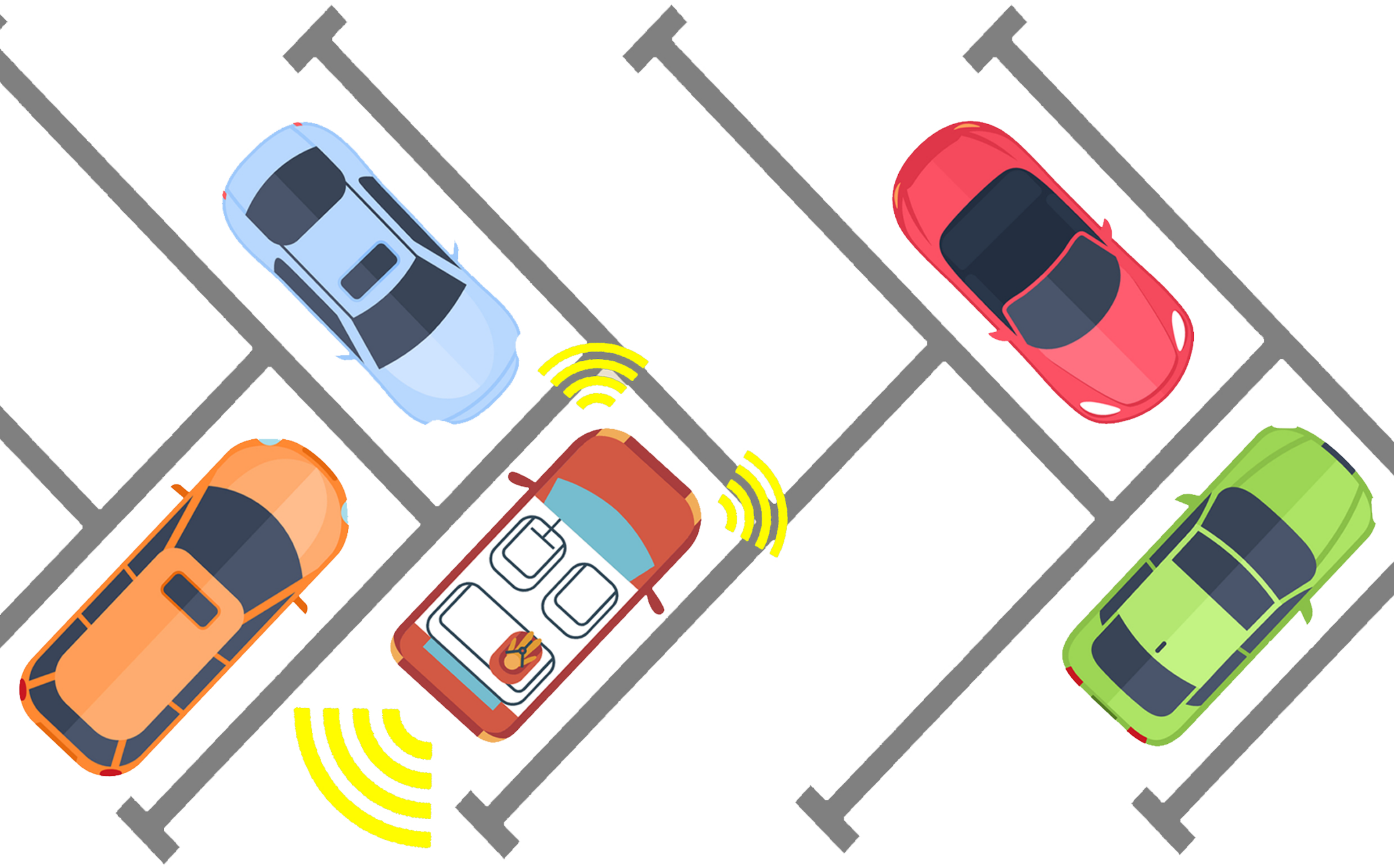
Child Presence Detection (CPD): Assessment Methodology & Guidelines for ASEAN NCAP

ASEAN NCAP COLLABORATIVE HOLISTIC RESEARCH [ANCHOR II]



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This research report comprised of all research activities on *Child Presence Detection (CPD): Assessment Methodology & Guidelines for ASEAN NCAP.* This research work is conducted in collaboration between UTM through its spin-off company ACTS Smart Solutions Sdn. Bhd. with MIROS and ASEAN NCAP. Other contributors include the Politeknik APP, Indonesia and Kasetsart University, Thailand.

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REPORT OUTLINE

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1 Introduction

1.1 Background of Project

There have been several tragic incidents in which children have been unintendedly left in closed parked vehicles after the drivers had reached their destination. Infant and young children are vulnerable to heat due to their physiological and behavioural characteristics. Globally, small children lose their lives due to being locked in the car under hot weather, either accidentally by the children themselves or forgotten by their guardians. According to Null (2016), an average of 38 children have been killed every year due to heatstroke in a locked automobile in the USA between 1998 and 2014. About half of the cases were due to parents leaving a child unintentionally in the car, while approximately 29% were due to children amusing themselves in parked vehicles, and another 18% were due to children being left intentionally by their caretakers. Meanwhile, a news analysis performed by Malaysian Institute of Road Safety Research (MIROS) on the matter found a total of 9 cases related to child death in parked vehicles until the end of 2018 (Mohd Jawi, 2018); the statistics increased in 2020 with three recent cases, making the number of total case to 12 (Figure 1).

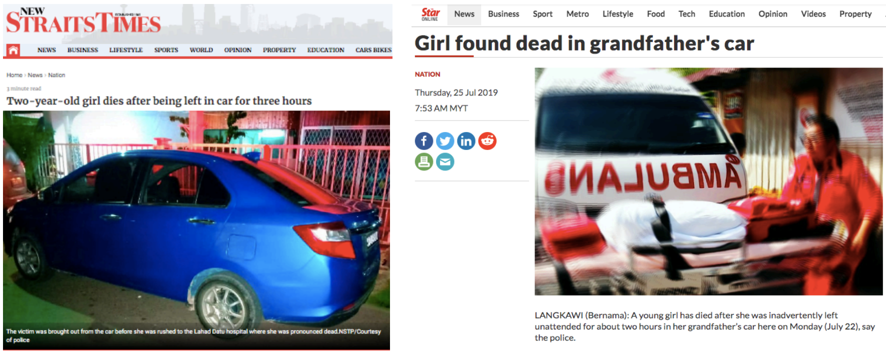

Figure 1: Newspaper clips regarding recent death cases of forgotten children in Malaysia

These unfortunate events often occur in countries with hot climate; usually caused by a condition called Vehicular Hyperthermia or Vehicular Heating, where the heat causes human core body temperature to exceed the normal value of around 37°C. As the core body temperature rises above 40°C, medical emergencies such as convulsions, coma, and ultimately, death can occur as depicted in Figure 2 (Ismail, 2018). Meanwhile, those who survive hyperthermia could experience severe and permanent neuropsychological deficits (Duzinski et al., 2014).

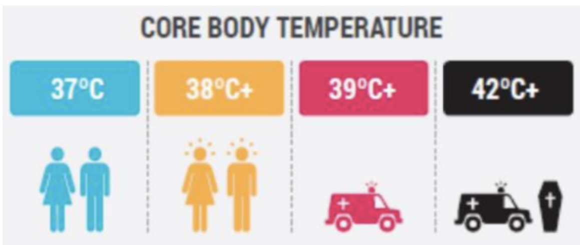

Figure 2: Effects of rising core body temperature (taken from Ismail, 2018)

When a vehicle is parked with all windows closed under direct sunlight, the vehicle interior temperature can build up into excessive heat in response to the greenhouse effect. The phenomenon is illustrated in Figure 3, where yellow arrows representing sunray entering a vehicle through its windshield. The heat is absorbed by vehicle interior parts such as seats, floor mats and dashboard, which in turn radiates within the vehicle cabin (red arrows) resulting in temperature increase inside the vehicle.

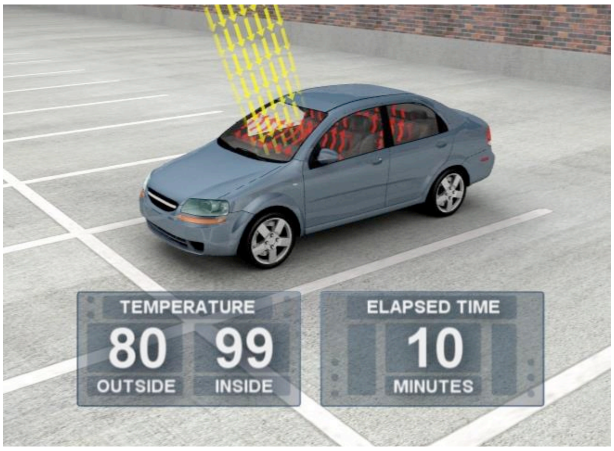

Figure 3: Temperature reading (in degree Fahrenheit) for closed vehicle within 10 minutes (Reproduce by Grundstein *et al*., 2009)

According to Abu Kassim (2018), 80% of the increase in vehicle interior temperature happens in the first 10 minutes, while Hwong (2018) - a Child Passenger Safety Consultant from Childline Malaysia, reported that a car interior temperature can rise by 16°C within 20 minutes. There are also various studies on temperature increase in vehicles, as summarised by Grundstein *et al*. (2010) in Table 1. This information on maximum temperature change rates inside motor vehicles should be useful in educating the public about the dangers of vehicle-related hyperthermia. The information provided by Grundstein *et al*. (2010) is vital, especially when coupled with temperature data within ASEAN countries. An article published by LivingASEAN in April 2017 outlined the highest recorded temperatures in the ten ASEAN countries (Figure 4). Myanmar recorded 47.2°C in May 2010, followed by Thailand at 44.6°C on April 28, 2016. Vietnam, Cambodia, Laos, and the Philippines observed a temperature of around 42°C between 2015 and 2016, while Malaysia recorded 40.1°C at Chuping on April 9, 1998. Indonesia, Singapore and Brunei all have recorded maximum temperature above 35°C.

Table 1: A summary of maximum temperature change rates inside motor vehicles by Grundstein *et al*. (2010)

Study	5 min	10 min	30 min	60 min	Max	Instrument type and location	Parked (h)	Location and dates
Gibbs et al. (1995)	7	16	24	27	60	Electronic; placed on front seat	1.5	New Orleans, LA; 27 Jul 1995; 1430–1600 LT
Grundstein et al. (2009)					76	Electronic; 15 cm below roof center	6	Athens, GA; 1 Apr–31 Aug 2007
King et al. (1981)	19	21	25	25	66	Electronic; 15 cm below roof center	2	Brisbane, Queensland, Australia; summer 1978 and 1979; 1100–1300 LT
Marty et al. (2001)					89	Electronic	12*	Zurich and Chur, Switzerland; Jan 1995–Mar 2000
McLaren et al. (2005)	4–10	7–13	17–18	22–23	47	Electronic; 38 cm above rear seat	1	Freemont, CA; 16 days; 15 May–8 Aug 2002
Roberts and Roberts (1976)			15		45	Liquid in glass; 15 cm above front seat cushion	0.75	Baltimore, MD; Sep 1975; afternoon
Surpure (1982)					78	Liquid in glass; suspended from driver's seat	8	Oklahoma City, OK; first week, Jul 1980; 0800–1600 LT
Zumwalt and Petty (1976)					58	Liquid in glass; back seat	5	Dallas, TX; Jun–Oct 1975; 1200–1700 LT

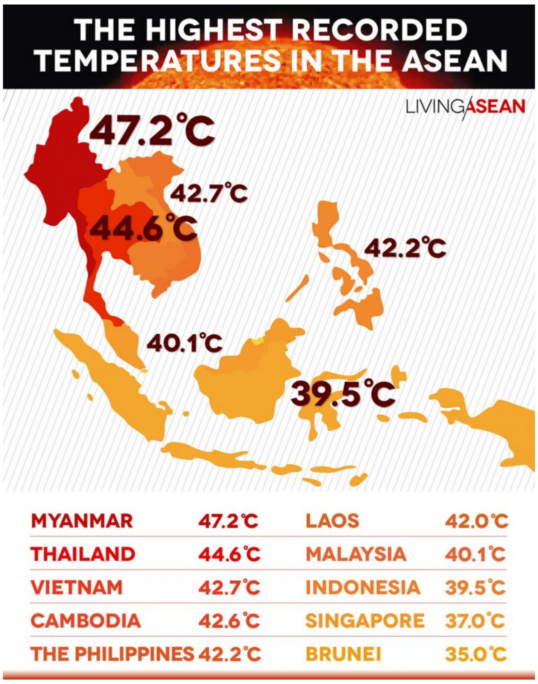

Figure 4: The highest temperature recorded in ASEAN (LivingASEAN, 2017)

In order to prevent further increase in child death due to vehicular heating, the New Car Assessment Programme for Southeast Asian Countries (ASEAN NCAP) has included the requirement of Child Presence Detection (CPD) technology in its ASEAN NCAP Roadmap 2021-2025 (ASEAN NCAP, 2018). This safety issue is also dealt with in other NCAPs. For instance, Euro NCAP 2025 Roadmap (EuroNCAP, 2017) states that a technological solution would be introduced and shall be employed by 2022 to track a child in a car and notify the owner of the car or emergency facilities should the circumstances become harmful. ASEAN NCAP and Euro NCAP will compensate vehicle manufacturers that provide these solutions as standard. These solutions to detect children or other vehicle occupants may come in different types of technologies and approaches. Each technology performs and functions differently, with varying effectiveness.

