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The potential for vehicle safety standards to prevent deaths and injuries in Latin America

An assessment of the societal and economic impact of inaction

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Executive Summary

In the European Union (EU) (and other industrialised regions) vehicle safety standards have improved considerably over the past few decades, resulting in the realisation of substantial casualty savings. These improvements have been driven by regulations (including frontal and side impact regulations) and consumer testing programmes such as the European New Car Assessment Programme (Euro NCAP), which have encouraged manufacturers to exceed the minimum requirements set out in the regulations.

Globally, over 1.25 million people died as a result of road accidents in 2013. Many of these casualties occurred in low- and middle-income countries where the estimated road traffic death rate is substantially higher than that in the safest European countries. Vehicle safety in these emerging markets is far behind that seen in Europe, and if the lessons learnt in industrialised regions could be effectively and efficiently applied then there could be considerable casualty reductions and economic benefits.

Vehicle safety can be split into two main types:

- Primary safety technologies such as Electronic Stability Control (ESC) reduce the chances of a collision occurring.
- Secondary vehicle safety includes technologies (such as airbags) and structural developments in vehicles that reduce the severity of injuries in a collision.

In 2015, TRL carried out a statistical analysis to determine how many lives could be saved in Brazil if minimum car secondary safety regulations and consumer testing programmes were applied to new vehicles (Cuerden, Lloyd, Wallbank, & Seidl, 2015). Primary safety was not considered.

The aim of this new study was to extend the previous analysis to predict how many car user deaths and injuries could be prevented in four Latin American countries (Argentina, Chile, Mexico and, from the previous study, Brazil) by establishing minimum car secondary safety regulations and consumer testing. The major regulations considered are United Nations (UN) Regulations No. 14, 16 (seat belts and anchorages), 94 (occupant protection in frontal collision) and 95 (occupant protection in side or lateral collisions).

The study concludes that up to 40,000 car occupant fatalities could be prevented across some of the major geographical regions of Latin American between 2016 and 2030, if minimum vehicle safety standards were adopted. If seriously injured occupants are also considered then it is estimated that up to 440,000 killed or seriously injured car user casualties could be prevented. Economic assessment suggests that these casualty reductions could save up to 143 billion US dollars over the period 2016 to 2030.

The casualty and monetary savings would be significantly greater if the whole Latin American region adopted minimum vehicle secondary safety standards.

Some Latin American countries have started the legislative process and are now applying some standards that are similar to the EU (and other similar industrialised regions), but there is still a significant gap between the regulated vehicle safety standards in the industrialised regions and Latin America. In particular, frontal and side impact tests meeting UN Regulations 94 and 95 should be mandated and applied to all new cars sold across the whole Latin American region as soon as practicable. In addition, seat belts should be

mandatory for all passengers and this should be enforced to ensure that wearing rates increase; without a substantial increase in the proportion of people wearing a seat belt the casualty savings estimated in this paper cannot be realised. Finally, it is strongly recommended that ESC (Global Technical Regulation (GTR) 8, or UN13H) and pedestrian protection (GTR 9 or UN127) are also adopted into Latin American car safety regulations as these are proven to be cost effective countermeasures with established UN Regulations.

1 Introduction

1.1 Global road safety

According to the World Health Organisation (WHO) over 1.25 million people died as a result of road accidents across the world in 2013. In addition, up to 50 million more people were seriously injured. Many of these casualties occured in low- and middle-income countries where the estimated road traffic death rate is substantially higher than that in the safest European countries. Economic growth and increasing motorisation is predicted to lead to a rise in these casualty figures, particularly in emerging economies.

The Decade of Action for Road Safety (2011-2020) was adopted by the United Nations (UN) General Assembly in 2010 in response to this predicted rise. This aims to “stabilize and reduce predicted levels of road traffic fatalities around the world”, focussing on five pillars:

1) road safety management;
2) safer roads and mobility;
3) safer vehicles;
4) making road users safer; and
5) improved post-crash response and hospital care.

More recently the UN Member States have adopted a target to halve road traffic deaths and injuries by 2020 (relative to 2010) as part of the Global Goals for Sustainable Development (UN, 2016).

This report specifically concentrates on the third pillar – the safety of global vehicles.

1.2 Global vehicle safety

Vehicle safety has developed substantially over the last 50 years, primarily driven by developments in Europe, Japan and the United States (US). Vehicles in these regions are now built to comply with and exceed minimum regulatory standards. These standards include both secondary safety developments which are designed to reduce the severity of injuies in a collision (for example, front and side impact tests) and primary safety technologies which reduce the chance of a collision occurring (for example, Electronic Stability Control (ESC) regulations). The standards aim to provide the highest level of cost-effective safety performance.

In the world’s emerging markets vehicles are not currently regulated to the same extent. The WHO 2015 Status report reveals that only 40 countries worldwide apply all of the most important vehicle safety standards. This lack of effective vehicle safety regulation contributes to the higher casualty rates in these emerging markets, and will continue to have an impact unless targeted and efficient interventions are planned and implemented urgently.

The UN Decade of Action for Road Safety encourages all countries to apply six motor vehicle safety regulations, which are defined as a minimum for today's world markets:

a) Seat belts and anchorages for all seating positions (UN Regulations 14 and 16).

b) Occupant protection in frontal collision (UN Regulation 94)

c) Occupant protection in side or lateral collision (UN Regulation 95)

d) Pedestrian protection (Global Technical Regulation (GTR) 9 or UN Regulation 127)

e) Electronic Stability Control (ESC) (GTR 8 or UN Regulation 13H)

In addition to the regulations, the UN Decade of Action also has a stated activity to: '*Encourage implementation of new car assessment programmes in all regions of the world in order to increase the availability of consumer information about the safety performance of motor vehicles*'. The European New Car Assessment Programme (Euro NCAP), introduced in 1997, created a five-star safety rating system to "*help consumers, their families and businesses compare vehicles more easily and to help them identify the safest choice for their needs"* (Euro NCAP, 2016). Euro NCAP provides an independent assessment of the safety of popular cars sold in Europe and aims to inform consumers of the relative performance of the cars they buy and to encourage manufacturers to exceed the minimum requirements set out by legislation. NCAPs now exist in almost all regions of the world and there is good evidence from individual countries that in combination these consumer testing programmes and regulations have reduced casualties (e.g. Lie & Tingvall (2000), Newstead *et al.* (2006) and NHTSA (2012)).

The lessons that have been learnt from the development and evaluation of vehicle safety standards and assessment programmes in industrialised regions should be quickly and cost effectively applied in emerging markets, so that vehicle safety is a right for all, regardless of wealth.

1.3 Casualty savings in Brazil

In 2010 it was estimated that 10,200 car occupants died in accidents on Brazilian roads. However, with rapid growth in passenger cars forecasted in Brazil, work carried out by TRL predicted that the number of road deaths and casualties will rise significantly, unless targeted and efficient interventions, including improvements to the vehicle safety performance standards for new cars, are urgently implemented (Cuerden, Lloyd, Wallbank, & Seidl, 2015).

A series of statistical models highlighted how many car user deaths and injuries would be prevented in Brazil if the experiences and lessons learned over the past 20 years in the European Union (EU), specifically establishing minimum car secondary safety regulations and consumer testing, were applied. In effect, the potential impact of UN Regulations Numbers 14, 16 (seat belts and anchorages), 94 (occupant protection in frontal collision) and 95 (occupant protection in side or lateral collision) have been modelled. Based on conservative assumptions, the study concluded that up to 34,000 fatalities and 350,000 seriously injured casualties could be prevented between 2015 and 2030.

In 2014, new regulations came into force that require manufacturers selling cars in Brazil to fit airbags and anti-lock braking systems (ABS), and which include requirements for manufacturers to meet a frontal impact crashworthiness test (either based on UN R94 or Federal Motor Vehicle Safety Standard (FMVSS) 208). These new regulations mean that Brazil has successfully started the legislative process and is now applying some standards that are similar to the EU or the US, but there is still a significant gap between the regulated vehicle safety standards in the industrialised regions and Brazil. The most significant shortfalls concern the lack of a side impact test requirement, ESC is not mandated and there are no requirements for pedestrian protection. Without these additional regulations, the full potential for casualty savings in Brazil may not be realised. However, at the Second Global High-level Conference on Road Safety, titled 'Time for Results', hosted in Brasilia in November 2015, the Brazilian government publically stated that it will: "*Promote the adoption of policies and measures to implement United Nations vehicle safety regulations or equivalent national standards to ensure that all new motor vehicles, meet applicable minimum regulations for occupant and other road users protection, with seat belts, air bags and active safety systems such as anti-lock braking system (ABS) and electronic stability control (ESC) fitted as standard"* (Brasilia Declaration, 2015).

The timescale for the introduction of these regulations is not clear and the authors would recommend rapid action to prevent further unnecessary loss of life and injury on the road.

1.4 Aims of this work

This specific aims of this project were to:

- Quantify how many car occupant (driver and passenger) fatalities and serious injuries could be prevented in Chile, Mexico and Argentina between 2016 and 2030 if basic minimum secondary safety measures were adopted, namely UN Regulations 14, 16, 94 and 95, and the impact that the New Car Assessment Programme for Latin America and the Caribbean (Latin NCAP) will provide on further real world vehicle improvements.
- Quantify the economic burden for Brazil, Chile, Mexico and Argentina associated with not adopting minimum car secondary safety standards.

This work builds on the methodology developed by TRL for the Brazilian (Cuerden, Lloyd, Wallbank, & Seidl, 2015) and Malaysian studies (Lloyd, Cuerden, Wallbank, & Seidl, 2015).

2 Method

In order to achieve the objectives, the method uses accident, exposure and vehicle data from Great Britain (GB) and three emerging markets (Chile, Argentina and Mexico) and involves three main tasks:

- Evaluate the impact that car secondary safety developments in Britain have had on the reduction in car user casualties since 1990;
- Identify the baseline years in Britain that the current vehicle fleet and safety situation in the emerging markets most closely reflect; and
- Assuming similar secondary safety developments could be seen in these emerging markets, predict the impact of vehicle safety changes in these emerging markets given the estimated impact in Britain and the baseline year.

2.1 Car secondary safety in Britain

The impact of car secondary safety developments in Britain has been investigated in a series of general linear models. In summary, in this approach, the proportion of casualties killed in road accidents (the injury severity proportion) is modelled by car registration year based on data from police reported injury accidents (from the British STATS19 accident database) occurring between 1989 and 2013.

The variables included in the model are:

- **Car registration year:** this is used to estimate the reduction in the severity of drivers' injuries linked to changes in succeeding 'cohorts' in the car fleet.
- **Year of accident:** this accounts for the fact that other road safety measures and conditions will have affected the road system.
- **Age/sex:** it is known that older drivers tend to be more seriously injured than younger drivers for physiological reasons and they are also more likely to drive older cars.
- **Size of car:** driver casualty rate falls markedly with size of car; larger cars tend to protect their occupants more than smaller vehicles.
- **Built-up (BU) and non-built-up (NBU) roads:** injury severity is influenced by the speed at which the accident occurs. The impact speeds of vehicles involved in injury accidents are not recorded in STATS19 but the speed limit of the road will be used as a proxy.

The results of the models predict the number of car user casualties which would have occurred if secondary safety had not improved over time. For example, it is possible to determine if the secondary safety of cars had remained at the level of the 1990-91 registered cars how many additional fatalities would have occurred in 2010.

The detailed method and results of this modelling are described in Lloyd *et al.* (2015).

2.2 Establishing a baseline year

The safety level of the current emerging markets' vehicle fleets was compared to the historic safety levels of the fleet in Britain using NCAP testing videos. The top selling cars in each market were identified and the relevant NCAP testing videos in each region (Latin NCAP and Euro NCAP) were identified. A group of vehicle safety experts viewed the NCAP videos, where available, for the top 20 new car sales in Argentina and Mexico in 2015 (top 12 in 2011 in Chile) and the top 10 new car sales in GB in 1994, 2004, 2009 and 2013. For the emerging markets, these were based on the latest available tests from 2010-2014 and for GB it included tests completed around 1997-2000, 2002-2005, 2007-2010 and 2011-2014 respectively.

As the NCAP protocols vary in different regions and have changed over time the official NCAP test results are not comparable over time or internationally. Therefore a basic but consistent method was applied to assess the cars across the different NCAP tests.

The cars were classified into a series of categories based on six questions:

- Did the vehicle have a stable structure to the passenger compartment?
- Where did the structure deform if relevant?
- Was the steering column stable?
- How did the steering wheel move if relevant?
- Was there an airbag present and if so, did it deploy correctly?
- Was there good airbag contact with the driver's head?

In addition, structural deformation was classified into one of nine categories:

1. No intrusion
2. Mild A-pillar damage
3. Severe A-pillar damage
4. Mild vehicle sill (base of door) or footwell movement/damage
5. Severe vehicle sill movement/damage
6. Mild A-pillar and sill damage
7. Severe A-pillar damage and mild sill damage
8. Mild A-pillar damage and severe sill damage
9. Severe A-pillar and sill damage

The results for the different Latin American countries are compared with the historic results from Britain in order to determine the baseline GB year with the most similar results.

There are some obvious limitations to this methodology including the subjective manner of the scoring and differences in the views provided in different tests. In addition, the overall method can only consider vehicles which have undergone NCAP testing. However, this is considered to be an acceptable limitation since the top 20 models (or 12 in the case of Chile) cover a large proportion of new cars sales (66% in Argentina, 33% in Chile and 56% in Mexico).

The methodology implemented here is consistent with the previous study for Brazil (Cuerden, Lloyd, Wallbank, & Seidl, 2015) and additional checks were carried out to ensure the scoring was done in a consistent manner:

- Re-rating of some of the vehicles from the Brazil study to calibrate the results from the benchmarking against that completed previously.
- Multiple vehicle safety experts independently scored the vehicles and then compared results.
- Checks were made against the description of structural stability and intrusion in the relevant Latin NCAP report (available from latinncap.com).

2.3 Predicting the impact in emerging markets

Based on the British models evaluating the impact of car secondary safety developments, and the baseline years devised using the method described above, it is possible to predict the potential future effect of secondary safety improvements in cars in emerging markets. Predictions are based on baseline models that model possible casualty trends over a number of possible traffic growth scenarios. To these the impacts of further car safety interventions can be added to predict the impact of these additional measures.

For the baseline model, the expected number of registered cars is predicted based on the following broad scenarios[1]:

a) Similar growth or decline to that observed in recent trends

b) No change in current level

c) Increased or decreased growth or decline relative to current trend

The casualty trend is predicted forward assuming a constant casualty rate (i.e. basic road safety efforts continue in the way that has been observed up until the current time) and using the traffic estimates via the following model:

$$C'(2030) = C(2014)\ [\ T(2030)\ /\ T(2012)\ ]\ (1-\alpha)^{17}$$

where:

- C'(2030) is the predicted adjusted number of car occupant fatalities in 2030 given current progress in vehicle safety
- C(2014) is the number of car occupant fatalities in 2014 (the latest known year)
- T(2030) is the expected number of registered cars in 2030 based on a series of scenarios
- T(2014) is the number of registered cars in 2014

[1] The specific scenarios applied for each of the three countries are detailed in Section 5.

- α is the average annual fatality rate of reduction (adjusted rate) predicted over the 17 year period 2014-2030

This baseline models predict the number of casualties expected if no further road safety interventions are introduced over a period of time, taking into account possible changes in traffic. The potential impact of new secondary safety measures are added to the baseline model by adding additional reductions to the baseline casualty trends.

The measures that are relevant to this research are the secondary safety initiatives that include the known impact of European Commission (EC) Directives and the impact of NCAP testing in Britain. In this research there are two assumed scenarios:

I. Introduction of similar regulations and adaptations to the NCAP testing regime, similar to those seen in Europe over the same time period (referred to as the 'similar timescale' scenario in Section 5)[2].

II. Introduction of regulations and NCAP adaptations as above, but over a shorter period (referred to as the 'quicker timescale' scenario in Section 5)[3].

It is also important to consider the timing and likely uptake of these new measures. This has been achieved by observing the current fleet turnover in Chile, Argentina and Mexico relative to that in Britain in the associated baseline year.

