

DOI: <https://doi.org/10.63332/joph.v5i2.415>

## Effectiveness of Road Safety Education in Reducing Teenage Traffic Accidents: A Systematic Review

Francis Walugembe<sup>1</sup>, Cua Ngoc Le<sup>2</sup>, Hien Thi Nguyen<sup>3</sup>, Sanhawat Chaiwong<sup>4</sup>

### Abstract

*Background:* This systematic review examined the impact of road safety education (RSE) on lowering teenage traffic accidents and injuries in Southeast Asia based on existing literature. We evaluated the effectiveness of road safety education programs, contextual and cultural adaptations, the integration of practical training, implementation challenges, and the long-term impacts on changing teenage behaviour. *Material and Methods:* The study followed the guidelines of Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA). This involved counting the number of studies showing a positive, negative, or no effect. A search of the articles in the electronic databases of PubMed, Scopus, and Google Scholar was conducted. The effectiveness of RSE was assessed by vote counting, tallying the number of studies showing positive, neutral, or negative impacts on teenage driving behaviour aged 13-19 years. A total of seventeen studies were selected for inclusion using predefined criteria. *Results:* Upon conducting a systematic review, 17 key studies were identified for inclusion, reflecting diverse methodologies and focus areas. Across the research, it is evident that teenagers benefit significantly from receiving both theoretical knowledge and practical training. This comprehensive approach enhances their confidence and skills in adhering to traffic safety laws. Moreover, the involvement of parents and communities emerges as a vital factor for the success of educational initiatives. *Conclusion:* The study emphasizes the paramount importance of prioritizing long-term behavioural change and sustainability in road safety initiatives, particularly focusing on teenagers. It advocates for a comprehensive approach involving community and parental engagement alongside educational programs. The findings emphasize the necessity for policymakers in Southeast Asia to allocate funding towards culturally sensitive and standardized RSE programs, integrating practical training and long-term reinforcement strategies.

**Keywords:** Road Safety Education, Teenagers, Road Traffic Accidents, Southeast Asia.

### Introduction

Mobility stands for the participation of people in social life and economic growth. Particularly, it is important for young people during the detachment phase from parental care to networking with the peer group. However, according to studies, mobility has significant negative consequences; for instance, Pandey et al. states that 400,000 young people aged between 15 to 29 years die annually in road traffic accidents globally [1]. In the Southeast Asian (SEA) Region, road traffic injuries (RTIs) are a serious public health concern and the leading cause of injury-related mortalities. The Southeast Asian Region is composed of eleven countries, namely Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste, and Vietnam. This region is situated in the Southeast of the Asian continent, bordered by the

<sup>1</sup> School of Public Health Walailak University, Thailand, Email: [walugembef@gmail.com](mailto:walugembef@gmail.com)

<sup>2</sup> School of Public Health Walailak University, Thailand, Email: [nvyct2004@gmail.com](mailto:nvyct2004@gmail.com)

<sup>3</sup> Faculty of Public Health, Can Tho University of Medicine and Pharmacy, Vietnam, Email: [nthien@ctump.edu.vn](mailto:nthien@ctump.edu.vn)

<sup>4</sup> Community Public Health Major Faculty of Science Nakhon Phanom University Thailand, Email: [sanhawat4@gmail.com](mailto:sanhawat4@gmail.com)  
[sanhawat.ch@wu.ac.th](mailto:sanhawat.ch@wu.ac.th)



Pacific Ocean to the east, the Indian Ocean to the south, and China to the north. The Southeast Asian region ranks third among the six World Health Organization (WHO) regions, with a rate of 16.4 road traffic injuries per 100,000 population [1]. Over 300,000 people are killed on the roads annually in the countries of this region, according to the WHO Global Status Report on Road Safety [1]. Young people are particularly susceptible due to their lack of driving excitement, expertise, and risk-taking nature, which arouses a big concern about their road safety. Adolescents are more vulnerable to auto accidents; they are often defined as anyone between the ages of 13 and 19, according to WHO [1]. The United Nations Children's Fund (UNICEF) present that automobile accidents are among the leading causes of death for teenagers in Southeast Asia and other regions of the world [1]. This susceptibility is exacerbated by a lack of experience, a sensitivity to peer pressure, and increased risk behaviours while riding motorbikes, which is a common mode of transportation in the region, such as speeding and riding without a helmet.

There is growing recognition of the role that education plays in addressing the road safety challenge [2-4]. Road safety education (RSE) programs, such as school-based curricula, community workshops, public awareness campaigns, driving schools, and online resources, aim to provide young people with the knowledge and skills necessary for safe driving. These classes often focus on recognizing road risks, comprehending traffic rules, and the consequences of irresponsible driving. Research shows that RSE could help reduce risky behaviours among youths [5-7]. While the impact of RSE on teenagers has been subjected to several studies, a comprehensive, regionally-specific synthesis of these findings still needs to be conducted. Zhang *et al.* [8] note that the cultural, economic, and infrastructural environments also impact the effectiveness of road safety measures.

SEA's location and regional countries present unique opportunities and challenges for RSE. This relates to the differences in the ways RSE programs are implemented and what they include, which suggests a need for consistency throughout the SEA region. There are significant differences in the content, duration, and method of delivery of programs. A thorough examination would provide a strong empirical foundation for developing a more standardized strategy for RSE that is customized to the regional context [2].