1.2 Problem Statement

Incidences of forgotten children in parked cars have driven the authorities (i.e., MIROS and ASEAN NCAP) to promote the use of any available technologies that could prevent such tragic incident from happening in the future. There are various types of CPD technologies that are readily embedded in vehicles, or commercially available in the market. These products employ different types of technologies and approaches to detect children; the technologies may be extended to other vehicle occupants as well. Each technology performs and functions differently, with varying effectiveness. Hence, it is necessary to establish a database of CPDs with their associated technologies. Based on this database, a proper assessment methodology must be established in order to gauge the effectiveness of each CPD system.

Another problem that is associated with child occupant safety is the placement of these children and vulnerable passengers when travelling in the vehicle. Ideally, they should be seated at the rear passenger seats to reduce the risk of injury during impact. However, it is not always the case in ASEAN where seating preferences may vary due to many factors such as lack of awareness, limitation of space, etc. Therefore, it is also vital to understand the passengers seating preferences in ASEAN vehicles so a better approach could be employed to increase the awareness level of ASEAN road users. Hence, a survey shall be conducted and its results would be analysed accordingly.

1.3 Project Aim and Objectives

This project aims to establish CPD database, ASEAN occupant seating preferences and CPD assessment methodology for ASEAN NCAP.

Specific objectives:

i. To study the vehicle occupant seating preferences in ASEAN to support the child occupant safety in vehicle
ii. To establish a database of CPD with their associated technologies and detection approaches
iii. To develop CPD assessment methodology in order to gauge the technology effectiveness

2 Child Presence Detection Database

2.1 Child Presence Detection

As an overview, a Child Presence Detection (CPD) technology is a safety system designed to assist the driver to prevent the consequences of mistakenly left children in closed parked vehicles especially if the child is sleeping in obscured position. CPD system may employ different types of technologies, which can be further categorised into three: integrated-in-vehicle, Child Restraint System (CRS)-based, and standalone system.

(a) Integrated-in-Vehicle CPD Systems

Rosli *et al*. (2019a) reviewed a number of methods taken to detect child presence in vehicle. Included in the paper is work conducted by Hashim et al. (2014) which designed a system that detects movements and sounds in vehicle when a child is locked behind, and sends an alert through Short Message Service (SMS). Samant *et al*. (2015) developed a system that employed a sound sensor to recognize crying voice of a child, and a temperature sensor to monitor the vehicle temperature. If a child is detected when the temperature of vehicle is above 35°C, vehicle alarm will be activated.

Gonçalves et al. (2018) presented a solution to prevent in-car infants' deaths, capitalizing on low-cost technologies that can easily be integrated on vehicle, including utilisation of motion sensors and vision algorithms (Figure 5). While an integrated system is idealized to optimally recognise the presence of children inside the vehicle, the study suggested a stand-alone application might be viable.

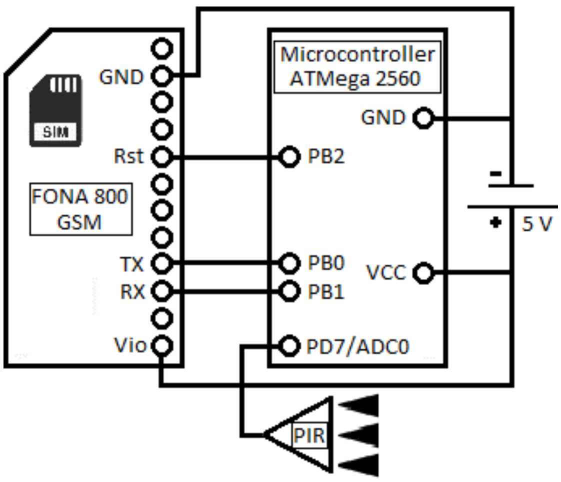

Figure 5: Electric circuit for microcontroller, motion sensor and GSM module (Gonçalves *et al*., 2018)

IEE, another technology developer, presented VitaSense (shown in Figure 6) that uses well-known 24 GHz low-power radio technology detects occupants based on their movements or breathing, even when they are sleeping (IEE, 2018).

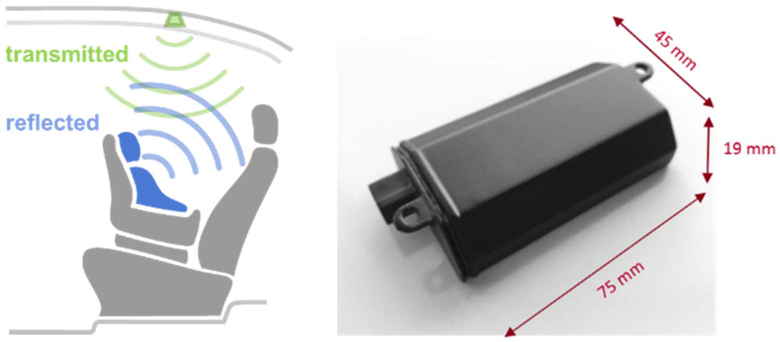

Figure 6: Radio-frequency based system sensor location (Mousel *et al.*, 2017)

Karaman *et al.* (2017) had proposed a system consisting of Sensor Unit, Processor Unit and Response Unit, as illustrated in Figure 7. It was designed to detect any movements in the vehicle for human presence and determine if the environment is a danger situation. The system will then notify related authorities or perform intervention such as lowering the vehicle window through response unit.

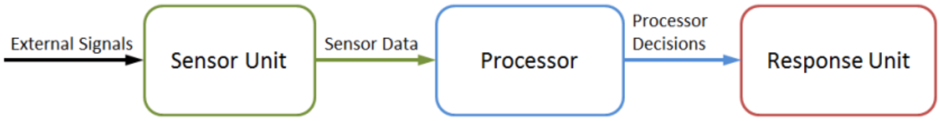

Figure 7: Block diagram of the child heat injury prevention system (Karaman *et al.*, 2017)

In proposed design by Anchala Baid *et al.* (2017), the system will trigger the alarm system when it detects child presence when the engine is OFF. Figure 8 shows a sound sensor is added to the system to recognize crying baby voice.

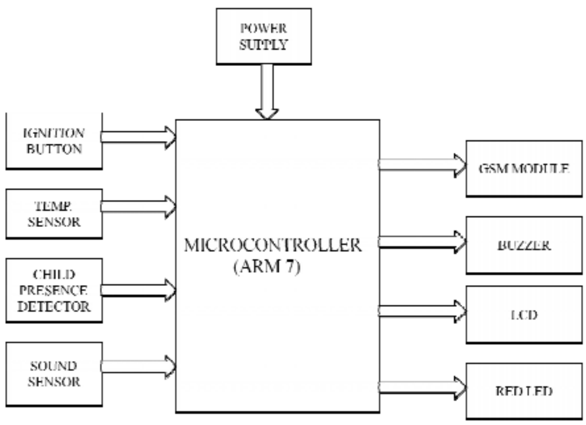

Figure 8: Block diagram of the Child Presence Detector in Unmanned Vehicle (Baid *et al.*, 2017)

Sulaiman *et al*. (2017) proposed a system to detect the presence of children including infants in unmanned vehicle. Figure 9 describes two major components of the system consisting of detection and feedback systems. The detection system detects voice, odor, motion and temperature inside the vehicle. This information will trigger the feedback system to perform feedback functions in stages:

i. the system sends notification to the driver's mobile phone through short messaging system once a child presence is detected;

ii. the system triggers the vehicle's alarm system if no action is taken by the driver; and

iii. the system lowers down the window to reduce temperature inside the vehicle.

Table 2 tabulates some of integrated in vehicle CPD systems.

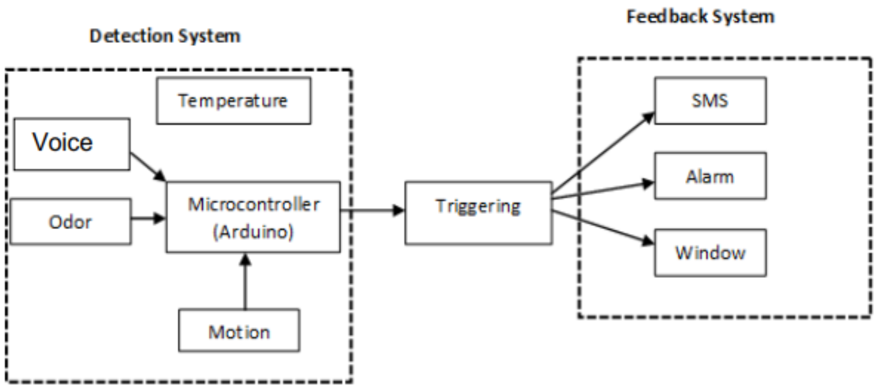

Figure 9: Block diagram of detection and feedback system (Sulaiman *et al*., 2017)

Table 2: Database of Integrated-in-Vehicle Child Presence Detection (CPD) systems

System Developer	Stage	Sensor Type	Sensor Location	Monitoring Parameter	Warning Indicator
IEE	R&D	Microwave radar	Under headlining	Breathing rate	Phone
Hashim *et al.*	R&D	PIR sensor, microphone	-	Motion, Voice	Short Message Service (SMS)
Samant *et al.*	R&D	Sound sensor, weight sensor, LM 35	-	Voice, Weight, Temperature	Alarm, Phone Call
Omron	R&D	Radiowave sensor	Ceiling of vehicle	Breathing rate	Alarm
Sulaiman *et al.*	R&D	PIR sensor, temperature sensor, EasyVR Shield, E-nose odor sensor	-	Motion, temperature, voice, odor	Alarm, Phone, Car Intervention
Gonçalves *et al.*	R&D	PIR sensor, microphone, weight, vision algorithm	-	Motion, weight, voice	Alarm, SMS

(b) *CRS-based CPD Systems*

The National Highway Traffic Safety Administration (NHTSA) investigated a number of CRS-based electronic reminder devices that was referred to as Unattended Child Reminder Systems (UCRS) in a report by Rudd *et al*. (2015) – front page as shown in Figure 10. Selected UCRS described in the report are outlined as follows.

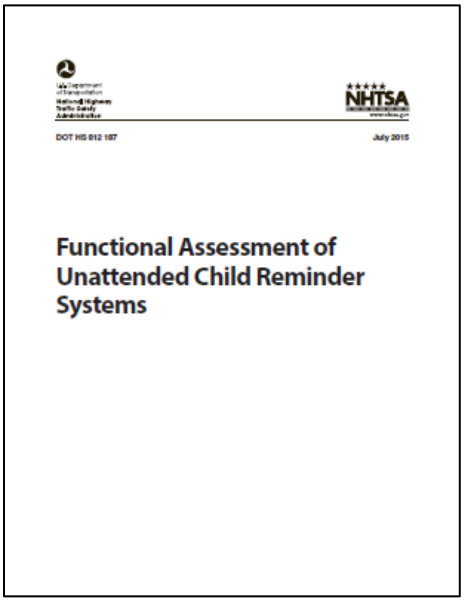

Figure 10: Front page of UCRS Functional Assessment Procedure

Aviso Child-in-Car Alert is an add-on vehicle-based and CRS-based system that interfaces with the vehicle's power and horn. The Aviso provides a detection confirmation tone when a child is placed in the CRS by sensing its weight, issues an end-of-trip convenience reminder when the vehicle power is shut off, and a left-behind alert if the child has not been removed from the CRS after the vehicle power is shut off for certain duration. Other systems using the same weight monitoring are called Forget Me Not, Suddenly Safe 'N' Secure Wireless Child Protection System, True Fit I-Alert, and ChildMinder Elite Pad System (Figure 11). Similarly to the Aviso, these abovementioned systems rely on a weight sensor placed under the CRS covers to detect the weight of a child. Once the child is seated in the CRS, the sensor detects its presence and continuously monitors the child's presence. The information is delivered to a fob or smartphone through a transmitter module, where an LED flashes on the fob and notification sent to the driver's phone as long as the child weight is maintained. Another ChildMinder product is called ChildMinder SoftClip (also shown in Figure 11), which employs a retrofit chest clip containing a transmitter and closure switch. Like the ChildMinder Elite Pad System, an LED flashes on the chest clip and the fob as long as the chest clip is fastened. An SOS system (name of another product) is also constructed using the same concept as the ChildMinder SoftClip, with additional interface to the vehicle's OBD-II port that supplies 12V power and vehicle status data.

Borgne et al. (2017) invented a seat alarm for child safety as shown in Figure 12. It has built in pressure sensors for detection of a child in the vehicle. If a child is detected, the alarm system will sound an initial alarm to grab the driver's attention. Then, louder alarm will be produced to alert the driver or surroundings of the presence of a child in the vehicle. The alarm is linked to the driver's phone.

