Table of Contents: Appendices

List of Tables: Appendices

List of Figures: Appendices

Appendix A. Economic Impact Analysis

The economic analysis of the Inspection Program comprises the following four general areas:

- **Basis, Information, Estimates, and Assumptions**

  This area contains general information about the program, the sources of that information, and the specific information needed to make the necessary calculations.

- **Income and Expenses for the Inspection Program (Continuing the Program)**

  This area identifies the revenue and expenses for the station owners and inspectors, the State of Texas, and vehicle owners. This is a snapshot of the current condition with the Inspection Program in place.

- **Income and Expenses for the Inspection Program (Discontinuing the Program)**

  This area identifies the revenue and expenses for the station owners and inspectors, the State of Texas, and vehicle owners. This assumes that the Inspection Program is discontinued by the Legislature.

- **Summary and Additional Considerations**

  This area provides a summary of the preceding revenue and expenses identified for each party and additional points and considerations that may result from discontinuing the Inspection Program.

A.1. Basis, Information, Estimates, and Assumptions

First and foremost, the basis of this study is the safety-only Inspection Program for passenger vehicles (PVs). This study does not address safety inspections for commercial motor vehicles (CMVs); nor does it address emissions testing for any vehicle.

To determine the revenues and expenses of various parties to the Inspection Program, the CTR study team gathered pertinent information and made certain estimates and assumptions necessary to most accurately determine those income and expense figures.

As much as possible, the CTR study team used the most current data available. This usually means data from FY 2017. This data changes from year to year and is driven by new vehicle sales and retirement of vehicles.

Information and data sources include the following:

- Texas Transportation Code
- Texas Administrative Code
- Literature reviews

- Texas Department of Public Safety (TxDPS)
- Texas Department of Motor Vehicles (TxDMV)
- Texas Department of Information Resources (TxDIR)
- Texas Commission on Environmental Quality (TCEQ)
- Texas Comptroller of Public Accounts (TxCPA is a pass-through for all monies remitted to the state)
- TxDPS Vehicle Inspection Advisory Committee
- Stakeholder workshop

A.1.1. Program Governance

The Inspection Program is governed by:

- Texas Transportation Code, Title 7, Subtitle C, Chapter 548, Subchapter A and
- Texas Administrative Code Title 37, Part 1, Chapter 23, Subchapter C

These set the program framework, administration, rules, fee structure, and fee disposition.

A.1.2. Fees Collected at Registration

Vehicles more than 2 years old require an annual safety inspection. Vehicle owners are charged either a $7.50 or a $5.75 fee to the state remitted at time of registration for safety inspection (TxDPS, 2016). The fee consists of these components:

- $2.00 for the Clean Air Fund,
- $3.50 for the Texas Mobility Fund, and
- $2.00 or $0.25 for Texas.gov fees to support website and database functions (vehicles in safety-only counties incur the $2 charge, while vehicles in emissions counties incur a $0.25 charge).

New vehicles (new and never registered) require a safety inspection good for 2 years. Vehicle owners are charged a state fee of $16.75 or $15 remitted at registration. The fee consists of these components:

- $2.00 for the Clean Air Fund,
- $12.75 for the Texas Mobility Fund, and
- $2.00 or $0.25 for Texas.gov fees to support website and database functions (vehicles in safety-only counties incur the $2 charge, while vehicles in emissions counties incur a $0.25 charge).

A.1.3. Fees Paid at Inspection

Vehicle owners are charged a fee of $7.00, paid to the station owner, for all safety inspections (one-year or two-year). The Transportation Code allows no more than $7.00 paid to station owners. Station owners are free to charge less. For our purposes, the CTR study team will use a standard fee of $7.00 per inspection.

A.1.4. Station Certification and Inspector License Fees

Station owners pay a certification fee of $100 plus $2 to support Texas.gov every other year. This is equivalent to $51 per year. The $100 portion of the fee goes to the Texas Mobility Fund.

Inspectors pay a license fee of $25 plus $2 to support Texas.gov every other year. This is equivalent to $13.50 per year. The $25 portion of the fee goes to the Texas Mobility Fund.

A.1.5. Inspection and Registration Data and Calculations

The CTR study team acquired relevant inspection, registration, and support data from TxDPS, TxDMV, and TxDIR and used this data to determine the number of vehicles inspected/registered, numbers of safety-only and emission/safety inspections, and apparent inspection failure rates. Tables A.1 and A.2 contain a substantial amount of data for use in our calculations. Table A.1 shows TxDPS inspection data and other data for stations and inspectors. Table A.2 shows TxDMV data based on registered vehicles.

A.1.5.1. Number of Vehicles Registered/Inspected

TxDPS inspection data is based on the number of inspections performed and is broken out to show the number of two-year inspections, safety-only inspections for motorcycles/trailers, and safety-only inspections and safety plus emissions testing. Inspections in emissions counties have no breakout for commercial and non-commercial vehicles, complicating the analysis.

TxDMV data shows a breakout of PVs, light trucks, and motorcycles (no trailers).

The TxDPS and TxDMV numbers do not agree because these two sets of numbers account for different aspects the program: vehicle inspections versus registrations. One would think that the number of vehicles registered should equal the number of inspections, but there are complications. New PVs and light trucks get a two-year inspection when first registered. These are counted in the year performed, but are not part of the inspection count for the next year as these vehicles are in the second year of the initial two-year inspection cycle. Some vehicles are sold out of state. Some vehicles are destroyed in accidents. Some vehicles get more than one inspection in a year.

Although the basis of the numbers is different, the CTR study team chose to combine the TxDPS and TxDMV data to develop the breakout number calculations necessary to perform the economic evaluation. We believe the error this introduces is not significant and represents a “best estimate” of these numbers. These numbers also change every year based on new vehicles sold, vehicles out of service, and vehicle location (safety-only versus emission/safety counties).

Table A.1. TxDPS Inspection Program data (based on TxDPS FY17 inspection statistics)

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
Total Emissions Inspections													
El Paso - TSI/OBD	44,035	42,632	39,675	40,860	48,739	50,843	63,232	49,674	50,750	46,834	46,666	47,881	571,821
Required Emissions Only	641	547	470	394	540	549	751	636	605	582	622	649	6,986
DFW/HGB - ASM/TSI	12,971	12,536	10,713	10,361	10,078	11,078	12,889	10,423	10,959	8,912	8,951	8,243	128,114
DFW/HGB - OBD	693,941	683,595	630,152	677,323	731,579	742,068	878,232	757,054	837,806	786,685	803,204	734,579	8,956,218
Austin - TSI/OBD	94,889	91,649	84,858	91,088	99,111	93,743	107,099	100,154	113,547	107,826	106,924	105,993	1,196,881
Total	846,477	830,959	765,868	820,026	890,047	898,281	1,062,203	917,941	1,013,667	950,839	966,367	897,345	10,860,020
Total Safety-Only Inspections													
Trailer/Motorcycle	75,747	70,372	52,916	44,554	60,808	73,518	97,455	90,900	98,626	91,656	81,756	76,304	914,612
Safety 1-Year	755,309	727,129	678,133	716,144	779,461	793,638	953,373	776,261	844,207	823,971	806,212	801,111	9,454,949
Commercial/Trailer	23,745	22,715	20,891	19,742	26,912	27,248	37,332	27,153	26,866	25,573	22,933	25,723	306,833
Safety-only 2-Year	139,300	142,668	132,010	138,693	129,454	122,119	152,485	132,205	137,678	130,817	111,010	120,334	1,588,773
Commercial/ Windshield	31,126	30,806	27,906	27,387	38,215	40,929	65,937	40,368	36,498	36,124	32,968	34,605	442,869
Total	1,025,227	993,690	911,856	946,520	1,034,850	1,057,452	1,306,582	1,066,887	1,143,875	1,108,141	1,054,879	1,058,077	12,708,036
Total Inspections	1,871,704	1,824,649	1,677,724	1,766,546	1,924,897	1,955,733	2,368,785	1,984,828	2,157,542	2,058,980	2,021,246	1,955,422	23,568,056
Total # of Passing VIRs Issued													
El Paso - TSI/OBD	41,926	40,441	37,714	38,818	46,133	47,973	59,749	47,148	48,054	44,350	44,040	45,099	541,445
Trailer/Motorcycle	75,491	70,132	52,734	44,415	60,562	73,276	97,112	90,571	98,323	27,984	81,473	76,051	848,124
Safety-only (1-Year)	743,768	715,912	668,164	705,955	763,652	775,907	932,997	760,593	827,962	807,795	790,601	785,450	9,278,756
Required Emissions Only	581	496	404	356	488	489	694	579	550	535	566	601	6,339
Commercial/Trailer	23,291	22,283	20,487	19,353	26,363	26,686	36,559	26,588	26,399	25,107	22,502	25,238	300,856
DFW/HGB - ASM/TSI	10,990	10,593	8,951	8,725	8,484	9,163	10,719	8,739	9,184	7,525	7,517	6,908	107,498
Safety-only (2-Year)	139,294	142,664	132,010	138,688	129,449	122,116	152,481	132,198	137,673	130,813	111,008	120,333	1,588,727
DFW/HGB - OBD	654,504	644,000	594,939	639,721	688,095	697,961	826,489	714,679	792,763	744,215	759,468	694,133	8,450,967
Commercial/ Windshield	30,085	29,797	27,027	26,598	36,950	39,556	63,674	38,964	35,396	34,995	32,017	33,522	428,581
Austin - TSI/OBD	87,491	84,407	78,550	84,152	90,438	85,516	97,811	91,870	104,477	99,169	98,006	97,270	1,099,157
Total	1,807,421	1,760,725	1,620,980	1,706,781	1,850,614	1,878,643	2,278,285	1,911,929	2,080,781	1,922,488	1,947,198	1,884,605	22,650,450
Total Safety-Only Failures	23,763	23,495	20,629	21,188	31,897	34,355	40,102	31,780	33,134	32,117	32,015	30,896	355,371
# of Active Stations	11,715	11,742	11,772	11,798	11,817	11,835	11,878	11,909	11,956	11,979	11,988	11,957	

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Total
# of Emissions Stations	5,237	5,251	5,265	5,272	5,283	5,283	5,318	5,349	5,364	5,384	5,401	5,413	
# of Active Inspectors	35,005	35,975	36,815	37,523	38,281	39,100	40,019	40,760	41,599	42,362	42,982	43,754	
# of Station Licenses Issued													
Initial Licenses Issued	91	94	82	113	98	115	145	104	138	105	94	118	1,297
Renewal Licenses Issued	0	1	0	0	302	175	285	322	258	752	2,817	5,425	10,337
Total Licenses Issued	91	95	82	113	400	290	430	426	396	857	2,911	5,543	11,634
# of Suspend/Revoke													
Station Suspend/Revoke	1	5	2	2	1	5	1	4	2	7	8	5	43
Inspect. Suspend/Revoke	45	49	43	66	35	35	31	44	31	46	44	65	534
Total Suspend/Revoke	46	54	45	68	36	40	32	48	33	53	52	70	577
# of Enforcement Actions													
Station Re-education	45	32	31	19	34	37	27	32	45	46	31	27	406
Station Warning	13	17	10	6	6	10	10	10	15	16	10	7	130
Station Citation	17	24	18	8	8	12	11	14	7	6	7	12	144
Station Suspension	0	0	0	0	0	0	0	0	0	0	0	0	0
Stations Revocation	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Station	**75**	**73**	**59**	**33**	**48**	**59**	**48**	**56**	**67**	**68**	**48**	**46**	**680**
Inspector Re-education	50	51	46	21	42	53	43	34	81	81	52	43	597
Inspector Warning	13	20	10	7	5	9	10	10	12	16	18	8	138
Inspector Citation	127	165	103	73	84	139	110	99	86	81	93	83	1,243
Inspector Suspension	0	0	0	0	0	0	0	0	0	0	0	0	0
Inspector Revocation	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Inspector	**190**	**236**	**159**	**101**	**131**	**201**	**163**	**143**	**179**	**178**	**163**	**134**	**1,978**
Total Enforcement	**265**	**309**	**218**	**134**	**179**	**260**	**211**	**199**	**246**	**246**	**211**	**180**	**2,658**
New Inspector License Issued	926	970	877	743	791	846	942	778	858	806	662	832	10,031

TSI = Two Speed Idle
OBD = On-Board Diagnostics
ASM = Acceleration Simulation Mode

DFW = Dallas-Fort Worth Area emissions counties
HGB = Houston-Galveston-Beaumont Area emissions counties

Table A.2. TxDMV registration data for PVs, light trucks, and motorcycles

Fiscal Year	Total PVs <=6,000 Lbs.	Total Trucks - One Ton or Less (Pickups)	Total Motorcycles	Total All Vehicles Registered
2001	9,984,030	4,813,943	201,834	17,906,116
2002	10,187,592	5,044,364	228,626	18,707,486
2003	10,174,751	5,139,701	250,589	18,621,915
2004	10,296,782	5,269,577	278,376	18,949,499
2005	10,517,928	5,371,040	313,619	19,144,792
2006	10,726,666	5,434,231	344,846	20,059,065
2007	11,069,564	5,592,441	372,862	20,864,318
2008	11,239,751	5,540,227	423,351	21,185,173
2009	11,453,354	5,588,568	423,444	21,446,721
2010	11,620,482	5,609,210	419,722	21,570,282
2011	11,832,416	5,612,457	430,422	21,939,786
2012	12,378,139	5,777,174	439,029	22,618,153
2013	12,818,065	5,854,158	438,960	23,227,032
2014	13,267,039	5,918,921	437,949	23,886,263
2015	13,288,425	5,780,988	375,455	23,751,503
2016	13,979,501	5,990,813	380,793	24,053,612
2017	14,299,326	6,055,188	375,169	24,527,939

The CTR study team used the following approach to determine the numbers of vehicles to use for fee calculations.

Since fees to the state are collected at registration, we need to know the number of non-commercial vehicles that get one-year and two-year inspections.

One can use TxDMV data for the numbers of cars, light trucks, and motorcycles. One can use TxDPS data to determine the number of trailers, 2017 two-year inspections, and 2016 two-year inspections. The 2016 two-year inspections incurred fees in 2016, but are not subject to fees in 2017.

- Cars (C) = 14,299,326
- Light Trucks (LT) = 6,055,188
- Motorcycles (M) = 375,169
- Trailers (T) = TxDPS motorcycles/trailers – TxDMV motorcycles = 539,443
- TxDPS 2017 Two-Year = 1,588,773
- TxDPS 2016 Two-year = 1,658,184
- **Number of vehicles with fee at registration of $7.50 or $5.75 = C + L + M + T - TxDPS 2017 Two-Year - TxDPS 2016 Two-year = 18,022,169**

- **Number of vehicles with fee at registration of $16.75 or $15.00 = TxDPS 2017 Two-Year = 1,588,773**

This is total of 19,610,942 non-commercial vehicles registered and we will use this as the total number of Inspection Program inspections.

A.1.5.2. Number of Safety-Only Inspections and Safety plus Emissions Inspections

Starting with the total Inspection Program inspections of 19,610,942, TxDPS data shows the number of safety-only Inspection Program inspections is 11,958,334, which we subtract from the total number of inspections to arrive at 7,652,608 non-commercial vehicles that were inspected for both safety and emissions. This is 39% of all current non-commercial vehicles currently subject to the Inspection Program.

A.1.5.3. Apparent Inspection Failure Rates (Safety-Only Inspections)

Table A.1 shows a breakout for failed safety-only inspections, which includes all vehicles (both commercial and non-commercial), from which the CTR study team developed a failure rate. For these safety-only inspections, there were 12,708,036 inspection and 335,371 failures for a 2.63% failure rate. This refers to vehicles that failed safety-only inspection and left without remedying the source of the failure, not to vehicles repaired during inspection. There is not a breakout for failed safety/emissions inspections.

A.1.5.4. Stations, Inspectors, and Locations

Table A.1 shows TxDPS data on the number of certified stations and inspectors. The number fluctuates, so the CTR study team will use the numbers for August 2017 that show 11,957 certified stations and 43,754 certified inspectors.

TxDPS shows data on the number of stations in emissions counties (conducting both emissions and safety inspections) and in safety-only counties (conducting only safety inspections). Following is the breakdown of these two station types:

- 17 emissions counties with 5413 stations
- 237 safety-only counties with 6544 stations

A.1.5.5. Data Collection and Database

In safety-only counties, the program supplies a safety inspection aid and electronic database connection device known as a VIC (Vehicle Inspection Connection) unit. TxDIR supplies these electronic devices through a third-party contractor. TxDIR has a new contract for these services. The contract is to supply any needed hardware for new stations, replace non-functioning hardware for existing stations, and provide a call center for stations to troubleshoot VIC units and internet connectivity. The contract is based on 6535 VIC units in service at any time, at a rate of $29.38 per VIC unit per month, amounting to a contract value of $2,303,980 per year. This may be adjusted if the number of TxDIR-supported VIC units is significantly higher.

A portion of the Texas.gov fee charged to vehicle owners at registration funds this service.

A.1.5.6. Other Loss of Income and Additional Expenses from Discontinuing the Inspection Program

TxDPS and TCEQ provided information on loss of income to certain accounts and costs associated with discontinuing the program.

- TxDPS identified a one-time cost of $33,480.
- TCEQ reports that the Clean Air Fund currently derives approximately one-third of its funding from the $2 per vehicle safety fee. Using 2017 inspections, this is 19,610,942 vehicles per year × $2 per vehicle = $39,221,884 per year.
- TCEQ would also incur an $800,000 one-time cost for programming changes to all the emission/safety testing-reporting devices used in emissions counties. This is to remove the Inspection Program reporting from the emissions-testing system.
- Since the emissions inspection program is separate from the Inspection Program, one can assume that TxDPS would still be the agency administering the emissions program, meaning TxDPS would continue to incur that program's administrative costs.

A.1.5.7. Additional Area-Specific Assumptions

The CTR study team will make some additional assumptions in other areas, as specified in the following sections.

A.2. Income and Expenses for the Inspection Program (Continuing the Inspection Program)

This section identifies the revenue and expenses for the station owners and inspectors, the State of Texas, and vehicle owners. This is a snapshot of the current condition with the Inspection Program in place and would continue to represent revenue and expenses for parties going forward if the program is not discontinued.

A.2.1. Station Owners and Inspectors (Continue Inspection Program)

Figure A.1 shows a graphical depiction of the revenue and expenses for the vehicle station owners and inspectors discussed in this section.

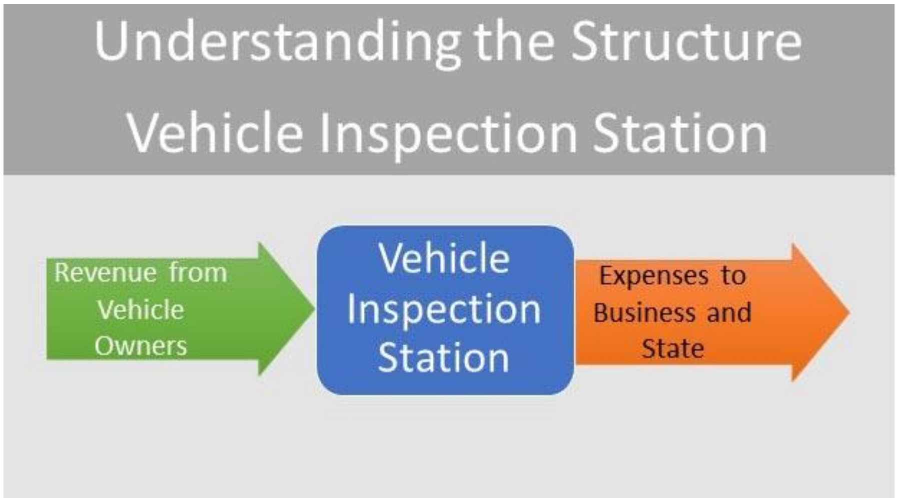


Figure A.1. Economic analysis—station owners and inspectors

A.2.1.1. Revenue

The CTR study team identified one source of revenue for station owners, which is the inspection fees remitted to the station owner by the vehicle owner at the time of inspection, calculated as:

19,610,942 inspections per year × $7.00 per inspection = $137,276,594 per year

It should be noted that a station may have other revenue derived from the program if:

- Maintenance is required for a vehicle to pass an inspection,
- The station is able to perform that work, and
- The vehicle owner agrees to have the work performed at that station.

This revenue would be unknown and outside the scope of this study.

Since there are no more identified revenue sources, the total revenue is $137,276,594 per year for station owners.

A.2.1.2. Expenses

A station owner incurs several areas of expense that offset the revenue. We list those here along with estimated costs; the testing and database communication device cost is listed last, as an extended narrative follows that item. Tables A.3 and A.4 then summarize the average costs for both establishing and maintaining an inspection operation.

1) *Station owners must have a facility that meets requirements of the Texas Administrative Code*. These include being a permanent facility, at least two walls and a roof, a hard-surface floor, adequate lighting, and secure storage of equipment among other requirements. We will not be able to place a value on this cost, but mention it as a cost of doing business.

2) *Printer*. All systems require a printer to provide an inspection report to the vehicle owner. We estimate this as a one-time $200 cost plus another $200 annually to cover the ongoing cost for consumables (paper and toner).

3) *Data transmission service (telephone line or internet access)*. We will assume $20/month ($240 per year).

4) *Station owner certification fees* equivalent to $51 per year (fee of $102 for a two-year term).

5) *Inspector license fees* equivalent to $13.50 per year (fee of $27 for a two-year term).

6) *Liability insurance*. Since safety inspectors drive the vehicle owners' cars to conduct testing, station owners need liability insurance. During a meeting with stakeholders, station owners indicated that if they did other business, such as auto repair, their liability insurance for that business would be sufficient. We are documenting the need for insurance here, but will not include it as an additional expense of the Inspection Program for station owners.

7) *Gas cap tester*. This one-time cost averages $600.

8) *Tire tread gage*. This one-time cost averages $4.

9) *Tint meter*. This one-time cost averages $80.

10) *Testing and database communication device*. This would be $0 for safety-only counties.

    As established earlier, the state is divided into safety-only counties and emissions counties. The 237 safety-only counties require only a vehicle safety inspection, while the 17 emissions counties require both a safety inspection and emissions testing.

    For the 6544 stations in safety-only counties, the state provides the testing equipment—the TxDIR-supplied VIC (see the Data Collection and Database section for a full description).

    In emissions counties, station owners provide their own equipment (at their cost) from an approved list of equipment providers. Emissions testing is additional work and requires more complicated testing equipment. By statute and rule, stations conducting emissions testing receive an additional fee for this testing, which helps offset the equipment purchase and maintenance costs. These units also function to collect the safety inspection information and record all information in a database. The one-time cost for the equipment purchase averages about $8000. Additionally, the equipment must have a maintenance agreement, which averages $800 per year. Emissions counties are in more populated areas of the state and consequently have more vehicles for testing (and thus a greater number of vehicle owners paying the emissions testing fee). While Texas has only 17 emissions counties, those counties contain 5413 of the 11,957 total stations.

    The self-funded nature of the emissions testing is a complicating factor that must be addressed in our analysis. The CTR study team determined two primary methods to address it:

1) divide stations into safety-only and emissions categories and break them out separately for the final expenses, or

2) assign the additional expenses to the emissions-testing program itself—as it is a separate program from the Inspection Program and will not be discontinued since it is federally mandated—and not include these costs as part of the Inspection Program.

The second option makes sense and simplifies the cost calculations. Therefore, the CTR study team decided to establish the costs (in the above narrative), but for simplicity keep them out of the current analysis. Thus, we assign a testing and database communication device cost of $0 for all stations.

From these identified expenses, we can generate a cost for getting into business and ongoing costs for staying in business.

To get into business (assuming they have a facility that meets the station requirements, already have liability insurance, the state provides the data transmission equipment, and they have only one inspector), a station's initial Inspection Program-related costs would be approximately $1233 (as Table A.3 demonstrates).

Table A.3. Initial startup costs for inspection stations

Expenses	Estimated Cost
Station Certification (2-year)	$102
Inspector License	$27
Printer Purchase	$200
Printer Consumables	$200
Data Transmission Line	$20
Gas Cap Tester	$600
Tire Tread Gage	$4
Tint Meter	$80
Total	**$1,233**

To remain in business, a station's Inspection Program-related expenses would be approximately $505 per year, as Table A.4 indicates.

Table A.4. Operating expenses for inspection stations

Expenses	Estimated Cost
Station Certification	$51
Inspector License	$13.50
Printer Consumables	$200
Data Transmission Line	$20
Total	**$504.50**

In aggregate, the annual expense for the program includes 43,754 inspectors and 11,957 stations and amounts to:

$51 per year-station × 11,957 stations + $13.50 per year-inspector × 43,754 inspectors + $200 per year-station (Consumables) × 11957 stations + $240 (Data Line) per year-station × 11,957 stations = $6,461,566 per year

A.2.2. State of Texas (Continue Inspection Program)

Figure A.2 shows a graphical depiction of the revenue and expenses for the State of Texas discussed in this section.

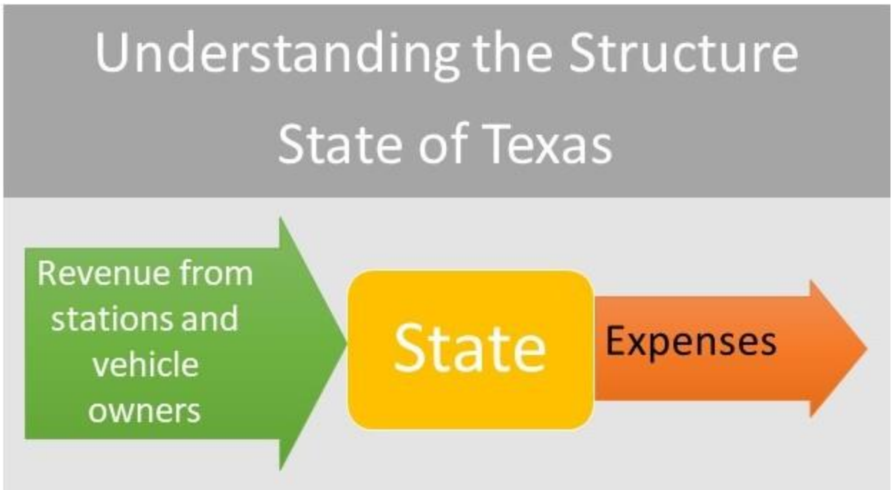


Figure A.2. Economic analysis—State of Texas

A.2.2.1. Revenue

The CTR study team identified three sources of revenue to the state.

- One-year inspection fees:
    - 18,022,169 inspections per year x 61% (vehicles in safety-only counties) × $7.50 per inspection in safety-only counties + 18,022,169 inspections per year x 39% (vehicles in emissions counties) x $5.75 per inspection in emissions counties = $122,866,137 per year
- Two-year inspection fees:
    - 1,588,773 inspections per year x 61% (vehicles in safety-only counties) × $16.75 per inspection in safety-only counties + 1,588,773 inspections per year x 39% (vehicles in safety-only counties) × $15 per inspection in emissions counties = $25,527,610 per year
- Total = $148,393,747 per year
- Station owner certification fees: 11,957 stations per year × $51 per station = $593,334 per year

- Inspector license fees: 43,754 inspectors per year × $13.50 per inspector = $590,679 per year

Thus, the total revenue is $149,577,760 per year.

As a point of interest, none of this revenue goes specifically to TxDPS for the Inspection Program.

A.2.2.2. Expenses

The CTR study team identified several areas of expenses.

1) *Cost of website, database, and troubleshooting*. A third-party vendor provides this service. Of the fees collected from vehicle owners at registration, $2.00 per vehicle in safety-only counties and $0.25 per vehicle in emissions counties goes to Texas.gov fees for the website, database, and support. This also supports functionality of the website www.Texas.gov. This same amount applies whether the inspection is for one or two years. Using calculations like A.2.2.1 above for the total fees paid at registration we get $25,837,416 per year.
2) *VIC units* (TxDIR provides VIC units to outfit new stations and replace non-functioning equipment). There are 6544 stations in safety-only counties. TxDIR reports that the service contract to deploy, troubleshoot, and replace VIC units costs $2,303,980 per year. However, this cost is covered by the Texas.gov fees and does not constitute an additional expense.
3) *Program administration*. TxDPS operates and manages the program and provides audit staff and program administration. This includes an overt and covert audit program, program administration, and staff overhead costs for the program and audit function. TxDPS reports that the audit program, program management, and overhead totaled $5,334,931 per year for FY 2017.
4) *Station signage*. TxDPS provides station signage to identify certified stations to the public. TxDPS contracts with a vendor to produce station identification signs. They recently acquired a new contract for $24.60 per sign. Their records show that in 2017 there were 1297 new stations certified. This totals $24.60 per sign × 1297 signs per year = $31,906 per year.

Thus, the total expenses are $31,204,253 per year for the state.

A.2.3. Vehicle Owner (Continue Inspection Program)

Figure A.3 shows a graphical depiction of the expenses discussed in this section for vehicle owners.

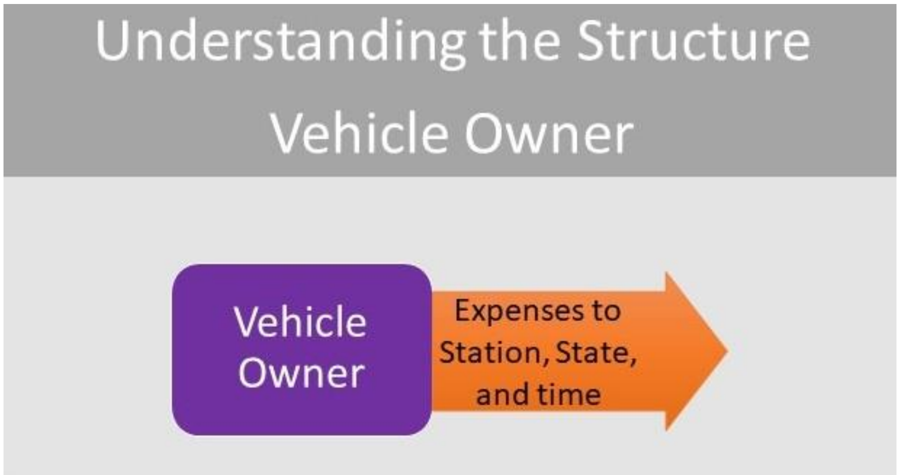


Figure A.3. Economic analysis—vehicle owner

In reviewing the costs to the vehicle owner, the CTR study team identified three categories of cost.

1) Payment to the station for the physical safety inspection fee,
2) Payment to the state at the time of vehicle registration for the safety fee, and
3) Cost of travel and waiting for inspection.

Excluded from analysis are any additional costs due to a failed inspection and subsequent repairs.

The vehicle owners' costs for the first two items are relatively easy to determine, but the cost of traveling to and from an inspection station and waiting for an inspection to be completed is harder to determine. The North Carolina Program Evaluation Division conducted a study for the North Carolina General Assembly to evaluate the North Carolina vehicle inspection program. They used a model that assumed a standard time for travel and waiting (30 minutes) and a standard value of a vehicle owner's time (one-half of the state minimum wage). If we use this same model in Texas, then we get a value of \$1.81 per year (0.5 hrs. per year × 0.5 of minimum wage × \$7.25 per hrs. minimum wage).

Further assumptions are the following:

- Cost to the vehicle owner for a two-year inspection on a new vehicle is included in the cost of the vehicle, and the vehicle owner uses no time traveling to or from and waiting at an inspection station. Thus, the two-year inspections are not included in the owner's cost.
- We can calculate the aggregate annual cost to vehicle owners using the one-year inspection (with no repair costs due to a failure).
- Owners in emissions counties must get an emissions inspection, so they would not be included in any owner's cost of traveling and waiting. They have to get the emissions inspection anyway and the safety inspection is not measurably more time. This means we need to include in this cost element only those who only get a safety inspection.

Costs for the three categories respectively would be:

1) Payment at Station = $137,276,594 per year
2) Payment at Registration = $148,393,747 per year
3) Cost for time and waiting = $1.81 per year-inspection × 11,958,334 inspections = $21,644,584 per year

This amounts to an aggregate total for vehicle owners of $307,314,925 per year.

A.3. Income and Expenses for the Inspection Program (Discontinuing the Program)

This area identifies the revenue and expenses for the station owners/inspectors, the State of Texas, and vehicle owners should the Legislature discontinue the Inspection Program.

A.3.1. Station Owners and Inspectors (Discontinue the Inspection Program)

A.3.1.1. Revenue

For the Inspection Program, the income seen in the previous section on "Income and Expenses for Parties to the Inspection Program" becomes $0. This is a loss of revenue of $137,276,594 per year for station owners by discontinuing the program.

Safety inspection of CMVs in all counties and emissions testing in emissions counties would continue, since both emissions testing of PVs and CMV safety testing is federally mandated, and remain a source of income that is outside the current study.

The 6544 stations currently in the 237 safety-only counties would derive no income from the program, and if they could not generate sufficient income from CMV safety inspections only, these stations may choose to cease operations.

A.3.1.2. Expenses

Safety inspection station owners and inspectors would technically have no expenses for discontinuing the Inspection Program.

For the record, if CMV safety inspections and emissions inspections continue, those stations conducting CMV safety inspections and stations in the emissions inspection program would continue to incur most of the costs they do now. These would be attributable to the commercial safety inspection program and the emissions inspection program and not the Inspection Program under study. Those station owners and inspectors that continue operating would have the same costs identified previously. See the previous analysis.

A.3.2. State of Texas (Discontinue the Inspection Program)

A.3.2.1. Revenue

If the Inspection Program is discontinued, revenue to the state is complicated by the continuing need for emissions and commercial safety inspections.

The revenue to the state that is collected at the time of vehicle registration would technically become $0, but since this money does not support the program directly (reference the Basis, Information, Estimates, and Assumptions section), fees may not go away. Since we do not know what legislation may be proposed, this is an unknown that we are not able to address.

Station owner certification fees for 11,957 stations and inspector license fees for 43,754 inspectors would be technically eliminated, reducing revenue to the state by $593,334 per year and $590,679 per year respectively; however, some of these would likely be continued for stations in emissions counties and safety-only county stations and inspectors where commercial safety inspection would continue. Fees from the 5413 stations in emissions counties and the corresponding inspectors needed to operate them would be an estimate of the money that would continue to come to the state. There is not a breakdown of inspectors in emissions counties, so if we used the same percentage of inspectors in emissions counties as there are percent of stations in emissions counties, we can use 19,807 continuing inspectors. This would mean that 5413 stations and 19,807 inspectors would continue paying fees. These would total 5413 stations per year x $51 per station = $276,063 per year and 19,807 inspectors per year x $13.50 per inspector = $267,394 per year. This revenue would total $543,457 per year and is a $640,556 per year reduction over current revenue.

This does not speak to the need for CMV inspections and how many safety-only county stations would continue operations to serve this need.

A.3.2.2. Expenses

Ongoing expenses identified for continuing the program would become $0, but there would be additional one-time expenses for discontinuing the program.

TxDPS has identified one-time expenses of $33,480 to change websites, databases, and interfaces and terminate contracts (identified by TxDPS in the fiscal note for SB1588).

It should be noted, however, that the emissions program is not likely to be discontinued and TxDPS is currently identified as the program administrator. They would continue to incur costs attributable to that program.

TCEQ has identified an $800,000 one-time expense for programming changes to the emissions/safety testing devices used in emissions counties to remove collection and data transfer of safety inspection information.

TxDIR has identified a one-time expense of $200,000 to retrieve all VIC units from existing locations.

These are one-time expenses and total to $1,033,480.

A.3.3. Vehicle Owner (Discontinue the Inspection Program)

Costs to the vehicle owner would become $0.

Fees paid to the stations would become $0.

Fees paid at registration would become $0, unless other fees replace them.

A.4. Summary and Additional Considerations

Developing the revenues and expenses for various parties for both continuing and discontinuing the Inspection Program is complicated. There are one-time expenses, aggregate program revenues and expenses, and there would be a loss of existing revenue to support various programs if the program is discontinued. The CTR study team has attempted to identify and account for them as best as possible.

A.4.1. Summary of Economic Analysis

The present Inspection Program represents the following revenue and costs:

- Station Owners and Inspectors
  - Revenue: $137,276,594 per year
  - Expenses: $6,461,566 per year
- State of Texas
  - Revenue: $149,577,760 per year
  - Expenses: $31,204,253 per year
- Vehicle Owners
  - Expenses: $307,314,925 per year

To discontinue the Inspection Program, the primary parties would incur these costs and savings:

- Station Owners and Inspectors
  - Revenue: $0 This represents a loss of $137,276,594 per year.
  - Expenses: $0
- State of Texas
  - Revenue: $0 This represents a loss of $149,577,760 per year.

- Expenses: $1,033,480 (one-time expense)

- Vehicle Owners
  - Expenses: $0

A.4.2. Additional Considerations

These other considerations may factor into a legislative decision:

- None of the current fees paid to the state at registration are directed to TxDPS to administer the program.
- Inspection Program fees paid to the state, collected at registration, go to support the Clean Air Fund and the Texas Mobility Fund; these programs will receive less funding on the order of $39 million and $83 million respectively. Discussions with TCEQ indicated that the current fees account for approximately 33% of funding for the Clean Air Fund.
- TxDIR pointed out that Texas.gov fees collected with most of the transactions support all the functions of www.Texas.gov as well as the safety inspection equipment deployment and troubleshooting. Loss of these fees would require replacement funding in some form. Currently this is approximately $26 million.
- If the Inspection Program were discontinued, there may not be enough commercial business to keep 12,000 inspection stations open to conduct only commercial safety inspections. Those stations in safety-only counties (with no emissions testing that brings in emissions testing fees) may face closure. This would mean loss of businesses and loss of jobs, and may also severely affect the availability of commercial safety inspections in the state.

Appendix B. Data Preparation

To extract useful information from the three large datasets used for the safety impact analysis, the study team examined the data elements carefully and pre-processed the data for final analysis. This appendix describes in detail how each dataset was prepared and pre-processed.

B.1. Crash Data Preparation

The study team obtained 2010–2017 crash records for the entire state of Texas from TxDOT Crash Record Information System (CRIS) Crash Query Tool[1]. These crash records include important information about every reportable crash, including every vehicle and person involved in each crash, which is extracted from the law enforcement officers' crash reports (CR-3 report). Important data elements include:

- Crash severity
- Number of fatalities, incapacitating, and non-incapacitating injuries
- Contributing factors
- Vehicle defects
- Vehicle type (PV, CMV [such as truck, bus, etc.], motorcycle)
- Vehicle make, model, and year
- Vehicle license plate state
- Person gender
- Person type (driver, passenger, pedestrian)
- Roadway surface condition

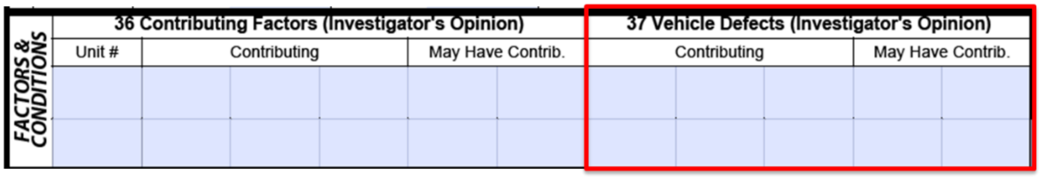
To identify crashes in which vehicle defects may have been contributing factors, the study team checked the following data columns:

- Vehicle Defect 1
- Vehicle Defect 2
- Vehicle Defect 3
- Possible Vehicle Defect 1
- Possible Vehicle Defect 2

Information in these five data columns was extracted from the item 37 in the CR-3 form, as shown in the red box in Figure B.1. Vehicle Defect 1, 2, and 3 are defects the investigator believes have

[1] https://cris.dot.state.tx.us/public/Query/app/public/welcome

contributed to the crash and Possible Vehicle Defect 1 and 2 are defects that the investigator believes may have contributed to the crash.