A number of reasonable assumptions are required in this prediction step:

a) Accident types for cars are similar in GB to emerging market accident types
b) The uptake rate of these regulations and the relative timing is the same in the emerging markets as the GB
    - This is a feasible requirement given that discussions are already underway in some countries
    - It is recognised that regulations take time to introduce but this has been incorporated into the estimate as the reductions are based on a timeline in GB of 1990-2010 which commences 8 years before the regulations were first introduced
c) The impact of NCAP in the emerging markets is insignificant but grows as seen in GB in terms of the impact on individuals' buying habits.

2.4 Monetise the preventable casualties

The prediction models assess the expected number of casualties saved due to implementation of secondary safety measures in Latin America. These savings are quantified

[2] Generally, vehicle fleet turnover in the emerging markets is slower than seen in Great Britain in the baseline year. As a result, this scenario takes into account differences in the fleet turnover to replicate a similar timescale for the uptake of the regulations into the fleet.

[3] The quicker timescale scenario is equivalent to the vehicle fleet turnover in each emerging market being similar to Great Britain in the baseline year.

economically using the Value of Statistical Life method associated with GDP and described in Bhalla *et al.* (2013) – see Section 6.

3 Establishing a Baseline Year

The performance of vehicles on sale in Argentina, Chile and Mexico and tested by Latin NCAP was benchmarked against data from Euro NCAP as outlined in Section 2.2. Section 3.1 presents some of the key results from the benchmarking exercise and Section 3.2 discusses the results, including some of the limitations of the process, and of the data that was available for analysis.

3.1 Results

Three progressively more complex methods have been used to identify potential equivalent Euro NCAP years. Initially, a simple comparison of structural stability was used to compare the cars in the emerging markets to vehicles in Europe. Table 1 shows the number of tested cars for which the structure was considered by the reviewers to be stable after the crash test. For comparison, the table also shows the same information for the Euro NCAP data that was assessed previously. Based on this comparison, the structural stability of the vehicles available in Argentina, Chile and Mexico were assigned an equivalent Euro NCAP year (Table 1).

Table 1: Euro NCAP equivalent year assessed by combined structural stability and structural deformation category (counts)

	Stable structure		Euro NCAP equivalent year
	N	Y	
Argentina (2015 data)	4	11	**2004**
Chile (2011 data)	4	1	**1999**
Mexico (2015 data)	5	7	**2004**
Euro NCAP 1999	9	1	
Euro NCAP 2004	2	6	
Euro NCAP 2009		5	
Euro NCAP 2013		8	

This analysis was also performed for the data weighted by new car sales volume in each country (Table 2).

Table 2: Euro NCAP equivalent year assessed by combined structural stability and structural deformation category (sales-weighted)

	Stable structure		Euro NCAP equivalent year
	N	Y	
Argentina (2015 data)	13%	36%	**2004**
Chile (2011 data)	12%	4%	**1999**
Mexico (2015 data)	17%	21%	**2001**
Euro NCAP 1999	31%	4%	
Euro NCAP 2004	6%	20%	
Euro NCAP 2009		16%	
Euro NCAP 2013		24%	

The comparisons by sales-weighted figures are considered to be more representative of the equivalent Euro NCAP year than the count of vehicles presented in Table 1, since these take into account how many of each car model have been purchased.

Similar comparisons were made for the other six questions listed in Section 2.2 (i.e. stable structure, structure deformation, stable steering column, steering column movement, airbag presence and airbag contact), although there were some challenges with accurately assessing a number of these measures (see Section 3.2).

As a result, the most accurate representation of the performance of cars was considered to be sales-weighted data, based on a combination of the structural stability and structural deformation category. This information was combined and the pattern compared with that for the Euro NCAP data assessed previously. Again, a Euro NCAP equivalent year was assigned based on this comparison (Table 3).

Table 3: Euro NCAP equivalent year assessed by combined structural stability and structural deformation category (sales-weighted %)

Stable structure	Y	Y	N	Y	N	Y	N	Y	N	
Structural Deformation Category	1	2	3	4	6	7	7	9	9	Euro NCAP equivalent year
Argentina (2015 data)	21		2	9	5	4	2	3	4	**2002**
Chile (2011 data)		4	4				4		4	**1999**
Mexico (2015 data)	10	6	3	1	2	5			12	**2000**
Euro NCAP 1999		4	6				10		15	
Euro NCAP 2004	13	3	4			4	2			
Euro NCAP 2009	11			5						
Euro NCAP 2013	17	2		5						

It can be observed that the sales-weighted results in Table 3 are the same for Chile, but slightly older for Argentina and Mexico than indicated by the earlier tables.

The equivalent Euro NCAP years identified in Table 3 are used for the modelling Argentina and Mexico in Section 5. However, the assessment for Chile was performed using data from 2011 and identifies the baseline year for cars as 1999. Assuming that car safety has developed in a similar manner to the way it did in GB, the modelling assumes that the frontal impact crashworthiness of cars in 2015 in Chile is equivalent to cars in Great Britain in 2003.

3.2 Discussion

The results in Section 3.1 give an indication of the Euro NCAP-equivalent year for vehicles sold in each market in 2015: 2002 for Argentina, 2003 for Chile and 2000 for Mexico. However, it should be noted that this analysis focussed solely on frontal offset crash test data because this was the only crash test configuration available for many of the Latin NCAP vehicles. Only nine of the Latin NCAP tests reviewed included a side impact barrier test, with 23 having no side impact test. None of the nine side impact test videos showed a side airbag deploying. By comparison all Euro NCAP vehicles in 1997 (20 cars) were side impact tested (barrier) and pole tests were introduced as an option from 1998. Therefore, the Euro NCAP-equivalent year for these vehicles is *older* than indicated in Section 3.1.

The frontal impact assessment was based on a number of criteria defined in Section 2.2, which can be summarised as:

- Structural integrity of the passenger compartment at the A-pillar and sill
- Degree of deformation of the A-pillar and/or sill
- Stability of the steering column
- Provision of front airbags (driver's steering wheel mounted and FSP's instrument panel mounted)
- Stability of airbag contact (for the driver)

In reviewing the Latin NCAP videos against these criteria a number of issues were noted.

In some cases the steering wheel moved upwards, which was counted as a loss of stability, but the engagement of the driver crash test dummy with the airbag was good and the head and chest injury metrics were acceptable (based on the NCAP rating colour for these regions). This indicated that the loss of stability would not be detrimental to the injury outcome for this size of occupant in the tested seating position; however, other sizes of occupant in other seating positions may be more affected by this type of steering wheel movement. Nevertheless, steering wheel stability was difficult to assess in some of the videos and so this factor was not used to differentiate vehicle performance.

Only one out of 20 drivers' airbags showed indications of unstable contact, with the driver's head tending to rotate past the rim of the steering wheel and towards the edge of the airbag. Similarly, only two out of 31 of the Euro NCAP tests that were analysed previously had poor airbag contact, both in 1999 vehicles. Therefore, this criterion was not found to be a good differentiator of vehicle performance.

A further 12 (38%) Latin NCAP vehicles (out of a total of 32 that were analysed) did not provide any frontal airbags for the front seat occupants. This compares with 100% fitment of frontal bags in the Euro NCAP dataset analysed previously, including the 1999 data. Therefore, by this metric the emerging market fleet is older than the baseline Euro NCAP year of 1999, especially Chile which had no frontal airbags in any of the tests that were analysed.

It was also observed that most of the frontal airbags appeared to be of a relatively old design compared with the current EU fleet. There have been many developments and improvements in frontal restraint system design since the introduction of Euro NCAP testing, for example:

- Shoulder belts with pretensioner and shoulder belt load limiter. Load limits have been gradually reduced over time to provide lower loads on the thorax and greatly reduced chest deflection measurements in tests. These reduced chest loads would be expected to have large injury reduction benefits in real-world collisions, with the benefit increasing with increasing car user age.
- Either high lap belt forces (often greater than 10 kN) to limit knee contact with the instrument panel and prevent excessive knee and femur forces, or lower lap belt forces in combination with a knee airbag to achieve the same effect.
- Anti-submarining structures in the seat base (under the foam cushion) that help reduce forward motion of the pelvis.
- Other systems, such as seat-belt tongues that lock on to the webbing when loaded in a crash and minimise belt slip.
- Changes to airbag inflation characteristics and venting to optimise the airbag performance. For example, modern frontal airbags typically use systems such as internal tethers to control the volume of the deploying airbag. If an occupant is seated further back, the leading edge of the airbag will displace further from the airbag module; this will pull internal tethers taut, closing some of the vent holes and allowing the bag to inflate to its maximum volume. If an occupant is seated closer to the airbag, the leading edge of the airbag will contact the occupant and stop; the internal tethers will not close some of the vents, so more gas escapes and the bag does not reach its maximum size. These systems allow the airbag to provide protection for taller occupants seated further from the steering wheel, while avoiding excessive airbag forces on shorter occupants seated closer to the wheel.

Further analysis would be required in order to understand how well the restraint systems compare with current EU practice; for example, the publically available data from Latin NCAP does not state whether shoulder belt load limiters are fitted and lap and shoulder belt loads are not stated. The presence of pre-tensioners in front seating positions is specified, but not all vehicles with airbags had these or had one only in the driver’s position, even for 2015 and 2016 vehicle models.

3.2.1 Additional Baseline

To account for the absence of a side impact test and differences in the fitment of front passenger and side airbags between Europe and the emerging markets, an additional baseline has been applied to all three markets in the modelling (Section 5). This alternative baseline assumes that cars in the emerging markets in 2015 are actually equivalent to cars in GB in 1995. This secondary analysis offers an upper limit on the car user casualty savings which could be achieved, assuming the equivalent European vehicle safety regulations are applied efficiently in each country.

4 Road Safety in Latin America

This section gives an overview of the population, road collision fatalities, vehicle fleet, road safety regulations and vehicle safety legislation in each of the emerging markets.

4.1 Argentina

4.1.1 Population

The population of Argentina reached approximately 43 million in 2014, up from approximately 33 million in 1990. Figure 1 shows an increase in the motorisation rate[4] alongside the increase in population.

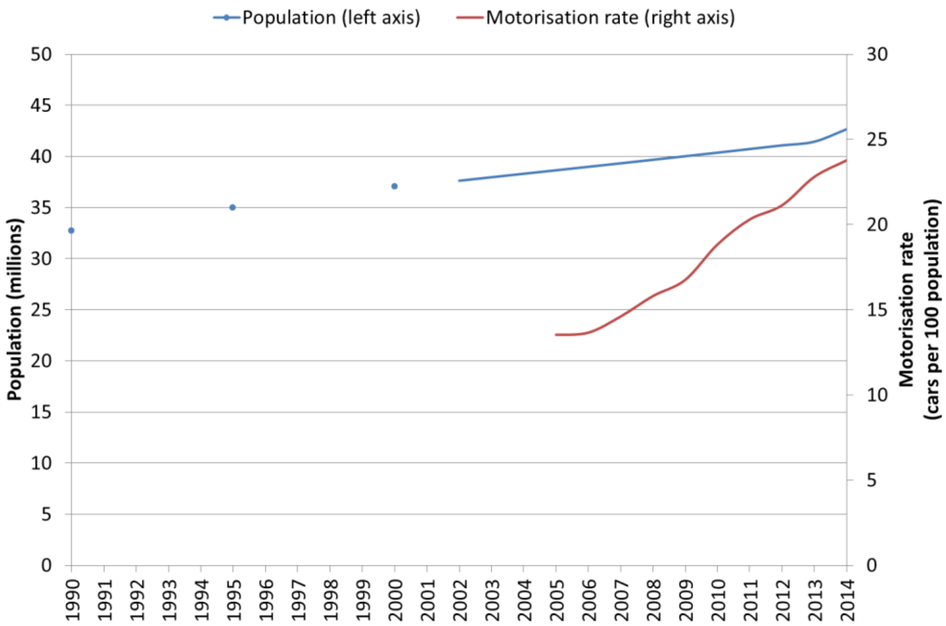

Figure 1: Population and motorisation rate in Argentina, 1990-2014 (World Population Review (2016) & WHO (2016))

The median age of the population was 31.4 years in 2015 (Central Intelligence Agency, 2015) and the Gross Domestic Product[5] (GDP) per capita in 2014 was 12,510 USD (World Bank Group, 2016a).

4.1.2 Road collision fatalities

The total number of fatalities and the number of car occupant fatalities in Argentina between 2009 and 2014 has remained relatively constant (note that data for the number of car occupant fatalities was only available for a subset of these years). Figure 2 presents the

[4] Motorisation rate refers to 'cars per population' throughout the report. Exceptional instances in which motorisation rate refers to all vehicles will be made clear.

[5] GDP is a measure of the value of all final goods and services produced by a country. It is commonly used to compare the economic performance of regions or countries.

total and car occupant fatalities and the total fatalities per million population from 2009 to 2014.

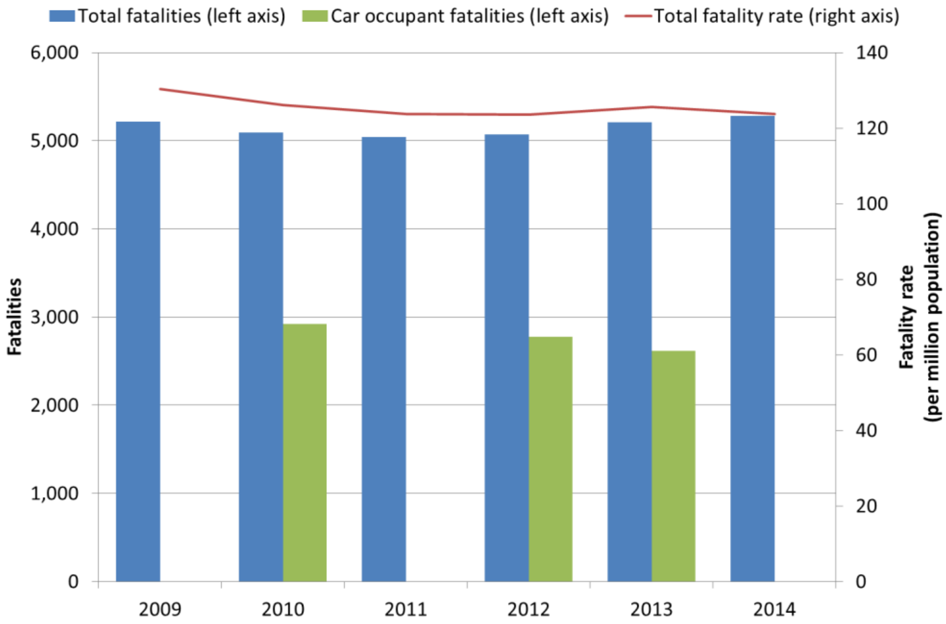

Figure 2: Number of fatalities and fatality rate per population in Argentina, 2009-2014 (OECD/ITF, 2015)

Although the number of fatalities has remained relatively constant, there seems to be a slight decreasing trend in the fatality rate (per million population) from 2009 to 2014.

The number of fatalities by road user type is presented in Figure 3.

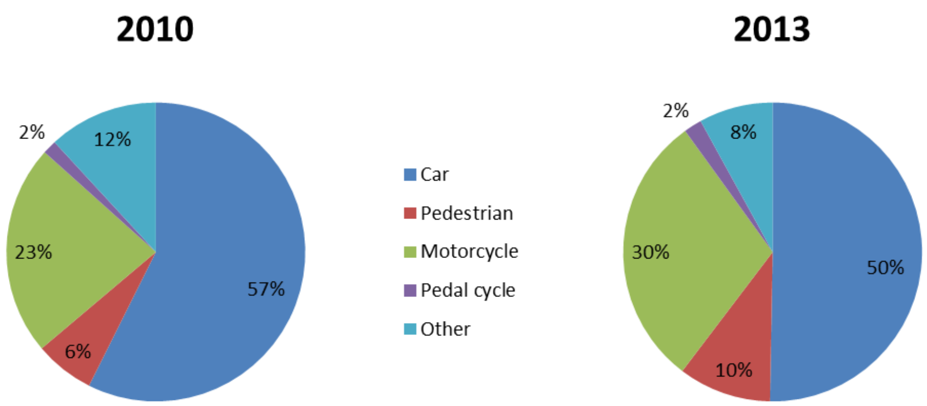

Figure 3: Number of fatalities in Argentina by road user group, 2010 & 2013 (OECD/ITF, 2015)

The proportion of fatalities that are car occupants decreased from 57% in 2010 to 50% in 2013, whereas the proportion of motorcycle and pedestrian fatalities increased over the same time period.

