What We Know About State Safety Inspection Programs: Implications for a Texas Study

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November 6, 2017
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Motivations

- Interested because there are interesting research and analytics opportunities.
- Interesting mix of data, technology, and socially-relevant problem solving.
- We can “play” by helping in I&M strategic discussions
- We feel the real costs and benefits have not been addressed adequately, and through analytics we can do a better job through data-driven studies.
- In other words, we fight power with data-driven studies.

Fast Facts About Passenger Vehicle Use (DOT)

Year	Average Age (years)	Average Annual Miles Driven Per Car	Percent of Cars >15 years old
1977	6.6	9,000	3%
1995	8.4	11,000	15%
2013	11.4	13,000	20%

- No good data, but aging vehicles in fleet means they have more total miles on them than in the past
- 15+ year old cars still driven on average 7,000 miles per year

Brief History of Safety Inspection Programs

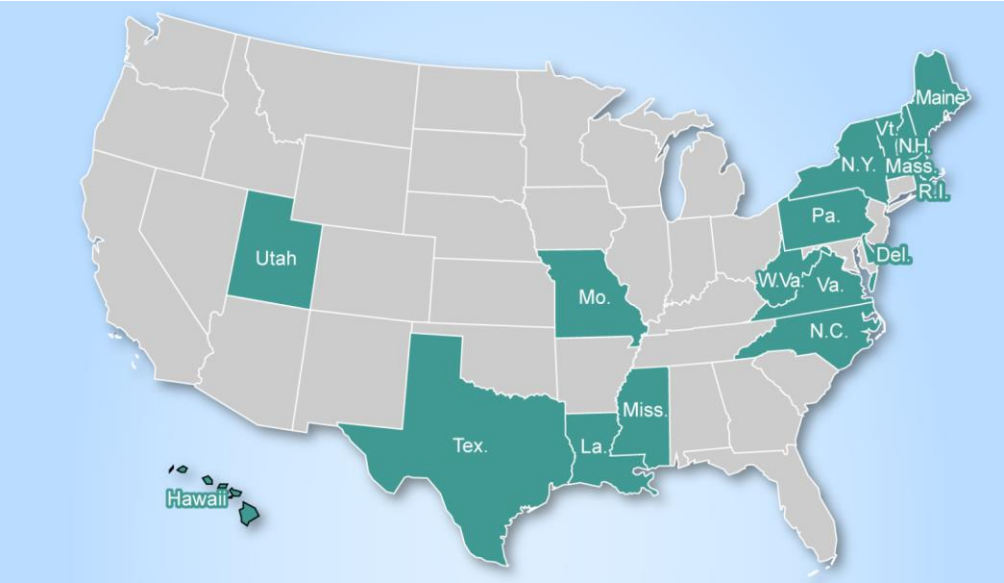
- 1960s: DOT had uniform standards for state inspection programs
- As of 1975: 31 states (+DC) had periodic programs
- Late 70s-80s: DOT changed rules that had withheld funding for removing, and that implicitly required, safety programs
- 1989: NHTSA did a study that said there was not conclusive evidence that programs reduced accident rates
  - GAO reviewed and cited data challenges, but disagreed, suggesting evidence

- Currently, NHTSA recommends but doesn’t require these programs

Current State and Questions

- Today, only 16 states have programs
  - Varying degrees of exemptions based on age
  - Most northeastern states do, extreme weather is a factor in component deterioration

- NHTSA has guidelines for inspection of safety systems
  - Last updated in 1979
  - But, states inevitably choose what is included in a program, and what is a pass or fail condition



Source: GAO report

- Frequent question: “do these programs have safety benefits (e.g., reduced crashes and/or fatalities)?”

Studies from Sutter and Colleagues

- Two studies, published in 1999, 2002– using data from 1981-1993
  - Statistical 'regression' model, commonly used for analyses
  - Used aggregate state *highway statistics* for counts of accidents, fatalities
  - Considered effects from annual as well as spot inspections by states

- In simplest model, found safety programs reduce fatalities by 2%
- More complex models found no statistically significant differences

Sutter, D., and Poitras, M., 'The Political Economy of Automobile Safety Inspections', *Public Choice*, 2002.
Merrell, D., Poitras, and Sutter, 'The Effectiveness of Vehicle Safety Inspections: Analysis Using Panel Data', *Southern Economic Journal*, 1999

New Data Sources Since 1993 - FARS

- DOT initiated Fatality Analysis Reporting System (FARS) to aid in policy and management of safety
  - They did this in part because only having standardized ‘counts’ of accidents made it hard to make decisions about safety-related issues
  - There are approximately 30,000 fatal crashes per year, 35,000 fatalities
- FARS (1994 -> now) has detailed records of EVERY FATAL CRASH IN US
  - Information source is police reports of the crashes, reported up the chain
  - Many fields, including time of day, seat belts, alcohol, etc.
- Some data relates to whether issues with vehicle safety components (e.g., faulty tires or brakes) are believed to contributed to the crash/fatality
    - More than 2% of fatal crashes have this cause

Non-Fatal Crash Injury Data Since 1989

- Like FARS, DOT initiated NASS-GES to track non-fatal crashes
  - There are approximately 6 million on-fatal crashes per year, 1.7 M injuries

- NASS-GES has only a '**national** statistical sample' of these crashes
  - 'Sample' represents overall US urban/rural, road/highway, cars, drivers
  - There are about 50,000 records in NASS-GES (about the same as FARS)
  - But since its not statistically 'correct' at the state level, it cannot (should not) be used to do comparisons of states. **So only FARS can be used!**
- Similar pedigree, fields as in FARS, including safety components
  - Only about 2% of crashes in GES have safety components as causes.

