Mediterranean Journal of Basic and Applied Sciences (MJBAS)
Volume 8, Issue 3, Pages 58-69, July-September 2024

Developing a Safety system for a new electric small family car (VW Golf Vehicle)

Gaspard Ukwizagira[1*], Amon Gasagara[2] & Patricia Dzigbordi Afedo[3]

[1]*Assistant Lecturer, Department of Civil Engineering, Rwanda Polytechnic/IPRC Huye, Huye-Rwanda, and Master Student, Transportation Sciences, Hasselt University, Belgium.* [2]*Doctor of Engineering, Deputy Principal in charge of Training, Rwanda Polytechnic/IPRC Huye, Huye-Rwanda.* [3]*Master Student, Transportation Sciences, Hasselt University, Belgium.*
Corresponding Author Email: ukwizagiragasp@gmail.com[*]

DOI: https://doi.org/10.46382/MJBAS.2024.8306

Article Received: 16 May 2024 *Article Accepted: 27 July 2024* *Article Published: 30 July 2024*

ABSTRACT

The developments for new electric small family car safety systems have significantly contributed to the overall reduction in road fatalities and severe injuries in Europe, with advanced safety technologies addressing the gap in the existing small family car rated at Euro-NCAP. People are much more likely to die in crashes that include a car. Vulnerable Road users represent a high number of fatalities due to a collision with motorized vehicles. Fatalities overwhelmingly occur in collisions between cars, trucks, and other impacts. The safety performance of cars needs to be further improved as part of an integrated road safety approach to protect vulnerable road users better as well as car occupants. Improving in-vehicle technologies increases vehicles' performance and capabilities to interact with the road driving environment, helping or replacing the driver to manage unexpected and unsafe traffic situations. This paper will describe adult restraints as passive safety systems and Active Safety systems for new cars (Electric) to be done by The Geely Motor Group. The proposed recommendation, according to the gaps that occur in VW Golf vehicles after comparing them with other vehicles, is described.

Keywords: Euro-NCAP; Vulnerable road users; Motorized vehicles; Passive safety; Active safety; Fatalities; Injuries; Crashes; Adult restraints.

1. Introduction

Adult Restraints and Active Safety systems for the new car are the basis for ensuring the safety of people in a car. Over the past decades, In-vehicle safety systems have substantially contributed to reducing road fatalities and severe injuries in Europe. However, many people are still losing their lives in crashes. Car safety systems are divided into two categories: active safety and passive safety systems. Active car safety systems are designed to prevent crashes from occurring in the first place. These systems use sensors and other technologies to detect potential hazards and provide warnings or intervene to prevent crashes from happening (Mikusova, 2017). Passive car safety systems are designed to protect the car occupants during a collision. These systems are not actively engaged by drivers.

Still, they are designed to work automatically in the crash to reduce the force of impact on occupants and prevent or minimize injuries. Adult Constraints are part of passive car safety systems designed to protect adult car occupants (Altaf, 2016). The effectiveness of a safety car system is not only related to its capacity to detect danger and the accuracy or power of mechanisms designed to prevent it but also to the efficiency of the human-machine interface (HMI) or the aggregate of means by which drivers interact with their motorized vehicle. As automotive safety is one of the critical success factors in the market, every company must have a strategy or a set of techniques that allow them to manufacture a competitive vehicle in terms of safety, considering their targeted market.

1.1. Study Objectives

The main objective of this study is to develop a safety system for new electric small family cars.

(i) To study the safety system of some electric small family cars by EURO-NCAP.

(ii) To compare the safety system of various vehicles with the VW Golf vehicle.

(iii) To assess the gap, that occurs in VW Golf vehicles and propose a solution.

