THE FUTURE OF TRANSPORT

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Relationship between vehicle defects checked in roadworthiness inspections and those identified in collision analyses

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Table of Contents

Executive summary

The received wisdom that periodic technical inspection (PTI) provides benefits is undisputed. However, the quantification of those benefits is subject to much debate because there is no straightforward agreed method for their quantification. A number of methods exist, the main ones being those based on:

1. Influence of vehicle technical defects on the causes of traffic accidents, e.g. analyses of collision rates of inspected vehicles between inspections
2. Comparison between jurisdictions with and without PTI
3. 'before and after' comparison for jurisdictions which have introduced PTI (or abolished it)
4. Comparison of crash rates between vehicles which undergo PTI with those that do not in same jurisdiction

The first is based on the analysis of collision data and the identification and quantification of collisions in which vehicle defects (deficiencies) were a contributory factor. The next three are based on comparative type analyses between real-world situations where PTI is present and not present. For these types of analysis, statistical techniques such as regression models are usually used to isolate the benefit of PTI from other factors and quantify it. The literature shows that studies using all types of methods predict a wide range of benefits.

However, in general, studies which use a vehicle deficiency collision data based method predict lower safety benefits than comparative type based ones. With this in mind, to investigate potential reasons for these differences, the objective of the work performed was to understand better the relationship between vehicle defects (deficiencies) checked in roadworthiness inspections and those identified as contributory factors to a collision in an investigative analysis.

To achieve this, based on experience in Great Britain, an analysis was performed to estimate how many of the defects (deficiencies) for the items checked at a roadworthiness inspection, i.e. those contained in Annex 1 of Directive 2014/45/EU, categorised as dangerous would be identified by collision investigators as vehicle contributory factors in the case that the vehicle defect had contributed to the cause of the collision. It was decided to focus on dangerous deficiencies because they constitute a direct and immediate risk to road safety and thus could likely contribute to the cause of a collision.

The results of the analysis showed that:

- A standard collision investigation performed by a trained police officer attending the scene should, overall, identify about half of the vehicle defects categorised as dangerous (i.e. potential vehicle contributory factors) included in a vehicle roadworthiness inspection; for some key safety items such as brakes this is less (38%) whereas for others such as tyres it is more (60%).
- An in-depth collision analysis performed by an expert collision investigator should, overall, identify the majority (88%) of vehicle defects categorised as dangerous

included in a roadworthiness inspection assuming that they are not hidden by collision damage.

The implication of these results is that if vehicle defect type contributory factors identified by police officers attending the scene and recorded in collision databases are used to estimate the potential benefit of roadworthiness inspection measures, the benefit will likely be underestimated because it is likely that many vehicle defect type contributory factors will not be identified.

1 Introduction

The received wisdom that periodic technical inspection (PTI) provides benefits is undisputed. However, the quantification of those benefits is subject to much debate because there is no straightforward agreed method for their quantification. A number of methods exist, the main ones being those based on:

1. Influence of vehicle technical defects on the causes of traffic accidents, e.g. analyses of collision rates of inspected vehicles between inspections
2. Comparison between jurisdictions with and without PTI
3. 'before and after' comparison for jurisdictions which have introduced PTI (or abolished it)
4. Comparison of crash rates between vehicles which undergo PTI with those that do not in same jurisdiction

The first is based on the analysis of collision data and the identification and quantification of collisions in which vehicle defects (deficiencies) were a contributory factor. The next three are based on comparative type analyses between real-world situations where PTI is present and not present. For these types of analysis, statistical techniques such as regression models are usually used to isolate the benefit of PTI from other factors and quantify it. The literature shows that studies using all types of methods predict a wide range of benefits. This is expected because the benefit is dependent on:

- Improvement in roadworthiness of vehicle driven by introduction of PTI
    - Potential to improve vehicle roadworthiness often greater in developing countries compared to developed countries, hence larger benefits can be delivered for developing countries depending on rigour of PTI introduced
- Analysis technique used

However, in general, studies which use a vehicle deficiency collision data based method predict lower safety benefits than comparative type based ones. This is illustrated by who performed a literature review and extracted safety benefits predicted as shown in Table 1 and Table 2.

