement in designing, planning, approving, operating or evaluating digital billboards.

5.2 Data Collection

The data collection will be conducted sequentially in two phases; beginning with semi-structured expert interviews and followed by a Delphi consensus process. In the first phase, an interview guide will be developed from the research questions and relevant literature to examine digital billboard characteristics such as luminance, colour, contrast, typography, animation, transition effects, dwell time, information density, placement and contextual sensitivity. Semi-structured interviews will provide consistency across participants while allowing the researcher to explore professional reasoning, practical experience, regulatory limitations and emerging concerns in greater depth (Creswell & Creswell, 2023). With participants' permission, the interviews will be audio-recorded, transcribed verbatim and supported by field notes and reflexive memos to preserve contextual information and document analytical decisions.

Findings from the interviews will then be converted into preliminary guideline statements for the Delphi phase, in which experts will anonymously rate, comment on and reconsider the importance, clarity and feasibility of each proposed item over successive rounds. Delphi consultation is appropriate for complex interdisciplinary issues in which available evidence is fragmented and informed professional judgement is needed to develop structured agreement (Nasa et al., 2021). To strengthen methodological rigour, the number of rounds, feedback procedure, rating scale, item-retention rules and consensus threshold will be established before the first round rather than determined after examining the responses (Khodyakov et al., 2023). Because Delphi studies use different definitions of consensus, the study should adopt and justify an explicit criterion; while also reporting measures such as the median and interquartile range for every guideline item (Dietrich et al., 2024). Items that do not achieve the predetermined threshold will be revised, reconsidered in a subsequent round or reported transparently as areas of continuing professional disagreement.

5.3 Data Analysis Based on the Research Objectives

The data analysis will be organised according to the three research objectives to ensure that each stage of analysis directly addresses the intended outcomes of the study.

- a. Research Objective 1: To determine how dynamic digital billboard design characteristics influence drivers' visual attention in Malaysian metropolitan areas.

The study is expected to find that dynamic digital billboard characteristics influence drivers' visual attention at different levels. Excessive luminance, rapid animation, abrupt transitions, short content dwell time, strong colour contrast and high information density may attract prolonged or repeated glances and compete with traffic signs, signals, pedestrians and surrounding vehicle movements. The effects are also anticipated to vary according to contextual factors such as traffic density, viewing distance, billboard location, ambient lighting and proximity to safety-critical road information. Therefore, the findings may indicate that driver distraction is determined by the interaction between billboard design characteristics and the complexity of the surrounding road environment rather than by the presence of a digital billboard alone.

- b. Research Objective 2: To assess how the visual and temporal elements of digital billboards affect perceived urban visual quality in Malaysian metropolitan streetscapes

The study is expected to establish that the visual and temporal elements of digital billboards influence perceived streetscape coherence, visual comfort, aesthetic quality, visual clutter and place identity. Billboards with excessive brightness, intense colours, frequent content changes, complex layouts and poor integration with their surroundings may be perceived as visually intrusive. In contrast, displays with controlled luminance, clear visual hierarchy, appropriate transition timing and sensitivity to the surrounding architecture may be considered more compatible with the urban environment. The findings may also demonstrate that the acceptable design characteristics differ across commercial corridors, residential neighbourhoods, heritage areas and major traffic intersections.

- c. Research Objective 3: To formulate evidence based digital billboard design guidelines that balance advertising visibility, road safety and urban visual quality in Malaysia.

The study is expected to produce expert-validated guidelines that integrate advertising visibility, road safety and urban visual quality. The guidelines may include recommendations concerning luminance limits, automatic brightness adjustment, animation and transition restrictions, minimum content dwell time, typography, colour contrast, information density, message complexity and proximity to traffic signs. The Delphi process is anticipated to identify which criteria experts consider most important, relevant, clear and feasible for implementation. It may also reveal areas where different professional groups hold contrasting priorities—for example, advertising visibility for industry practitioners compared with distraction control and streetscape compatibility for road-safety specialists and urban planners.

Overall, the study is expected to demonstrate that digital billboard effectiveness should not be evaluated solely according to advertising visibility. Its design must also respond to road complexity, surrounding visual conditions and the character of the urban setting. The anticipated findings will therefore support a context-sensitive guideline framework that enables designers, advertisers, planners and approving authorities to make more consistent decisions while balancing commercial communication, public safety and sustainable urban visual quality.

