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MINI-REVIEW

Characteristics and Potential Impacts of Rest Areas Proximate to Roadways: A Review

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Abstract:

Objective:

Rest areas are one of the most common roadside service facilities designated for parking and resting purposes. They are considered crucial components in the roadway network since they provide road users with a safe and comfortable place nearby the mainline. Obtaining extensive information on the planning, advantages, and potential effects of rest areas will help establish a better understanding of their characteristics and essential benefits. This will enable decision-makers and safety engineers to implement effective policies. Therefore, this paper reviews the literature on the development and impact of rest areas close to roadways. The objectives of this paper are as follows: to discuss the potential positive and negative effects of rest areas, to determine major challenges, to provide recommendations for implementing such facilities based on the literature search, and to fill a research gap.

Methods:

The review focuses on articles and reports addressing the features and impacts of rest areas and parking facilities published in English. The literature on parking demands related to rest area facilities is not within the scope of this research.

Results:

The challenges and recommendations concerning the development and safety aspects of rest areas are critically discussed. The review of numerous studies concerning the safety and operation of rest areas has revealed conflicting results. Although several studies found that establishing rest area facilities proximate to roadway segments positively impacts safety and operation, some indicated that such facilities might pose safety and operation risks along adjacent sections. Thus, this paper highlights a gap in the research area, determining the distribution patterns of crashes occurring along the proximate segments of rest areas.

Conclusion:

Although rest areas do help in mitigating fatigue-related crashes, the review highlights that future research should investigate the relationship between roadway features and collisions occurring along nearby segments of rest areas to fully understand the safety effects of rest areas nearby the mainline. This work is beneficial for decision-makers and safety engineers since it provides valuable information in terms of the planning features of rest areas and parking facilities, along with their essential impact.

Keywords: Rest area, Parking facility, Planning, Benefit, Safety, Crash, Fatigue.

Article History	Received: January 20, 2021	Revised: October 21, 2021	Accepted: November 04, 2021

1. INTRODUCTION

Roadside service facilities are generally designed to provide various services and opportunities depending on their functionality. These facilities fall into two general types: parking facilities (such as rest areas, parking and rides, and truck stops) as well as enforcement facilities (commonly recognized as fixed weigh stations or inception stations) [1, 2]. However, the rest area facility is one of the most common roadside service facilities designated for parking and resting purposes [3]. Essentially, this facility has been established to provide road users with various services to rest, sleep, eat, use the restroom, or check vehicles and goods [4, 5].

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Drowsy and fatigued drivers use rest areas as safeguarded parking spots to pull over and rest before continuing their journey [6]. Although commercialized facilities, such as fuel stations, truck stops, and fast-food restaurants may provide more services than rest areas, accessibility to rest areas in limited-access roadways is more convenient and comfortable than these alternative facilities [7]. Rest areas also possess incomparable characteristics that are not found at other facilities, for instance, the ability to walk and enjoy the natural surroundings, accommodating features for children and disabled users, and available parking lots for heavy vehicles [7]. The locations of rest areas are designed to provide stopping opportunities in rural routes, between towns, and at state borders or large metropolitan regions where road users are in great need of services [8]. Rest area facilities generally help improve traffic safety, promote travelers' comfort and convenience, and readily provide relevant information to road users [6].

This paper focuses on the safety aspect of the presence and utilization of rest area facilities due to the extraordinary growth of freight transport, which reflects on the increase in the implementation of such facilities alongside transport channels. Research synthesis methodology is specifically applied to collect, summarize, and review the literature by concentrating on specific objectives in the topic of rest areas (*i.e*., potential safety impacts). Other researchers had focused on different aspects regarding this topic, such as parking demands, designs, landscapes, and operational cost-efficiency. The novelty of this paper is that according to our best knowledge, this is the first study that reviews the characteristics and potential impacts of rest areas.

The primary objective of this review is to extensively summarize and document information regarding the planning, benefits, and potential impacts of rest areas to enhance the understanding and evaluation of their features and essential influences. This will aid decision-makers and safety engineers in implementing effective policies that will improve the safety level in public transportation. This review further provides insight into the planning and essential benefits of rest area facilities. The potential adverse effects, challenges, and recommendations for implementing such facilities are also discussed.

The review is organized as follows: Section 2 provides the strategies and sources of literature in the paper. Section 3 presents the features of rest area planning. Section 4 discusses the three essential benefits of rest areas: enhanced traffic safety, comfort and convenience, and reduced excess travel and diversion. Section 5 highlights the potential adverse effects of rest areas. Section 6 examines the literature related to the challenges and recommendations of developing and implementing rest areas. Finally, Section 7 concludes the findings of this paper.

2. STRATEGIES AND SOURCES OF LITERATURE

A literature search of major databases has been conducted to better understand the attributes and features of rest area systems. This includes the planning, benefits, possible adverse effects, as well as challenges and recommendations. Electronic database engines, such as Scopus, ProQuest, Transport Research International Documentation (TRID), Web of Science, and Google Scholar, have been intensively used during the literature search. The review consists of different research types such as international journals, conferences, as well as academic and technical reports.

The literature's scope focuses on four main subjects concerning rest area facilities: rest area planning, benefits of rest areas, potential adverse effects of rest areas, and the challenges and recommendations. The selection of studies was restricted to those published in English. The utilization, demand, and supply of rest area facilities were not within the scope of this paper. The scientific literature was retrieved using keywords and terms, such as “rest area,” “rest service area,” “truck parking,” “parking facility,” “commercial motor vehicle,” and “truck.” These terms were all separately combined with: “crash,” “accident,” “safety,” “fatigue,*” and “drowsing*.” The search then extracted a total of 74 references relevant to the aforementioned subjects. Table **1** illustrates the trend of references based on the publication year and subject concerned. Most studies were published between the period of 2011 and 2015 with 35 (47%), followed by the period after 2016 with 17 (23%). Each research paper or report was critically examined, summarized, and reviewed.