Comprehensive research might have significant effects on policymakers and educators. This can help identify the most effective components of RSE programs, enabling policymakers to make informed decisions about the best ways to deploy funds, launch new initiatives, and pass legislation. Likewise, educators may better use the research results to design curricula that appeal to the local teenage population while reducing the likelihood of accidents and injuries due to driving [3]. To this end, it is critical to increase public knowledge of road safety in a region where fatalities from traffic accidents are still frequent. A thorough systematic review can help in achieving this goal by stressing effective teaching strategies and emphasizing the value of RSE in public discourse [3]. As such, this review may have long-term benefits for public health. A reduction in teenage traffic injuries might have a significant positive impact on the region's overall quality of life, public health outcomes, cost of living, and overall road safety of teenagers, on top of contributing to the attainment of the Sustainable Development Goal (SDG) 3.6 and SDG 17 which aim to reduce the global number of deaths and injuries from road traffic accidents and focuses on strengthening global partnerships for sustainable development by 2030 respectively.

This review, therefore, intends to answer the major research question: How effective are RSE programs and training compared to no standard programs or practices in minimizing road traffic

## **Methodology**

### **Study Design**

This is a systematic review conducted in adherence to the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) guidelines, ensuring transparency and methodological consistency. The approach guides the study search, inclusion criteria, and final study selection processes to minimize the review's vulnerability to invalidity (external or internal sources).

### **Literature Search**

A systematic search was conducted across multiple electronic databases, including PubMed, Scopus, and Google Scholar, and search for studies to explore the effectiveness of RSE comprehensively. The search strategy employed a combination of keyword combination and Boolean operators to comprehensively identify relevant studies on the impact of RSE programs for teenagers in Southeast Asia (SEA). The following search terms were used: "road safety education," "teenagers" OR "adolescents," "Southeast Asia" OR "SEA," "program" OR "intervention," "traffic safety" OR "road traffic accidents," "effectiveness" OR "impact." These search terms were adapted to fit the specific requirements of each electronic database. The search strategy also utilized field tags, truncation, and wildcard symbols to capture variations of keywords and increase the sensitivity of the search. In addition, filters were applied to limit the search results to studies published within the last ten years (2013-2023) and those available in the English language.

The search strategy was systematically implemented across all selected databases, with results exported to reference management software for further screening and analysis. Besides, to ensure the comprehensiveness of the search, manual searches of reference lists from identified articles and relevant reviews were conducted to identify any additional studies that may have been missed during the database search. The assessment of RSE's impact on teenage driving behaviour, specifically targeting individuals aged 10 to 19 years, was conducted through a systematic approach known as vote counting. This involved tallying the number of studies demonstrating positive, neutral, or negative effects. Randomized Controlled Trials (RCTs) were specifically chosen for inclusion. This selection was based on the rigorous nature of RCTs in evaluating intervention outcomes, ensuring a higher level of evidence quality and minimizing biases.

Despite the inclusion of RCTs, meta-analysis was omitted due to the diversity in study methodologies, intervention types, and outcome measures, which could introduce potential inaccuracies. Instead, a narrative synthesis approach was adopted to provide a thorough overview of the findings. Furthermore, reference lists of identified articles and relevant reviews were manually searched to identify further studies that may have needed to be included in the database search.

### **Protocol and Registration**

The review was conducted following the PRISMA guidelines. The protocol for this review was registered with the National Institute for Health and Care Research (NIHR) PROSPERO registration number CRD42023472661 to help ensure transparency and adherence to predefined processes, objectives, and methodologies. The registration details, including the registration number, are provided to allow for verification and future updates.

## **Eligibility Criteria**

Two independent investigators reviewed all the relevant articles, and any disagreement was resolved by involving a third reviewer or reaching a consensus. Studies were selected according to the establishment eligibility criteria following the PICO framework. The review focused on studies that evaluated the impact of programs for RSE on teenagers in SEA. The inclusion criteria involved studies with participants aged between 13 and 18 years and were focused on both practical training and theoretical instructions in RSE. Also, the reviewers only included full-text articles and excluded short-paper-based studies for a thorough assessment. For studies to qualify for selection, they needed to focus on and report direct effects on road traffic accidents or involved injuries. The included articles utilized different study designs, such as cohort studies, randomized controlled trials (RCTs), and cross-sectional or case-control studies.

The selection was limited to articles written only in English and published in the last ten years (2013 - 2023). This ensured the feasibility of analysis and relevance to the current context of the study topic. The reviewers also excluded articles focusing on young children, adults, or other interventions apart from RSE and training. Those studies that did not present relevant behavioural outcomes were also excluded from this systematic review. Other excluded sources included non-English articles, non-peer-reviewed papers, and those published before 2013 to maintain relevance and scientific rigor.

## **Data Extraction**

Two reviewers working independently of each other performed extracted data from different studies. Using a standardized Excel sheet, data from the chosen studies was extracted. The charted variables included authors, publication year, database or journal, type of the study, subject characteristics, location, method/ design, theme, key findings, educational strategies, impact on risky behaviours, and comparative insights. The same investigators were involved in this data extraction phase during the study selection phase.