FACTORS & CONDITIONS	36 Contributing Factors (Investigator's Opinion)			37 Vehicle Defects (Investigator's Opinion)	
	Unit #	Contributing	May Have Contrib.	Contributing	May Have Contrib.

Figure B.1. Fields in CR-3 form containing vehicle defects information

These defect types were found in the crash data for PVs:

- Defective or slick tires
- Defective or no head/tail/stop lamps
- Defective steering mechanism
- Defective or no vehicle brakes
- Defective or no turn signal lamps
- Defective trailer hitch
- Defective or no trailer brakes
- Other (explain in narrative)

Following is the criterion the study team used to identify crashes involving vehicles with defects:

IF

None of the five vehicle defect columns has data (“No Data”), the vehicle is treated as a vehicle without any defects.

OTHERWISE

The vehicle is treated as a vehicle with a defect[2].

The data field “Commercial Motor Vehicle Flag” was used to distinguish PVs and CMVs.

B.2. TxDPS Citation Data Preparation

TxDPS maintains the Texas Highway Patrol High Value Dataset database of traffic stop citation data. This dataset is available for public access at the TxDPS website. This database includes information about each roadside traffic stop made by law enforcement officers. The study team

[2] Note that a vehicle involved in a crash might have had one or more defects based on the investigating officer’s assessment. In addition, the study team combined vehicles with defects that may have contributed to a crash with vehicles with defects that contributed to a crash for this analysis. Types of defects, bad brakes, defective or slick tires, etc., are the same in either case.

downloaded 2012–2016 citation data from the TxDPS website[3]. TxDPS further provided the data for 2010 and 2011 at CTR's request. Important data elements of this dataset include, but are not limited to, the following:

- Citation issue time
- Citation issue location
- If the vehicle is a CMV or not
- Reason for stop (citation or warning)
- Vehicle type (passenger car, SUV, pickup truck, bus, etc.)
- Vehicle year, make, and model
- Weather condition
- Traffic condition
- Violation category
- Violation name

This analysis was used to identify stopped vehicles that were noted by the law enforcement officer as having one or more defects. The data field "Violation Category" was used to identify vehicles with a defect. Only vehicles with following five types of defects are included in our analysis:

- Brakes
- Lights
- Steering
- Tires/Axle/Wheels
- Windows/Film/Glazing

B.3. TxDMV Vehicle Registration Data Preparation

Through an Open Records Request, the study team obtained the vehicle registration data from 2015 through 2017 from TxDMV[4]. The dataset includes the following information about every vehicle registered in Texas from 2015 to 2017:

- Vehicle Year
- Vehicle Make

[3] Texas Highway Patrol High Value Data Sets:
http://www.dps.texas.gov/director_staff/highValueDataSets.htm

[4] The study team requested vehicle title registration (VTR) data from earlier years as well, but was informed that all VTR data prior to September 2015 had been purged from the system during implementation of a new VTR data management software program.

- Body Type
- Vehicle Class

Vehicle body type was used to determine if a vehicle is a PV or a CMV. Specifically, vehicles with the following descriptions in the “BODY_TYPE” column were treated as PVs (the designation in parenthesis is the study team’s interpretation of the vehicle type):

- MTRCYCLE (Motorcycle)
- PASS (Passenger Vehicle)
- PASS-TRK (Pickup Truck)
- TRK<=1 (Trucks One Ton or Less)
- NEV (Neighborhood Electric Vehicle)
- MOPED (Moped)

Vehicles with other body types are treated as CMVs.

Appendix C. Crash Costs

According to the National Safety Council's (NSC) publication *Injury Facts* (2017 edition), two methods are commonly used to measure the costs of motor-vehicle crashes: the economic cost framework and the comprehensive cost framework. According to NSC, the economic costs should not be used for a cost-benefit analysis because they do not reflect what society is willing to pay to prevent a statistical fatality or injury. Therefore, this study focuses on evaluating the comprehensive costs of those crashes involving vehicles with defects. The comprehensive costs include following components:

1) Wage and productivity losses, which include wages, fringe benefits, household production and travel delay.
2) Medical expenses, including emergency service costs.
3) Administrative expenses, which include the administrative cost of private and public insurance plus police and legal costs.
4) Motor-vehicle damage, including the value of damage to property.
5) Uninsured employer costs for crashes involving workers.
6) The value of lost quality of life associated with deaths and injuries—that is, what society is willing to pay to prevent them.

The NSC publication provides the average comprehensive costs in 2015 on a per-person basis. Their values are shown in Table C.1.

Table C.1. NSC average comprehensive motor-vehicle crash costs

Injury Severity	Comprehensive Costs, 2015
Death	$10,080,000
Disabling injury	$1,100,000
Evident injury	$304,000
Possible injury	$140,000
No injury observed	$46,500
Property damage only	$8,500

To use these costs to calculate the total comprehensive loss due to crashes involving vehicles with defects in Texas, the study team first established the following correspondence (Table C.2) between NSC injury severity types shown in Table C.1 and the injury severity types used by TxDOT in its crash database.

Table C.2. Correspondence between NSC and TxDOT injury severity types

NSC Injury Severity		TxDOT Crash Database Injury Severity
Death	....	Fatal
Disabling injury	....	Incapacitating Injury
Evident injury	....	Non-Incapacitating Injury
Possible injury	....	Possible Injury
No injury observed	....	Unknown
Property damage only	....	Not Injured and Over $1000 Damage to Any One Person's Property

Table C.3 presents the number of people killed, injured, or had property damaged in crashes involving vehicles with defects in Texas from 2015 to 2017.

Table C.3. Number of people killed or injured in crashes involving vehicles with defects

Person Injury Severity	2015		2016		2017	
	PV	CMV	PV	CMV	PV	CMV
Fatal	100	37	108	35	96	21
Incapacitating injury	433	67	499	59	478	53
Non-Incapacitating injury	1,662	167	1,880	243	2,009	183
Possible injury	2,584	240	2,997	212	2,858	288
Unknown	637	38	722	33	771	56
Not injured and over $1000 damage to any on person's property	5905	712	6586	701	6466	836

Using the counts shown in Table C.2 and the NSC crash costs shown in Table C.1, the total comprehensive costs of all crashes involving vehicles with defects in Texas are calculated and presented in Table C.4.

Table C.4. NSC comprehensive costs of crashes involving vehicles with defects

		2015	2016	2017
Comprehensive Costs	PV	$2.4 billion	$2.7 billion	$2.6 billion
	CMV	$539 million	$529 million	$376 million
	Total	**$3.0 billion**	**$3.2 billion**	**$3.0 billion**

This demonstrates that the comprehensive costs of Texas crashes involving vehicles with defects is over $3 billion and more than $2.5 billion of those costs are associated with PV crashes.

Appendix D. Defect and Non-Defect Crashes

Table D.1. Comparison between defective and non-defective PVs in terms of number of fatalities

PV	2015		2016		2017	
	Defective	Non-defective	Defective	Non-defective	Defective	Non-defective
Number of fatalities	100	2,925	109	3,170	96	3,070
Number of vehicles in crashes	9,847	1,013,141	11,131	1,080,797	10,972	1,055,040
Fatalities per number of vehicles in crashes	**1 fatality / 98 vehicles**	**1 fatality / 346 vehicles**	**1 fatality / 102 vehicles**	**1 fatality / 341 vehicles**	**1 fatality / 114 vehicles**	**1 fatality / 343 vehicles**

Table D.2. Comparison between defective and non-defective PVs in terms of number of incapacitating injuries

PV	2015		2016		2017	
	Defective	Non-defective	Defective	Non-defective	Defective	Non-defective
Number of incapacitating injuries	436	15,634	502	16,168	480	16,056
Number of vehicles in crashes	9,847	1,013,141	11,131	1,080,797	10,972	1,055,040
Incapacitating injuries per number of vehicles in crashes	**1 incapacitating injury / 23 vehicles**	**1 incapacitating injury / 65 vehicles**	**1 incapacitating injury / 22 vehicles**	**1 incapacitating injury / 67 vehicles**	**1 incapacitating injury / 23 vehicles**	**1 incapacitating injury / 66 vehicles**

Table D.3. Comparison between defective and non-defective PVs in terms of number of non-incapacitating injuries

PV	2015		2016		2017	
	Defective	Non-defective	Defective	Non-defective	Defective	Non-defective
Number of non-incapacitating injuries	1,669	71,842	1,893	77,551	2,018	76,325
Number of vehicles in crashes	9,847	1,013,141	11,131	1,080,797	10,972	1055,040
Non-incapacitating injuries per number of vehicles in crashes	**1 non-incapacitating injury / 6 vehicles**	**1 non-incapacitating injury / 14 vehicles**	**1 non-incapacitating injury / 6 vehicles**	**1 non-incapacitating injury / 14 vehicles**	**1 non-incapacitating injury / 5 vehicles**	**1 non-incapacitating injury / 14 vehicles**

Table D.4. Comparison between defective and non-defective CMVs in terms of number of fatalities

CMV	2015		2016		2017	
	Defective	Non-defective	Defective	Non-defective	Defective	Non-defective
Number of fatalities	37	583	35	560	21	588
Number of vehicles in crashes	1,102	72,837	1,080	72,881	1,273	76,048
Fatalities per number of vehicles in crashes	**1 fatality / 30 vehicles**	**1 fatality / 125 vehicles**	**1 fatality / 31 vehicles**	**1 fatality / 130 vehicles**	**1 fatality / 61 vehicles**	**1 fatality / 129 vehicles**

Table D.5. Comparison between defective and non-defective CMVs in terms of number of incapacitating injuries

CMV	2015		2016		2017	
	Defective	Non-defective	Defective	Non-defective	Defective	Non-defective
Number of incapacitating injuries	67	1,486	59	1,389	53	1,491
Number of vehicles in crashes	1,102	72,837	1,080	72,881	1,273	76,048
Incapacitating injuries per number of vehicles in crashes	**1 incapacitating injury / 16 vehicles**	**1 incapacitating injury / 49 vehicles**	**1 incapacitating injury / 18 vehicles**	**1 incapacitating injury / 52 vehicles**	**1 incapacitating injury / 24 vehicles**	**1 incapacitating injury / 51 vehicles**

Table D.6. Comparison between defective and non-defective CMVs in terms of number of non-incapacitating injuries

CMV	2015		2016		2017	
	Defective	Non-defective	Defective	Non-defective	Defective	Non-defective
Number of non-incapacitating injuries	167	4,555	246	4,541	183	4,738
Number of vehicles in crashes	1,102	72,837	1,080	72,881	1,273	76,048
Non-incapacitating injuries per number of vehicles in crashes	**1 non-incapacitating injury / 7 vehicles**	**1 non-incapacitating injury / 16 vehicles**	**1 non-incapacitating injury / 4 vehicles**	**1 non-incapacitating injury / 16 vehicles**	**1 non-incapacitating injury / 7 vehicles**	**1 non-incapacitating injury / 16 vehicles**

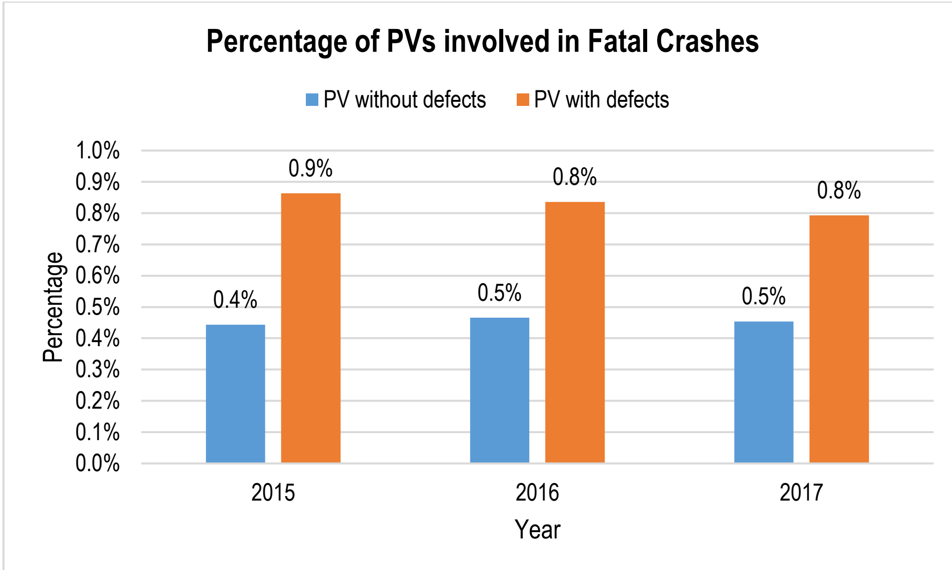


Figure D.1. Percentage of PVs with or without defects involved in fatal crashes

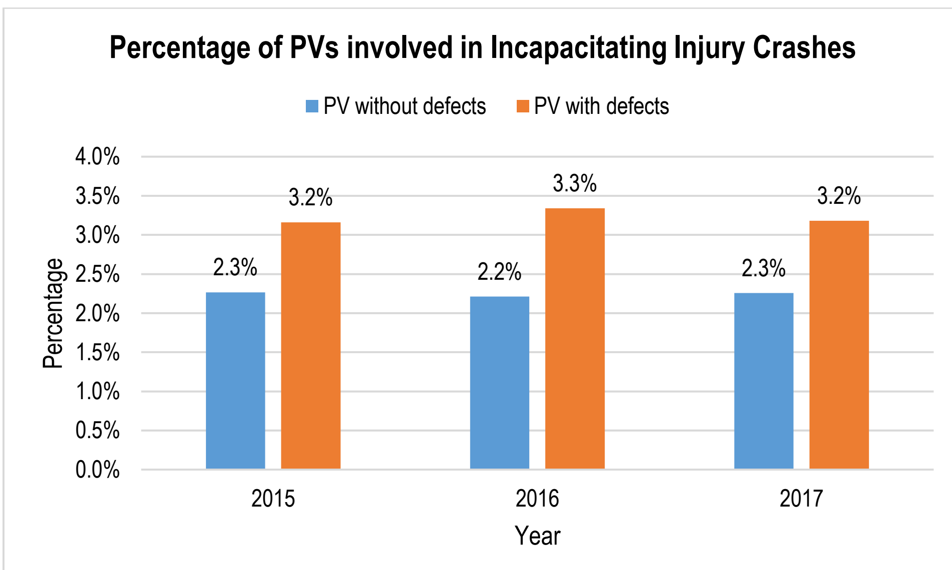


Figure D.2. Percentage of PVs with or without defects involved in incapacitating-injury crashes

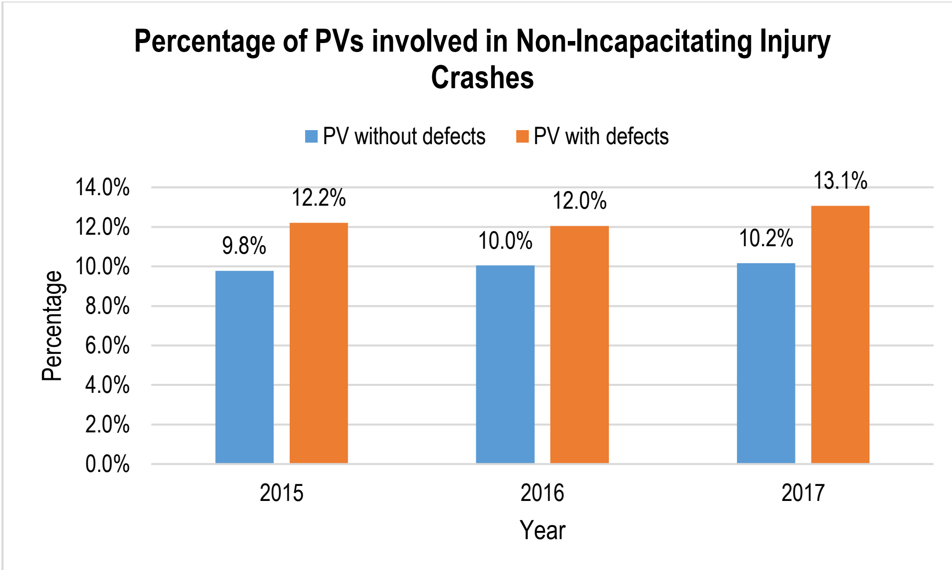


Figure D.3. Percentage of PVs with or without defects involved in non-incapacitating-injury crashes

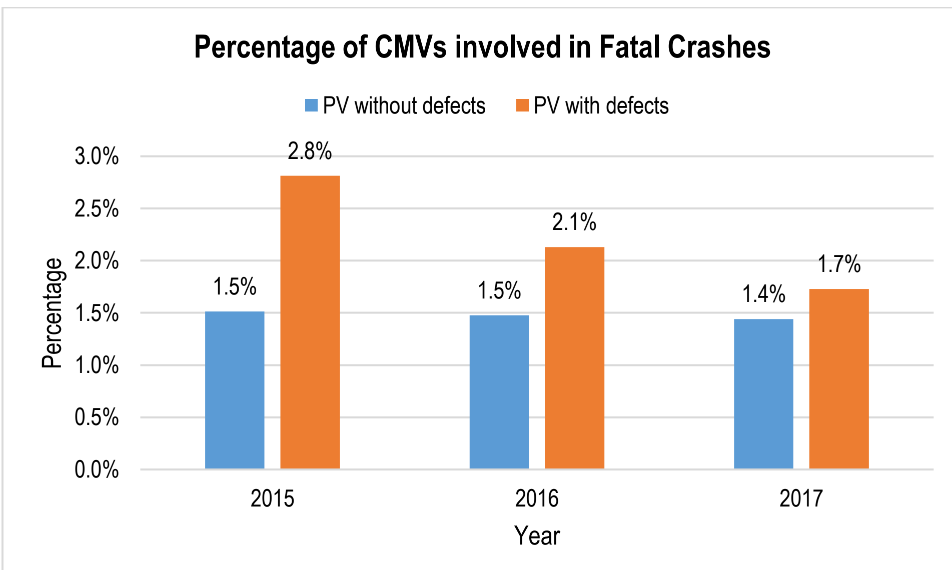


Figure D.4. Percentage of CMVs with or without defects involved in fatal crashes

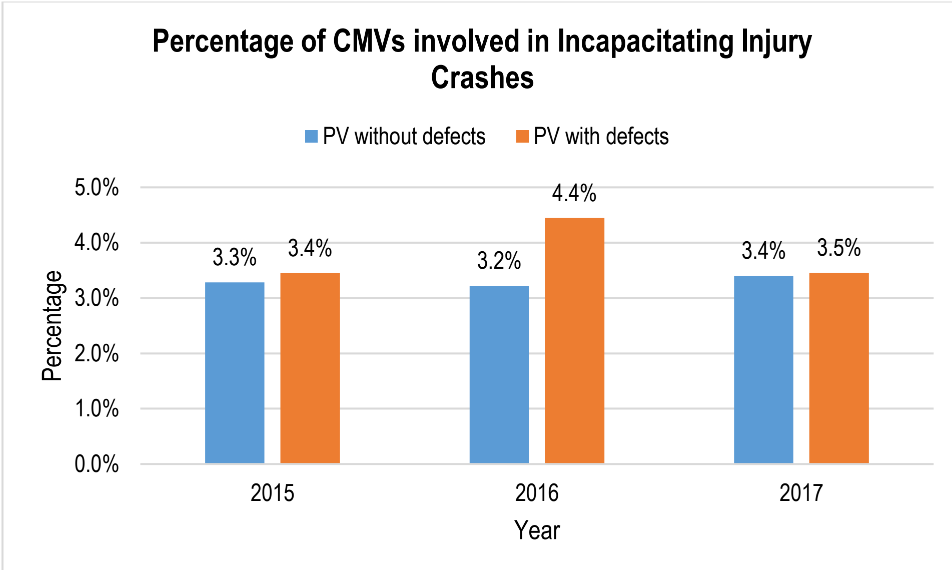


Figure D.5. Percentage of CMVs with or without defects involved in incapacitating-injury crashes

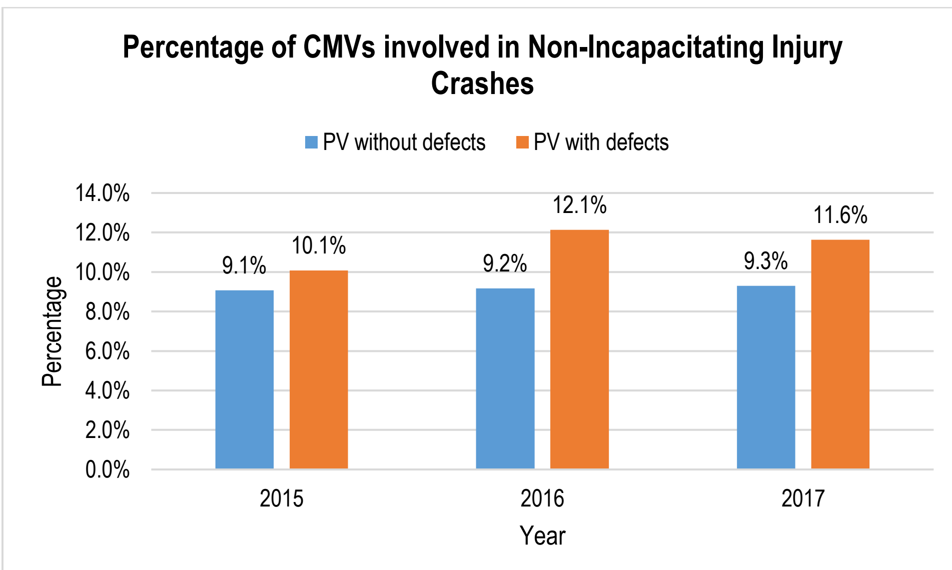


Figure D.6. Percentage of CMVs with or without defects involved in non-incapacitating-injury crashes

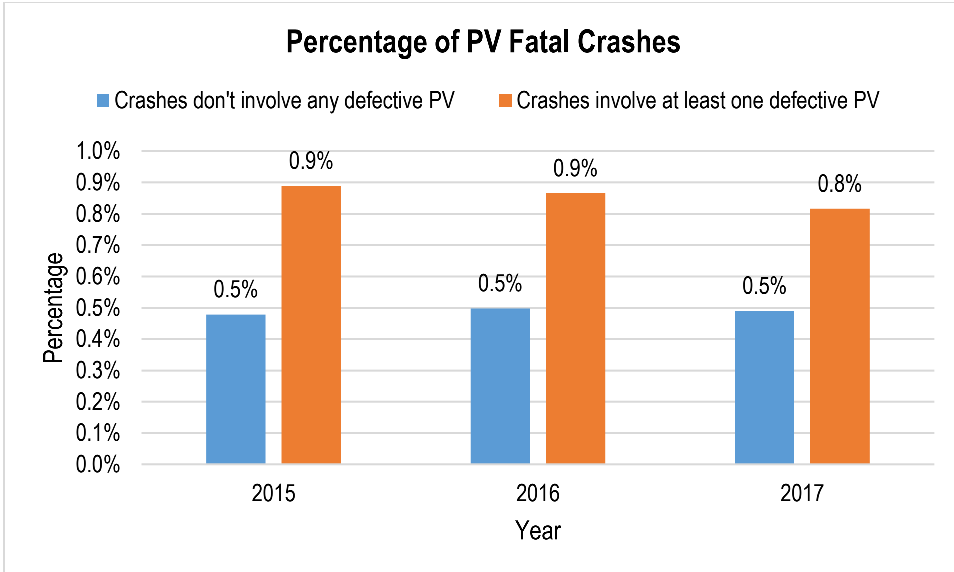


Figure D.7. Percentage of fatal crashes among all crashes involving PVs with or without defects

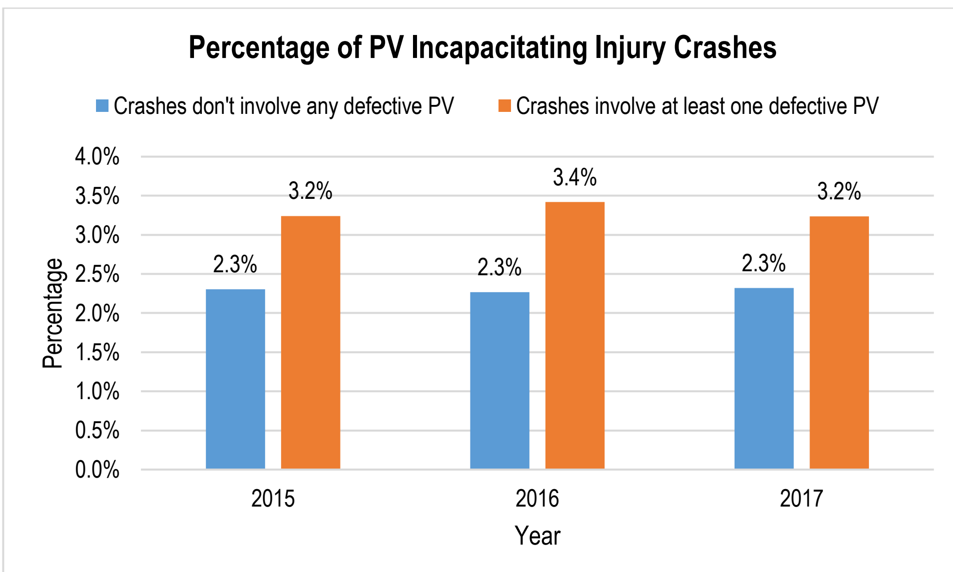


Figure D.8. Percentage of incapacitating-injury crashes among all crashes involving PVs with or without defects

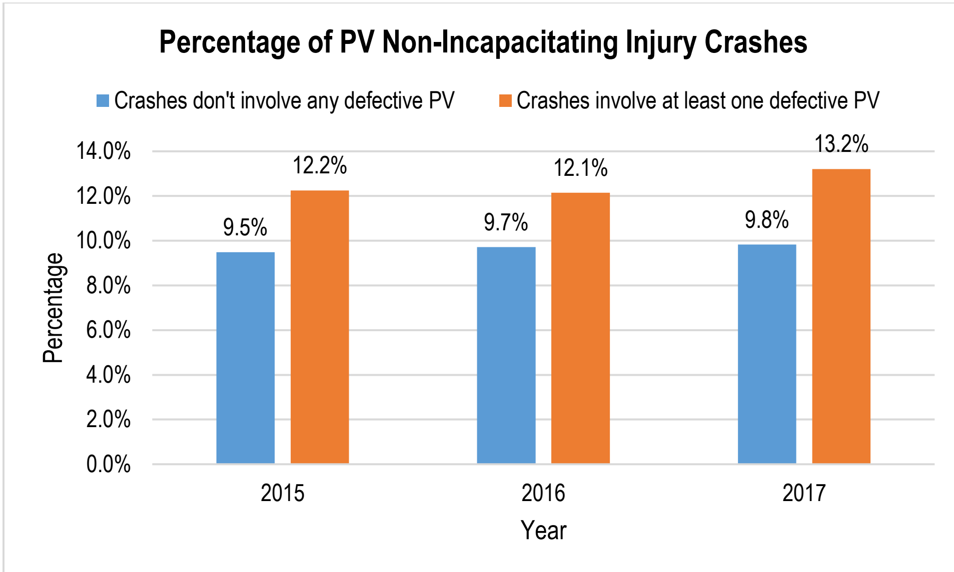


Figure D.9. Percentage of non-incapacitating-injury crashes among all crashes involving PVs with or without defects

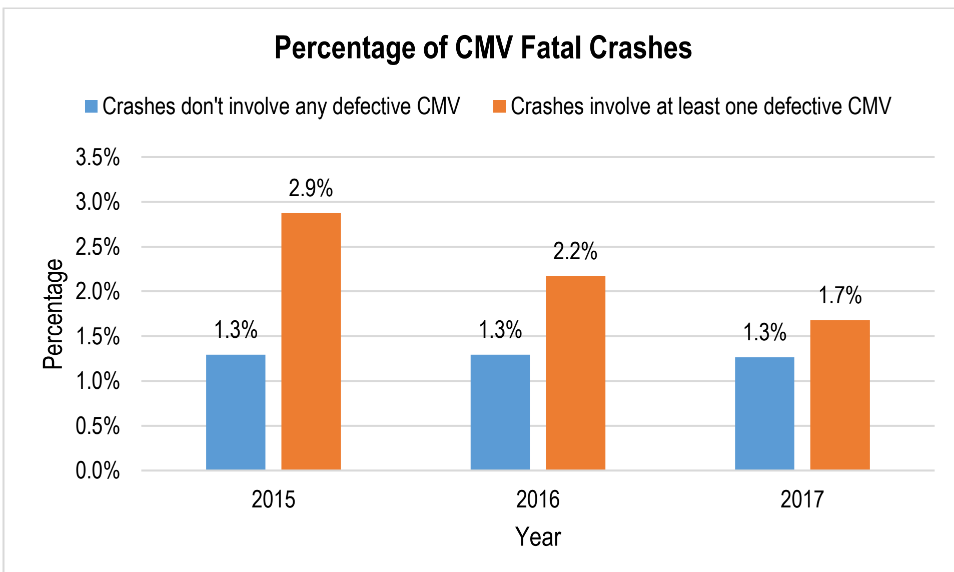


Figure D.10. Percentage of fatal crashes among all crashes involving CMVs with or without defects

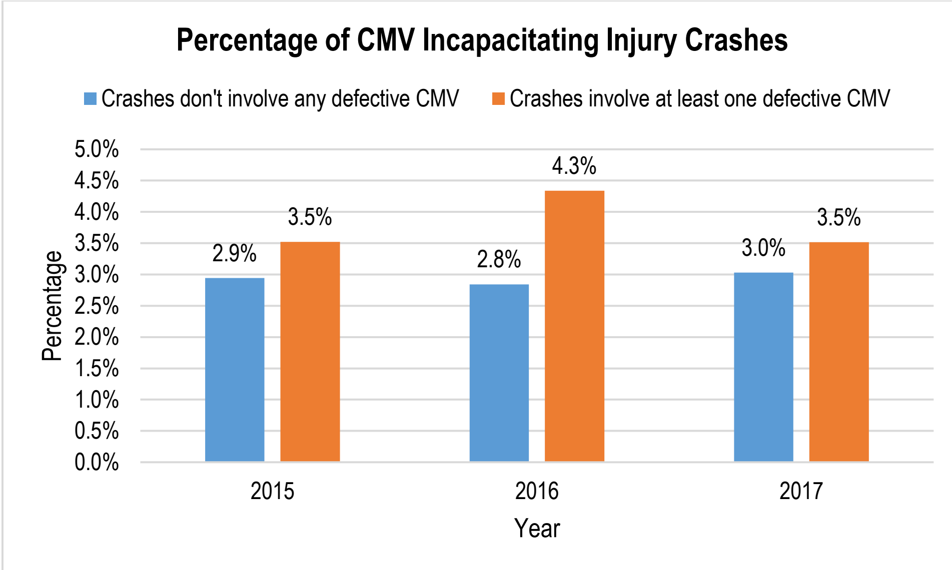


Figure D.11. Percentage of incapacitating-injury crashes among all crashes involving CMVs (defective and non-defective)

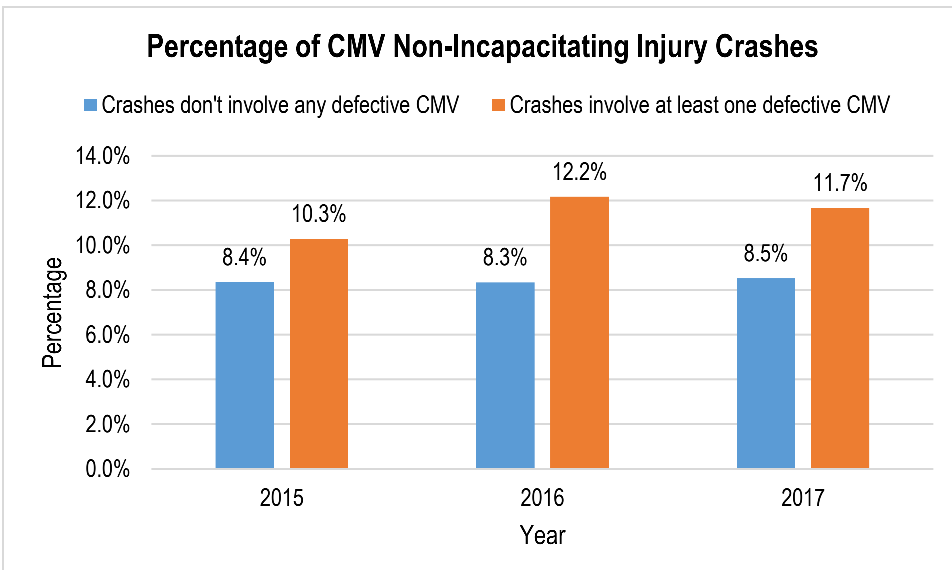


Figure D.12. Percentage of non-incapacitating-injury crashes among all involving CMVs (defective and non-defective)

Figure D.13 illustrates the distribution of Texas-licensed drivers by age in 2016, based on the information obtained from the Federal Highway Administration (FHWA, 2018). According to Figure D.13, the majority of the licensed drivers in Texas are between the ages of 20 and 64. Since no more detailed information was provided within each age group, the research team used the average age of each age group when calculating the overall average age of Texas licensed driver. For example, age 27 was used to represent the 25–29 age group, age 32 was used to represent the 30–34 age group, and so on. Consequently, the average age of Texas-licensed drivers in 2016 was found to be 46 years.

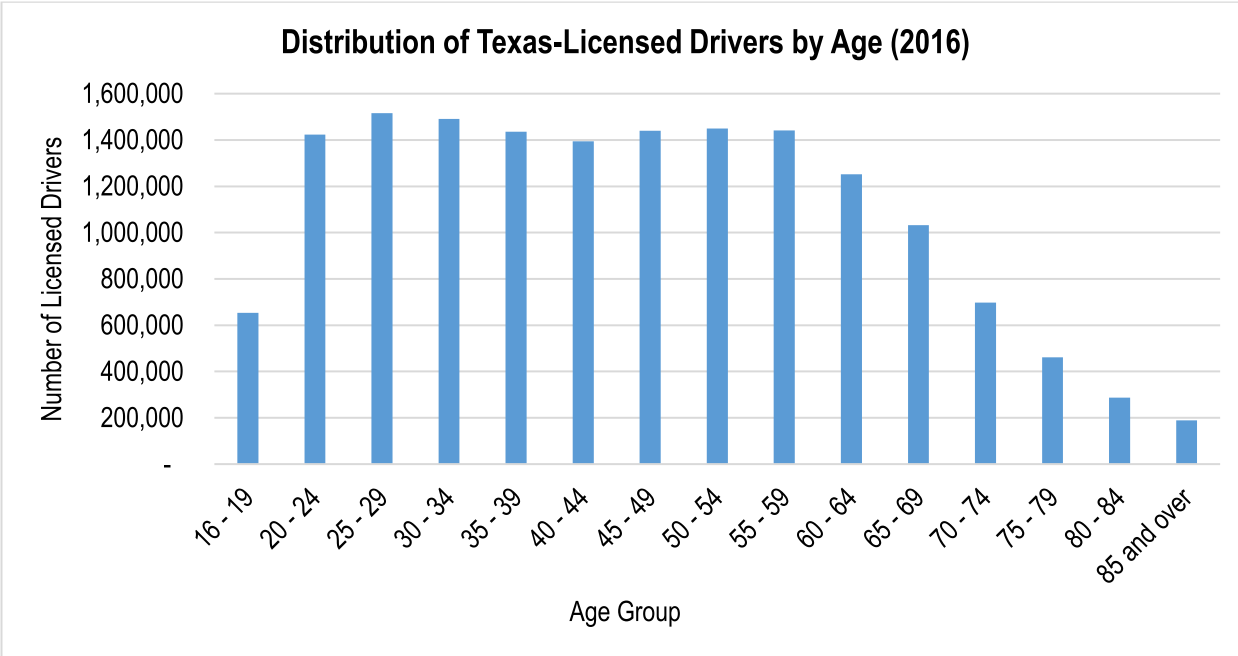


Figure D.13. Distribution of Texas-Licensed Drivers by Age in 2016

Appendix E. Crashes Involving Out-of-State Vehicles

Table E.1. Number of non-commercial vehicles coming from states that do not require vehicle safety inspection for PVs and had crashes in Texas[5,6]

State	2010		2011		2012		2013		2014		2015		2016		2017		Average percentage of defective vehicles
	All	Def.	All	Def.	All	Def.	All	Def.	All	Def.	All	Def.	All	Def.	All	Def.	
Alabama	486	8	479	8	579		611	4	654		806	8	809	9	796	7	0.87%
Alaska	178	1	179		193		213	1	196		219		197	2	230	2	0.36%
Arizona	1041	13	1143	11	1281	6	1340	20	1378		1622	31	1606	14	1540	20	1.03%
Arkansas	1841	25	1636	14	1812	3	1907	17	1932		2223	46	2223	38	2294	30	1.04%
California	2316	37	2265	21	2540	6	2746	32	2783		3318	64	3461	44	3428	45	1.05%
Colorado	849	7	836	2	995	4	1040	12	1032		1212	20	1338	17	1309	12	0.81%
Connecticut	101		102		137	1	161	1	169		191	1	197	1	179	1	0.37%
D.C.	32	1	25		24		43		27		50	1	49	1	51	2	1.39%
Florida	2090	28	1839	13	2094	9	2252	19	2413		2974	37	3155	39	3164	46	0.91%
Georgia	902	7	895	14	1075	2	1176	5	1243		1417	23	1507	29	1334	17	0.97%
Idaho	160	3	156	2	162		173	3	156		185	1	182	3	174	5	1.24%
Indiana	423	4	357	3	411		437	6	469		559	8	561	4	559	10	0.89%
Iowa	280	2	229	2	300	1	279	6	300		329	2	334	5	354	3	0.88%
Kansas	604	7	587	5	714	3	724	9	710		792	8	870	2	771	4	0.68%
Kentucky	216		224	3	248	1	234	1	282		290	4	301	5	308	3	0.77%
Maryland	283	4	252		319	3	327	4	383		413	2	438	4	467	8	0.84%

[5] Empty cells in these tables are 0.

[6] Mississippi and New Jersey are not included in these tables because their programs were discontinued during the study period, respectively at July 1, 2015 and August 1, 2010.