2. European background

In 2020, there were an estimated 758,000 road crashes, and 18,800 people were killed on the European Union roads (European Commission, 2022). Although the COVID-19 restrictive measures on passenger transport are primarily responsible for the drop in road deaths compared with 2019 (-17%), the absolute number of fatalities in EU countries remains of concern. Additionally, more than 500,000 people were injured in road crashes during 2020. Among the most vulnerable during traffic crashes, occupants of small vehicles such as passenger cars are included. Car occupants (drivers and passengers) accounted for 43% of all road deaths, meaning they still need more protection (Pawłowski, et al., 2019).

Despite the actions taken to enhance road safety, injuries arising from traffic incidents continue to be a severe health and economic concern in European Union countries (Pawłowski et al., 2019). Ways to address this issue, the EU has implemented various regulations and initiatives to improve vehicle safety, such as testing the safety of new vehicles sold in Europe (Euro NCAP). These efforts have contributed to decreased road fatalities and injuries in the EU in recent years but are not enough. Continued effort is needed to ensure that vehicles become even safer. Road crashes continue to decline as planned in the Decade of actions for global Road Traffic Safety (Mayorov et al., 2023).

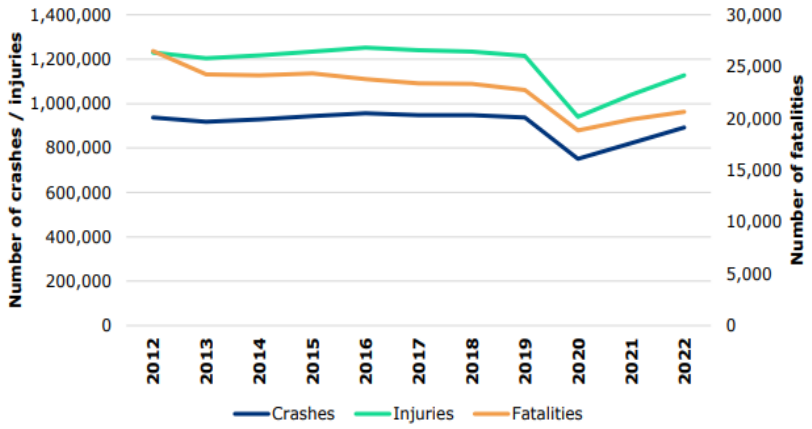


Figure 1. Number of road crashes, fatalities, and injured people in the EU (Annual et al., 2024)

3. Competitors' benchmarking

Consumers are beginning to expect assisted-driving features as a condition of buying. On the other hand, automakers must focus on producing better cars and providing better experiences to stay competitive in the changing automotive industry. In Europe, testing newly manufactured vehicles is one of the strategies used to assess car competencies and maximum protection for occupants and external road users. Based on regulations and standards set by the European Union, Euro NCAP organizes crash tests on vehicles and provides consumers with a realistic safety performance of some of the most popular cars sold in Europe. After testing a new vehicle, the Euro-NCAP rate stars according to performance and compliance with preset safety standards and four assessment

areas. Different articles have been established by describing the specific requirements for vehicles. The article 5 of the Regulation (EC) No 661/2009 specifies general requirements for all vehicles. Anti-lock Braking Systems appear here, among others. Manufacturers must ensure that new vehicles are designed, constructed, and assembled according to safety measures to minimize crashes and injury to vehicle occupants or vulnerable road users (European Parliament, 2019). A series of technology tests and crash test dummies are designed and carried out to assess the level of safety of individual cars under the four main assessment areas:

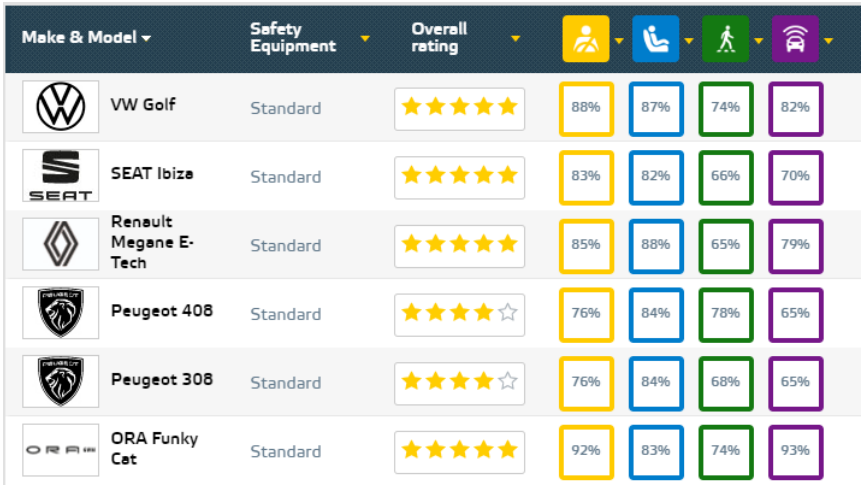
● **Adult occupant protection:** This is calculated using frontal, lateral, and whiplash tests to assess the vehicle's safety for adult drivers and passengers, as well as an assessment of the mechanisms in place for rapid and safe rescue and extrication.

● **Child occupant protection:** The assessment of the Child Protection rating is based on three factors: the protection provided by child restraint systems in frontal and side-impact tests, the vehicle's ability to accommodate various sizes and designs of child restraints, and the availability of provisions for safe child transport in the car.

● **Vulnerable road user protection:** Euro NCAP tests show how well vehicle systems can protect vulnerable road users. Injury risks to a pedestrian's head, pelvis, and upper and lower leg are assessed. Cars with an automatic emergency braking system (AEB) that identifies pedestrians and bicycles can get extra points.

● **Safety Assist:** The score is based on tests of the essential driver-assist technologies that can help safe driving and prevent or minimize accidents. Euro NCAP evaluates systems operation performance in everyday driving and probable accident scenarios. The tested safety assist technologies include AEB car-to-car, Occupant status monitoring, Speed assistance, and Lane support.

The VW Golf car is a small family car class rated with five stars. It means that they have all met Euro NCAP safety standards and regulations and demonstrated high safety performance in all tested areas.



Make & Model	Safety Equipment	Overall rating				
VW Golf	Standard	★★★★★	88%	87%	74%	82%
SEAT Ibiza	Standard	★★★★★	83%	82%	66%	70%
Renault Megane E-Tech	Standard	★★★★★	85%	88%	65%	79%
Peugeot 408	Standard	★★★★☆	76%	84%	78%	65%
Peugeot 308	Standard	★★★★☆	76%	84%	68%	65%
ORA Funky Cat	Standard	★★★★★	92%	83%	74%	93%

Figure 2. 2022 Year, Euro NCAP Rating

3.1. Passive and active safety systems fitted in 2022 tested cars

All safety systems developed in selected top 5 cars tested in 2022 are divided into passive and active safety systems. Passive safety systems absorb or limit the injuries or damage to vehicle occupants or vulnerable road

users once a crash occurs. Active safety systems prevent the crash from happening or reduce the severity of an impact. Based on the car rating described in Fig, Table 1-4 details all available technologies in small family cars, such as the VW Golf, Seat Ibiza, and Renault Megane E-Tech, Peugeot 408, Peugeot 308 and Ora funky (small family car).

Table 1. Passive safety systems-Frontal crash protection (Source: Euro NCAP, 2022)

Safety systems	Occupant	VW Golf	Seat Ibiza	Renault Megane E-Tech	Peugeot 408	Peugeot 308	Ora funky cat
Front Airbag	Driver	Yes	Yes	Yes	Yes	Yes	Yes
	Passenger	Yes	Yes	Yes	yes	Yes	Yes
	Rear	N/A	N/A	N/A	N/A	N/A	N/A
Belt pretensioner	Driver	Yes	Yes	Yes	Yes	Yes	Yes
	Passenger	Yes	Yes	Yes	Yes	Yes	Yes
	Rear	Yes	Yes	Yes	Yes	Yes	Yes
Belt load limiter	Driver	Yes	Yes	Yes	Yes	Yes	Yes
	Passenger	Yes	Yes	Yes	Yes	Yes	Yes
	Rear	Yes	Yes	Yes	Yes	Yes	Yes
Knee airbag	Driver	No	No	No	No	No	No
	Passenger	No	No	No	No	No	No
	Rear	N/A	N/A	N/A	N/A	N/A	N/A