Another design proposed by Khamil *et al.* (2015) comprises a reminder system that includes a safety pad fixed into a child car seat or a child restraint system (CRS), and a keychain alarm device for the driver (Figure 13). An overview of the safety pad design is shown in next figure. There are three major components in the safety pad, which are the load sensor, Arduino UNO and 1Sheeld. Arduino UNO provides the converted and amplified load sensor signal to 1Sheeld and gives notification to the driver's smart phone. On the other hand, keychain alarm device uses radio frequency signal to determine the range between the keychain and the child car seat. When the weight of a child is detected in the CRS while the keychain alarm device is within specific range, a reminder will be sent to the driver through smartphone. As the distance of the keychain alarm device getting further from the set range, a notification is given to the driver to remind that the driver has left the vehicle without the child.

Table 3 tabulates some of CRS-based CPD systems.

Figure 11: Examples of ChildMinder's child seat reminder products available in the market

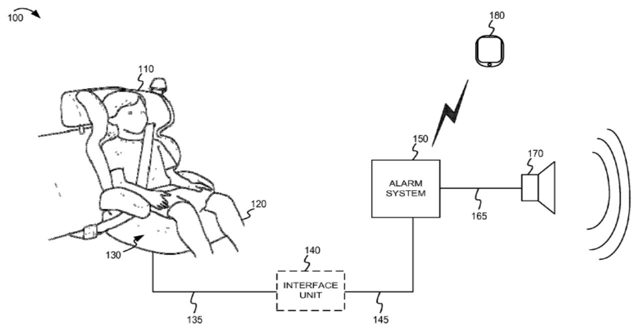

Figure 12: Layout of child safety seat alarm system proposed by Borgne *et al.* (2017)

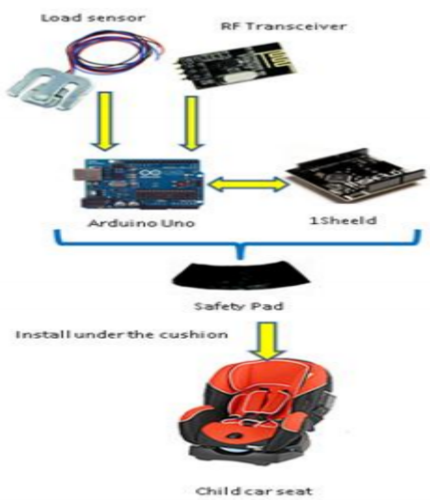

Figure 13: Safety pad design consist of load sensor, Arduino UNO and 1Sheeld (Khamil *et al.,* 2015)

Table 3: Database of Child Restrained System-based Child Presence Detection systems

CRS-based system	Stage	Sensor type	Sensor location	Monitoring parameter	Warning parameter
Aviso Child-in-Car Alert	Commercialized	Weight	Base child seat	Weight	Audible
Forget Me Not	Commercialized	Weight	Base child seat	Weight	Phone, key fob
Suddenly Safe 'N' Secure Wireless Child Protection System	Commercialized	Weight	Base child seat	Weight	Phone, key fob
True Fit I-Alert	Commercialized	Weight	Base child seat	Weight	Phone, key fob
ChildMinder Elite Pad System	Commercialized	Weight	Base child seat	Weight	Phone, key fob
Elite Pad System	Commercialized	Weight	Base child seat	Weight	Audible
ChildMinder Softclip	Commercialized	Clip closure	Child seat strap	Clip closure	Audible
Sense A Life	Commercialized	Weight	Base child seat	Weight	Audible
Sunshine Baby iRemind Car Seat Alarm	Commercialized	Weight	Base child seat	Weight	Audible, visual, phone
Elpho eClip	Commercialized	Bluetooth	Any part of child seat	Clip closure	Phone
Driver's Little Helper	Commercialized	Weight	Base child seat	Weight	Phone
The Backseat App	Smartphone app		Any part of child seat	Not applicable	Phone

(c) Standalone CPD Systems

One example of standalone CPD is called the OleaVisionTM, developed by Olea Sensor Networks (2018). This life presence detector includes a wireless, contactless device, which can be installed in the cabin of any vehicles. OleaVisionTM is able to detect the presence of a living being in the vehicle cabin, even if the subject is motionless or sleeping.

Table 4 tabulates some of standalone CPD systems.

Table 4: Database of Standalone Child Presence Detection (CPD) systems

Standalone system	**Stage**	**Sensor type**	**Sensor location**	**Monitoring parameter**	**Warning parameter**
Oleo Vision	R&D	FMCW radar (24Ghz)	child seat strap	Respiration	Audible, phone
Intel Smartclip	R&D	Bluetooth, temperature	child seat strap	Temperature	Audible, Phone

2.2 Vehicle Reminder Systems

A different approach to the Child Presence Detection is a Vehicle Reminder System. For instance, General Motors introduced Rear Seat Reminder starting with GMC Acadia in 2016, and to its other models in 2017 and 2018. In 2017, Nissan North America added its Rear Door Alert starting with the 2018 Nissan Pathfinder. The most advanced and commercially available system is Hyundai's Rear Occupant Alert equipped in 2019 Santa Fe for its American market and later introduced in 2020 Santa Fe for Malaysian market - figures below. The system utilises ultrasonic sensor to continuously monitor the rear seats after the vehicle is parked and all doors are locked. Notification will be sent to the driver's phone through its Blue Link apps, while alerts will be provided via horn sounds and lights flash. Good effort by these vehicle manufacturers; however, the reminder system is still insufficient to perform presence detection functions.

Table 5 tabulates some of VRS systems.

Figure 14: Santa Fe's ultrasonic sensor in the headliner

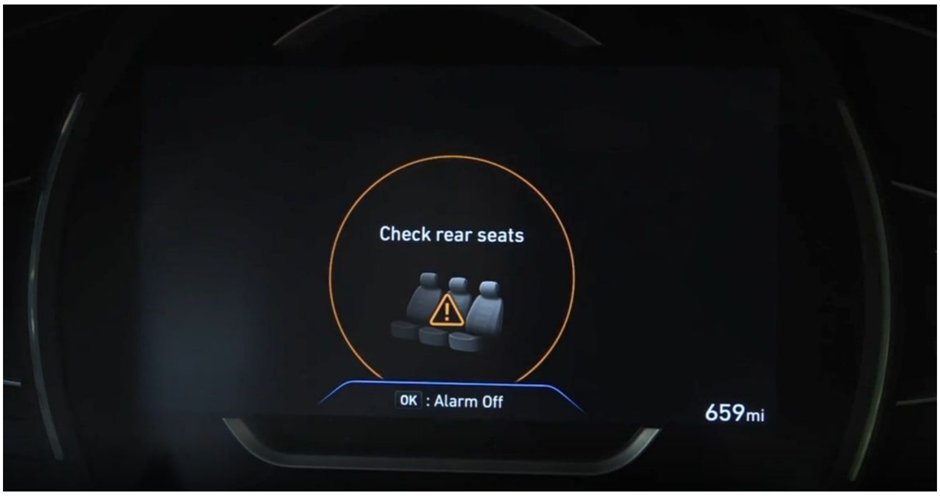

Figure 15: Santa Fe's reminder message display on the instrument cluster

Table 5: Database of Vehicle Reminder System (VRS) available in the market

Vehicle Reminder System	Model	Sensor type	Sensor location	Monitoring parameter	Warning parameter
Integrated	Hyundai Santa Fe 2019	Ultrasonic	Under headlining	Movement	Phone, meter cluster
Integrated	GMC Acadia 2018	Door switch	Door	Door open and close	Meter cluster
Integrated	Nissan Rogue 2019	Door switch	Door	Door open and close	Meter cluster
Integrated	Kia Telluride 2020	Door switch	Door	Door open and close	Meter cluster, audible
Integrated	Subaru Ascent 2020	Door switch	Door	Door open and close	Meter cluster, audible
Integrated	Chevrolet Equinox 2019	Door switch	Door	Door open and close	Meter cluster, audible
Standalone	Bee-Alert	Door switch	Door	Door sequence	Audible
Standalone	Ride N Remind	Door switch	Door	Door sequence	Audible

2.3 Gaps in Technology

It is apparent from the literature that almost all CPD systems use motion as sensing parameter. However, this parameter is less effective in detecting sleeping newborns in CRS because their movement is not so obvious to be detected by the sensors. We recommend to include other vital signs such as body heat, pulse and other combination as detection parameters. Further to that, these systems do not take into account of situation when the baby is intentionally left by the driver for refuelling or getting something from the car boot. Moreover, these systems are ineffective for situation where children unknowingly gain access to the vehicle and get trapped inside parked vehicle. Another significant aspects, these systems require the driver to take action in response to the warning given. Therefore, it is important to identify fundamental requirements for efficient CPD that could provide automatic response in addition to the warning system to eliminate human interventions.

Based on a study conducted by Rosli et al. (2019b), 70% of parents in Malaysia are willing to pay for CPD system in the car because they are well aware of the risk relating to vehicular heating. Therefore, implementation of CPD system may immediately start in Malaysia starting with the vehicle reminder system that should be immediately followed by full CPD system in the near future – in line with ASEAN NCAP Roadmap 2021-2025. With this information, vehicle manufacturers and suppliers must enhance their effort in developing suitable systems for their products.

3 CPD Assessment Methodology

3.1 Proposed CPD Assessment Methodology

A comprehensive procedure is proposed for ASEAN NCAP's Child Presence Detection assessment methodology, as summarised in Figure 16. The flowchart describes a laboratory-based simulation to assess the effectiveness of a Child Presence Detection system. The procedure is constructed to assess functionality, repeatability and effectiveness of the CPD system. An alternative assessment is included for Vehicle Reminder System (VRS). A more detailed procedure is explained in the following sections.

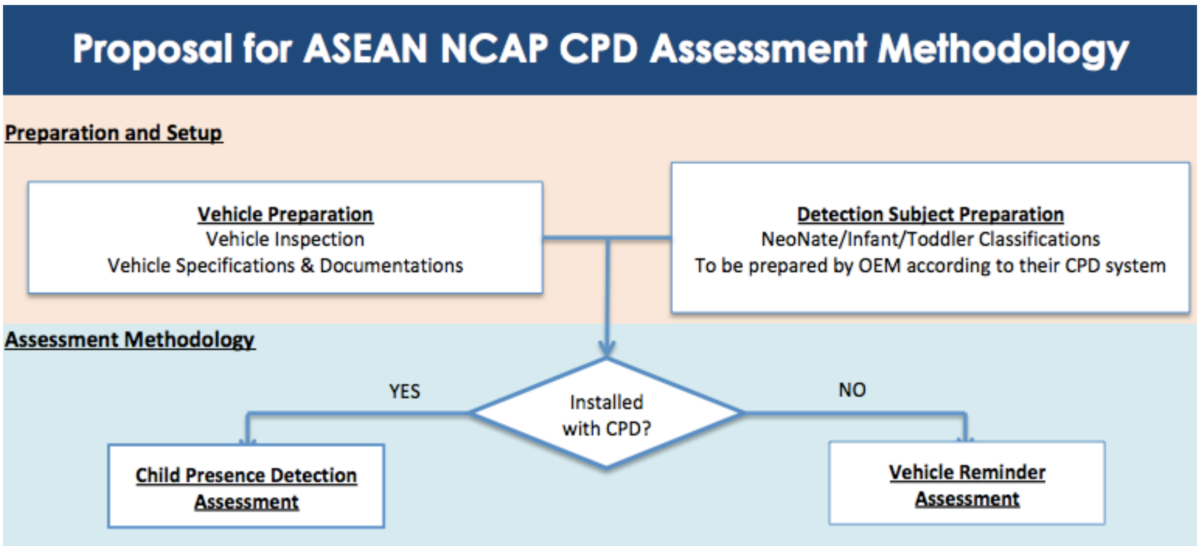

Figure 16: Summary of proposal for ASEAN NCAP CPD assessment methodology

3.2 Vehicle Preparation

Vehicle preparation is conducted first by recording and confirming that vehicle make, vehicle model, model year, *etc*., are in compliance to all requirements stated by the vehicle manufacturers. Proper documentation shall be produced and signed by the assessor and witnesses.

3.3 Detection Subjects

The assessment procedure is designed to cover small occupants ranging from sleeping newborns (or neonate) up to children aged 5 years old. The Detection Subjects are classified according to age group, as detailed in Table 6. The classification is formulated based on the Paediatric Protocols for Malaysian Hospitals (Muhammad Ismail *et al.*, 2018), followed by consultations with a number of Malaysian medical experts.

Table 6: Detection Subjects classification

Detection Subject Classification	Age Group
Classification 1: Sleeping Neonate	Birth to 1 month
Classification 2: Infant	> 1 month to 2 years
Classification 3: Toddler	> 2 years to 5 years

These Detection Subjects should be secured in suitable CRS accordingly, as stated in Table 7. The manufacturers may prepare a surrogate to represent the Detection Subjects in order to avoid using real children for the assessment. For example, the NHTSA used anthropomorphic test devices (ATDs) in its assessments.

Table 7: Detection Subjects and CRS installation

	Classification	CRS Direction
1	Sleeping Neonate	Rearward Facing (Rwd)
2	Infant	Rearward Facing (Rwd)
3	Toddler	Forward Facing (Fwd)

3.4 Assessment Methodology

As shown in Figure 16, the proposed assessment procedure would consider two situations: (i) a vehicle equipped with integrated CPD system (Figure 17), and (ii) a vehicle equipped with integrated reminder system (Figure 18). Assessment methodology for each category is explained as follows.