State	2010		2011		2012		2013		2014		2015		2016		2017		Average percentage of defective vehicles
	All	Def.	All	Def.	All	Def.	All	Def.	All	Def.	All	Def.	All	Def.	All	Def.	
Michigan	711	15	623	7	720	3	729	5	722		841	12	798	9	724	7	0.98%
Minnesota	357	4	334	2	342	1	369		416		421	3	428	4	394		0.46%
Montana	99		92	3	101		107	1	107		117	1	130		113	1	0.74%
Nebraska	208	5	193		235		227		223		249		266	2	260	3	0.54%
Nevada	299	5	270		307	2	292	1	316		364	3	384	4	370	2	0.63%
New Mexico	2424	32	2602	17	2752	2	2816	26	3069		3376	66	3585	76	3516	67	1.12%
North Dakota	61	2	58		79		83		105		111	2	123	2	159	2	1.00%
Ohio	554	8	515	1	563	2	580	5	651		714	6	688	7	695	6	0.70%
Oklahoma	2248	36	2075	14	2296	3	2472	25	2729		2931	35	3030	47	2997	53	0.99%
Oregon	253	5	200		235	1	249	1	260		264	2	293	3	293	2	0.66%
South Carolina	321	2	337	3	360		388	6	425		515	7	537	7	486	8	0.92%
South Dakota	102	1	103		93		94	1	100		123		115	1	122	1	0.47%
Tennessee	698	10	755	7	903	1	981	7	998		1105	22	1089	16	1102	11	0.96%
Washington	516	8	533	7	730	1	730	4	748		901	15	880	9	895	2	0.81%
Wisconsin	305	5	319	3	397	3	373	2	408		444	7	497	6	452	6	1.00%
Wyoming	106	1	120		118		129	1	139		128	1	125	1	148	2	0.58%
																Average	**0.83%**

Table E.2. Number of non-commercial vehicles coming from states that do require PV safety inspection and had crashes in Texas

States	2010		2011		2012		2013		2014		2015		2016		2017		Average percentage of defective vehicles
	All	Def	All	Def	All	Def	All	Def	All	Def	All	Def	All	Def	All	Def	
Delaware	44	1	43		51		44		73		60	2	66		76	2	1.03%
Hawaii	112		110		153		152		129		139	2	135	3	133	2	0.65%
Illinois	890	6	863	2	994	1	1090	11	1071		1251	3	1357	18	1307	14	0.58%
Louisiana	3005	66	2780	29	3419	3	3533	43	3869	2	4306	65	4566	61	4659	60	1.09%
Maine	55	1	39		61		53		58		72		60		57		0.23%
Massachusetts	171	4	163	1	208	3	256		188		299	2	280	2	277	4	0.90%
Missouri	631	4	658	2	747	3	807	7	835		1072	5	1026	22	1018	12	0.75%
New Hampshire	55	1	57		47		71		60		58		82		67	1	0.41%
New York	530	10	524	2	583		631	1	685		849	5	897	10	849	7	0.62%
North Carolina	590	4	545	3	704		702	5	737	1	948	10	899	12	936	11	0.71%
Pennsylvania	346	2	329	2	356		473	2	492		541	4	586	10	520	6	0.65%
Rhode Island	34		37		36		34		49		33		51		37		0.00%
Utah	226	5	232	1	243		279	1	256		299	7	317	2	291	6	1.00%
Vermont	25		26		35		30		22		29		41		19		0.00%
Virginia	508	5	422	1	544		575	6	582		675	12	785	7	748	6	0.72%
West Virginia	57		71		48		74		73		78	1	98	1	79	1	0.45%
																Average	**0.61%**

Appendix F. Statistical Analysis for Crashes Involving Out-of-State Vehicles

To test whether the difference between the average percentage of defective vehicles out of all vehicles for the states with or without inspection programs is significant, the study team performed statistical tests on the two groups of numbers shown in the last column of Tables E.1 and E.2 in Appendix E.

Before conducting the t-Test, an F-Test was first conducted to compare the variance of these two groups of data so that a proper t-Test can be selected. The F-Test results are shown in Table F.1. The test results indicate that with 95% confidence, we accept the null hypothesis that these two groups of data have equal variances (because the P-value is larger than 0.05).

Table F.1. Results of F-Test for variances

F-Test Two-Sample for Variances		
	Variable 1	*Variable 2*
Mean	0.006115	0.008327
Variance	0.000011	0.000006
Observations	16	32
df	15	31
F	1.86078	
P(F<=f) one-tail	**0.07044**	
F Critical one-tail	2.00301	

Based on the F-Test results, a t-Test assuming equal variances was selected to compare the means of the two groups of data from states with and without vehicle safety inspection programs. The test results, provided in Table F.2, show that the P-value (0.01) is smaller than 0.05. This means we can conclude that, with 95% confidence, the percentage of defective vehicles from states with and without the inspection requirement is significantly different. By extension, we can conclude that vehicle safety inspection programs might help to reduce the number of defective vehicles.

Table F.2. State comparison t-Test results

t-Test: Two-Sample Assuming Equal Variances		
	Variable 1	*Variable 2*
Mean	0.006115	0.008327
Variance	0.000011	0.000006
Observations	16	32
Pooled Variance	7.57E-06	
Hypothesized Mean Difference	0	
df	46	
t Stat	-2.62597	
P(T<=t) one-tail	0.00585	
t Critical one-tail	1.67866	
P(T<=t) two-tail	**0.01169**	
t Critical two-tail	2.01290	

Appendix G. Supplementary Materials for Literature Review

This appendix provides additional detailed information regarding the literature review presented in Chapter 4.

G.1. Vehicle Inspection Program Practices in Other States

The study team performed an extensive review to see how other U.S. states perform vehicle inspections. The review also revealed the priorities and differences between each state regarding vehicle inspection programs. Four states have only safety inspection programs. Eighteen states (including the District of Columbia) operate only emission inspection programs. Fourteen states maintain both safety inspection and emission inspection programs. The other fifteen states do not have either safety or emissions inspection programs. In other words, a total of eighteen states maintain a safety inspection program and thirty-two states operate an emission inspection program.

More detailed information on each state's inspection program is summarized and listed in Table G.1, including inspection program type, inspection frequency, and cost.

Table G.1. Vehicle inspection programs in different U.S. states[7]

State	Vehicle Types	Safety Inspection	Emission Inspection	First Inspection (Vehicle Age)	Inspection Frequency	Cost
Alabama	All vehicles	✓	-	Prior to sale or transfer of ownership	-	-
Arizona	Vehicles in selected counties	-	✓	Upon registration. Phoneix and Tucson metro only.	Biennial	-
California	Vehicles in selected counties	-	✓	Upon registration. Required in 41 counties.	Biennial	-
Colorado	Vehicles in selected counties	-	✓	Upon registration. Required in nine counties.	-	\$15–25
Connecticut	All vehicles	-	✓	Upon registration	Biennial	\$20
Delaware	All vehicles	✓	✓	Upon registration	Biennial	Free
District of Columbia	All vehicles	-	✓	Upon registration	Biennial (PV), annual (CMV)	-
Georgia	Vehicles in selected area	-	✓	Upon registration. Required for Atlanta metro.	Annual	\$25
Hawaii	All vehicles	✓	-	Upon registration	Annual	\$15–20
Idaho	Vehicles in selected counties	-	✓	Emission inspection required for Ada and Canyon counties	Biennial	\$11
Illinois	Vehicles in selected counties	-	✓	Emission inspection required for Chicago and St. Louis metros. Vehicle older than four years.	Biennial	-
Indiana	Vehicles in selected counties	-	✓	Upon registration. Required for Lake and Porter counties.	Biennial	\$40
Louisiana	All vehicles	✓	✓	Upon registration. Emission inspection is required for Baton Rouge metro.	Annual	\$18
Maine	Most vehicles	✓	✓	Emission inspection is required for Cumberland county only	Annual	\$12.50

[7] States not listed in this table do not have either safety or emission inspection programs.

State	Vehicle Types	Safety Inspection	Emission Inspection	First Inspection (Vehicle Age)	Inspection Frequency	Cost
Maryland	Used vehicles	✓	✓	Upon transfer. Emission inspection is required biennially for 13 counties and Baltimore.	-	-
Massachusetts	All vehicles	✓	✓	-	Annual	$35
Missouri	All vehicles	✓	✓	Emission inspection is required for St. Louis metro	Biennial	$10–12
Nebraska	All out-of-state vehicles	✓	-	Upon registration for out-of-state vehicles	-	$10
Nevada	Vehicles in selected counties	-	✓	Only for urban areas of Clark and Washoe counties	Annual	-
New Hampshire	All vehicles	✓	✓	Upon registration	Annual	$20–50
New Jersey	Most vehicles	-	✓	Upon registration. Exempt for first five years, then biennially.	Biennial	-
New Mexico	Certain vehicles	-	✓	-	Biennial	-
New York	All vehicles	✓	✓	Upon registration. Emission inspection is required for 48 counties.	Annual	$6–25
North Carolina	All vehicles	✓	✓	Upon registration	Annual	$43.60
Ohio	Vehicles in selected counties	-	✓	Emission inspection is required for Cleveland metro	Biennial	$18
Oregon	Most vehicles	-	✓	Upon registration. For Portland and Medford metros only.		$10–21
Pennsylvania	All vehicles	✓	✓	Emission inspection is required in 25 counties	Annual	-
Rhode Island	Most vehicles	✓	✓	Upon registration	Biennial	$55
Tennessee	Vehicles in selected counties	-	✓	Emission inspection is required for selected Nashville counties/Chattanooga area	Annual	-

State	Vehicle Types	Safety Inspection	Emission Inspection	First Inspection (Vehicle Age)	Inspection Frequency	Cost
Texas	All vehicles	✓	✓	Upon registration. Emission inspection is required in 17 counties.	Annual	$14.5–62
Utah	Vehicles in selected counties	-	✓	Emission inspection is required for the top four populated counties	-	-
Vermont	All vehicles	✓	✓	-	Annual	$35-50
Virginia	All vehicles	✓	✓	Upon registration. Emission inspection is required in urban and suburban northern Virginia.	Annual (safety), biennial (emission)	$12–51
Washington	Most vehicles	-	✓	For urban areas of selected counties	Biennial	$15
West Virginia	Most vehicles	✓	-	-	Annual	$14.66
Wisconsin	All vehicles	-	✓	Emission inspection for selected counties. After the vehicle is three years old.	Biennial	-

G.2. Vehicle Inspection Program Practices in Other Countries

Vehicle inspection programs are carried out in many countries around the world. A variety of vehicular systems are checked, and tests are performed to evaluate a vehicle's risk for crash and contribution to emissions. Table G.2 lists the vehicle components inspected during safety inspections worldwide.

Table G.2. Vehicle components inspected during safety inspections worldwide

Exhaust system	Engine	Suspension
Steering	Electrical systems	Tires
Windshield wipers	Defrosters	Bodywork
Brakes	Lighting	Signaling devices
Wheels	Structure	General components
Seat belts	Driver's view	Fuel systems
Speedometer	Headlamp	Undercarriage
Airbags	Mirrors	Bumpers
Fenders	Seats	Doors
Horn	Engine lights	Filler neck restriction
Warning devices	Chassis	

Because different countries have different implementing regulations and policy goals, the study team investigated how different countries perform vehicle inspections. The literature review revealed the current practices of inspection programs in other major countries, summarized in Table G.3.

Table G.3. Vehicle inspection programs in other countries

Country	Inspection Criteria	Safety Check	Emission Check	First Inspction (Vehicle Age)	Inspection Period	Cost
Australia	All motorized vehicles; inspection standards depend on states	✓	-	Upon registration	Annual	-
Canada	Imported vehicle and cars to be sold; CMVs in some areas	✓	✓	Varies among provinces	-	-
UK	Motorized vehicles	✓	✓	-	Annual	£54.85 ($72.63)
France	All motorized vehicles, optional for motorcycles	✓	✓	4 years	Biennial for safety; annual for emission	-
Hong Kong	All vehicles	✓	✓	6 years	-	-
Italy	All automobiles	✓	-	4 years	Biennial	-
Japan	All cars and motor vehicles	✓	-	Upon registration	1–3 years, depending on vehicle type	-
Malaysia	Company registered and private vehicles	✓	✓	-	Annual	-
New Zealand	Cars	✓	-	-	Annual if vehicle is younger than 6 years; 6 months if older	-
Singpore	All vehicles	✓	✓	3 years	Biennial	-
Spain	Cars, motorcycles, and quad bikes	✓	-	4 years	Biennial until 10 years of age; annual if older	-
Switzerland	Cars and motorcycles	✓	✓	4 years	Biennial	56–150 CHF ($56.29–150.77)
Thailand	Cars and motobikes	✓	✓	7 years, 5 years, respectively	Annual	-

G.3. Past Research on the Effectiveness of Inspection Programs

G.3.1. Involvement of Vehicle Defects in Crashes

This section provides the detailed review of studies that were included in Table 2.1 in Chapter 2.

- *McLean, A.J., Brewer, N.D., Hall, T., Sandow, B.L., & Tamblyn, P.J. (1979). Adelaide In-depth Accident Study. Part 4: Motorcycle accidents. The University of Adelaide.*
- *McLean, A.J., Aust, H.S., Brewer, N.D., & Sandow, B.L. (1979). Adelaide In-depth Accident Study. Part 6: Car accidents. The University of Adelaide.*

The researchers from the University of Adelaide conducted a series of observational studies to investigate the role of vehicle defects in an accident. A sample of accidents, where an ambulance was called in the Adelaide metropolitan area, was investigated at the scene by a multi-disciplinary team from the Road Accident Research Unit of the University of Adelaide over a 12-month period from March 1976. An engineer, a psychologist, and a medical officer investigated each accident. The observations began on average 10 minutes after the ambulance was called and were supplemented by follow-up investigations, including interviews with people involved in the accidents, observation of uninterrupted traffic behavior at the same time of day as the accident, inspection of crashed vehicles at towing sites, and detailed examination of the accident site.

A total number of 304 accidents were observed, which involved 386 vehicles. Of the 386 cars examined, eleven (2.8%) were found to have defects identified as significant contributing factors and three (0.8%) in which the defect was definitely the major factor in the causation of the accident. Tires were the most common defects detected. The results of these studies indicate that vehicle defects are significant contributing factors to a small portion (2.8%) of accidents.

- *Haworth, N., R. Smith, I. Brumen and N. Pronk. 1997a. Case-control study of motorcycle crashes. Report CR 174, Federal Office of Road Safety, Australia*

Haworth et al. (1997a) conducted a case-controlled study of 222 motorcycle crashes in the Melbourne metropolitan area from late November 1995 to January 30, 1997. In these crashes, either the rider or the passenger was taken to the hospital or died. The controls were 1,195 motorcyclist trips that passed the crash site at the same time of the day and day of the week the crash occurred. It was found that mechanical faults contributed to about 12% of crashes overall. The authors also noted that the proportion was much higher for single-vehicle crashes, at 28%. The incidence of defects contributing to multi-vehicle crashes was 7%.

- *Haworth, N., P. Vulcan, L. Bowland, and N. Pronk, 1997b. Estimation of Risk Factors for Fatal Single Vehicle Crashes. Reports No. 121, Monash University Accident Research Centre, Australia.*

Haworth et al. (1997b) conducted a case-controlled study of fatal single-vehicle crashes in Victoria from December 1, 1995 to November 30, 1996. The cases are fatal crashes with information on driver and passenger, vehicle characteristics, and location. The controls are trips without crashes that also have information on driver and passenger, vehicle characteristics, and location. Of all the crashed cars, 37% had defects that rendered them un-roadworthy. In addition, it was found that mechanical defects contributed to 3% of crashes. Tire and brake problems were the most common defects.

The researchers also found that drivers over age 60 and under 25 experienced a higher risk of being involved in a fatal single-vehicle crash than drivers aged between 25 and 59. In particular, drivers aged over 70 (including 70) and under 21 had the greatest risks.

- *Grandel, J. (1985). Investigation of the technical defects causing motor vehicle accidents. Field Accidents: Data Collection, Analysis, Methodologies, and Crash Injury Reconstructions. SAE International Congress and Exposition, Detroit, February 25-March 1, 1985.*

German law requires that all the accidents involving fatality, injury, or severe property damage need to be reported and examined. The German Motor Vehicle Inspection Association (DEKRA) analyzes the technical defects found during the inspection of vehicles after accidents regarding the causing potential. Each accident vehicle is examined as soon as possible after a crash. An engineer who has been specially trained to detect defects in crashed vehicles conducts the inspection. In addition to the standard accident data, details on the causes of accidents were collected.

Grandel (1985) applied DEKRA data to present a collective analysis describing which vehicle components are considered to be the causes of accidents. He found that over half of the vehicles inspected had defects. The results of the study indicate that 6.5% of passenger cars and 5% of two-wheeled vehicles (including motorbikes, mopeds, and motorized bicycles) involved in crashes had defects that may have contributed to the crash. The most common defects that contributed to accidents are brake components and tires.

- *Masui, J., Sasaki, A., Urano, T. 1982. Legal system of Japan on motor vehicles. Part 5; Technical Sessions. SAE Report No. 826109.*

According to Masui et al. (1982), in Japan, drivers are expected to examine their own vehicles every day, and follow up with a more thorough (usually professional) check monthly, or biannually. Therefore, the statistics regarding the vehicle defects contributing to accidents is low. About 1.3% of accidents in Japan are attributable to vehicle defects (Masui et al., 1982; Rechnitzer et al., 2000).

- *Treat, J.R., 1977. Tri-level study of the causes of traffic accidents: an overview of final results. In Proceedings: American Association for Automotive Medicine Annual Conference (Vol. 21, pp. 391-403). Association for the Advancement of Automotive Medicine.*

The Institute for Research in Public Safety (IRPS) conducted an in-depth study of car accidents in Monroe County, Indiana, from the period of August 1972 to June 1977. In the report, the term ‘cause’ was defined as a deficiency but for which an accident would not have occurred. The researchers investigated the accident immediately after the crash and they conducted this independently from the police. The vehicles were inspected briefly, physical evidence was collected, and the drivers were interviewed at the accident scene. The technicians also made clinical assessments of the causes of the accident. Of 2,258 accidents investigated, a subset of 420 were investigated in greater depth by a multidisciplinary team of professionals. Sample selection for this section was based on the willingness of subjects to participate. An automotive engineer at the IRPS inspection facilities inspected these vehicles.

Treat (1977) noted that many causes might contribute to one accident at the same time, such as the vehicle defects, the environmental issues, and the driver factors. Based on the investigation results of the multidisciplinary team and on-site teams, human factors were cited as probable causes in 93% of accidents, compared to 34% for environmental factors and 13% for vehicular factors. Leading human factors included excessive speed, improper lookout, inattention, and improper evasive action. Slick roads and view obstructions were leading environmental factors. In terms of the vehicle defects, the most common defects that had caused accidents were the braking system (2.9% to 5.2%), tires and wheels (0.5% to 4%), communication systems such as lights and glazed surfaces (0.2% to 1.7%), steering systems (0.2% to 1%), and body and doors (0.5% to 0.7%). Vision (especially poor dynamic visual acuity) and personality (especially poor personal and social adjustment) were also related to accidents.

- *Fazzalaro, James. Periodic Motor Vehicle Safety Inspections. Connecticut General Assembly Office of Legislative Research. October 2007.*

Factors contributing to accidents in Connecticut appear to be overwhelmingly behavioral (driver-related) or environmental (road or weather conditions). According to accident data compiled by the Department of Transportation, of the approximately 80,000 reported accidents that occur in Connecticut each year, mechanical failure of a vehicle is listed as a contributing factor in only about 0.7% of accidents, 0.6% of the injury-producing accidents, and 0.35% or less of the fatal accidents. Unsafe or failed vehicle tires are typically listed as a contributing circumstance in 0.35% of all accidents, 0.2% of injury-producing accidents, and 0.33% or less of fatal accidents. Thus it appears that these vehicle-related factors taken together are shown as contributing factors in only about 1% of reported accidents in Connecticut each year.

- *Rompe, K. and Seul, E., 1985. Advantages and disadvantages of conducting roadworthiness tests to monitor the mechanical condition for private cars, the impact of such tests on road safety, environmental protection and the renewal of the vehicle fleet and the scope for introducing roadworthiness testing throughout the European community. Final report commissioned by the Directorate-General for Transport. VII/G-2 of the Commission of the European Communities. Drawn up by the TUV Rheinland.*

Rompe and Seul (1985) found that several in-depth studies have concluded that vehicle defects have directly or substantially contributed to approximately 3% to 24% of all crashes. In terms of the effectiveness of inspection programs, they noted that about 50% of the accidents caused by vehicle defects could be reduced by periodic vehicle inspections, based on the results of one cautious and accurate U.S. survey (Rechnitzer et al. 2000).

Both Vaughan (1993) and Rompe and Seul (1985) found that the occupants are more likely to be killed if involved in crashes associated with older cars. This is due to several reasons: older vehicles have more vehicle defects due to deterioration; older cars provide lower levels of occupant protection than newer cars do; and newer vehicles provide improved safety features.

- *Manitoba Infrastructure, 2018. Online reference. The official website of Manitoba Province, Canada. http://www.gov.mb.ca/mit/mcd/mcs/index.html. Retrieved on June 22, 2018.*

The province of Manitoba published the Commercial Vehicle Safety Alliance (CVSA) inspection report from 2008 to 2017, where the failure rate for 2017 inspection is 30.61%. The failure rate has kept increasing since 2013. The failure rate from 2008 to 2017 is presented in Figure G.1. The most common failure factor is brakes.

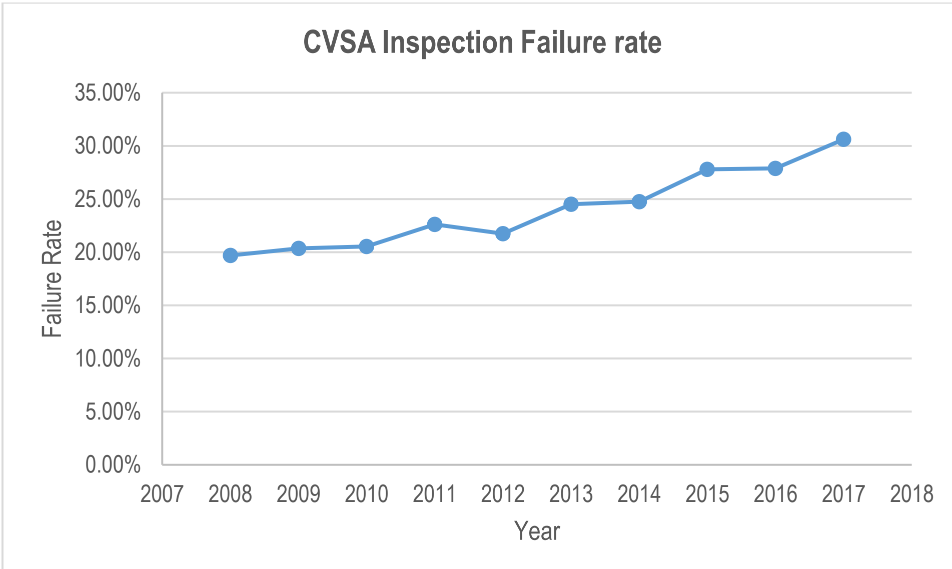


Figure G.1. CVSA inspection failure rate reported by Manitoba Province

G.3.2. The Effect of Vehicle Age in Crashes

During the past several decades, several studies have investigated the effect of vehicle age in crashes. In general, they found that older vehicles are more likely to be involved in a crash. This is due to three possible reasons:

1) Vehicle components deteriorate over time. Older vehicles may be in poorer conditions than newer cars.
2) Updated vehicle designs and construction make newer vehicles safer overall, providing higher levels of occupant protection than older cars do.
3) The types of people driving older cars may differ from those driving newer cars (Vaughan, 1993; Youngman and Stolinski, 1994).

Table G.4 lists the studies examining the relationship between vehicle age and crashes (Rechnitzer et al., 2000).

Table G.4. Summary of studies examining relationship between vehicle age and crashes

Authors	Findings	Implications
Treat (1977)	Cars older than eight years were twice as likely to crash as a result of vehicle factors than for all cars.	Older cars are more likely to crash as a result of vehicle defects.
Jacobson (1982)	Driver compensation may result in no increase in non-emergency accident rate in older cars. Crash tests of two corroded cars revealed little structural resilience in corroded sections of the car body.	Older cars are not necessarily at higher risk of non-emergency accidents. Corroded vehicle bodies offer little structural resilience.
Vaughan (1993)	Older cars are in more crashes than younger cars.	Older cars are more likely to crash.
Motoring Directions (1998)	Older cars are in more crashes than younger cars.	Older cars are more likely to crash.

- *Treat, J.R., 1977. Tri-level study of the causes of traffic accidents: an overview of final results. In Proceedings: American Association for Automotive Medicine Annual Conference (Vol. 21, pp. 391-403). Association for the Advancement of Automotive Medicine.*

After investigating more than 2000 car accidents in Monroe County, Indiana, Treat (1977) found that older cars with mechanical problems were over-involved in accidents. Treat concluded that the probability of an accident-involved vehicle eight years or older being cited for a causative vehicular problem was more than two times greater than for accident-involved vehicles in general.

- *Vaughan, R., 1993. Vehicle ageing and safety. In Wheels '92: Conference and Workshop; Proceedings (p. 47). Institution of Engineers, Australia.*

Vaughan (1993) analyzed New South Wales crash data from 1977 to 1991 (inclusive) in which occupants of passenger cars were killed. Vaughan found that the occupant death rate per 100 million kilometers (62.1 million miles) of travel in older cars has consistently been the highest in all vehicle age categories. This trend is supported by the findings from other research conducted in other countries, including the USA (NHTSA, 1989), Sweden (Rechnitzer et al., 2000), and Germany (Grandel, 1985).

- *Motoring Directions. (1998). Arresting the ageing of Australia's vehicle fleet. Motoring Directions, 3(4), 8-11.*

This study was conducted by representatives of federal and state road, transport authorities, motoring organizations, the automotive manufacturing, retail industries, and independent road safety experts. They found that older vehicles were over-represented in crashes where deaths and serious injuries occur. For a pre-1970 model year vehicle, the risk of being injured in a crash is double that for a 1990 model year vehicle. It needs to be pointed out that this study focused more on the effect of newer cars with improved safety features as the reason why newer cars have a lower crash rate, rather than the contribution of the defects in the older cars.

- *Jacobson, M.A. (1982). Accident avoidance: How age deterioration can affect car safety. SAE Report No 826100. Experimental Safety Vehicles; Section 5: Technical Sessions.*

Jacobson (1982) noted that there is a progressive deterioration with age and mileage of steering, suspension, and brakes. Tires also deteriorate with time. However, Jacobson questioned if there is enough reliable data to quantify the number of older or badly maintained cars that are experiencing higher risks due to vehicle defects. He suggested that driver factors were the main causation of the crashes. Jacobson found that deterioration of older cars does not necessarily contribute to the incidence of accidents in most of cases due to driver factors.

G.3.3. Safety Effectiveness of Inspection Programs

This section lists the detailed review on studies that were included in Table 2.2 in Chapter 2.

- *Peck, D., Matthews, H.S., Fischbeck, P. and Hendrickson, C.T., 2015. Failure rates and data driven policies for vehicle safety inspections in Pennsylvania. Transportation Research Part A: Policy and Practice, 78, pp.252-265.*

Peck et al. (2015) combined Pennsylvania vehicle registration data with two large samples of results from state safety inspections. They used a logistic regression model to determine if any independent variables of vehicle characteristics are statistically significant in predicting the dependent variable of vehicle safety inspection outcome (whether a vehicle will pass or fail inspection). After a series of analyses, the authors found that the state of Pennsylvania safety inspection fail rate for light-duty vehicles is 12–18%, well above the often-cited rate of 2%. In addition, vehicles that are older than three years or have more than about 30,000 miles can have much higher rates. They also pointed that accurate inspection data is limited and often incorrectly analyzed. They concluded that the importance of vehicle maintenance over a vehicle's lifetime is evident, and that vehicle safety inspections should continue to be implemented in order to keep driving conditions safe.

- *GAO, 2015. United States Government Accountability Office. Vehicle Safety Inspections. Improved DOT Communication Could Better Inform State Programs. Report to the Honorable Claire McCaskill, U.S. Senate. Report No. GAO-15-705*

In a report published by the United States Government Accountability Office (GAO, 2015), Pennsylvania state data show that in 2014, about 20% of vehicles in the state failed inspection and then underwent repairs to pass, which is well above the often-cited 2%. In addition, a before-and-after analysis of Oklahoma and New Jersey was conducted. The state of Oklahoma eliminated its safety inspection program in 2001 and New Jersey eliminated theirs in 2010. Data on the number of crashes recorded in the state and the number of crashes recorded with vehicle component failures before and after the program elimination was collected. Data from 1995 to 2013 was obtained for Oklahoma and data from 2005 to 2013 (three years after the elimination) was obtained for New Jersey. The authors also analyzed national level crash data from NHTSA's National Automotive Sampling System General Estimates System (NASS-GES) for the years 2009–2013. The purpose was to determine the estimated number of total crashes with vehicle factors nationwide as well as the specific vehicle component failures that were reported, such as issues with brakes, tires, and steering. In both instances, crashes involving vehicle component failure were generally between 2 and 3% of all crashes and varied little from year to year, even after the elimination of the inspection programs. The crash rate was also calculated with controlling for vehicle miles traveled. The results also indicated that the rate did not significantly change for either state. However, the authors note that this analysis does not provide sufficient evidence to conclude that inspection programs did not have an effect on crash rates because additional factors—such as implementation or increased enforcement of traffic safety laws—could influence crash rates

- *Keall, M.D. and Newstead, S., 2013. An evaluation of costs and benefits of a vehicle periodic inspection scheme with six-monthly inspections compared to annual inspections. Accident Analysis & Prevention, 58, pp.81-87.*

Keall and Newstead (2013) evaluated the safety impact of doubling the inspection frequency, from annual to biannual, when the vehicle reaches six years of age. Reductions in safety-related vehicle faults were estimated together with the value of the safety benefits compared to the costs. They analyzed merged crash data (2004–2009), licensing data (2003–2008), and roadworthiness inspection data (2003–2009) provided by the New Zealand Ministry of Transport and the New Zealand Transport Agency. These three data sets were merged for each year available using the registration plate number to match crash and licensing data and a unique vehicle identification number to then link these data to the inspection data. There were estimated to be improvements of 8% (95% CI 0.4–15%) in injury crash involvement rates and 13.5% (95% CI 12.8–14.2%) in prevalence of safety-related faults associated with the increase from annual to six-month inspections.

It is noteworthy that the periodic vehicle inspection regime in New Zealand is referred to as the warrant of fitness (WoF) scheme. Vehicles are required to be inspected every year up until six years since manufacture and thereafter every six months. The following figures present some statistical findings of the study. Only vehicles sold new in New Zealand are analyzed to avoid distortions to the time series associated with vehicles introduced into the fleet from other countries (mainly Japan) where different schedules of mechanical maintenance and different degrees of wear and tear associated with road conditions may apply.

Figure G.2 shows the percentage of WoF inspections in which the vehicle failed and the mean number of faults identified per WoF inspection by the age of the vehicle. A failure occurs when at least one fault (defect) is identified. This shows that the failure rate generally increases with increasing vehicle age.

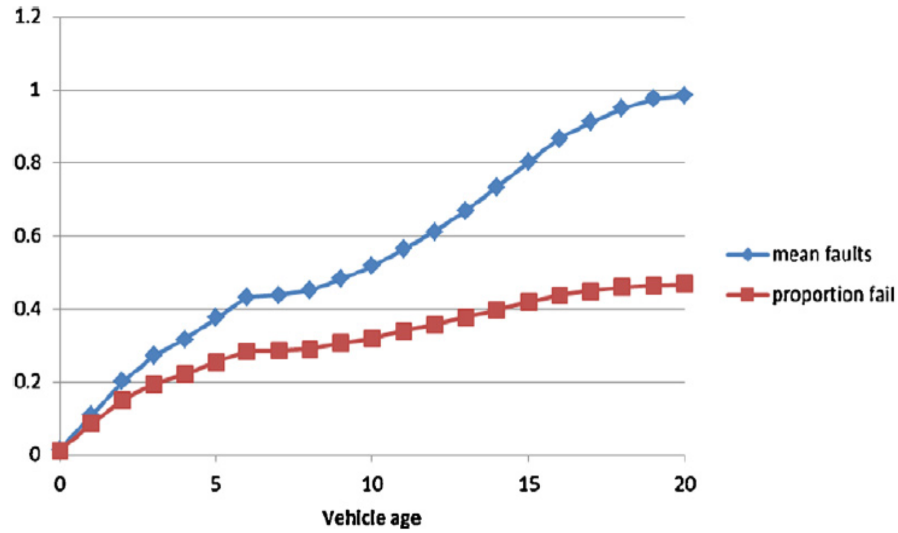


Figure G.2. Percentage of WoF inspections where the vehicle failed and mean number of faults found by the age of the vehicle

Figure G.3 shows the mean number of faults identified per WoF inspection regarding the four most common fault types: brakes, tires, steering/suspension, and lights. Similar to the pattern shown in Figure G.2, all fault types increase as the vehicle age increases. They show a marked flattening of the curve after the vehicle reaches six years old, when the vehicles are inspected at six-month intervals.

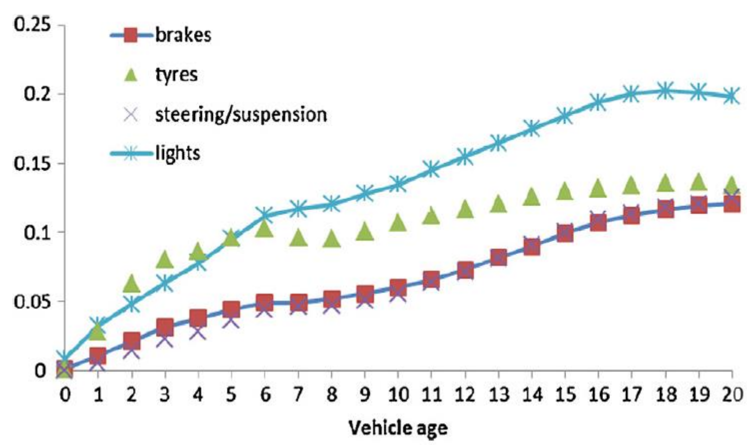


Figure G.3. Mean number of faults identified per WoF inspection by the age of the vehicle and class of fault identified

Figure G.4 shows how the mean number of faults varies based on the age of the owner. The greatest number of faults is found for younger owners: those aged less than 30. Owners aged over 60 have the lowest average rate of faults, followed by owners aged between 30 and 59.

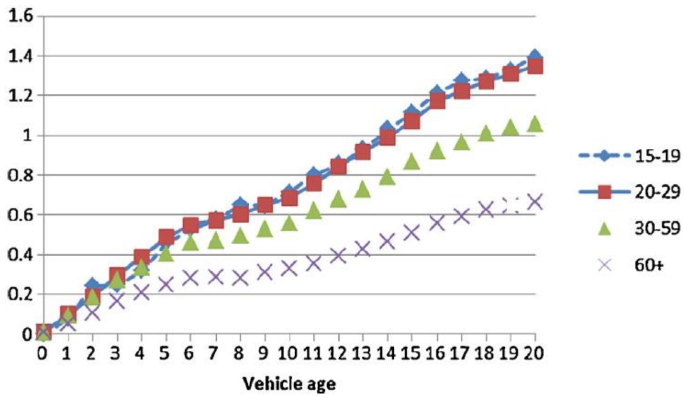


Figure G.4. Mean number of faults identified per WoF inspection by the age of the vehicle and age group of owner

A logistic regression model was used to analyze the merged crash and licensing data. As Figure G.5 depicts, the crash risk increases as the vehicle age increases. According to Keall and Newstead (2013), the crash rate was estimated to fall by 8% with 95% confidence interval 0.4–15% due to the switch from annual to six-month inspections starting at the vehicle age 7.

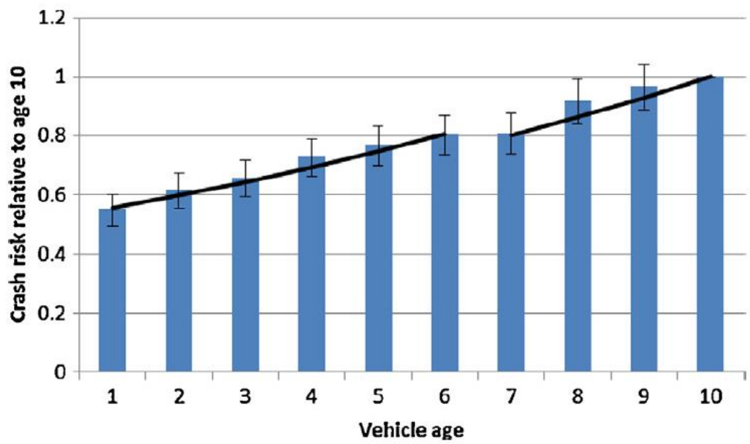


Figure G.5. Crash risk of vehicles by age of vehicle relative to vehicles aged 10

- *<u>Vlahos, Nicholas J., Samuel T. Lawton, Anurag K. Komanduri, Yasasvi D. Popuri, and Danena L. Gaines, 2009. Pennsylvania's Vehicle Safety Inspection Program Effectiveness Study (070609) Summary of Findings. The Pennsylvania Department of Transportation. Report No. PA-2009-004-070609. Prepared by Cambridge Systematics.</u>*

Vlahos et al. (2009) conducted a study to consider the effectiveness of vehicle safety inspections on the number of fatal crashes, and the benefits of the program compared to the cost of inspections to the owners of Pennsylvania-registered vehicles. They developed and implemented a statistical analysis based on crash data from the Fatality Analysis Reporting System (FARS), control data from a variety of national sources, and characteristics of existing programs nationwide. They also conducted telephone interviews with representatives from New York Department of Motor Vehicles, Vermont Department of Motor Vehicles, Missouri State Highway Patrol, and Ohio DPS.

They used three different classes of model formulations and the results were clear and consistent: states with vehicle safety inspection programs have significantly fewer fatal crashes than states without programs. The benefits of the program as derived from all three models exceed the user costs of the program.

Based on the model results, Pennsylvania can be expected to have between 115 and 169 fewer fatal crashes each year, corresponding to between 127 and 187 fewer fatalities each year, than it would if it did not have a vehicle safety inspection program. They concluded that their results clearly demonstrated that the vehicle safety inspection program in Pennsylvania is effective and saves lives.

- *Christensen, P. and Elvik, R., 2007. Effects on accidents of periodic motor vehicle inspection in Norway. Accident Analysis & Prevention, 39(1), pp.47-52.*

Christensen and Elvik (2007) evaluated the effects on accidents of periodic inspections of cars, excluding trucks and buses. They applied negative binomial regression models to fit the data on 1998–2002 accidents and inspections created by merging data files provided by a major insurance company and by the Norway Public Roads Administration. Their findings suggest that technical defects in cars are associated with a small but statistically significant increase in accident rate. Inspections were able to strongly reduce the number of technical defects in cars. However, no effect of inspections on accident rate were found. It is suggested that car owners adapt driving behavior to the technical condition of the car and that the effect attributed to technical defects before inspection may in part be the result of a tendency for owners who are less concerned about safety to neglect the technical condition of their cars.

- *Poitras, M. and Sutter, D., 2002. Policy ineffectiveness or offsetting behavior? An analysis of vehicle safety inspections. Southern Economic Journal, pp.922-934.*

Poitras and Sutter (2002) developed an econometric model to examine the effect of inspection on registrations of old vehicles using panel observations of the 48 contiguous states and the District of Columbia. The panel data was obtained from Automotive Industries and consist of 733 observations for the years 1953–1967. They found that inspection has no significant impact on old cars or repair industry revenue, which implies that inspection does not improve the mechanical condition of vehicles. They also distinguished between policy ineffectiveness and Peltzman-type offsetting behavior as sources of inspection failure. Poitras and Sutter (2002) suggest that periodic vehicle inspection is a poor instrument for achieving policy goals.

- *Sutter, D. and Poitras, M., 2002. The political economy of automobile safety inspections. Public Choice, 113(3-4), pp.367-387.*

Sutter and Poitras (2002) developed econometric models to examine the incidence of inspection across states, and determinants of regulated inspection fee. They used 1981 to 1983 panel data of 50 U.S. states. Their results indicate no significant correlation between predicted roadway casualties and inspection requirements, and their hypothesis of misallocation of inspection resources cannot be rejected.

- *Rechnitzer, G., Haworth, N. and Kowadlo, N., 2000. The effect of vehicle roadworthiness on crash incidence and severity (No. 164). Monash University, Accident Research Center.*

Rechnitzer et al. (2000) conducted a comprehensive literature review and data analysis, involving Victorian Case-Control Study of Fatal Single-Vehicle Crashes, Victorian Case-Control Study of Motorcycle Crashes, and the Coroner’s database (Victoria, Australia). They found that there was significant variation in study findings regarding the role of vehicle defects in crash causation and the effectiveness of Periodic Motor Vehicle Inspections programs in reducing defects and crashes. Studies of crashed vehicles have shown that defects contribute directly or substantially from around 3% to 19%, with the more robust studies indicating at least 6%. Common defects identified relate to brakes and tires, which could be detected during an inspection. In addition, the effect of inspection programs on accident rates as assessed by the studies varied significantly, from no effect to decreasing the accident rate by up to 16%. The authors noted that few studies examined the effect of inspection programs on the incidence of defects: for example, NHTSA (1989) found that an inspection program was associated with a 2.5% reduction; and in Sweden, it was found that 7–8% of vehicles with serious defects were replaced after the introduction of an inspection program (Asander, 1993). The authors also noted that some studies suggest that periodic roadworthiness tests could reduce the number of crashes caused by vehicle defects by about 50% (for example, a study conducted by Romp and Seul in 1985).