Table 1. Reference trends and related subjects included in the review.

Demographic	Category	No. of References n (%)
Publication Year	Before 2005	13 (17%)
	2006-2010	9 (12%)
n = 74	2011-2015	35 (47%)
	After 2016	17 (23%)
Subject Concern*	Rest Area Planning	19
	Benefits of Rest Areas	47
	Potential Adverse Impacts of Rest Areas	20
	Challenges and Recommendations	21

*Note: Several studies covering more than one subject

3. REST AREA PLANNING

The planning process of the rest area system along a roadway should begin with a thorough development program. However, the remoteness of certain regions can further complicate the functional safety of rest areas [9]. Suggestions have been made for rest area planning components in Montana, specifically regarding location, development, operation, maintenance, and design [10, 11]. In terms of rest area planning, 16% and 25% of mainline peak traffic volume utilize rest points of arterial and interstate highways, respectively [7]. In 2012, the aspect of fatigued road users, in terms of public health and environmental issues, was investigated by Munala and Maina (2012) to suggest suitable planning engineering options along with road infrastructure to alleviate fatigue [12].

It is essential to consider the objective of rest areas and the needs of road users [13]. The three major groups of road users include general road users, truck drivers, and tourists. Each group has a distinct motivation for stopping [14]. General road users include village and town residents traveling for personal matters, such as shopping or work. Truck drivers must stop for a particular period following HOS regulations. Since tourists usually travel in diverse groups, they can choose when they would like to stop.

The planning of rest areas is based on the classification and amenities provided at a particular rest area location. However, classification and services are influenced by several parameters, such as the volume of traffic, highway classification, local factors, and economic analysis outcomes. Table **2** presents the different classes of rest areas and an overview of the necessary amenities and safety features [15].

Road users are encouraged to report their duration of stay at rest areas. Field observations can be simultaneously conducted to determine the user's length of stay. This will help determine the type of services required at rest areas in the planning stage, including the number of toilets, phone communication, picnic tables, and parking bay sizes required [16, 17].

It is generally recommended to divide the area into functional zones to separate the traffic of specific vehicles on the site and maintain the safety of facility users (Fig. **1**) [14].

3.1. Considerations for Spacing Distance Between Rest Areas

Rest areas are mostly designed for travelers on limited-access roadways who travel long distances. Drivers and passengers can rest, eat, or refuel without exiting onto secondary roads. Nonetheless, the past four decades have seen growing interest regarding the development, usage, and sufficiency of rest areas. According to rest area policies of development and maintenance in the US, under the AASHTO guidelines, the spacing distance of rest areas must be 100 km or 60 minutes of driving, as illustrated in Fig. (**2**). Long-term parking spaces for trucks should also be allocated at rest areas in a routine manner. In this case, suitable separate facilities within the rest site must be planned to meet all physical needs [18].

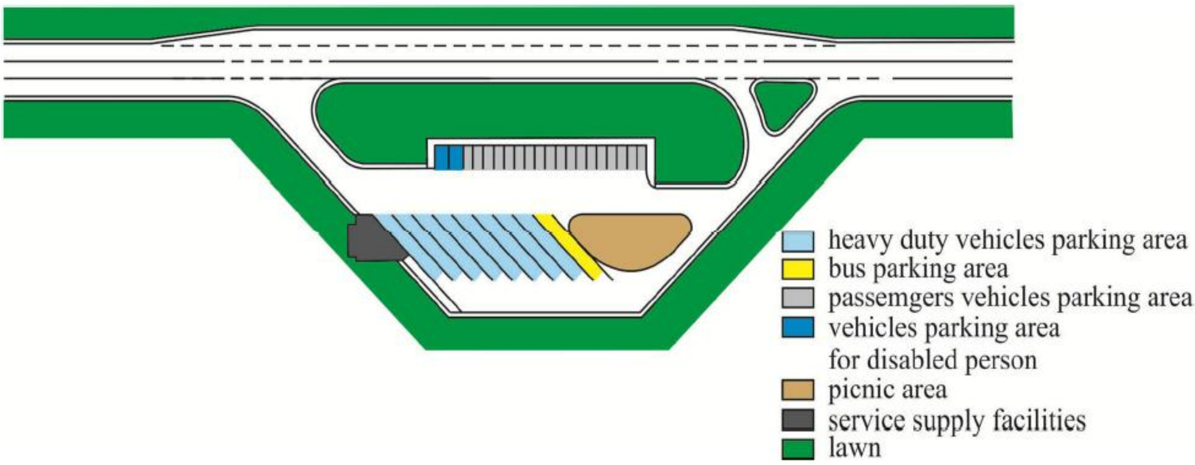

Fig. (1). Typical functional zones of rest area divisions [14].