Table 2. Passive safety: Side crash protection

Safety systems	Occupant	VW Golf	Seat Ibiza	Renault Megane E-Tech	Peugeot 408	Peugeot 308	Ora funky cat
Side head Airbag	Driver	Yes	Yes	Yes	Yes	Yes	Yes
	Passenger	Yes	Yes	Yes	Yes	Yes	Yes

	Rear	Yes	Yes	Yes	Yes	Yes	Yes
Side chest airbag	Driver	Yes	Yes	Yes	Yes	Yes	Yes
	Passenger	Yes	Yes	Yes	Yes	Yes	Yes
	Rear	N/A	No	No	No	No	No
Side Pelvic Airbag	Driver	No	Yes	No	No	No	Yes
	Passenger	No	Yes	No	No	No	Yes
	Rear	No	No	No	No	No	No
Centre Airbag	Driver	Yes	No	Yes	No	No	Yes
	Passenger	Yes	No	Yes	No	No	Yes
	Rear	N/A	N/A	N/A	N/A	N/A	N/A

Table 3. Passive safety systems protection (Source: Euro NCAP, 2022)

Safety systems	**Occupant**	**VW Golf**	**Seat Ibiza**	**Renault Megane E-Tech**	**Peugeot 408**	**Peugeot 308**	**Ora funky cat**
Isofix/i-size	Driver	N/A	N/A	N/A	N/A	N/A	N/A
	Passenger	Yes	No	Yes	No	No	No
	Rear	Yes	Yes	Yes	Yes	Yes	Yes
Integrated Child Seat	Driver	N/A	N/A	N/A	N/A	N/A	N/A
	Passenger	No	No	No	No	No	No
	Rear	No	No	No	No	No	No
Airbag cut-off switch	Driver	N/A	N/A	N/A	N/A	N/A	N/A
	Passenger	Yes	Yes	Yes	Yes	Yes	Yes
	Rear	N/A	N/A	N/A	N/A	N/A	N/A

Table 4. Active safety systems-Safety Assist (Source: Euro NCAP, 2022)

Safety systems	Occupant	VW Golf	Seat Ibiza	Renault Megane E-Tech	Peugeot 408	Peugeot 308	Ora funky cat
Seatbelt Reminder	Driver	Yes	Yes	Yes	Yes	Yes	Yes
	Passenger	Yes	Yes	Yes	Yes	Yes	Yes
	Rear	Yes	Yes	Yes	Yes	Yes	Yes
Active Bonnet		No	No	No	yes	No	No
AEB Vulnerable Road Users		Yes	**Yes**	**Yes**	Yes	Yes	Yes
AEB Pedestrian – Reverse		No	No	No	No	No	Yes
AEB Car-to-Car		Yes	Yes	Yes	Yes	Yes	Yes
Speed Assistance		Yes	Yes	Yes	Yes	Yes	Yes
Lane Assist System		Yes	Yes	Yes	Yes	Yes	Yes

As described in the tables above, Euro NCAP rates the selected cars. The resulting star rating levels indicate the level of safety the vehicle provides to its occupants and pedestrians when a crash occurs. It also defines the vehicle's technological ability to avoid or minimize the effects of a collision. Concerning Figure 2, four cars are rated five stars and two with four stars; however, their safety protection levels differ based on all tested details, as in Table 1-4. While VW Golf and Ora funky are the best class compared to other classes with an overall rate for adult occupant protection of 92% scores for Ora funky and 88% for VW Golf but with 92% score for Safety Assist (Ora) and 82% for VW and vulnerable road users Peugeot is better with 78%, For child occupants Renault is better with 88%. By going through the specification, VW Golf is better than other classes even if there are some defects to be treated.