Rechnitzer et al. concluded that vehicle age was found to be an important factor. In Australia, it was found that the likelihood of being involved in a fatal single-vehicle crash was 2.5 times greater for a driver of a pre-1978 vehicle than a newer vehicle.

- *Merrell, D., Poitras, M. and Sutter, D., 1999. The effectiveness of vehicle safety inspections: An analysis using panel data. Southern Economic Journal, pp.571-583.*

Merrell et al. (1999) examined the effectiveness of state automobile safety inspections from a panel of the 50 states for the years 1981–1993. They estimated a fixed effects regression model that incorporated state-specific shifts in casualty rates. They found no evidence that inspections significantly reduce fatality or injury rates. They also provided evidence on the effects of speed limits, seat belts, and Peltzman’s offsetting behavior hypothesis. The authors noted several potential reasons that account for the failure of safety inspections to reduce accidents. First, inspections may induce an offsetting increase in driving intensity. Second, drivers have a strong incentive to perform maintenance to provide for their own safety. Third, inspections can at best prevent only a small fraction of accidents since most accidents do not involve mechanical failure. Additionally, inspectors can fail, intentionally or unintentionally, to report vehicle defects. Inspectors may fail to report defects to minimize customer hassle and increase the number of inspections performed; they noted, for example, that Hemenway (1989) found evidence that motorists tend to patronize repair shops with a low failure rate on inspections.

- *Holdstock, J., Zalinger, D. and Hagarty, D., 1994. Review of a mandatory vehicle inspection program: project report.*

The British Columbia Government ended a periodic mandatory private-vehicle inspection program in 1983. This study was initiated to assess whether a cost-beneficial program exists or could be developed that would improve highway safety through the reduction of accidents, particularly those with fatalities or injuries. The authors analyzed the statistics of accidents caused by defective or unsafe motor vehicles in B.C. or other jurisdictions; assessed the impact of vehicle-inspection programs on vehicle fitness and road safety; and conducted a survey of the public's opinion on the importance of such a program. They also conducted regression analysis using 1990–1991 data for 50 states, District of Columbia, and 10 Canadian provinces. The results indicated that it was unable to establish a statistically significant effect of vehicle inspection program on fatalities or injury rates.

- *Asander, S., 1993. Vehicle safety inspection systems. In Wheels '92: Conference and Workshop; Proceedings (p. 63). Institution of Engineers, Australia.*

Asander (1993) summarized statistical reports since the introduction of inspection program in Sweden in 1965, which are published by AB Svensk Bilprovning, the Swedish motor-vehicle inspection company. The statistics showed that that introduction of a compulsory inspection program in Sweden has resulted in a vehicle fleet with fewer defects than before its introduction. The first change made after the introduction of compulsory inspection program is to reduce the most serious defects in the vehicle fleet. In 1965, 7–8% of vehicles were replaced due to serious defects. Asander (1993) suggested two reasons for this: one is that car owners were more aware of the condition of their own vehicles and chose to replace them in order to pass inspections. The other is that the owners felt that it was not worthwhile to repair the defects identified at an inspection, and scrapped the vehicles.

In addition, police reported accidents with personal injury decreased by 16% between 1964 and 1966, the years immediately preceding and following the introduction of compulsory inspection program.

- *Fosser, S., 1992. An experimental evaluation of the effects of periodic motor vehicle inspection on accident rates. Accident Analysis & Prevention, 24(6), pp.599-612.*

Fosser (1992) conducted an experimental evaluation of the effects of periodic motor vehicle inspection on accident rates. In the research, 204,000 cars were randomly assigned to three different experimental conditions. First, 46,000 vehicles were inspected annually during a period of three years (inspected in 1986, 1987, and 1988); 46,000 cars were inspected once during those three years (inspected in 1986 only); and 112,000 cars were not inspected (control group). The number of accidents was recorded for a period of four years. The technical condition of inspected vehicles improved compared to those not inspected. However, no differences in accident rates were found between the groups. It is concluded that periodic motor vehicle inspection has no preventive effect on the technical condition of cars in a system where roadside inspections also exist. The authors also caution that there are a number of factors that should be considered in the interpretation of the results. In Norway, there is a high level of random roadside inspection (about 20% of vehicles per year) and this might be enough incentive for owners to prevent and remedy defects in their vehicles such that periodic inspections have no additional effect.

Finally, the age of the cars in this study was deliberately restricted to between approximately 7 and 11 years, so that the cars would be old enough to have developed technical defects, but not too old as to be likely to be scrapped during the experiment. It may be that periodic inspections have a beneficial effect for vehicles older than 11 years.

- *NHTSA (1989). Study of the effectiveness of state motor vehicle inspection programs: Final report. Report of the US Department of Transportation: USA*

Three series of analyses were conducted in this report to determine whether inspection programs were reducing the crash rates of passenger cars. The crash rate proportion of old to new vehicles in each state was analyzed. The results for states with and without inspection programs were compared. At the time of this study, 22 states had inspection program while 29 did not, noting the fact that 19 out of the 29 states without inspection program conduct random inspections of PVs. In addition, considerable variation exists in the equipment items inspected and the procedures, rules, and regulations for inspections within the 22 states with inspection program.

Three main data sources used in this study through three types of analysis included the Fatal Accident Research System (FARS); state accident data obtained from each state (since not all the states maintain the crash database, data from four states with inspection programs and six states without were used); and component failure data obtained from the Crash Avoidance Research Data files (CARDfile) coded by the police officers.

- **Series One Analysis**

  The researchers made two comparisons in the series one analysis. In both comparisons, the crash rates of vehicles with different ages were compared between states with inspection program and states without inspection program.

  The first comparison used FARS and state accident data (vehicles one to three years old), over a single 12-month crash period between July 1, 1985, and June 30, 1986. The researchers found that there is no effect of inspection programs on the fatal crash involvement rate according to the FARS data. Based on the state accident data, the overall accident rate was always higher in states without inspection programs, regardless of the age of the vehicle.

  The second comparison used FARS data to compare crash rates of 1975 model year cars over the years 1976 to 1986. They found that there was no difference between states with and without inspection programs for cases in which older cars have crashes.

- **Series Two Analysis**

  NHTSA conducted a second series analysis using CARDfile from 1984 to 1986 for four states: Maryland, Washington, Pennsylvania, and Texas. Maryland and Washington do not have inspection programs, while Pennsylvania and Texas do. Almost 600,000 PVs were examined from Maryland and Washington, and over 1.5 million PVs were examined from Pennsylvania and Texas. Only passenger cars 10 years or younger were included in the analysis. Based on the CARDfile, the proportion of crashed vehicles with a component failure identified as a contributing factor was found to be significantly greater in states without inspection programs for cars of all ages. This difference ranged from less than 0.25% to a 2.5% difference, depending on the age of the car. Older cars experienced a greater difference.

In the follow-up analysis, vehicle component failures reported by police in fatal crashes were analyzed using FARS data from 1985 to 1987. It was found that the proportion of vehicles involved in a fatal crash with defects identified as contributing factors is consistently higher in states without inspection programs than states that are performing inspections.

The researchers found that the fact the proportion of older crashed vehicles with a component failure identified as a contributing factor was greater in states without inspection programs, which supports the notion that the difference is due to inspections.

- **Series Three Analysis**

In the series three analysis, the researchers used CARDfile data to conduct analysis by defect type. They found that tire failures were significantly more common (up to 2.5%) in states without inspection programs for almost all vehicle ages, which possibly indicates that the inspection program is effective.

- *White, W.T., 1986. Does periodic vehicle inspection prevent accidents? Accident Analysis & Prevention, 18(1), pp.51-62.*

New Zealand has a mandatory biannual vehicle safety inspection program. In this study, White examined the accident rate of New Zealand vehicles in relation to the time since their most recent inspection. He obtained over 21,000 written inspection records from inspection stations and Traffic Accident Report data from the New Zealand Ministry of Transport. A 13-month period was chosen for analysis as this was just over twice the official inter-inspection period. The results indicated that the probability of accident involvement increases with time since last inspection. More specifically, the accident rates were lowest one week after inspection, and then increased by 10–15% over the next six months until a peak one week before the next inspection. The author concluded that mandatory safety inspection has an immediate safety benefit that decreases over time. The study suggests that vehicle defects do contribute to accidents, but that periodic vehicle inspections may not be the best method to maintain roadworthiness. White also noted that the data was not of ideal quality since it was obtained from one area of New Zealand and could not be representative of the whole country.

- *Rompe, K. and Seul, E., 1985. Advantages and disadvantages of conducting roadworthiness tests to monitor the mechanical condition for private cars, the impact of such tests on road safety, environmental protection and the renewal of the vehicle fleet and the scope for introducing roadworthiness testing throughout the European community. Final report commissioned by the Directorate-General for Transport. VII/G-2 of the Commission of the European Communities. Drawn up by the TUV Rheinland.*

This analysis reviewed U.S. studies on the effectiveness of periodic vehicle inspection and found that periodic inspection could reduce the number of accidents caused by vehicle defects by about 50%. They also found that inspection programs might also affect and reduce the crashes by improving the drivers’ knowledge and understanding of the need for regular maintenance, safety issues, and the condition of their own cars.

- *Berg, G., Danielsson, S. and Junghard, O., 1984. Trafiksäkerhet och periodisk fordonskontroll (Traffic safety and periodic vehicle inspections).*

Sweden introduced mandatory annual inspection of all cars in 1966. This analysis performed a time-series analysis covering the years from 1955 to 1981, both before and after the safety inspection program is introduced. They found that the number of cars involved in police-reported accidents decreased by 14% following the introduction of annual inspections. The number of injury accidents declined by 15%. The number of injured persons declined by 9% and the number of property-damage-only accidents decreased by 3%.

- *Loeb, P.D. and Gilad, B., 1984. The efficacy and cost-effectiveness of vehicle inspection: a state specific analysis using time series data. Journal of Transport Economics and Policy, pp.145-164.*

This study employed a time-series analysis of the efficacy of inspection in reducing fatalities, injuries, and accidents. They used New Jersey data and developed an econometric model to evaluate inspection while accounting for various socio-economic factors, as well as technology- and driving-related variables. The study analyzed time-series data for the years 1929 to 1979, which includes data from both before and after the introduction of compulsory inspection program to New Jersey in 1938. The results of the econometric study are then used to evaluate a partial benefit/cost analysis of the system of motor vehicle inspection. Regression analyses were carried out separately for accident rates, fatality rates, and injury rates. The results indicate that the presence of the inspection program statistically significantly reduced the number of highway fatalities (by over 300 per year) and accidents (by almost 38,000 per year) in New Jersey. No significant effect of inspection program on reducing injuries was found. They suggested two reasons why there are significant decrease in fatalities and accidents but not injuries: one is that inspections may detect major safety defects but not minor ones. The other is that inspection may play a role in changing the attitudes of drivers such that they fix major safety defects.

- *Van Matre, J.G. and Overstreet Jr, G.A., 1982. Motor vehicle inspection and accident mortality: A reexamination. Journal of Risk and Insurance, pp.423-435.*

This study applied a multiple regression mode to study the relationship of motor vehicle inspections and accident mortality. Three inspection schemes are explicitly considered: periodic inspection, random inspection, and no inspection. They used very detailed data published by the American Statistical Association; U.S. Bureau of the Census; U.S. Department of Health, Education and Welfare; U.S. Department of Transportation; Federal Highway Administration; and NHTSA. The fatality rate model indicates that both random and periodic schemes are effective in reducing fatality rates when compared to states with no inspection. The fatality rate per 100,000 inhabitants was about 10% lower in states with periodic motor vehicle inspection than in other states. They also pointed that random inspection appears to be more effective than periodic inspection.

- *National Highway Traffic Safety Administration (NHTSA), United States Department of Transportation, (1980): The Effects of Automobile Inspections on Accident Rates. HJS-805-401.*

In this experimental study, vehicles were grouped into two samples: one consisted of vehicles that underwent (voluntary) inspection, and the other of non-inspected vehicles. The accident rate of vehicles was observed over a 12-month period. The two samples were matched for make, model, and year of manufacture. The results showed a statistically significant difference in accident rates: the inspected vehicles had fewer accidents than the non-inspected ones. The results also held when accident rates were adjusted for differences in sex and age. However, since non-random sampling procedure used in the study may have biased the selection of drivers, these results should be interpreted with caution.

- *Crain, W.M., 1980. Vehicle safety inspection systems. How effective? American Enterprise Institute for Public Policy Research: Washington DC.*

This analysis used 1974 data (which contains fatality rate, injury rate, and accident rate) and certain socio-economic variables (e.g., population density, median family income, fuel consumption, etc.). Crain compared accident rates in states with periodic motor vehicle inspection to states without the program. Crain did not find any statistically significant differences in fatality rates between states with periodic motor vehicle inspection and states without it. There was a non-significant tendency toward higher fatality rates in states with periodic motor vehicle inspection. In addition, Crain noted that there was no statistically significant difference in accident rates between states with biannual inspections and states with annual inspections. He concluded that the vehicle inspection programs do not have the expected effect of reducing accident rates, and that more frequent inspections do not tend to reduce accident rates. Crain also pointed out that random vehicle inspections were found to be those with the lowest accident rates. Crain (1980) suggested two possible reasons why inspection programs may have failed to reduce crash rates in his study. One is that additional resources devoted to vehicle maintenance because of periodic inspection may not improve the inherent safety characteristics of the vehicle; the other is that periodic vehicle safety inspection do make the vehicle safer, but this potential for improved safety is dissipated by adjustments in driver behavior.

- *Schroer, B.J. and Peyton, W.F., 1979. The effects of automobile inspections on accident rates. Accident Analysis & Prevention, 11(1), pp.61-68.*

This study compared the accident rates of vehicles that participated in the Alabama Motor Vehicle Diagnostic Inspection Demonstration Program (similar to periodic motor vehicle inspection because Alabama does not have a mandatory inspection program) with vehicles that did not actively participate.

The authors used data from the Auto Check inspection files, the Madison County motor vehicle registration files, and the Alabama DPS accident files. A sample of cars (1968 to 1973 model years) from urban areas was selected that had a first periodic inspection between April 1975 and December 1976. The Auto Check sample comprised almost 8,500 vehicles and the non-Auto Check sample comprised over 30,000 vehicles.

They found that the accident rate of inspected vehicles represents was 9.1% lower than the rate for uninspected vehicles in Huntsville. Moreover, the drivers who returned for subsequent periodic inspections experienced a 21% improvement over the accident rate of drivers in the uninspected vehicle group. The study also indicated that the monthly accident rate of the responsive participants who returned for subsequent periodic inspections did not significantly increase over eighteen months, while the monthly accident rate of unresponsive participants increased to the level of uninspected vehicles.

In addition, the accident rate of inspected vehicles decreased at least 5.3% after inspection. The inspection reject rates for the brake, steering suspension, and wheel alignment systems for Auto Check vehicles involved in accidents were compared to the reject rates for the non-accident vehicles. Vehicles involved in accidents were in significantly worse mechanical condition on the average than those not involved in accidents. The results suggest that poor mechanical condition is a significant factor in motor vehicle accidents and annual inspections are a desirable and effective means of reducing accident rates. However, the influence of self-selection on the results cannot be ruled out, as the subjects for the study were all volunteers.

- *United States Department of Transportation, National Highway Traffic Safety Administration (NHTSA): Costs and Benefits of Motor Vehicle Inspection, 1975.*

In the report published by NHTSA (1975), the states of Nebraska and Alaska conducted a descriptive comparison of accident rates before and after the introduction of inspection program, respectively. NHTSA compared the percentages before and after the introduction of the inspection program of all fatal accidents, where vehicle defects played a causative role. Both states saw a decline in these percentages, which indicates that their inspection programs had a positive impact on reducing the fatal accident rates.

- *Little, J.W., 1971. Uncertainties in evaluating periodic motor vehicle inspection by death rates. Accident Analysis & Prevention. 2, 301-313.*

This study conducted a controlled before-and-after study to examine the effect of inspection program on fatality rates, where six U.S. states formed the experimental group and various other states formed control groups. The data are obtained from the National Safety Council, which consists of death rates and numbers of deaths. There was some variation in results within each group studied. For example, some test states experienced an increase (5%) in death rates following the introduction of inspection program, and some experienced a decrease in death rates over the same period of time. There was no statistical difference in crash rates between inspecting and non-inspecting control groups over time. There was no statistically significant difference in the increase in death rates between test states and the nation as a whole. Compared to a simple before-and-after study or a simple with-and-without comparison, the use of control groups is an advantage of this study. However, the differences found between test and control states were not necessarily caused by the introduction of periodic motor vehicle inspection alone. Little noted that "the most reasonable conclusion may be that something more fundamental than inspection is at work in producing and changing death rates."

- *Fuchs, V.R. and Leveson, I., 1967. Motor accident mortality and compulsory inspection of vehicles. Journal of the American Medical Association, 201(9), pp.657-661.*

This analytical study employed multivariate statistics to examine the relationship between motor accident mortality and compulsory vehicle inspection. They conducted the study by regressing age-standardized mortality ratios on inspection and other variables across states. Their model used 1960 data and allowed for the effect of several variables simultaneously, and thus more clearly isolated the effect of inspection. They considered 11 independent variables; however, in their linear unweighted model, only three were significant: gas consumption, population density, and other accident mortality. When the inspection variable was the only independent variable, they found a significant negative effect on accident death rates. When more regressors were added to the model, the efficacy of motor vehicle inspection in reducing mortality rates was not statistically significant. They concluded that inspection is negatively related to mortality, but the net effect of inspection is very small and does not generally differ from zero at high levels of statistical significance.

- *Buxbaum, R.C. and Colton, T., 1966. Relationship of motor vehicle inspection to accident mortality. Journal of the American Medical Association, 197(1), pp.31-36.*

This study used 1960 data to examine the role of mechanical failure in automobile accidents by comparing motor vehicle mortality among men aged 45 to 54. They compared the statistics between the states that do and do not require motor vehicle inspection. The results indicated that inspection is associated with lower mortality, and this association prevails under varying economic, geographic, and demographic conditions.

Appendix H. Stakeholder Interviews

In order to obtain more insightful information regarding the Inspection Program the CTR team interviewed nine stakeholders who are experienced industry professionals, including inspectors, car dealers, and inspection station owners. Most of the interviews were conducted through teleconference. Their experiences are valuable to this study. The key points recorded and are summarized below.

H.1. Interview with Laird Doran and Mike Sullivan

Laird Doran is the Vice President, Government Relations and Senior Counsel of The Friedkin Group/Gulf States Toyota. Gulf States Toyota is the world's second-largest distributors of Toyota cars and parts. Mike Sullivan is the Director of Governmental and Public Affairs of Group 1 Automotive. Group 1 Automotive has the largest fleet in volume participating in the Inspection Program in Texas. The teleconference was conducted at 3:00 p.m. on April 25, 2018.

Below are the key points made during the interview:

- Gulf States Toyota performs mandated inspections on new vehicles to ensure the vehicle is in the safest condition possible; approximately 180,000 inspections are performed annually.
- Dealerships always check if there is recall on the vehicle.
- Approximately 20% of vehicles that come to the Group 1 Automotive dealership for inspection have an open recall.
- The CTR study team should compare the recall completion rates between states with and without inspection programs.
- Somebody has to physically inspect the vehicle no matter how complicated the vehicle technology is.

When asked about potential improvements to the Inspection Program to tackle fatality-causing vehicle fires, the following was suggested:

- Texas should enhance the Inspection Program by incorporating an open recall check.

H.2. Interview with Shelly Richardson

Shelly Richardson is President of HAF, Inc., and co-owner with her husband of an inspection station in the City of Houston. During the initial interview, CTR learned that the City of Houston contracted with HAF and one other station to perform inspections from 2011 to 2016 of taxi cabs and limousines operating in Houston. The taxi and limousine inspection was separate from and in addition to the state motor vehicle inspection also required for these vehicles. The CTR team traveled to Houston on July 20, 2018, to pick up the inspection records, on loan, from the station for further analysis; see Chapter 6 for the results.

The teleconference was conducted at 9:00 a.m. on June 5, 2018. Below are the key points made during the interview:

- The emissions and safety inspection equipment (made by World Wide, Inc.) can print out vehicle safety recall information; VIC safety-only units provided by TxDIR cannot print out vehicle safety recall information.
- Ms. Richardson has found many defects on vehicles with salvaged titles and almost all vehicles inspected for the City of Houston (she does not believe the state should allow salvaged titles).
- Since 2007, Richardson's station has performed inspections of taxi and limousines—they were found to have many safety issues.
- Ms. Richardson's station has seen too many vehicles with serious defects; she cannot imagine [how many more] without the Inspection Program.
- Ms. Richardson is firm in her belief that the Texas needs the Inspection Program and that it should not be eliminated.

H.3. Interview with Grady McGoldrick

Grady McGoldrick has 18 years of experience as an inspection operator. The teleconference was conducted at 9:00 a.m. on June 6, 2018. Below are the key points made during the interview:

- Mr. McGoldrick's station inspects more than 100 vehicles per week. The number is larger during the first week of each month.
- DPS officials check the inspection stations about once a month.
- Many people do not realize the importance of proper state inspections, and how vital it is for everyone's safety. Under the current inspection program, people can assume that other drivers on the roadway have had a proper vehicle inspection at least within the last 12 months, and are driving with safe tires and brakes. Without the state inspection program, traveling on Texas roads and highways will be much more dangerous for the public.
- In the 18 years he has been inspecting vehicles, a common problem with front wheel drive vehicles is steel belt showing on the back side of the tire tread—although the visible outside tread will look perfectly fine. Mr. McGoldrick commented, "I don't know how many times I have been thanked by customers for catching this dangerous situation before it could have resulted in a blow-out and possibly loss of control of their vehicle."
- Mr. McGoldrick worries about who would bear the responsibility of conducting vehicle safety checks if there is no state inspection program. He thinks that expecting state troopers to pull cars over when they think there is a problem with the car is not a solution. He says

it is very difficult to know that a car is not safe from pure observation and that Texas can't solely rely on state troopers to conduct safety checks. He notes that it would be impossible for state troopers to know the condition of tires, brakes, exhaust, and other inspection items while sitting on the side of the road. Inspections need to be done in a location safe for both trooper and driver. For example, 25 feet of roadway is required for conducting a brake test, which would be neither safe nor sensible if taking place along the roadway with traffic flowing past.

When Mr. McGoldrick was asked about his thoughts on potential improvements to the inspection program to tackle fatality-causing vehicle fires, he mentioned:

- If an inspector smells a gas or oil leak, the car should fail the inspection.
- There is no way to know if the vehicle has a salvage title or not during the inspection.
- Texas needs the Inspection Program and the program should not be eliminated.

H.4. Interview with James Loftin

James Loftin worked for NASA for 40 years prior to operating an inspection station in an emissions and safety testing county for four years. The teleconference was conducted at 10:00 a.m. on June 6, 2018. Below are the key points made during the interview:

- TxDPS audits Mr. Loftin's station every one or two weeks.
- Mr. Loftin uses a stationary laptop, ESP System 1. The ESP System 1 provides statistics on how many vehicles are inspected and how many failed, as well as the number of the vehicles that pass the inspection after repairs.
- TxDPS sends decoy defective vehicles to stations. The decoy driver requests an inspection and if the inspector does not find the defect during the inspection, the TxDPS auditor might issue a citation to the inspector and/or the station. Depending on historical conduct of the station, the station may lose its station license for a specified period of time.
- Mr. Loftin expressed concerns about the placement of the battery in some newer vehicles. Some cars place the battery under the rear seat or in the trunk, which are typically considered difficult-to-reach areas. Mr. Loftin has some concerns about battery acid leaks or other problems related to the battery that are currently not inspected during a safety inspection.
- Mr. Loftin tells his customers whether their vehicle has an open recall (if there is an open recall, he tells the customer what the recall is about).
- Mr. Loftin thinks every station should be able to print a list of open recalls. Currently, only stations that are in emissions testing counties have equipment that can print out a list of open recalls for a vehicle. Stations in safety-only counties that use the VIC unit cannot print out vehicle recall notices.
- Mr. Loftin attended a two-day school for station operators organized by TxDPS.

- Texas needs and should not eliminate the Inspection Program.

H.5. Interview with Terry Meyer

Terry Meyer owned ten inspection stations for five years. He now owns five inspection stations. He has maintained a database for each station and each vehicle inspected, including whether the vehicle failed the inspection the first time, the types of repairs (costs) needed, and whether the vehicle passed the final inspection. The teleconference was conducted at 12:00 p.m. on June 6, 2018. Below are the key points made during the interview:

- Mr. Meyer's stations inspect about 10,000 vehicles a month in recent years.
- Mr. Meyer named the three most common inspection station equipment providers:
    1. Tabis Unit provided by TxDPS – Meyer's station uses this
    2. ESP System 1 – combo of safety and emission, provides recall information
    3. World Wide – safety and emission
- DPS inspects the inspection stations by sending an auditor and/or decoy vehicle to identify compliance issues.
- DPS auditors are always plain-clothed, and are typically the same person from year to year.
- Mr. Meyer mentioned that inspectors that make procedural mistakes receive either written or verbal warnings.
- Inspection reports always provide open recall information to customers in emission counties, but not safety-only counties.
- Texas needs and should not eliminate the Inspection Program.

When Mr. Meyer was asked to suggest improvements to the safety inspection program, he mentioned the following:

- Tell the customers about the recalls—currently inspectors do not need to provide recall information to the customers. Recall information should appear on all inspection reports.
- The inspection should check for massive oil leaks.
- The inspection should check wire harnesses.
- The inspection should check the amount of water in the braking system—this is mandatory in European countries.
- The inspection should check tires; as no one is considering what the tires look like inside and rotting tires can pose a safety hazard.

Mr. Meyer suggested a few potential causes of vehicle fires for consideration when suggesting enhancements to the safety inspection check:

- If a vehicle is in a crash, the fuel pump might still be pumping fuel even after the engine has stopped; this could result in a fire.

- EPA promotes soy-based plastics for electrical wiring insulation, which he believes are more susceptible to fire.
- Batteries located under the rear seat.

H.6. Interview with James Bell

James Bell has been in the vehicle inspection business for 50 years and has extensive experience with safety inspections. The teleconference was conducted at 2:00 p.m. on June 6, 2018. Below are the key points made during the interview:

- A TxDPS auditor comes to the station at least once a month.
- Stations can issue coupons to reduce the inspection fee. An inspection station can charge less than the state-allowed fee of $7.00, but not more than the allowable amount.
- Mr. Bell suggested the following improvements to the safety inspection program:
    a. Wire inspection: wire failure (due to rubber aging or other natural deterioration) could be listed as one inspection criterion
    b. Tire rot check: Tires rot on the inside because of age. Keeping a set of tires for 10 years is too long.
    c. Tread depth gauge to check across the entire width of the tire and not just in the center
    d. A more comprehensive inspection of brakes would improve the inspection program.
- Police officers used to remove inspection stickers if a car was damaged in a crash, and would require the owner to conduct an inspection within a given time period. Now that registration and inspection are covered with only one sticker, it may no longer be possible for an officer to ensure a crashed car is re-inspected after a crash.
- The cost of the Inspection Program to TxDPS includes the auditor and the decoy vehicles used to monitor stations.
- Mr. Bell will fail the inspection if he sees any age cracks in the tire.
- Mr. Bell’s inspection testing equipment gives him recall information, and he provides the recall information to the owners.
- Some businesses perceive that business volume will drop if they do inspections right.
- Mr. Bell believes (automobile) manufacturers should bear the responsibility of recall issues, including contacting the owners.
- In emission counties, station owners pay for the inspection equipment.
- Texas needs and should not eliminate the Inspection Program.

H.7. Interview with Abel Porras

Abel Porras is the co-chair of the Texas State Inspection Association. He visited the Center for Transportation Research on June 13, 2018. The CTR team met with him in person and conducted the interview at 9:00 a.m. Below are the key points made during the interview:

- The minimum and maximum size of mud flaps (splash guards) should be required and added to the safety inspection.
- The Two Steps, One Sticker program is more efficient, and eliminates the need for inspection stations to buy stickers in advance.
- Vehicle safety inspection is not trivial—it is a serious issue. Once, Mr. Porras inspected a vehicle and pointed out a defect that was fixed, and the owner came back to his shop to thank Mr. Porras for saving his life.
- Many companies (such as large tire companies, for example) hold seminars to emphasize the importance of proper inspection of wear-and-tear items, therefore encouraging inspectors to take pride in their work. While being an inspector is not the most high-paying job, inspectors know that their job is important and understand that the outcome of their efforts is saving lives.
- Laws protect against corruption.
- When considering adding inspection items to the list, officials should pay careful attention to making sure the inspection does not over-inspect vehicles by inspecting more unnecessary items, which could increase the likelihood of false failures.
- It would be much better to inspect tire tread depth across the width instead of the middle point only.
- The relationship between inspectors and customers is important because the inspectors make recommendations to the customers about repairs.
- Many first-time failures that are not recorded; therefore, the statistics contained within the TxDPS database do not show a complete picture.
- Though the inspection process has some flaws and shortcomings, it is much better than having nothing.

H.8. Interview with Ed Martin

Ed Martin is the director of Safety & Emission Inspection, Take 5 Oil Change LLC. Mr. Martin is also the Chair of the Texas Vehicle Inspection Association, an advocacy group that represents all vehicle inspection stations. He has worked in and around the automotive service industry segment since the late 1970s. The teleconference was conducted at 10:30 a.m. on June 13, 2018. Below are the key points made during the interview:

- Vehicle recall information is very important and can be obtained during an inspection.

- Moving away from two stickers to one sticker is an improvement. The inspection/registration process is more efficient and effective.
- Mr. Martin has met with Dr. Matthews (who performed a safety inspection study for Pennsylvania) in person. Their studies for Pennsylvania indicate that safety inspections are effective in reducing crashes.
- Mr. Martin does not think that a $7 safety inspection fee costs that much relative to the services rendered.
- Inspection machines have the capability of capturing first-time failures. There is an option that indicates “passed the inspection after repair.”
- DPS offers a two-day training for inspectors. No repeat training is required.
- Some inspection criteria were changed around four years ago.
- The Inspection Program is needed and should not be eliminated.

Appendix I. Workshop

I.1. Workshop Agenda

THE UNIVERSITY OF TEXAS AT AUSTIN
CENTER FOR TRANSPORTATION RESEARCH

Agenda

Costs and Benefits of the Texas Motor Vehicle Safety Inspection Program for passenger vehicles

June 26, 2018

9AM – 3PM

University of Texas at Austin – Pickle Research Campus
Commons Learning Center – Balcones Meeting Room

9AM – 11AM

1. Welcome and brief introductions	Mike Murphy (CTR)
2. Plenary Session Presentations	
a. Overview – Study Scope and Objectives	Mike Murphy (CTR)
b. 'Big Data' Analysis – preliminary results	Nan Jiang (CTR)
c. MVSIP costs	Darren Hazlett (CTR)
d. Incorporating recalls in MVSIP	Michael St. Denis (Revecorp)
e. Online surveys – preliminary results	Mike Murphy (CTR)

Buffet Lunch 11AM – 12PM

12PM – 2PM

3. Breakout Sessions

a. BEVO Room – Workshop attendees
b. Stadium Room – Workshop attendees
c. Balcones Room – WebEx

2PM – 3PM

4. Reconvene – Balcones Room Breakout Session Key Takeaways

5. Adjourn

I.2. Workshop Plenary Session Summary

Dr. Mike Murphy, Dr. Nan Jiang, and Darren Hazlett presented their preliminary findings from this study.

Dr. Michael St. Denis, President of Revecorp, presented information about increasing vehicle recall completion rates by including recall information in the vehicle safety inspection report. Revecorp is currently assisting several states with increasing recall program effectiveness.

Dr. St. Denis pointed out that vehicle recalls are more common than ever. The Takata "Alpha" airbag recall, the biggest in history, is attempting to remedy defective airbags that have a 50% chance of causing death or serious injury if activated. Yet, in general only 65% of vehicle owners perform recall repairs even though repairs are free of charge.

He presented results on a case study conducted with the District of Columbia and Vermont Department of Motor Vehicles on incorporating recall information on vehicle safety inspection reports. This case study showed a 400% increase in recall remedy after printing recall information on the vehicle inspection report. Dr. St. Denis estimated $242 million of potential Texas revenue inflow to Texas car dealerships that service recalls as a benefit of the recall application. The State of Texas would benefit from taxes resulting from repairs and/or replacements of defective parts.

It was noted that in Texas safety and emissions counties do have inspection equipment that can report open recalls. However, safety-only counties do not use the same type of equipment and cannot print out the safety recall information as part of the inspection report.

Ms. Ember Brillhart, a Honda North America company state relations representative, presented the issues associated with unrepaired recalls from the manufacturers' perspective. In general, it is the manufacturer's responsibility to get all recalls fixed to ensure consumer safety; however, reaching all owners is a challenge. Working together with States by either requiring mandatory repairs or helping notify owners of open recalls is key to preventing serious injuries or even deaths associated with recalls. Ms. Brillhart pointed out that Texas is a key Takata state, because the high heat and humidity increases the risk for the Takata airbag to fail. Honda has done everything possible to try to reach all owners about the Takata airbag recall, yet still many vehicles need to be remedied.

Ms. Brillhart mentioned two solutions with a potential of significantly ameliorating the unfixed recall issue. The first is to make open recall repairs mandatory at the State level, and the second is to leverage inspection facilities as a way to notify owners of open recalls. Incorporating recall information into the vehicle inspection report would add additional value to the Inspection Program by enhancing safety for all road users. Some specific points made by Ms. Brillhart and Dr. St. Denis about Texas included the following:

- Honda estimates that approximately 1,000,000 Honda vehicles are on the road in Texas still equipped with Takata airbags. Honda has made several different attempts to reach these motorists through Honda dealerships, newspaper ads, direct mailings, and other methods. Honda employees have also located crashed or junked Hondas, which had intact Takata airbags. These vehicles were then purchased by Honda to ensure that defective spare parts would not be resold to the public.

- One problem with making recall repairs mandatory to pass a state inspection is repair parts availability. In some instances, very large recalls might result in delays of several months before repair parts for the recall are available. Thus, it would not be appropriate to prevent a motorist from passing a state safety inspection due to unrepaired recalls due to lack of repair parts.

I.3. Breakout Group Discussion Questions

These questions were presented to breakout groups for discussion after breakouts sessions were completed.

1) The CTR study team is analyzing the following data types. Are there other types of data we should also consider? If so, do you know who we would contact to obtain this data for Texas?

- Crash Record Information System (CRIS) data	TxDOT
- Law Enforcement Officer's CR-3 crash investigations	TxDOT
- Highway Safety Improvement Program crash costs	TxDOT
- Texas Roadway posted speeds by route type and/ or lane miles	TxDOT
- Enforcement Officer's Roadside Stop Citation data	TxDPS
- Inspection Program Costs	TxDPS, TxDIR
- Vehicle Registration Data	TxDMV
- Vehicle Owner Surveys about inspections	CTR Survey
- Inspection Station Owner Surveys	CTR Survey
- In person or telephone interviews with stakeholders	CTR

2) Are there any additional factors that the CTR study team should consider regarding benefits or dis-benefits of Motor Vehicle Safety Inspections for passenger vehicles?

3) For a number of years, the City of Houston has conducted separate motor vehicle safety inspections of taxis and limos that include more factors than the Inspection Program. These inspections were conducted at a Texas motor vehicle inspection station and comprise several thousand records. If CTR obtained access to these records, do you think this information:

a) would help inform this study, though only about a small sub-set of vehicles.
b) would not be applicable to this study even if the results were reported separately from the Texas Motor Vehicle Safety Inspection analyses.

4) A Texas motor vehicle station operator has maintained detailed records about the inspection process including the number of first-time failures, the specific parts that were replaced or repairs that were made and whether the vehicle passed second inspection. This information includes thousands of vehicles inspected at 10 stations located in emissions counties and counties in which vehicle emissions testing is not required. If CTR obtained access to analyses results from these records, do you think this information:

a) would help inform this study, though only about a small sub-set of stations and vehicles.

b) should not be included in this study even if the results were reported separately from the Texas Motor Vehicle Safety Inspection analyses.
c) I am unsure

5) The CTR study team has talked with many advocates of motor vehicle safety inspections, but few individuals who opposed inspections. Can you suggest certain types of drivers, companies, commercial trade / advocacy groups or other entities that might support elimination of motor vehicle safety inspections for passenger vehicles? We would like to interview those individuals.

6) Are there improvements to the vehicle safety inspection process that could enhance highway safety in Texas? Some examples that have been discussed with stakeholders include:

a) Reporting vehicle open recalls as part of the inspection report. This is currently done only in Texas's emissions counties which use different equipment than counties which do not conduct emission testing and cannot produce recall reports.
b) Taking tire tread depth measurements across the width of the tire, not just in the center.
c) Checking electrical wiring and wiring harnesses for cracked insulation and possible other defects that could potentially result in a vehicle fire.
d) Requiring tires older than six years to be inspected on the inside for tire rot, or even requiring replacement of tires based on age.
e) Checking battery condition for leaks or other signs of defects. Batteries are sometimes mounted within the passenger compartment under a seat, or within the trunk which protrudes into the passenger space.

Are there any other inspection items that you think should be added to this list?

7) Do you think that advances in passenger vehicle design have eliminated the need for motor vehicle safety inspections in Texas?

a) If yes, which particular vehicle design advancements have made the greatest contribution?
b) If no, why do you think this is the case?

8) Do you think that advances in passenger vehicle design within the next 20 years—vehicle-to-vehicle (V2V) communications; vehicle-to-infrastructure (V2I) communications; fully autonomous vehicles—will eliminate the need for passenger vehicle safety inspections in Texas?

a) If yes, which particular future vehicle design advancements will make the greatest contribution?
b) If no, why do you think this is the case?

9) In general, do you think vehicle owners have a good knowledge about the specific items that are being checked during a vehicle safety inspection?

a) Very few vehicle owners know what is being inspected
b) Perhaps half of vehicle owners know what is being inspected
c) The majority of vehicle owners know what is being inspected

d) Not sure

If 'very few vehicle owners know what is being inspected', do you think that an education program for motorists is needed to improve their knowledge of the inspection process? Could this enhance highway safety?

If 'half of vehicle owners know what is being inspected' does this still support the need for an education program for motorists to improve their knowledge of the inspection process? Could this enhance highway safety?

If 'Most Vehicle owners know what is being inspected', how did these individuals learn about the Safety Inspection process and which items are inspected?

If you are 'unsure', do you think it is important for vehicle owners to know what is being checked during a safety inspection? Could this enhance highway safety?

10) Referring to the following two graphs [Figures I.1 and I.2], do you think this information supports keeping the motor vehicle safety inspection fee the same as it is now, increasing the fee, or decreasing the fee?