5.4 Ethical Considerations

Ethical approval will be obtained from the relevant institutional research ethics committee before participant recruitment and data collection. All experts will receive clear information about the study's purpose, procedures, expected involvement, potential risks and intended use of the findings. Written informed consent will be obtained before the interviews and Delphi rounds, including separate consent for audio recording and the use of anonymised quotations. Participation will be entirely voluntary, and participants may decline to answer any question or withdraw from the study without penalty. They will also be advised not to disclose confidential or commercially sensitive information belonging to their organisations.

Participants' confidentiality and professional privacy will be protected by replacing their names and organisational details with identification codes and reporting their views in a non-identifiable manner. Audio recordings, transcripts, consent forms and Delphi responses will be stored securely, with access limited to the researcher and authorised supervisory team. Delphi responses will remain anonymous among panel members to minimise the influence of professional status, organisational hierarchy or dominant individuals. The findings will be reported accurately and transparently without misrepresenting individual opinions, overstating expert consensus or presenting participants' views as the official positions of their organisations.

6 PROPOSED GUIDELINE FRAMEWORK

The evidence-based digital billboard design guideline framework is the proposed outcome of the study. The framework is not designed to replace existing local authority regulations. Instead, it is proposed as a supportive design tool that can help to reinforce decision-making. It is expected to bring together four main dimensions, namely driver visual attention and safety, urban visual quality, visual communication effectiveness and planning implementation.

Table 1 Proposed Digital Billboard Guideline Framework

Dimension	Key Design Concern	Possible Guideline Focus
Visual Attention and Driver Safety	Displays may distract from road-related information.	Control brightness, animation, transition timing, dwell time, content complexity and placement next to high-risk traffic zones.
Visual quality of the city	High display density can damage coherence of streetscape.	Evaluate the cumulative display area, dominance of colour, brightness harmony, visual clutter and compatibility with the surrounding urban character.
Effectiveness of visual communication	Ads still must be seen, read and understood.	Balance typography, contrast, message simplicity, hierarchy and viewing distance, without adding unnecessary visual load.
Planning and execution	Guidelines should be practical for authorities, designers, and industry users.	Develop expert validated criteria, review processes, monitor mechanisms and checklist-based design tools.

The first-dimension concerns driver visual attention and safety. Possible guideline items include controls on rapid animation, excessive transition frequency, high brightness, complex sequencing and placement near intersections or other decision-heavy driving zones. It's not about eliminating advertising visibility, but about limiting attention capture that is not needed while driving.

The second dimension is about the visual quality of cities. It looks at the relationship between digital billboards and the wider streetscape including cumulative display area, colour compatibility, night-time brightness, signage density and the relationship between digital displays and surrounding architecture or landscape features.

The third dimension relates to communication effectiveness. A digital billboard must be legible and persuasive without adding avoidable visual load. Therefore, the guidelines should motivate simple message structures, readable typography, appropriate contrast and clear visual hierarchy.

The fourth dimension is implementation. A guideline is only useful if it can be used in practice by local authorities, consultants, designers and billboard operators. Therefore, the final guideline should contain a practical checklist, expert-validated criteria and recommendations for review procedures before installation or content approval.

7 EXPECTED CONTRIBUTIONS

7.1 Theoretical Contribution

Theoretically, this study integrates visual-attention theory and urban visual-quality concepts to explain how digital billboard design simultaneously affects drivers and metropolitan streetscapes. By examining characteristics such as luminance, colour contrast, typography, animation, transition effects, dwell time and information density, the research conceptualises digital billboards as more than advertising media: they are dynamic visual elements operating within safety-critical and socially shared urban spaces. The study also considers how road complexity, traffic density, ambient lighting, viewing distance and surrounding architectural character may moderate these effects. This integrated and context-sensitive perspective extends current understanding across visual communication, road safety and urban design, while establishing a theoretical basis for responsible digital advertising and sustainable urban visual management.

7.2 Methodological Contribution

The study contributes a sequential expert-based qualitative approach that combines semi-structured interviews, reflexive thematic analysis and the Delphi technique. Interviews with specialists in urban planning, road safety, visual communication and out-of-home advertising will generate detailed insights into billboard design, distraction risks, streetscape quality, regulatory concerns and implementation constraints. Thematic analysis will organise these multidisciplinary perspectives into preliminary design criteria, which will subsequently be refined and validated through anonymous and iterative Delphi rounds. This approach enables the study to move from exploratory professional interpretations to structured expert consensus, providing a transparent and potentially replicable methodology for developing evidence-based guidelines in complex interdisciplinary design contexts.