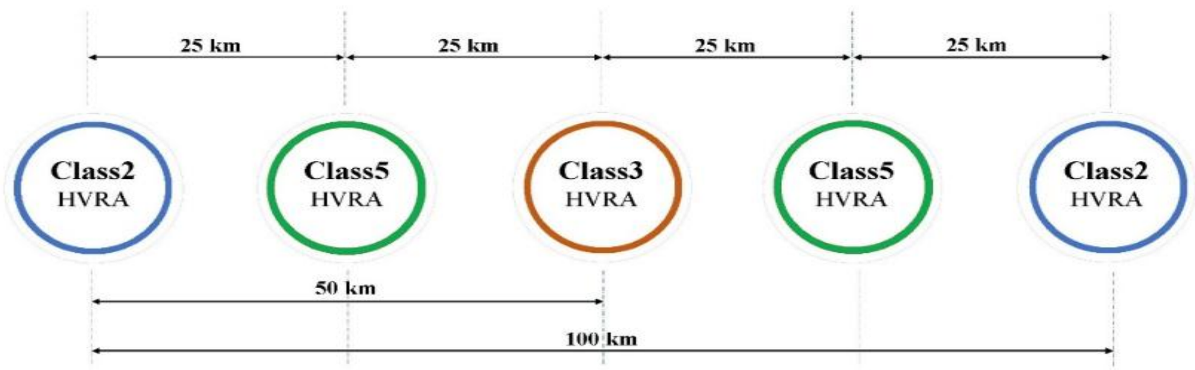

Fig. (2). Example of heavy vehicle rest area (HVRA) spacing.

Table 2. Classification of different rest areas for heavy vehicles [15].

Key Features	HVRA Classification		
	1 and 2	3 and 4	5
The flow of unidirectional freeways	√	√	√
No reverse movements (pull-through (clearway) capability)	√	√	√
Safe vehicle movement and access, including accommodating dimensions reflecting on the likely maximum truck size	√	√	√
Minimized chance for conflict between vehicles and pedestrians	√	√	-
Separation of light and heavy vehicles	√	-	-
Separation of vehicles carrying noisy freight	√	-	-
Separation for short term/long term visitors	√	-	-

Table 3. Various Types and Distances of Rest Areas by Countries.

Country	Type	Standard Spacing (Km)
U.S.	Service Area Safety Rest Area	100 40–50
Japan	Service Area Parking Area	50 15
U.K.	Service Area Service Area	48 100
Australia	Simplified Service Area Parking Area	50 30
China	Service Area	60
France	Service Area	20
Finland	Rest area	20
Spain	Rest Area Service Area	25 70
Poland	Rest Area Service Area	40 80
Korea	Service Area Safety Rest Area	25 42
Malaysia	Service Area Safety Rest Area	25 80
Nigeria	Rest Area	30
Denmark	Service Area Rest Area	30 70
Germany	Service Area Parking Area	35 10

The use of a rest area can be affected by facility characteristics, including capacity, accessibility, and visibility. The capacity of the rest area should accommodate the current parking demands. Moreover, to provide road users with a sense of safety, at least part of the rest area must be visible from the roadway. The other two main issues regarding public travel are cleanliness and safety [12]. In Finland, the local municipality is responsible for providing local maps and sanitary services. In terms of commercial activities, shops are in charge of the area's cleanliness [19]. According to the leading nations' road safety figures, the average rest area's spacing is roughly 15 km [20, 21]. Table **3** presents the standard spacing distance between consecutive rest areas in some countries. In Japan, rest areas are spaced every 50 km, and relatively small rest areas are set up every 15 km.

It was suggested that insufficient parking spaces are considered to be a factor of rest area planning [22 - 26]. The number of parking spaces provided should be given thorough consideration since distinct locations will have diverse traffic demand fluctuations. The combination of parking spaces allocated for light and heavy vehicles will vary between rest areas.

4. BENEFITS OF REST AREAS

The rest area is a vital and integral element of primary road networks as it provides distinct benefits to road users, stakeholders, and external entities [6]. In general, the rest area offers quick access from the mainline and provides basic amenities, such as parking, restrooms, food, picnic tables, and travel information [7]. Three groups have been identified to benefit from the presence of rest areas on the mainline: road users, roadway stakeholders and other authorities, and outer entities (*e.g.*, the tourism industry, local commercial businesses, *etc.*) [6]. The literature exclusively covers benefits associated with road users. Other beneficiary groups are not within the scope of this paper. Essentially, there are different groups of road users: passenger vehicle occupants, heavy vehicle operators, motorcyclists, vacationers, recreational vehicle drivers, *etc* [5]. The benefits of rest areas can be divided into three main categories: enhanced safety in public transportation, improved comfort and convenience of a roadway, and reduced excess travel and diversion [4, 6, 7].

4.1. Enhance Safety and Traffic Operation

In general, rest areas aim to improve traffic safety and traffic operation by reducing fatigue-related crashes, mitigating shoulder parking issues, and providing shelter during hazards and emergency conditions [6]. The rest area's primary role is to enhance traffic safety by reducing crash incidents on the roadway. Another significant strategy in the rest area system is to enhance the operation of traffic by reducing parked trucks on the shoulder or ramp of high-velocity roadways, thereby providing safer environments to users. Sufficient parking at rest areas is a significant issue that is currently a national concern [27].

Four prevalent methods are usually employed to evaluate and estimate the rest area's safety and operational benefits: the before and after analysis, the case and control analysis, regression analysis, and the Empirical Bayes model. Researchers can also combine these methods to overcome their drawbacks [6]. Two types of analyses are generally employed to explore the relationship between traffic safety and rest areas. First, the direct analysis involves the relationship between crash location and rest area sites or crash frequency along the proximate segments of a rest area. Secondly, the indirect analysis estimates a decrease in expected crash contributing factors (*i.e.*, driving fatigue, shoulder parking, *etc*.) and subsequent mitigations in crash frequency along the proximate segments of a rest area [6]. Overall, investigating and understanding the causes and patterns of traffic accidents related to rest areas are essential and should receive considerable research attention.