4. Description of Passive Safety Systems

4.1. Front crash protection

1. Seatbelt pre-tensioner and load limiter: According to (Walz 2004) seatbelt pre-tensioner tightens the seatbelt to keep the occupant securely in their seat, using an explosive charge or a pyrotechnic device to retract the seatbelt quickly, removing any slack that may have been in the belt. At the same time, load limiters allow safety belts to yield in a crash. Combining pre-tensioners and load limiters considerably improved automobile belt efficacy. If the belt incorporates a pre-tensioner and a load limiter, a belted driver or right-front passenger has a 12.8 percent decreased fatality risk (Kahane, 2013). For the VW Golf, both the seatbelt pretensioner and load limit are safe for the driver, passenger and rear.

2. Frontal Airbags (Steering wheel, Foot, and Knee): Frontal airbags that deploy from the steering wheel to prevent the driver from striking other parts of the car in a frontal crash. In addition, they include knee airbags and footbags installed in the lower portion of the dashboard to reduce leg and foot injury risks. With effective restraint systems, front airbags reduce the risk of death or severe head injury in a frontal impact crash by more than half.

4.2. Side crash protection

1. Side airbags: Such airbags are usually located in the seat's backrest and inflate between the door and the seat occupant. Side airbags can reduce serious chest injuries in side-impact collisions by approximately 25%. There are two types of airbags. First is the torso airbag, which protects your torso, and the second is the curtain airbag, which deploys from the car ceiling to safeguard your head. Monash University Accident Research Centre (MUARC) reported in 2012 that the combination of curtain and side torso airbags reduced by 60% the incidence of severe injury and death in side impacts (Dominguez & Fraser, 2019).

2. Central airbags: The operation of airbags is the same as that of side or frontal airbags. However, in a test conducted by Euro NCAP, the Born's Center airbag, designed to reduce injuries from occupant to occupant in side crashes, performed well.

4.3. Rear crash protection (Whiplash)

Neck injuries are the most frequent serious injuries reported in car collisions. According to Smith and Pharm (2019), initial strategies to protect the neck and avoid whiplash are based on car seat design and the introduction of head constraints intended to constrain the head in a collision. The high-protection seats appear to reduce the risk by more than 50%. According to Euro NCAP (2022), Tests on the front seats and head restraints of VW Golf demonstrated good protection against whiplash. A geometric analysis of the rear seats also indicated good whiplash protection. Furthermore, the design should be forgiving for different sizes of occupants and sitting postures (Victor, 2015). The headrests are also positioned at a height that is level with the occupant’s head, which helps to prevent excessive movement of the head and neck during a collision (Volvo, 2020).

4.4. Rollover crash protection

A rollover occurs when a car rolls over on its side or roof during a collision before coming to a stop. This incidence rate is escalated by different factors, including distracted driving, speeding, and drinking (El-Menyar, et al., 2014). Rollover sensing side airbags with head/torso protection keep occupants in the vehicle and prevent occupants from hitting the window, roof rail, A-pillar, or B pillar, fracturing skull, head, and brain injuries.

Figure 3. Rollover examples

5. Description of the Active safety system

5.1. Warning-only systems

These systems are established to warn the driver but do not take any action to prevent an accident. When the system detects a potential hazard, it will warn the driver, usually as a visual or audible alert.

1. Seatbelt reminder systems (SBRS): Seat belt reminders are intelligent, visual, and audible devices that detect whether seat belts are worn in various seating positions and issue increasingly alarming signals until worn. When the system notices that a seatbelt is not worn, it will sound an audible bell or turn on a warning light to remind drivers and passengers to fasten their seatbelts. The alert continues until the seatbelt is buckled or the car is switched off. According to the Euro NCAP, the VW Golf seatbelt reminder system operates well and meets the standards.