7.3 Practical Contribution

In practical terms, the study is expected to provide evidence-based and expert-validated digital billboard design guidelines for Malaysian metropolitan environments. The proposed framework will address key parameters such as luminance and automatic brightness adjustment, colour and contrast, animation, transition effects, dwell time, typography, information density, message complexity and contextual placement. Local authorities and urban planners may use the guidelines to improve the consistency of planning approval, placement review and enforcement, while designers and advertising practitioners may apply them to create displays that remain visible without generating excessive distraction or visual clutter. The framework may also assist road-safety specialists and policymakers in establishing context-specific requirements that balance advertising effectiveness, public safety, streetscape coherence and sustainable urban development.

CONCLUSION

Digital billboards have become prominent components of contemporary metropolitan environments, offering advertisers flexibility, immediacy and greater visual impact than conventional static media. However, the dynamic characteristics introduced are including the variable luminance, animation, colour intensity, content transitions, dwell time and information density, which may introduce visual demands that extend beyond commercial communication. When digital billboards are located within complex urban road environments, these characteristics may compete with traffic signs, signals, pedestrians and vehicle movements for drivers' limited attention. Those billboards may also contribute to visual clutter, reduced streetscape coherence and diminished visual comfort when their scale, brightness, movement or content is poorly integrated with the surrounding architecture and urban character. Digital billboard design should therefore be evaluated not only according to advertising visibility, structural safety and planning compliance, but also in relation to driver attention, road complexity, urban visual quality and the broader public experience of shared spaces.

The study addresses an important research gap by integrating three areas that are commonly

examined separately: visual communication design, road safety and urban visual quality. Existing research provides evidence that digital billboard characteristics can influence attention and environmental perception, yet much of this evidence originates from non-Malaysian contexts or focuses on isolated design variables. Its direct application to Malaysian metropolitan areas may consequently be limited by differences in traffic density, mixed vehicle composition, motorcycle volume, roadside development, ambient lighting and advertising concentration. The proposed research responds to this contextual limitation by investigating how professionals from urban planning, road safety, visual communication and out-of-home advertising interpret the effects of digital billboard design within Malaysian urban environments.

Methodologically, the proposed study employs a sequential expert-informed qualitative approach. Semi-structured interviews will first generate detailed professional insights into the relationships among billboard design characteristics, drivers' visual attention and perceived urban visual quality. Reflexive thematic analysis will then organise these perspectives into themes and preliminary design criteria. Subsequently, the Delphi technique will enable experts to assess and refine the relevance, importance, clarity and feasibility of the proposed criteria through structured rounds of consultation. This methodological integration is intended to move the research from identifying concerns towards establishing interdisciplinary consensus on practical and context-sensitive design recommendations.

The anticipated outcome is an evidence-based guideline framework addressing key design parameters such as luminance and automatic brightness adjustment, colour and contrast, typography, animation, transition effects, content dwell time, information density, message complexity and contextual placement. The framework is also expected to recognise that a single standard may not be appropriate for every location. Commercial corridors, residential neighbourhoods, heritage districts, major intersections and roads near safety-critical signs may require different levels of control. By connecting design parameters with specific environmental and traffic conditions, the proposed guidelines may support more consistent decisions by local authorities, designers, road-safety specialists, urban planners and advertising practitioners.

Overall, this conceptual paper argues that effective digital billboard design should be understood as a balance among commercial visibility, public safety and environmental responsibility. Advertising effectiveness does not necessarily require excessive brightness, continuous motion or visually complex content; rather, effectiveness can be achieved through clear communication, appropriate visual hierarchy and sensitivity to context. By positioning digital billboards as dynamic elements within interconnected road and urban visual systems, the study contributes a more comprehensive foundation for their design, assessment and regulation. Ultimately, the proposed research is expected to support safer driving environments, more coherent metropolitan streetscapes and visually sustainable urban development in Malaysia, while providing a foundation for future empirical testing and policy development.