4.1.1. Reducing Fatigue-Related Crashes

Research on fatigue-related crashes has been the topic of study worldwide to address road safety concerns [13]. Reducing fatigue should be considered as it is a significant contributing factor to crashes, affecting road safety. Several studies have confirmed that fatigue (which refers to human failure) is a cause of road accidents [14, 15, 28]. Travelers are known to experience fatigue during their journeys. Physical fatigue is prevalent among passengers, and psychological fatigue heavily affects drivers [16].

Fatigue and drowsiness essentially result from long driving hours or scheduled work demands. Both lead to an increased risk of collisions [29]. Accidents involving fatigue are more severe in injury and cause fatality compared to other crash types [30 - 32]. The impact of fatigue on road safety can result in severe consequences. In 2004, Dagli noted that fatigue affects driving performance by reducing attention and focus, slowing the reaction time, causing poor decision making, etc [33]. Fatigue and sleep are the main contributing factors of collisions involving passenger vehicles and trucks [34 - 36].

Interestingly, fatigue is the most prevalent factor associated with truck collisions after speeding [37]. Researchers have indicated that nearly 20% of trucks involved in crashes are related to fatigue or drowsiness [34, 38, 39]. The most effective action to mitigate fatigue is pulling over on the road and having a rest or break [40].

The Federal Motor Carrier Safety Administration (FMCSA) legislated the existing Hours-of-Service (HOS) regulations for truck drivers, which only allows a maximum of 11 hours of driving after 10 hours of consecutive rest is taken, and only 60/70 total hours of driving over 7 or 8 successive days [41]. As a result, providing rest areas immediately adjacent to the mainline for truck drivers (and other road users) to comply with their HOS regulations is essential. Rest areas are therefore considered a vital safety countermeasure to reduce fatigue-related crashes.

Table 4. Summary of previous studies on the relationship between crash types and parking facilities.

<table>
<tr><th>Author/ Year</th><th>Study Area</th><th>Crash Type</th><th>Methodology</th><th>Summary of Key Findings</th></tr>
<tr><td>Taylor et al. [42]/ 1999</td><td>Interstate and US routes in Michigan</td><td>Fatigue-related truck and single truck crashes</td><td>Discriminant analysis/ Regression analysis</td><td rowspan="2">The frequency of single-unit truck crashes increases during the night once the spacing distance increases between rest areas. The SRF in the study obtained similar findings as Taylor’s study except for the frequency, which showed that single truck crashes increase during all times of the day.</td></tr>
<tr><td>SRF Inc. [43]/ 2007</td><td>Rural interstate in Minnesota</td><td>Truck crashes</td><td>R-squared test</td></tr>
<tr><td>Banerjee et al. [30]/ 2010</td><td>Freeways in California</td><td>All crashes</td><td>Two-sample t-test method</td><td rowspan="5">The presence of rest area facilities decreases fatigue-related crashes.</td></tr>
<tr><td>McArthur et al. [44]/ 2013</td><td>Rural freeways and highways in Michigan</td><td>Fatigue-related and single-vehicle crashes</td><td>Negative binomial model</td></tr>
<tr><td>Tipakornkiat [45]/ 2014</td><td>Highway in Thailand</td><td>All crashes</td><td>Negative binomial model</td></tr>
<tr><td>Kang et al. [22]/ 2015</td><td>Interstate highways in Alabama</td><td>Fatigue-related and single-vehicle crashes</td><td>Shapiro–Wilk tests</td></tr>
<tr><td>Chun [45]/ 2017 and Jung et al. [16]/ 2017</td><td>Highways in Korea</td><td>Fatigue-related crashes</td><td>Regression model</td></tr>
</table>

(Table 4) contd.....

Lang [41]/ 2019	Public highways	Truck crashes	Ordered probit model	A positive relationship was found between the number of inadequate truck parking spaces and the severe injury of truck drivers and fatigue-related crashes involving trucks.
Crizzle *et al*. [49]/ 2020	Highways in Saskatchewan	Fatigue-related truck crashes	Chi-square test	
Bunn *et al*. [46]/ 2019	Interstates and parkways in Kentucky	Truck driver at fault crashes	Multiple logistic regression model	The frequency of fatigue-related truck accidents is significantly associated with the nearest parking facility.
Rahman and Kang [47]/ 2020	Rural freeways in Alabama	All crashes	Empirical Bayes method	The existence of rest areas and their upstream segments equipped with a DDR system significantly reduces the total number of crashes.

Several studies have investigated the relationship between crash types and parking facilities (Table **4**). Taylor *et al.* and SRF Inc. explored the relationship between rural interstate highway collisions and rest area spacing with other potentially influencing factors [42, 43]. Both studies found that the frequency of single-unit truck crashes increases when the spacing between two consecutive rest areas is more than 30 miles. Banerjee *et al.* found that the pattern of fatigue-related crashes tends to immediately decrease after rest areas and sharply increase after 30 miles from rest areas. Fatigue and non-fatigue-related crash rates within 10 miles upstream are substantially higher than those within 10 miles downstream [30]. McArthur *et al.* further discovered that traffic volume and proximate segments of rest areas significantly influence fatigue-related accidents [44]. They indicated that fatigue-related crashes decrease within 20 miles upstream and downstream segments of rest areas. Another study suggested that the crash rate related to fatigue increases when the distance between consecutive rest areas increases by 1 km; therefore, the distance between consecutive rest areas should be less than 16 km [45]. Bunn *et al.* showed that the frequency of fatigue-related truck collisions is significantly associated with the nearest parking facility exceeding 20 miles from crash locations [46]. Lang investigated the association between the number of truck parking spaces and the severity of truck drivers' injuries. The results revealed that increasing the total number of parking spacing within a thirty-minute driving spans will decrease the likelihood of sustaining a severe injury during truck accidents [41].