4.1.3 Vehicle fleet

There are several conflicting data sources estimating the number of vehicles registered in Argentina; for example, 2011 estimates range from 11 million (OICA, 2016a) to 20 million (OECD/ITF, 2015). The values presented are taken from the Argentinian Road Safety Observatory website (Seguridad Vial - Ministerio de Transporte, 2016b) which estimate that in 2011 there were approximately 15 million vehicles (see Figure 4). The estimated number of passenger cars is also presented (OICA, 2016a).

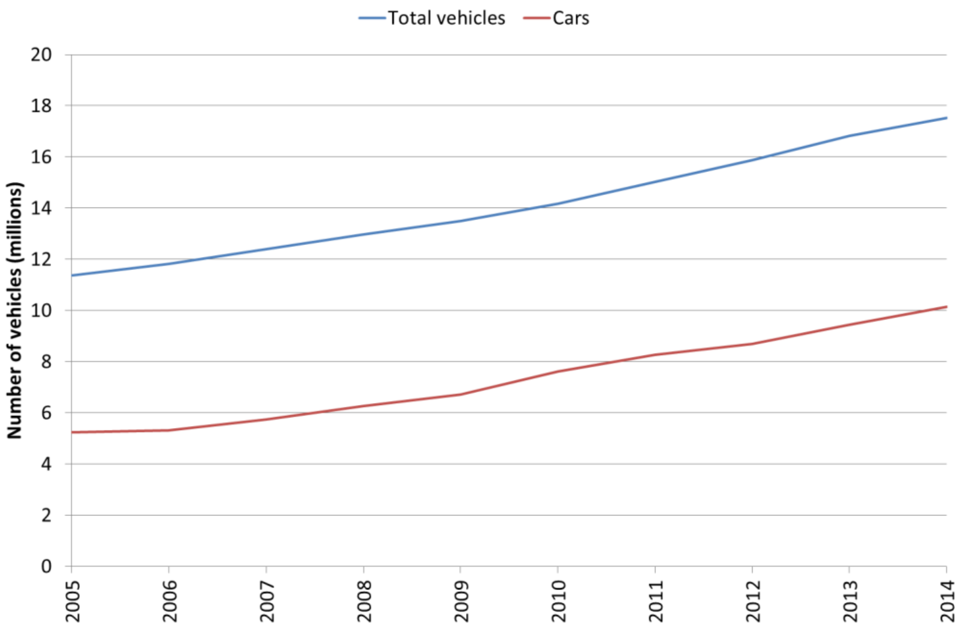

Figure 4: Total number of registered vehicles (Seguridad Vial - Ministerio de Transporte, 2016b) and number of cars (OICA, 2016a) in Argentina, 2005-2014

The total number of vehicles has increased by over 54% between 2005 and 2010 but the car fleet has been growing faster: is it estimated that cars accounted for approximately 46% of the vehicle fleet in 2005 but by 2014 this had grown to 58%. Over this period the growth in the number of cars from the previous year has been an average of 7.7%.

Figure 5 shows that the number of new cars being introduced into the market has been fluctuating over the period 2005 to 2015. There was a slight increasing trend in the number of new car sales up to 2013 but this has fallen in recent years.

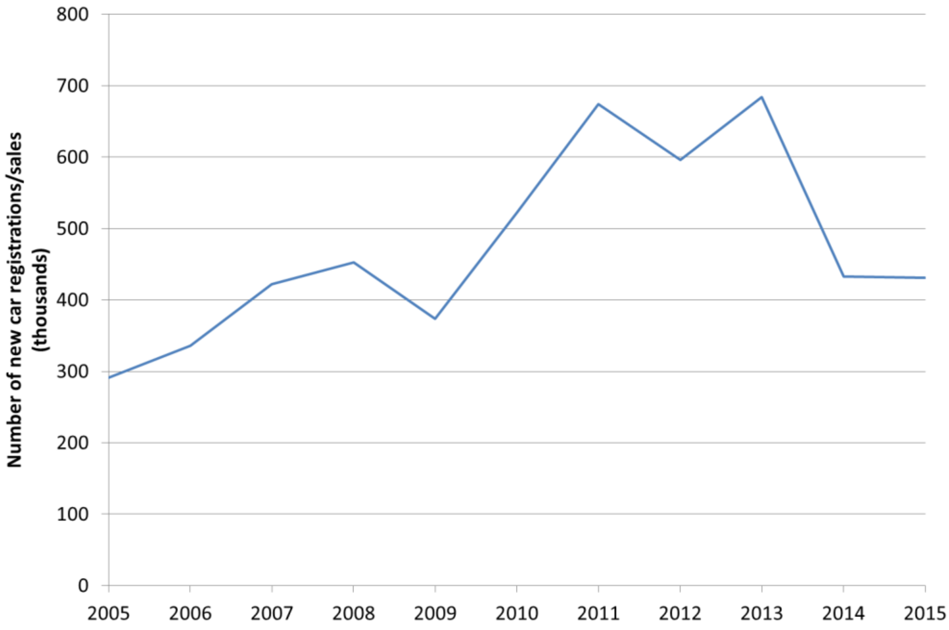

Figure 5: New car sales in Argentina, 2005-2015 (OICA, 2016b)

These data indicate that, on average over the past 10 years, around 6.5% of the car fleet each year are registered as new.

Six car and light van manufacturers combine for approximately 82% of the market share in Argentina. Table 4 presents the market share for each of these manufacturers.

Table 4: Market share for car manufacturers in Argentina (U.S. Department of Commerce, 2014)

Make	Market share (%)
Volkswagen	17.2%
Renault	15.3%
Chevrolet	15.2%
Ford	12.6%
Fiat	11.4%
Peugeot	10.7%

The top ten models (based on 2015 sales numbers) are presented in Table 4 with the corresponding proportion of all new car sales. The top 10 models make up approximately 41% of the new car fleet.

Table 5: Rankings of make and model in Argentina by 2015 sales figures (Focus2Move, 2016a)

Rank	% sales	Model	Rank	% sales	Model
1	5.1%	Volkswagen Gol	6	4.0%	Ford Ecosport
2	4.8%	Chevrolet Classic	7	3.6%	Renault Clio
3	4.6%	Toyota Hilux	8	3.5%	Ford focus
4	4.2%	Ford Fiesta	9	3.5%	Toyota Etios
5	4.1%	Fiat Palio	10	3.2%	Volkswagen Amarok

4.1.4 Road safety

In 2013, 59% of car occupant fatalities were not wearing a seat belt (OECD/ITF, 2015). Although compulsory since 1995, the seat belt wearing rates in 2014 were 45% and 19% for front seat and rear seat passengers respectively (OECD/ITF, 2015).

Additionally, 13.5% of all accidents in 2013 had speed recorded as a contributory factor (OECD/ITF, 2015). A national speed limit law applies in Argentina with maximum urban road, rural road and motorway speed limits of 60, 110 and 130 km/h respectively (WHO, 2015).

In 2012, drink driving was a factor in 24% of fatal accidents in Argentina, where the legal limit is 0.05g/dL (OECD/ITF, 2015).

4.1.5 Vehicle safety legislation

The laws and decrees relating to traffic and road safety, including vehicle safety requirements, are listed on the Seguridad Vial website (Seguridad Vial - Minesterio de Transporte, 2016a). Law 26363/2008 created the National Road Safety Agency, as well as amending previous laws on driver licencing and penalties for driving offences. Article 29 notes that via the last paragraph of Article 29 (Safety Conditions) of Law 24449/1994 (Ministerio de Justicia y Derechos Humanos, 1994) the National Highway Traffic Safety Agency have required driver and front seat passenger airbag, anti-lock braking system (ABS), audible seat-belt reminder alert and automatic lights, among others as determined by the regulations. No specific performance requirements are defined in either of these laws.

Decree 779/95: Approval of the regulations of Law No. 24,449 defines Category L, M, N and O vehicles, and their sub-categories, very similarly to UN Regulation (Annex 1, Article 28). Some differences in the definitions were observed: for instance, L Category vehicles have constraints at 40 km/h, compared with 50 km/h in UN Regulations, and M1 vehicles have a mass limit of 3500 kg, whereas there is no specified limit in UN Regulations.

Annex 1 of the Decree covers many issues such as training and licencing, but also defines minimum standards for some aspects of vehicle design such as brakes, steering, suspension and tyres (Article 29). The requirements in Article 29 mostly reference Instituto Argentino de Normalización y Certificación (IRAM; an ISO member) standards. The same Article also sets vehicle emissions limits and references US and EU legislation as acceptable ways to demonstrate compliance.

Annex B specifies safety requirements for steering columns and seat anchorages that appear to be similar to UN Regulations. Annex C defines requirements for seat-belts and head restraints similar to UN Regulations. Similarly, other annexes specify requirements, for example wiper systems, glazing, door locks and mirrors.

Requirements for frontal and side impact collision safety were not identified in the Decree. Nevertheless, the OECD (2015) have noted that:

- In 2011, an agreement was reached with car manufacturers to implement European standards for new vehicles (for example, from January 2014, every new car should include ABS and airbags);
- Agreement reached in 2014 to make ESC mandatory in vehicles by 2018.

4.2 Chile

4.2.1 Population

Figure 6 shows that the population in Chile has been steadily increasing from approximately 13 million in 1990 to just less than 18 million in 2014. Over the same period, the motorisation rate has also increased.

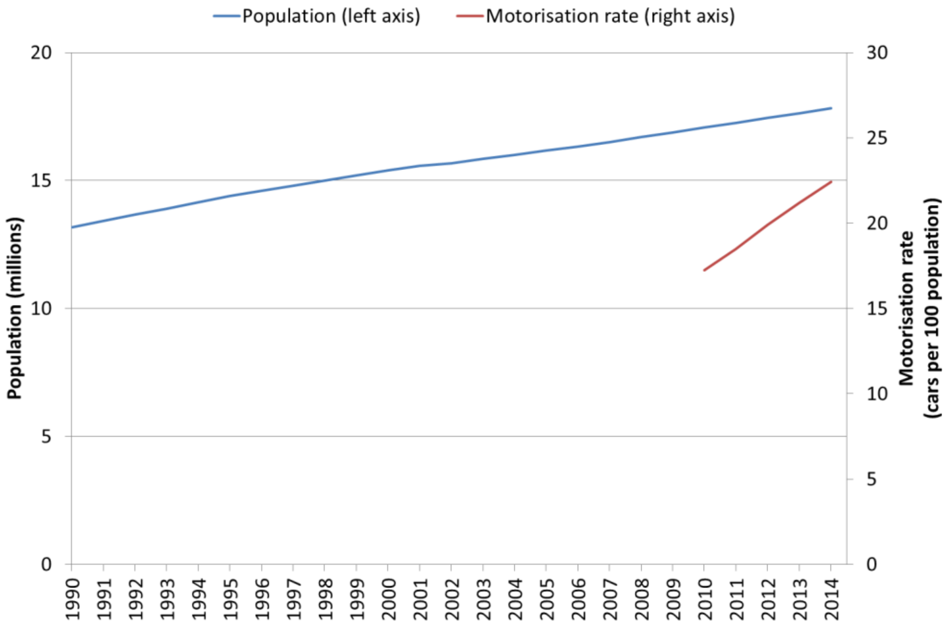

Figure 6: Population and motorisation rate for Chile, 1990-2014 (CONASET, 2016c)

The median age in Chile in 2015 was 33.7 years (Central Intelligence Agency, 2015). The GDP per capita in Chile in 2014 was 14,528 USD (World Bank Group, 2016a).

4.2.2 Road collision fatalities

The number of road accident fatalities in Chile has been fluctuating since 1990 with no obvious trend and, although the population has been steadily increasing (as shown in Section 4.2.1), the number of fatalities has not risen in line with this increase. As a result, the fatality rate (per million population) has generally been decreasing since 1998.

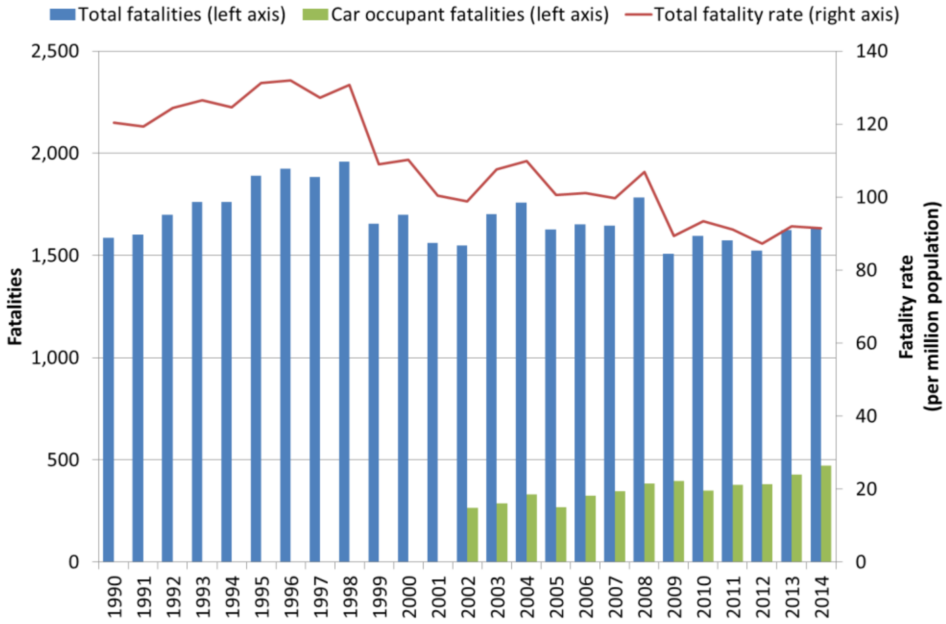

Figure 7: Number of fatalities and fatality rate per population in Chile, 1990-2014 (CONASET, 2016c)

The proportion of car occupant fatalities has increased from 22% in 2010 to 29% in 2014. This may be associated with the increase in registered cars over that same time period (see Section 4.2.3).

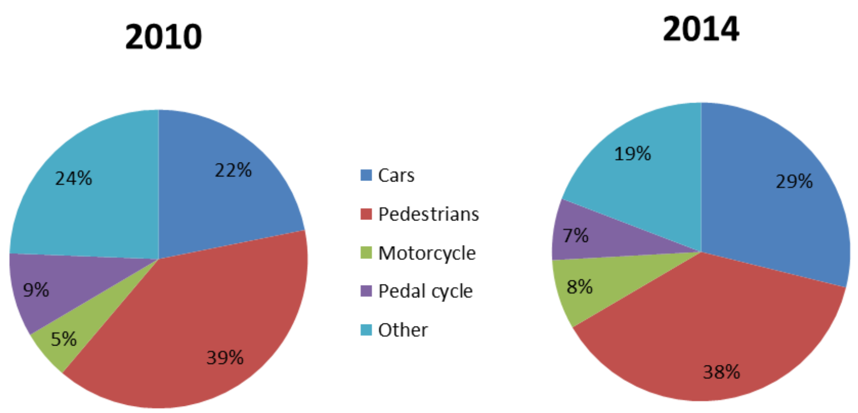

Figure 8: Number of fatalities in Chile by road user group, 2010 & 2014 (CONASET, 2016c)

4.2.3 Vehicle fleet

The trend in the total number of vehicles and the number of vehicles by vehicle type are presented in Figure 9. The number of registered vehicles in Chile has increased substantially in recent years; growing by 35% between 2010 and 2014. There was similar growth in the number of cars (an increase of 38%). Although small, relative to the increase in the number of cars, increases in other modes existed. For example, the number of motorcycles increased from approximately 100,000 in 2010 to approximately 170,000 in 2014 (64% increase), suggesting that motorcycles are becoming a more popular mode of transport.