Back to Studies: Cambridge Systematics (2009)

- Highly credible transportation consulting firm in US.
- Contracted by Pennsylvania (my state)
  - Cambridge doesn't work in inspection domain, no obvious conflict of interest

- Study posted online in 2009 – using FARS data from 2004-2007
  - Focused only on fatal crashes due to data issue on previous slide
  - Similar statistical method as done by Sutter et al study
  - But used the newer official, consistent FARS dataset and fields
  - Benefit: 1-2 less fatal crashes per billion VMT in states with safety programs

Pennsylvania's Vehicle Safety Inspection Program Effectiveness Study (070609) Summary of Findings, by Cambridge Systematics, for Pennsylvania Department of Transportation, 2009.

Carnegie Mellon (2014)

- Done in 2015– used FARS data from 2000-2009. Not published yet.
  - Similar type of study as Cambridge, similar data
  - We tried to model difference in robustness of state program
  - Similar results as Cambridge study

US Federal Government (GAO) Report (2015)

- Requested by Sen. McCaskill of Missouri
- Focused after 1990, time of GAO's last report
- There are ~100,000 crashes per year in US due to safety components
- Noted difficulties in inspecting new technologies
- NHTSA is focused on driver behavior not inspections

Source: VEHICLE SAFETY INSPECTIONS: Improved DOT Communication Could Better Inform State Programs, GAO-15-705

Known Issues in the Current Datasets

- While they're much better than the 'counts' we had previously..
- States required to report to DOT, but not mandated how or who
  - Who does the report tracking, fills out forms, etc? Some have state police do it, with formal training programs (mostly safety states). Others do not
  - No blame: police are busy and doing their best. They aren't trained mechanics
  - Result, especially in the 'safety component cause' fields, is undercounting of safety component-related crashes
    - There are states which have zero safety component caused crashes in the datasets
- GAO also noted this, mentioned alternate studies that have found 3-4x higher rates of safety-related crashes than what is in FARS or GES

A Different Kind of Study - Peck et al (2015)

- Totally different kind of study. Focused on Pennsylvania
- Data-driven analysis of “adjusted” failure rates from data
- Used official data from state voluntary record program, and from a private vendor of safety inspection management software
- Considered records of “work done to pass” as implicit failures

- About 20% of vehicles in PA “fail” inspections

Dana Peck, H. Scott Matthews, Chris Hendrickson, and Paul Fischbeck, "An Analysis of Vehicle Safety Inspection Data in Pennsylvania: Expected Failure Rates", Transportation Research Part A, Volume 78, August 2015, Pages 252–265, 2015.

PA Inspection & Registration Data

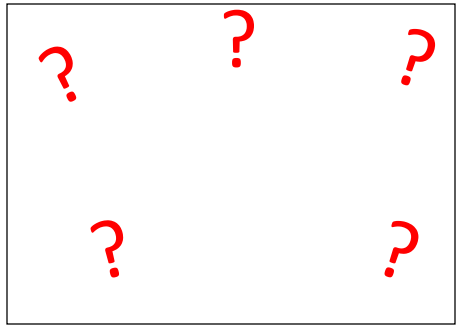
	e-SAFETY	CompuSpections	Registration
Record Count	980k (total)	3.3 million (total)	10 million (each)
Frequency	7 years (2008-2014)	5 years (2008-2014)	4 snapshots (March '12 & November '13 November '14, May '17)
Percent of Registered Vehicles per Year	~3%	~10%	~100%
VIN	X	X	X
Odometer	X	X	X*
Date	X	X	X*
Location (zip code/county)	X	X	X*
Vehicle make and/or model	X	X	
Inspection Type (e.g., annual)	X	X	
Inspection Action (e.g., pass, new)	X	X	
Insurance Policy	X	X	

*At time of registration for current owner in PA

How is a Fail Classified?

What Happens within the Inspection Black Box…?

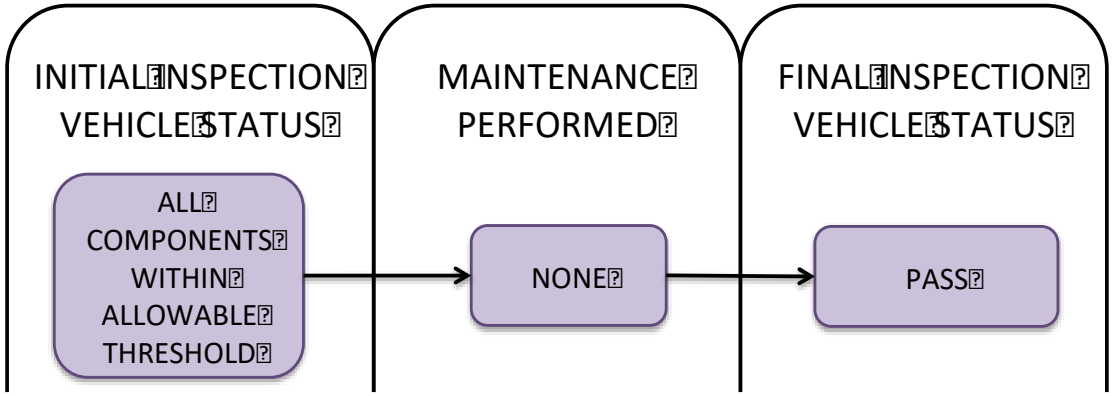
Vehicles with work performed → Vehicles that *would have failed*



new, repair, or adjust

Leave with a ‘pass’ or ‘fail’