## **Data Analysis**

In the data analysis phase, collected data underwent cleaning and preparation, ensuring accuracy and consistency. Descriptive statistics were computed to summarize the characteristics of included studies, participants, and RSE programs, while thematic analysis provided insights into program effectiveness and implementation. Subgroup analyses explored variations in program effectiveness across different study characteristics. The synthesized findings were interpreted in the context of existing literature, offering implications for policy, practice, and future research. The systematic data analysis process aimed to generate robust insights into the effectiveness and implementation of RSE programs, contributing to the advancement of knowledge in the field.

## **Risk of Bias in Individual Studies**

In assessing the risk of bias in individual studies, the Cochrane Risk of Bias Tool was utilized for randomized controlled trials (RCTs), which are widely recognized for their reliability and validity in assessing the risk of bias in intervention studies. This tool evaluates various domains of bias, including selection bias, performance bias, detection bias, attrition bias, and reporting bias. Each eligible study underwent a thorough evaluation using the Cochrane Risk of Bias Tool, with specific criteria applied to assess the risk of bias within each domain.

## **Results**

### **Study Selection**

The risk of missing relevant studies was minimized by two independent researchers, which ensured a rigorous and systematic approach to identifying useful studies for inclusion in the review. Initially, all authors participated in the initial screening stage, where titles and abstracts of potentially relevant studies were assessed for their alignment with predefined inclusion criteria. This phase involved each author independently reviewing a subset of the identified studies, dedicating several hours each day over approximately two weeks to complete the screening process. Following the initial screening, the authors collectively progressed to the full-text assessment stage. During this phase, the full-text articles of studies that appeared to meet the inclusion criteria based on their titles and abstracts were thoroughly evaluated. Each author independently reviewed a portion of the full-text articles, dedicating several hours each week over approximately one month to assess their eligibility for inclusion in the review.

After completing the full-text assessment, the authors convened to finalize the list of studies that met all inclusion criteria. Through collaborative deliberation and unanimous agreement, the authors determined the final selection of studies for inclusion in the review. This final inclusion phase lasted for about one week, during which authors cross-checked their assessments and compiled the list of included studies. Throughout the entire study selection process, clear communication and coordination among the authors were paramount to ensuring the integrity and reliability of the selection process, ultimately leading to the identification of the final set of studies included in the review.

A sum of 89 studies were identified from online database searches (Medline: 19, Google Scholar: 34, PubMed: 17, ScienceDirect: 9, Web of Science: 7, and Springer: 3. Figure 1 below illustrates a PRISMA flow diagram that illustrates the study selection process.