Kang *et al.* found that the patterns of fatigue-related crashes of upstream rest areas are higher than those downstream. However, crash patterns near rest areas located at urban or nearby urban areas have no significant changes upstream or downstream [22]. Two studies had examined the impacts of installing fatigue shelters, called Drowsy Shelters, along Korea's highways [16, 45]. Their findings revealed that supplemental rest areas are more likely to decrease fatigue-related crashes. Recently, Rahman and Kang have evaluated the implementation of a drowsy driving advisory (DDA) system on rural freeways in Alabama [47]. The outcomes demonstrated that rest areas and upstream segments equipped with the DDR system significantly reduced the total number of fatigue-related crashes. Several studies have concluded that the presence of rest areas on roadways will decrease fatigue-related crashes [30, 41, 44, 48, 49].

4.1.2. Mitigating Shoulder Parking Issues

The previous section established that parking and resting are major safety benefits of rest areas. Due to the dramatic growth of industrial and marketing sectors over the past years, freight movement is expected to substantially increase, leading to operational issues, congestion, and overcapacity at parking facilities (*i.e*., rest areas and truck stops) [50, 51]. The lack of adequate parking supply in rest areas further prompts vehicles and trucks to park on the ramp, roadway shoulder, or facility shoulder, which poses safety hazards [52] and significant maintenance issues [53]. Several studies have indicated that inadequate distance in the spacing between rest areas or shortages in parking spaces contribute to accidents along their proximate segments [4, 30, 44, 51, 54, 55]. Bunn *et al.* and Boggs *et al*. found a positive relationship between the shortage of truck parking facilities and shoulder or ramp crashes involving illegally parked trucks [46, 51]. Drivers who park in unauthorized or unsafe locations are vulnerable to criminal assault. Thus, adequate parking spaces will mitigate shoulder parking issues alongside the roadway network.

Table 5. Summary of previous studies that investigated shoulder parking issues and shortages in parking facilities.

Authors	Study Area	Crash Type	Methodology	Summary of Key Findings
Pigman *et al.*[23]/ 2015	Interstate and parkways in Kentucky	Fatigue-related and shoulder-related crashes	Descriptive analysis	Crash hot spots are directly related to the vicinity and utilization rate of parking facilities.
Kimley Horn [53]/ 2015	14 Corridors of Statewide Significance in Virginia	Truck crashes	Descriptive analysis	25% of truck crashes take place at corridor ramps. It was concluded that parked trucks pose safety risk concerns for road users.
Anderson *et al.* [50]/ 2018	The Pacific Northwest of Oregon	None	Ordered probit model	Several significant factors appear to influence the frequency of parking on shoulders and ramps, namely, driver attributes, travel features, parking shortages, real-time information, the performance of parking enhancements, and amenities of parking facilities.

(Table 5) contd.....

Boggs *et al.* [51]/ 2019	Freeways in Tennessee	Parking-related truck crashes	Bayesian binary logit models	Factors, such as the existence of a parking area on the exit, diverging ramps, ramps with illegal parking, and ramp attributes, contribute positively to crash frequency involving trucks parked on shoulder ramps.

Road users usually park for various reasons (*e.g*., fatigue, bathroom usage, food, severe weather, and/or to obey HOS regulations). However, when rest areas are unavailable, road users will experience a shortage of parking space and knowledge regarding any nearby parking facility available [56]. Drivers have two options: either proceed to drive and search for a parking spot at a designated rest stop or be forced to illegally park on the shoulder or ramp along the roadway's mainline [50, 52]. Both options raise safety and financial concerns [26, 50, 52, 54, 57, 58]. Truck operators may illegally park on the shoulder or ramp for various reasons (other than not finding adequate parking), such as to preserve privacy, for comfort and convenience, dissatisfaction with parking facility, or simply unfamiliar with the location of adequate facilities [53, 59].

Several studies have investigated shoulder parking issues and their relationship with shortages of parking facilities, as illustrated in Table **5**. Pigman *et al.* examined safety concerns related to shortage or inadequacy in Kentucky's parking facilities [23]. The study found that parking facilities with high utilization rates experience high levels of shoulder-related truck crashes compared to those with low utilization rates. The findings suggested that a saturated parking facility will create shoulder parking issues on its proximate segments. In 2015, research on truck parking was conducted for the Virginia Department of Transportation to determine patterns of parked trucks on unauthorized parking spots (*i.e*., shoulders or ramps) proximate to interchanges, rest areas, and welcome centers alongside corridors statewide [53]. The study concluded that illegally parked trucks pose safety risk concerns for road users. Anderson *et al.* applied the ordered probit model to explore the factors influencing truck drivers' choice to park on freeway shoulders and ramps [50]. The results revealed several significant factors, namely, driver attributes, travel features, parking shortages, real-time information, the performance of parking enhancements, and amenities of parking facilities. Boggs *et al.* analyzed the impact of truck parking shortage on the crash frequency of illegally parked trucks on freeway ramps in Tennessee [51]. The outcomes showed that a parking facility at the exit significantly increases the frequency of illegally parked trucks involved in accidents. However, the authors explained that truck drivers only attempt to park at illegal and unsafe areas when the parking facility exceeded its capacity. The research highlighted the importance of having sufficient parking spots at parking facilities for traffic safety.