(a) Child Presence Detection Assessment Procedure

There are three levels of functions for the CPD assessment, as illustrated in Figure 17:

<u>Function 1: Detection</u>
The system must demonstrate its ability to detect the presence of children in parked vehicle by means of notifications to phone, fob, *etc*. that is perceptible by the driver.

Function 2: Alert
If no action is received from the driver, the vehicle must alert its surrounding by means of horns, hazard light, alarm, *etc.* to attract attention.

Function 3: Intervention
The vehicle should initiate intervention measures (e.g., window down, engine on, *etc.*) to allow air ventilation into the car cabin if no further action is taken by the car driver.

The CPD assessment must be conducted by positioning the Detection Subject in CRS on each position at rear passenger seats, and repeated until all three Detection Subjects are tested. A timeline of 5 minutes is suggested for the whole assessment duration, based on the findings presented by Grundstein *et al*. (2010) that indicated maximum in-vehicle temperature increase of 4-19°C within 5 minutes under hot weather. Furthermore, the short timeline will ensure that the driver is still in the vicinity of the parked vehicle to take immediate action.

(b) Vehicle Reminder System Assessment Procedure

Similar to the CPD assessment, vehicles with a reminder system will undergo three stages of reminder assessment within 5 minutes, as shown in Figure 18. However, the assessment methodology is more straightforward than the CPD assessment.

Reminder 01
Reminder 01 shall provide an alert to the driver when the engine is turned off. Reminder alert may be introduced by means of audio or visual display at the car instrumentation panel, *etc.* that is easily perceptible by the driver.

Reminder 02
The vehicle must be able to provide a further reminder to the driver by means of notifications to phone, fob, *etc*. which should be turned off or snoozed by the recipient.

Reminder 03
If no action is received from the driver, a final reminder with more pronounced audio/visual measures should be introduced to attract the driver's attention.

3.5 Assessment Matrices and Scoring

Findings from each assessment will be recorded accordingly using the assessment matrices presented in Tables 8 and 9 for the CPD System and Reminder System, respectively. As stated in the flow chart, the assessment shall be concluded whenever it obtains FAIL status. Else, assessment shall continue until completion.

Assessment scoring is tabulated in Table 10. CPD system shall carry a full score of 2 points, while Vehicle Reminder System shall carry a full score of 1 point only. Scoring examples are given for more clarification of scoring.

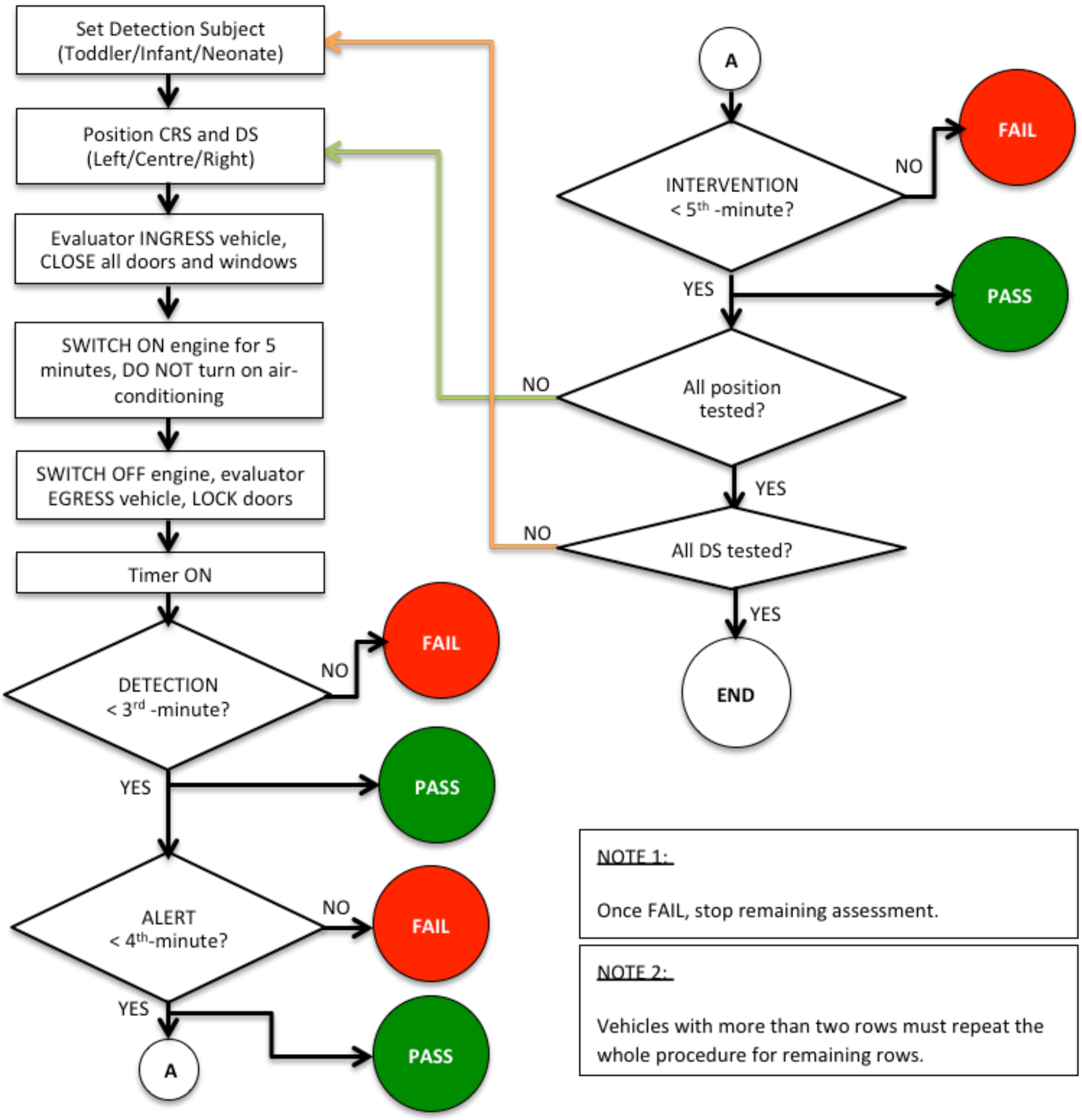

Figure 17: Flow chart of CPD System assessment methodology

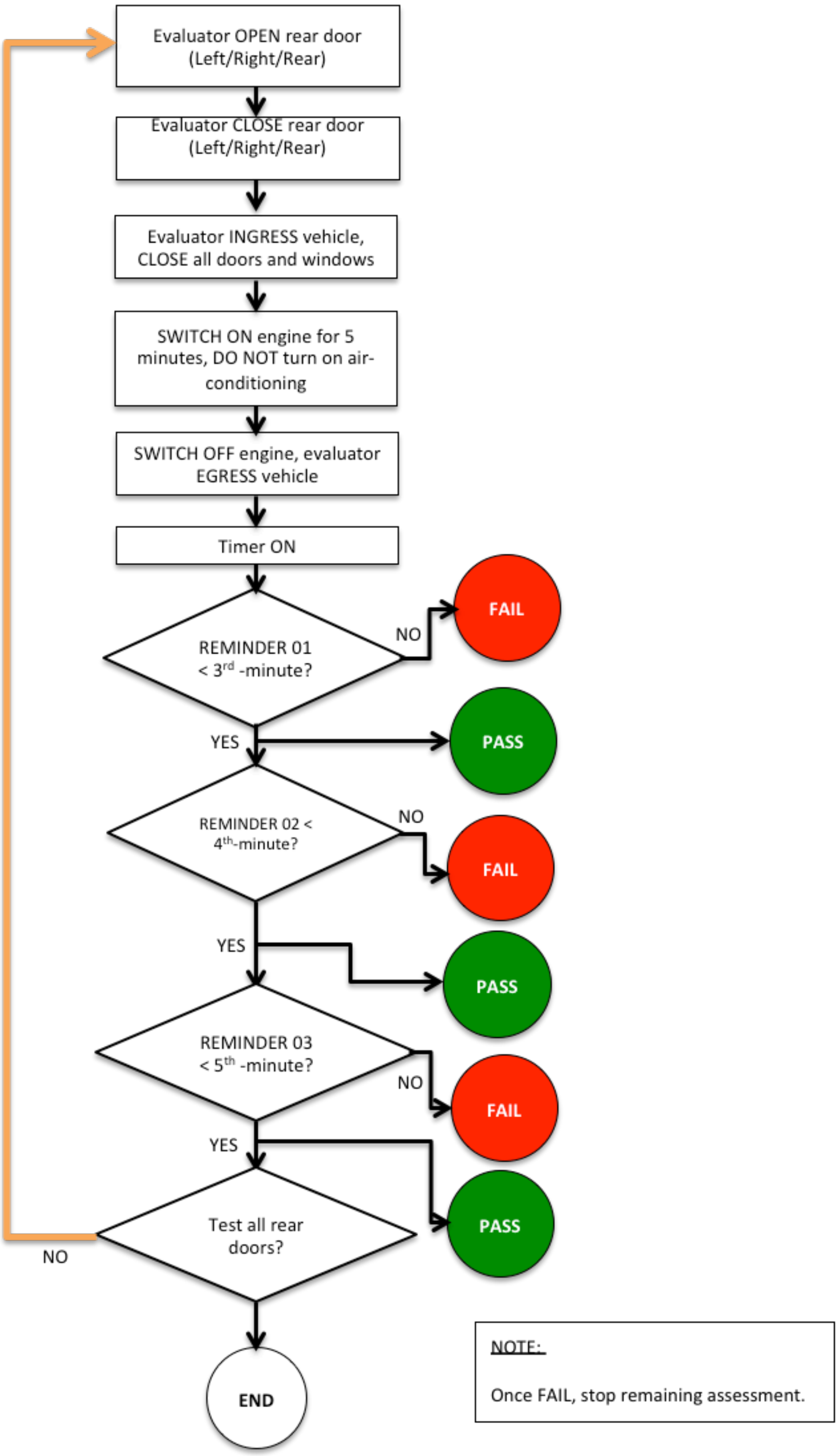

Figure 18: Flow chart of Vehicle Reminder System assessment methodology

Table 8: Assessment matrix for CPD System with full score rating

Child Presence Detection Assessment			DETECTION						ALERT						INTERVENTION						Score	Point
			2nd row			3rd row			2nd row			3rd row			2nd row			3rd row				
			Left	Centre	Right	Left	Centre	Right	Left	Centre	Right	Left	Centre	Right	Left	Centre	Right	Left	Centre	Right		
	Classification	CRS Direction																				
1	Sleeping Neonate	Rwd	Pass	Pass	Pass	N/A	N/A	N/A	Pass	Pass	Pass	N/A	N/A	N/A	Pass	Pass	Pass	N/A	N/A	N/A	1.00	2.00
2	Infant	Rwd	Pass	Pass	Pass	N/A	N/A	N/A	Pass	Pass	Pass	N/A	N/A	N/A	Pass	Pass	Pass	N/A	N/A	N/A	1.00	
3	Toddler	Fwd	Pass	Pass	Pass	N/A	N/A	N/A	Pass	Pass	Pass	N/A	N/A	N/A	Pass	Pass	Pass	N/A	N/A	N/A	1.00	

Table 9: Assessment matrix for Vehicle Reminder System with full score rating

Vehicle Reminder System Assessment	REMINDER 01	REMINDER 02	REMINDER 03	Score	Point
	Pass	Pass	Pass	1.00	1.00

Table 10: Assessment scoring

Assessment	Level	Criteria	Point
CPD	1	Coverage for all passengers – Sleeping Neonate Rearward Facing, Infant Rearward Facing, Toddler Forward Facing	2.00
	2	Coverage for Infant Rearward Facing, Toddler Forward Facing only	1.75
	3	Coverage for Toddler Forward Facing only	1.50
VRS	4	Coverage for Whole Vehicle	1.00

Scoring Examples

Example 1: No CPD system installed; a Reminder System is in-placed; gives reminder two times only within 5 minutes.

Vehicle Reminder System Assessment	REMINDER 01	REMINDER 02	REMINDER 03	Score	Point
	Pass	Pass	Fail	0.00	0.00

Example 2: CPD only detects Toddler within 3 minutes; gives second notification before fourth-minute; gives third notification before fifth-minute.

Child Presence Detection Assessment			DETECTION						ALERT						INTERVENTION						Score	Point
			2nd row			3rd row			2nd row			3rd row			2nd row			3rd row				
			Left	Centre	Right	Left	Centre	Right	Left	Centre	Right	Left	Centre	Right	Left	Centre	Right	Left	Centre	Right		
	Classification	CRS Direction																				
1	Sleeping Neonate	Rwd	Fail	Fail	Fail	N/A	N/A	N/A	Fail	Fail	Fail	N/A	N/A	N/A	Fail	Fail	Fail	N/A	N/A	N/A	0.00	1.50
2	Infant	Rwd	Fail	Fail	Fail	N/A	N/A	N/A	Fail	Fail	Fail	N/A	N/A	N/A	Fail	Fail	Fail	N/A	N/A	N/A	0.00	
3	Toddler	Fwd	Pass	Pass	Pass	N/A	N/A	N/A	Pass	Pass	Pass	N/A	N/A	N/A	Pass	Pass	Pass	N/A	N/A	N/A	1.00	

Example 3: CPD only detects Infant within 3 minutes; gives second notification before fourth-minute; gives third notification before fifth-minute.