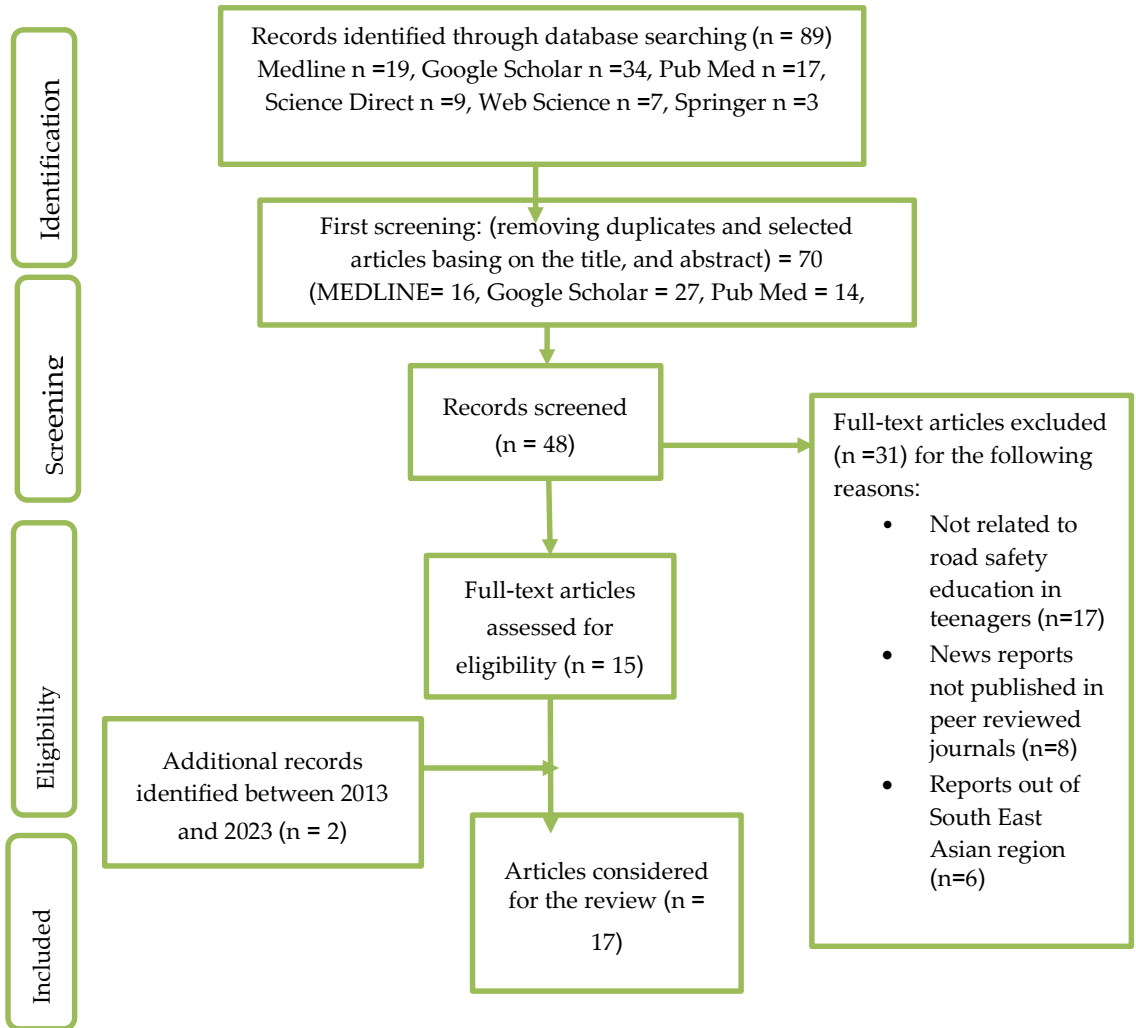


Figure 1: A PRISMA flowchart for the literature extraction

## 166 Effectiveness of Road Safety Education in Reducing Teenage

Author(s)	Database/Journal	Article/Study type	Subject Characteristics	Location	Methods (Design)	Key Findings	Comparative Insights
Alonso et al. [11]	International Journal of Environmental Research and Public Health	Research Article	Parents and Teenagers	Urban areas	Survey	Examined the role of parents in Road Safety RSE	The study emphasized the need for tailoring content to specific local transportation contexts, aligning with findings from Kitamura et al. [9]
Andarini et al. [12]	International Journal of Public Health Science	Cohort Study	Teenagers	Palembang, Indonesia	Statistical Analysis	Factors related to road accidents	Highlighted the importance of developing age-appropriate educational materials, consistent with insights from Yu Hong [26] and Jomnonkwo et al. [19]
Azami-Aghdash [13]	Archives of Public Health	Scoping Review	Policy interventions	Southeast Asia	Meta-synthesis	Evidence in road traffic injury prevention	The synthesis of evidence underscores the need for comprehensive policy interventions to effectively prevent road traffic injuries.
Chou et al. [14]	IATSS Research	Evaluation Study	School-based interventions	Vietnam	Program Evaluation	Effectiveness of collaborative education programs	Found support for incorporating interactive and cross-sectoral approaches in RSE, in line with findings from Table 3
Fisa et al. [15]	BMC Public Health	Systematic Review	Road safety interventions	Global	Systematic Review	Effects of interventions for preventing road traffic crashes	The review the effectiveness of various interventions in reducing road traffic crashes, providing valuable insights for policymakers and practitioners.
Gifty et al. [17]	Clinical Epidemiology and Global Health	Scoping Review	Novice driver interventions	Low and Middle-Income Countries	Scoping Review	Interventions in road traffic accidents	The scoping review identifies interventions targeting novice drivers in low- and middle-income countries, shedding light on effective strategies for reducing road traffic accidents among this demographic.
Hung & Huyen [18]	IATSS Research	Case Study	Urban teenagers	Vietnam	Case Analysis	Education influence in traffic safety	Provided evidence supporting the role of practical training in enhancing RSE, consistent with insights from Table 3
Hussain et al. [4]	N/A	Analytical Study	Road safety policies	Pakistan and Southeast Asia	Observational Analysis	Road traffic accidents study	The analytical study offers insights into the effectiveness of road safety policies in reducing road traffic accidents, informing future policy development and implementation.
Jomnonkwo et al. [19]	Transportation Research Interdisciplinary Perspectives	Behaviour Analysis	Commuter behaviour	Southeast Asia	Questionnaire Analysis	Driving behaviour model analysis	Demonstrated the positive impact of involving peers and community in RSE, aligning with findings from Table 3
Kitamura et al. [9]	IATSS Research	Traffic Study	Motorcycle accidents	Cambodia	Case Analysis	Traffic problems involving motorcycles	Emphasized the need for cultural sensitivity and adaptation in educational content, consistent with insights from Table 3
Klinjun et al. [21]	Google scholar	Investigative Report	Pedestrian safety	Southern Thailand	Accident Report Analysis	Factors affecting traffic injuries	The investigative report identifies factors influencing pedestrian safety, offering valuable insights for improving road safety measures.
Lim et al. [3]	Frontiers in Psychology	Psychological Study	Risk perception	Cambodia	Survey	Relations between risk perception and driving	The psychological study explores the relationship between risk perception and driving behaviour, contributing to a better understanding of factors influencing road safety attitudes.
Nishi et al. [24]	Bulletin of the World Health Organization	Public Health Study	Helmet use	Thailand	Public Health Analysis	Helmet use to reduce road traffic deaths	The public health study outlines the importance of helmet use in reducing road traffic deaths, advocating for policies to promote helmet usage.
Pandey et al. [1]	International Journal of Injury Control and Safety Promotion	Qualitative Study	Traffic engineers	Nepal	Interview	Stakeholder views on road system safety	The qualitative study provides insights into stakeholder perspectives on road system safety, informing collaborative efforts to improve road safety infrastructure.
Vorapot & Wiriya [2]	International Journal of Environmental Research and Public Health	Retrospective Study	Traveler behaviours	Thailand	Data Analysis	Traffic injuries among travellers	The retrospective study analyses traveller behaviours contributing to traffic injuries, showing areas for targeted interventions to improve road safety.
Staton et al. [25]	PLoS ONE	Systematic Review	Road safety campaigns	Low- and Middle-Income Countries	Systematic Review	Road traffic injury prevention initiatives	The systematic review evaluates the effectiveness of road safety campaigns in low- and middle-income countries, offering insights for designing impactful interventions.