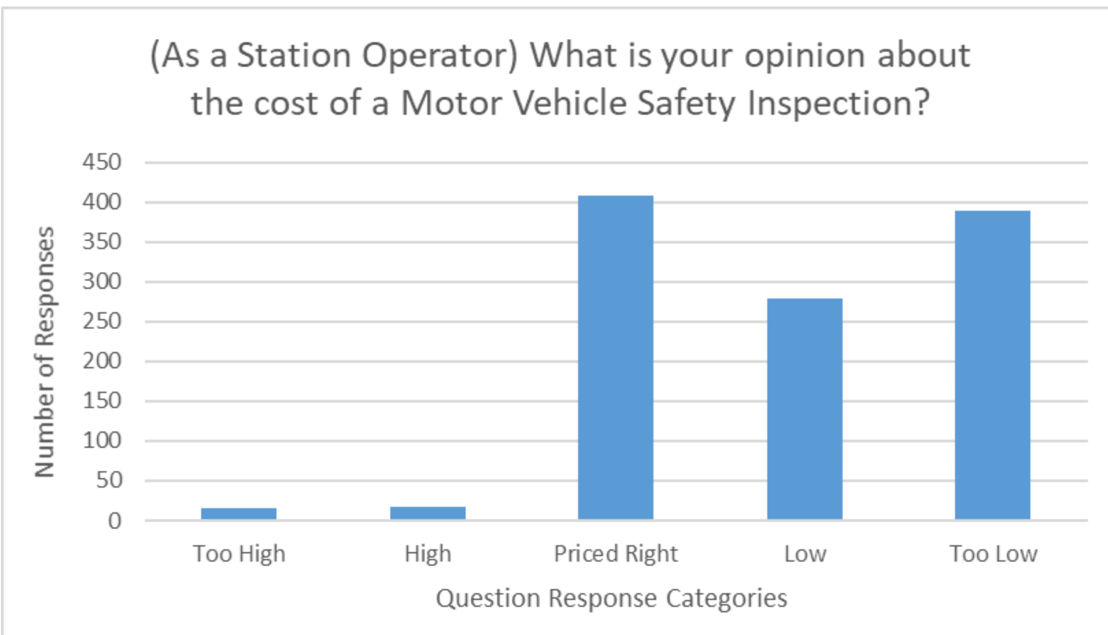


Figure I.1. Safety inspection station operators' opinions about the cost of an inspection

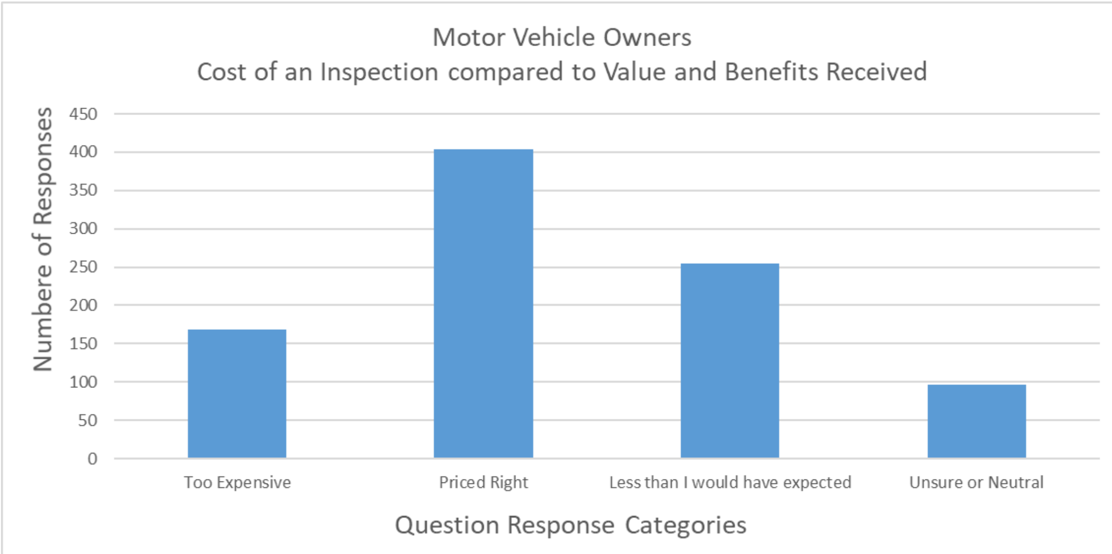


Figure I.2. Vehicle owners' opinions about the cost of an inspection

11) Texas is noted for having the highest posted speed limit in the U.S. (85 mph on a toll road between San Antonio and Austin), and the highest average speeds for rural interstates. Do you think if passenger vehicle safety inspections were eliminated in Texas this would:

a) Result in higher risk for Texans and out-of-state motorists traveling in Texas, compared to other states?
b) Result in about the same risk for Texans and out-of-state motorists traveling in Texas, compared to other states?
c) Result in lower risk for Texans and out-of-state motorists traveling in Texas, compared to other states.
d) Why or why not?

12) Based on rough estimates, it is believed that a fatality crash usually requires from four to six hours to be investigated and cleared from the roadway. Incapacitating injury crashes may require less time—though each crash might still require hours to investigate and clear from the roadway.

13) It has been stated that Texans spend 9,000,000 hours per year having their passenger vehicles inspected. Do you think that:

a) The number of hours of delay should at least equal or exceed the total number of hours Texan's spend having their vehicles inspected to demonstrate that Safety Inspections are beneficial.
b) The number of hours of delay could be less than the total number of hours Texan's spend having their vehicles inspected, but still demonstrate that Safety Inspections are beneficial. However, the number of hours of delay should be at least __________ % of the total hours of Safety Inspection time.
c) I'm unsure.

14) Did CTR miss an important question that should be discussed during the breakout session? If so, please write the question below—we may have time to discuss your question during the breakout session.

I.4. Breakout Group Discussion Summary

The following subsection reviews the answers given by stakeholders for each question.

Question 1

The first question listed all the data sources currently being evaluated by the CTR team members and asked stakeholders to suggest additional data sources that would benefit this study. Stakeholders suggested the following items:

- Consider first-time failure rates at "inspection only" stations
- Obtain inspection and failure rate information from vehicle fleet owners
- Obtain open vehicle recall data from NHTSA
- Obtain fatality crash data from FARS
- Obtain repair receipt data to calculate first-time failure rates
- Consider relevant data from neighboring states
- Evaluate motorcycle data
- Increase the number of motor vehicle survey responses
- Obtain access to an insurance claims database

Stakeholders also suggested contacting various associations that might have information, personal contacts, or data that would benefit this study. These following associations were named:

- Texas Sheriff's Association
- Texas Police Chiefs Association
- DPS Officers Association
- Houston Police Association
- Houston Police Union
- American Automobile Association
- Councils of governments (COGs) and metropolitan planning organizations (MPOs)

Question 2

This question asked whether there were additional factors that could contribute to the benefits and/or dis-benefits of the Inspection Program that should be considered by the CTR team members.

Suggestions for additional factors to consider ranged from economic factors to educational benefits. The following additional factors were mentioned by stakeholders:

- Positive economic impact resulting from higher recall completion rates
- Positive economic impact to business
- Customer services aspect of the safety inspection program
- Safety failures that cause a property-damage-only crash and are not reported
- Positive effect of vehicle safety educational campaigns
- Registration rates in states with different safety inspection frequency requirements or with no safety inspection program

The discussion handout gave an example regarding the effects of an educational campaign initiated by the State of California. As part of an educational campaign, a pamphlet describing the meaning of various engine warning lights was made and distributed to Californians. According to the workshop attendee, the pamphlet was very well received, quite popular, and overall useful to the public. There are other programs similar to this one that would be useful to review. The handout noted that the North Central Texas Council of Governments (NCTCOG) has developed a similar educational pamphlet that has been well received.

Stakeholders mentioned that the CTR team should carefully consider the validity of the data being considered. For example, some states have tweaked their safety inspection program in terms of the items reviewed. These differences in programs could make a safety inspection program seem less defendable in terms of benefits versus costs if those differences are not considered.

Another stakeholder commented that it is important to note that any perception of "savings" from dissolving the program is false because the funds would just get reallocated to another portion of the budget.

Question 3

Question 3 asked stakeholders if they believed that reviewing the City of Houston taxi and limo vehicle inspection database, which includes more factors than TxDPS state safety inspections, would help inform the study. It was mentioned that perhaps the CTR team members could mine some first inspection failure rate information from the Houston database. Concerns and comments regarding extracting information from this database included:

- Data might not be useful for PVs because taxis and limos are high mileage (500,000+ mi on odometer), which means they deteriorate faster.
- This is a small subset of data for a single location within the state.
- Every fleet has its own standards.

In general, all groups, except for one, believed that the Houston database would help this study in at least some way. The one group who did not agree that this database would help stated that that the additional factors likely only include softer items, such as a background check. One of the stakeholders in this group had previously served on the Houston City Council and remembered seeing the list of additional safety items for the taxis and limos. He believes that the fleet relies on the state safety inspection for the vehicle fleet. However, another stakeholder in a different group has participated in conducting the taxi/limo inspections for Houston for many years and did not mention that the additional factors only include soft items that would not benefit this study.

Other comments were made by stakeholders that do not directly answer Question 3, but are useful for this study. For example, it was mentioned that City of Dallas had a similar program for taxi and limo inspections that was recently suspended, but data from the program can be provided by a workshop attendee. Another comment was made about cab companies not being the only ones with vehicles deteriorating much faster than the average vehicle. Other types of ride sharing vehicles are likely putting many more miles on their own personal vehicles than the average motorist. A workshop attendee offered to provide more information about one of the new 'for hire' ride share companies.

Question 4

This question asked stakeholders whether they believed that information from one particular station operator who has maintained very detailed inspection records for ten stations he owns would help inform this study. These detailed records include the number of first-time failures, the specific parts replaced, and the whether the vehicle passed the second inspection.

The overall consensus from workshop attendees was that there is no harm in analyzing these results and that the statistics would help this study. In fact, one group mentioned that it is possible that these ten stations represent the true population group. The concerns that were mentioned regarding reviewing this database include:

- Missing first-time failure data from situations, for example, when customers are advised to fix parts upon entering the station to ensure passing before officially starting the inspection.
- Needs contextualization in terms of vehicle density/population.

Question 5

This question asked stakeholders to suggest certain types of drivers, companies, groups, or other entities that might support the elimination of the Inspection Program. In general, the political groups that veer to the hard right and are against taxes and regulations are possible supporters of the Inspection Program elimination.

Certain types of drivers and companies were suggested as potential supporters of the Inspection Program elimination:

- *Companies that have the means and desire to maintain their own fleet of vehicles.* One stakeholder suggested that AT&T might be one of those companies. With respect to the certain types of drivers that would support the elimination of the program, it was suggested that there are some people that simply do not like others touching their car. These people tend to do all their own maintenance work and believe that their car is safe and well maintained.
- *People who prefer that no one touch their vehicle*. According to a station operator, 'people who don't want someone else touching (or driving) their vehicle, are in the minority. It was mentioned that drivers that have many vehicles perhaps view taking all of their vehicles to get inspected as a time-consuming burden.
- *Low-income families. A*lthough the fee is affordable, might have a tight budget and feel that the fee is an issue.
- *Advocacy groups for the elderly might be possible supporters*. One group mentioned that some of the elderly might be eligible for some sort of inspection exemption. However, this claim has not been corroborated.

Question 6

This question asked stakeholders to suggest possible improvements to the safety inspection process and provide examples. The list of examples follows:

- Reporting open recalls info in the inspection report in safety-only counties.
- Taking tire tread depth measurements across the entire width of the tires.
- Checking for cracked insulation in electrical wiring and wiring harnesses.
- Inspecting tires older than six years for tire rot, and require replacement of rotting tires.
- Checking battery condition for leaks or other signs of defects.

The overall consensus was that the inspection report should list vehicle safety recall information. Questions were raised as to whether completing the safety recall should be made mandatory before issuing a new registration sticker. The problem with making recalls mandatory is there are times when vehicle manufactures are behind in producing replacement parts, as mentioned in the Takata airbag case during the plenary session. WebEx group members noted that it is not fair to hold owners at fault for something that the manufacturer cannot make available.

There were some concerns expressed with respect to the examples listed in the question. With respect to taking tread depth measurements, some tires have low profile diameters, which make measuring across width difficult or perhaps impractical. Another stakeholder questioned the value of preventing a fire hazard by checking for cracked insulation in wiring. Another stakeholder mentioned that the battery leak check is not necessary, and for batteries that are very difficult to reach this item would be cost prohibitive. Lastly, there were concerns with inspecting tires older than six years. Stakeholders suggested that 10 years seems more practical, and that in reality it is very difficult to know the age of a tire. Though after the workshop, CTR obtained information about tire date information based on a National Transportation Safety Board presentation advocating inspections for tire age, that the age is printed on the side of the tire including the week and year the tire was manufactured. Thus, 2915 would mean that the tire had been manufactured in the 29th week of 2015.

Some stakeholders suggested additional items to add to the safety inspection list. The following items were suggested:

- Add tire inflation pressure assessment.
- Check for obvious fluid leaks.
- Check headlight integrity.
- Address airbag-related items in the inspection process. According to a group expert, airbag lights are on in approximately one-third of vehicles inspected, highlighting the need.
- Improve the braking test.
- Add information on items that are technically passing, but very close to the end of their service life to the report.

There were concerns about “over-testing” as a result of trying to increase the scope of the safety inspection. For example, in newer cars an on-board diagnostic (OBD) scanner can run diagnostics to determine issues, such as problems with sensors. However, there are times when the scanner is wrong. An expert mentioned that not all inspection stations have an automotive expert present that has the ability to check whether the OBD is working well. A TxDPS member agreed and mentioned that it is best to keep the scope to a minimum by only checking the basic wear and tear items. Another point mentioned was that increasing the number of items in the list will increase the fees. However, most safety inspection items are not directly linked to the OBD; rather emissions testing items such as sensor malfunctions that can cause and engine check light to come on are connected to the OBD. A malfunctioning gas cap, which is checked during a safety inspection can also cause the engine check light to illuminate.

Question 7

This question asked stakeholders if they believed that advancements in PV design have eliminated the need for the Inspection Program in Texas. Overall, all stakeholders agreed that vehicle advancements do not eliminate the need for the safety inspection program.

Despite all the advanced safety features provided, the likelihood is high that there will be some items that the average owner will have trouble identifying or will forget to check. The safety program ensures that key wear and tear items, which pose a safety hazard to drivers and other road users, are indeed checked. Even brand-new cars have a chance of failing inspection. One stakeholder believes that up to 11% of new vehicles could fail inspection at the point of drop-off at a dealership. Stakeholders believed that the inspection provides benefits to owners, other road users, and provides the opportunity to get recalls fixed.

Question 8

Similar to the previous question, this question asked stakeholders if they believed that advancements within the next 20 years will eliminate the need for the Inspection Program in Texas. Once again, the overall group consensus was that even in the next 20 years, advancements in design will not eliminate the need for the program. Stakeholders as a whole do not anticipate that autonomous vehicles or other advancements in design will have components that are totally immune to wear and tear. In short, the safety inspection should always remain since vehicle components will always wear down.

Question 9

Stakeholders were asked if they believe that vehicle owners have a good understanding about the specific items that are checked during the safety inspection. Opinions varied across the board, but overall consensus was that the majority of people probably know at least a few items, but very small percentage know the entire list.

It was generally agreed upon that enhanced education efforts would be beneficial and are important. Suggested methods for disseminating information included:

- Posters
- Brochures
- Advertisements
- Billboards (digital and traditional)
- Direct mail
- Pamphlets describing the various check lights that appear on a dashboard, similar to ones made in California
- Social media
- Technology-based dissemination, i.e., sending out push notifications when vehicles are a determined number of days away from inspection

TxDPS group members made note that all information related to the inspection can be found online, including inspection training videos. Some challenges with respect to circulating educational information were mentioned, including:

- Some people do not care to know.
- Some people do not want to know.
- Some people do not look at educational materials, even if it is there in front of them.

Question 10

Stakeholders were asked whether they believed the data presented by two charts supported keeping the inspection fee the same or changing it. The graphs that were presented to them at the workshop are provided as Figures I.3 and I.4.

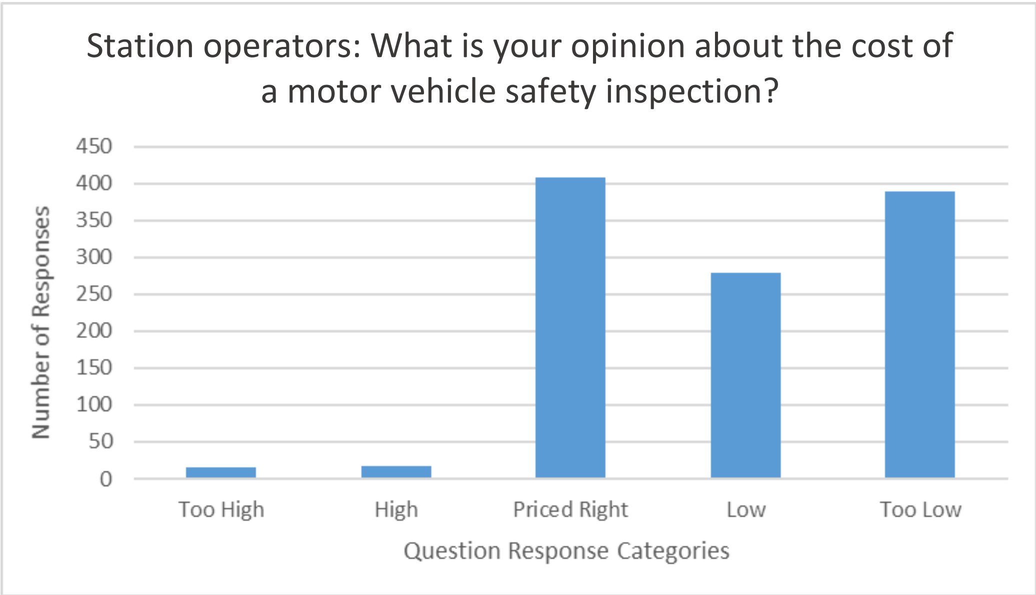


Figure I.3. Inspection station operators' opinions about the cost of an inspection

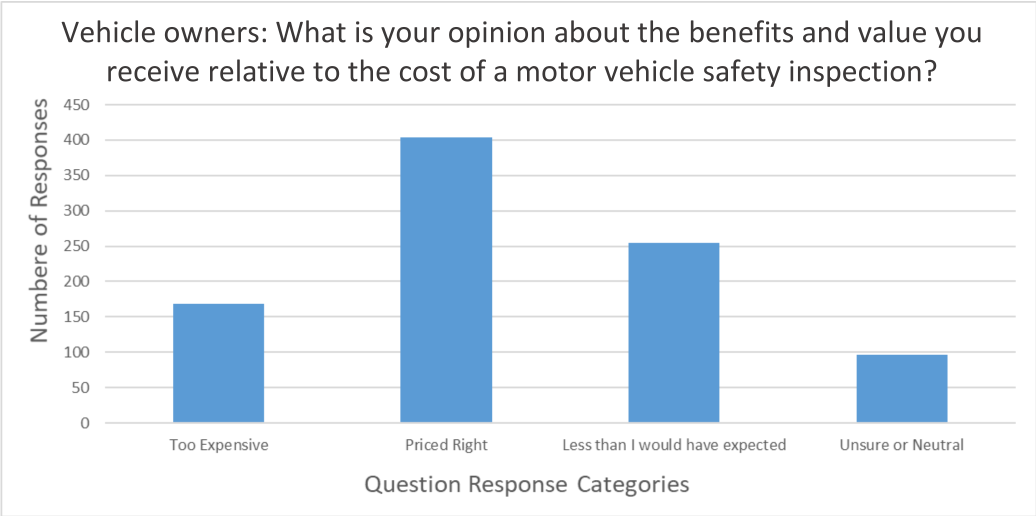


Figure I.4. Vehicle owners' opinions about the cost of an inspection

Two groups expressed concern with how the question was phrased in the survey. Specifically, this question did not clarify that the cost was supposed to be the safety fee only, which is $7.00 paid to the inspection station; an additional $7.50 fee is paid at registration. Some survey respondents may have answered based on the safety and emissions inspection, costing up to three times more than the safety-only inspection. There was also some concern with respect to whether or not this sample represents a true cross-section of the population. For example, it is not clear that the elderly or families with a low socioeconomic status are represented in this sample.

Broadly, stakeholders believe that this data can support increasing the inspection fee. One group said that most people would agree that $7 for a safety inspection is a bargain. Another mentioned that individually checking all the items on the list costs more than the pre-arranged price, especially when considering that the value of an inspector's time is undervalued with the current pricing. Those that mentioned the graphs support keeping the fee the same did mention they believed the market could tolerate a higher fee.

Question 11

This question asked stakeholders if eliminating vehicle safety inspections in Texas would affect accident risk, given the fact that Texas has the highest posted speed limit and more miles of roadway with high speed limits in the country. The question had three options: risk increases, risk stays the same, or risk decreases. One stakeholder was wondering why stakeholders were being asked about risk staying the same.

Many stakeholders remembered the presentation given in the plenary session and said that it is very clear that higher speed limit results in increased fatality risk. Various studies and anecdotal evidence were suggested to support the perception of higher risk for Texans, such as the following:

- A study from Pennsylvania showing inspections should continue.
- A North Texas Toll Authority study.
- Anecdotal evidence from South Carolina indicates numbers of crashes have increased since safety inspections were eliminated.
- Anecdotal comment noted that cars from Oklahoma are in poorer conditions than Texas vehicles, which was attributed to that state not having an inspection program.

A stakeholder mentioned a highway in Germany, which has no speed limit, but has remarkably low crash rates. In Germany, cars undergo extensive vehicle testing and inspection. These inspections are mandatory and are conducted by highly trained engineering professionals.

Question 12

Stakeholders were told that fatality crashes take about four to six hours to clear from the roadway and that Texans spend 9 million hours a year getting PVs inspected. This question asked stakeholders to state the relationship (equal, exceed, other) between hours of delay and hours of inspection would show that safety inspections are beneficial.

Out of the six groups, only one suggested a relationship for the hours of delay to hours of inspection to show the benefit of time spent getting an inspection. The group suggested that the hours of delay should at least equal the hours spent getting an inspection. Every other group mentioned that this comparison does not make much sense.

Stakeholders mentioned the following concerns with respect to this comparison:

- Validation of the 9 million hours estimate in general. For example, inspections during the middle of the month usually have less wait time.
- The value of time for ensuring safety and the value of time for convenience are not the same.
- Not clear if the time saved since Texas went stickerless is factored in.
- Need to disaggregate data on regular congestion from incidence times to determine the calculation versus inspection time.
- Need very accurate data on incident clearance.
- Need to clean data points to adjust for time taken for other maintenance and the inspection is an ancillary add on.

Overall, stakeholders agree that without a safety inspection program, there will be more crashes on Texas roadways, causing more time spent in traffic for users.

Question 13

Stakeholders were asked if they believed serious crashes resulting in totaled vehicles could result in negative impacts to the environment. Comprehensively, the group agreed that one or more totaled vehicles could result in negative impacts to the environment. One group commented that it will probably be difficult to quantify the impact with the data sources that are available. Possible environmental impacts were suggested, such as:

- Petroleum product leaks.
- Hazardous material spills.
- Broken vehicle parts and debris.
- Vehicle fire.
- Smoke.
- Increased emissions from congestion.
- Battery leaks.

A stakeholder suggested that the impacts might be different if a crashed vehicle remains on the road versus drives to a different location.

Question 14 (Other Issues)

Stakeholders had an opportunity to discuss other issues, comments, or opinions that were did not pertain specifically to the list of questions. The feedback gathered was combined and is described below:

On Inspection Stations in Texas

- There are too many stations and too many inspectors in Texas.
- Some inspection stations do not necessarily do a thorough job conducting a safety inspection, which casts doubt on the integrity of the program.
- TxDPS conducts audits of safety inspection stations, but it is unknown how effective these audits are in eliminating inspection stations that 'sell' passing inspection reports.

However, these comments are points of view based on anecdotal evidence and not currently substantiated with facts or data—at least based on what has been provided to the CTR study team.

TxDPS does not have the authority to deny an individual from applying for an inspection station license and being approved to conduct safety inspections as long as the state guidelines and rules are met. Additional authority and resources should be provided to TxDPS to provide more effective management of inspection stations and the inspection program.

On the opposing side, one group commented that there were an insufficient number of inspection stations for the 22 million inspections conducted in Texas last year.

On the Data Collection Effort

- As a whole, the surveys as presented seemed complete to stakeholders; however, better outreach efforts are needed.
- Local law enforcement agencies are responsible for the majority of accident reporting, and for non-fatality crashes level of detail might be lower than needed for this study.
- Some stakeholders believe that law enforcement does not have the ability to visually identify more complex mechanical defects, and that there is a significant degree of vehicle defect under-reporting in CR-3 reports.
- The CTR team should visit an inspection station to gain insights on first-time failure rates.
- The CTR team should consider trailer inspection data.

Miscellanea

- Dealership owners might support the legislation promoting complete vehicle inspections to increase revenues. Complete inspections costs $25 instead of $7.
- Long waiting times should not motivate the abolishment of the Inspection Program. Some station operators indicated that the number of drivers requesting an inspection increases significantly during the last and first week of the month, increasing wait times for this group.
- CTR should estimate the potential increase in Texas liability insurance rate as a result of abolishing the program.

Appendix J. Vehicle Owner Online Survey

CTR developed an online survey (shown below) to obtain information regarding the public's experience with and opinions about the costs and benefits of PV safety inspections. UT is licensed to use the Qualtrics™ online survey and data analysis tools.

--Reproduction of Online Survey ---------------------------------

Information only
Texas Motor Vehicle Safety Inspection Program Survey

The State Legislature has required the Texas Department of Public Safety (DPS) to report on the costs and benefits of the Texas Motor Vehicle Safety Inspection Program. DPS has contracted with the University of Texas at Austin – Center for Transportation Research to assist in preparing this report. Your participation in completing this survey is much appreciated.

If you have any questions regarding this survey, please contact:

Dr. Mike Murphy, P.E.
(512) 232-3134
michael.murphy@engr.utexas.edu

THE UNIVERSITY OF TEXAS AT AUSTIN
CENTER FOR TRANSPORTATION RESEARCH

Page Break

Q1 Please tell us the location of the Vehicle Safety Inspection Station where you often have your vehicle inspected:

- ◯ City: (1) ____
- ◯ County: (2) ____

Q2 What is your gender?

- ◯ Male (1)
- ◯ Female (2)

Q3 Please tell us more about your vehicle:

- ◯ Year: (1) ____
- ◯ Make: (2) ____
- ◯ Model: (3) ____

Q4 Do you think having a Vehicle Safety Inspection Program improves highway safety in Texas?

- ◯ Strongly agree (1)
- ◯ Somewhat agree (2)
- ◯ Neither agree nor disagree (3)
- ◯ Somewhat disagree (4)
- ◯ Strongly disagree (5)

Q5 Do you think that having your vehicle inspected annually helps improve highway safety?

- ◯ Definitely yes (1)
- ◯ Probably yes (2)
- ◯ Might or might not (3)
- ◯ Probably not (4)
- ◯ Definitely not (5)

Q6 Do you think having your vehicle inspected takes too much time?

- ◯ Definitely yes (1)
- ◯ Probably yes (2)
- ◯ Might or might not (3)
- ◯ Probably not (4)
- ◯ Definitely not (5)

Q7 Please indicate your opinion about the money you pay for a Motor Vehicle Safety Inspection:

- ◯ I regard it a "tax" for which I receive a service (1)
- ◯ I regard it a "fee" for which I receive a service (2)
- ◯ I am unsure if it is a "tax" or a "fee", but I do receive a service (3)
- ◯ I am unsure if it is a "tax" or a "fee", but I don’t think I receive a service (4)

Q8 Do you think vehicles on the road that have defects (e.g., slick tires, bad brakes, head or tail lights out, signal lights not working, steering problems) could contribute to an accident?

- ◯ Definitely yes (1)
- ◯ Probably yes (2)
- ◯ Might or might not (3)
- ◯ Probably not (4)
- ◯ Definitely not (5)

Q9 Do you think for the benefits and value you receive, the cost of a Motor Vehicle Safety Inspection is:

- ◯ Too Expensive (1)
- ◯ Priced right (2)
- ◯ Less than I would have expected (3)
- ◯ Unsure or Neutral (4)

Q10 In the past, have you had a Motor Vehicle Safety Inspection which found a safety problem that required repairs or replacement parts for your vehicle? (check all that apply)

- ▢ Yes, repairs or replacement parts were needed. The Inspection Station was able to fix the problem. (1)
- ▢ Yes, repairs or replacement parts were needed. However, I had to take my car elsewhere to have the repairs done. This took more time. (2)
- ▢ Yes, repairs or replacement parts were needed. However, I bought the parts and did the repair myself or with relatives/friends. This took more time. (3)
- ▢ No, my vehicle has never needed any repairs or replacement parts (4)

Q11 If you have had repairs or purchased replacement parts as a result of a Motor Vehicle Safety Inspection, please indicate the number of times this has happened over the years:

____

Q12 If you have had repairs or purchased replacement parts as a result of a Motor Vehicle Safety Inspection, what types of repairs or replacement parts were needed? (check all that apply)

- ☐ Worn, slick or defective tire(s) (1)
- ☐ Headlight was out (2)
- ☐ Tail light was out (3)
- ☐ Signal Light(s) were out (4)
- ☐ Horn was not working (5)
- ☐ Muffler needed replacement (6)
- ☐ Windshield Wiper Blades needed replacement (7)
- ☐ Steering mechanism needed repair (8)
- ☐ Worn brakes which needed adjustment or replacement (9)
- ☐ Other reason(s) (Please specify in the next question) (10)

Q13 You selected other reason(s) in the last question, please specify them here:

____

____

____

____

Q14 If your vehicle needed a repair or replacement parts before it would pass a Safety Inspection, please indicate which of the following statements are true. (check all that apply)

- ▢ The vehicle inspector noticed the problem before the Inspection was performed and told me to have the problem repaired, then bring my vehicle back for the Inspection. (1)
- ▢ The vehicle inspector talked to me after the inspection had started and told me I needed repairs or replacement of parts that could be done by the Inspection Station. If the repairs were not done, my vehicle would not pass. I had the Inspection Station make the repairs. (2)
- ▢ The vehicle inspector conducted the Inspection, found a problem and failed my Vehicle. I then had the repair made at another location and brought my vehicle back for a 2nd inspection. This took additional time. (3)

Q15 Do you pay more attention to your car's maintenance during the year because you know that your car must eventually pass a Motor Vehicle Safety Inspection?

- ○ Definitely yes (1)
- ○ Probably yes (2)
- ○ Might or might not (3)
- ○ Probably not (4)
- ○ Definitely not (5)

End of Block: Default Question Block

The survey was designed to provide the CTR study team with anonymous information from both male and female drivers from all regions of the state. The primary distribution methods included the following:

1. A poster was developed for placement in over 6,500 inspection stations. The poster provided a brief explanation of the purpose of the survey and provided a QR Code and the URL for the online survey (Figure J.1).

Figure J.1. Poster advertising the vehicle owner survey

2. TxDPS posted a link to the survey on the Inspection webpage of the TxDPS website.
3. CTR posted the link to the survey on its various social media pages (Facebook, Twitter, etc.)
4. The following councils of governments (COGs) and metropolitan planning organizations (MPOs) posted the survey link on their social media pages.
    a. Corpus Christi MPO

   b. Alamo Area COG
   c. Texoma COG
   d. Brownsville MPO
   e. Harlingen-San Benito MPO
5. The following COGs and MPO agreed to distribute the survey link to individuals using their email distribution lists.
   a. North Central Texas COG
   b. Deep East Texas COG
   c. Heart of Texas COG
   d. San Angelo MPO
6. CTR obtained email addresses by examining many different online sources including town and city chambers of commerce, Texas associations and advocacy groups, and random searches for email addresses based on job types (house painter, welder, real estate agent etc.). In addition, the selection of faculty and staff emails from both public and private universities, community colleges, independent school districts, and many other sources were used to obtain the required number of completed surveys to provide a statistically significant sample size for different survey categories.
   a. This approach was taken since other methods that were implemented early in the study, though helpful, were not providing a sufficient number of surveys to achieve a statistically significant sample size for the various disaggregation methods CTR intended to use to study the data.
   b. A Texas resident email address data source was not available to the study team members from which random email addresses could be selected.
   c. Purchasing a sufficient number of email addresses from a private company to obtain the desired sample size would have been prohibitively expensive. However, purchasing a random selection of email addresses from one or more private companies may not have accomplished study objectives in any case, as described in the following sections.
   d. A purely random selection of email addresses for Texas residents, though in any case not available, was considered to be inappropriate for this particular study for the following reasons:
      i. Texas has a population of approximately 25 million people based on the 2010 US Census and just over 28 million based on 2017 state population estimates (US Census Bureau, 2012). The US Census Bureau methodology for determining rural, mostly rural, urban, and mostly urban county designations was used in this study based on US Census Bureau definitions and information (US Census Bureau 2012) (US Census Bureau 2016). Surveys were distributed to ensure all four county designations were sampled.

ii. Approximately 76% of the state's population lives within the Texas Triangle megaregion (see Figure J.2), which is encompassed by Dallas-Ft. Worth in the north, Austin-San Antonio in the southwest, and Houston-Galveston in the southeast (America 2050, n.d.) (Harrison and Johnson 2012).

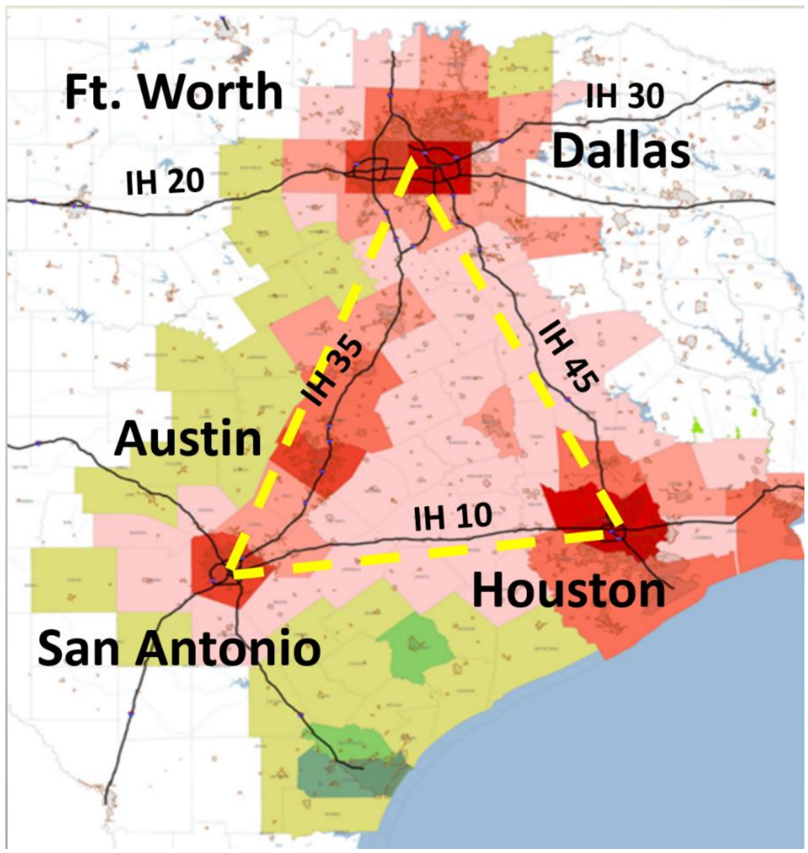


Figure J.2. Texas Triangle megaregion (bounded in yellow dashed line) modified from Harrison et al. 2012

iii. Approximately 84% of the Texas population lives in urban or partially urban counties, based on the US Census Bureau definitions, which encompass the Texas Triangle megaregion and additional smaller cities outside the megaregion. The remaining 16% of the population live in rural or mostly rural counties

iv. The CTR study team made the decision that only email addresses that contained a person's initial and last name or a first and last name would be used in the emailed invitations. Thus, the team did not purposefully send email invitations to a business email address or other similar addresses with, as examples, an impersonal prefix such as info@, Receptionist@, or bidestimate@. During the search for email addresses meeting these criteria, the team noted that females are more likely to include their first and last name or initial and last name in a business email address than are males. Thus, though the study team did not purposely choose to send emails to either males or females, or record the number of emails sent to male or female recipients, based on experience more invitation emails were sent to females than males. However, the study team found that when receiving completed survey responses, throughout the course of the email survey invitation campaign, more males than females responded based on survey responses.

Thus, as invitations were distributed, consideration was given to county location within the Texas Triangle megaregion, the US Census county definitions based on county population distribution (urban, mostly urban, rural, or mostly rural), and other factors when selecting and distributing emails. If emailed invitations had been distributed purely randomly to Texas counties without regard to population, this may have resulted in under- or over-representation of one or more of factors. These factor include, but are not limited to, 1) emissions and safety inspection counties (17 out of 254 counties) versus safety-only inspection counties (237 out of 254 counties); 2) sufficient numbers of survey responses from rural county residents and Texas Triangle counties in consideration of local and regional populations; and 3) adequate representation from each region of the state, such as West Texas, which may have one or two counties with a large population surrounded by several counties with very small populations (e.g., El Paso, Lubbock, Amarillo, Midland, and Odessa).

v. For purposes of the following discussion, a "completed survey" is one that the Qualtrics Data & Analysis metadata indicated is 100% complete. This means that all questions in the survey contained a response, though the survey respondent might not have indicated their location, gender, or type of vehicle. However, the vast majority of all completed survey responses also included gender, city, county, and vehicle information.

Through these methods approximately 69,200 invitations to participate in the online survey were emailed by CTR statewide to every county. However, as survey responses were received from various counties, it was found that the response rates varied significantly between urban and rural areas. At the time of this writing, approximately 1,096 completed surveys have been received from rural or mostly rural counties, which required sending nearly 26,000 emailed survey invitations—this represents a response rate of approximately 4%. Approximately 4,841 completed surveys have been received from urban or mostly urban counties, which required sending approximately 43,200 email survey invitations—which represents a response rate of approximately 11%. Approximately 99 surveys have been received from survey participants who did not provide gender and/or city/county information, though all survey questions about their inspection experience were answered.

Thus, in total, 5,937 surveys were received for which all questions related to the motorist's vehicle inspection experience and opinions were completed, though of this number, 5,839 surveys also contain gender and city/county information. At least 1 and as many as 460 completed surveys were received for 234 out of 254 counties in Texas. Thus, 20 counties provided no survey responses; however, these include certain rural counties with extremely small populations such as Loving County (population 82), King County (population 286), and Borden County (population 641).

vi. The calculations shown in bullet v. include but did not separate out the 216 surveys (170 completed) received from vehicle owners who used the QR code on the posters located in inspection stations. Further, it is not possible for the CTR study team to separate survey responses received from vehicle owners who used the URL links on the posters; CTR, MPO, COG, and TxDPS websites; or the email invitations distributed by the COGs and MPOs—though CTR certainly appreciates this support.

vii. The email message that accompanied the survey invitation included the study team leader's office phone and email address in case questions occurred. It is estimated that approximately 50–60 phone calls and 20–30 response emails were received from survey invitation email recipients, primarily requesting verification that the survey was legitimate prior to clicking the hyperlink that accessed the survey. In some cases the caller would be the IT support person for an organization, who would verify the legitimacy of the email survey invitation and then advise those he supported that it was ok to click the hyperlink and take the survey.

viii. It should be noted that since not all Texans have broadband internet access, not every Texan could have been reached by an emailed survey invitation or by internet access to the TxDPS website or MPO/COG social media page links to the survey.

The US Census Bureau estimated that in 2016 approximately 80.5% of Texas households had broadband internet subscriptions (Ryan C. & Lewis J., 2018). To some degree the number of people who could be reached by email would be increased by the fact that many invitation emails were sent to business, public school, university, or other non-residential email addresses if a person's name was part of the address.

The 2015 report *Connected Texas* estimated that approximately 105,000 Texas businesses did not have broadband internet access. However, there is no way to determine how this might have affected the total percentage of the Texas population that can be reached by email (Connected Texas 2015).

The CTR team considered it impractical to send surveys to residents by mail since it could not be determined who did or did not have access to the internet and also had an email address. In addition, telephone survey interviews were also considered impractical.

ix. The Qualtrics analytic tools provide a histogram of responses that peaked within a day or two of email distributions and returned to typical response rates of from one to five surveys per day once email distribution responses had dissipated. Dissipation of survey response rates typically occurred with two to four days after the initial email campaign distribution.

Again, all survey responses received were anonymous, though the city and county of the participant was requested, but not required. Qualtrics does provide GPS coordinates as part of the metadata that accompanies a survey response, but based on discussions with the Qualtrics data support team, the GPS coordinates are only accurate to the city level and cannot be used to determine the exact location where a survey was actually submitted. The team also noted that there were 46 surveys in which all questions were answered, but the survey respondent did not provide city or county information and the GPS coordinates normally provided by Qualtrics metadata were absent.