2. Blind Spot Detection (BSD): The blind spot detection system avoids 61-95% of fatal accidents that should occur during lane changes. Radar or camera sensors are mounted on the sides or the rear of the vehicles, near the side mirrors or rear bumper. The sensor scans the surrounding areas, looking for other cars approaching from the side or rear. If the sensor detects a vehicle in the blind spot, the system alerts the driver with a visual or audible warning through the side mirror or dashboard.

Figure 4. Blind spot monitoring

3. Drowsiness and attention detection systems (DADS): These systems help drivers stay alert and focused while driving, reducing the risk of crashes caused by fatigue or distraction. Fatigue and microsleep at the wheel are often the cause of serious accidents. A driver drowsiness detection system is an artificial intelligence-based solution that uses a vision-based analysis system to detect driver fatigue, drowsiness, and distraction. Algorithms analyze these signals to determine the driver's degree of attentiveness and concentration. If the system detects the driver's sleepiness or distraction, it will often sound an alert, display a warning on the dashboard, or vibrate the steering wheel or seat to notify the driver.

(DADS)

4. Speed limit information (SLI): Driving at excessive or inappropriate speed is a significant threat to safety on the road. It is estimated that 10 to 15% of all crashes and 30% of all fatal crashes directly result from speeding or inappropriate speed (Regulations EU, 2019-2144). SLI detects and reads speed limits along the road; the system displays information to the driver through the car’s dashboard, allowing the driver to easily see the current speed limit and adjust the speed accordingly.

5. Tyre pressure monitoring systems (TPMS): Underinflated tires have more sidewall flexion than properly inflated tires, resulting in lower fuel economy, sluggish handling, longer stopping distances, increased stress on tire components, and heat buildup, all of which can result in severe tire failures like cracking, component separation, or blowout. These failures can result in a loss of vehicle control and collision. Using a wheel-mounted sensor, TPMS monitors the air pressure of a vehicle's tires. The sensor then displays the information on the car's dashboard.

6. Lane departure warning (LWD): This system uses a camera or sensors to monitor the car's position within the lane. A vehicle's lane departure warning system uses front-facing cameras on the windshield next to the rearview mirror. Cameras keep an eye on lane markings. When the turning signal is not on, the system warns the driver if the car starts deviating from the suggested lane. A lane departure warning signal may sound, appear on the dashboard, or cause the driver's seat or steering wheel to vibrate. This system was introduced in a single vehicle in the US. However, LDW reduces injury occurrences by 21% (Lane Departure Warning: What LDW Is & How It Works, 2021).

Figure 5. Lane departure warning

7. Forward Collision Warning (FCW): This system uses sensors to detect the distance and speed of the vehicles in front of the car. If the system determines that a collision is imminent, it will provide an audible or visual warning to the driver to take action.

5.2. Semi-autonomous systems

1. Adaptive Cruise Control (ACC): When slower-moving traffic is detected, the system automatically uses the vehicle's forward-looking radar or cameras to adjust the speed. The driver sets a maximum speed, and the car keeps it but also has the option to slow down if another car gets in the way automatically.

2. Anti-lock braking systems (ABS): Many crashes occur due to skidding and wheel lock due to heavy brakes. ABS systems help prevent vehicle wheels from locking when braking heavily and enable the driver to keep steering. ABS sensors on each wheel detect wheel locking or skid and then pump the brakes hundreds of times a second. This stops the wheels from skidding and helps keep the driver in control of the vehicle.

3. Lane Keeping Assist (LKA): This system is designed to help the driver maintain a vehicle's position within the lane. LKA system has two options: system and autonomous assist. The LKA technology uses the camera positioned on the windshield to identify lane markings. If the vehicle approaches or crosses a sideline, a vibration in the steering wheel will inform the driver (Sternlund et al., 2017). According to Utriainen et al. (2020), the

number of crashes involving a vehicle with LKA reduced head-on and single-vehicle crash types by 33% in Australia and New Zealand and 53 in Sweden.