Child Presence Detection Assessment			DETECTION						ALERT						INTERVENTION						Score	Point
			2nd row			3rd row			2nd row			3rd row			2nd row			3rd row				
			Left	Centre	Right	Left	Centre	Right	Left	Centre	Right	Left	Centre	Right	Left	Centre	Right	Left	Centre	Right		
	Classification	CRS Direction																				
1	Sleeping Neonate	Rwd	Fail	Fail	Fail	N/A	N/A	N/A	Fail	Fail	Fail	N/A	N/A	N/A	Fail	Fail	Fail	N/A	N/A	N/A	0.00	0.00
2	Infant	Rwd	Pass	Pass	Pass	N/A	N/A	N/A	Pass	Pass	Pass	N/A	N/A	N/A	Pass	Pass	Pass	N/A	N/A	N/A	1.00	
3	Toddler	Fwd	Fail	Fail	Fail	N/A	N/A	N/A	Fail	Fail	Fail	N/A	N/A	N/A	Fail	Fail	Fail	N/A	N/A	N/A	0.00	

3.6 Recommendations for Implementation

The proposed methodology is very comprehensive and may not be realizable for the year 2021 implementation. To give ample time for product development and vehicle integration to the manufacturers and product developers, it is recommended for ASEAN NCAP to execute the assessment in stages, with a view for full implementation by end of 2025 in accordance to their 2021-2025 Roadmap.

The recommended assessment implementation is as follows:

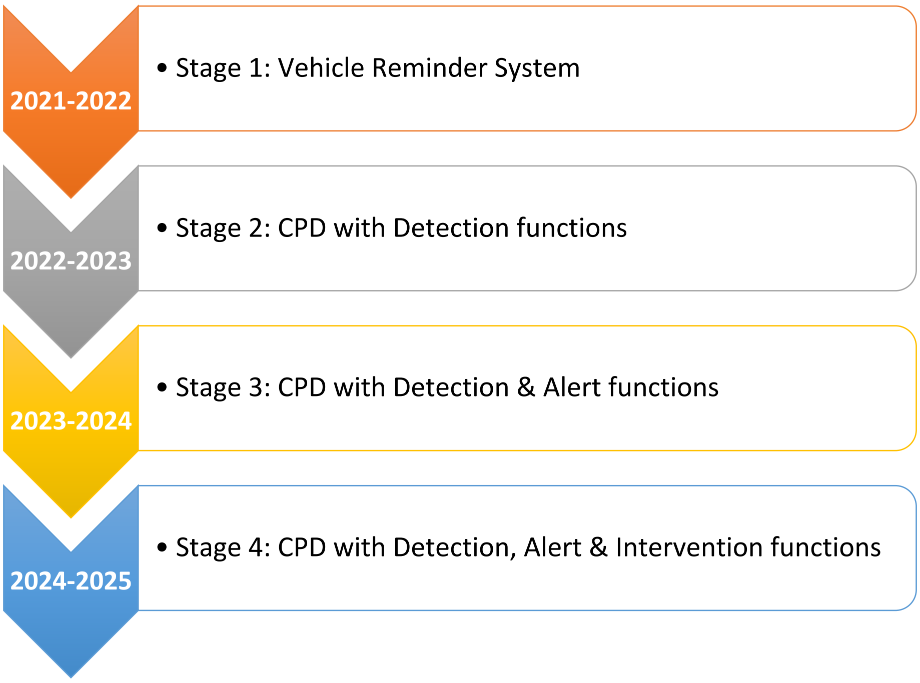

Figure 19: Recommendation for Implementation of CPD Assessment

Furthermore, ASEAN NCAP may want to expand CPD coverage to the elderly in the future. In addition, once the technology has matured enough, stricter scoring criteria could be introduced by assigning weightage to each Detection Subjects classification and also Level of Functions. Moreover, more points should be allocated to Child Presence Detection as the technology progresses.

3.7 Actual Implementation by ASEAN NCAP

ASEAN NCAP has released its Child Occupant Protection Protocol in November 2019, where Section 6 outlines the implementation of Child Presence Detection Procedure. The actual implementation basically covers Stage 1 and Stage 2 of the proposed methodology.

4 Vehicle Occupant Seating Preferences Survey

4.1 Survey methodology

For this research, the survey methodology was employed to collect information about the seating position preferences among Malaysian, Thai and Indonesian that represent ASEAN population. The questionnaire was designed to get information on:

i. Demography that will provide information on drivers, type of vehicles driven and the number of passengers they usually travel with in vehicle.

ii. The common position of different type of passengers (i.e., children and elderly, CRS usage)

Questionnaire development

The questionnaire is developed in three versions, each version using native language of participating countries (i.e., Malaysia, Indonesia and Thailand). For each version, additional English translation is also included for non-native speakers.

The questionnaire structure is divided into 3 parts. Section A covers the demographic characteristics such as age, nationality, type of vehicle driven and number of passengers they usually travel with in the vehicle. Section B focuses on the seating position preference. Section C attempts to measure the awareness of driver on unintended children left incidences using a 5-point Likert Scale.

Expert validation

The questionnaire is validated by at least one expert from academia and one from the industry with a minimum of ten years working experience to ensure the questionnaire has covered important aspects of the study, and to identify if any components are missing from the survey.

Pilot study

Prior to commencing the pilot study, the developed questionnaire was submitted to a group of target respondents. The respondents will ask to complete the questionnaire and give feedback in term of the problems they face or difficulty to answer the questionnaire.

Population and Sampling

The research study focused on a targeted population of Malaysia, Thailand and Indonesia to represent ASEAN countries. These three countries were chosen because of their larger market in the ASEAN region. This study calculates the sample size using Raosoft sample size online calculator by employing 5% margin of error, 95% confidence level and 50% response distribution.

Data Collection

Data collection method was performed both in paper form and digital form (i.e., Google Form). Link to the questionnaire was sent out through Whatsapp, Facebook and official online platforms of ASEAN NCAP, where respondents may click the link and start answering the questions. Online survey form was activated from 1st October 2019 to 30th November 2019. The respondents are given approximately 3 to 5 minutes to answer the questions.

Reliability and Validity

The consistency of the survey is evaluated using internal consistency via SPSS. For the validity of the survey, face validity method was used through the selected experts.

4.2 Data Collection & Analysis

Table 11 tabulates the respondents' profile from the three participating countries. Data includes demographic information (gender and age), type of vehicle used, and vehicle occupants information. Collected data from the survey is further analysed using SPSS.

Table 11: Respondents' Profile

		Malaysia (N=217)		Thailand (N=258)		Indonesia (N=205)		ASEAN (N=680)	
		N	%	N	%	N	%	N	%
Gender	Male	142	65.4	119	46.1	161	78.5	422	**62.1**
	Female	75	34.6	139	53.9	44	21.5	258	37.9
Age	Below 20 years old	0	0	11	4.3	0	0	11	1.6
	20-29 years old	29	13.4	87	**33.7**	26	12.7	142	20.9
	30-39 years old	87	**40.1**	41	15.9	94	**45.9**	222	**32.6**
	40-49 years old	56	25.8	72	27.9	53	25.9	181	26.6
	50-59 years old	43	19.9	37	14.4	29	14.1	109	16.0
	Above 60 years old	2	0.9	10	3.9	3	1.5	15	2.2
Vehicle Type	Compact	87	**40.1**	98	**38.0**	50	24.4	235	**34.6**
	Sedan/Saloon	71	32.7	1	0.4	12	5.9	84	12.4
	5 seater SUV	36	16.6	17	6.6	32	15.6	85	12.5
	7 seater SUV/MPV	17	7.8	33	12.8	92	**44.9**	142	20.9
	Executive/Luxury Sedan	4	1.8	77	29.8	3	1.5	84	12.4
	Pick up	2	0.9	32	12.4	16	7.8	50	7.4
Travel with children	With	98	**45.2**	56	**21.7**	51	**24.9**	205	**30.1**
	Without	119	54.8	202	78.3	154	75.1	475	69.9
Travel with elderly	With	85	**39.2**	123	**47.7**	65	**31.7**	273	**40.1**
	Without	132	60.8	135	52.3	140	68.3	407	59.9

As an overview, 217 responses are gathered from Malaysia, 258 from Thailand, and 205 from Indonesia, which brings the total number to 680 responses (refer Figure 20 for better visual understanding). Out of these responses, 62.1% was obtained from male respondents while remaining 37.9% are female (Figure 21). These respondents information are distributed further according to age range, as illustrated in Figure 22. It is found that most respondents are from the age range between 30-39 years old, followed by 40-49 years old and 20-29 years old categories. To detail further, majority of Malaysian and Indonesian's respondents are from the age group of 30-39 years old, while Thai respondents are mostly from the younger group of 20-29 years old. The smallest contribution comes from the age group of below 20 years old and above 60 years old, a trend that is observable for all participating countries.

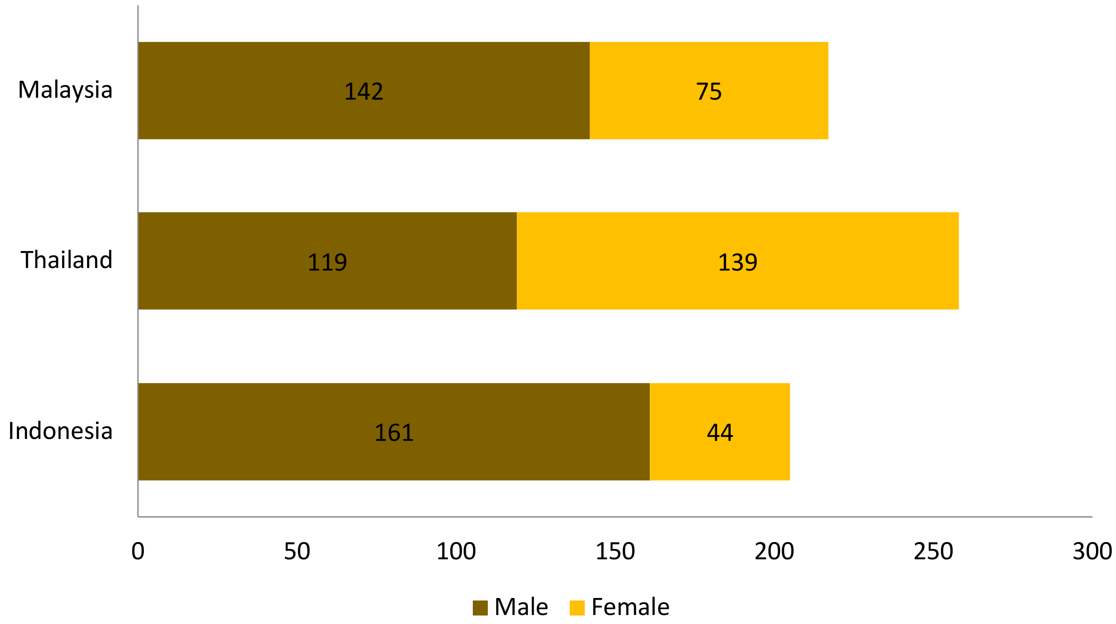

Figure 20: Number of respondents according to countries and gender

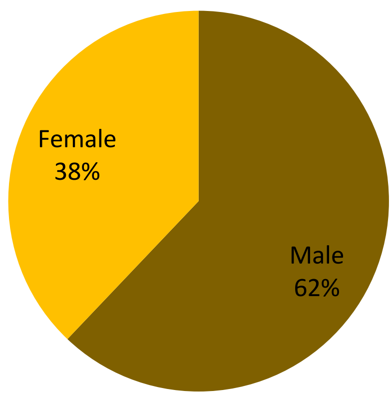

Figure 21: Percentage for overall respondents according to gender

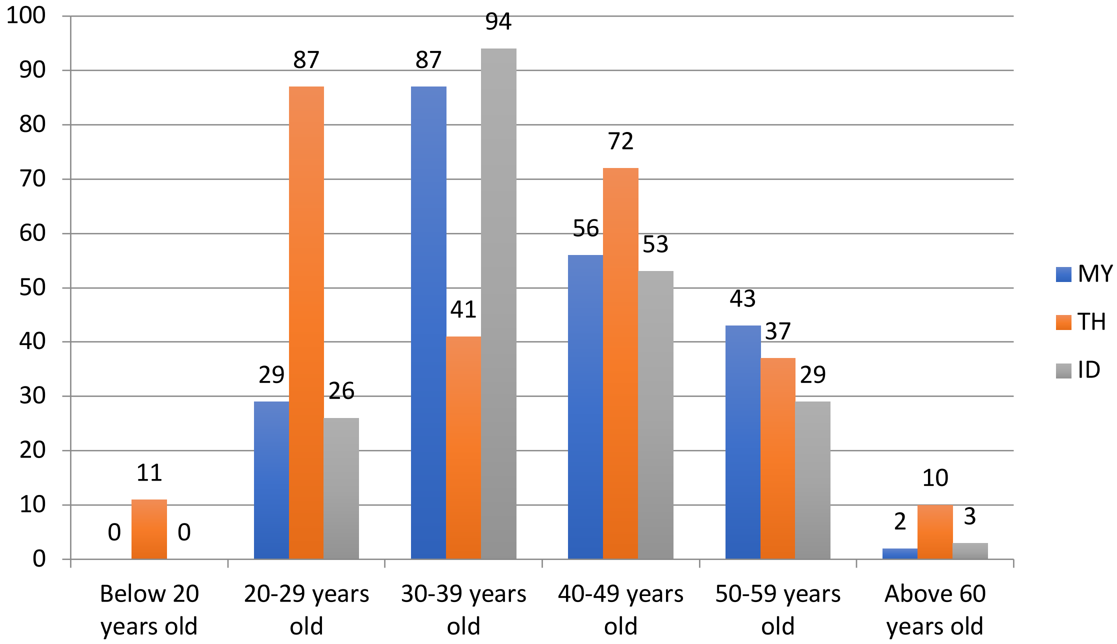

Figure 22: Distribution of respondents (N) according to countries and age range

The type of vehicles driven by the respondents are also analysed, as shown in Figure 23. Based on the distribution, it is demonstrated that most respondents in Malaysia are driving compact-sized cars (40.1%), followed by sedan/saloon cars (32.7%). In comparison, Thai respondents are also mainly driving the compact vehicle type (38%); however, their next choice of vehicle comes from the executive/luxury sedan type (29.8%). Indonesian respondents are showing a different preference, where vehicle type is dominated by the 7 seater SUV/MPV (44.9%), followed by the compact vehicle type (24.4%). When combined, the vehicle type preference is illustrated as in Figure 24. Based on the chart, it may be assumed that ASEAN prefers to own compact vehicles (35%) and 7-seater SUV/MPV (21%), followed by the 5-seater SUV (13%).