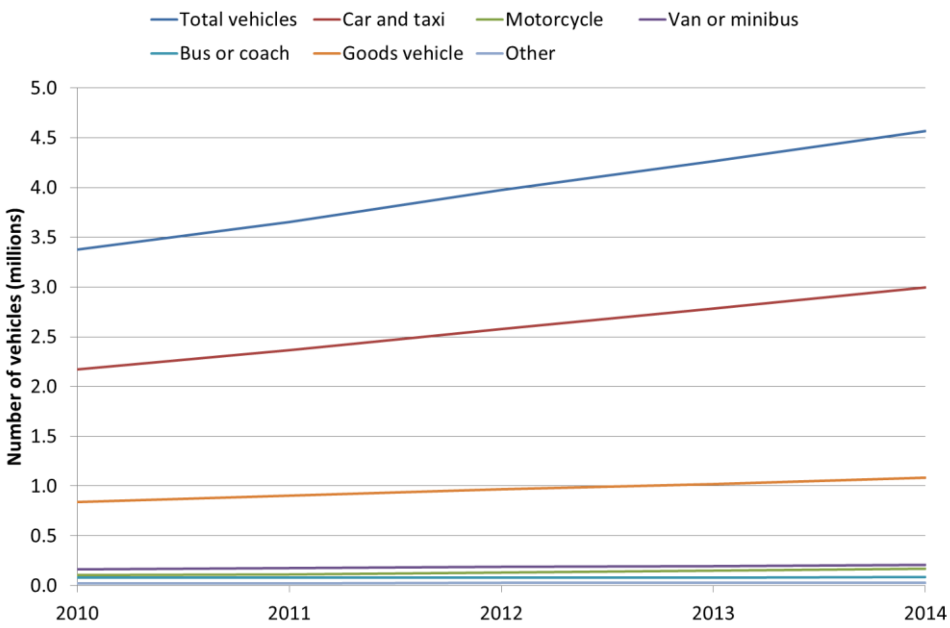

Figure 9: Total number of registered vehicles and number of vehicles by type in Chile, 2010-2014 (CONASET, 2016c)

Despite their noticeable increase over that time period, cars still make up a similar proportion (66% in 2014) of the vehicle fleet (see Figure 10).

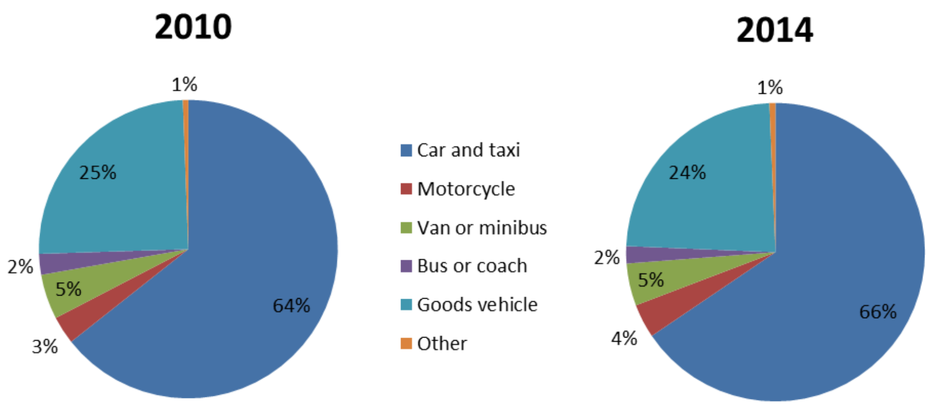

Figure 10: Proportion of vehicle fleet in Chile by vehicle type, 2010 & 2014 (CONASET, 2016c)

Figure 11 shows the number of new car sales between 2008 and 2015. The number of new car sales increased between 2010 and 2013; however new car sales appear to have slowed in 2014 and 2015. In 2015, the proportion of the medium and light fleet (which includes cars) which were less than 1 year was 12%.

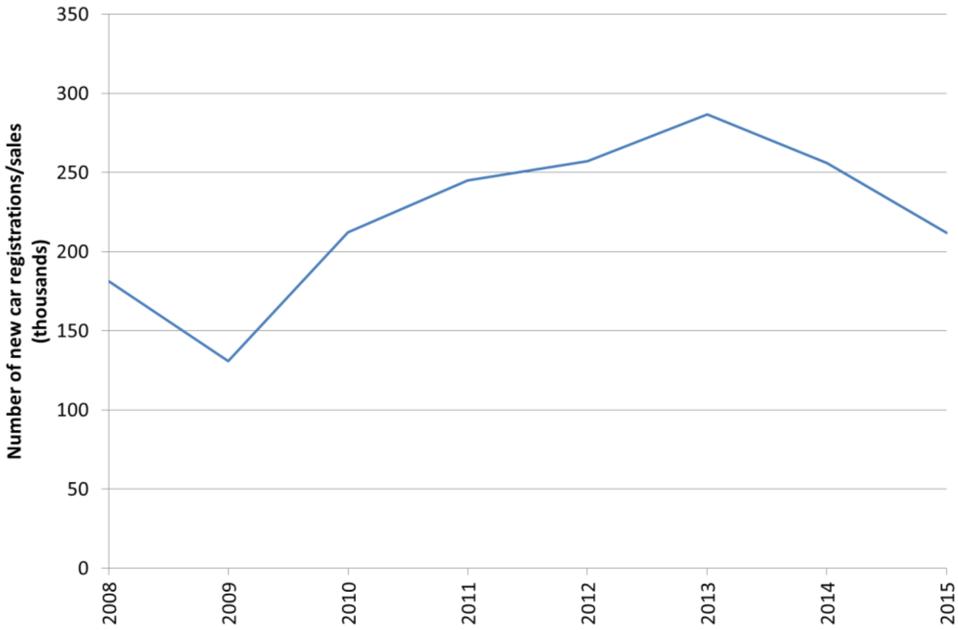

Figure 11: New car sales in Chile, 2008-2014 (OICA, 2016b)

Following the large number of new car sales in 2012 and 2013, the deceleration of the Chilean economy led to a reduction in new car sales and a propensity to purchase older used cars (Mazzucco, 2015).

In 2015, 45% of vehicles in circulation were aged 6 years or less with 11% of vehicles aged 20 years or older. Figure 12 shows the proportion of the medium and light vehicle fleet by vehicle age.

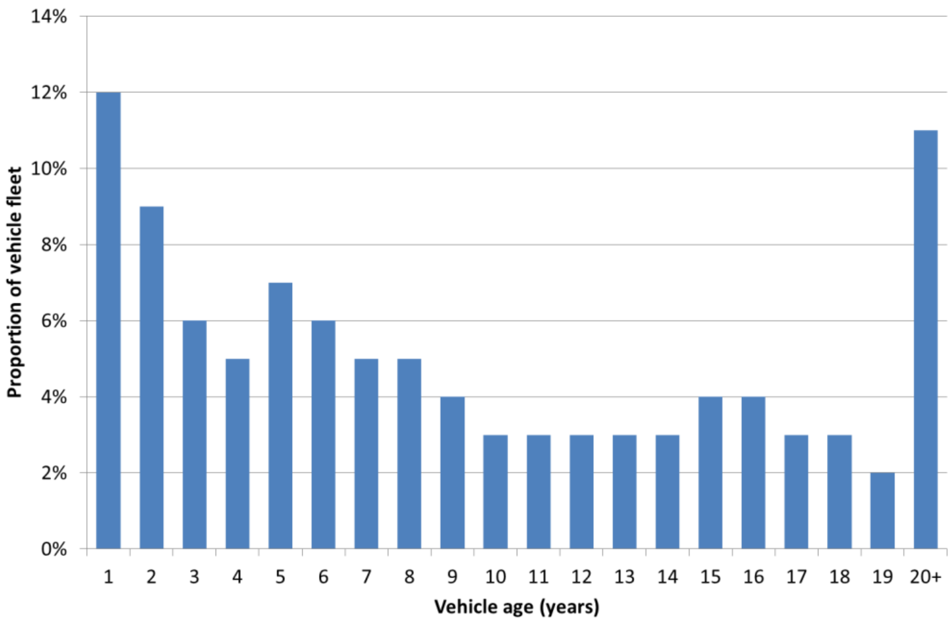

Figure 12: Proportion of the medium and light vehicle fleet in Chile by vehicle age in 2015 (Mazzucco, 2015)

Data from 2016 relating solely to the make of vehicles is presented in Table 6. Hyundai, Chevrolet and Nissan all feature in the top five manufacturers, alongside Suzuki and Kia.

Table 6: Top 10 vehicle manufacturers in Chile, March 2016 (Mazzucco, 2015)

Make	Proportion of sales	Make	Proportion of sales
Hyundai	9.9%	Toyota	5.9%
Chevrolet	9.6%	Peugeot	5.2%
Suzuki	8.9%	Ford	5.0%
Kia	8.8%	Mazda	4.5%
Nissan	7.5%	Mitsubishi	4.0%

Data related to make and model show that Nissan and Chevrolet vehicles made up the majority of the new cars sales in July 2011 (see Table 7). These 10 models represent 30% of all new car sales.

Table 7: Top selling cars in Chile, July 2011 (The Truth About Cars, 2012)

Model	Proportion of vehicle fleet	Model	Proportion of vehicle fleet
Nissan Tiida	4.1%	Kia Rio	2.5%
Chevrolet Sail	4.1%	Samsung SM3	2.5%
Nissan Terrano	4.0%	Chevrolet Spark GT	2.2%
Chevrolet Spark	3.7%	Kia Morning	2.1%
Hyundai Accent	2.8%	Suzuki Alto	1.9%

4.2.4 Road safety[6]

The use of seat belts in Chile was made compulsory for front seats only in 1985. This was extended to include front and rear seats in 2006, with wearing rates for drivers and front-seat passengers recorded as 78% and 62% respectively and 15% for rear-seat passengers in 2014.

Information about the role that speed plays in collisions is limited although it is estimated that it is a factor in approximately 33% of collisions. The speed limit on urban roads in Chile is 60 km/h, 120 km/h on motorways and between 100 and 120 km/h on rural roads.

In 2012, a new policy for drink driving was defined. Two offences are possible: 'driving under the influence of alcohol' is used when a Blood Alcohol Content (BAC) of between 0.3 g/L and 0.8 g/L is detected and 'driving while intoxicated' when the BAC is over 0.8 g/L. Since 2002, the number of fatalities caused by drink driving reached the lowest point of 148 (9% of fatalities) in 2013 from a high point of 244 (14%) in 2008.

[6] All figures in this section are sourced from OECD/ITF (2015).

4.2.5 Vehicle safety legislation

A series of improvements to vehicle safety legislation have been introduced since 2012 (OECD/ITF, 2015):

- Audible alarm for non-use of seatbelts (introduced in 2013)
- Mandatory ISOFIX or LATCH anchoring systems (introduced in 2014)
- In-vehicle reflective vests (introduced in 2016)
- Compulsory use of seat-belts in inter-urban buses (introduced in 2012)
- New safety devices for inter-urban buses, such as: ABS, ESC, rear fog light, reversing alarm (introduced in 2013)

An overview of the key light vehicle safety legislative requirements is given on the website of the Comisión Nacional de Seguridad de Tránsito (CONASET, 2016a) (CONASET, 2016b). Most of these systems are listed in Decree 26/2000 (updated 12 May 2015) (BCN, 2015) – see Table 8. Article 2 of Decree 26 lists and defines the systems and all of the safety systems listed (or their equivalent) are mandatory except (Article 8):

- Passenger cars: frontal airbags, ABS, seat-belt pretensioner, shoulder-belt force limiter, and ESC
- Light commercial vehicles as passenger cars plus: rear window demist, interior rear view mirror with day/night function, and occupant protection system.

Table 8: Light passenger and commercial vehicle requirements in Chile

Safety system	Legislation
Seat-belts	DS MTT 26/2000 makes it mandatory to have seat-belts in both front and rear seats. Article 75 of the Traffic Act makes it mandatory use the seat-belts
Safety windscreen glass	DS 26/2000 MTT mandates that motor vehicles must be homologated with this safety feature
Rear screen demist	According to Resolution 48:2000 this system does not have to meet any particular performance requirements, rather it is simply confirmed to be present
Head restraints	DS 26/2000 MTT requires a head restraint for all seats that have mandatory three-point seat-belts
Interior mirror with day / night adjustment	DS 26/2000 MTT mandates that motor vehicles must be homologated with this safety feature
Seat anchorages	Resolution 48:2000 defines requirements for seat anchorages
Retractable steering column	DS 26/2000 MTT mandates that motor vehicles must be homologated with this safety feature
Airbags	DS 249/2014 MTT has a requirement to have airbags in light vehicles entering the vehicle fleet progressively from 2015, according to the type of vehicle.

Safety system	Legislation
Antilock braking systems (ABS)	DS MTT 26/2000 establishes ABS as an option for light vehicles. However, manufacturers who approve a vehicle with this feature must certify that the ABS meet one of the listed international standards DS MTT 158/2013 mandates that intercity passenger buses must have ABS (buses registered since December 2014)
Child restraint systems (CRS)	DS MTT 176/2006 establishes the requirements for child restraint systems DS MTT 155/2014 (effective November 2015) amends DS MTT 176/2006 to require CRS that comply with international standards Article 75 of the Traffic Act makes the use of CRS mandatory for children under four years old
Occupant protection system	DS 26/2000 MTT mandates vehicle body crumple zones, passenger survival cell and side impact protection structural elements to protect occupants in a collision or rollover. Resolution 48/2000 (updated February 2016) (BCN, 2016) requires compliance with standards such as the old EU front and side impact directives (96/79/EC and 96/27/EC)
Seat-belt pretensioner	Resolution 48/2000 (updated February 2016) states that the seat-belt pretensioner (if fitted – see DS MTT 26/2000) must comply with the general requirements on seat-belts
Shoulder-belt force limiter	Resolution 48/2000 (updated February 2016) states that the seat-belt pretensioner (if fitted – see DS MTT 26/2000) must comply with the general requirements on seat-belts
Folding external rear view mirror	According to Resolution 48:2000 this system does not have to meet any particular performance requirements, rather it is simply confirmed to be present
Seat-belt reminder alert	DS MTT 26/2000 mandates that from May 2015, light vehicles must be fitted with seat-belt reminder alerts
Electronic stability control (ESC)	DS 158/2013 MTT makes ESP mandatory for intercity passenger buses that have engine power equal to or exceeding 350 HP, registered since December 2014 For other vehicles, this system is optional

Although the above systems are non-mandatory at the present time, if a manufacturer chooses to fit a particular system then it must comply with the defined requirements.

Decree 249/2014 (BCN, 2015) appears to have amended Decree 26/2000 to make frontal airbags mandatory in light vehicles entering the fleet between April 2015 and December 2016, with the exact date depending on the vehicle type. It should be noted that some of the referenced regulations do not explicitly require an airbag to be fitted, or define the performance of the airbag per se; instead, they define performance requirements for anthropometric test devices in the vehicle which may be most easily met by the use of a suitable airbag in combination with the seat-belt.

Decree 155/2014 (with deferred effect to 27 November 2015) amends Decree 176 by adjusting the current legislation to international requirements regarding child safety devices. This now requires CRS that meet R.44 (NB: the series of amendments is not defined) or CFR 49 Part 571 FMVSS 213.

The presence or absence of the features must be clearly labelled on each vehicle by the manufacturer (Article 8); the format of the label is controlled by Article 5 of Resolution

48/2000 (updated 21 February 2016), which also specifies more precisely the international regulations that shall be satisfied in compliance with Decree 26/2000. These include US CFR, EU Directives, UN Regulations and regulations in Brazil, Japan or Korea.

Not all of the items listed have performance requirements – for instance Resolution 48 states that it is only necessary to verify that the rear screen demist function and folding external rear view mirror are present.

Other systems such as tyres, brakes and lighting are also covered by legislation.

4.3 Mexico

4.3.1 Population

The population of Mexico has risen from approximately 86 million in 1990 to just over 125 million in 2014 as shown in Figure 13. The motorisation rate has also increased over the same time period.