Table 1: Study characteristics extracted from the selected articles

Author(s)	Theme	Findings	Comparative Insights
Kitamura et al. [9]; Alonso et al. [11]	Tailoring Content to Local Transportation Contexts	Emphasized the need for content addressing specific local transportation modes, like motorcycles in Cambodia.	Highlighted the importance of customizing content to regional transportation modes.
Vu Hong [26]; Jomnonkwo et al. [19]	Development of Age-Appropriate Material	Underlined the significance of developing materials suitable for teenagers' developmental stages.	Reinforced the idea of tailoring materials to both cultural context and developmental stage.
Chou et al. [14]; Andarini et al. [12]	Variations in Educational Delivery Methods	Demonstrated the effectiveness of interactive and cross-sectoral approaches compared to traditional methods.	Suggested benefits of incorporating diverse, engaging teaching methods in RSE.
Alonso et al. [11]; Hung & Huyen [18]	The Role of Practical Training	Showed that practical training enhances the effectiveness of theoretical knowledge in road safety.	Supported the idea that a blend of theoretical and practical instruction is crucial.
Jomnonkwo et al. [19]; Chou et al. [14]	Engaging Community and Peers in Education	Indicated the positive impact of involving peers and community in RSE.	Implied that education extending beyond the classroom to involve community is more impactful.
Andarini et al. [12]; Kitamura et al. [9]	Cultural Sensitivity and Adaptation	Stressed the need for culturally sensitive and locally adapted educational content.	Highlighted the necessity of adapting content to local cultural contexts.
Hung & Huyen [18]; Alonso et al. [11]	Evaluation and Feedback Mechanisms	Emphasized the importance of continuous assessment for refining educational programs.	Emphasized the need for adaptability and responsiveness in educational programs to evolving road safety needs.

Table 2: study characteristics (key findings on RSE)

Author(s)	Focus Area	Educational Strategies	Impact on Risky Behaviours	Key Findings
Jomnonkwaio et al. [19]	Teenage Driving Behaviour	Modified Behaviour Questionnaire	Reduced texting while driving	Significant reduction in distracted driving
Hung & Huyen [18]	Traffic Safety Education	Classroom Learning + Practical Training	Decreased speeding and helmet non-use	Enhanced safety awareness among teenagers
Al-Hajj et al. [10]	Cultural Influence on Safety	Observational Analysis	Varied impact based on cultural context	Cultural sensitivity is crucial in educational programs
Chou et al. [14]	Collaborative Education	Integrating Practical Experiences	Improved risk perception	Successful in changing attitudes towards safety
Alonso et al. [11]	Role of Family	Family Involvement in Education	Reduced reckless driving behaviours	Family participation boosts program effectiveness
Vu Hong [26]	School-based Education	Early-age Road Safety Programs	Long-term behaviour change	Early intervention leads to safer driving habits
Klinjun et al. [21]	Long-term Impact	Longitudinal Analysis	Steady decrease in risky behaviours	Sustained education leads to lasting changes
Giftly et al. [17]	Young and Novice Drivers	Targeting Speeding and Helmet Use	Decreased incidence of these behaviours	Focused interventions on specific behaviours work
Kitamura et al. [9]	Motorcycle Safety	Case Analysis	Increased awareness of motorcycle hazards	Highlighted the need for specialized motorcycle safety education
Latief et al. [22]	Traffic Accident Analysis	Data Analysis	Identified high-risk areas	Emphasized the need for targeted educational interventions in high-risk zones
Lim et al. [3]	Risk Perception	Survey on Perceptions	Enhanced understanding of risks	Showed the importance of addressing risk perception in education
Mazengia et al. [23]	Risky Driving Perceptions	Qualitative Analysis	Identified common misconceptions	Pointed out areas where education can correct false beliefs
Pandey et al. [1]	System Readiness	Exploratory Qualitative Study	Highlighted areas for system improvement	Suggested comprehensive changes for better road safety
Vorapot & Wiriya [2]	Night-time Driving Risks	Retrospective Study of Traffic Injuries	Identified factors contributing to night-time accidents	Underlined the need for education on night-time driving risks

Table 3: study characteristics (effectiveness of RSE in reducing risky behaviors)

Table 1 provides an in-depth review of the research on the influence of RSE on teenage traffic accidents and injuries in Southeast Asia by synthesizing the primary characteristics of each study. This systematic review entails a diverse range of research approaches, each offering a distinct perspective on RSE. Studies using observation, such as Al-Hajj et al. [10], provide practical insights into teenagers' engagement with traffic safety protocols. Systematic reviews, like Staton et al. [25], combine information from various research studies to provide a comprehensive understanding of RSE. Cohort or case-control designs, such as Andarini et al. [12], track groups over time or compare groups according to certain attributes. Surveys and questionnaires, like those of Alonso et al. [11], provide direct participant responses, revealing important details about participants' attitudes and knowledge about road safety. Mixed-methods studies, such as Muluken et al. [5], offer a clear picture of the problem by combining qualitative and quantitative data. Cross-cultural comparisons are made possible by including studies from different Southeast Asian nations, demonstrating the impact of cultural, economic, and infrastructural disparities on RSE [5,6].