Table J.1 summarizes these surveys according to different factors that were used to disaggregate and evaluate the data.

Table J.1. Vehicle owner inspection survey categorized by factors

Factor	Number of Texas Counties	Number of Counties from which at least 1 Survey was received	Total Population	Number of Completed Surveys Received
Urban Counties	22	22	16,288,524	2,603
Mostly Urban Counties	96	93	6,358,362	2,154
Rural Counties	58	43	233,396	186
Mostly Rural Counties	78	76	2,291,818	896
County name not stated				98
Totals	**254**	**234**	**25,172,100**	**5,937**
Emissions and Safety Inspection County	17	17	**14,206,933**	2,471
Safety Inspections only County	237	217	**10,965,167**	3,368
County name not stated				98
Totals			**25,172,100**	**5,937**
Male				3,167
Female				2,714
Gender not stated				56
Totals				**5,937**
Vehicle year, make and model provided				**5,912**

J.1. Reviewing Survey Responses to Identify "Careless Responses"

The CTR study team downloaded surveys from the Qualtrics Data & Analysis website on a routine basis. Each survey response was examined to eliminate responses that did not apply to the study and "careless responses," which were considered to contain either intentionally or unintentionally inaccurate data that could not be used in the analysis (Meade & Craig, 2012). Examples of data that was removed from the survey and are not included in the previous statistics include:

a. Respondents who listed a commercial motor vehicle (CMV) such as an 18-wheeler tractor or a commercial bus as the vehicle for which their Safety Inspection question responses applied.

b. Respondents who listed a school bus as the vehicle for which their safety inspection question responses applied.

c. Respondents who listed a vehicle which did not represent any known vehicle type, such as:

    - 1906 Lincoln Emperial
    - 2018 UT Longhorn

d. Respondents who listed an exotic or unusual vehicle and provided questionable responses that were considered unlikely, such as:

    - 2018 Lamborghini Haracan, was inspected, a problem was found; however, the inspection station was able to repair the problem.
    - This vehicle is an exotic, $350,000 sports car. A 2018 model would have been purchased with a two-year inspection such that an inspection would not be required in 2018.

e. The Qualtrics metadata includes the total number of seconds a respondent took to open, complete, and submit a survey, which was converted during the analysis to minutes to complete the survey. The average time for a female to complete the survey was calculated to be 5.2 minutes. The average survey completion time for a male to complete the survey was determined to be 5.7 minutes. The median completion time was 4.0 minutes.

    - Surveys with unusually long completion times extending to hours or even days were closely examined to ensure survey responses were sensible.
    - Surveys with unusually short completion times, usually considered to be less than 2 minutes, were closely examined to ensure survey responses were sensible.

f. The CTR study team contacted Qualtrics technical chat support to discuss survey responses that seemed unlikely to be valid.

    - The data support person was asked to review five survey responses submitted from the same city and county within seconds of each other. Various metadata were examined by Qualtrics™ data support and the responses considered valid.
    - The CTR team reviewed selected survey responses to ensure data validity. For example, several surveys were received soon after an email campaign that had the same make of vehicle though different vehicle ages and models. After examining other data provided in the survey, these were determined to be valid.

J.2. General Statistics based on Survey Responses

The following information provides general statistics about the survey data, which was checked with other data sources to determine reasonableness and/or validity for analysis. The CTR study team established a 95% significance level with +/- 3% error for all analyses based on vehicle owner survey data.

1. TxDMV provided three years of vehicle registration data that was used to determine the average vehicle age in Texas (2010). It was found that the average vehicle age for all survey respondents was 2010.6, which rounded to 2011 but was considered reasonable. It was further determined that on average, males drive 2010 model year vehicles while, on average, females drive 2012 model year vehicles. Table J.2 provides a summary of the number and percentage of vehicles described in the survey responses. Note, due to the small number of entries, information was not provided for recreational vehicles (RVs) though these vehicles are considered a type of PV in Texas and therefore are subject to this study. A total of 5,912 vehicles are identified in this table.

Table J.2. Vehicle types, quantities, and percentages from the motor vehicle inspection surveys

	Passenger car	Compact Car	Hybrid passenger car	Hybrid SUV	Electric Car	Sports car	Pickup
Number of Vehicles	1,036	539	95	17	13	217	1,631
Percentage of total Vehicles	17.5%	9.1%	1.6%	0.3%	0.2%	3.7%	27.6%
	SUV	**Compact SUV**	**Crossover**	**Station Wagon**	**Van**	**Motorcycle**	**Scooter**
Number of Vehicles	1,668	330	73	53	139	77	1
Percentage of total Vehicle	28.2%	5.6%	1.2%	0.9%	2.4%	1.3%	0.0%

Note: According to manufacturers, a sport utility vehicle (SUV) is based on a truck chassis, while a crossover is an SUV-type vehicle based on a car chassis.

The vehicle type information was used along with information available from vehicle parts dealers to determine the weighted average cost of different types of repair or replacement parts identified by survey respondents. Table J.3 provides a summary of the number of repairs made, percentage of total repairs, and total cost of each type of repair/repair part based on the more common repairs identified in the survey. Thus, 5,597 repairs of different types are identified out of 5,620 repairs or replacement parts that were actually identified. These additional repairs include items such as serpentine belt replacement and other less commonly listed items. A total of 2,957 survey respondents indicated that repairs or replacement parts were needed to pass inspection.

Table J.3. Repairs and repair parts identified in the motor vehicle inspection survey

Repair Part	Defective or Slick Tires	Head Light	Tail Light	Signal Light	Windshield Wiper Blades	Worn or Defective Brakes	Muffler	Exhaust Leak
Number of Repairs noted by Survey Respondents	695	526	1,117	632	1,579	309	183	11
Percentage of Respondents who had this repair	23.5%	17.8%	37.8%	21.4%	53.4%	10.4%	6.2%	0.4%
Estimated Cost of Repairs	$129,409	$52,600	$88,243	$50,560	$47,370	$68,289	$88,735	$550
Repair Part	**Parking Brake**	**Window Tint**	**Steering Mechanism**	**Horn**	**License Plate Light**	**Gas Cap**	**Seat Belt mal-function**	**Mirror**
Number of Repairs noted by Survey Respondents	27	49	51	201	111	92	8	6
Percentage of Respondents who had this repair	0.9%	1.7%	1.7%	6.8%	3.8%	3.1%	0.27%	0.2%
Estimated Cost of Repairs	$2,862	$9,865	$12,427	$25,728	$3,212	$7,176	$400	$300

The reader should note that this information was provided by the survey respondents based on their experience having a vehicle inspected over a period of years, not a single year. Respondents indicated that in some cases, they had failed inspections anywhere from once to 15 times—up to every time a respondent had their car inspected. Thus, these repairs and information do not represent a single year or point in time. Rather this information represents the programmatic first-time failure and repairs conducted over the periods of time that these survey respondents had vehicles inspected. In some cases, the respondent might have only ever had one safety inspection in Texas; in other cases, 30 or more years of safety inspections. However, the programmatic (rather than an annual) first-time failure rate provides a broader picture of the effectiveness of safety inspections in addressing vehicle defects and repairing those defects.

Thus, for a total of 5,912 vehicles (vehicle owners) identified in the survey, 2,957 vehicle owners indicated that they had had first-time failures that comprised 5,620 repairs or replacement of parts. The actual calculated percentages for survey respondents who reported first-time failures and the need for repairs and replacement parts is approximately 50% of all respondents. However, calculations of the number of survey respondents indicating they had never had repairs or replacement parts does not also equal 50% for two reasons.

1. Some individuals who indicated they had never had a repair or needed a replacement part did in fact list repairs or replacement parts such as windshield wipers, gas caps, and other items.
2. A certain percentage of individuals who indicated they had never had a repair or needed a replacement part also indicated that the safety inspection station owner or inspector had first noticed a defect on their vehicle and advised the vehicle owner to have the defect repaired, then bring their vehicle back for inspection.

   Based on calculations performed using the survey data, approximately **24.9%** of individuals who indicate they have never had repairs were told by the inspection station that their vehicle had a defect that should be repaired before the inspection was performed.

Thus, if not notified by the inspection station, these individuals would have been included in the first-time failure group. According to the survey responses, (5,912 – 2957) = 2,955 survey respondents indicated they had first-time failures, but were told to have defects repaired before the inspection. Thus, 2,955 respondents x 24.9% = 736 respondents who actually would have had first-time failures if not notified by the inspector. This results in 2,219 individuals who actually have never had parts replaced or repairs made, which constitutes 37% of the total respondents. Therefore the actual, programmatic first-time failure rate is 1 – 37% = 63% of survey respondents.

Again, it is important to note that this figure does not represent the annual first-time failure rate for the survey respondents; rather, this figure represents the first-time failure rate over the period of time that this group of drivers have had their cars inspected. To recap, 37% have never failed an inspection and 63% have failed an inspection at least once, and up to several times over this period of years.

J.3. Survey Responses regarding Inspections and Highway Safety

The following sections provide a series of figures that explain what this group of survey respondents think about safety inspections in terms of enhancing highway safety, the cost and time spent having their vehicle inspected, and additional explanatory factors.

Figure J.3 shows the number of respondents who think that vehicles with defects can contribute to an accident. Defects are defined as the components that are evaluated during a routine safety inspection, such as defective or slick tires, defective or no brakes, defective steering mechanism, inoperable headlights, tail lights and/or signal lights, horn, and other items.

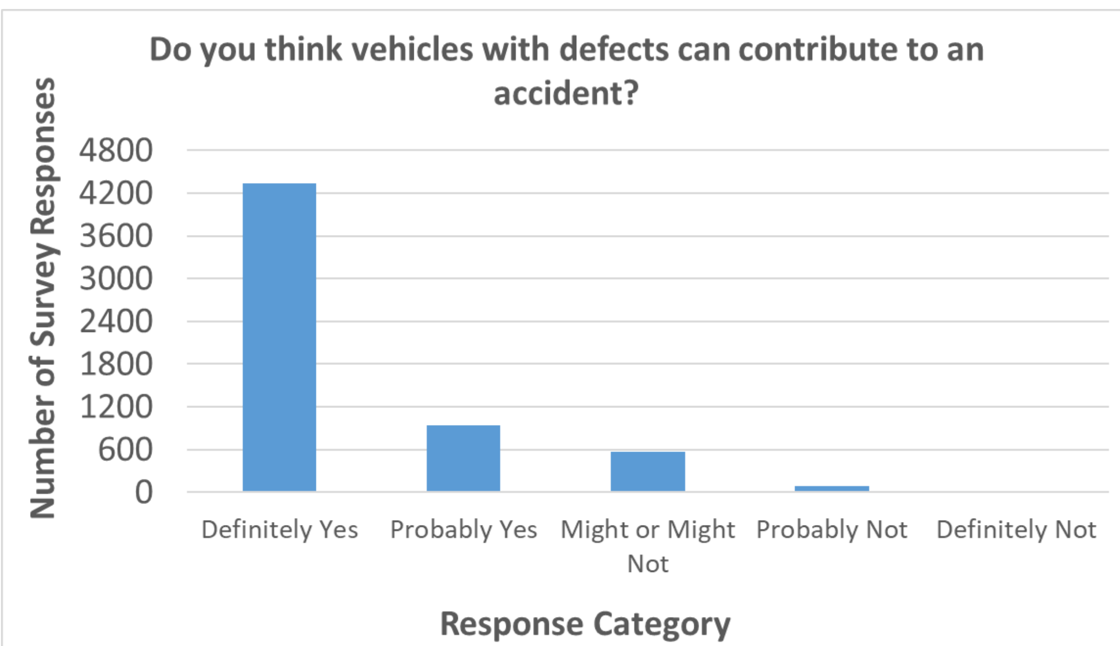


Figure J.3. Number of respondents who think that vehicle defects can contribute to an accident

Figure J.4 shows the number of respondents who think that safety inspections either do or do not benefit highway safety in Texas.

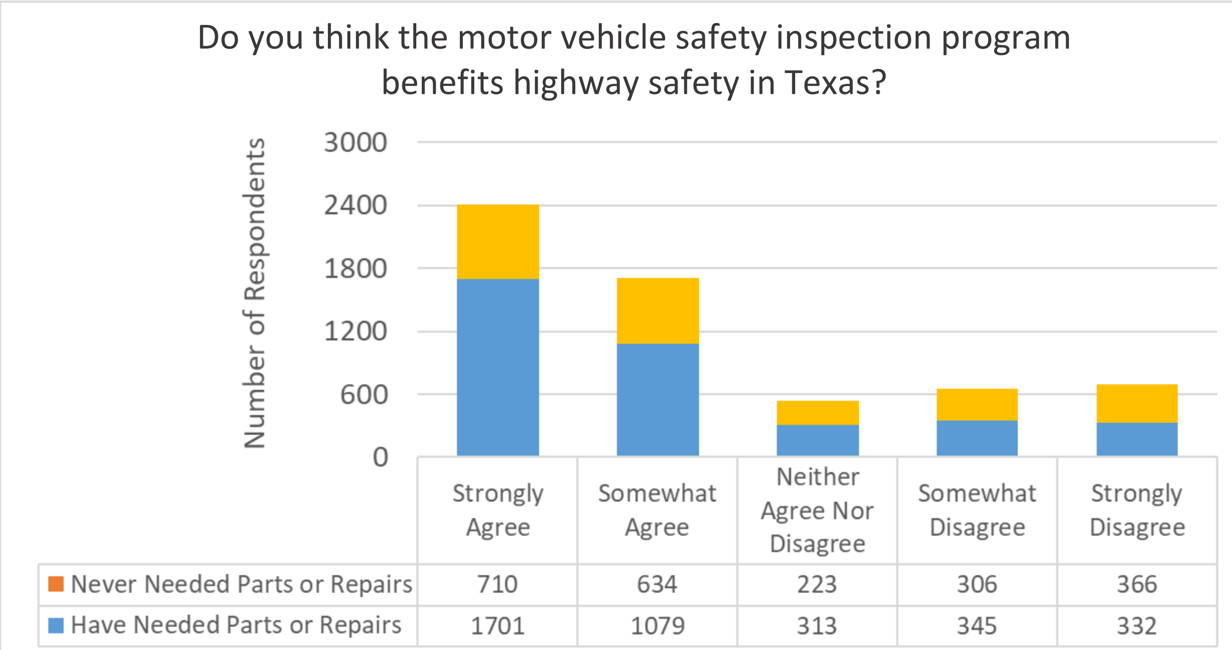


Figure J.4. Number of respondents who think the Inspection Program benefits highway safety

Approximately 4,124 respondents indicated that they 'strongly' or 'somewhat agree' that vehicle inspections benefit highway safety in Texas while approximately 1,349 respondents indicated that inspections 'definitely' or' probably did not' benefit highway safety. It is important to note that of the 4,124 respondents who strongly or somewhat agree, approximately 1,344 (32.6%) have not required repairs or replacement parts; thus, approximately 67% of respondents have required repairs or parts. Further, of the 1,349 who strongly or somewhat disagree that vehicle inspections benefit highway safety, approximately 672 (49.8%) have never had repairs or required replacement parts during an inspection

Figures J.3 and J.4 show vehicle owners' opinions about whether vehicle defects might contribute to crashes and whether safety inspections benefit safety in Texas.

Figure J.5 provides information about whether vehicle owners think that safety inspections of <u>their vehicle</u> benefits highway safety. Approximately 3,572 (60%) of respondents indicated that they 'strongly' or 'somewhat agree' that vehicle inspections benefit highway safety in Texas while approximately 1,656 (27.9%) of respondents indicated that inspections 'definitely' or 'probably did not' benefit highway safety.

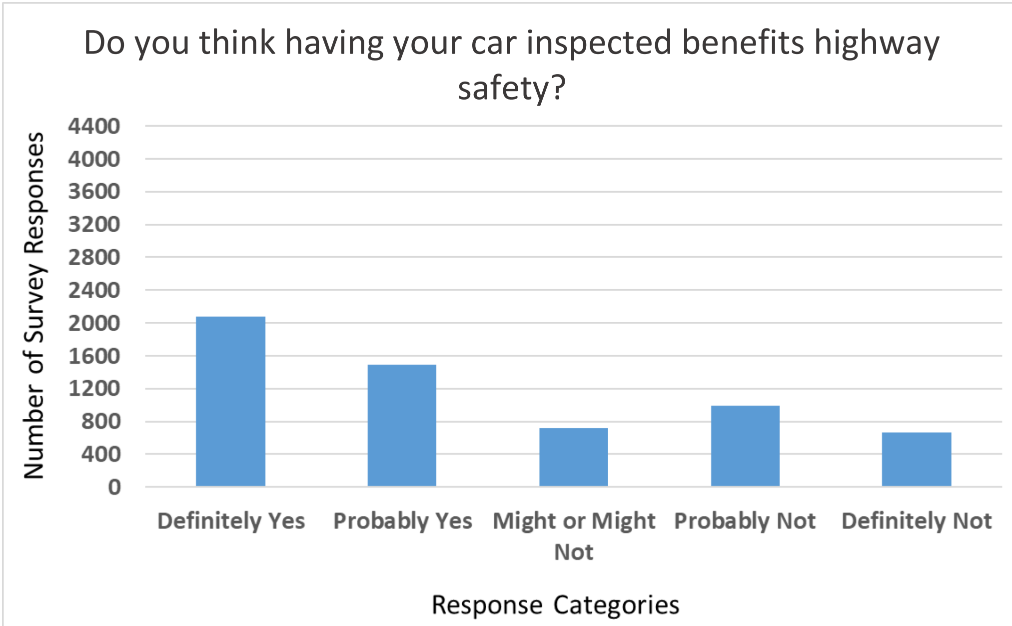


Figure J.5. Responses to the question "Do you think having your car inspected benefits highway safety?"

Figure J.6 provides information about whether vehicle owners think that the Inspection Program influences them to pay more attention to their vehicle's maintenance because they know their vehicle must eventually pass inspection. Approximately 2,682 (45.6%) of respondents indicated 'Definitely' or 'Probably Yes' while approximately 2,516 (42.8%) of respondents indicated that they 'Definitely' or 'Probably [did] Not' pay more attention to their vehicle's maintenance because their vehicle would eventually need to pass inspection.

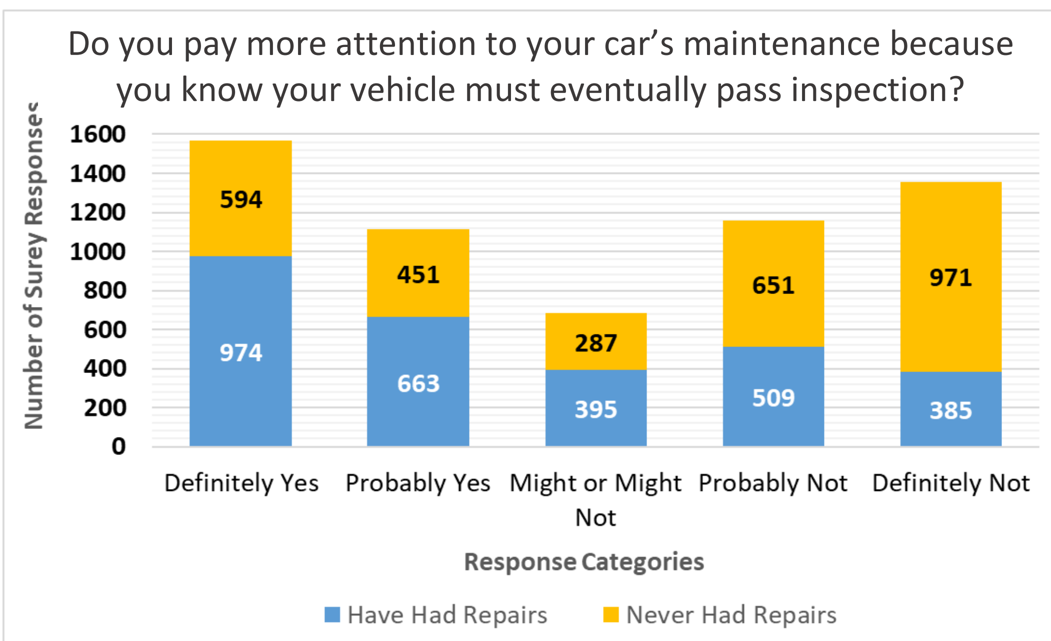


Figure J.6. Responses to the question "Do you pay more attention to your car's maintenance because you know your vehicle must eventually pass inspection?"

It is further noted that some survey respondents expressed opinions about the fact that they take care of their vehicle as needed and do not wait until the inspection program to have repairs made.

However, there are also individuals who maintain their vehicles in preparation for the annual vehicle safety inspection or wait until their car is inspected to conduct needed maintenance or repairs. A separate document has been prepared with vehicle owner comments and can be obtained by making a request to TxDPS or CTR.

Figure J.7 provides information regarding whether vehicle owners think they are receiving a service by having their vehicle inspected.

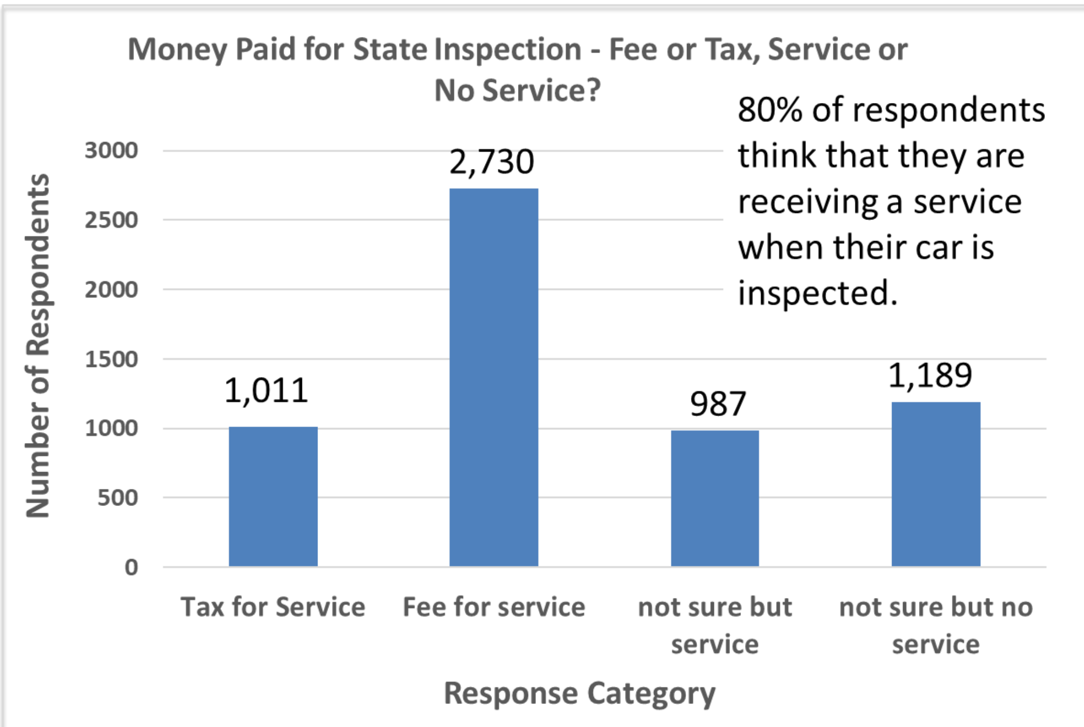


Figure J.7. Responses to the question "Do you think you are receiving a service when having your vehicle inspected?"

Approximately 80% of respondents think they are receiving a service when having their car inspected while 20% of respondents do not think they are receiving a service.

Figure J.8 shows the responses to the question regarding vehicle owners' interactions with the inspection stations with regard to obtaining repairs at the station during inspection or through other sources. Based on this information, about 48.6% of respondents indicated that they had never had repairs or replacement parts. However, as mentioned previously approximately 24.9% of these individuals were advised prior to the inspection that their vehicle had one or more defects that needed repair prior to the beginning of the inspection. Thus, though no adjustment is made in these numbers or the graph, approximately 750 respondents who indicated that they had never had repairs would have had repairs made 'elsewhere'—that is, at another business location—or would have purchased the parts and made the repairs at home. Since it was not possible to distribute these 750 responses to other categories based on available information, no adjustment was made.

Thus about 21.6% of respondents indicated that the inspection station made the necessary repairs, approximately 15.6% of respondents had repairs made elsewhere (another business), and approximately 14.1% of respondents made the repairs at home.

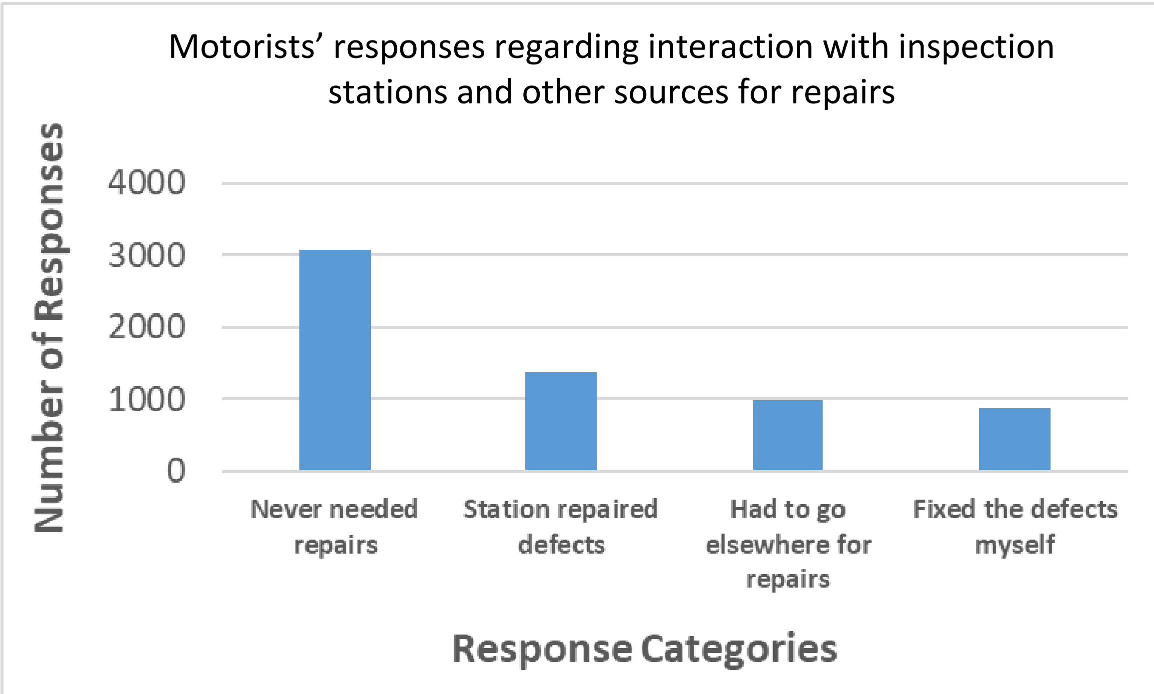


Figure J.8. Responses to the question about interactions with inspection stations or other sources for repairs

Regarding whether vehicle owners think that an inspection takes too much time, the interpretation of the responses varied depending on how the data is presented. Figures J.9–J.13 show these variations.

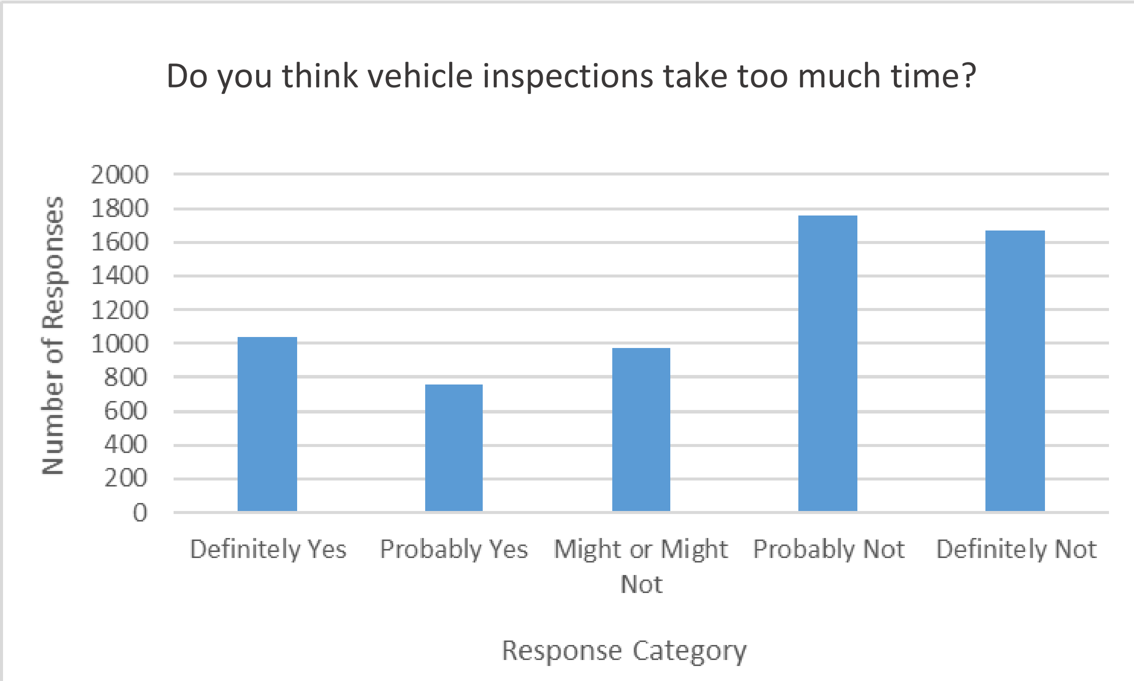


Figure J.9. Responses to the question "Do you think vehicle inspections take too much time?"

Figure J.10 displays respondents who only replied 'Definitely Yes' to the question 'Do you think vehicle inspections take too much time? It is apparent that vehicle owners who have never had to have replacement parts or repairs comprise the majority of individuals who do think inspections take too much time.

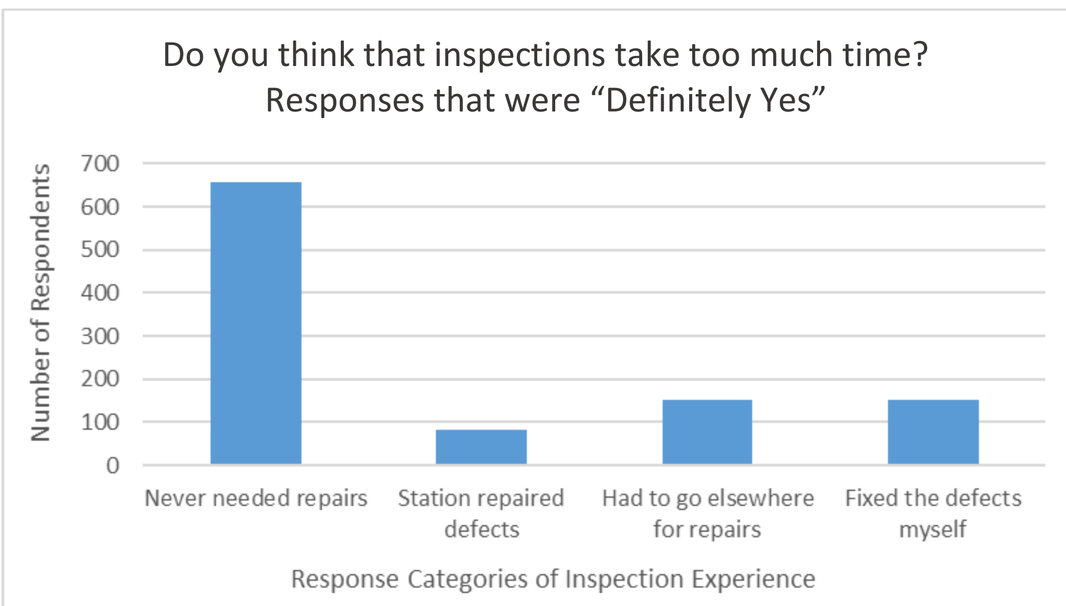


Figure J.10. Responses to the question about whether vehicle inspections take too much time

Figure J.11 shows the response distribution for vehicle owners who required repairs to their vehicle and were able to have the repairs performed at the inspection station.

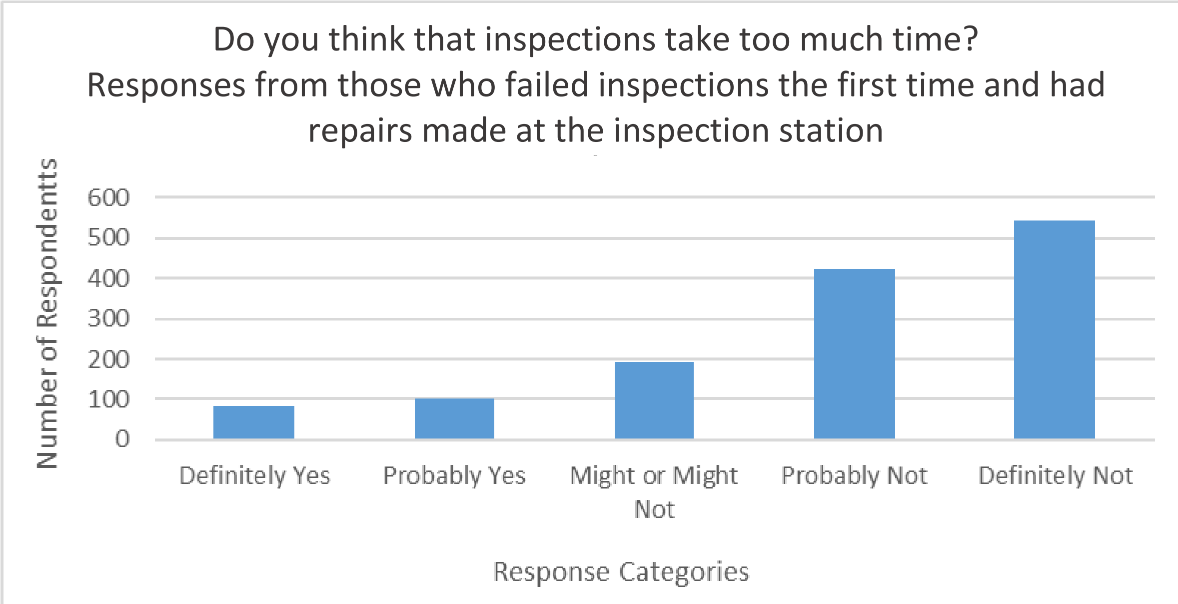


Figure J.11. Number of respondents who failed the inspection but were able to have their vehicle repaired at the inspection station

Figure J.12 shows responses from individuals who failed the inspection first-time and took their vehicle home for repairs before taking it back to the inspection station for a second inspection. The results are similar (Figure J.13) for individuals who failed inspection first-time and had to take their car ‘Elsewhere’, that is, to another mechanic, tire shop, or repair shop for repairs. This can occur if the inspection station is not equipped to perform the required repair or is out of parts for that particular brand and model of vehicle.

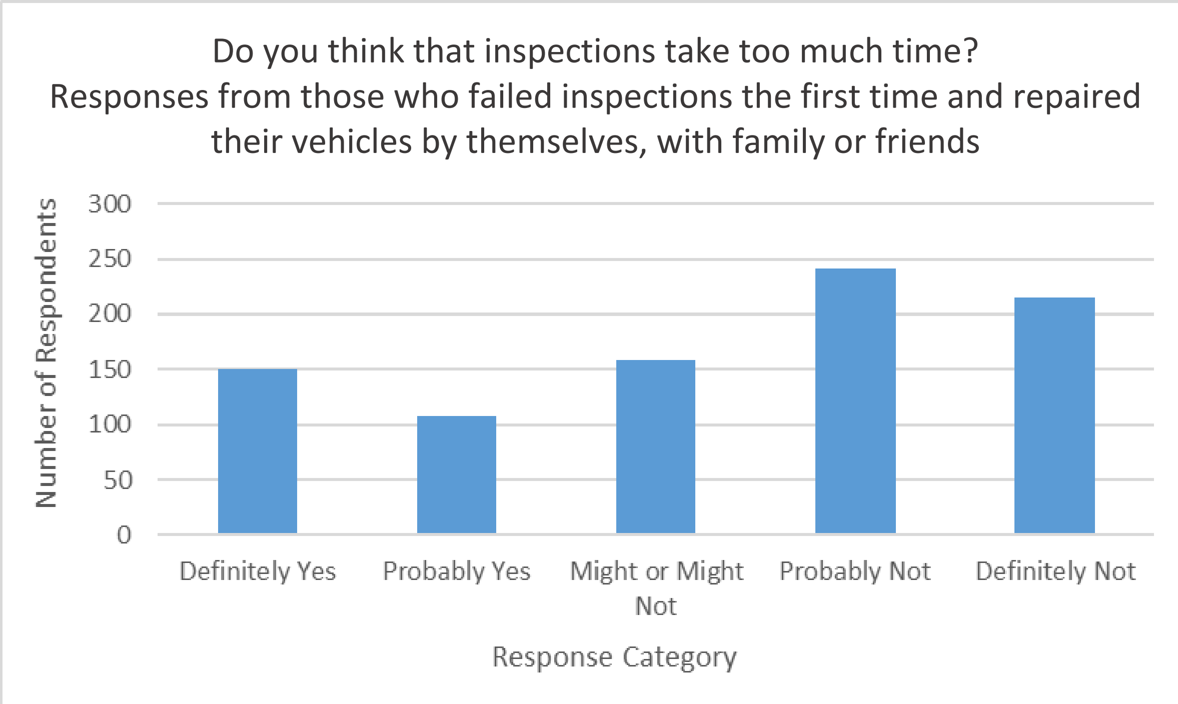


Figure J.12. Number of respondents who failed first-time inspection and took their car home for repairs.

Figure J.13. Number of respondents who failed first-time inspection and took their car elsewhere for repairs

Finally, vehicle owners were asked about the cost of a safety inspection. However, during the workshop discussed in Chapter 5 of the main report, stakeholders pointed out that inspection fees are more expensive in emissions counties than in safety-only counties and that the survey did not clearly explain that the inspection fee only pertained to the $7.00 safety inspection fee, not the emissions and safety inspection fee.

Thus, the graph in Figure J.14 is displayed for informational purposes only and should not be used to arrive at conclusions about vehicle owners' opinions regarding the safety inspection fee.

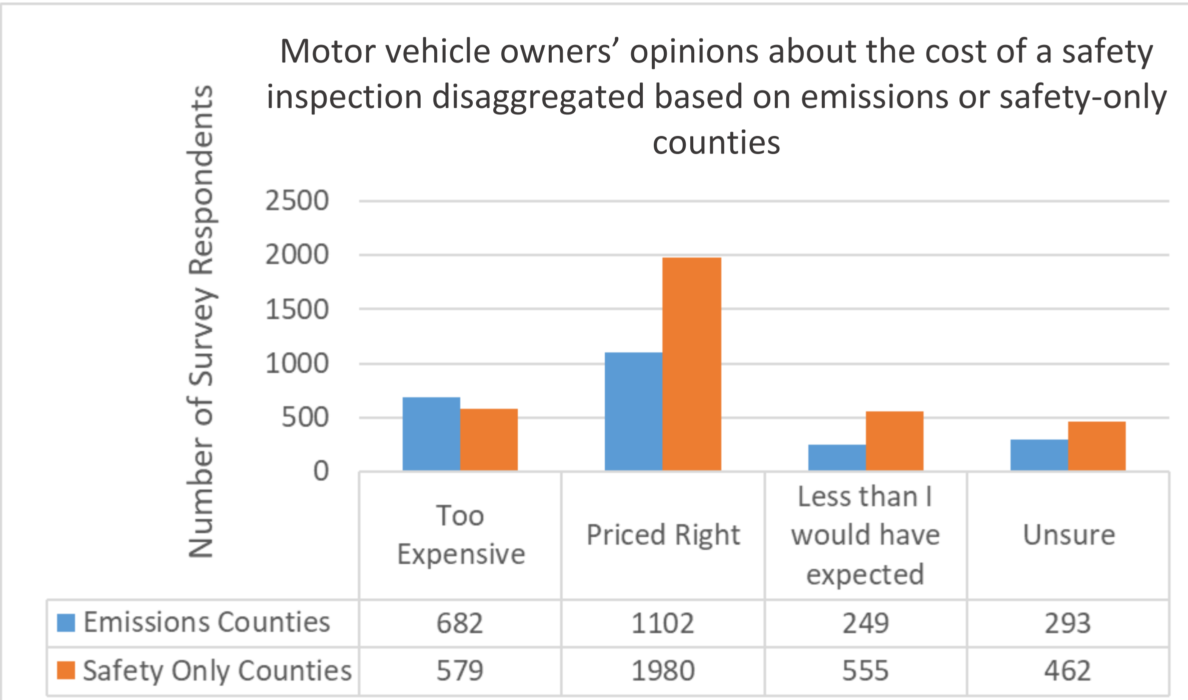


*Figure J.14. Vehicle owners' opinions about the safety inspection fee***

**The authors note that the survey question did not make clear that this question pertained only to the $7.00 safety inspection fee paid to an inspection station owner for the safety-only portion of a vehicle inspection.