[1] Hudec J and Sarkan B (2022): Effect of periodic technical inspections of vehicles on traffic accidents in the Solvak repubic. Viewed July 2024, available from:

https://komunikacie.uniza.sk/artkey/csl-202203-0017_effect-of-periodic-technical-inspections-of-vehicles-on-traffic-accidents-in-the-slovak-republic.php.

Table 1: Safety benefits predicted by previous studies using method based on analyses of vehicle technical deficiencies

Study	Percentage of vehicles with vehicle technical defects that caused the traffic collision
Fazzalaro (2007), USA	1%
Asander (1992)	23% (direct causes or increasing damage or injury) (Finland) 7-9% (major causal role, a contributing cause, or by increasing the consequences of the accident) (Denmark)
RACQ (1990)	5%
Rompe and Seul (1985)	3-24% 1.3% (Japan)
Grandel (1985)	2-10%
McLean et al. (1979), Australia	1.5% motorcycles 2.9% passenger cars
Treat (1977)	4.5% passenger cars

Table 2: Safety benefits predicted by previous studies using method based on comparative type analyses between real-world situations where PTI is present and not present

Study	Percentage reduction in collision rate
European Commission (2019)	18% (in fatalities in Spain for mopeds)
Schulz and Scheler (2019)	40% (in collision rate in Costa Rica)
Schulz and Scheler (2016)	15% (in fatalities in Turkey)
Keall & Newstead (2013), New Zealand	8% (during the transition from an annual to a semi-annual frequency of technical inspections)
Rune Elvik (2001), Norway	5-10% (with an increase in the frequency of technical inspections by 100%)
Asander (1992), Sweden	16% (in collision rate with serious injury)
NHTSA (1989), USA	10% (in collision rate)
White (1986), New Zealand	10-15% (in collision rate)
Rompe & Seul (1985)	50% (in collision rate, from US studies)
Berg et al. (1984), Sweden	14% (in police reported collisions) 15% (in accident rate with serious injury)

Study	Percentage reduction in collision rate
Schroer and Peyton (1979), USA	9.1% (in accident rate, after technical inspection, compared to uninspected vehicles) 21% (in accident rate, after periodic technical inspection, compared to uninspected vehicles) 5.3% (in accident rate for inspected vehicles compared to accident rates of vehicles before the inspection)
Little (1971), USA	5% (in death rates)

With this in mind, to investigate potential reasons for these differences, the objective of the work performed was to understand better the relationship between vehicle defects (deficiencies) checked in roadworthiness inspections and those identified as contributory factors to a collision in an investigative analysis.

To achieve this an analysis was performed to estimate how many of the defects (deficiencies) for the items checked at a roadworthiness inspection, i.e. those contained in Annex 1 of Directive 2014/45/EU, would be identified by collision investigators as vehicle contributory factors in the case that the vehicle defect had contributed to the cause of the collision.

2 Method

Directive 2014/45/EU specifies the minimum regulatory requirements for periodic roadworthiness tests for motor vehicles and their trailers used on public roads in the European Union. Annex I lists the minimum requirements concerning the contents and recommended methods of testing and includes the following:

- vehicle items which shall be inspected, e.g. braking equipment, steering equipment etc.
- methods of inspection, e.g. visual inspection (while the equipment is operated), performance measurement (brake efficiency), etc.
- reasons for failure, e.g. damage, corrosion or excessive wear likely to affect function of system, prescribed performance measure (brake efficiency) not met, etc.
- assessment of deficiencies (defects) into one of the following groups:
    - (a) minor deficiencies having no significant effect on the safety of the vehicle or impact on the environment, and other minor non-compliances
    - (b) major deficiencies that may prejudice the safety of the vehicle or have an impact on the environment or put other road users at risk, or other more significant non-compliances
    - (c) **dangerous deficiencies constituting a direct and immediate risk to road safety** or having an impact on the environment which justify that a Member State or its competent authorities may prohibit the use of the vehicle on public roads.