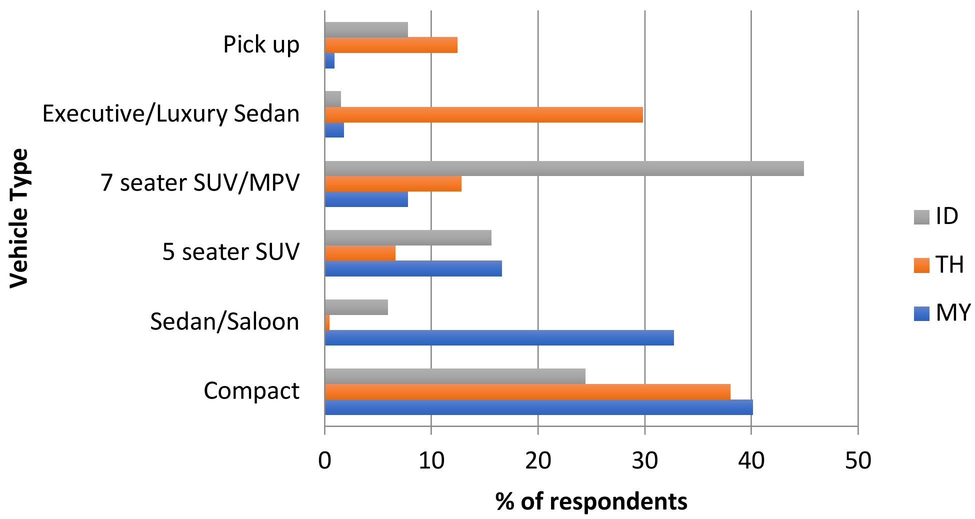

Figure 23: Distribution of respondents (%) according to type of vehicles

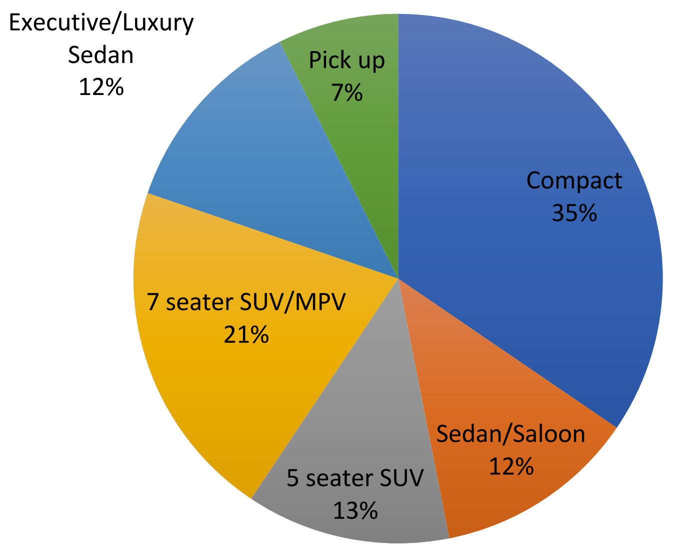

Figure 24: Distribution of total respondents (%) according to type of vehicles

Align with the survey objective (i.e., to investigate seating preference when travelling with children and elderly), the respondents were asked if they travel with children below 5 years old and elderly above 60 years old. Figure 25 summarizes the findings according to countries, while Figures 26 to 28 detail the vehicle occupants age for each country. Based on Figure 25, Malaysian tends to travel with children more than with the elderly, which is opposite to Thai and Indonesian. In addition to that, vehicle occupant data for each country shows that majority of respondents travel with children aged between 6 to 12 years old, while similar trend is observed for elderly occupants that are above 60 years old.

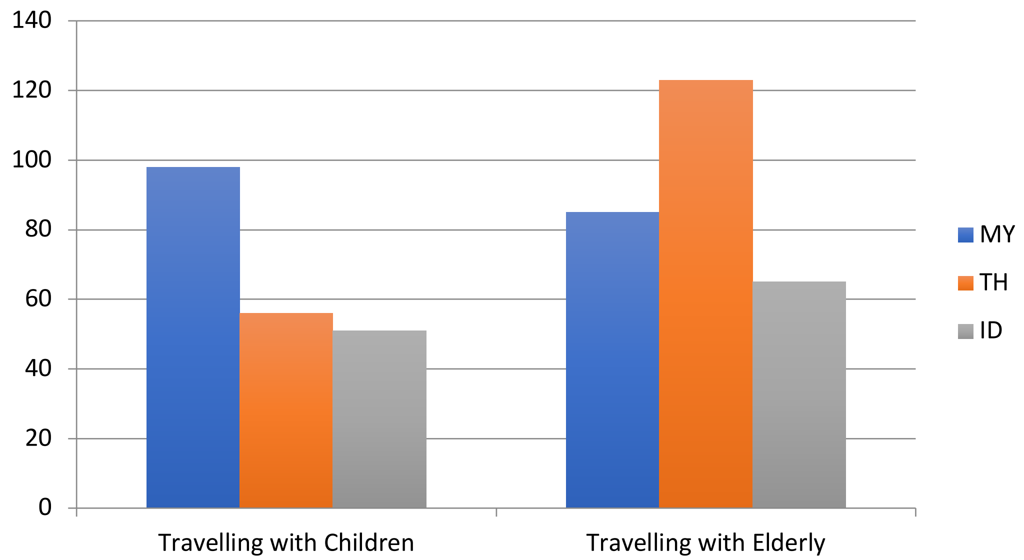

Figure 25: Number of respondents (according to countries) that travel with children and elderly

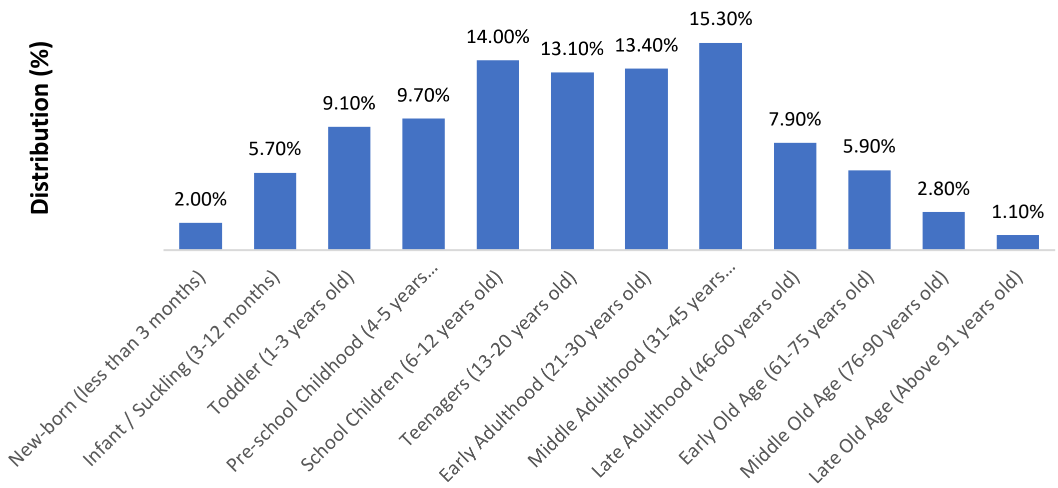

Figure 26: Percentage distribution of vehicle occupant based on age (Malaysian)

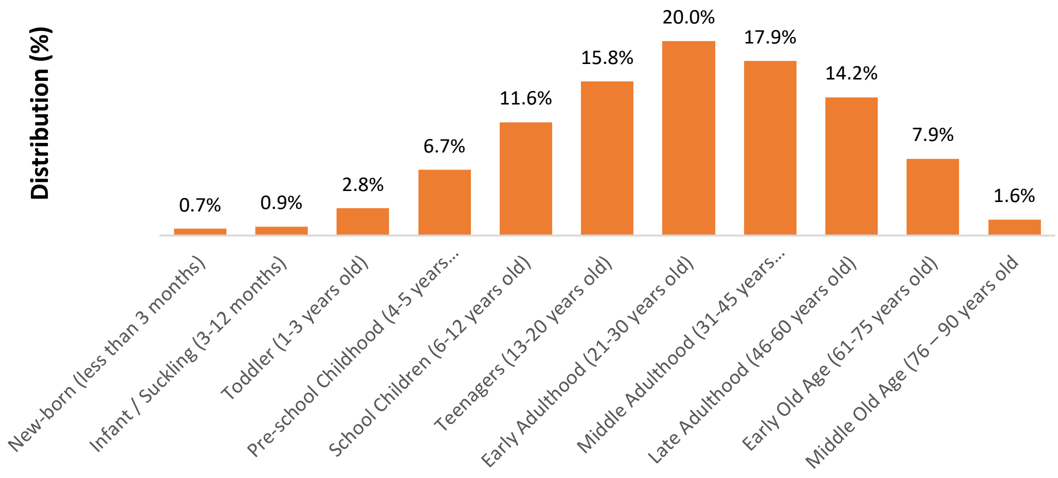

Figure 27: Percentage distribution of vehicle occupant based on age (Thailand)

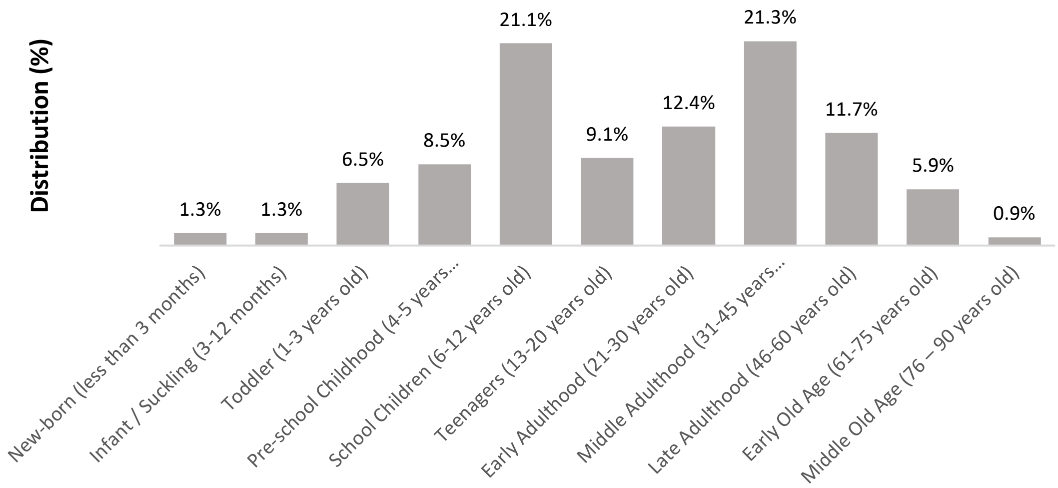

Figure 28: Percentage distribution of vehicle occupant based on age (Indonesia)

Another highlight that could be deduced from Figures 26 to 28 is between 20% to 40% of vehicle occupants are children below 12 years old. Hence, it is important to investigate the positioning of these children when they travel in moving vehicles. Respondents were asked to select common positioning for their children based on Figure 29 for each sitting row. Results for each country are presented in Figures 30 to 31. (Note: Position 3 (driver seat) is included to see if the driver is driving with child on laps.) Based on the findings, it can be concluded that children are often placed at Position 6, followed by Position 4. It is also found that Thai and Indonesian also have high preference to put their children at Position 1, that is at the front row.