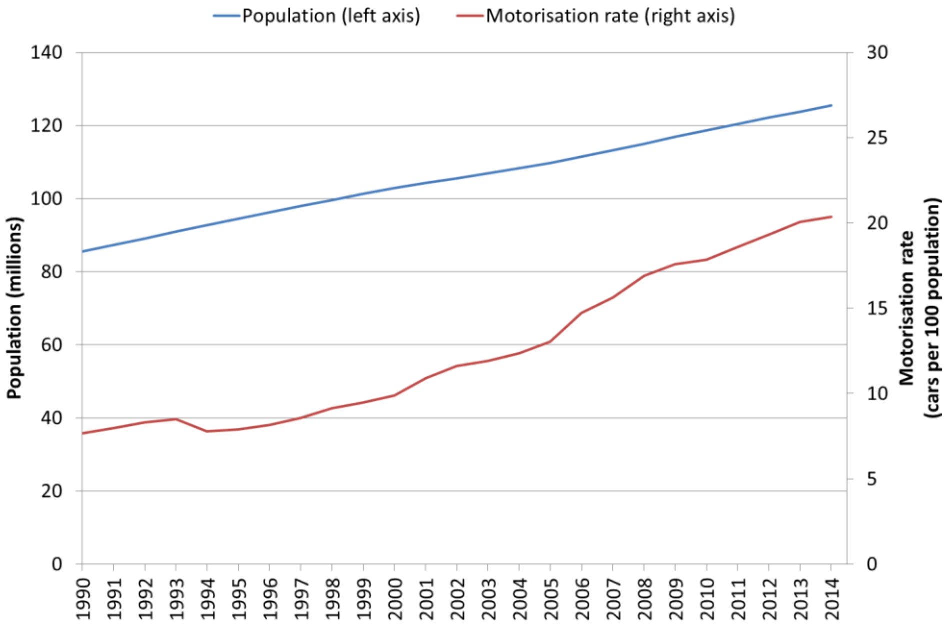

Figure 13: Population and motorisation rate in Mexico, 1990-2014 (World Bank Group (2016b) & INEGI (2016a))

The median age of the population was 27.6 years in 2015 (Central Intelligence Agency, 2015) and the GDP per capita in 2014 was 10,326 USD (World Bank Group, 2016a).

4.3.2 Road collision fatalities

Road fatality data were available from 1998 onwards and were broken down by road user type. Figure 14 presents the number of fatalities and the fatality rate (total fatalities per million members of the population). The number of fatalities for which the user type is unknown has been redistributed proportionately. The number of car occupant fatalities reached a maximum of approximately 6,300 in 2009 but has been declining since that point. The total fatality rate has been declining over the same period.

It is important to note that there were a large numbers of unknowns when the total number of fatalities was broken down by road user type (e.g. 6,801 out of 16,456 fatalities in 2014 were recorded as road user type unknown). These unknown values have been redistributed into the different road user types in Figure 14 and Figure 15.

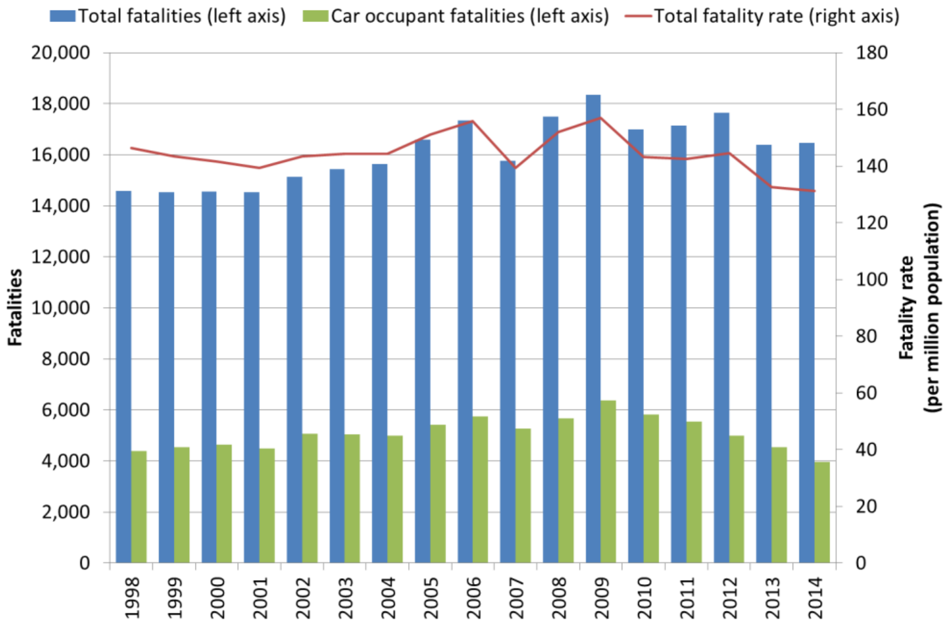

Figure 14: Number of fatalities and fatality rate (per million population) in Mexico, 1998-2014 (INEGI (2016b) & World Bank Group (2016b))

The proportion of fatalities by road user group is presented in Figure 15. Note the large number of unknown road user types.

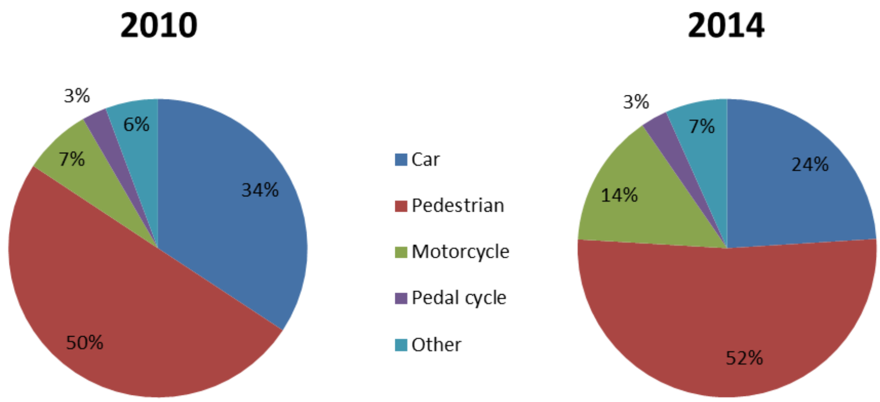

Figure 15: Number of fatalities by road user group in Mexico, 2010 & 2014 (INEGI, 2016b) [Unknown road user types redistributed proportionately amongst known types]

Pedestrians account for the majority of fatalities in Mexico (50% of all fatalities in 2010 and 52% in 2014). The proportion of all fatalities that were car occupants decreased from 34% in 2010 to 24% between 2010 and 2014 whereas the proportion of all fatalities that were motorcycle riders doubled from 7% to 14% over the same time period.

4.3.3 *Vehicle fleet*

Data for the number of cars in Mexico was available for the period from 1990 to 2014. Figure 16 shows that the total number of cars has increased substantially over that time period. There is also a relatively steady increasing trend in the number of kilometres travelled by all vehicles.

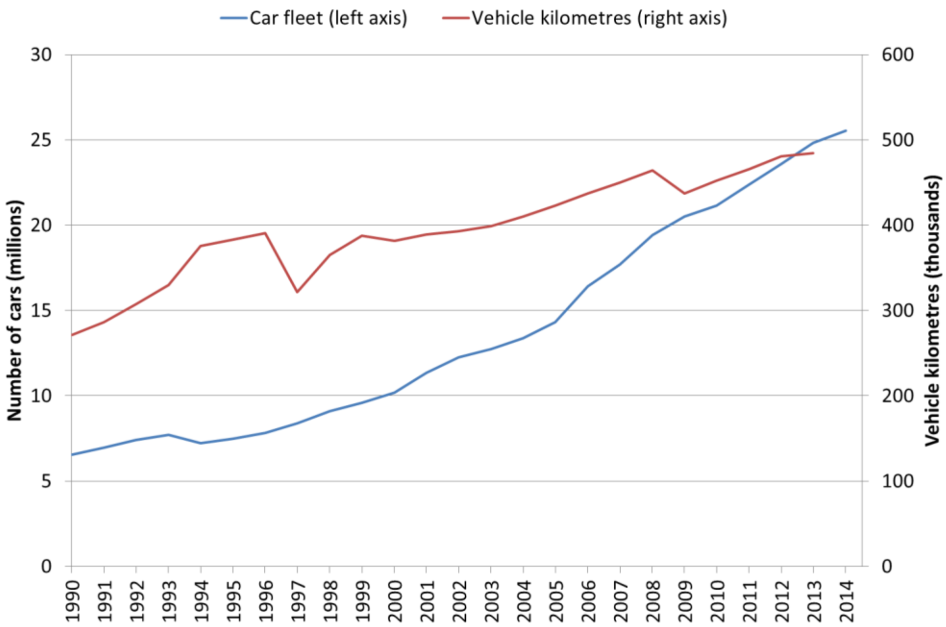

Figure 16: Total number of cars, 1990-2010 (INEGI, 2016a), and total vehicle kilometres in Mexico, 1990-2014 (OECD/ITF, 2015)

Over this period the growth in the number of cars from the previous year has been an average of 6.7%; however, this was lower between 2013 and 2014 (2.9%) suggesting that the rate of turnover may have slowed.

New car registrations have increased in recent years (Figure 17).

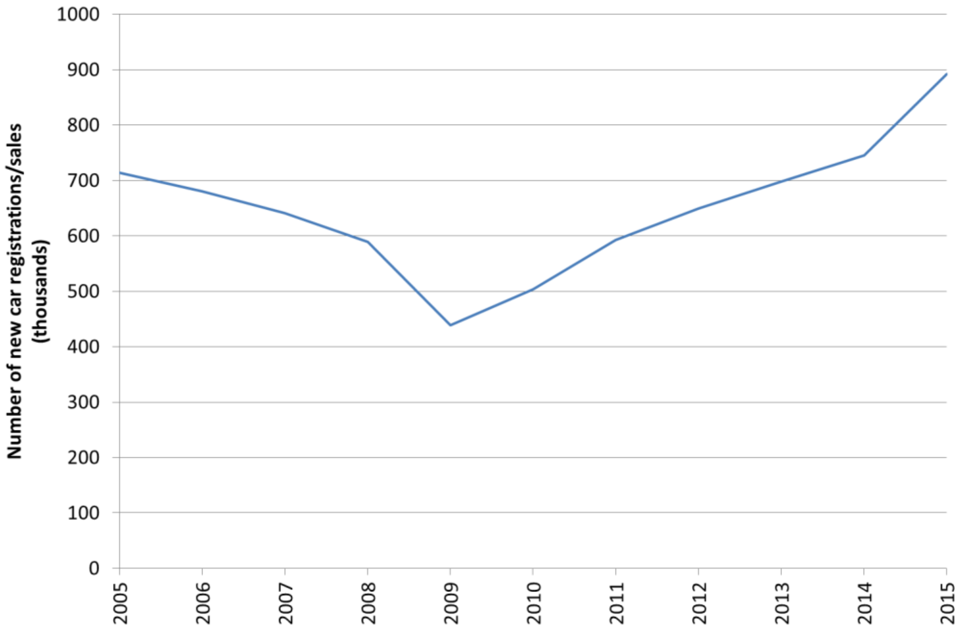

Figure 17: New car sales in Mexico, 2000-2015 (OICA, 2016b)

These data indicate that, on average over the past 10 years, around 3.1% of the car fleet each year are registered as new.

The top ten makes and models are presented in Table 9 based on their 2015 sales figures; these models represent 38% of all new car sales. Volkswagen, Nissan and Chevrolet dominate the top ten with many other makes from the same manufacturers featuring outside the top 10.

Table 9: Rankings of make and model in Mexico by 2015 sales figures (Focus2Move, 2016b)

Rank	% sales	Model	Rank	% sales	Model
1	5.7%	Chevrolet Aveo	6	3.7%	Nissan March
2	4.8%	Nissan Versa	7	3.6%	Nissan Tsuru
3	4.4%	Nissan Pick-up	8	3.2%	Chevrolet Spark
4	3.9%	Volkswagen Vento	9	2.7%	Nissan Sentra
5	3.8%	Volkswagen Jetta	10	2.3%	Chevrolet Sonic

4.3.4 Road safety

In Mexico, each state has its own traffic regulations. In Mexico City, for example, Article 37 of the Traffic Regulations Federal District mandates the use of seat belts for drivers and occupants of vehicles (excluding taxi drivers) (Administración Pública del Distrito Federal, 2015), but the WHO report indicates that there is no national seat belt law which applies to front and rear seat occupants (WHO, 2015). In 2013, the seat belt wearing rates were 36% for front seat drivers/passengers and 13% for rear seat passengers (WHO, 2015).

The maximum speed limits on urban roads, rural roads and motorways were 70, 90 and 110 km/h respectively (WHO, 2015). There were no data available about the proportion of collisions that have speeding as a contributory factor.

Five percent of road traffic fatalities involved alcohol (WHO, 2015). Drink driving limits vary between state with some states setting the BAC at 0.08g/dL and others not.

4.3.5 Vehicle safety legislation

In 2013, no vehicles standards were applied in Mexico. In other words, there were no frontal impact standards and no regulations surrounding ESC or pedestrian protection (WHO, 2015). However, recently Mexico has enacted a new Official Standard covering vehicle safety: Norma Oficial Mexicana NOM-194-SCFI-2015 Dispositivos de Seguridad Escenciales Envehículos Nuevos – Especificaciones de Seguridad (Mexican Official Standard – Safety Devices in New Vehicles – Safety Specifications) (Diario Oficial de la Federacion, 2016).

Section 4 of the NOM specifies requirements for 'essential safety devices' (e.g. seat-belts, brakes, tyres and head restraints) and lighting (e.g. indicators, headlamps and hazard warning lamps). These refer to either US regulations (Code of Federal Regulations (CFR) 49 Part 571 FMVSS regulations or Society of Automotive Engineers (SAE) standards), European Directives, UN Regulations, or Japanese, Korean or Brazilian regulations, with some also having the option to use Mexican national standards for approval (Table 10).

Section 5 of the NOM specifies frontal and side impact crash test, ABS and seat-belt reminder requirements. Again, these refer to international regulations and standards in other regions, including FMVSS and UN regulations. For instance, the front and side impact crash test requirements can be met by demonstrating compliance with UN Regulations 94 and 95 respectively, which have also replaced the quoted EC Directives in the EU.

The new standard was adopted on 27 January 2016, but the Section 5 requirements only come into force for new vehicle types in January 2019 and for existing vehicle types in January 2020.