J.4. Details of Method 2 First Time Failure Rate Calculation

In the survey presented at the beginning of this appendix, vehicle owners were asked to indicate the number of times that they had repairs or purchased replacement parts as a result of a safety inspection (Question 11). The answers ranged from zero (vehicle never needed any repairs or replacement parts) to as many as 30 times. The research team realizes that an individual might own more than one car, thus, 10 failed inspections could occur in any combination of years that adds up to 10 or more. However, the team did not know how many vehicles a person owned over the period in which the reported failures occurred. According to FHWA, there were 16,162,382 licensed drivers in Texas in 2016 (FHWA, 2018). Based on the registration data obtained from TxDMV, the total number of registered passenger vehicles (1980 and newer models) in 2016 was 19,640,255. Thus, the team used the average number of vehicles owned in Texas, which is 1.2 ($\frac{19,640,255}{16,162,382} = 1.2\ veh / driver$), to adjust the following calculations (FHWA, 2018). The research team interpreted the number of times as the number of failures because those safety issues would fail a safety inspection unless repaired. In order to obtain the adjusted first time failure rate, the research team:

- established the maximum and minimum analysis periods for each individual who had repairs or purchased replacement parts as a result of a safety inspection;
- calculated all probable unadjusted (without considering the average vehicle ownership rate) first time failure rates for each individual within the minimum and maximum analysis periods;
- summarized and analyzed the statistics of all probable unadjusted first time failure rates; and
- adjusted the first time failure rates by considering the average vehicle ownership rate.

The maximum analysis period is set as 30 years since the maximum reported number of failed inspections by survey respondents was 30 times. The minimum analysis period is determined when the unadjusted failure rate reaches 100%. Therefore, it varies from individual to individual and equals to the number of failed inspections each respondent reported. For example, if the vehicle owner failed three times, the minimum analysis period is three years and the maximum is 30 years. The respondent might fail three times in three years, or he/she might fail three times in four years, or five years … or 30 years. All probable unadjusted first time failure rates are: $3/3 = 100\%$, $3/4 = 75\%$, $3/5 = 60\%$, … $3/28 = 10.7\%$, $3/29 = 10.3\%$, $3/30 = 10\%$. Similarly, if the vehicle owner failed 7 times, then all probable unadjusted first time failure rates are: $7/7 = 100\%$, $7/8 = 87.5\%$, … $7/29 = 24.1\%$, $7/30 = 23.3\%$. In addition, for those who never failed an inspection, all probable unadjusted first time failure rates are: $0/1 = 0\%$, $0/2 = 0\%$, … $0/29 = 0\%$, $0/30 = 0\%$.

The research team calculated all probable unadjusted first time failure rates for each individual. Consequently, a total of 171,932 failure rates were obtained. The histogram and cumulative probability of all probable failure rates were developed. The bin size of the histogram was selected as three percent. The detained histogram bin information and its corresponding cumulative probability are listed in Table J.4.

Table J.4. Detained Histogram Bin Information and Its Corresponding Cumulative Probability

Bin Center	Range	Frequency	Cumulative Probability	Bin Center	Range	Frequency	Cumulative Probability
1.5%	[0%, 3%)	66,570	38.7%	52.5%	[51%, 54%)	101	95.4%
4.5%	[3%, 6%)	21,364	51.2%	55.5%	[54%, 57%)	284	95.5%
7.5%	[6%, 9%)	17,142	61.2%	58.5%	[57%, 60%)	219	95.7%
10.5%	[9%, 12%)	14,182	69.4%	61.5%	[60%, 63%)	810	96.1%
13.5%	[12%, 15%)	9,625	75.0%	64.5%	[63%, 66%)	34	96.2%
16.5%	[15%, 18%)	6,935	79.1%	67.5%	[66%, 69%)	1,452	97.0%
19.5%	[18%, 21%)	6,076	82.6%	70.5%	[69%, 72%)	252	97.2%
22.5%	[21%, 24%)	3,242	84.5%	73.5%	[72%, 75%)	22	97.2%
25.5%	[24%, 27%)	4,008	86.8%	76.5%	[75%, 78%)	619	97.5%
28.5%	[27%, 30%)	2,313	88.2%	79.5%	[78%, 81%)	171	97.6%
31.5%	[30%, 33%)	949	88.7%	82.5%	[81%, 84%)	241	97.8%
34.5%	[33%, 36%)	3,962	91.0%	85.5%	[84%, 87%)	57	97.8%
37.5%	[36%, 39%)	986	91.6%	88.5%	[87%, 90%)	38	97.8%
40.5%	[39%, 42%)	1,664	92.6%	91.5%	[90%, 93%)	58	97.9%
43.5%	[42%, 45%)	765	93.0%	94.5%	[93%, 96%)	20	97.9%
46.5%	[45%, 48%)	339	93.2%	97.5%	[96%, 99%)	1	97.9%
49.5%	[48%, 51%)	3,652	95.3%	100.5%	[99%, 102%)	3,779	100%

Based on Table J.4, the histogram and cumulative probability of all unadjusted first time failure rates are presented in Figure J.15. Recall that in previous survey analyses, there are 2,219 respondents who actually have never had vehicle parts replaced or repairs made. This results in 66,570 ($2,219 \times 30 = 66,570$) probable failure rates of zero percent considering the minimum analysis period is one year and the maximum is 30 years. Therefore, the frequency in the first bin is larger than any other bins, which can be verified by both Table J.4 and Figure J.15. In addition, based on the calculation, the first bin contains only the zero percent failure rates since the next smallest probable failure rate is $1/30 = 3.3\%$. Previous analyses also indicated that 37% had never failed an inspection and 63% had failed an inspection at least once. According to the first bin in Table J.4, using this methodology, the percentage of respondents who have never failed an inspection is 38.7%, which is very close to (slightly higher than) previous analysis results. This is within the 5% error tolerance ($\frac{38.7\% - 37\%}{37\%} = 4.6\% < 5\%$). The rest of bins account for 61.3% of all probable failure rates, which represents the percentage of respondents who has failed an inspection at least once. This is within the 3% error tolerance ($\left|\frac{61.3\% - 63\%}{63\%}\right| = 2.7\% < 3\%$). It can be observed that the results calculated using this method are very close to those obtained from previous analyses.

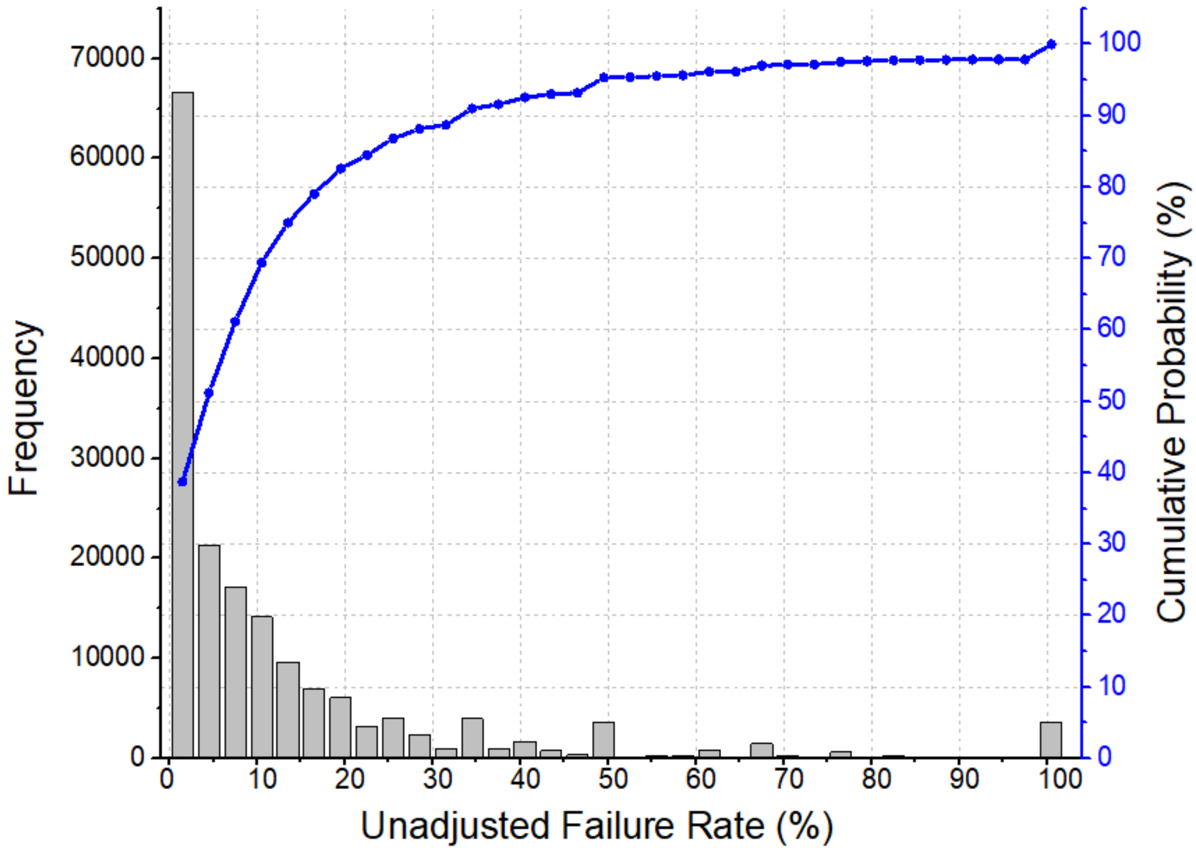


Figure J.15. Histogram and Cumulative Probability of Unadjusted First Time Failure Rate

As can be seen from Figure J.15, the histogram shows an exponential distribution, which is expected because exponential distribution is one of the most common failure distributions in reliability engineering (Ebeling, 2004). Theoretically speaking, failures due to completely random or chance events will follow exponential distribution (Ebeling, 2004). Considering failures of parts on passenger vehicles that are included in the Safety Inspection, the reader can understand that no one can predict when their left headlight, right rear signal light, gas cap seal, and even tire tread depth or tire deterioration will require replacement of these parts. Tires perhaps can be monitored to estimate failure condition using the tread depth bars or a tread depth gauge; however, number of miles driven, driving habits, such as fast acceleration or hard braking can result in different amounts of tire wear between different drivers. Thus, for this analysis the team believes that random inspection component failures are reasonable. The mean value of all the unadjusted first time failure rates is 12.4%. By considering the average vehicle ownership is 1.2 vehicle per licensed driver, the adjusted mean value of the first time failure rate is $\frac{12.4\%}{1.2} = 10.3\%$, which is in the range of 7.5% to 12.5% from 5.5.1 and is substantially higher than the currently captured 2.63%.

Appendix K. Inspection Station Online Survey

CTR developed an online survey to provide information regarding motor vehicle safety inspection station operators' experiences with and opinions about safety inspections. UT is licensed to use the Qualtrics™ online survey and data analysis tools. An online survey was developed by CTR and reviewed by TxDPS study team leaders for suggestions. The online survey is shown below.

-------------------------------------- Inspection Station Survey--

Information only

Texas Motor Vehicle Safety Inspection Program Survey

The State Legislature has required the Texas Department of Public Safety (DPS) to report on the costs and benefits of the passenger vehicle Texas Motor Vehicle Safety Inspection Program. DPS has contracted with the University of Texas at Austin – Center for Transportation Research to assist in preparing this report. Your participation in completing this survey is very important to this report and much appreciated.

If you have any questions regarding this survey, please contact:

Dr. Mike Murphy, P.E.
(512) 232-3134
michael.murphy@engr.utexas.edu

THE UNIVERSITY OF TEXAS AT AUSTIN
CENTER FOR TRANSPORTATION RESEARCH

Page Break

Q1 Please tell us the location of your station:

- City: (1) ____
- County: (2) ____

Q2 How will your business be impacted if the passenger Vehicle Safety Inspection Program is eliminated in Texas? Check all that apply.

- [ ] My business would be severely impacted because Vehicle Inspections and related repairs and other products purchases are a major part of my business. (1)
- [ ] My business would be slightly impacted as only a small portion of my business profit is from Vehicle Safety Inspections and related repairs. (2)
- [ ] My business won't be really impacted since we don't get much business from conducting Vehicle Safety Inspections anyway (4)
- [ ] I'm really not sure how my business would be impacted. (6)

Q3 My station has the following Endorsements. Check all that apply

- [ ] 1Y - may inspect any vehicle requiring a one-year inspection (1)
- [ ] 2Y - may inspect any vehicle requiring a two-year inspection (2)
- [ ] CW - may inspect any vehicle requiring a commercial inspection (3)
- [ ] CT - may inspect any vehicle requiring a commercial trailer inspection (4)
- [ ] TL - may inspect any vehicle requiring a trailer inspection (5)
- [ ] MC - may inspect any vehicle requiring a motorcycle inspection (6)

Q4 We don't do repairs or sell replacement parts if needed to pass the Vehicle Safety Inspection. If the vehicle fails the inspection the owner must go elsewhere to have repairs made.

- ○ Yes (4)
- ○ No (5)

Q5 We can make small repairs and sell some replacement parts if needed to pass the Inspection. However, the customer may need to go to another business if the repairs are more complex.

- ○ Yes (1)
- ○ No (2)

Q6 We can make any type of repairs or obtain/sell replacement parts needed to pass the Vehicle Safety Inspection.

- ○ Yes (5)
- ○ No (6)

Q7 How many years has your station provided the Vehicle Safety Inspection service?

- ○ Less than 1 year (1)
- ○ 1 to 3 years (2)
- ○ 3 to 5 years (3)
- ○ 5 to 7 years (4)
- ○ 7 to 10 years (5)
- ○ 10 to 15 years (6)
- ○ 15 to 20 years (7)
- ○ 20 to 30 years (8)
- ○ greater than 30 years (9)

Q8 On average how many certified full-time employees (40 or more hours per week) do you have who can perform Vehicle Safety Inspections as part of their duties?

- 0 full-time certified employees (1)
- 1 - 2 full-time certified employees (2)
- 3 - 4 full-time certified employees (3)
- 5 - 7 full-time certified employees (4)
- 8 - 10 full-time certified employees (5)
- 11 - 15 full-time certified employees (6)
- 16 - 20 full-time certified employees (7)
- 21 - 25 full-time certified employees (8)
- greater than 25 full-time certified employees (9)

Q9 On average how many certified part-time employees (less than 40 hours per week) do you have who can perform Vehicle Safety Inspections?

- 0 part-time certified employees (1)
- 1 - 2 part-time certified employees (2)
- 3 - 4 part-time certified employees (3)
- 5 - 7 part-time certified employees (4)
- 8 - 10 part-time certified employees (5)
- 11 - 15 part-time certified employees (6)
- 16 - 20 part-time certified employees (7)
- 21 - 25 part-time certified employees (8)
- greater than 25 part-time certified employees (9)

Q10 On average, how many vehicles does your station inspect per week?

- 1 - 5 vehicles (1)
- 6 - 10 vehicles (2)
- 11 - 20 vehicles (3)
- 21 - 30 vehicles (4)
- 31 - 40 vehicles (5)
- 41 - 50 vehicles (6)
- 51 - 75 vehicles (7)
- 76 - 100 vehicles (8)
- 101 - 150 vehicles (9)
- greater than 150 vehicles (10)

Q11 On an average weekday, how many vehicles does your station fail due to one or more safety issues when performing the first inspection?

- no vehicles (1)
- 1 - 2 vehicles (2)
- 3 - 4 vehicles (3)
- 5 - 10 vehicles (4)
- 11 - 15 vehicles (5)
- 16 - 20 vehicles (6)
- 21 - 25 vehicles (7)
- 26 - 30 vehicles (8)
- 31 - 40 vehicles (9)
- 41 - 50 vehicles (10)
- Greater than 50 vehicles (11)

Q12 On average, how many vehicles per week fail the Safety Inspection and must go to another business to have repairs or replacement parts done before they can come back to your station to pass inspection?

- ○ 0 vehicles (1)
- ○ 1 - 2 vehicles (2)
- ○ 3 - 5 vehicles (3)
- ○ 6 - 10 vehicles (4)
- ○ 11 - 15 vehicles (5)
- ○ 16 - 20 vehicles (6)
- ○ 21 - 25 vehicles (7)
- ○ 26 - 30 vehicles (8)
- ○ 31 - 40 vehicles (9)
- ○ 41 - 50 vehicles (10)
- ○ Greater than 50 vehicles (11)

Q13 On average, how long does it usually take for one vehicle to be inspected for safety (no emissions testing) if no repairs or replacement parts are needed?

- ○ 30 minutes or less (1)
- ○ between 31 minutes and 45 minutes (2)
- ○ between 46 minutes and 1 hour (3)
- ○ between 1 hour and 1 hour-30 minutes (4)
- ○ between 1 hour-30 minutes and 2 hours (5)
- ○ greater than 2 hours (6)

Q14 On average, how long does it usually take for one vehicle to be inspected for safety if repairs or replacement parts are needed and are performed at your station?

- 30 minutes or less (1)
- between 31 minutes and 45 minutes (2)
- between 36 minutes and 1 hour (3)
- between 1 hour and 1 hour-30 minutes (4)
- between 1 hour-30 minutes and 2 hours (5)
- between 2 hours and 2 hours-30 minutes (6)
- between 2 hours-30 minutes and 3 hours (7)
- greater than 3 hours (8)

Q15 Please click each of the types of repairs or replacement parts you typically perform so that a vehicle with a safety issue is able to pass inspection.

- ▢ Replace worn wiper blades (1)
- ▢ Replace head light(s) (2)
- ▢ Replace tail stop light(s) (3)
- ▢ Replace turning signal light(s) (4)
- ▢ Repair a tire with an air leak (5)
- ▢ Replace one or more slick tire(s) that are below legal tread depth (6)
- ▢ Replace brake pads that are below legal standards (7)
- ▢ Perform brake adjustments (8)
- ▢ Perform repairs or adjustment to the emergency brake (9)
- ▢ Repair cracks or damaged areas to a windshield (10)
- ▢ Repair a horn that does not work (11)
- ▢ Repair a steering mechanism problem (12)
- ▢ Replace a rear view mirror (13)
- ▢ Adjust or replace seat belts (14)
- ▢ Replace or repair the high beam indicator (15)
- ▢ Repair or replace the license plate light (16)
- ▢ Repair or replace red rear reflectors (17)
- ▢ Repair gas cap or replace missing gas cap (18)
- ▢ Replace window tint that does not meet safety criteria (19)
- ▢ Replace or repair wheel rims (20)

Q16 If your station also does vehicle emissions testing, how long does the vehicle emissions test take?

- ○ Less than 30 minutes (1)
- ○ 31 minutes - 1 hour (2)
- ○ greater than 1 hour (3)

Q17 Do you think that the Vehicle Safety Inspection Program improves highway safety in Texas?

- ○ Definitely yes (1)
- ○ Probably yes (2)
- ○ Might or might not (3)
- ○ Probably not (4)
- ○ Definitely not (5)

Q18 What's your opinion about the cost of a Motor Vehicle Safety Inspection:

- ○ Too high (1)
- ○ High (2)
- ○ Priced right (3)
- ○ Low (4)
- ○ Too low (5)

Q19 If you know a vehicle is going to fail the inspection, what would you do? Check all that apply.

- ☐ Before the inspection, you see that there is a safety problem and tell the vehicle owner to have the problem fixed then the inspection will be performed. (1)
- ☐ During the inspection, you tell the vehicle owner that there is a safety problem(s) which your station can fix, after the repair(s) or part(s) replacement(s) are performed the vehicle will pass the inspection. (2)
- ☐ Fail the vehicle during the inspection then tell the vehicle owner to have the problem fixed and bring their vehicle back. Afterward you will perform a 2nd inspection after the repairs are performed (3)

Q20 Please write additional comments you may have about the Texas Motor Vehicle Safety Inspection Program and its effect on Highway Safety in Texas.

____

End of Block: Default Question Block

A list of inspection station email addresses was obtained from TxDPS to distribute a link to the online survey to each station. A total of 6,545 stations were contacted. Of those stations contacted, 1,823 survey responses were received, of which 1,582 surveys responded to 100% of the survey questions. The number of 100% completed surveys represents approximately 86.8% of all survey responses received and 24.2% of stations contacted by email. During the course of the study period reminder emails were distributed by both TxDPS (2) and CTR (3) to encourage more stations to complete the survey. Each of these reminders resulted in additional survey responses.

The number of completed survey responses received included 757 from stations that perform only safety inspections and 805 survey responses from stations that perform both emissions and safety inspections. These sample sizes provide a sufficient number of survey to make statistically valid statements about Texas safety inspection stations statewide at the 95% confidence interval, +/- 3% error.

In addition, enough surveys were obtained to make statistically valid statements about individual categories of stations such as ‘emissions and safety inspection stations’ in comparison to ‘safety-only stations’, ‘urban or rural county locations’, and ‘distributions of responses for small, intermediate and large station operations’ at the 95% confidence interval +/- 4% error.

K.1. Economic Impact on Inspection Stations if Safety Inspections Are Eliminated

Figure K.1 shows the number inspection stations categorized by the number of vehicles that are inspected per week (on average). It is important to note that these values are calculated average numbers and that inspection station owners pointed out during the Workshop that many vehicle owners have their cars inspected either at the end or beginning of the month. It is conjectured that these individuals choose to have their cars inspected near the end of the month since payday occurs at this time for many individuals. Thus, weekly numbers of inspections might vary significantly over the course of a month.

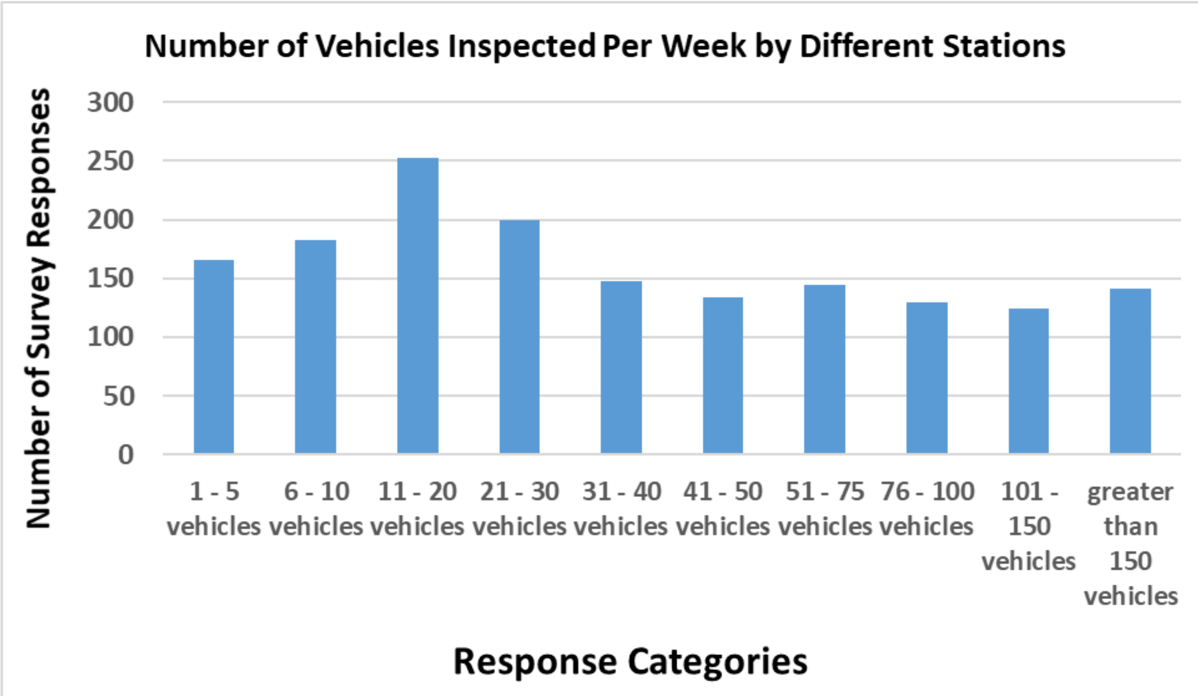


Figure K.1. Number of inspection stations categorized by number of vehicles inspected per week

Figure K.2 shows the inspection station responses to this question "How will your business be impacted if safety inspections for passenger vehicles in Texas are eliminated?"

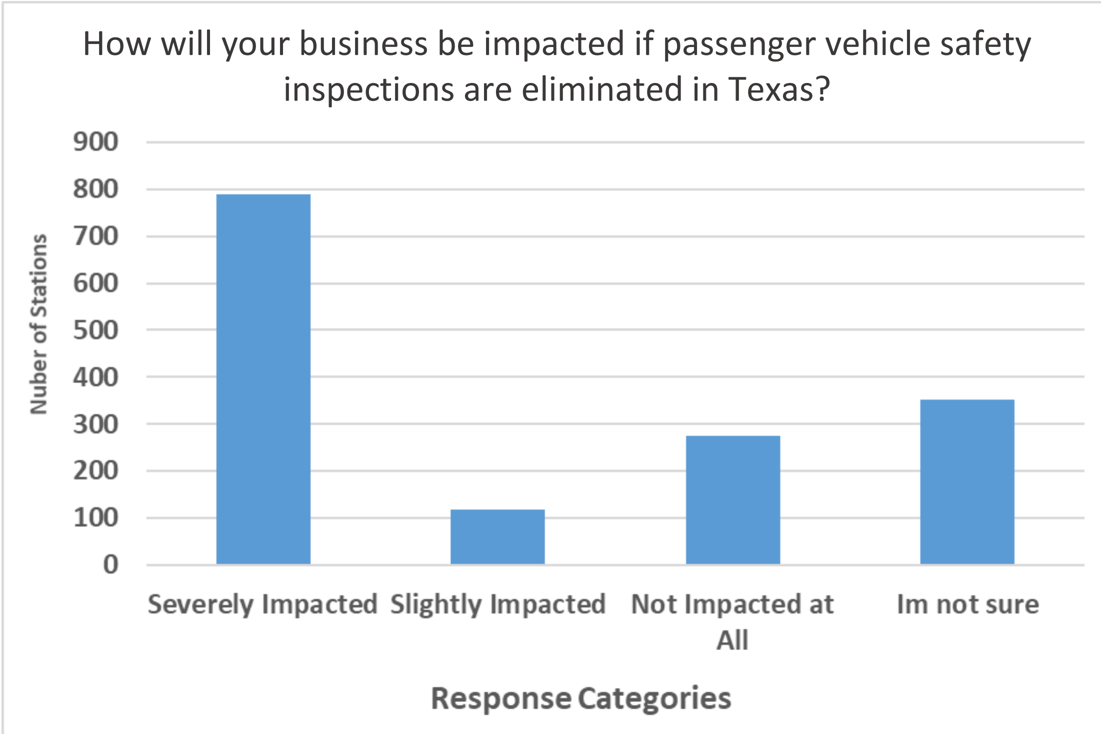


Figure K.2. Responses about potential impact to vehicle inspection stations if the safety inspection for PVs is eliminated

Approximately 50.5% (790) of station operators surveyed indicated that their business would be severely impacted; 7.8% (119) would be slightly impacted, 17.9% (274) would not be impacted at all, and 22.9% (351) were unsure how their business would be impacted.

Figure K.3 shows the distribution of years in business for the survey respondents.

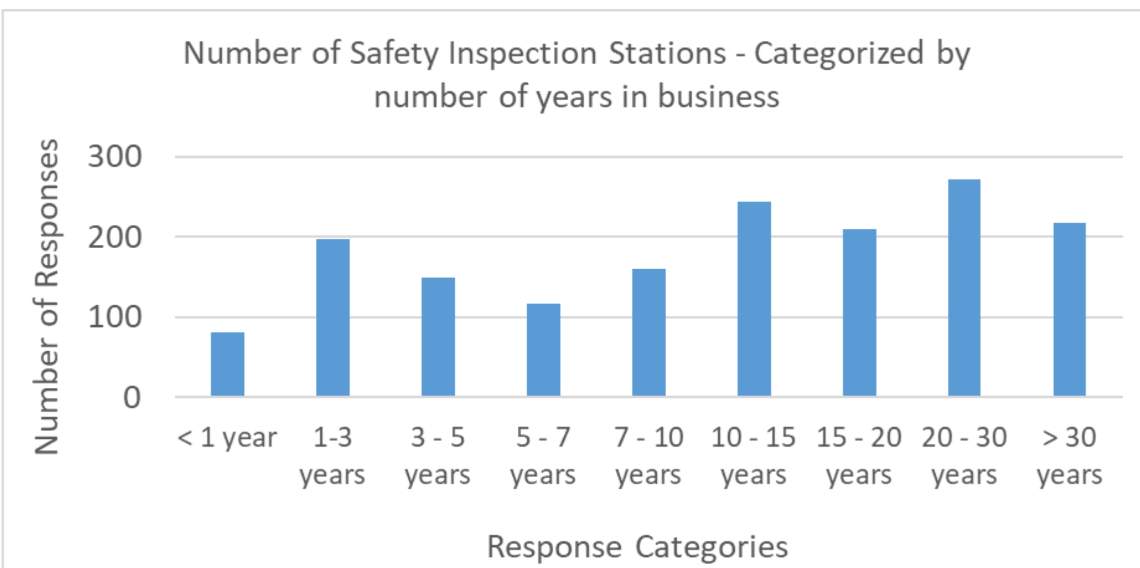


Figure K.3. Inspection stations categorized by number of years in business

Approximately 57.3% of inspection businesses have been in operation 10 or more years. Approximately 16.8% of inspection businesses have been in operation three or less years.

Figure K.4 shows the number of full-time certified employees. The estimated total number of certified inspection technicians is approximately 5,439 individuals.

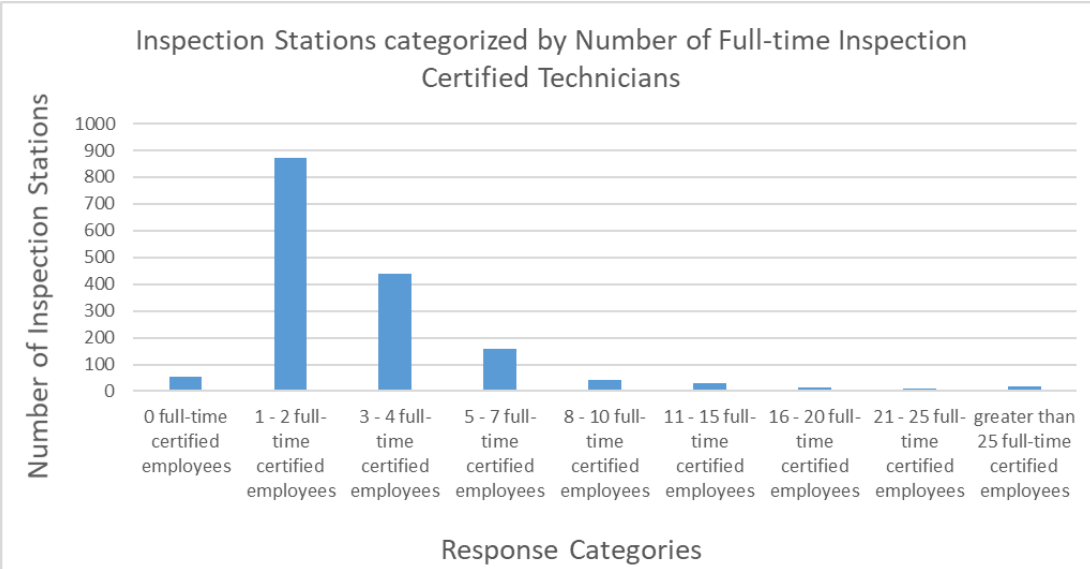


Figure K.4. Inspection stations categorized by number of full-time certified inspection technicians

Figure K.5 shows the number inspection stations with from zero to more than five part-time certified inspection technicians on staff. Based on this information, approximately 983 part-time certified inspection technicians are on staff with the stations surveyed. If each of these technicians work half-time, this is the equivalent of 482 additional full-time employees, which when added to the previously calculated number of full-time inspection technicians (5,439) results in the equivalent of 5,921 full-time employees. Using information about the number of inspection stations that responded to the survey, the percentage of stations that responded to this question, and the numbers of full- and part-time employees, this results in an estimated 45,300 employees for all inspection stations statewide (approximately 12,500). This number closely agrees with the number of employees mentioned in Chapter 2.

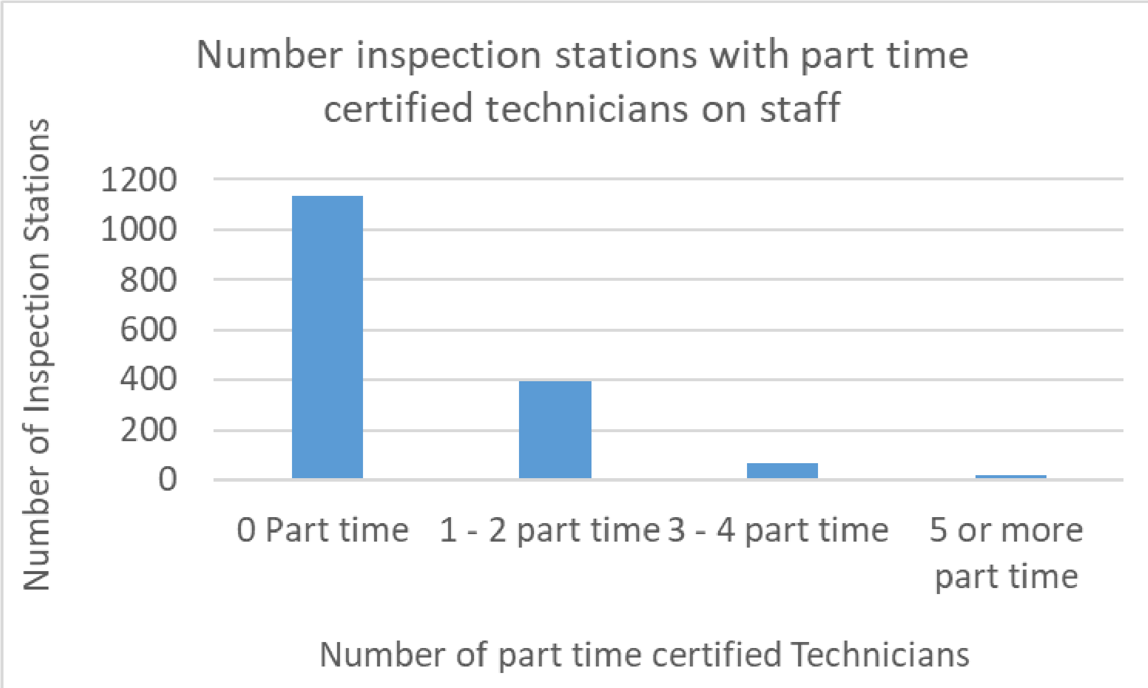


Figure K.5. Number of part-time certified inspection technicians reported by the survey respondents

Figure K.6 shows responses to this question: "Do you think the vehicle safety inspection program improves highway safety in Texas?" Approximately 82.5% of survey respondents indicated 'Definitely' or 'Probably Yes', 7.8% indicated that safety inspections 'Might or Might Not Improve Highway Safety', and 9.6% of stations indicated that safety inspections 'Probably Not' or 'Definitely Not' improved safety.

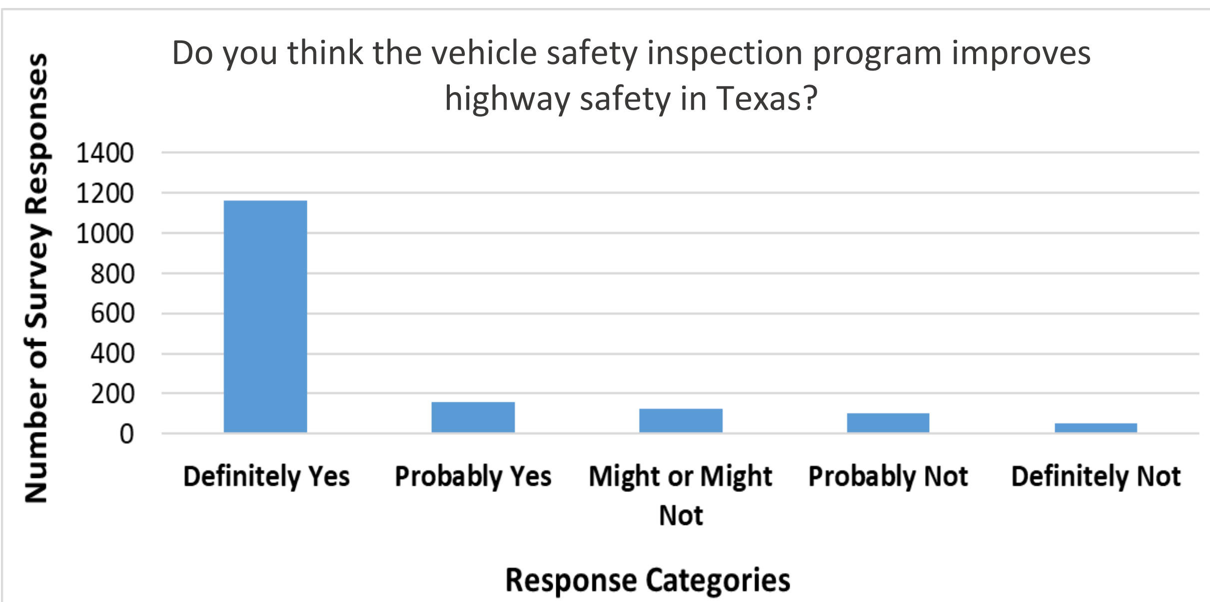


Figure K.6. Responses about whether vehicle inspections benefit highway safety in Texas

The majority of inspection station operators who responded that that safety inspections do benefit highway safety pointed out that low-income individuals or families may not be able to perform maintenance of their vehicles as needed. In other cases, elderly drivers may not be aware of maintenance issues and appreciate having a safety inspection to ensure that defects are addressed and their vehicles are in compliance.

An extremely important point that should be emphasized is that safety inspections not only benefit the vehicle owner, but also benefit all other drivers on the road. Crashes involving vehicles with defects often occur with another vehicle that does not have defects. In some cases, fatalities or serious injuries that result from the crash occur in the vehicle without defects. Thus, everyone benefits when all vehicles on the road are in compliance with safety inspection requirements.

Some station owners who responded that they 'Probably' or 'Definitely [did] Not' think safety inspections support safety took the time to comment that this sentiment reflects their opinions about the state rules and the inspection fee that affects their business operations, rather than directly about how safety inspections affect highway safety.