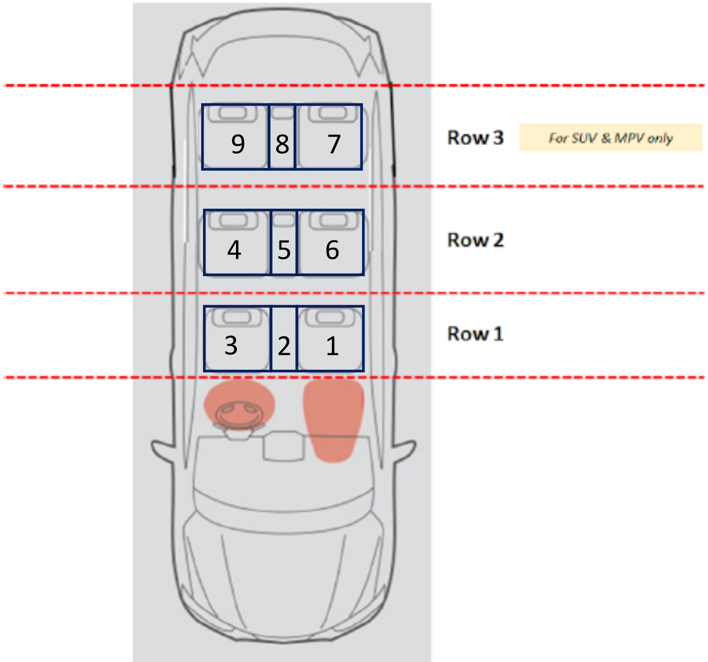

Figure 29: Seating positioning layout

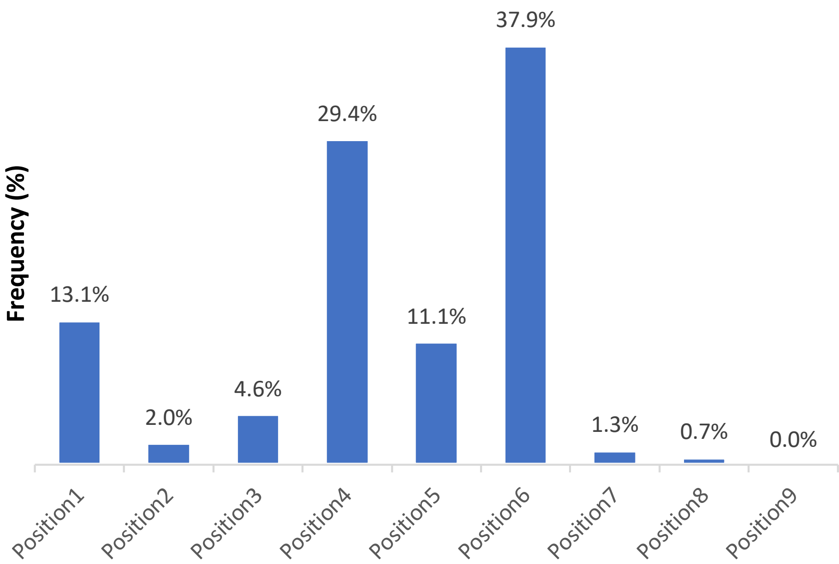

Figure 30: Malaysian seating preference for children positioning

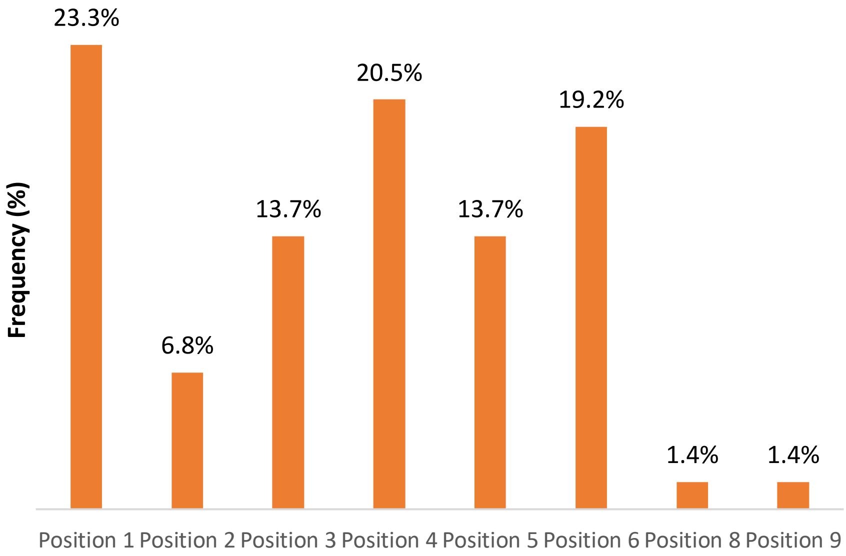

Figure 31: Thai seating preference for children positioning

Figure 32: Indonesian seating preference for children positioning

Further analysis was made to assess the usage of Child Restraint System (CRS) when travelling with children in moving vehicle. Figures 33 to 38 depicts the distribution of respondents (by age) utilising CRS when travelling with children. It is clear from Figure 33, Figure 35, and Figure 37 that respondents aged between 30 to 39 years old has the most awareness for CRS usage. Further detail shows that CRS are used mostly for children aged between 1 to 5 years old, as illustrated in Figure 34, Figure 36 and Figure 38.

Additional analysis was performed for children not using CRS when travelling. Figures 39 to 41 exhibit the responses captured for Malaysian, Thai and Indonesian respectively. The results demonstrate mixed awareness level in all countries, which highlight the need to increase awareness regarding children's safety when travelling in vehicles.

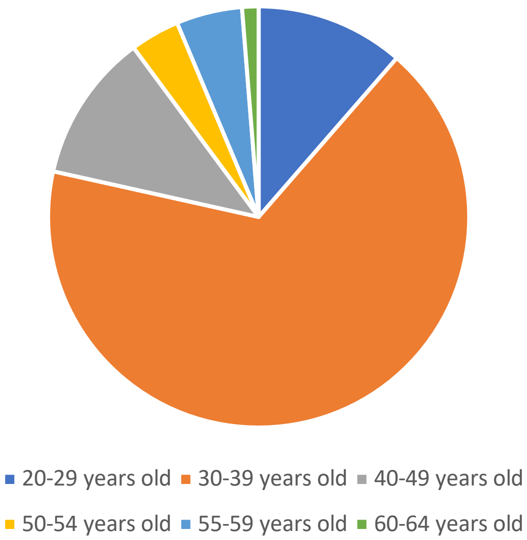

Figure 33: Malaysian respondents (according to age group) with CRS awareness

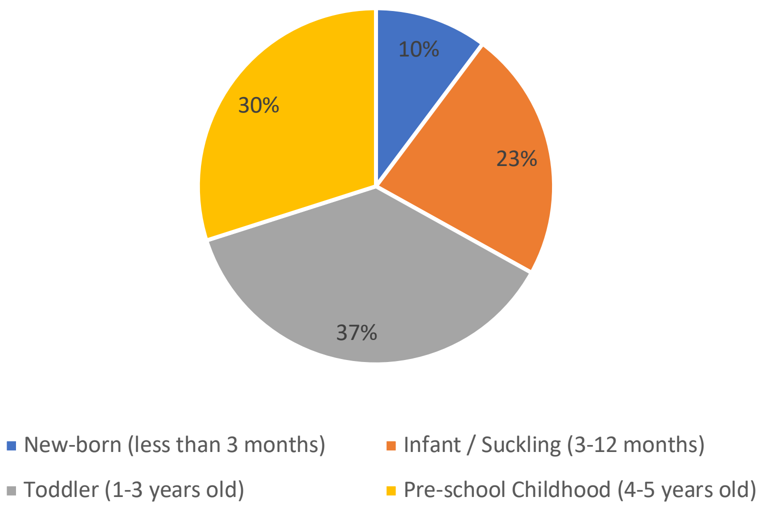

Figure 34: Percentage distribution of CRS usage for Malaysian children

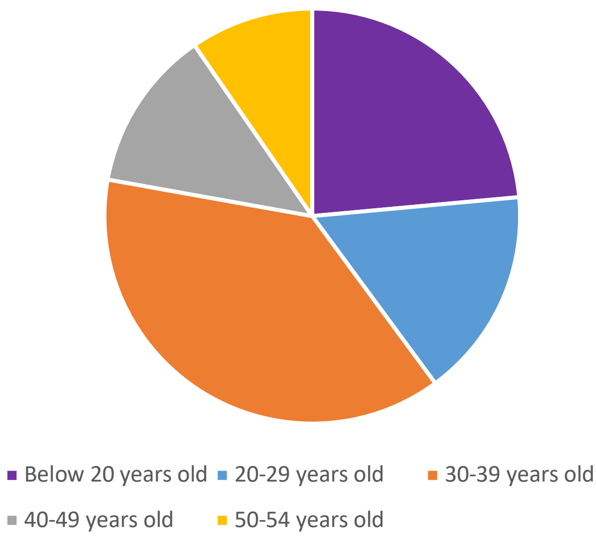

Figure 35: Thai respondents (according to age group) with CRS awareness

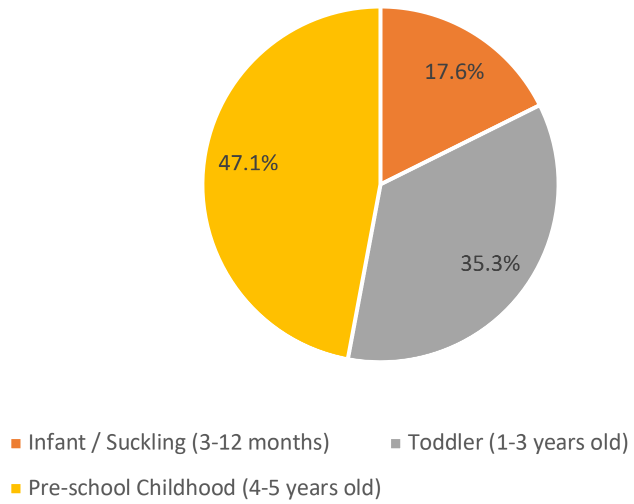

Figure 36: Percentage distribution of CRS usage for Thai children

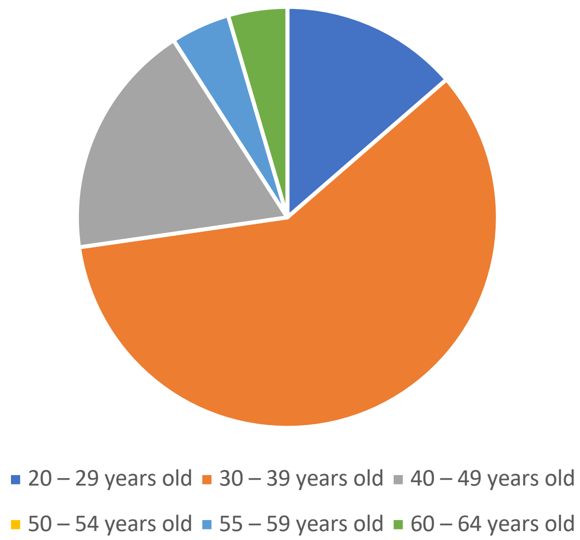

Figure 37: Indonesian respondents (according to age group) with CRS awareness

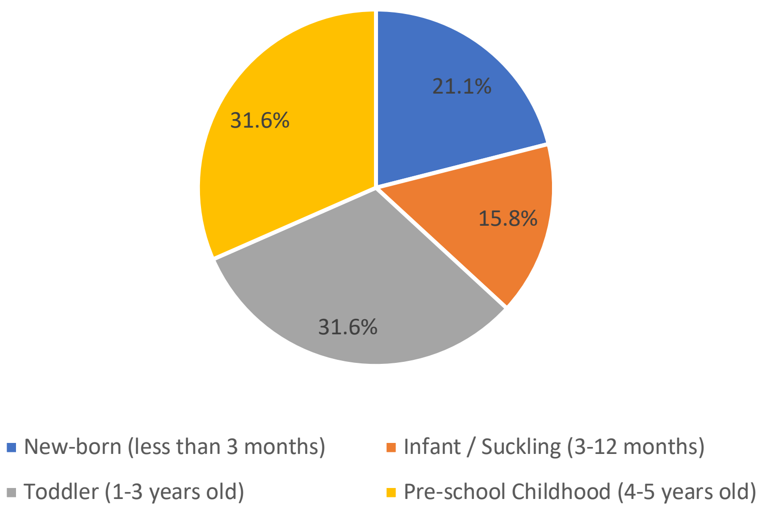

Figure 38: Percentage distribution of CRS usage for Indonesian children

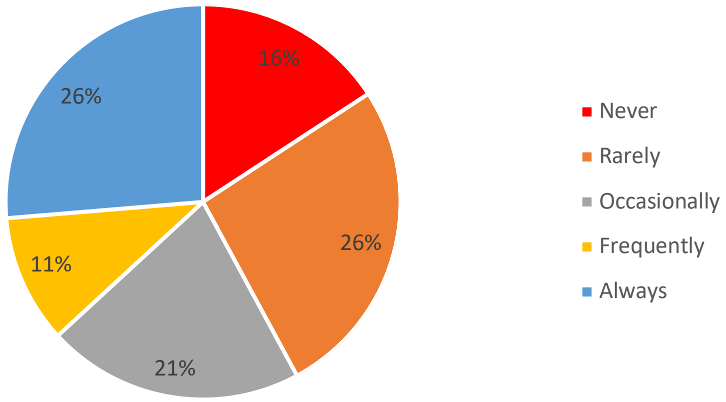

Figure 39: Percentage distribution of Malaysian respondents fastening seatbelts for their children when not using CRS