Table 10: Selected vehicle safety and design requirements in Mexico

Requirement	NOM or NMX (MX)	FMVSS or SAE (US)	European Directive (EU)	SRRV TRIAS (JP)	KMVSS (KR)	CONTRAN (BR)	UN
Protection of occupants in frontal impacts		208	96/79/EEC	Art.18 Att.23 18-J023-01	Art 102	221/07 NBR 15300-1, 15300-1 & 15300-3 Edict 190/09 255/07	R94
Protection of occupants in side Impacts		214	96/27/EEC	Art.18 18-J024 R95.01	Art.102 Art.104	ABNT 16204	R95
Head restraints	---	202 or 202a	78/932/EEC or 74/408/EEC	Art.22-4 1983 Att.34 32-2-2005	26 or 99	220 or 518	R25 or R17

Requirement	NOM or NMX (MX)	FMVSS or SAE (US)	European Directive (EU)	SRRV TRIAS (JP)	KMVSS (KR)	CONTRAN (BR)	UN
Anti-lock braking system	---	105 or 135 or 126	R13, R13h or R131 or EU/347/2012 or EU/2015/562	Art.12 (Details of safety reg. Art.15)	Art.15 and Art.90	CONTRAN Resolution 380/11 and 519/2015	R13, R13h or R131
Seat belt reminder	---	208	ECE R16 or 76/115 / EEC (96/38) or 77/541 / EEC (90/628)	Art. 22-3 (Details of safety reg. Art. 30) Att.33, 22(3)-J033-01	Art.27 or Art.103	---	R16
Seat belt	---	209 or 210 or 208	76/115/EEC and 77/541/EEC	Art.22-3 31-1994 37-1998 Att. 31/32/33	27 or 103	048 or 220 or 518	R14 or R16 Supp. 10
Mirrors (interior and exterior)	---	111	71/127/EEC)	Art.44 29-1973 39-1975 Att.79/80/81	50 or 108	226	R46
Seating systems	---	207	78/932/EEC and 74/408/EEC	Art.32 35-2-2005 36-1995 Att. 30	97 or 98	463 or 220 or 416	R17
Tyres	NMX-D-136-CT-1988	109 or 139 or 110	458/2011/ EEC	Art.9 43-1992 Att.2	12 or 88-2	14 or 259 or 558	R30 or R54
Headlights	NMX-D-051-1971	108 (Dec07) or SAE J945, J592e, J594f and J566	76/761/EEC or 76/756/EEC or 76/758/EEC	Art.32 Att.22-1996 50	Art 38, 106.1	227 or 383 or 294	R48 or R112
Brake light	NMX-D-233-1984	108, SAE J586	76/758/EEC or 76/756/EEC	Art.39 01/01/1996 Att.70; BLUE BOOK 39	43, 106	227 or 383 or 294	R48 or R07
Braking system	148.NMX-D-SCFI-1979	105 or 135	71/320/EEC	Art.12 Att. 12/02/2001 12	90	463 or 777 or 380 or 395 or 519	R13 or R13h

5 Estimating the potential impact of vehicle safety developments in Latin America

Using the methodology outlined in Section 2, this section presents the results of the potential casualty savings which could be achieved in Argentina, Chile and Mexico if similar regulations to those seen in Britain were implemented urgently in the emerging markets. There are four main steps to this method:

- Understanding the current fatality rate in the emerging market
- Predicting the growth in passenger cars forward into the future
- Applying the fatality rate to the growth in passenger cars to estimate a baseline number of fatalities if developments in road safety do not change
- Applying the quantified changes in fatalities observed in Britain due to secondary safety to these baseline scenarios, taking into account the current vehicle safety standards in the fleet and the current turnover of vehicles.

The relevant data for each country is presented in sections 5.2 (Argentina), 5.3 (Chile) and 5.4 (Mexico). Relevant population, vehicle and casualty figures for each emerging market are described in Section 4 and a summary is given in Appendix A.

5.1 Modelling data from Great Britain

The results from the modelling for Great Britain are documented fully in Cuerden *et al.* (2015) and Lloyd *et al.* (2015) and are not replicated here. However, the estimated car driver fatality savings in Great Britain due to improvements in secondary safety from the baseline years for each country (discussed in Section 3) are presented in Table 11.

Table 11: Estimated car driver fatality numbers over a 15 year period in GB if secondary safety had remained at level of the baseline year

Baseline year for 2015	Actual (estimated) casualty numbers	Estimated casualty numbers if secondary safety had not improved	Estimated reduction in casualties due to secondary safety improvements	Proportional casualty saving over 15 years assuming vehicle secondary safety remained at baseline year
2002 (Argentina)	11,961	12,610	650	5.2%
2003 (Chile)	11,078	11,790	712	6.0%
2000 (Mexico)	13,469	14,419	950	6.6%
1995 (Alternative baseline)[7]	16,275	18,951	2,676	14.1%

[7] The alternative baseline is applied to each of the three countries in the following sections.

These results indicate that the proportion of car driver fatalities saved over 15 years by secondary developments since the early 2000's is around 5-6%. Vehicle safety developments were more effective in the mid 1990's, with an estimated 14% reduction in car driver fatalities over a similar 15 year period.

5.2 Argentina

Figure 18 combines information on the number of car occupant (driver and passenger) fatalities (Figure 2) with the number of registered cars (Figure 4) to show how the car occupant fatality rate per million registered cars has changed over the period 2010 to 2013. An exponential trend has been applied to the rate.

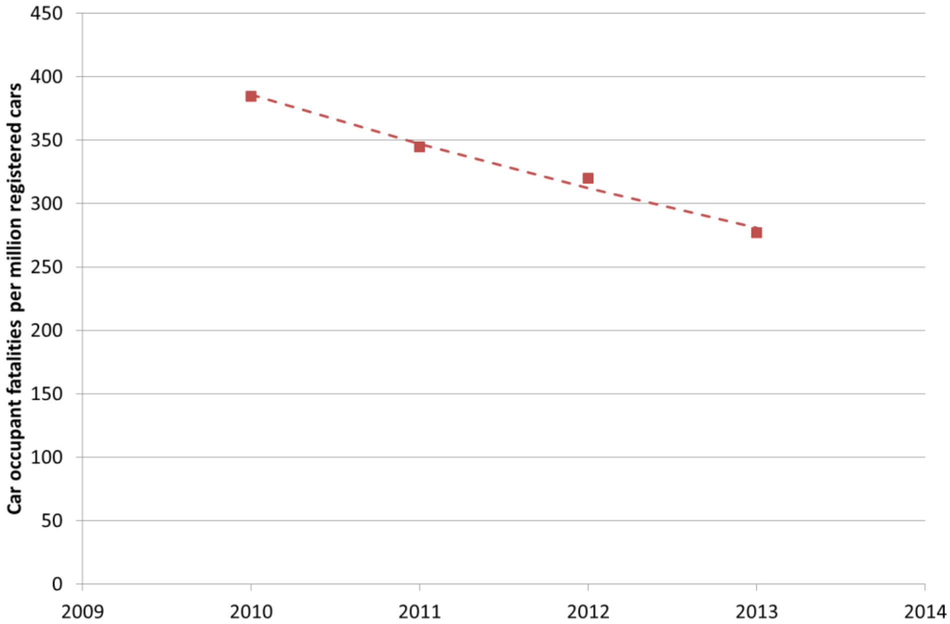

Figure 18: Car occupant fatality rate (per million registered cars) for Argentina, 2010-2013

In order to predict casualty trends forwards, the growth in passenger cars is required. The possible baseline scenarios for car registration growth in Argentina from 2015 to 2030 have been devised as:

a) The trend in car registrations continues to grow linearly at the current rate: an average annual rate of 5.2% relative to 2014.

b) The trend in car registrations continues to grow linearly at an average annual rate of 0.9% relative to 2014[8].

c) The trend in car registrations continues to grow linearly at an average annual rate of 6.0% relative to 2014[9].

[8] This is equivalent to the lowest average of each 10 year registered vehicle trend in GB, relative to the last available year within those 10 years i.e. is equivalent to the average annual increase in registered vehicles in GB between 2006 and 2015, relative to 2015.

d) The trend in car registrations continues to grow linearly as in scenario a) but also encompasses a gradual move from motorcycles to cars[10]. This is equivalent to an annual average increase of 5.5%.

The impact these scenarios have on the number of registered cars predicted between 2015 and 2030 is shown in Figure 19.

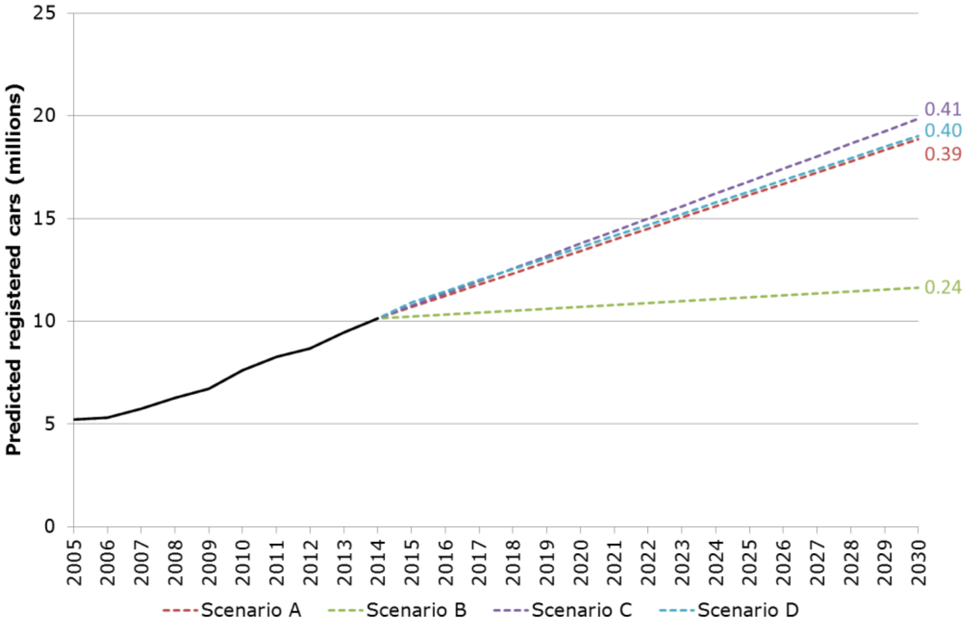

Figure 19: Actual number of registered cars in Argentina from 2005 to 2014 and predicted number from 2015 to 2030 by scenario (the motorisation rate i.e. number of cars per person in 2030 is included on the right)

The scenarios predict that in 2030 there will be between 11.6 and 19.9 million registered cars; equating to between 0.24 and 0.41 cars per person by 2030 (assuming a linear growth in the population). The current motorisation rate in Argentina is 0.24 and in Great Britain is 0.45 so all the scenarios are realistic.

Assuming that the relationship between car occupant fatalities and registered cars remains the same as in Figure 18 and the registered cars grow as seen in Figure 19, then the predicted number of car occupant fatalities between 2015 and 2030 is shown in Figure 20.

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[9] This is equivalent to the highest average of each 10 year registered vehicle trend in GB, relative to the last available year within those 10 years i.e. is equivalent to the average annual increase in registered vehicles in GB between 1956 and 1965, relative to 1965.

[10] This scenario assumes that the number of motorcycles remains stationary at around 6 million thus resulting in the proportion of the vehicle fleet which are motorcycles declining gradually over time. The difference in the proportion of total vehicles between one year and the next is assumed to be reassigned to cars.

Note that this scenario is very different from the scenarios for Chile (Section 5.3) and Mexico (Section 5.4) since motorcycles are estimated to make up a much larger proportion of the total vehicle fleet in Argentina (around 30% compared to 3%). This proportion has been growing in recent years but it would be unrealistic to assume that it will continue to do so.

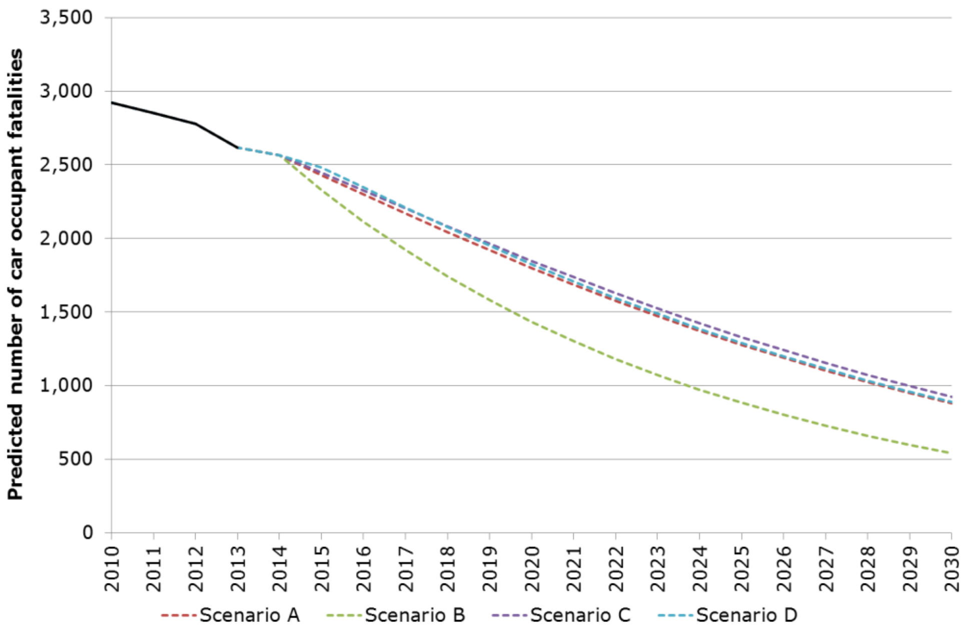

Figure 20: Actual number of car occupant fatalities in Argentina from 2010 to 2013 and predicted baseline number from 2014 to 2030 by scenario

In 2013 there were 2,619 car occupant fatalities. By 2030 it is predicted that the number of car occupants is between 540 (a reduction of 79% relative to 2013) and 930 (a reduction of 65% relative to 2013).

As outlined in Section 3, the baseline year for cars in Argentina in 2015 was identified as 2002 i.e. in terms of frontal impact crashworthiness cars in Argentina are estimated to be around 13 years behind developments in secondary safety in Great Britain.

Relatively little information on the age of the Argentinian car fleet is available publically and thus some assumptions must be made about the rate of turnover of the fleet. On average, over the past 10 years, around 6.5% of the car fleet each year are registered as new. The growth in the number of cars from the previous year has been an average of 7.7%. In comparative terms, the previous study (Cuerden, Lloyd, Wallbank, & Seidl, 2015) showed that in Brazil 5.5% of the fleet in 2014 were new and the number of cars grew by 6.1%. This study used a figure of 60% to multiply the Brazilian casualty savings by in order to account for the slower turnover of the Brazilian fleet compared to the British fleet. The same proportion is applied to the 'similar timescale' scenario here.

Combining these results and assuming the uptake of regulations and vehicle safety developments in Argentina follows a similar timescale to the uptake in Britain or a quicker timescale than the uptake in Britain, Table 12 shows the potential casualty savings which could be achieved between 2016 and 2030.

Table 12: Potential fatality savings in Argentina between 2016 and 2030 due to secondary safety developments from the baseline of 2002

Scenario	Number of fatalities predicted without vehicle safety developments	Similar timescale		Quicker timescale	
		Saving in fatalities	Proportional saving	Saving in fatalities	Proportional saving
A	25,199	824	3.3%	1,374	5.5%
B	19,868	573	2.9%	955	4.8%
C	25,911	858	3.3%	1,430	5.5%
D	25,560	833	3.3%	1,388	5.4%

It is estimated that if the Argentinian vehicle fleet is similar to the fleet seen in Britain in 2002 and similar vehicle regulations to those seen in Britain are soon implemented, then over the next 15 years approximately 570 (2.9%) to 1,400 (5.5%) car occupant fatalities could be saved, depending on the level of fleet turnover.

However, as discussed in Section 3.2 the cars in the three emerging markets are not currently required to undertake equivalent side impact tests to those used in Britain and thus, from the limited information available it is estimated that the vehicle fleet performance may in fact be much older than 2003. If 1995 is taken as the baseline year instead of 2003 then the potential casualty savings are much greater (see Table 13).

Table 13: Potential fatality savings in Argentina between 2016 and 2030 due to secondary safety developments from the alternative baseline of 1995

Scenario	Number of fatalities predicted without vehicle safety developments	Similar timescale		Quicker timescale	
		Saving in fatalities	Proportional saving	Saving in fatalities	Proportional saving
A	25,199	1,730	6.9%	2,883	11.4%
B	19,868	1,209	6.1%	2,015	10.1%
C	25,911	1,799	6.9%	2,999	11.6%
D	25,560	1,748	6.8%	2,914	11.4%

Based on these assumptions, up to 3,000 (12%) car occupant fatalities could be prevented over the same time period.

5.3 Chile

Figure 21 combines information on the number of car occupant fatalities (Figure 7) with the number of registered cars (Figure 9) to show how the car occupant fatality rate per million registered cars has changed over the period 2005 to 2014. An exponential trend has been applied to the rate.

Figure 21: Car occupant fatality rate (per million registered cars) for Chile, 2005-2014

The declining trend in Figure 21 will be used to predict the baseline casualty trend in Chile from 2015 to 2030.

The possible baseline scenarios for car registration growth in Chile from 2015 to 2030 have been devised as:

a) The trend in car registrations continues to grow linearly at the current rate: an average annual rate of 5.2% relative to 2014.

b) The trend in car registrations continues to grow linearly at an average annual rate of 0.9% relative to 2014[8].

c) The trend in car registrations continues to grow linearly at an average annual rate of 6.0% relative to 2014[9].

d) The trend in car registrations continues to grow linearly as in scenario a) but also encompasses a gradual move from motorcycles to cars[11]. This is equivalent to an annual average increase of 5.7%.