The analysis performed consisted of the following three steps:

1. Format data
2. Assess selected deficiencies (defects)
3. Analyse outputs

Details of these steps are described in the sub-sections below.

Key to the successful application of the method was the experience of the expert collision investigator who assessed the selected deficiencies. He had over thirty years of experience in collision investigation and also had experience in vehicle roadside inspection, so was familiar with the vehicle technical inspection process. Also, it should be noted that regular meetings between the TRL team and CITA were necessary to help steer the project, especially during the period in which the method was developed.

2.1 Step 1: Format data

In order to arrange the data into a suitable format for analysis the table in Annex 1, containing vehicle items, methods of inspection, reasons for failure and assessment of deficiencies, was transferred into an excel spreadsheet. Rows with ‘reasons for failure’/ ‘deficiencies’ classified as ‘dangerous’ were selected (filtered) for further analysis because by definition (see above) these constitute a direct and immediate risk to road safety and thus could likely contribute to the cause of a collision. Reasons for failure / deficiencies classified as major may prejudice the safety of a vehicle and thus could potentially contribute to the cause of a collision but would be much more unlikely to do so compared to a dangerous deficiency. Thus, they were not selected for further analysis.

2.2 Step 2: Assess selected deficiencies (defects)

An expert collision investigator assessed whether each selected 'reason for failure' / 'deficiency' classified as dangerous would be identified in a collision investigation as a contributory factor, assuming that the vehicle deficiency was present and that it likely contributed to the cause of the collision. Because for many 'deficiencies' it was uncertain whether or not they would be identified, they were rated on a scale of zero to five with zero being virtually impossible to identify and five almost always identified.

Identification of each deficiency was assessed for two types of collision investigation as follows:

- A standard collision investigation which in GB:
  - Is performed by a police officer trained in collision investigation attending the scene and typically based on officer judgement usually at the roadside or within a short time of the collision.
  - Is performed for the majority of collisions
    - For example, in 2022, 60% of all collisions, 90% of fatal collisions
  - Is recorded in the national (STATS19) database.
    - Up to 6 potential contributory factors can be selected from a grid of 77 as very likely or possible. An 'other' category with free text is available for factors not included in grid. For fatal collisions, 2.5 contributory factors were assigned on average in 2021.
- An in-depth collision investigation which in GB:
  - Is performed by an expert collision investigator and involves a thorough investigation with inspection of vehicles usually conducted in garages where investigators have access to equipment such as ramps, inspection pits, brake testers, fault code readers, etc.. Thus, the results of the investigation may not be available for some time after the collision.
  - Is performed for selected collisions only, usually ones in which a fatality occurs.
  - Is recorded in police force collision databases
    - As many contributory factors as appropriate are recorded.

Assumptions such as collision damage does not hide deficiency damage to component / system, were noted if and when applicable. Also, caveats such as for a standard level analysis a deficiency may be unlikely to be detected because not checked for this level of investigation and / or the police officer performing the investigation may not have the level of expertise required to detect it, were also noted.

For each type of collision investigation, two columns were added to the spreadsheet to record the results of the assessment, one column to record whether or not the deficiency would be detected in a collision investigation on a scale of 0 (virtually impossible to detect) to 5 (almost always detected)) and another column to record any assumptions and / or caveats.

2.3 Step 3: Analyse outputs

The results of the assessments for standard and in-depth type collision investigations were analysed and are presented in Section 3 below.

3 Results and discussion

The assessment showed that for all 'reasons for failure / deficiencies' in Directive 2014/45/EU categorised as dangerous, assuming they were present and contributed to the cause of the collision, about half (50%) and the majority (88%) of them would be identified as contributory factors to the collision in standard and in-depth collision investigations, respectively (Table 3). Note that assumed identified if assessed as 5 or 4 on identification scale.