4. Electronic Stability Control (ESC): ESC helps prevent a vehicle from skidding and prevents the driver from losing control while turning a corner. ESC technology can automatically activate the brakes to help steer the car in the right direction. ESC is highly effective in reducing single-vehicle crashes in cars and SUVs. Fatal single-vehicle crashes involving cars are reduced by about 30-50% and SUVs by 50-70% (Ferguson, 2007).

5.3. Fully autonomous systems

1. Advanced e-Call system: This emergency response system is designed to alert emergency services when serious road crashes occur automatically. Assists in the instant notification of a crash to emergency services. When a collision is detected, the system sends a minimum set of data containing information about the occurrence, such as the geographic location and the vehicle identification. The signal contains information regarding the collision scene, the collision's time, and the number of passengers in the car.

2. Intelligent speed assistance (ISA): ISA systems can actively prevent drivers from exceeding the speed limit using road sign recognition cameras or GPS-linked speed-limit databases. The system advises drivers of the current speed limit and automatically limits the vehicle's speed by the limit speed of that area. When the speed limit of the road is detected, ISA does not automatically apply the brakes. Still, it limits engine power, preventing the vehicle from accelerating beyond the current speed limit.

3. Alcohol interlock installation facilitation: This system prevents a driver from driving while under the influence of alcohol. The device will examine the breath sample through a tube or mouthpiece attached to the device. The vehicle will start if the blood alcohol content is below the device's limit. The car can't begin if the driver's BAC is above the legal limit (Sitran et al., 2014).

4. Event data recorders (EDR): A device installed in the car to record technical vehicle and occupant information before, during, and after an event, typically a crash or near-crash event. These data or records can be valuable when analyzing and reconstructing an accident.

5.4. Gaps of the VW Golf highlighted by the Euro-NCAP test

After looking at the results of the Euro-NCAP test of the VW Golf and comparing them to the other five cars of the small family class, the VW Golf Active Bonnet is a fully automatic system that uses pyrotechnics to lessen head injuries for both cyclists and pedestrians in frontal collisions When the collision occurs, the front bumper's sensors can detect an impact on a pedestrian. There is a gap also between the Knee Airbags and the Side Pelvis Airbags. The Knee airbags protect occupants from knee and leg injuries caused by front collisions. However, side pelvis airbags protect against pelvic injury to the occupant. If the new electric small family car is equipped with Knee and pelvis airbags for all occupants, it will be an added value during performance tests.

6. Conclusion

European Parliament 2019 declared that the current safety approach would only handle the effects of increasing traffic volumes with new measures on general road safety. Thus, the safety performance of vehicles needs to be

further improved as part of an integrated road safety approach to protect road users better. The VW Golf vehicle has some safety gaps that need to be improved, such as the safety of knee airbags, side pelvis airbags, and active bonnet. Apart from filling the above-mentioned gaps, the VW Golf cars should be fitted with trusted passive safety systems such as Seat belt pre-tensioners and load limiters. It should be equipped to each seat to ensure an efficient restraint system that could contribute to comfort and reduce direct and indirect crash impacts inside the new electric vehicles. Airbags should be designed for cars with a minimized possibility of body and vehicle contact during crashes. The overall recommendation is to comply with the minimum requirement of the European standards for the abovementioned gaps, mixing a passive safety system (the best of the class in adult restraints) with an active safety system by adding some active safety systems such as Blind Spot Detection, Drowsiness and attention detection systems (DADS), Speed limit information Tyre pressure monitoring systems, Forward Collision Warning gives a safer car than those on the market and promote safe driving and real-time warnings to minimize crash risks. After covering those gaps in airbags and active bonnet with the active safety system, the VW Golf will be the best compared to other remaining vehicles in the competition. When assessing and comparing the safety of different cars, particularly the VW Golf and its competitors, it's crucial to prioritize models with high safety standards, specifically those that have received a 5-star rating from EURO-NCAP. To ensure you choose a car with the highest safety standards, focus on models with 5-star EURO-NCAP ratings. Golf is a reliable option, but competitors also offer excellent safety.