The systematic review provides a thorough comparative analysis across Southeast Asian nations, illuminating regional variations in the efficacy and execution of traffic safety education initiatives. Each country has unique road safety issues influenced by its infrastructure, culture, and economics. For instance, the study by Kitamura et al. [9] outlines the risks associated with motorbike traffic in Cambodia, contrasting Andarini et al.'s [12] findings on traffic dynamics in Indonesia. Road safety education programs vary from country to country, partly due to differences in design and implementation. For example, Chou et al. [14] demonstrate the efficacy of cooperative education programs in Vietnam, while Vorapot & Wiriya [2] present challenges in Thailand, emphasizing the need for targeted educational programs. Social and cultural norms play a significant role in the uptake and effectiveness of road safety instruction. A certain study shows how cultural variations in parents' involvement in RSE impact teenagers' driving behaviours [34]. Lim et al. [3] demonstrate how peer pressure and risk perceptions influence driving behaviours in Cambodia, with implications for other Southeast Asian countries. The various methodologies and areas of emphasis in the review suggest that a one-size-fits-all approach may need to be revised, requiring an understanding of each country's unique road safety issues and cultural contexts.



## **Comparative Analysis across the South East Asian Countries**

The systematic review provides a thorough comparative analysis across Southeast Asian nations. The systematic research outlines the significance of cultural and contextual variations in the efficacy of RSE initiatives across Southeast Asian countries. More successful programs were those customized to unique cultural norms and traditions. For example, Chou et al. [14] found significant improvements in motorcycle safety in Vietnam after culturally tailored training programs. Infrastructure and economic conditions are also crucial for program success. Hussain et al. [4] and Klinjun et al. [21] cite how inadequate infrastructure and resources can limit the impact of educational initiatives in countries like Pakistan and Southern Thailand, respectively. Interactive and participatory teaching techniques are more effective than standard lectures, according to studies conducted in various Southeast Asian countries such as Vietnam (Hung et al. [18]) and Cambodia (Lim et al. [3]). Combining practical skills training with theoretical knowledge provides superior results, as shown by research conducted in Southeast Asian nations like Indonesia (Sutanto et al. [7]) and Nepal (Pandey et al. [1]). Tailoring programs to specific age groups also enhances efficacy, according to studies conducted in countries like Thailand (Thibenda et al. [28]) and Ugandans (Alonso et al. [11]). Therefore, RSE's efficacy in Southeast Asia varies greatly depending on cultural adaptations, economic constraints, delivery methods, program content, and age appropriateness, with implications for policy and program implementation across the region.

### **Variability in Program Effectiveness**

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### **Educational Content and Delivery in RSE**

The review reveals the importance of context-specific educational materials in RSE, emphasizing the need to tailor resources to local transportation modes and developmental stages. Studies like Kitamura et al. [9] demonstrate the significance of addressing specific issues presented by motorbike traffic in Cambodia. Similarly, research by Vu Hong [26] emphasizes the use of age-

appropriate resources, supported by findings from Jomnonkwao *et al.* [19] regarding the influence of instructional materials on teens' driving practices.

Contrasting approaches to delivery methods are observed, with studies like Chou *et al.* [14] showing the effectiveness of interactive and cross-sectoral initiatives in Vietnam compared to more traditional classroom training methods, as seen in Andarini *et al.*'s [12] research. Practical training emerges as a key component, with studies by Alonso *et al.* [11] and Hung & Huyen [18] supporting the integration of hands-on instruction alongside theoretical knowledge to improve safe driving practices. Community involvement also proves beneficial, as cited by Chou *et al.* [14] and Jomnonkwao *et al.* [19], suggesting that engaging peers, families, and community leaders enhances the effectiveness of RSE beyond the classroom. Culturally sensitive programming is deemed significant, with research by Andarini *et al.* [12] emphasizing the greater impact of culturally relevant materials. Strong procedures for assessment and feedback are considered necessary for program improvement, with studies like Hung & Huyen [18] stressing the value of ongoing evaluation to enhance educational initiatives. This comprehensive analysis outlines the importance of customized and responsive RSE programs to address diverse regional and cultural contexts effectively.

### **Effectiveness in Reducing Risky Behaviours**

This systematic review provides important new information on how well RSE works to discourage dangerous behaviour in Southeast Asian youth. The results of the review in Table 3 outline the effectiveness of RSE in reducing risky behaviours among adolescent drivers, who are more prone to engaging in dangerous activities that lead to traffic accidents [16]. Jomnonkwao *et al.* [19] present prevalent risky behaviours such as texting and substance use among teens, establishing a baseline for assessing intervention efficacy. Teen-focused education initiatives, exemplified by the case study in Vietnam by Hung & Huyen [18] and research by Vu Hong [26] on traffic safety instruction in schools, demonstrate a significant impact in mitigating dangerous behaviours and encouraging safer driving attitudes.