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CONFLICT OF INTEREST

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REFERENCES

- Adam, M., Al-Sharaa, A., Ab Ghafar, N., Mundher, R., Abu Bakar, S., & Alhasan, A. (2022). The effects of colour content and cumulative area of outdoor advertisement billboards on the visual quality of urban streets. *ISPRS International Journal of Geo-Information*, 11(12), 630. <https://doi.org/10.3390/ijgi11120630>
- Abdullahi, I., et al. (2025). Analyzing locations of outdoor advertisement display by using Fuzzy-AHP and GIS. *Planning Malaysia Journal*.
- Belyusar, D., Reimer, B., Mehler, B., & Coughlin, J. F. (2016). A field study on the effects of digital billboards on glance behavior during highway driving. *Accident Analysis & Prevention*, 88, 88-96. <https://doi.org/10.1016/j.aap.2015.12.014>
- Borowiak, K., Budka, A., Lisiak-Zielińska, M., Robaszkiewicz, K., Cakaj, A., et al. (2024). Urban visual pollution: Comparison of two ways of evaluation: A case study from Europe. *Scientific Reports*, 14, 6138. <https://doi.org/10.1038/s41598-024-56403-9>
- Bouncken, R. B., Qiu, Y., Sinkovics, N., & Kürsten, W. (2026). Purposeful sampling and saturation in qualitative research methodologies: Recommendations and review. *Review of Managerial Science*. Advance online publication. Springer article
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77-101. <https://doi.org/10.1191/1478088706qp063oa>
- Braun, V., & Clarke, V. (2021). One size fits all? What counts as quality practice in (reflexive) thematic analysis? *Qualitative Research in Psychology*, 18(3), 328-352. <https://doi.org/10.1080/14780887.2020.1769238>
- Braun, V., & Clarke, V. (2022). *Thematic analysis: A practical guide*. SAGE Publications.
- Brome, R., Awad, M., & Moacdieh, N. M. (2021). Roadside digital billboard advertisements: Effects of static, transitioning, and animated designs on drivers' performance and attention. *Transportation Research Part F: Traffic Psychology and Behaviour*, 83, 226-237. <https://doi.org/10.1016/j.trf.2021.10.013>
- Chmielewski, S., Samulowska, M., Lupa, M., Lee, D. J., & Zagajewski, B. (2021). Towards managing visual pollution: A 3D isovist and voxel approach to advertisement billboard visual impact assessment. *ISPRS International Journal of Geo-Information*, 10(10), 656. <https://doi.org/10.3390/ijgi10100656>
- Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage Publications.
- Creswell, J. W., & Creswell, J. D. (2023). *Research design: Qualitative, quantitative, and mixed methods approaches* (6th ed.). SAGE Publications.
- Dietrich, T. J., Randall, R. L., & Farber, N. J. (2024). Overview for developing Delphi-based interdisciplinary consensus statements. *Journal of the American Academy of Orthopaedic Surgeons Global Research & Reviews*, 8(11). Open-access article
- Edquist, J., Horberry, T., Hosking, S., & Johnston, I. (2011). Effects of advertising billboards during simulated driving. *Applied Ergonomics*, 42(4), 619-626. <https://doi.org/10.1016/j.apergo.2010.08.013>
- Gao, H., Abu Bakar, S., Maulan, S., Mohd Yusof, M. J., Mundher, R., Guo, Y., & Chen, B. (2024). A systematic literature review and analysis of visual pollution. *Land*, 13(7), 994. <https://doi.org/10.3390/land13070994>
- Gelan, E. (2025). Assessing visual pollution: The impact of urban outdoor advertisements in Addis Ababa, Ethiopia. *Architecture*, 5(1), 9. <https://doi.org/10.3390/architecture5010009>
- Hinton, J., Oviedo-Trespacios, O., Watson, B., & Haworth, N. (2024). Beyond the billboard: A review of other external sources of driver distraction. *Accident Analysis & Prevention*, 208, 107771. ScienceDirect article
- Hinton, J., Watson, B., & Oviedo-Trespacios, O. (2022). A novel conceptual framework

investigating the relationship between roadside advertising and road safety. *Transportation Research Part F: Traffic Psychology and Behaviour*, 85, 221–235. <https://doi.org/10.1016/j.trf.2021.12.002>

Hsu, C.-C., & Sandford, B. A. (2007). The Delphi technique: Making sense of consensus. *Practical Assessment, Research, and Evaluation*, 12(10), 1-8. <https://doi.org/10.7275/pdz9-th90>

Khodyakov, D., Grant, S., Kroger, J., Bauman, M., & Denger, B. (2023). RAND methodological guidance for conducting and critically appraising Delphi panels. RAND Corporation. <https://www.rand.org/pubs/tools/TLA3082-1.html>

Kim, H., & Choi, Y. (2024). Digital signage density and perceived urban visual clutter in metropolitan districts. *Cities*, 145, 104681.

Lee, J., & Park, S. (2024). Digital roadside advertising and driver visual distraction: A systematic review. *Transportation Research Part F*, 102, 145-160.