Inspection Process



These vehicles pass with or without the current safety inspection program in place

Failure Scenarios

- Overall State Failure Rate
  - ~~2%, as claimed by PA State Legislators~~

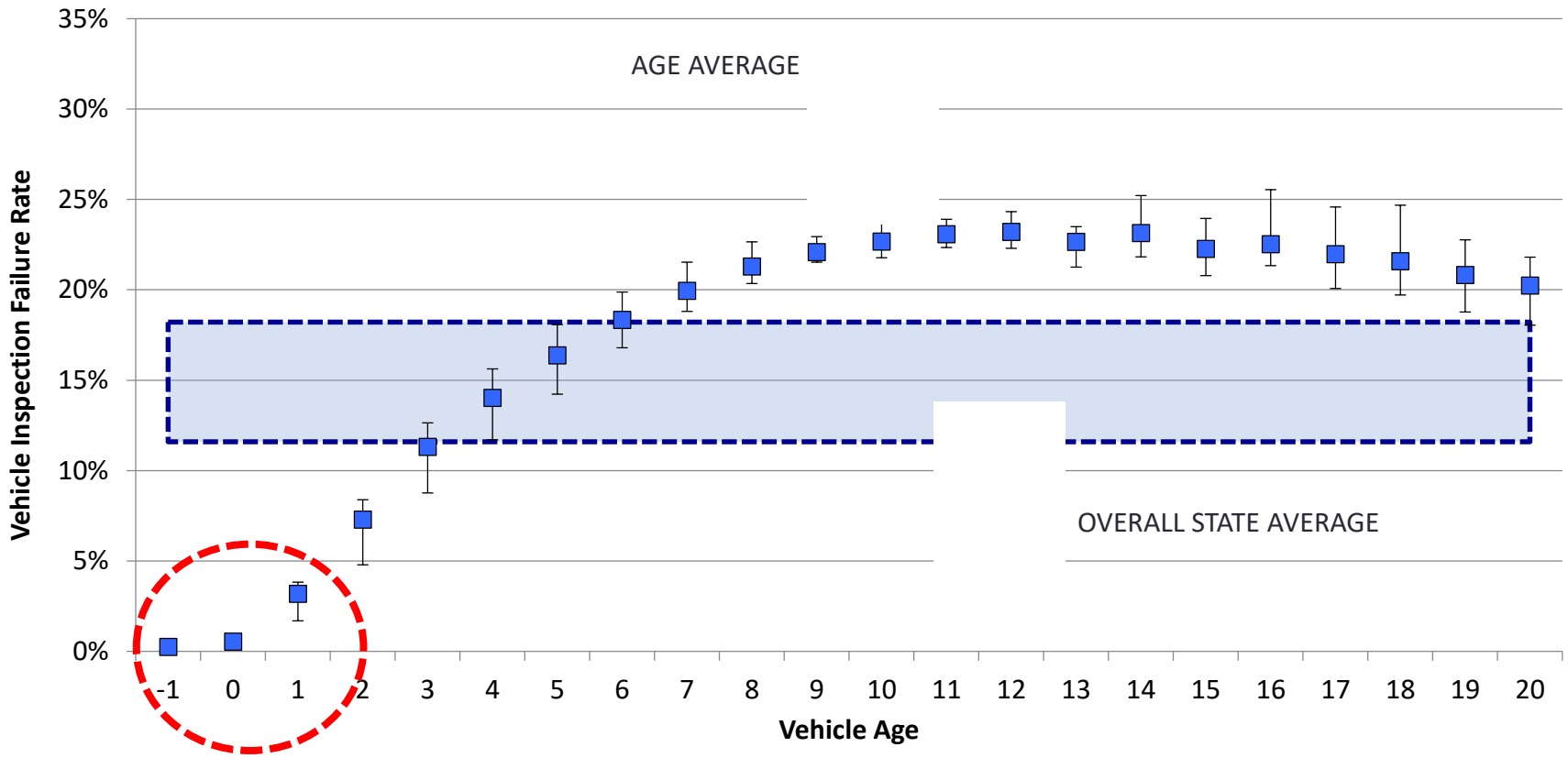
OUR DATA ANALYSIS RESULTS SHOW:

13%-18%

OVERALL FAILURE RATE

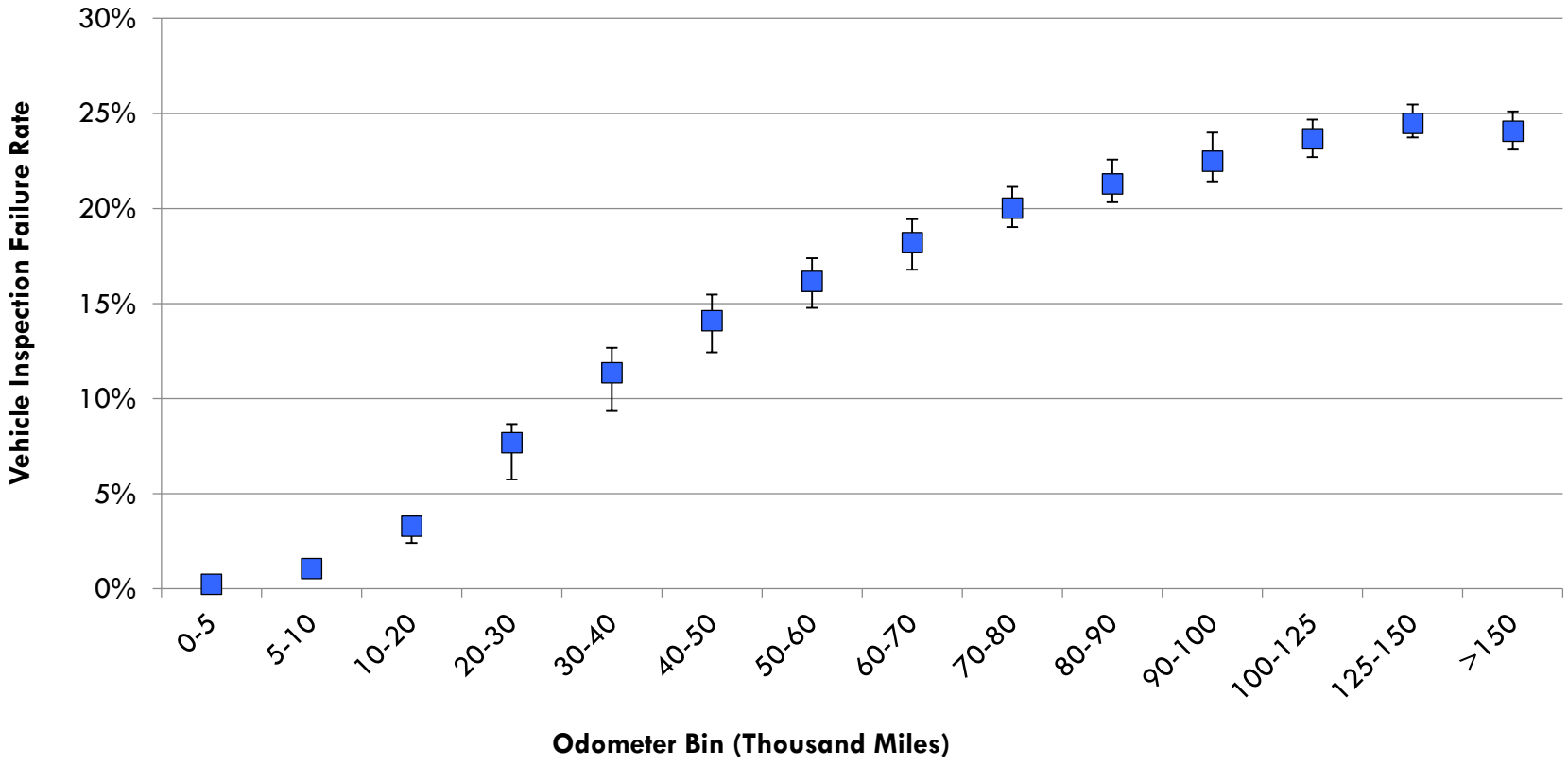
- Failure Rate Varies By:
  - Age
  - Odometer Reading