Table 3: Identification rates for 'reasons for failure / deficiencies' in Directive 2014/45/EU categorised as dangerous as collision contributory factors in standard and in-depth collision investigations

Identification scale	Standard collision investigation	In-depth collision investigation
5 (Almost always)	21%	58%
4	29%	30%
3	20%	7%
2	8%	3%
1	19%	1%
0 (Virtually never)	3%	0%

Further examination of the results shows that the identification rate varies with the vehicle system (Table 4):

- Identification rate (5 and 4)
  - Overall: standard 50%; in-depth 88%
  - Brakes: standard 38%; in-depth 93%
  - Axles, wheels, tyres, suspension: standard 52%; in-depth 83%
  - Tyres alone: standard 60%; in-depth 80%

Table 4: Comparison of identification rates for different vehicle systems for 'reasons for failure / deficiencies' in Directive 2014/45/EU categorised as dangerous as collision contributory factors in standard and in-depth collision investigations

Identification scale	Overall		Brakes		Axles, wheels, (tyres), suspension	
	Standard	In-depth	Standard	In-depth	Standard	In-depth
5 (Almost always)	21%	58%	20%	68%	24% (40%)	66% (40%)
4	29%	30%	18%	25%	28% (20%)	17% (40%)
3	20%	7%	33%	5%	28% (20%)	17% (20%)
2	8%	3%	18%	3%	3% (0%)	0% (0%)
1	19%	1%	10%	0%	17% (20%)	0% (0%)
0 (Virtually never)	3%	0%	3%	0%	0% (0%)	0% (0%)

For a standard collision investigation further examination of the results revealed the vehicle deficiencies likely to be identified and those unlikely to be identified:

Vehicle deficiencies likely to be identified:

- Braking (including parking brake) – major loss of efficiency / performance caused by, for example, servo not working, worn / broken pads / disc / drum, fluid loss from broken pipes/ hoses
- Steering - large freeplay or fractures / detachments and loss of power steering, for example caused by damaged cables / hoses and fluid loss
- Visibility – condition of glass
- Lamps – non-functioning light sources, for trailers electrical connection failure
- Axles, wheels, tyres and suspension – axles, wheels and springs; worn, damaged or insecure fixing.
- Tyres – worn, damaged
- Chassis and attachments – leaking fuel, body condition (corrosion, deformation, likely to fall off), driver's seat (loose)
- Other equipment - restraint system, anchorage points, pre-tensioners, airbag deployment
- Nuisance – exhaust major damage and fluid leaks
- Supplementary – stairs and steps condition affecting stability

Vehicle deficiencies unlikely to be identified:

- Braking - reduced efficiency / performance unless very large reduction

- Steering - condition affecting functionality unless large free play or becomes detached completely
- Stub axles - unless broken
- Tyres - Insufficient load or speed category
- SRS – seat belt load limiter
- Coupling / towing device - wear or unsafe modification unless fails

The results were somewhat expected. For example, the result that about half of the dangerous deficiencies checked for in a roadworthiness inspection would be identified in a standard collision investigation as a vehicle defect contributory factor to the collision, whereas the majority (88%), but not all, would be identified in an in-depth collision investigation can be explained by the nature of these investigations as follows.

A standard collision investigation is performed by a trained police officer who attends the scene of the collision. The police officer will gather evidence from the scene to enable him / her to complete the report required – see Appendix A. This will involve gathering evidence from participants and witnesses and an examination of the scene which will include a visual examination of the vehicles involved. Usually, it will be one officer who performs the full investigation. Hence, the time spent on the vehicle inspection may be compromised if there are numerous witnesses to be dealt with at the scene. Also, as most collisions are due to 'human factors', e.g. excess speed, there may be unconscious bias on the part of the investigator, who may feel they already know the likely cause of the collision, and may not look too hard for any further vehicle mechanical issues that may 'muddy the waters'. In addition, many vehicle defects are difficult to identify with a visual examination, so unless they are indicated by other evidence, it is likely that they may not be identified and reported. Furthermore, because the investigation report only allows a maximum of 6 contributory factors to be reported the police officer may have to judge which ones are the more important which may cause vehicle defect type factors to drop off the end of the list because often driver related type contributory factors such as 'travelling too fast for conditions' or 'failed to look properly' are judged to be more important In short, there are a significant number of factors associated with a standard collision investigation that are likely to lead to the under reporting of vehicle defect type contributory factors.