One inspection station owner commented that he/she sees vehicles with defects driving on the road, despite the Inspection Program's existence. This could be due, in part, to safety inspections occurring every 12 months. A vehicle that barely passes inspection can be out of compliance within a few months. Thus, there are vehicles on the highway that have passed the annual safety inspection within the past year, but now, due to continued wear of tires, brakes, and other components, would currently not pass an inspection. In addition, as pointed out by the station operator, there are businesses in Texas that rent tires to customers. The study team's examination of crash reports found a law enforcement officer's statement that the vehicle owner had rented a tire that was not properly mounted and came off the vehicle, causing a crash. It is feasible that vehicle owners who do not have adequate resources to buy one or more new tires might choose to rent tires to pass an inspection, in order to continue driving their vehicle. In that case, the vehicle owner might also choose to return the rental tires and remount their defective or slick tires.

Figures K.1 through K.6 provide additional insights about whether safety inspections improve highway safety in Texas. Figure K.7 shifts the focus to perceived impact of discontinuing the Inspection Program. This graph depicts the number of stations that indicated they would not be impacted at all if safety inspections were eliminated, categorized by number of vehicles inspected per week.

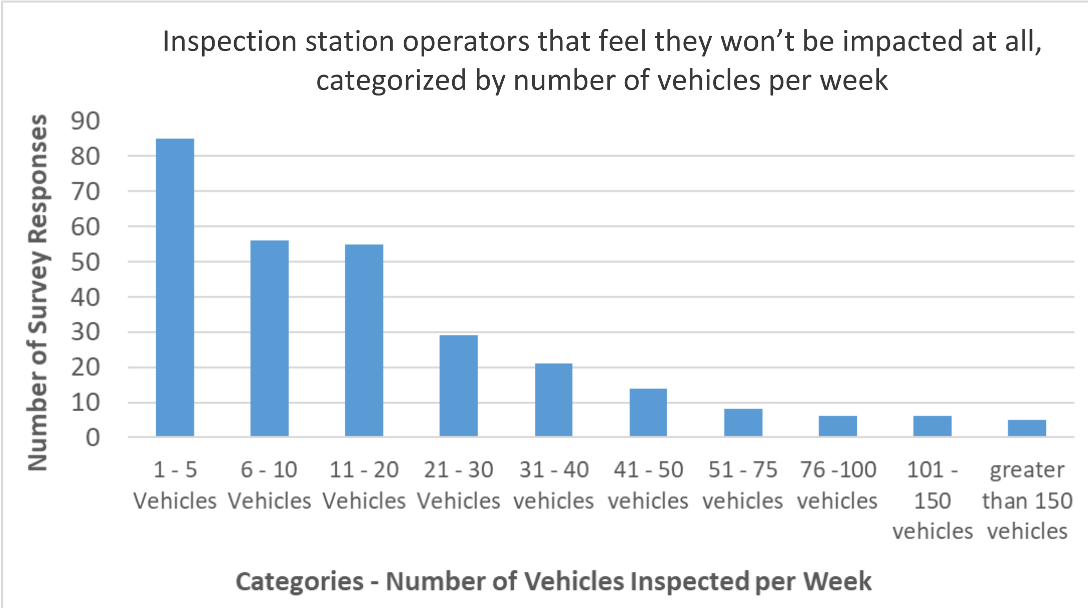


Figure K.7. Number of stations that would not be impacted categorized by number of vehicles inspected per week

Of the 285 stations who indicated they would not be impacted at all, approximately 33% inspect from one to five vehicles per week and approximately 79% inspect 30 or fewer vehicles per week.

Approximately 30% of stations that inspect 30 or fewer vehicles per week indicated their business *would* be severely impacted. In addition, of the 152 inspection stations that indicated either 'Probably' or 'Definitely Not' regarding whether safety inspections improved safety, 71% inspect 30 or fewer vehicles per week.

However, it bears repeating that the majority of comments from individuals who responded either 'Probably' or 'Definitely Not' regarding whether safety inspections improved highway safety are individuals who focused on the operational aspects of the safety inspection program and their frustration with the $7.00 safety inspection fee as limiting factors in providing an effective safety inspection.

These comments may beg the question of why these stations remain in business if they cannot make a profit performing safety inspections. This issue was discussed during the workshop and during stakeholder interviews that involved experienced inspection station operators. Most safety inspection stations offer other services to their loyal and routine customers, such as major repairs, oil changes, and other routine maintenance. The expectation of these loyal customers is to also have their car inspected by the same business that performs repairs and maintenance on their vehicles during the year. Thus, as a service to their customer base, safety inspections are performed, often at a profit loss.

In Appendix J, it was shown that vehicle owners stated that approximately 25% of the time, inspection station operators notice a defect and tell the driver to have the defect fixed, then come back to the station for an inspection.

The safety inspection station survey had a similar question, which asked, "If you know a vehicle will fail the inspection, what would you do? (Check all options that apply)."

The option to check all applicable options was offered because inspection station operators might respond differently depending on the circumstances, when first viewing a vehicle to be inspected. As a result some station operators checked more than one option, creating the need to prorate the responses when more than one response was given.

Q19 If you know a vehicle is going to fail the inspection, what would you do? Check all that apply.

- [ ] Before the inspection, you see that there is a safety problem and tell the vehicle owner to have the problem fixed then the inspection will be performed. (1) **690 Responses (29.7%)**
- [ ] During the inspection, you tell the vehicle owner that there is a safety problem(s) which your station can fix, after the repair(s) or part(s) replacement(s) are performed the vehicle will pass the inspection. (2) **947 Responses (40.7%)**
- [ ] Fail the vehicle during the inspection then tell the vehicle owner to have the problem fixed and bring their vehicle back. Afterward you will perform a 2nd inspection after the repairs are performed. (3) **688 Responses (29.6%)**

Question 19 has been underscored since these responses apply only to vehicles that the inspector knows will fail the inspection and thus do not apply to vehicles that pass inspection. It should be further noted that survey respondents could check more than one response if each applied to their business practices. Thus, though some inspection station operators checked only one option, others checked two or three options. This required prorating the multiple responses by multiplying 2 responses by 0.5 and 3 responses by .333, considering that the actual percentage of time that one or the other action would be taken if two (or three) actions were checked.

Based on this analysis, the adjusted percentages for each action are given below.

- [ ] Before the inspection, you see that there is a safety problem and tell the vehicle owner to have the problem fixed then the inspection will be performed. (1) **(23%) adjusted to 25%**
- [ ] During the inspection, you tell the vehicle owner that there is a safety problem(s) which your station can fix, after the repair(s) or part(s) replacement(s) are performed the vehicle will pass the inspection. (2) **(42%)**
- [ ] Fail the vehicle during the inspection then tell the vehicle owner to have the problem fixed and bring their vehicle back. Afterward you will perform a 2nd inspection after the repairs are performed. (3) **(33%)**

Thus station operators indicated that they tell a vehicle owner to have a defect repaired, then come back for the inspection, about 23% of the time, compared to 25% based on vehicle owner responses. These values are within the +/- 3% error band for these analyses and it can be said that in either case about 25% of the time the vehicle owners are told to have a defect repaired before the inspection is performed. Again, this results in an under-counting of first-time failures.

In Appendix J, it was determined that approximately 37% of vehicles have not needed parts or repairs; therefore, it follows that 63% of vehicles have failed an inspection at least once and have required parts or repairs.

Question 19 applies only to vehicles that the inspection station operator knows will fail the inspection. Thus, the following case study of 1,000 vehicles illustrates the most likely failure responses:

Never needed parts or repairs = 1,000 x 37% = **370** vehicles. Thus, the remaining 63% of vehicles **(**630 vehicles) fail inspection in one of the following three manners:

1. Before the inspection, you see that there is a safety problem and tell the vehicle owner to have the problem fixed then the inspection will be performed. 630 vehicles x 25% = **157 vehicles.**

2. During the inspection, you tell the vehicle owner that there is a safety problem that your station can fix, and after the repair or part replacement is performed, the vehicle will pass the inspection. 630 vehicles x 42% = **265 vehicles**

3. Fail the vehicle during the inspection, then tell the vehicle owner to have the problem fixed and bring their vehicle back. You will perform a second inspection after the repairs are performed. 630 vehicles x 33% = **208 vehicles**

Thus, of every 1,000 vehicles inspected, it is estimated that the station operator performs repairs on approximately 265 vehicles. The remaining vehicles either pass inspection with no need for repairs or fail inspection but are sent elsewhere for parts before the final inspection is performed.

Appendix L. Supplementary Materials for Houston Taxi and Limousine Inspection Data Evaluation

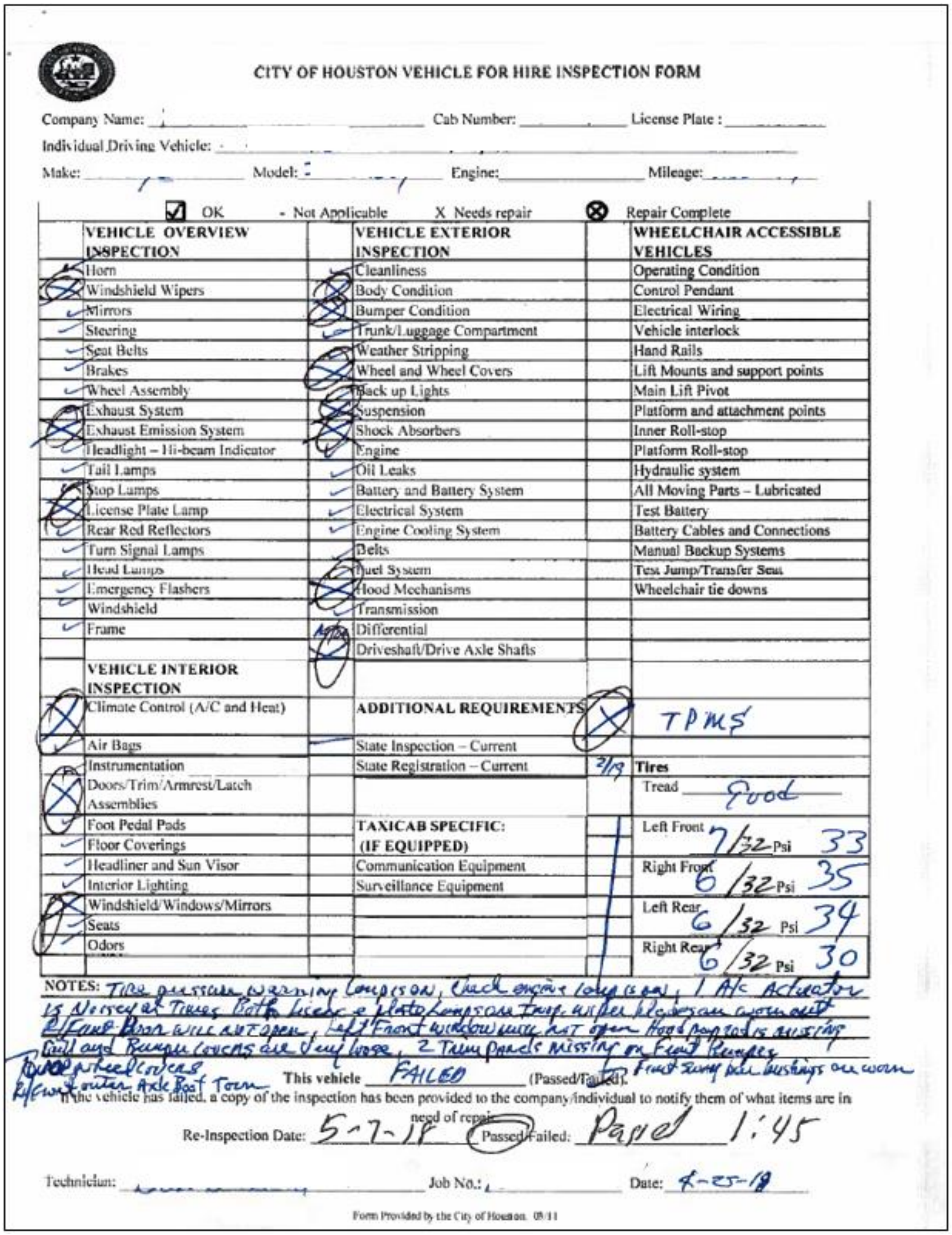
This appendix provides additional detailed information regarding Houston taxi and limousine inspection data evaluation and analysis, which is presented in Chapter 6.

Houston ran a mandatory inspection program for the city's taxis and limousines from 2011 through 2016. This inspection was separate from and in addition to that of the state Inspection Program. The City developed its own inspection standards that examined about 77 items, which exceeds the number of items inspected during mandatory state inspection. The CTR team obtained inspection records for this program from a Houston-based inspection station (HAF, Inc.) with whom the City had contracted to provide this service.

L.1. Inspection Data Processing

The Houston taxi and limousine inspection records were obtained as four boxes of paper copies. In order to study and analyze the inspection reports, CTR developed an Excel database to store all the information found on the detailed inspection result sheet, including first inspection date, cost of the inspection, vehicle year, vehicle make and model, mileage, first inspection result, detailed failure reasons, number of defective items, re-inspection date and result, etc. In the report, the inspector wrote the detailed reason why the vehicle failed the first inspection and whether the vehicle was re-inspected. Figure L.1 shows one example of detailed inspection result sheet, where all the corresponding information can be found. Table L.1 lists the items that were inspected under the program.

In total, about 3,000 inspection records were obtained. The study team randomly selected 714 records for processing 714. For our analysis, the study team calculated the first-time failure rate, the vehicle age when the vehicle was inspected, and the days between the first and second inspections. Since the taxis and limousines followed the same inspection standard, the study team combined taxi and limousine inspection results for analysis purposes.



CITY OF HOUSTON VEHICLE FOR HIRE INSPECTION FORM

Company Name: ______ Cab Number: ______ License Plate: ______

Individual Driving Vehicle: ______

Make: ______ Model: ______ Engine: ______ Mileage: ______

☑ OK - Not Applicable X Needs repair ⊗ Repair Complete

VEHICLE OVERVIEW INSPECTION	VEHICLE EXTERIOR INSPECTION	WHEELCHAIR ACCESSIBLE VEHICLES
Horn	Cleanliness	Operating Condition
Windshield Wipers	Body Condition	Control Pendant
Mirrors	Bumper Condition	Electrical Wiring
Steering	Trunk/Luggage Compartment	Vehicle interlock
Seat Belts	Weather Stripping	Hand Rails
Brakes	Wheel and Wheel Covers	Lift Mounts and support points
Wheel Assembly	Back up Lights	Main Lift Pivot
Exhaust System	Suspension	Platform and attachment points
Exhaust Emission System	Shock Absorbers	Inner Roll-stop
Headlight – Hi-beam Indicator	Engine	Platform Roll-stop
Tail Lamps	Oil Leaks	Hydraulic system
Stop Lamps	Battery and Battery System	All Moving Parts – Lubricated
License Plate Lamp	Electrical System	Test Battery
Rear Red Reflectors	Engine Cooling System	Battery Cables and Connections
Turn Signal Lamps	Belts	Manual Backup Systems
Head Lamps	Fuel System	Test Jump/Transfer Seat
Emergency Flashers	Hood Mechanisms	Wheelchair tie downs
Windshield	Transmission	
Frame	Differential	
	Driveshaft/Drive Axle Shafts	
VEHICLE INTERIOR INSPECTION		
Climate Control (A/C and Heat)	**ADDITIONAL REQUIREMENTS**	TPMS
Air Bags	State Inspection – Current	
Instrumentation	State Registration – Current	2/19 **Tires**
Doors/Trim/Armrest/Latch Assemblies		Tread Good
Foot Pedal Pads	**TAXICAB SPECIFIC: (IF EQUIPPED)**	Left Front 7/32 Psi 33
Floor Coverings		
Headliner and Sun Visor	Communication Equipment	Right Front 6/32 Psi 35
Interior Lighting	Surveillance Equipment	
Windshield/Windows/Mirrors		Left Rear 6/32 Psi 34
Seats		
Odors		Right Rear 6/32 Psi 30

NOTES: Tire pressure warning comes on, check engine light is on, 1 A/C actuator is noisey at times, Both license plate lamps are out, wiper blades are worn out, R/Front door will not open, Left Front window will not open, Hood prop rod is missing, Grill and Bumper covers are very loose, 2 Trim panels missing on Front Bumper, Front sway bar bushings are worn, Four wheel covers, R/Front outer Axle Boot Torn

This vehicle FAILED (Passed/Failed).

If the vehicle has failed, a copy of the inspection has been provided to the company/individual to notify them of what items are in need of repair.

Re-Inspection Date: 5-7-18 Passed/Failed: Passed 1:45

Technician: ______ Job No.: ______ Date: 4-25-18

Form Provided by the City of Houston. 09/11

Figure L.1. An example of a Houston Taxi and Limousine Inspection Report

Table L.1. Detailed inspection items during Houston taxi and limousine inspection

Vehicle Overview	Vehicle Exterior	Wheelchair Accessible Vehicles
Horn*	Cleanliness	Operating condition
Windshield Wiper*	Body condition	Control pendant
Mirrors*	Bumper condition	Electrical wiring
Steering*	Trunk/luggage compartment	Vehicle interlock
Seat belts*	Weather stripping	Hand rails
Brakes*	Wheel and wheel covers	Lift mount and support points
Wheel Assembly*	Back up lights	Main lift pivot
Exhaust system*	Suspension	Platform and attachment points
Exhaust emission system*	Shock absorbers	Inner roll-stop
Headlight–Hi-beam indicator*	Engine	Platform roll-stop
Trail lamps*	Oil leak	Hydraulic system
Stop lamps*	Battery and battery system	All moving parts – lubricated
License plate lamp*	Electrical system	Test battery
Rear red reflectors*	Engine cooling system	Battery cables and connections
Turn signal lamps*	Belts	Manual backup system
Head lamps*	Fuel system	Test jump/transfer seat
Emergency flashers	Hood mechanisms	Wheelchair tie downs
Windshield	Transmission	
Frame	Differential	**Tires (tread depth and pressure)***
	Driveshaft drive axle shaft	
Vehicle Interior		
Climate control	**Additional Requirements**	
Air bags	State inspection– Current	
Instrumentation	State registration-Current	
Doors/Trim/Armrest/ Latch assemblies		
Foot pedal pads	**Taxicab Specific (if equipped)**	
Floor coverings	Communication equipment	
Headliner and Sun visor	Surveillance equipment	
Interior lighting		
Windshield windows mirror		
Seats		
Odors		

*Note: Items with * are also inspected under the Inspection Program.*

L.2. Analysis of Houston Taxi and Limousine Inspection Records

This section analyzes the inspection reports using Houston's inspection standard. A vehicle (taxi or limousine) fails the inspection if one or more defective items are identified during the inspection.

Of the 714 taxi and limousine vehicle inspection records processed, 590 (82.6%) failed the first inspection with one or more defective items. Only 124 (17.4%) vehicles passed the first inspection. Table L.2 summarizes the average vehicle age when the taxi was inspected and the average mileage information.

Table L.2. Average vehicle age and mileage for Houston taxis and limousines

	Number of Vehicles	Average Age	Average Mileage
All vehicles	714	5.9 years	257,640 miles
Vehicle failed first inspection	590 (82.6% first-time failure rate)	5.9 years	260,569 miles
Vehicle passed first inspection	124	5.7 years	243,727 miles

Note that the average age difference between vehicles that either failed or passed the first inspection is very small (0.2 years). In addition, all the vehicles have very high mileage—on average 257,640 miles, which is much higher than for a typical PV. The vehicles that failed the first inspection have a higher mileage (260,569 miles) than those that passed first inspection (243,727 miles). Figure L.2 shows the mileage distribution of all the 714 vehicles in database.

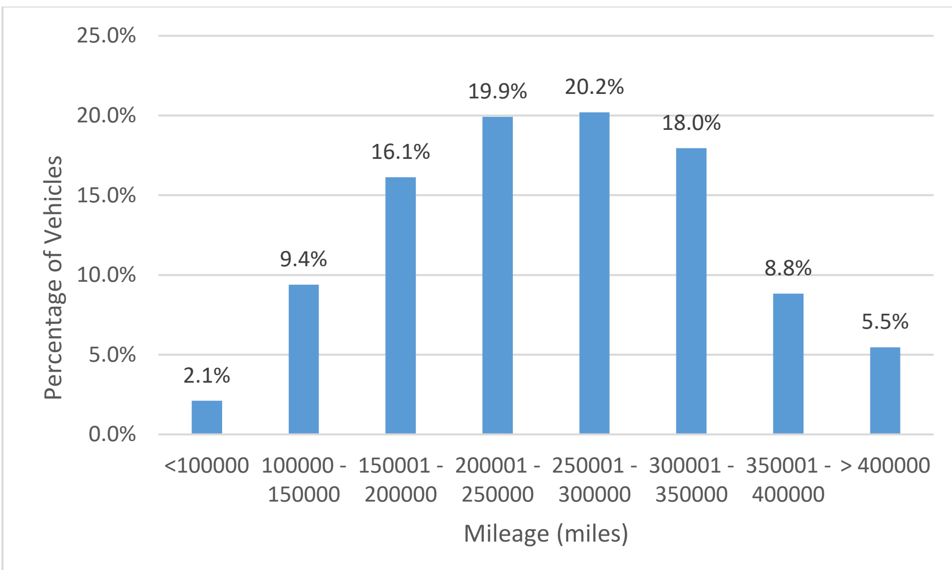


Figure L.2. Mileage distribution of Houston taxis and limousines

The study team found that high mileage is one shared characteristic of Houston taxis and limousines. As Figure L.2 illustrates, the mileage is "normally" distributed with most of the vehicles (74.2%) in the mileage range of 150,001 to 350,000.

It is noteworthy that 98.5% of the vehicles (581 out of 590) that failed the first inspection were re-inspected and passed the re-inspection. The inspection reports showed that HAF Inc. did not have re-inspection information on the other nine vehicles. For the 581 vehicles that were re-inspected, about 7 days on average passed before the vehicles were repaired and returned to pass the re-inspection. Figure L.3 presents the distribution of number of days between inspections.

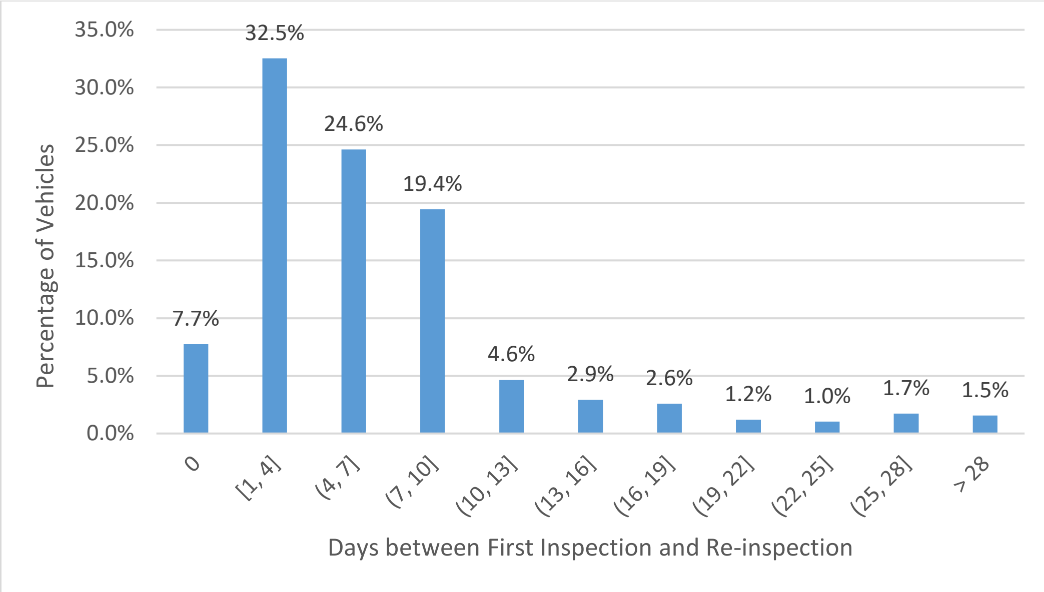


Figure L.3. Distribution of days between inspections for Houston taxis and limousines

Figure L.3 indicates that most of the vehicles (84.3%) completed the repair and passed the re-inspection within 10 days. Only 7.7% of the vehicles (45 out of 581) made the repair and passed the re-inspection on the same day, while 1.5% (9 out of 581) took more than 28 days. The longest duration in the database is one taxi that conducted re-inspection after 113 days.

The vehicle will fail an inspection if at least one or more defective items were identified during the inspection. Table L.3 lists the average number defective items for the vehicles.

Table L.3. Average failure reasons and defective items for Houston taxis and limousines

	Number of Vehicles	Average Defective Items
Vehicles failed first inspection	590 (82.6% first-time failure rate)	5
Vehicles passed first inspection	124	0
All vehicles	714	4

On average, each taxi or limousine inspected had about four defective items. The average number of defective items increases to five for those vehicles that failed the first inspection. Figure L.4 presents the distribution of number of defective items.

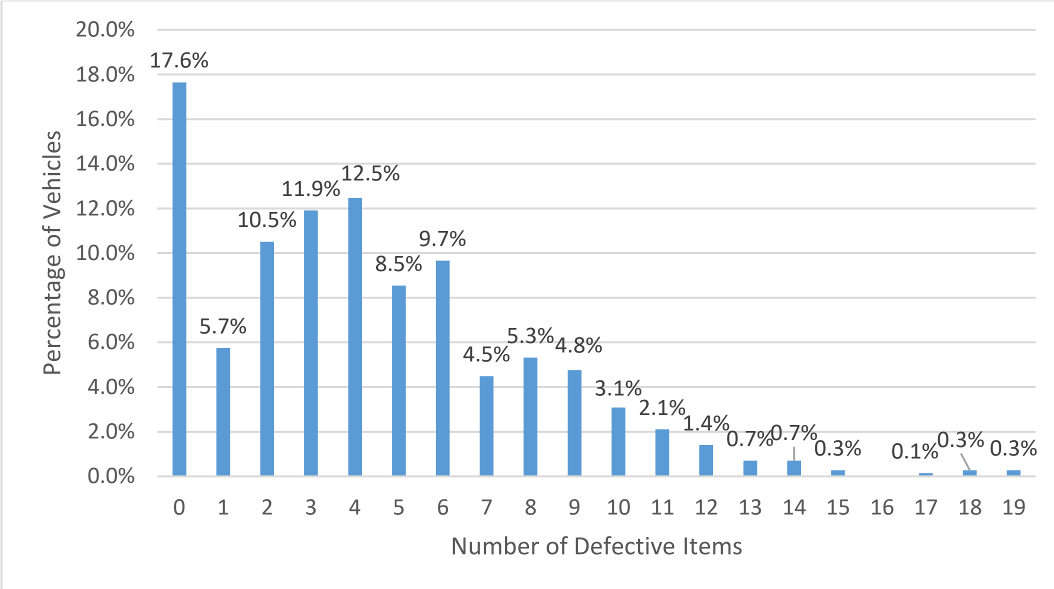


Figure L.4. Distribution of number of defective items for Houston taxis and limousines

Figure L.4 indicates that vehicles with no defective items (17.6%) are those that passed the first inspection. Of the 590 vehicles that failed first inspection, 420 (58.8%) have 6 or fewer defective items. There are 64 (9%) vehicles with 10 or more defective items. Two vehicles had 19 (the most) defective items.

Brakes represented the most common defect, found in 275 (38.5%) vehicles. The next most common defect was suspension (253 vehicles, 35.4%), then steering (181 vehicles, 25.4%), engine (166 vehicles, 23.2%), and head lamps (144 vehicles, 20.2%). This indicates that about 4 vehicles out of 10 would fail the inspection due to some defect associated with the brakes. Table L.4 summarizes all the defective items and the number of vehicles associated with them.

Table L.4. Summary of all defective items for Houston taxis and limousines

Defective Item	Number of Vehicles (percentage)	Defective Item	Number of Vehicles (percentage)
Brakes*	275 (38.5%)	Seat Belts*	22 (3.1%)
Suspension	253 (35.4%)	Exhaust System*	21 (2.9%)
Steering*	181 (25.4%)	Differential	19 (2.7%)
Engine	166 (23.2%)	Horn*	17 (2.4%)
Head lamps*	144 (20.2%)	Cleanliness	16 (2.2%)
Wheel and wheel covers	132 (18.5%)	Belts	13 (1.8%)
Doors/Trim/Armrest/Latch Assemblies	130 (18.2%)	State Inspection - current	12 (1.7%)
License plate lamp*	121 (16.9%)	Foot pedal pads	12 (1.7%)
Oil leaks	117 (16.4%)	Tail lamps*	9 (1.3%)
Battery and battery system	107 (15.0%)	Floor coverings	9 (1.3%)
Stop lamps*	100 (14.0%)	Headliner and sun visor	9 (1.3%)
Tires*	95 (13.3%)	Wheel Assembly*	8 (1.1%)
Instrumentation	76 (10.6%)	Seats	8 (1.1%)
Transmission	70 (9.8%)	Mirrors*	7 (1.0%)
Hood mechanisms	67 (9.4%)	Windshield	7 (1.0%)
Body condition	62 (8.7%)	Platform and attachment points	7 (1.0%)
Turn signal lights*	61 (8.5%)	State Registration - current	7 (1.0%)
Engine cooling system	59 (8.3%)	Headlight - Hi-beam indicator*	5 (0.7%)
Air bags	56 (7.8%)	Odors	4 (0.6%)
Climate Control (A/C and Heat)	55 (7.7%)	Electrical system	4 (0.6%)
Driveshaft/Drive axle shafts	52 (7.3%)	Weather stripping	4 (0.6%)
Windshield wipers*	50 (7.0%)	Frame	3 (0.4%)
Bumper condition	39 (5.5%)	Communication equipment	3 (0.4%)
Trunk/luggage compartment	38 (5.3%)	Fuel system	2 (0.3%)
Back up lights	37 (5.2%)	Emergency flashers	2 (0.3%)
Exhaust emission system*	35 (4.9%)	Interior lighting	1 (0.1%)
Shock absorbers	35 (4.9%)	Wheelchair tie downs	1 (0.1%)
Windshield/windows/mirrors (interior)	27 (3.8%)		

*Note: Items with * are also included in Inspection Program.*

Figure L.5 presents the top 15 defective items that failed an inspection under Houston inspection standard.

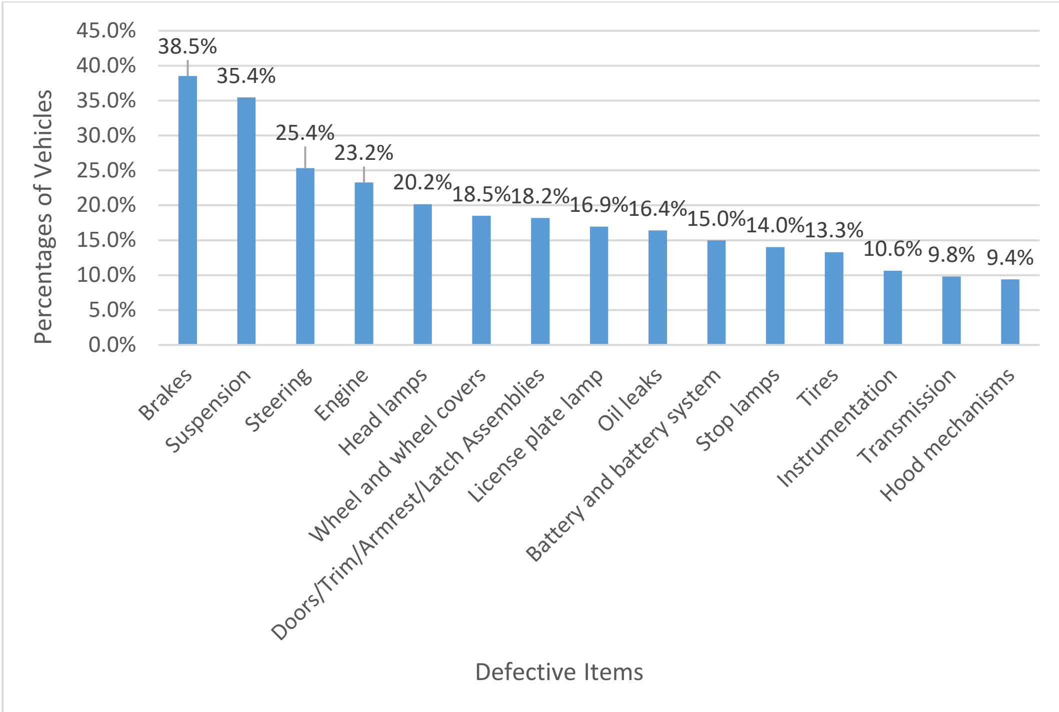


Figure L.5. Top 15 defective items for Houston taxis and limousines

L.3. Analysis of Houston Taxi and Limousines Inspection Records Using Inspection Program Standards

The high rate of first-time failure for these high-mileage vehicles signifies the importance of ensuring that PVs for used for commercial purposes (including PVs used by the increasingly prevalent transportation network companies such as Uber and Lyft) be subject to inspection. Given that the Houston program had more stringent standards, the study team was interested in determining how these same vehicles would fare under the Inspection Program standards.

Houston's inspection program examined about 77 items, most of which are not required by the Inspection Program (items without an asterisk in Table L.4). In other words, some vehicles failed that the Houston inspection might pass the mandatory state inspection. This section analyzes the inspection records through the lens of the Inspection Program standards. The items considered in this section are the ones marked with asterisks in Table L.4.

Of the 714 vehicle records the study team examined, 71.6 % (511 vehicles) would have failed the first inspection with one or more defective items under the Inspection Program standard, which is an 11% decrease compared with the Houston Standard because fewer items were inspected. This means 203 (28.4%) vehicles would have passed the first inspection under Inspection Program standard. Table L.5 summarizes Inspection Program evaluation, the average vehicle age when the taxi was inspected, and the average mileage information.

Table L.5. Inspection Program evaluation results under Inspection Program standards, with average vehicle age and mileage for Houston taxis and limousines

	Number of Vehicles	Average Age	Average Mileage
All vehicles	714	5.9 years	257,640 miles
Vehicle would fail first inspection	511 (71.6% first-time failure rate)	5.9 years	261,024 miles
Vehicle would pass first inspection	203	5.8 years	249,136miles

The average mileage of vehicles that would have failed the first inspection (261,024 miles) is higher than that of the vehicles that would have passed the inspection (249,136 miles).

On average, there are about 2 defective items with each taxi or limousine under the Inspection Program standard. Figure L.6 presents the distribution of number of defective items under Inspection Program standard.

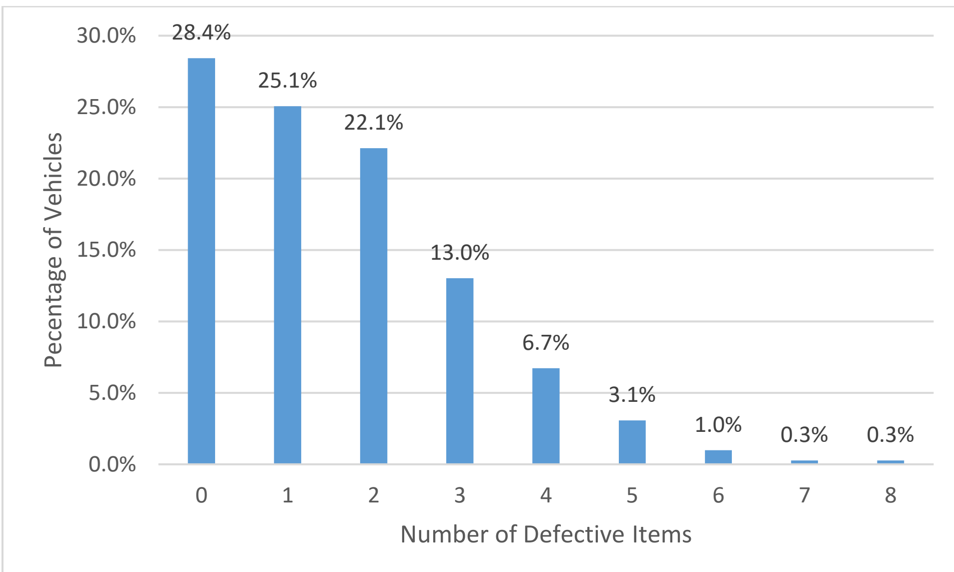


Figure L.6. Distribution of number of defective items for Houston taxis and limousines under Inspection Program standards

Figure L.6 indicates that 28.4% of the vehicles would pass the inspection under the TxDPS Inspection Program standard. Of the 511 vehicles that would fail the first inspection, 430 (60.2%) have three or fewer defective items. The remaining 81 (11.3%) vehicles with 4 or more defective items. Two vehicles had eight (the most) defective items.

In terms of defective items, brakes are still the most common at 275 (38.5%) vehicles, followed by steering (181 vehicles, 25.4%), head lamps (144 vehicles, 20.2%), license plate lamps (121 vehicles, 16.9%), stop lamps (100 vehicles, 14.0%), and tires (95 vehicles, 13.3%). Table L.6 summarizes all the defective items and the number of vehicles associated with them under the Inspection Program standards.

Table L.6. Summary of all defective items for Houston taxis and limousines under Inspection Program standards

Defective Item	Number of Vehicle (percentage)	Defective Item	Number of Vehicle (percentage)
Brakes	275 (38.5%)	Exhaust emission system	35 (4.9%)
Steering	181 (25.4%)	Seat Belts	22 (3.1%)
Head lamps	144 (20.2%)	Exhaust System	21 (2.9%)
License plate lamp	121 (16.9%)	Horn	17 (2.4%)
Stop lamps	100 (14.0%)	Tail lamps	9 (1.3%)
Tires	95 (13.3%)	Wheel Assembly	8 (1.1%)
Turn signal lights	61 (8.5%)	Mirrors	7 (1.0%)
Windshield wipers	50 (7.0%)	Headlight - Hi-beam indicator	5 (0.7%)

Note: All items in the table are included in Inspection Program.

Figure L.7 presents the top 15 defective items that fail an inspection under Inspection Program standard.

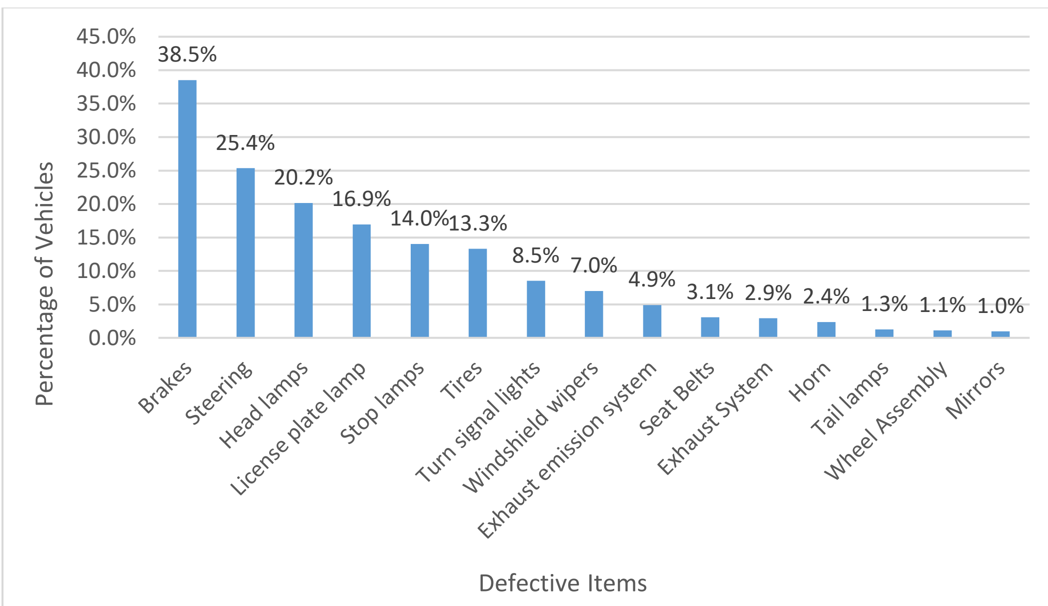


Figure L.7. Top 15 defective items for Houston taxis and limousines under Inspection Program standards

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