4.1.3. A Shelter During Hazardous or Emergency Conditions

Road users may be forced to leave the roadway for several reasons: adverse weather, bad visibility conditions, road closures, or emergency circumstances [4, 6, 12]. Pahukula *et al.,* and Islam & Hernandez indicated that driving during extreme weather conditions increases the likelihood of sustaining a severe injury during a crash [60, 61]. When a traveling vehicle encounters minor mechanical failure on the roadway, the driver will proceed driving in the search for a safe and secure spot rather than unsafely stop on the roadway's shoulder [4, 6]. A rest area is considered to be a shelter under the aforementioned situation instead of parking at an undesignated or unsafe spot (*e.g*., the shoulder or ramp) [4, 6, 12]. Highway authorities also use rest area facilities as assembly points during unforeseen circumstances (*e.g*., weather, road condition, current traffic, *etc*.) to provide crucial information that helps travelers choose safe and comfortable routes [4]. However, no study has explored or measured the safety benefits of rest areas under adverse weather conditions or emergency situations [6]. It can be concluded that rest areas play an essential role in mitigating driving accidents in emergency and hazardous conditions.

4.2. Comfort and Convenience Benefits

One of the primary benefits of a rest area facility is to enhance the comfort and convenience for road users [4]. There is a general agreement that the benefits gained from rest areas do not come directly from the facility. Instead, these benefits originate from the generated impacts on roadways [62]. Carson *et al.* reported that several benefits can represent convenience and comfort associated with a rest area, including drinking fountains, bathrooms, vending machines, parking lots for heavy and light vehicles, accommodation, communication, entertainment, and availability of other amenities. Several benefits of convenience and comfort offered by rest areas are intangible and hard to quantify directly [6]. However, they can be measured by a proxied monetary value that assesses road users' willingness to pay for using rest area services [4, 6, 7]. Although the willingness to pay method is commonly used to estimate the cost of intangible benefits from rest areas, respondents of such surveys may underestimate the actual value of such benefits [4, 6, 7].

Moreover, amenities may vary from one rest area to another. The willingness to pay method cannot consider that variation in usage fees [6]. In 2011, Gates *et al.* conducted surveys on a set of willingness to pay at 15 rest areas and welcome centers in Michigan state [7]. A total of 2556 responses to the questionnaires indicated that potential values of comfort and convenience at typical rest areas and welcome centers are \$1.68 and \$2.21, respectively.

4.3. Benefits of Reduced Excess Travel and Diversion

Rest areas at partially and fully controlled access roadways affect road users' driving behaviors and attributes. Therefore, rest areas provide substantial benefits to road users by mitigating excess travel and diversion time that they may spend seeking desired services on the roadway (*e.g*., restroom, communication, safe parking spot, *etc*.) [4, 6, 7] other than protecting the infrastructure of secondary roadways [6]. In terms of rest area benefits, excess travel on limited-access roadways is known as the numerical difference between the actual distance needed to travel (*e.g*., distance or time) to the nearest commercial service centers (*e.g*., gas station, truck stop, small supermarket, *etc*.) and the actual distance needed to enter a rest area [4, 6, 7]. Carson *et al.* indicated that excess travel distances and detours result in additional costs related to consumption time and operation (*i.e*., consuming fuel, depreciating vehicle, vehicle deterioration, and maintenance cost) [6]. Thus, beneficial reductions from excess travel and diversion can be measured from the excess travel time and operating vehicle costs resulting from leaving a limited-access roadway in search of the nearest alternative service facility [5, 6].

In the case where a rest area is absent or inadequate on a roadway, road users would have the option to depart and search for alternative commercial services, park at an undesignated spot, or proceed driving to the next rest area [5, 62]. Estimating the travel time value relies upon several factors, such as vehicle type, occupancy, trip purpose, cost, information, and assumptions [6]. In this regard, Gates *et al.* conducted a survey on 762 rest area patrons in Michigan. One of the survey questions was, "If this rest area was closed, where would you have stopped instead?" [7]. Table **6** illustrates the patrons' alternative options as a response to the above question based on vehicle type and the total vehicle categories.

It can be seen that 61.7% of the total responses preferred to depart from the roadway in search of the desired services if the rest area is closed or inadequate. The survey also found that passenger vehicles are more likely to leave the roadway for an alternative service location than truck operators. Approximately 65.9% of road users prefer to leave the roadway in search of desired services, and 25.2% of them would choose to continue driving to the next rest area. However, the percentage of truck operators who would like to depart to seek similar services and those who would prefer to proceed driving to the next rest area is almost similar (38.3% and 39.1%, respectively).

Overall, the literature review has explored and summarized several benefits for road users that stem from the existence of rest areas on roadways. Table **7** illustrates the benefits, as mentioned earlier, based on category benefit type. It should be noted that the benefits of excess travel and diversion related to rest areas can be exclusively applied on limited-access roadways [7].

5. POTENTIAL ADVERSE EFFECTS OF REST AREAS

The literature search has identified several studies that demonstrated diverse inferences concerning the safety impact of using rest area facilities. Numerous researchers have examined the safety effect of the presence of rest areas on roadways, further assessing the crash frequency and injury severity on their proximate segments. Several studies have found a positive relationship between fatigue-related crashes and the spacing distance between two consecutive rest areas [22, 30, 41 - 48].

Table 6. Survey responses of rest area patrons regarding unavailable rest areas [7].

-	Passenger Vehicle		Truck		All	
-	Number of Responses	Percent of Total	Number of Responses	Percent of Total	Number of Responses	Percent of Total
Parked at Closest Exit with Alternative Service Facility	418	65.90%	44	38.30%	470	61.70%
Parked at Next Rest Area on Roadway	160	25.20%	45	39.10%	208	27.30%
Parked Alongside Roadway (Shoulder)	17	2.70%	16	13.90%	34	4.50%
Continue Driving (Not Stopping)	39	6.20%	10	8.70%	50	6.60%
Total	**634**	**100.00%**	**115**	**100.00%**	**782**	**100.00%**

Table 7. Potential benefits of rest areas for the travelling public [4], [6], [7].