In contrast, an in-depth collision investigation is performed by an experienced collision investigator who has more knowledge, will not have the time pressures associated with a standard investigation carried out at the roadside and is likely to be disengaged from any bias. The vehicle examination will usually be carried out at a garage, therefore dismantling and/or testing of the vehicle can be performed to identify vehicle defect type contributory factors and thus all contributory factors should be identified, i.e. no limits on number. However, even with this depth of investigation, some vehicle defect contributory factors may not be identified because they may be hidden by crash damage, e.g. brake lamp failure in rear impact type collision, and / or tests to identify them may not be performed, e.g. moderately reduced brake efficiency which increased stopping distance slightly, there may be little evidence to indicate this vehicle defect and / or may not be possible to test brake efficiency because of crash damage.

It should also be noted that some vehicle deficiencies are much easier to identify than others, for example a bald tyre with little / no tread can be seen with a quick glance at the tyres, whereas a reduction in brake efficiency may require dismantling of the brakes to enable examination of the brake linings to identify.

To provide some understanding of how the contributory factors recorded in a standard collision investigation (i.e. those recorded in the national (STATS19) collision database) compared to those recorded in an in-depth investigation (i.e. those recorded in more in-depth investigations performed for fatal collisions), the UK Department for Transport (DfT) commissioned a study[2]. The study found that:

- Overall, at national level, the main contributory factors in fatal collisions were broadly similar whether based on those captured in the standard investigation or those updated by the in-depth investigation.
- However, at a case level over a third of contributory factors recorded in the standard analysis were removed or changed when updated with results from the in-depth analysis.
- Some contributory factors, particularly those related to speed and impairment by drink or drugs appear more frequently when updated with results from the in-depth analysis, meaning that STATS19 national data potentially understates the impact of these factors.
- Over a third of fatal collisions had a speed-related factor (exceeding the speed limit or travelling too fast for conditions) when updated with results from the in-depth analysis, compared with around a quarter in standard analysis recorded in the STATS19 national database, making speed, when considered in this way, the most prevalent factor in fatal collisions. The next most prevalent factors were also related to the driver/rider, namely:
    - Loss of control
    - Failed to look properly
    - Reckless or in a hurry

  Contributory factors related to vehicle defects were not recorded often with 'tyres illegal, defective or under inflated', 27th on the list.
- Detailed examination of contributory factors related to vehicle defects revealed that they changed enormously and increased by about 80% when updated with results from the in-depth analysis indicating that they are often incorrectly recorded and under-recorded in the STATS19 national database (Table 5).

[2] Contributory factors in fatal collisions: comparing STATS19 with post-investigation recording, 2021 data: https://www.gov.uk/government/statistics/contributory-factors-in-fatal-collisions-comparing-stats19-with-post-investigation-recording-2021-data/contributory-factors-in-fatal-collisions-comparing-stats19-with-post-investigation-recording-2021-data#background

Table 5: Comparison of contributory factors assigned in standard and in-depth collision investigations for fatal collisions in Great Britain

Contributory Factor (CF) code	Contributory Factor (CF) name	Count in standard investigation	of which remaining post update with in-depth investigation	of which removed post update with in-depth investigation	of which added post update with in-depth investigation	Count post update with in-depth investigation	Percentage of standard analysis collisions where CF removed	Percentage of in-depth investigation collisions where CF added	Overall percentage change
All	All contributory factors	2,480	1,600	880	1,105	2,705	36%	41%	9%
201	Tyres illegal, defective or under inflated	13	10	3	10	20	23%	50%	54%
202	Defective lights or indicators	0	0	0	5	5	[x]	[x]	[x]
203	Defective brakes	9	5	4	6	11	44%	55%	22%
204	Defective steering or suspension	6	5	1	4	9	17%	44%	50%
205	Overloaded or poorly loaded vehicle or trailer	0	0	0	5	5	[x]	[x]	[x]
Vehicle	All vehicle contributory factors	28	20	8	30	50	29%	100%	79%