Vehicle Age & Failure Rates



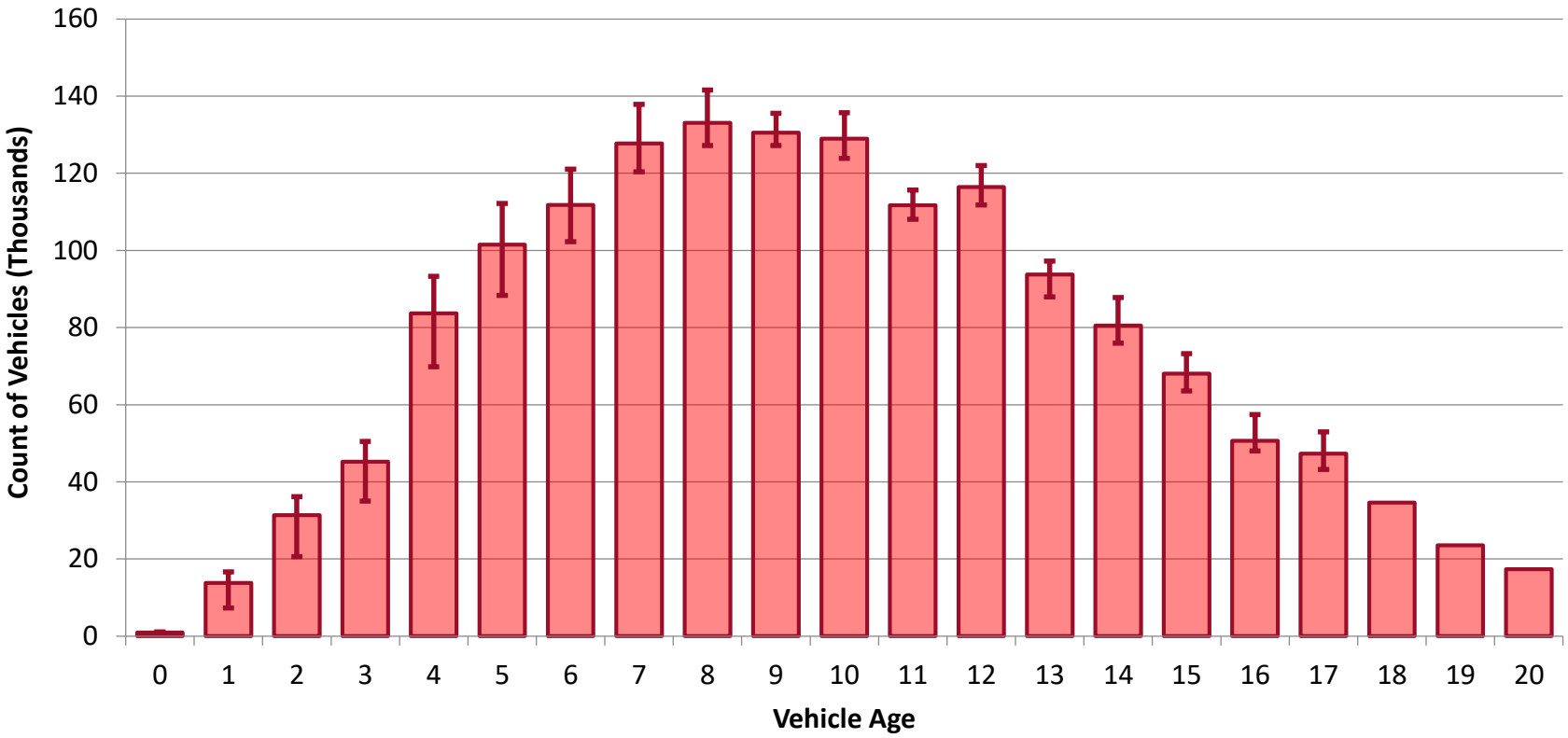
- Average failed vehicles over six years of data with min and max range bars (2008-2012)
- Failure rate increases with age, plateauing at 10-12 years old at ~24%

Miles Driven & Failure Rates



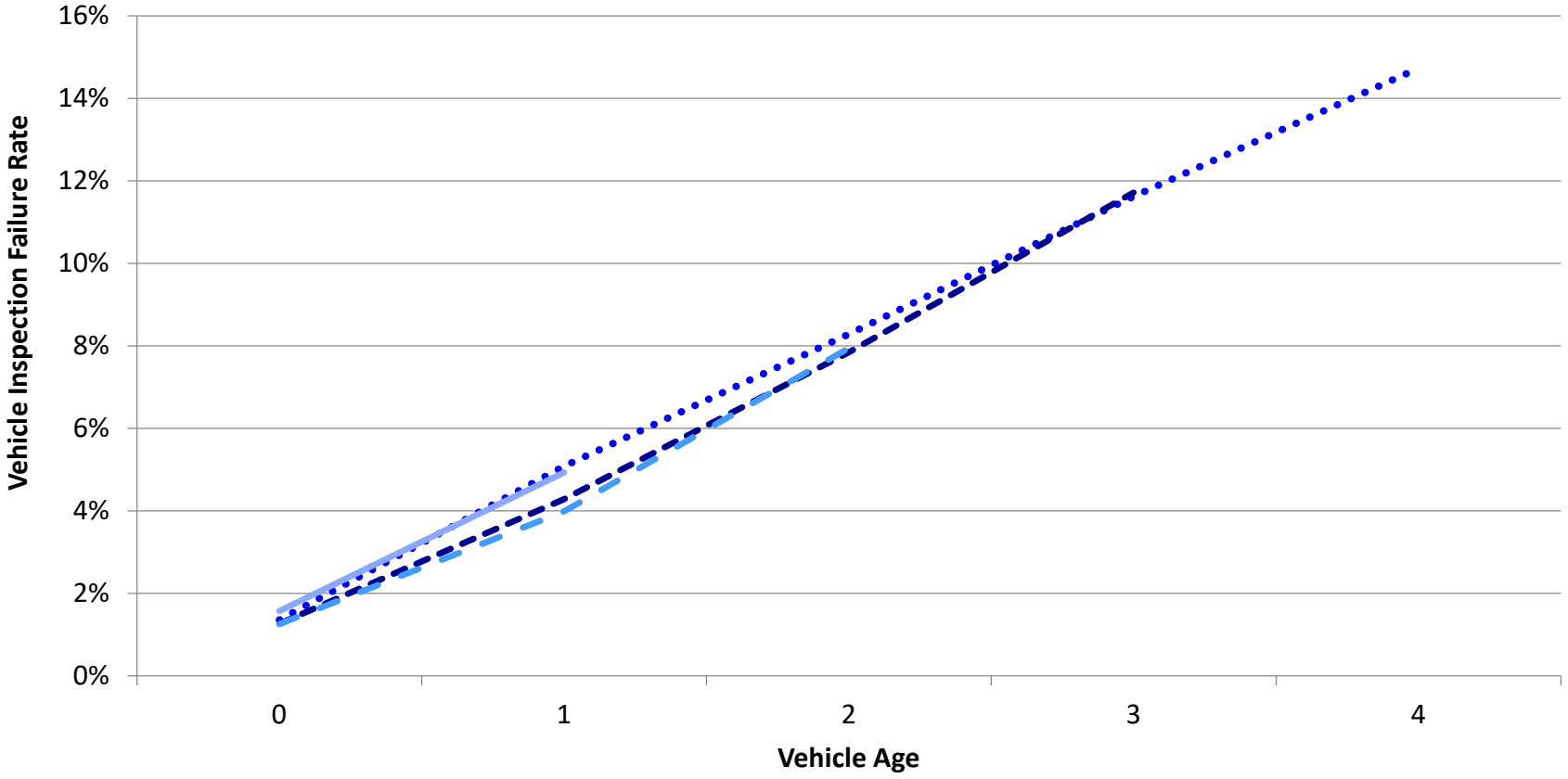
- Average failed vehicles over six years of data with minimum and maximum range bars (2008-2011)
- Increasing failure rate with increasing vehicle odometer mileages