Category	Benefit	Estimation Method
Safety	Reduction in Fatigue-related Crashes	Crash Analysis
	Mitigating Shoulder Parking Issues	
Comfort and Convenience	Restroom Access	Self-reported value of rest area services from road user surveys
	Rest/ Relax/ Walk	
	Break for Children	
	Picnic	
	Trip Planning/Navigation	
	Safeguard During Hazard/Emergency Conditions	
	Commercial Vehicle Parking	
Excess Travel and Diversion	Travel Time Savings	Reduction in excess travel time and distance to/from alternative services
	Vehicle Operating Cost Savings	

Table 8. Summary of previous studies highlighting the potential of existing rest areas regarding traffic safety.

Authors	Study Area	Crash Type	Methodology	Summary of Key Findings
Banerjee *et al.* [30]/ 2010	Freeways in California	All crashes	Two-sample t-test method	The patterns of non-fatigue-related crashes are significantly high within 30 miles downstream from rest areas and start declining past 30 miles. However, fatigue-related crashes have the opposite pattern.
Alkhatni [63]/ 2013	Interstate and US routes in Michigan	All crashes	Negative binomial and ordered probit models	The presence of weigh stations and rest area facilities along roadways is more likely to increase the crash frequency of nearest adjacent segments.
Chiou & Fu [70]/ 2015	Freeways No. 1 in Taiwan	All crashes	Multinomial generalized Poisson model with error components (ST-EMGP)	The existence of rest areas increases the crash frequency, the percentage of injury, and PDO crashes on freeway segments.
Hernández & Anderson [71]/ 2017	Corridor US-97 and segment of I-84 routs in Oregon	Truck crashes	Descriptive statistic/Survey analysis	Locations of truck collision hotspots are proximate to parking facilities and the segments between these facilities.
Manap *et al.* [72]/ 2019	North-south expressway in Malaysia	All crashes	Moran's I statistic test	Hotspots are mostly concentrated near traffic flow disturbed by road facilities, such as interchange ramps, slip roads, rest areas, or lay-bys.
Hadi *et al.* [73]/ 2020	Indonesia Toll Roads	All crashes	Negative binomial model	The presence of rest areas increases the crash frequency on toll segments with dual two-lane and some other road segments. Nevertheless, crash frequency reduces at toll segments with dual three-lane and has no effect on toll segments with dual four-lane.

Although the safety benefits of rest area facilities have been previously discussed, the design, location, and operation of rest areas and their proximate segments may pose safety concerns. Potential adverse effects of rest areas may result from the additional diverging and merging lanes and lane changing in the proximity of facility entrances and exits [1, 6, 63]. For instance, when truck drivers attempt to enter or exit a facility, a speed variation occurs on traffic stream, posing direct or indirect safety concerns at proximate segments [64]. Another example is that when trucks enter a rest area, they begin maneuvering and changing lanes to access the facility, thus causing safety risks at the mainline [1, 65].

Inadequate design or parking space shortage at rest areas may also contribute to road accidents along proximate segments [30, 44, 51, 54, 55]. Pigman *et al.* found that truck collision hot spots are directly related to parking facilities' proximity and utilization rate [23]. Banerjee *et al.* also reported a low crash frequency at rest area ramps and that most crashes related to rest area ramps occur in parking lots [30]. The authors suggested that inadequate design or parking space shortage may lead to this result. However, other researchers had found that crash severity decreased in the proximity of exit and entry ramp locations [66 – 68]. These studies have explained that drivers are usually attentive and reduce their speed while maneuvering to merge and diverge on ramps. Chiou & Fu, and Lang came to the same conclusion; however, they found that the presence of rest areas on roadways increases the likelihood of sustaining property damage only (PDO) during a crash [41, 69].

Essentially, several researchers have noted that the presence of rest areas in proximity to the mainline may generate road accidents (Table **8**). McArthur *et al.* explained that proximate segments to entry ramps of rest areas experience high crash frequency due to access issues [44]. Banerjee *et al.* found that the patterns of non-fatigue-related crashes are significantly high within 30 miles downstream of rest areas and begin to decline after 30 miles [30]. However, there is no clear evidence or explanation for this phenomenon regarding these segments in particular. Alkhatni indicated that the presence of weigh stations and rest area facilities adjacent to the mainline are more likely to increase crash frequency along with their nearest adjacent segments [63]. Chiou & Fu found that the presence of rest areas increases the crash frequency, the percentage of injury, and PDO crashes on freeway segments [70]. Hernández & Anderson identified truck collision hotspots close to parking facilities and the segments between those facilities [71]. The researchers suggested that some locations that experience a high frequency of truck crashes may be related to parking facilities, yet this relationship is ambiguous. Manap *et al.* indicated that hotspots are concentrated near traffic flow disturbed by road facilities, such as interchange ramps, slip roads, rest areas, or lay-bys [72]. More recently, Hadi *et al.* have found that the rest area's presence increases the crash frequency on toll segments with dual two-lane and other toll segments [73]. Nevertheless, crash frequency reduces at toll segments with dual-three lanes and has no effect on toll segments with dual-four lanes.

6. CHALLENGES AND RECOMMENDATIONS

Several issues and challenges have been encountered during the development and implementation of rest areas, including the spacing distance between rest areas, truck parking lot capacity, and the opportunities to decrease infrastructural costs while maintaining needed demand [7]. It is obvious from the literature that deficiency in rest area parking supplies poses safety and utilization concerns. Thus, it is highly recommended to embrace strategies to address the overcapacity issue and maintain an adequate parking supply [74]. In this regard, Fleger *et al.*, Kimley Horn, and Pigman *et al.* suggested employing other roadside facilities such as park and ride lots, weigh stations or using abandoned facilities as supplement parking lots to mitigate the demand for parking facilities (*i.e.*, rest areas and truck stops) [52, 59, 75]. Adopting public and private partnerships should be accomplished to cover the expenses associated with developing and constructing rest areas and road user services.