The impact these scenarios have on the number of registered cars predicted between 2015 and 2030 is shown in Figure 22.

[11] This scenario assumes that motorcycles remain at 3.5% of the vehicle fleet - this is similar to GB between 2004 and 2014 (3.2%). All the vehicles which were predicted to be motorcycles (given that motorcycle use has been growing) are assumed to now be cars.

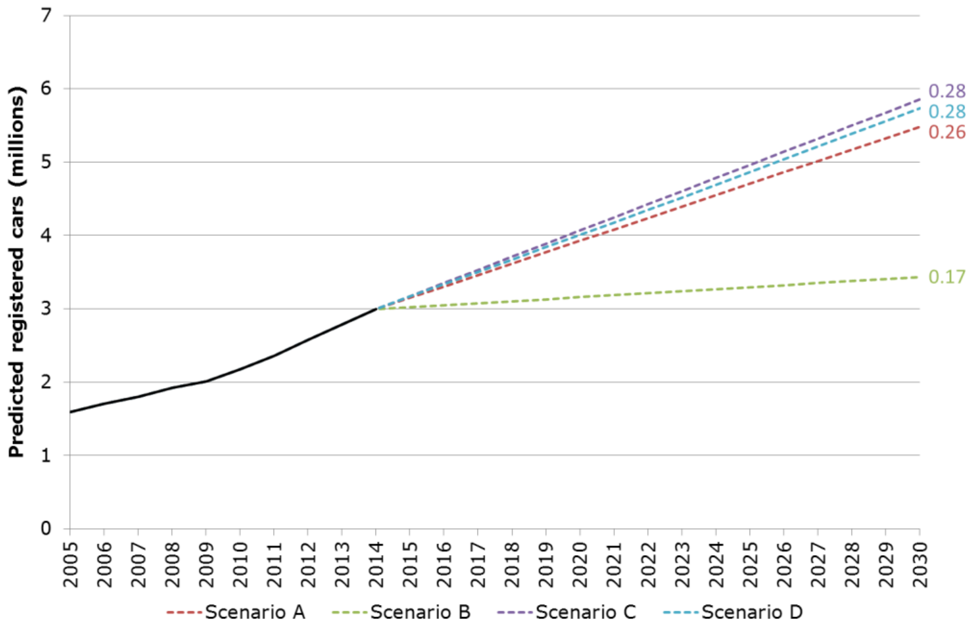

Figure 22: Actual number of registered cars in Chile from 2005 to 2014 and predicted number from 2015 to 2030 by scenario (the motorisation rate i.e. number of cars per person in 2030 is included on the right)

The scenarios predict that in 2030 there will be between 3.4 and 5.9 million registered cars. Assuming a linear growth in the population, these figures suggest the number of cars per person will be between 0.17 and 0.28 by 2030. The current motorisation rate in Chile is 0.17 and in Great Britain is 0.45 so all the scenarios are reasonable.

Combining these results, the number of car occupant fatalities between 2016 and 2030 would be expected to follow a similar trend to those seen in Figure 23.

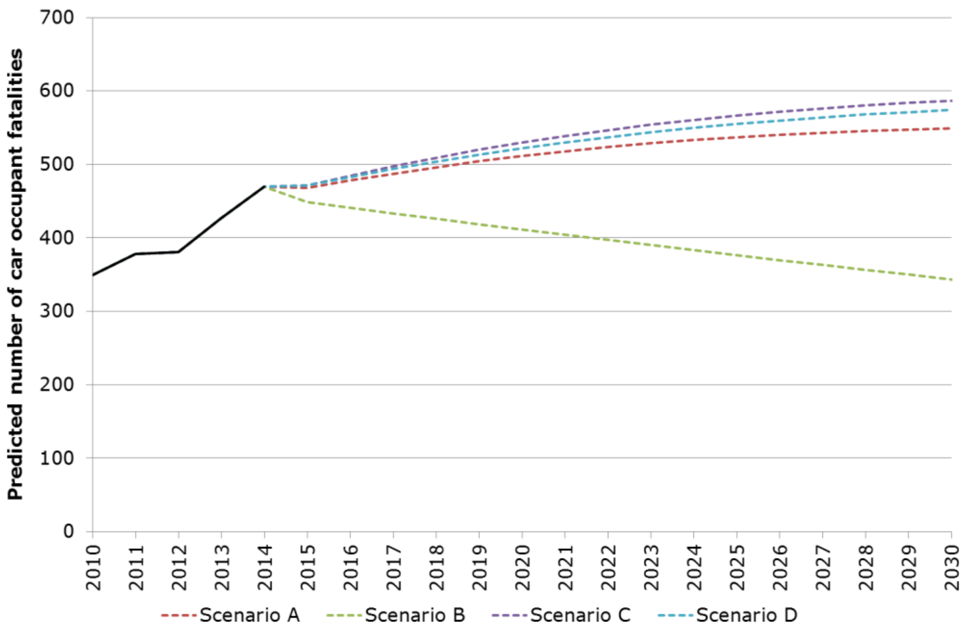

Figure 23: Actual number of car occupant fatalities in Chile from 2010 to 2014 and predicted baseline number from 2015 to 2030 by scenario[12]

In 2014 there were 470 car occupant fatalities. By 2030 it is predicted that the number of car occupants would be between 340 (a reduction of 27% relative to 2014) and 590 (an increase of 25% relative to 2014).

As outlined in Section 3, the baseline year for cars in Chile in 2011 was identified as 1999. Assuming, that car safety has developed in a similar manner to the way it did in Great Britain, this analysis assumes that the frontal impact crashworthiness of cars in 2015 in Chile is equivalent to cars in Great Britain in 2003.

As shown in Figure 12, Chile's car fleet is relatively new. In 2015, the proportion of the medium and light fleet (which includes cars) which were less than 1 year was 12% (but the economy is slowing), and the proportion of the fleet which is six years or younger was 45%. In Britain the comparable figures in 2003 were 9% and 52% respectively. Based on these proportions, it is expected that the impact of introducing new safety measures into the car fleet will take slightly longer in Chile than observed in Britain due to the older cohort of cars.

As Table 11 shows, it is estimated that the impact of secondary safety in Britain over a 15 year period was a reduction in casualties of around 6.0%, assuming a baseline of 2003. It is proposed that this proportional saving is multiplied by 80%[13] to take account of the differences in turnover of the Chilean and British fleets.

Combining these results and assuming the uptake of regulations and vehicle safety developments in Chile follows a similar timescale to the uptake in Britain or a quicker

[12] The step change in the graph between 2014 and 2015 links the modelled results from 2015 onwards to the actual known fatality numbers up to 2014. The modelled results are based on the average trend from 2010 to 2014 which explains why the transition between 2014 and 2015 is not smooth.

[13] The proportion of the car fleet that was 6 years or younger in Chile in 2015 was approximately 80% of the equivalent proportion in Britain in 2003.

timescale than the uptake in Britain, Table 14 shows the potential casualty savings which could be achieved between 2016 and 2030.

Table 14: Potential fatality savings in Chile between 2016 and 2030 due to secondary safety developments from the baseline of 2003

Scenario	Number of fatalities predicted without vehicle safety developments	Similar timescale		Quicker timescale	
		Saving in fatalities	Proportional saving	Saving in fatalities	Proportional saving
A	8,312	569	6.8%	711	8.6%
B	6,313	394	6.2%	492	7.8%
C	8,680	601	6.9%	752	8.7%
D	8,542	589	6.9%	737	8.6%

It is estimated that if similar vehicle regulations to those seen in Britain are rapidly implemented in Chile, then over the next 15 years approximately 390 (6.2%) to 750 (8.7%) car occupant fatalities could be saved.

However, if the baseline year is taken as 1995 instead (to account for the potential differences in the side impact performance of cars in Chile relative to GB) then the casualty savings are much greater (see Table 15).

Table 15: Potential fatality savings in Chile between 2016 and 2030 due to secondary safety developments from the alternative baseline of 1995

Scenario	Number of fatalities predicted without vehicle safety developments	Similar timescale		Quicker timescale	
		Saving in fatalities	Proportional saving	Saving in fatalities	Proportional saving
A	8,312	1,001	12.0%	1,251	15.1%
B	6,313	693	11.0%	866	13.7%
C	8,680	1,058	12.2%	1,322	15.2%
D	8,542	1,037	12.1%	1,296	15.2%

Based on these assumptions, up to 1,300 (15%) car occupant fatalities could be prevented over the same time period.

5.4 Mexico

The number of car occupant fatalities in Mexico was estimated by redistributing the large unknown road user types proportionately amongst those of known type (Figure 14 and Figure 15). This was then combined with the number of registered cars (Figure 16) to estimate how the car occupant fatality rate per million registered cars has changed over the period 2005 to 2014 (Figure 24). An exponential trend has been applied to the trend.

Figure 24: Car occupant fatality rate (per million registered cars) for Mexico, 2005-2014

The possible baseline scenarios for car registration growth in Mexico from 2015 to 2030 have been devised as:

a) The trend in car registrations continues to grow linearly at the current rate: an average annual rate of 4.9% relative to 2014.

b) The trend in car registrations continues to grow linearly at an average annual rate of 0.9% relative to 2014[8].

c) The trend in car registrations continues to grow linearly at an average annual rate of 6.0% relative to 2014[9].

d) The trend in car registrations continues to grow linearly as in scenario a) but also encompasses a gradual move from motorcycles to cars[14]. This is equivalent to an annual average increase of 5.9%.

As a result, the number of registered cars is predicted to grow as seen in Figure 25.

[14] This scenario assumes that motorcycles remain at 3.8% of the vehicle fleet - this is similar to GB between 2004 and 2014 (3.2%). All the vehicles which were predicted to be motorcycles (given that motorcycle use has been growing) are assumed to now be cars.

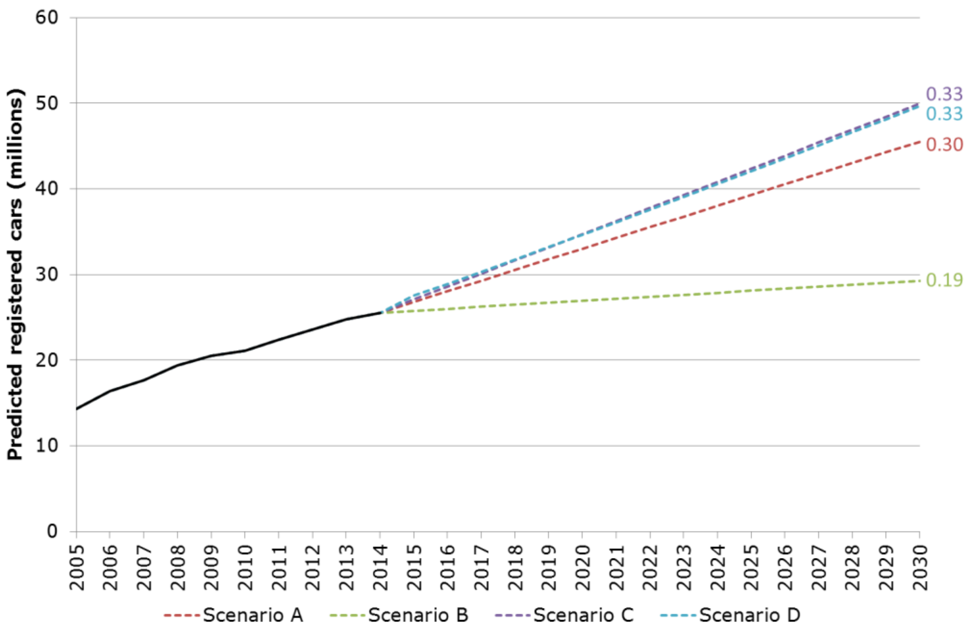

Figure 25: Actual number of registered cars in Mexico from 2005 to 2014 and predicted number from 2015 to 2030 by scenario (the motorisation rate i.e. number of cars per person in 2030 is included on the right)

The scenarios predict that in 2030 there will be between 29 and 50 million registered cars; equating to between 0.19 and 0.33 cars per person by 2030 (assuming a linear growth in the population). The current motorisation rate in Mexico is 0.20 and in Great Britain is 0.45 so all the scenarios are realistic.

Combining these results, the number of car occupant fatalities between 2016 and 2030 is expected to follow similar trends to those seen in Figure 26.

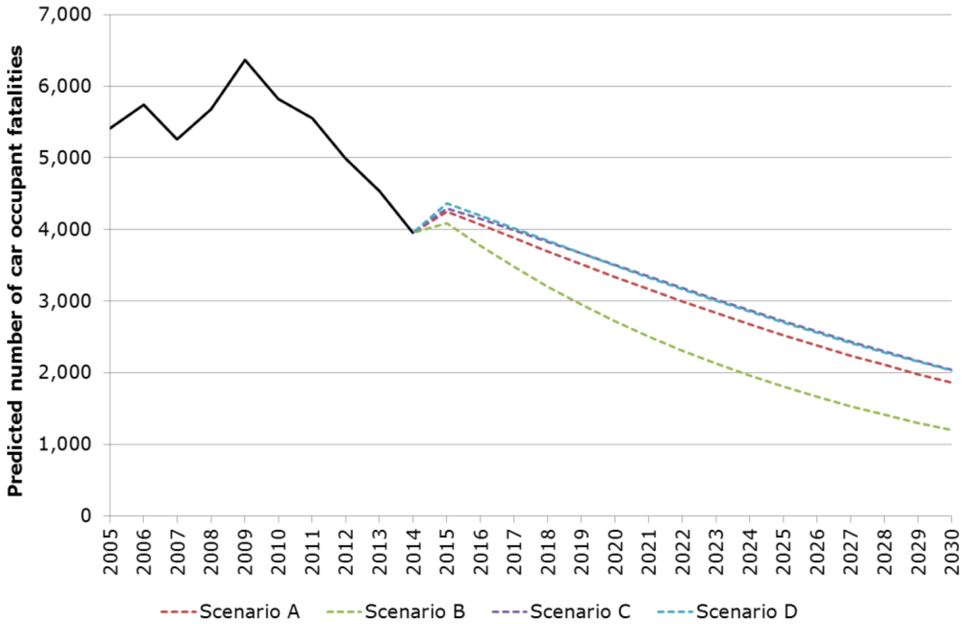

Figure 26: Actual number of car occupant fatalities in Mexico from 2005 to 2014 and predicted baseline number from 2015 to 2030 by scenario[12]

In 2014, it is estimated there were 3,952 car occupant fatalities in Mexico. Assuming the car occupant fatality rate continues to fall as it has been (Figure 24), by 2030 it is predicted that the number of killed car occupants will have fallen to between 1,200 (a reduction of 70% relative to 2014) and 2,050 (a reduction of 48% relative to 2014).

As outlined in Section 3, the baseline year for cars in Mexico in 2015 was identified as 2000 i.e. in terms of frontal impact crashworthiness cars in Mexico are estimated to be around 15 years behind developments in secondary safety in Great Britain.

Relatively little information on the age of the Mexican car fleet is available publically and thus some assumptions must be made about the rate of turnover of the fleet. On average, over the past 10 years, around 3.1% of the car fleet each year are registered as new. The growth in the number of cars from the previous year has been an average of 6.7%; however, this was lower between 2013 and 2014 (2.9%) suggesting that the rate of turnover may have slowed. In comparative terms, the previous study (Cuerden, Lloyd, Wallbank, & Seidl, 2015) showed that in Brazil 5.5% of the fleet in 2014 were new and the number of cars grew by 6.1%. This study used a figure of 60% to multiply the Brazilian casualty savings by in order to account for the slower turnover of the Brazilian fleet compared to the British fleet.

Table 20 in Appendix A also shows that growth and new car sales were also larger in both Argentina and Chile in 2014 (which as discussed above are multiplied by 60% and 80% respectively to account for the differences in turnover).

It is estimated that the impact of secondary safety in Britain over a 15 year period was a reduction in casualties of around 6.6%, assuming a baseline of 2000 (see Table 11). It is proposed that this proportional saving is multiplied by 40% to take account of the differences in turnover of the Mexican and British fleets.

Table 16 shows the potential casualty savings which could be achieved between 2016 and 2030 if the uptake of regulations and vehicle safety developments in Mexico were rapidly applied and if the uptake of these regulations follows a similar timescale to the uptake in Britain or a quicker timescale than the uptake in Britain.