PA Estimated Failed Vehicles, 2012



- Range between state and private datasets
- Decreasing number of failed vehicles after age 12 due to fewer in fleet, even though the failure rate is consistently high for the older vehicles
- In one year, **1-2 million vehicles would have failed**

Argument by PA Legislators:
Vehicles have "never been safer"



Problem is:

The safety features people are thinking of when they say this aren't being inspected!

Summary of Facts

- Using newest data sources, there is mixed (and growing) evidence that safety programs reduce the number of fatal crashes.
- Programs keep ‘unsafe’ (as defined by inspection criteria) vehicles off the road at surprisingly high rates - 20%
- GAO, the independent auditing agency of the federal government agrees with both of these statements.
- We still have problems with the data, including how it is recorded and reported
- Modern data-driven studies that compare states to find benefits from safety programs can only use fatal crashes (even though safety failures lead to many non-fatal crashes), thus undercount benefits

Opinion on State Program Comparisons

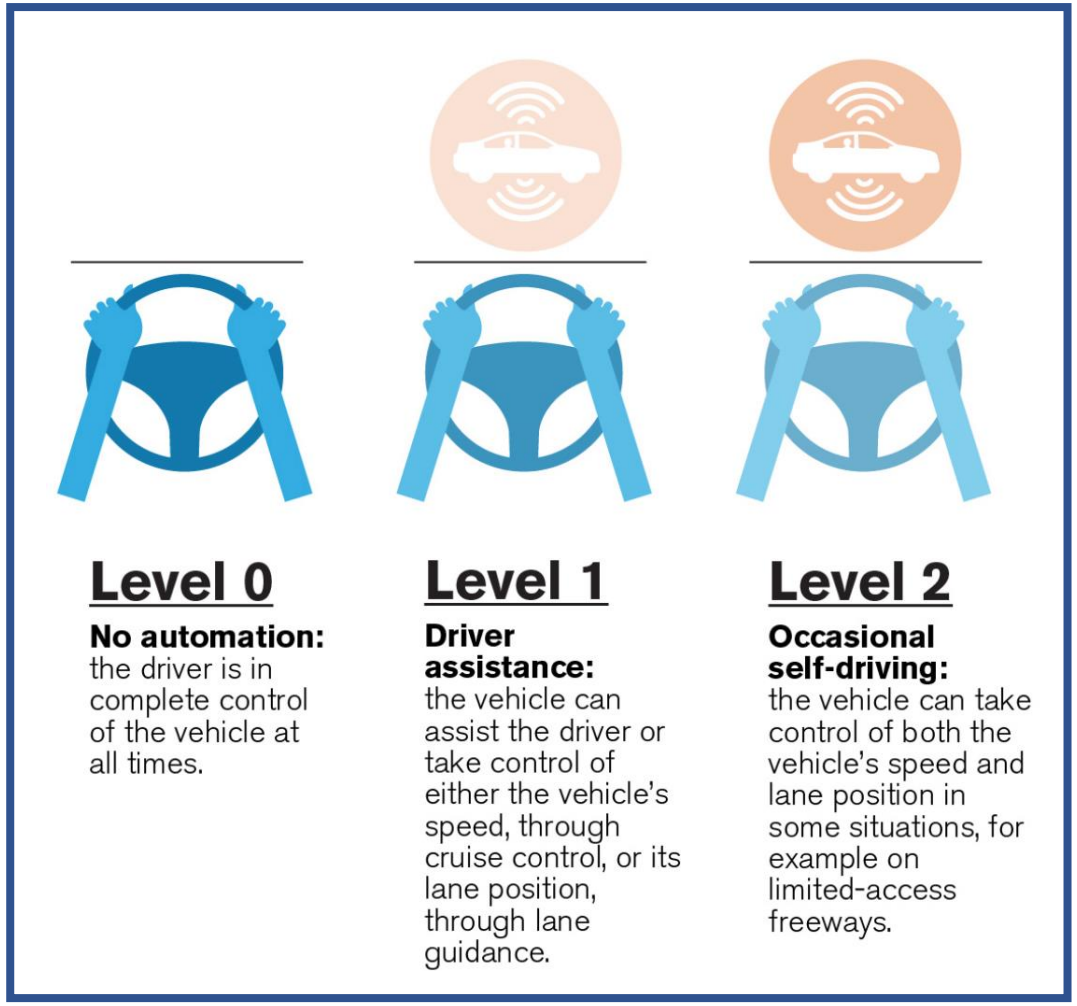
- All studies are imperfect
- BUT, assuming all studies are credible and unbiased, what do we know?
  - Sutter: 25 years ago, there was not much evidence that safety inspection programs led to reduced fatal crashes / saved lives.
  - Cambridge and CMU: By 10 years ago, there was evidence that they do. And that was based only on fatalities.
- Not considered in these studies is long-term trend of owners ignoring proactive maintenance, coupled with increased annual VMT and total lifetime VMT of cars