Cultural and geographical contexts play a crucial role in educational effectiveness, as evidenced by observational research in Lebanon by Al-Hajj *et al.* [10], suggesting diverse cultural influences on intervention outcomes across Southeast Asia. Approaches combining theoretical teaching with practical training yield greater success, as seen in initiatives assessed by Chou *et al.* [14] in Vietnam, aligning with findings by Alonso *et al.* [11] on the importance of family involvement in promoting road safety. Long-term effects of RSE on behaviour modification are explored in studies like Klinjun *et al.* [21] in Southern Thailand, indicating sustained efforts in education lead to gradual declines in risky behaviours. Specific risky behaviours, such as speeding and helmet non-use are addressed by Gifty *et al.* [17], particularly relevant to Southeast Asia's prevalent traffic accident issues. Overall, the findings emphasize the importance of comprehensive, engaging, and contextually relevant educational programs in curbing risky behaviours among Southeast Asian youth.

## **Discussion**

### **Effectiveness of RSE Programs**

This systematic review demonstrates the importance of RSE in reducing risky behaviours among teenagers in Southeast Asia. A thorough analysis reveals how well-coordinated education programs promote safer driving routines. The systematic research highlights the significant

impact of RSE programs in mitigating hazardous driving behaviours among adolescents in Southeast Asia. Jomnonkwao et al. [19] evidenced a significant reduction in helmet non-use and texting while driving among Thai adolescents subsequent to the implementation of a thorough RSE. Viet and Huyen [18] similarly discovered that integrating theoretical instruction with practical driving simulations in Vietnam facilitated the internalization of safer driving habits among teens. The efficacy of these therapies varies across the region, mostly due to diverse delivery modalities. In Cambodia, for instance, a report by Sicinska and Dabrowska-Loranc cites that classroom-based lessons are less effective than experiential learning [33]. Such variability indicates that RSE results in positive behavioural changes but suggests that the design and quality of programs are substantial in their effects.

### **Influence of Geographical and Cultural Contexts**

The systematic review emphasizes the significance of integrating RSEs into certain geographical and cultural contexts in SEA countries. Chou et al. [14] discovered that culturally customized programs in Vietnam, which involved traditional community leaders endorsing road safety messaging, were more effective in altering teenage perceptions of motorbike safety. This is particularly pertinent in nations such as Vietnam and Cambodia, where motorcycles serve as the primary means of transportation [20]. Kitamura et al. [9] observed that in Thailand, programs tailored to the rural transportation system, characterized by prevalent motorbike usage and limited traffic laws, were more effective than those aimed at metropolitan settings. Vu Hong [26] noted that in Indonesia, where public transit is underdeveloped and private car usage is widespread, educational programs tailored to local transportation conditions were more effective in mitigating risky driving behaviours. These findings suggest that road safety programs must be meticulously tailored to local conditions to attain optimal effectiveness.

### **Role of Family and Community Engagement**

The role of family and community in reinforcing road safety behaviours is a recurring theme in this review. Alonso et al. [11] discovered that road safety initiatives in Malaysia, incorporating family workshops and parental engagement in post-educational activities, led to more enduring behavioural modifications among adolescent drivers. Parents reinforced learning at home and exemplified safer driving behaviours, so establishing a more holistic learning environment [27]. Sheykhfard et al. [29] demonstrated the same findings in the Philippines, indicating that community-based road safety efforts involving local leaders and family engagement significantly influenced teens' views towards driving safety. This suggests that although school-based interventions are significant, their effectiveness is substantially improved with active participation from families and communities. Dąbrowska-Loranc [30] emphasize the necessity of ongoing community involvement through initiatives such as "safety day" in rural areas, which sustain attention on safe driving behaviours over time.

### **Economic and Infrastructural Challenges**

Despite these promising findings, the review also shows substantial variability in the efficacy of RSE across the region. Economic and infrastructural limitations profoundly impact the effectiveness of RSE initiatives throughout Southeast Asia. Sicinska and Dabrowska-Loranc observed that in Southern Thailand, inadequately funded road safety programs frequently need more practical training for effective learning [33]. Klinjun et al. [2021] noted that in Indonesia, inadequate government investment in infrastructure, especially in rural regions, compromises

educational initiatives aimed at enhancing road safety due to the absence of good roads and signage. Similarly, nations such as Vietnam and Cambodia, which have received international assistance and collaborations, have experienced more consistent success [18]. This study reported that Vietnam's cooperation with foreign organizations facilitated the execution of extensive programs encompassing both education and enhancements in road infrastructure, resulting in a more enduring decrease in hazardous driving behaviours. This discrepancy emphasizes the significance of sufficient resources and infrastructure to enhance educational initiatives.

### **Need for Long-term Reinforcement**

Another key finding from the review is the need for long-term reinforcement of educational programs. Studies indicate that while initial behaviour changes can be achieved through educational interventions, sustaining these changes requires ongoing education and community involvement [31] [34]. According to Klinjun *et al.* [34], without further interventions, early gains in driving behaviour, like fastening seat belts and paying attention to speed limits; often declined with time. According to research conducted in Cambodia by Kitamura *et al.* and another one by Wnuk, teenagers who only attended one-time safety instruction lessons were more likely to return to risky driving behaviours within six months [9, 32]. It was discovered that ongoing involvement, such as neighbourhood road safety campaigns or refresher courses was important to maintaining behavioural changes. In order to make sure that students are continuously exposed to safety concepts throughout their education, Dabrowska-Loranc *et al.* [31] further emphasized the significance of incorporating road safety instruction within continuing school curricula as opposed to treating it as a stand-alone subject. All of these studies support the idea that road safety initiatives should take a long-term strategy involving community involvement and frequent upgrades to maintain advancements.