Numerous studies have investigated crash patterns around proximate segments of rest areas and parking facilities. Interestingly, this paper found several contradictory findings regarding the safety impacts of rest areas and parking facilities on road users. Some studies have concluded that these facilities are beneficial to improve the level of safety. Other research indicated that although these facilities may mitigate a particular type of crash (*i.e*., fatigue/sleep-related crashes), it is unclear how they affect other types of crashes.

Studies that explored fatigue-related crashes proximate to parking facilities further suggested that identifying the leading cause of such crashes is a difficult task and maybe inaccurate [6, 7, 30, 41, 44, 46, 51]. For instance, identifying a crash as fatigue-related may be biased and subjective from the aspect of police officers and/or other narrations. In 2011, fatigue-related crashes were 15%, and around 30% of collisions and fatalities from all crashes were in South Korea. This rate is very high compared to the US rate, which is 2.3% to 2.5% of all fatal crashes from 2011 to 2015, despite the vast difference in size between the two countries [45]. However, Wheaton *et al.* noted that between 15% to 33% of fatal crashes in the US are related to fatigue-related crashes [32]. Another study had stated that about 40% to 50% of severe injury crashes are related to fatigue driving accidents [22]. It can be noted that this variation in study outcomes may be attributed to inaccurate crash data and other factors. Fatigue-related crashes may be underreported for various reasons, such as insufficient report crash forms, biased police officer reports, and lack of information testimony [22, 34, 47, 76]. According to Stern *et al.,* two primary reasons make it hard to define whether a crash is attributed to fatigue or driving while sleepy [34]. First, the absence of a credible method makes it difficult to determine whether fatigue or sleeping factors are the primary cause of crash incidences. Second, crash risks can be attributed to several factors, such as driver demographics and behavior, vehicle properties, and roadway environment. Overall, researchers recommend that further studies should be conducted to determine the appropriate approach for investigating fatigue driving data and fatigue crash estimations.

Researchers recommend several beneficial strategies to enhance the safety aspect of rest areas. Studies recommend educating road users on the hazards and consequences of fatigue and sleeping behind the wheel and their proper countermeasures. Real-time information regarding the locations of adequate rest areas should be provided to road users. The level of security and safety should also be enhanced at rest areas by equipping them with lighting, CCTV cameras, patrols, etc [23, 53, 74]. Implementing the DDA system between two consecutive rest areas, particularly those with long spacing distances and/or in rural areas, is considered an effective countermeasure for fatigue-related crashes [22, 47]. Electronic logging devices mandate strategy and stricter enforcement. These have been introduced to force truck drivers to comply with HOS regulations [77]. These devices further minimize shoulder parking incidents alongside roadway segments. Proper strategies should also be adopted such as expanding the current parking supply with the use of intelligent transportation systems (ITS) to improve parking capacity as well as constructing a new parking facility [57, 78]. Finally, introducing intelligent transport, such as vehicular automation, is expected to mitigate fatigue driving issues [79] which can help minimize the utilization and presence of rest areas alongside roadways in the future.

The review emphasizes the concern of Hernández and Anderson’s study, *i.e*., the presence of rest areas and their impact on injury severity, frequency of crashes (excluding fatigue-related crashes), and accurate estimation of crash patterns on proximate segments have not been thoroughly investigated [71]. Proximate segments of rest areas have also not been sufficiently identified.

CONCLUSION

The present paper provided an extensive review of the literature featuring the beneficial impacts of rest area facilities. The potential adverse effects, challenges, and recommendations were also addressed. This paper reviewed the current literature works addressing the characteristics of rest area planning. Three main categories of rest area benefits were discussed and summarized as follows: the enhancement of traffic safety, improvement in the comfort and convenience of roadways, and reduction of excess travel and diversion. The strategies and planning implemented to evaluate and measure the benefits of rest areas from the aspect of road users were briefly reviewed and discussed. The review found that although several studies have found that establishing rest area facilities proximate to roadway segments has positive effects on safety and operation, the presence of such facilities may also pose safety and operation risks along with their adjacent segments.

The study noticed that most research works focused on analyzing fatigue-related crashes at proximate segments of rest areas while neglecting other crash types. Therefore, this review also highlights the following research gap, *i.e*., investigating the relationship between roadway features and crashes occurring along proximate segments of rest areas to understand the distribution patterns of crashes that occur on prominent segments of such facilities. For instance, sensitivity comparison analysis should be performed on the collisions occurring near ramps of rest areas and similar geometric facilities (*e.g*., interchanges, slip roads, and weigh stations) to identify the contributing factors of crashes. Temporal and spatial analysis are other study areas that can be performed to determine crash patterns related to rest areas. Incorporating these study areas with a simulation approach to model the impact of rest areas on driving behavior would provide conclusive results.

Finally, the paper summarized and discussed the challenges and recommendations regarding the rest area's implementations and safety evaluation. This work also provided valuable information that can aid decision-makers and safety engineers in improving the benefits, safety, and planning of parking facilities in general.

CONSENT FOR PUBLICATION

Not applicable.

FUNDING

This work was supported by the Universiti Teknologi MARA (UiTM).

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS

The authors would like to thank Universiti Teknologi MARA (UiTM), Malaysia for their financial support. The authors also are grateful to Dr. Valerian Kwigizile for offering valuable suggestions and recommendations to improve the paper.

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