Opinion on Failure Rate Analyses

- Variations in extreme weather will lead to deterioration in other geographic areas

- Failure rates are significantly under-estimated due to data problems and human factors. Two examples:
  - Inspectors that aren't sufficiently trained, or don't care, to report workflows
  - Customer service – suggesting or making repairs before an inspection officially begins in support of good client relationships

And.. Autonomous Vehicles Will Change Everything



Source: SAE, NHTSA, GHSA

Five Levels of Vehicle Autonomy

My Expectation of How It Will Change

- AV's require hardware /software integration – sensors that follow programmed instructions.
- AV Technologies aim to make driving less mentally taxing. Will encourage distracted drivers, will lead to drivers that are less able to react and respond quickly in critical situations.
- Performance of AV technologies critical, will need to be assured to be working
  - Since cars will be able to stop themselves and avoid front-end collisions, they will still need to have safe brakes, tires, etc.
- I believe states will seek to ADD items to inspection criteria, AND that more states will want to have programs to inspect technologies like sensors, radar, etc., supporting autonomous features.
- We can't trust manufacturers to create robust self-diagnosis of those systems.

Path Forward

- It seems a ‘study’ is desired. What do I recommend?
- Even though evidence is growing, as GAO notes, “the benefits of inspection programs are difficult to quantify”
  - Don’t bother doing another Sutter/Cambridge like study.
  - Can only use fatality data, and I don’t believe currently collected data represents safety component issues
  - In a best case scenario, detractors will still claim its not enough evidence.
  - Ensure Texas state police are well trained and doing their best to represent safety component-related crashes

- Start with a Peck-like study, where you leverage existing data to show (and track over time) the ‘true failure rates’ in your state
  - AND continue re-certification and training efforts for safety inspectors to ensure they are appropriately recording the workflow in an inspection (all work done)
  - Need to try harder to ensure the data matches reality

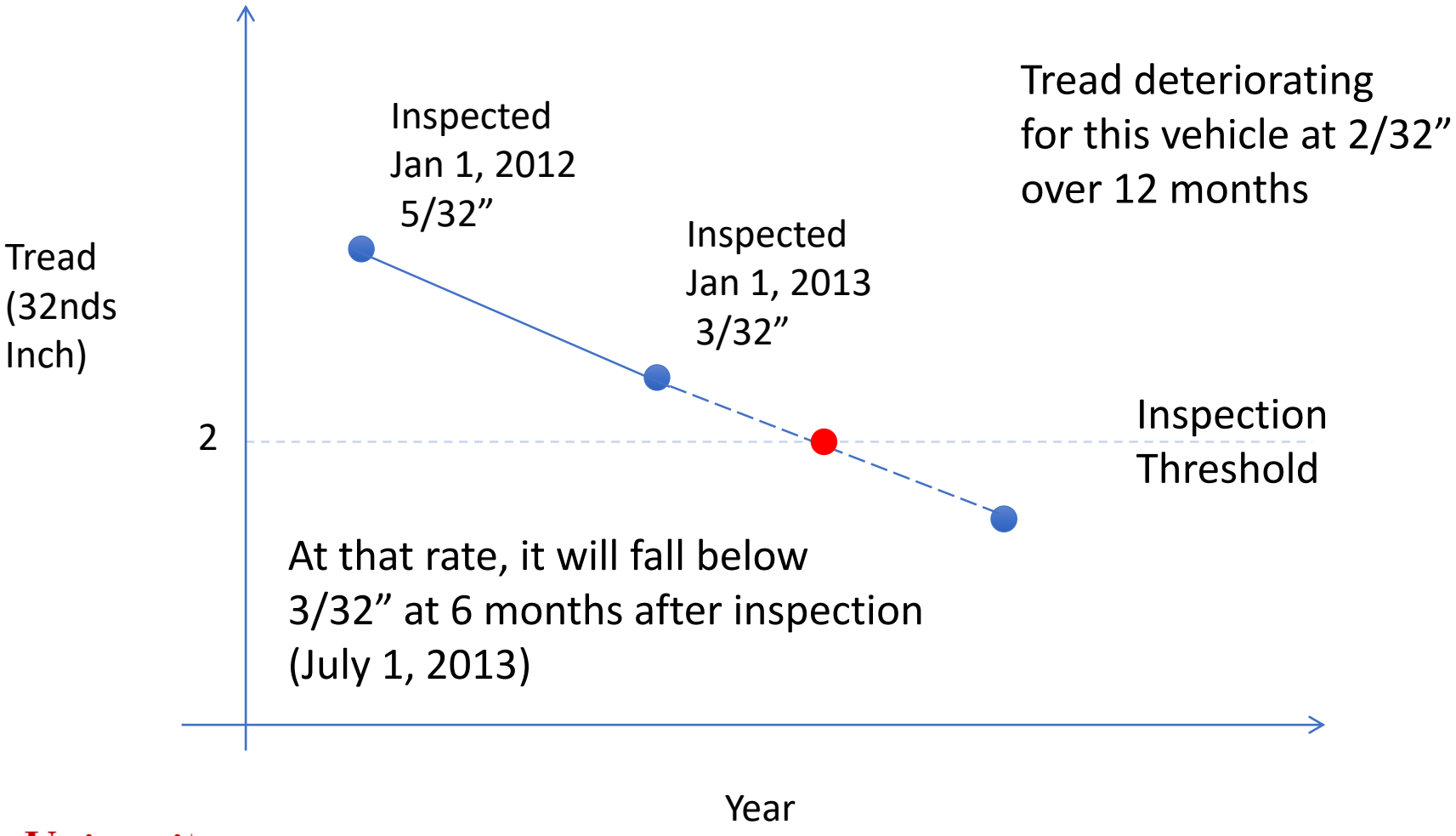
Example of Leveraging Inspection Records