4 Conclusions

Based on experience in Great Britain, an analysis was performed to estimate how many of the deficiencies checked in roadworthiness inspections categorised as dangerous would be identified by collision investigators as vehicle contributory factors in the case that the vehicle deficiency (defect) had contributed to the cause of the collision.

It was found that:

- A standard collision investigation performed by a trained police officer attending the scene should, overall, identify about half of the vehicle defects categorised as dangerous (i.e. potential vehicle contributory factors) included in a vehicle roadworthiness inspection; for some key safety items such as brakes this is less (38%) whereas for others such as tyres it is more (60%).
- An in-depth collision analysis performed by an expert collision investigator should, overall, identify the majority (88%) of vehicle defects categorised as dangerous included in a roadworthiness inspection assuming that they are not hidden by collision damage.

Other work commissioned by the UK DfT supported these findings in that it found that a standard collision investigation only identified about half the number of vehicle defect type contributory factors that an in-depth collision investigation did. This other work also found that many contributory factors were incorrectly identified by a standard collision investigation.

The implication of these conclusions is that if vehicle defect type contributory factors identified by police officers attending the scene and recorded in collision databases are used to estimate the potential benefit of roadworthiness inspection measures, the benefit will likely be underestimated because it is likely that many vehicle defect type contributory factors will not be identified.

Appendix A GB standard collision analysis - contributory factors

For a standard collision analysis in GB, the police officer attending the scene of the collision is required to complete a report to record data about the collision in a defined format which is used to populate the national collision (STATS19) database. The STATS20 document provides instructions for this process[3]. Instructions are provided for:

- Accidents to be reported
    - All road accidents involving human death or personal injury occurring on the Highway and notified to the police within 30 days of occurrence, and in which one or more vehicles are involved
- Vehicles to be reported
- Casualties to be reported
- Contributory factors

The Contributory Factors in a road accident are the key actions and failures that led directly to the actual impact. They show why the accident occurred and give clues about how it may have been prevented. Up to 6 potential contributory factors can be selected from a grid of 77 defined factors, as very likely or possible.

The categories of contributory factors are:

- Road environment: 10 factors, for example poor or defective road surface
- Vehicle defects: 6 factors, for example, tyres illegal, defective or under-inflated
- Injudicious action: 10 factors, for example, disobeyed traffic signal
- Driver / rider error or reaction: 10 factors, for example, failed to look properly
- Impairment or distraction: 10 factors, for example, impaired by alcohol
- Behaviour or experience: 7 factors, for example, aggressive driving
- Vision affected by: 10 factors, for example, dazzling headlights
- Pedestrian only: 10 factors, for example, failed to look properly
- Special codes: 5 factors, for example, stolen vehicle

  and code 'Other' to be used only when no contributory factor is available to describe a particular circumstance which contributed to the accident.

The contributory factors for the vehicle defects category are:

201: Tyres illegal, defective or under-inflated

[3] STATS20 – Instructions for the completion of road accident reports from non-crash sources: https://assets.publishing.service.gov.uk/media/60d0cc968fa8f57cf3f0b3ad/stats20-2011.pdf

202: Defective lights or indicators

203: Defective brakes

204: Defective steering or suspension

205: Defective or missing mirrors

206: Overloaded or poorly loaded vehicle or trailer

Note code 999 should be used where a vehicle defect not listed below has caused, or contributed to, the accident. Brief details must be supplied.

Relationship between vehicle defects checked in roadworthiness inspections and those identified in collision analyses

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