Declarations

Source of Funding

This study did not receive any grant from funding agencies in the public, commercial, or not–for–profit sectors.

Competing Interests Statement

The authors declare no competing financial, professional, or personal interests.

Consent for publication

The authors declare that they consented to the publication of this study.

Authors' contributions

All the authors took part in literature review, analysis, and manuscript writing equally.

References

Altaf, S. (2016). Passive & Active Safety System in Car. Retrieved from https://www.academia.edu/24259734/Passive_and_Active_Safety_system_in_Car.

European Commission (2022). Annual statistical report on road safety in the EU, 2021. European Road Safety Observatory, Brussels, European Commission, Directorate General for Transport.

Dominguez, S., & Fraser, T. (2019). Whichcar. Retrieved from https://www.whichcar.com.au/car-advice/what-airbags-do-and-how-airbags-keep-you-safe.

El-Menyar, A., Latifi, R., Parchani, A., Peralta, R., Tuma, M., Zarour, A., & El-Hennawy, H. (2014). Epidemiology, causes and prevention of car rollover. Annals of Medical and Health Sciences Research, 4(4): 495. doi: https://doi.org/10.4103/2141-9248.139279.

Ferguson, S.A. (2007). The Effectiveness of Electronic Stability Control in reducing real-world. Traffic Injury Prevention, 8(4): 329–338. doi: https://doi.org/10.1080/15389580701588949.

Kahane, C.J. (2013). Injury vulnerability and effectiveness of occupant protection technologies for older occupants and women. Retrieved from https://caradas.com/understanding-adas-lane-departure-warning/.

Mayorov, V.I., Denisenko, V., & Solovev, G.S. (2023). A systemic approach to road safety in the EU. JURÍDICAS CUC, 19(1). doi: https://doi.org/10.17981/juridcuc.19.1.2023.09.

Mikusova, M. (2017). Crash avoidance systems and collision safety devices for vehicle occupants. 107. doi: https://doi.org/10.1051/matecconf/201710700024.

Pawłowski, W., Lasota, D., Goniewicz, M., Rzońca, P., Goniewicz, K., & Krajewski, P. (2019). The effect of ethyl alcohol upon pedestrian trauma sustained in traffic crashes. International Journal of Environmental Research and Public Health, 16(8). doi: https://doi.org/10.3390/ijerph16081471.

Sitran, A., Pastori, E., & Rosa, C. (2014). Technical development and deployment of alcohol interlocks in road safety policy. Retrieved from https://www.researchgate.net/publication/278714875_Technical_development_and_deploym.

Smith, B.Y., & Pharm, B. (2019). Whiplash Protection System. Volvo, Pages 1–5.

Sternlund, S., Strandroth, J., Rizzi, M., Lie, A., & Tingvall, C. (2017). The effectiveness of lane departure warning systems–A reduction in real-world passenger car injury crashes. Traffic Injury Prevention, 18(2): 225–229. doi: https://doi.org/10.1080/15389588.2016.1230672.

Utriainen, R., Pollanen, M., & Liimatainen, H. (2020). The safety potential of lane-keeping assistance. IEEE Transactions on Intelligent Vehicles, 5(4): 556–564. doi: https://doi.org/10.1109/tiv.2020.2991962.

Victor, L., Lindman, M., & Björklund, T. (2015). Rear-End impact – crash prevention and occupant.

Volvo (2020). Whiplash protection system.

Walz, M. (2004). NCAP test improvements with pretensioners and load limiters. Traffic Injury Prevention, 5(1): 18–25.