- Main failure rate analysis just looked at overall pass/fail data in the inspection categories

- We wanted to leverage our analytics engine for each vehicle inspection to demonstrate what kinds of data-driven analyses are possible. Chose a hot topic.

- **Example Questions**:
  - What is the deterioration rate of tire tread in passenger vehicles?
  - Given inspection thresholds, how many cars would be expected to be “below threshold” before their next annual inspection?
  - How many are potentially driving around ‘unsafe’ on bald tires?
  - Should we look harder at the safety thresholds?

Data-Driven Tire Tread Deterioration Motivating Example



Projections and Policy Analysis

"What Does This Mean"

- Overall average: -0.2 per 1,000 mi. Given average 10,000 VMT, 2/32" per year
- We'd expect an average car at 4/32" (i.e., within 2/32" of the limit) at time of an inspection to need new tires before next inspection.
  - If driven more than average, will need new tires sooner
  - Drivers who don't do routine maintenance will be driving on unsafe tires soon after the inspection.
  - None of this is news to those who do inspections, or sell tires!
- A fixed inspection threshold (e.g., 2/32") might not be anticipating problems for cars that will dip under the threshold soon after their inspection (and drive around for nearly a whole year)
- Overall, we estimate about **20%** of cars will "need new tires" before next inspection.
- We're currently analyzing data to retrospectively consider how many of those cars in the past waited until the next inspection to replace
  - Current estimate is **40%**. **The data shows how many ignoring maintenance**

Implications of Data-Driven Analysis

- At the least, better information about driver behavior as connected to safety thresholds, such as willingness to drive on bad tires

- Implications for a state..
  - What about changing the thresholds (e.g., 3/32”)? What was annual VMT when they were codified?
  - What about having different thresholds for different types of passenger vehicles (cars vs. SUVs)?
  - What about considering VMT at time of inspection (as done for emissions exemptions)?

- Overall, lots of potential ways in which analyzing your own data can lead to potential program improvements and safer transportation

Thanks for your Attention

Any Questions?

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Using This Data for Studies

- “Some researchers have used FARS in their analyses in order to perform state-by-state comparisons, but detecting the effect of inspection programs on crash rates is difficult because few crashes involve fatalities, and relatively few of those fatal crashes are noted in police reports as having vehicle component failure as a potential contributing factor. “
- You cannot overcome these problems with existing data.
- We can start trying to get better data collected (e.g., for all crashes), but that will take years to happen, then years to do analysis

Tire Tread Slides

- Context: example of how the standards and criteria of inspection programs can be defeated by drivers, specifically increased USE

- When did NHTSA set tire tread standard of 2/32”, and why that value. What was average VMT then, what is it now, and what does that mean?

Challenges Inherent in Existing Data

- “The number of crashes related to vehicle component failure may also be generally underreported. Some literature and safety advocate organizations we spoke with noted that police officers filling out accident reports often do not have the time and resources to conduct a thorough vehicle check to determine if a vehicle component failure contributed to the crash. Other factors, such as driver behavior, may be more easily ascertained. For a 2008 NHTSA crash causation survey, researchers conducted thorough investigations of over 5,000 crashes over a 2-year period (2005—2007) to determine factors that contributed to the crashes.18 While this study did not identify vehicle component failure as necessarily the cause of the accident, vehicle component failures were found to be present in 6.8% of crashes. The crash causation survey utilized a more comprehensive mechanical examination of the vehicle(s) involved in crashes than the police accident reports used as the data collection instrument for the NASS-GES crash data. The results of the crash causation survey suggest that the percentage of crashes related to vehicle component failure is higher than the estimates produced by the NASS-GES because of the more detailed analysis of the vehicles involved in the crashes."