Table 16: Potential fatality savings in Mexico between 2016 and 2030 due to secondary safety developments from the baseline of 2000

Scenario	Number of fatalities predicted without vehicle safety developments	Similar timescale		Quicker timescale	
		Saving in fatalities	Proportional saving	Saving in fatalities	Proportional saving
A	47,533	1,299	2.7%	3,247	6.8%
B	38,058	922	2.4%	2,306	6.1%
C	50,128	1,402	2.8%	3,505	7.0%
D	50,126	1,393	2.8%	3,483	6.9%

It is estimated that approximately 900 (2.4%) to 3,500 (7.0%) of car occupant fatalities could be saved in Mexico if the regulations were applied rapidly.

Results are also shown for the alternative baseline (1995) assuming that the side impact standard of vehicles in Mexico is much worse than that currently seen in Britain (Table 17).

Table 17: Potential fatality savings in Mexico between 2016 and 2030 due to secondary safety developments from the alternative baseline of 1995

Scenario	Number of fatalities predicted without vehicle safety developments	Similar timescale		Quicker timescale	
		Saving in fatalities	Proportional saving	Saving in fatalities	Proportional saving
A	47,533	2,283	4.8%	5,707	12.0%
B	38,058	1,644	4.3%	4,109	10.8%
C	50,128	2,458	4.9%	6,145	12.3%
D	50,126	2,444	4.9%	6,111	12.2%

Based on these assumptions, up to 6,100 (12%) car occupant fatalities could be prevented over the 15 year time period.

5.5 Summary

In conclusion, based on the benchmarking described in Section 3, the cars in the three emerging markets are considered to perform similarly in frontal impact tests to cars in Great Britain in the early 2000's, putting vehicle safety up to 15 years behind that seen in Europe.

Using estimates of the fatality savings achieved in Great Britain due to improvements in secondary safety over a 15 year period, and combining this with predictions on fleet growth and casualty rate trends in the emerging markets, it has been possible to estimate how many car occupant fatalities could be saved between 2016 and 2030 if a minimum standard of vehicle safety regulations equivalent to those seen in Europe (specifically, approved seat belts and anchorages for all seating positions (UN Regulations 14 and 16); occupant protection in frontal collision (UN Regulation 94) and occupant protection in side or lateral collisions (UN Regulation 95)) are rapidly applied:

- Between 570 and 1,400 fatalities in Argentina
- Between 390 and 750 fatalities in Chile
- Between 900 and 3,500 fatalities in Mexico.

In the previous study (Cuerden, Lloyd, Wallbank, & Seidl, 2015), it was estimated that between 12,000 and 34,000 car occupant fatalities could be saved in Brazil. Combining the figures for the four countries, it is estimated that between 14,000 and 40,000 car occupant fatalities could be prevented across the Latin American region if vehicle safety standards were improved.

This analysis focussed on the number of car user fatalities that could be saved by improvements to secondary safety, but in addition there are likely to be reductions across all injury severities including serious and slight casualties. Information on the number of non-fatal casualties was not available, but if the ratio of fatalities to serious injuries is assumed to be similar in the Latin American region to that of Great Britain (widely considered to be approximately 1 fatality to every 10 serious injuries), then the number of killed or seriously injured car user casualties prevented by improvements to secondary safety could be in the region of 160,000 to 440,000.

Limited information on the performance of Latin American vehicles in equivalent side impact tests to those seen in Europe is available. If the performance of these vehicles is worse than seen in the frontal impact tests, then vehicle safety in these countries could in fact be more than 15 years behind that of Great Britain. If this is the case, then rapid introduction of equivalent European vehicle standards could have an even greater impact than predicted above.

6 Economic burden for Latin America

Bhalla *et al.* (2013) reviews the methods of evaluating the economic impact of road traffic crashes in order to estimate the cost of road accidents in a number of Latin American countries. It identifies two main methods of estimating the economic losses due to road traffic crashes: the valuation of a statistical life (VSL) and cost-of-illness.

The cost-of-illness method combines estimates of labour loss, medical, funeral, property damage, transport delays and administrative (including insurance and police) costs. Whilst these costs are tangible and can be separated into easily interpretable categories, the results cannot meaningfully be linked to Gross Domestic Product (GDP), kept updated easily or be compared across countries.

The VSL methods are based on a willingness to pay to avoid injury and are related to GDP per capita. This method has a stronger theoretical economic background, can be compared cross-nationally and is readily computable from health burden data. However the values cannot be divided into clear categories and evidence on willingness-to-pay is varied, leading to a range of estimates. Based on these advantages Bhalla *et al.* (2013) states that the VSL method is preferred by economists, and therefore this method it utilised here.

In the relevant VSL studies reviewed, the economic loss of death due to a traffic collision has been equated to between 70 and 137.6 units of GDP per capita. One study also estimated the value of serious non-fatal injuries as equivalent to 17 times GDP per capita.

Table 18: Economic loss of death and serious injury using VSL method

	GDP per capita (2014) (current USD) (World Bank Group, 2016a)	**Economic loss of one death due to traffic collision (current USD, thousands)**	**Economic loss of one serious injury due to traffic collision (current USD, thousands)**
Argentina	12,509.5	876 – 1,721	213
Chile	14,528.3	1,017 – 1,999	247
Mexico	10,325.6	723 – 1,421	176
Brazil	11,726.8	821 – 1,614	199
UK	46,297.0	3,241 – 6,370	787

Bhalla *et al.* (2013) shows that different methods and studies result in vastly different estimates of the cost of a fatality or serious injury. This is not just an issue with shortage of data resulting in substantial assumptions, but also lack of agreement as to what should be included, in particular in relation to essentially unquantifiable measures such as the value of pain, grief and suffering. For example, the UK cost of a fatality based on a combination of lost output, medical and ambulance costs and human costs (incorporating a willingness to pay element) is valued at the equivalent of 1.8m USD, and of a serious injury is valued at 0.25m USD (Department for Transport, 2012). These costs are around one third of the values computed in Table 18. Any estimate should therefore be interpreted with extreme care.

Combining these figures with the fatality savings described in Section 5.5 results in a wide estimate of the economic savings which could be made if vehicle safety standards were improved (see Table 19).

Table 19: Potential economic savings between 2016 and 2030 due to secondary safety improvements

	Car occupant fatalities prevented	Economic saving as a result of the fatalities prevented (current USD, millions)
Argentina	570 - 1,400	500 - 2,500
Chile	390 - 750	400 - 1,500
Mexico	900 - 3,500	700 - 5,000
Brazil	12,500 - 34,200	10,300 - 55,200
Total	**14,000 - 40,000**	**11,900 - 64,200**

It is estimated that improvements to vehicle safety standards which reduce the number of car occupant fatalities could save Latin America up to 64 billion USD over the period 2016 to 2030. When serious injury savings are also considered (assuming there is approximately 10 serious injuries for every fatality in the Latin NCAP region), the benefit could be an additional 79 billion USD.

Note that these potential savings take no account of the cost involved with implementing the vehicle safety standards, and thus a full cost-benefit analysis is not possible. However, the minimum regulations represented by this work[15] have been implemented in Europe for many years and thus application in other regions is likely to be cost-effective since the development costs will be minimal.

[15] approved seat belts and anchorages for all seating positions (UN Regulations 14 and 16); occupant protection in frontal collision (UN Regulation 94) and occupant protection in side or lateral collisions (UN Regulation 95)

7 Conclusions

In the EU (and other industrialised regions) vehicle safety standards have improved substantially over the past few decades, resulting in the realisation of substantial casualty savings. These improvements have been driven by regulations (including frontal and side impact regulations) and consumer testing programmes such as Euro NCAP, which have encouraged manufacturers to exceed the minimum requirements set out in the regulations.

Globally, over 1.25 million people died as a result of road accidents in 2013. Many of these casualties occurred in low- and middle-income countries where the estimated road traffic death rate is substantially higher than that in the safest European countries. Vehicle safety in these emerging markets is far behind that seen in Europe, and if the lessons learnt in industrialised regions could be effectively and efficiently applied then there could be considerable casualty reductions and economic benefits.

Vehicle safety is one of the five pillars of the United Nations Decade of Action for Road Safety (2011-2020), and as a result it is important to ensure it is on the agenda of policy makers across the world.

7.1 Potential casualty savings in Latin America

This project aimed to quantify the number of car user fatalities and serious injuries which could be prevented in the some of the major geographical regions in Latin American (specifically, Argentina, Chile, Mexico and, from a previous study, Brazil) if vehicle secondary safety regulations were applied to passenger cars.

The project estimates the impact of implementing regulations equivalent to these as a minimum:

- Approved seat belts and anchorages for all seating positions (UN Regulations 14 and 16);
- Occupant protection in frontal collision (UN Regulation 94), and
- Occupant protection in side or lateral collisions (UN Regulation 95).

In addition to implementation of the regulations, the modelling assumes that the consumer testing programme Latin NCAP, which was initiated in 2010, will have an equivalent impact to that seen in Europe.

Note that this modelling is restricted to analysis of the impact of car user secondary safety improvements, since the benefits of these are possible to estimate from the casualty figures[16]. In Europe, primary safety regulations including Anti-Lock Braking Systems (ABS) and Electronic Stability Control (ESC) are in-place and if these features were also mandated[17] (or at the very least actively encouraged by Latin NCAP), then the casualty savings presented here would be higher.

[16] Primary safety is more difficult to assess as it involves estimating the number of casualties which have not occurred.

[17] Note that some countries have already begun implementing these features: ABS is required in Argentina; ESC will be fitted in Argentina by 2018 and ABS will be mandatory in Mexico by 2019/20.

Based on an engineering visual assessment which compared the performance of cars in Latin and Euro NCAP frontal impact tests, it was concluded that broadly, today's Latin American cars are performing approximately 15 years behind cars in Great Britain. However, due to the absence of side impact tests and differences in the fitment of front passenger and side airbags between Europe and the emerging markets, it is possible that cars in these emerging markets are actually up to 20 years behind those in Great Britain in terms of performance in a crash. Therefore, concluding that the following represent conservative assumptions:

- new cars sold in Argentina in 2015 are like those sold in the EU in 2002;
- new cars sold in Chile in 2015 are like those sold in the EU in 2003;
- new cars sold in Mexico in 2015 are like those sold in the EU in 2000, and
- new cars sold in Brazil in 2015 are like those sold in the EU in 2001 (Cuerden, Lloyd, Wallbank, & Seidl, 2015)

As a result, the casualty savings presented here underestimate the potential benefits from introducing minimum regulations in conjunction with Latin NCAP testing.

Applying the secondary safety benefits seen in Great Britain over the past few decades to the emerging markets, it is estimated that up to 40,000 car occupant fatalities could be prevented across the Latin American region between 2016 and 2030 if minimum vehicle safety standards were adopted. This analysis focussed on the number of car user *fatalities* that could be saved, but in addition there are likely to be reductions across all injury severities including serious and slight casualties. Using a broad assumption about the number of seriously injured occupants for every fatally injured occupant results in an estimate of up to 440,000 killed or seriously injured car user casualties prevented between 2016 and 2030 if these regulations were implemented.

7.2 Economic benefit

The Valuation of Statistical Life (VSL) methodology estimates the economic loss due to a traffic collision in terms of GDP per capita. This methodology has its limitations, but application to the casualty savings suggests that improvements to vehicle safety standards could save Latin America up to 64 billion USD over the period 2016 to 2030. When serious injury savings are also considered, the total benefit could be up to 143 billion USD.

7.3 Recommendations

The three emerging markets studied in this project are all at different stages in terms of implementation of the regulations:

- Argentinian passenger cars are required to have driver and front seat passenger airbags, anti-lock braking systems, audible seat-belt reminder alerts and automatic lights, but no specific performance requirements have been defined. Some aspects of vehicle design have minimum standards, including seat belts and seat anchorages which appear to be similar to UN Regulations. Frontal and side impact regulations are not yet included in Argentinian law.

- In Chile, passenger cars are required to have seat belts, seat anchorages and, for light vehicles entering the vehicle fleet progressively from 2015, airbags are also required. In light vehicles the use of crumple zones, passenger survival cells and side impact protection structural elements to protect occupants in a collision or rollover are mandated. These vehicles should comply with the EU front and side impact directives (96/79/EC and 96/27/EC).
- Mexico has recently enacted a new Official Standard covering vehicle safety which specifies essential safety devices, including seat-belts, brakes, tyres and head restraints, all which meet certain standards. Frontal and side impact crash tests, anti-lock brakes and seat-belt reminders are also required for new vehicle types from January 2019 and for existing vehicle types from January 2020. The front and side impact crash test requirements can be met by demonstrating compliance with UN Regulations 94 and 95 respectively.

This demonstrates that some countries have started the legislative process and are now applying some standards that are similar to the EU (and other similar industrialised regions), but there is still a significant gap between the regulated vehicle safety standards in the industrialised regions and Latin America. In particular, frontal and side impact tests meeting UN Regulations 94 and 95 should be mandated across the whole Latin American region, not just in Mexico and Brazil.

Electronic Stability Control (ESC) and Pedestrian protection measures have not been assessed by this study. However, there is established international evidence that these safety features are effective and could reduce casualties in Latin America if incorporated into vehicle regulations. In particular, vulnerable road user impact-friendly vehicle design is particularly important, especially for Chile and Mexico which have a large proportion of pedestrian fatalities. As a result, it is strongly recommended that ESC (GTR 8) and pedestrian protection (GTR 9) are adopted into Latin American car safety regulations.

The turnover of the vehicle fleet is much slower in the emerging markets and so uptake of the regulations into the fleet is likely to be slower than seen in Great Britain. This further highlights the need to accelerate progress with regard to introducing new vehicle regulations as soon as practicable.

This study has considered how vehicle safety can reduce casualties in emerging markets. However, the 'Safe System' approach requires action with respect to safe vehicles, speeds, roads and road users. Only by making improvements to all areas of road safety, including road engineering, vehicle safety, enforcement and improved post-crash, can casualty reductions be maximised. Harmonising not only vehicle safety regulations but also other road safety legislation, for example mandating and enforcing seat belt wearing for front and rear seat occupants across the Latin NCAP region, would go some way to help to achieve this.

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Appendix A Summary statistics

Table 20: Summary statistics by country

	Great Britain						Argentina	Chile	Mexico
	1994	1998	2002	2006	2010	2014	2014[18]	2014	2014
Population (millions)	56.2	56.8	57.7	59.1	61.0	62.8	42.7	17.8	125.4
No. registered vehicles (millions)	25.2	27.5	30.6	33.1	34.1	35.6	17.5	4.3	38.0
No. registered cars (millions)	20.5	22.1	24.5	26.3	27.0	28.2	10.1	3.0	25.5
% of registered vehicles that are cars	81%	80%	80%	79%	79%	79%	58%	70%	67%
Growth in registered cars from previous year	1.9%	2.0%	2.7%	0.3%	0.6%	1.7%	7.3%	7.5%	2.9%
Proportion of registered cars new	8.8%	9.7%	10.3%	8.2%	6.5%	7.7%	4.3%	8.6%	2.9%
Proportion of cars aged 6 years or less	48%	48%	52%	52%	44%	40%	unknown	45%	unknown
Motorisation rate (cars per population)	0.36	0.39	0.43	0.44	0.44	0.45	0.24	0.17	0.20
All road accident casualties	3,650	3,421	3,431	3,172	1,850	1,775	5,209	1,630	16,456
Car occupant casualties	1,764	1,696	1,747	1,612	835	797	2,619	2,619	3,951[19]
% fatalities which are car occupants	48%	50%	51%	51%	45%	45%	50%	50%	24%[19]
Car occupant casualty rate (per million registered cars)	86.1	76.7	71.2	61.3	30.9	28.3	277.1	277.1	154.7[19]
Car occupant casualty rate (per million population)	31.4	29.9	30.3	27.3	13.7	12.7	63.2	63.2	31.5[19]

[18] The casualty data for Argentina in this table is from 2013.

[19] Car occupant casualties in Mexico have been estimated by redistributing casualties of 'unknown' road user type proportionately amongst those that are known.

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