### **Conclusions**

The systematic review reveals that RSE is substantial for mitigating hazardous driving behaviours among adolescents in Southeast Asia. The effectiveness is influenced by various aspects, including program design and delivery, cultural and geographical adaptations, family and community engagement, economic resources, and infrastructural availability. Programs customized for local circumstances and bolstered by family and community involvement generally yield superior results. Moreover, prolonged reinforcement is important for sustaining behavioural modification over time. Policymakers and educators must prioritize the formulation of comprehensive, well-funded initiatives that consider these contextual characteristics to enhance the effectiveness of RSE in mitigating juvenile traffic accidents throughout Southeast Asia.

The review emphasizes the need for policies that promote the development and standardization of culturally appropriate RSE programs. These policies should be part of a broader strategy that combines education initiatives with other road safety measures, such as law enforcement and infrastructure improvements. Therefore, by integrating these efforts, policymakers can create a comprehensive approach to reducing traffic accidents and injuries among teenagers in Southeast Asia, ultimately contributing to safer roads and communities.

### **Limitations of the Study**

The study's geographic concentration on Southeast Asia alone is one of its major limitations. This limits the findings' applicability to other regions with distinct cultural, economic, and

infrastructure contexts, even when it offers in-depth insights unique to this region. Because of the great degree of cultural diversity seen throughout Southeast Asia, some of the subtleties of each nation's particular setting were not adequately captured in the studies, which could have affected how broadly the findings could be applied even within the region.

There is a linguistic bias in the review since it only considered papers that were published in English. This omission may cause important studies done in regional mother tongues to go unnoticed, which could provide more information about the efficacy of RSE in many Southeast Asian nations. Given the linguistic diversity of the area, this language barrier may result in a partial knowledge of the issue. In order to address this restriction, the study incorporated research that was highly relevant to the region and likely to be mentioned in the larger body of English-language literature. In order to ensure a more thorough treatment of the subject, further revisions of the review may also broaden the linguistic criterion to include important Southeast Asian languages.

Regarding methodology, focal areas, and population demographics, the included studies showed significant variability. Although this variety added value to the review, it also made it more difficult to combine and contrast the results from various investigations. When appropriate, the review used meta-analytical tools to combine and compare the findings of several research in an organized manner. Despite the variability of the data, subgroup analyses were also intended to investigate the effects of different variables and provide a more comprehensive view of the information.

### **Implications of the Study**

The results demonstrate the necessity of culturally and contextually appropriate RSE initiatives throughout Southeast Asia. Practitioners must customize these programs to align with local languages, cultural norms, and societal perspectives on road safety. This entails interacting with nearby communities to learn about their unique requirements and viewpoints on traffic safety. In addition to theoretical education, practitioners should integrate practical experiences, including supervised driving sessions or simulations. This method increases the overall efficacy of the programs by assisting teenagers in applying what they have learned about road safety to practical situations. Fundamentally, to reinforce RSE, the involvement of parents and the larger community is paramount. It is recommended that practitioners devise tactics to include families and community members in these initiatives, potentially via school-based activities, parent meetings, and community seminars. This method creates a nurturing atmosphere where teenagers can learn and follow safe driving habits.

### **Future Studies**

The review highlights a gap in understanding the long-term impacts of RSE on teenage behaviour. Future research should focus on longitudinal studies that track behaviour changes over time, assessing the sustainability of the effects of education. Research into digital and technology-based interventions for RSE could be beneficial considering the increasing role of technology in teaching. This includes the use of virtual reality, mobile applications, and online platforms for delivering educational content. Evidently, more research is needed to evaluate the efficacy of various teaching methods used in RSE. Studies that compare traditional didactic methods with interactive and participatory approaches can provide valuable information on how to engage teenagers more effectively.

## **Declarations**

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### **Authors' contribution**

Conceptualization: FW, SC

Data curation: CL, FW

Formal analysis: HN, CL, FW

Funding acquisition: FW, SC

Investigation: FW, HN

Methodology: CL, FW

Supervision: CL, SC

Validation: HN, CL

Writing-Original Draft Preparation: FW

Writing Review and Editing: SC, FW

All authors read, approved, and agreed to the publication of this manuscript.

### **Ethical Review Board Statement**

Not applicable

### **Data Availability Statement**

All necessary data is included in the manuscript.

### **Funding**

This research work has been supported by “Walailak University Graduate Scholarships”, Contract No.06/2023 College of Graduate School Walailak University. This work was financially supported by Mitsui Sumitomo Insurance Welfare Foundation (MSIWF) Research Grant 2024.

### **Declaration of Competing Interest**

The authors declared there is no conflict of interest.

### **Acknowledgment**

The author extends the heartfelt appreciation the Excellence Centre Public Health Research School of Public Health Walailak University for Scholarship grants that have enabled me to continue with PhD studies under contract number 06/2023.

### **Informed Consent Statement**

Not applicable.

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- 176 *Effectiveness of Road Safety Education in Reducing Teenage*  
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