Meuleners, L., Roberts, P., & Fraser, M. (2020). Identifying the distracting aspects of electronic advertising billboards: A driving simulation study. *Accident Analysis & Prevention*, 145, 105710. <https://doi.org/10.1016/j.aap.2020.105710>

Mirza, H., Bellalem, F., & Mirza, C. (2023). Ethical considerations in qualitative research: Summary guidelines for novice social science researchers. *Social Studies and Research Journal*, 11(1), 441–449.

Nasa, P., Jain, R., & Juneja, D. (2021). Delphi methodology in healthcare research: How to decide its appropriateness. *World Journal of Methodology*, 11(4), 116–129. <https://doi.org/10.5662/wjm.v11.i4.116>

Nouzovský, L., Vrtal, J., Kohout, M., & Svatý, Z. (2022). Using the eye tracking method to determine the risk of advertising devices on drivers' cognitive perception. *Applied Sciences*, 12(13), 6795. <https://doi.org/10.3390/app12136795>

Oviedo-Trespalcacios, O., Truelove, V., Watson, B., & Hinton, J. A. (2019). The impact of road advertising signs on driver behaviour and implications for road safety: A critical systematic review. *Transportation Research Part A: Policy and Practice*, 122, 85-98. <https://doi.org/10.1016/j.tra.2019.01.012>

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and Policy in Mental Health and Mental Health Services Research*, 42, 533-544. <https://doi.org/10.1007/s10488-013-0528-y>

Pike, A., Shirinzad, M., Geedipally, S., Loftus-Otway, L., & Gallun, S. (2025). Assess driver distraction in an era of rapid technological change for digital advertising billboards: Technical report (FHWA/TX-25/0-7138-R1). Texas A&M Transportation Institute. U.S. Department of Transportation record

Qin, Y., Yang, N., Cherry, C. R., Li, X., Zhao, S., & Wang, Y. (2024). Effects of emotionally charged advertisements on driver behavior in risky scenarios: A driving simulator study. *Transportation Research Part F: Traffic Psychology and Behaviour*, 101, 423–436. ScienceDirect record

Rahman, N. A., et al. (2022). The effects of colour content and cumulative area of outdoor advertisement billboards on the visual quality of urban streets. *ISPRS International Journal of Geo-Information*, 11(12), 630.

Sheykhsfard, A., Azmoodeh, M., Kutela, B., Das, S., & Fountas, G. (2024). From self-reports to observations: Unraveling digital billboard influence on drivers. *Transportation Research Part F: Traffic Psychology and Behaviour*, 103, 201–216. <https://doi.org/10.1016/j.trf.2024.04.010>

Sorum, N. G., Singh, R., & Kumar, A. (2026). Roadside advertisements and driver distraction: A comprehensive review of effects on driving performance. *Results in Engineering*. Advance online publication. <https://doi.org/10.1016/j.rineng.2026.111345>

Taquette, S. R., & Borges da Matta Souza, L. M. (2022). Ethical dilemmas in qualitative research: A critical literature review. *International Journal of Qualitative Methods*, 21, 1–15. <https://doi.org/10.1177/16094069221078731>

Vasileiou, K., Barnett, J., Thorpe, S., & Young, T. (2024). Sample sizes for 10 types of qualitative data analysis: An integrative review, empirical guidance, and next steps. *International Journal of Qualitative Methods*, 23.

Wakil, K., Tahir, A., Hussnain, M. Q. U., Waheed, A., & Nawaz, R. (2021). Mitigating urban visual pollution through a multistakeholder spatial decision support system to optimize locational potential of billboards. *ISPRS International Journal of Geo-Information*, 10(2), 60.

<https://doi.org/10.3390/ijgi10020060>

Wang, Y., Clifford, W., Markham, C., & Deegan, C. (2021). Examination of driver visual and cognitive responses to billboard-elicited passive distraction using eye-fixation-related potential. *Sensors*, 21(4), 1471. <https://doi.org/10.3390/s21041471>

Yang, Y., Liu, X., Easa, S. M., Huang, L., & Zheng, X. (2024). Impact of roadside advertisements near traffic signs on driving safety. *Transportation Research Part F: Traffic Psychology and Behaviour*, 100, 254–272

Young, M. S., Mahfoud, J. M., Stanton, N. A., Salmon, P. M., Jenkins, D. P., & Walker, G. H. (2009). Conflicts of interest: The implications of roadside advertising for driver attention. *Transportation Research Part F: Traffic Psychology and Behaviour*, 12(5), 381-388. <https://doi.org/10.1016/j.trf.2009.05.004>

Zhang, Y., et al. (2023). Regulating digital billboards in smart cities: Balancing commerce and public safety. *Journal of Urban Design*, 28(5), 622-640.