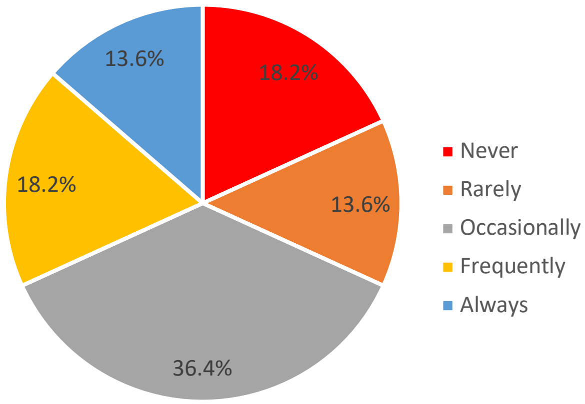

Figure 40: Percentage distribution of Thai respondents fastening seatbelts for their children when not using CRS

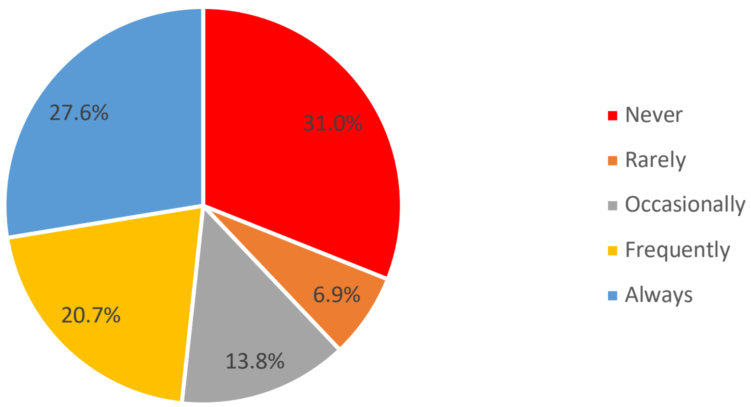

Figure 41: Percentage distribution of Indonesian respondents fastening seatbelts for their children when not using CRS

Figures 42 until 47 provide information about the tendency of respondents to leave children unattended in the vehicle. It is good to observe that majority of respondents have never left their children unattended in vehicles. Based on the survey as well, those leaving their children unattended in the vehicle only did so for less than 5 minutes. Similar analyses were performed for elderly occupants above 60 years old, as presented in Figures 48 to 50. Based on the findings, it can be concluded that the elderly are often left unattended in vehicles between 5 to 10 minutes.

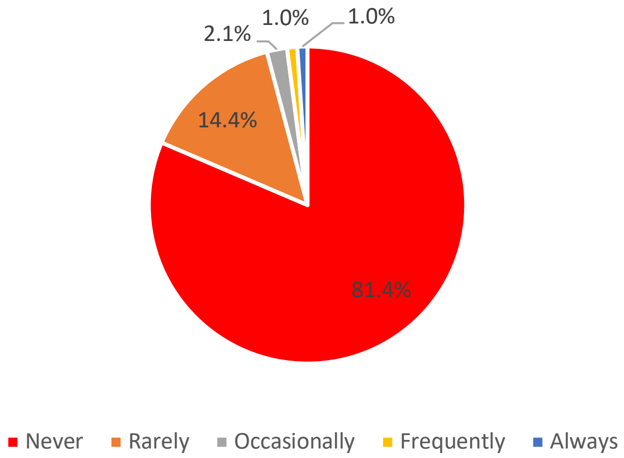

Figure 42: Tendency to leave children unattended in vehicle (Malaysian)

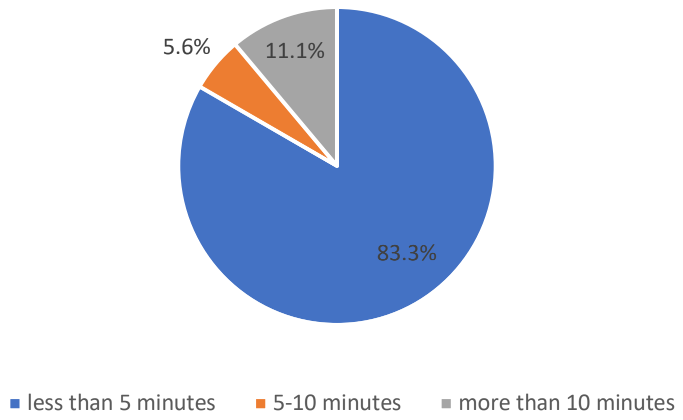

Figure 43: Duration of children being left in vehicle unattended (Malaysian data)

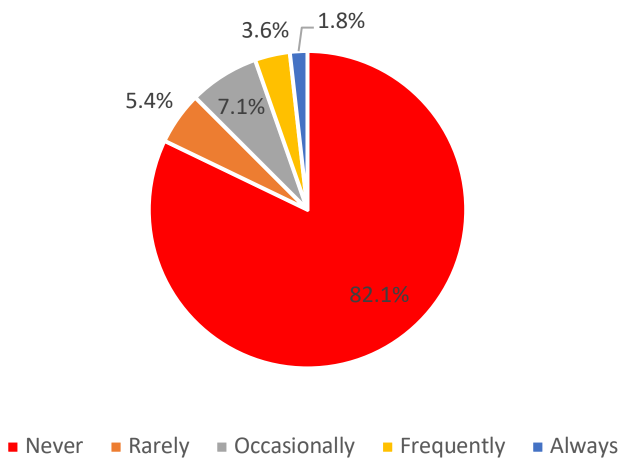

Figure 44: Tendency to leave children unattended in vehicle (Thai)

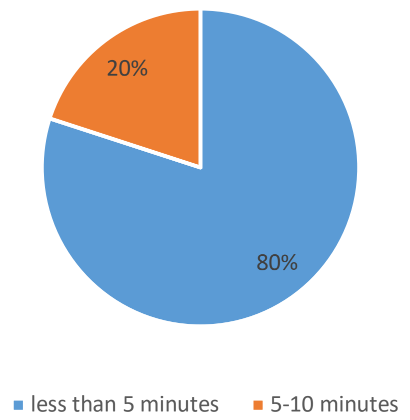

Figure 45: Duration of children being left in vehicle unattended (Thai data)

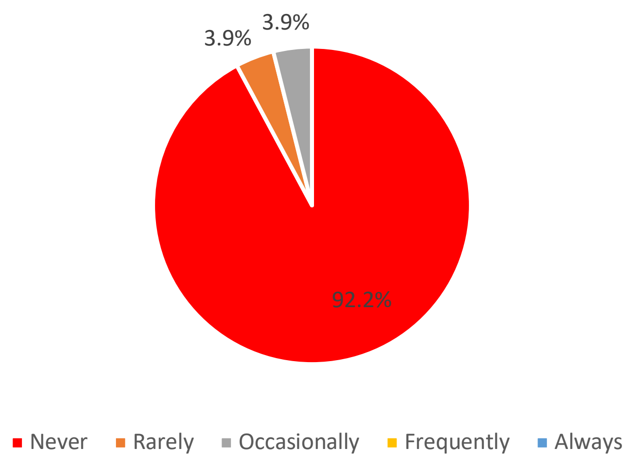

Figure 46: Tendency to leave children unattended in vehicle (Indonesian)

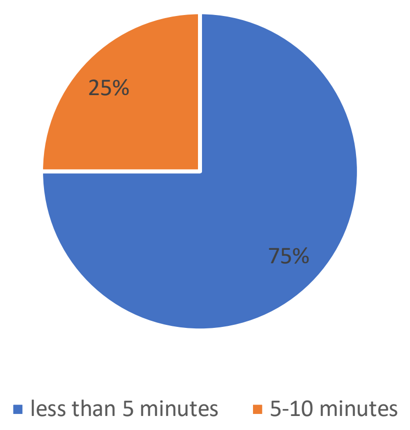

Figure 47: Duration of children being left in vehicle unattended (Indonesian data)

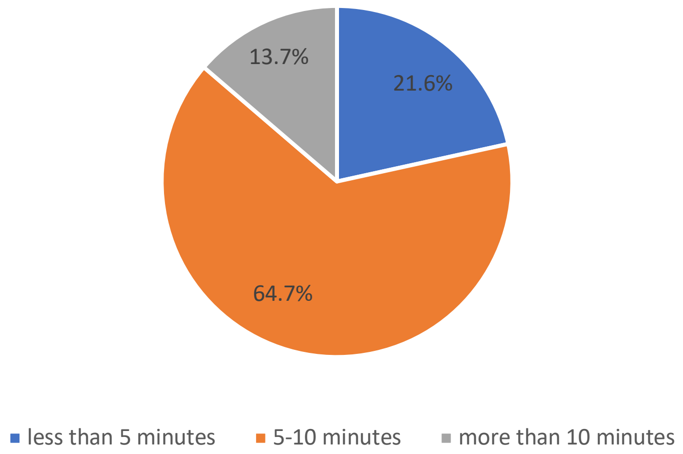

Figure 48: Duration of elderly being left in vehicle unattended (Malaysian data)

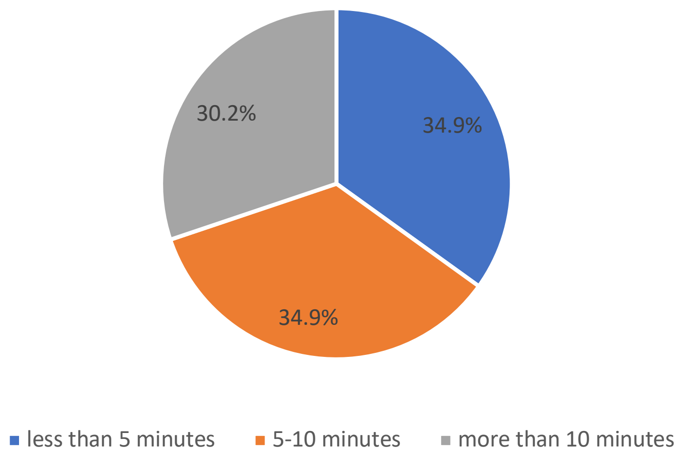

Figure 49: Duration of elderly being left in vehicle unattended (Thai data)

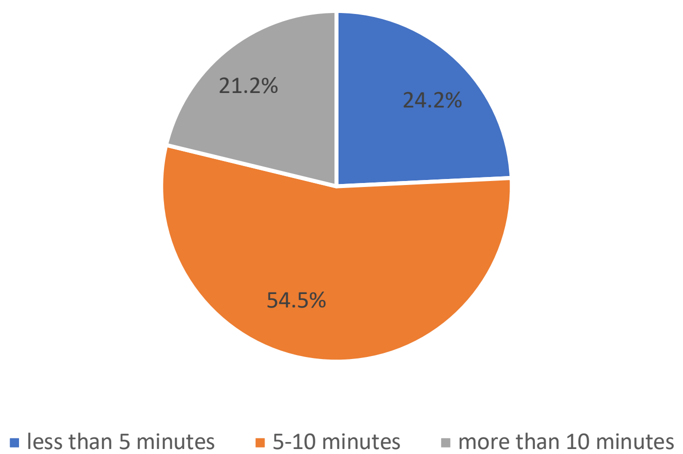

Figure 50: Duration of elderly being left in vehicle unattended (Indonesian data)

5 LIST OF OUTPUT

5.1 Publication

i. Abu Husain, N., Ismail, N. H. F., Mansor, M. S. F., Mohd. Zaki, N. I., Abu Husain, M. K., Ma'aram, A., Wiyono, A. S., Chaiyakul, T., Ahmad, Y. and Abu Kassim, K. A., (2019). *Child Presence Detection System and Associated Technologies*, presented at ICSM2019, Bali, Indonesia.

ii. Abu Husain, N., Ismail, N. H. F., Mansor, M. S. F., Mohd. Zaki, N. I., Abu Husain, M. K., Ma'aram, A., Wiyono, A. S., Chaiyakul, T., Ahmad, Y. and Abu Kassim, K. A., (2019). *Child Presence Detection: Assessment Methodology for ASEAN NCAP*, presented at ICSM2019, Bali, Indonesia.

iii. Child Presence Detection Handbook (completed - pending ISBN)

5.2 Intellectual Property Rights

i. Child Presence Detection Assessment Methodology (LY2019007047)

ii. Survey on Vehicle Passengers Seating Positioning (LY2019007046)

5.3 Human Capital

i. One (1) intern student (Completed)

ii. One (1) Master student (Ongoing)

6 CONCLUSION

This book outlines the achievement of ANCHOR II project on Child Presence Detection (CPD): Assessment Methodology & Guidelines for ASEAN NCAP. The project was successfully conducted with good collaboration between Malaysia, Thailand and Indonesia team.

In general, all three project's specific objectives have been successfully accomplished. In terms of outputs, preferred positioning of children when travelling in vehicles are identified, together with level of awareness regarding CRS usage and seatbelts utilisation. Moreover, the project also managed to contribute to the Child Occupant Protection Protocol, specifically on Section 6 for Child Presence Detection Procedure. Furthermore, two (2) conference papers have been produced, one (1) book is awaiting ISBN registration, two (2) IPRs have been registered, and two (2) human capitals have been developed throughout the project duration.

It is hoped that the methodology proposed in this document could help ASEAN NCAP in accomplishing its roadmap. Furthermore, it should also guide the vehicle manufacturers, product developers and innovators to bring more robust child safety products to market.

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