**Naturalistic Driving Events:
No Harm, No Foul, No Validity**

Ronald R. Knipling

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"No Validity" -- Overview

- **Challenge to validity of vehicle-based Naturalistic Driving (ND) mixed "Safety-Critical Event" (SCE) datasets in relation to serious crashes.**
- **Focus on truck HOS/fatigue studies, but argument is generalizable to other vehicle types and crash factors.**
- **Core arguments**
  - **Crashes are heterogeneous; thus, one cannot generalize across crash categories.**
  - **ND SCEs are not crashes and are not like crashes.**
  - **Therefore, SCEs are invalid and inappropriate for most crash causation research.**

Today's Topics

- **Crash Harm**
- **Crash Heterogeneity**
- **SCEs ≠ Crashes**
- **SCEs ≠ Fatigue**
- **Establishing a Link**

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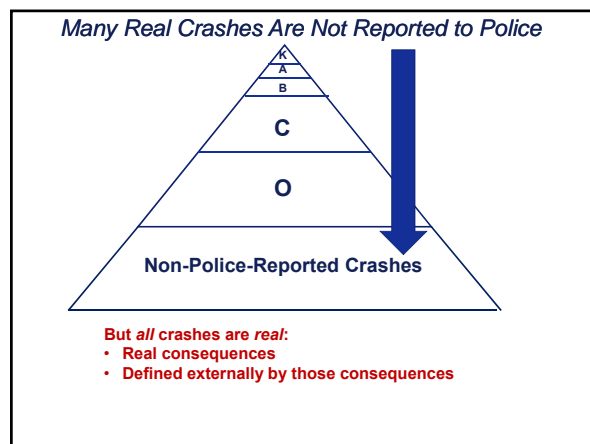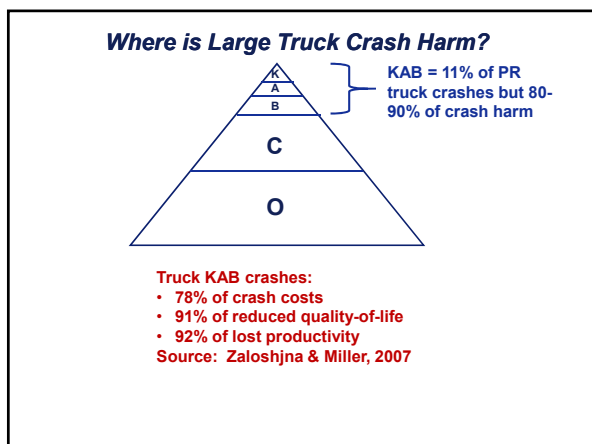
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Why are we here?

Crash Harm

- **Quantitative measure of human + material loss based on monetary valuation of crashes of various severities.**
- **Includes property damage, injuries, lost income, lost time, and other crash consequences.**
- **Scales:**
  - **Economic loss only**
  - **Comprehensive (includes "pain and suffering")**
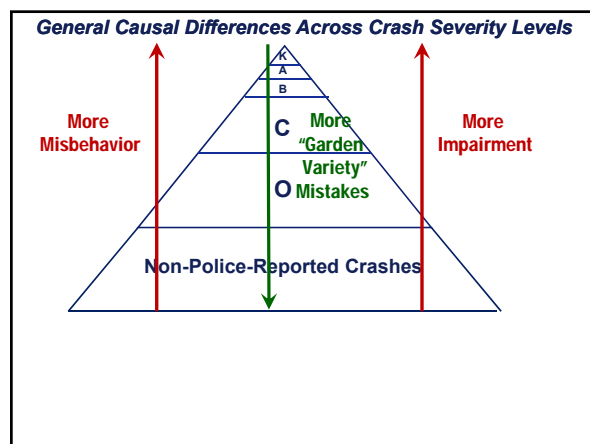- **Permits objective yet human-centered comparisons across different categories of crashes.**

Where is Large Truck Crash Harm?

KAB = 11% of PR truck crashes but 80-90% of crash harm

Truck KAB crashes:
• 78% of crash costs
• 91% of reduced quality-of-life
• 92% of lost productivity
Source: Zaloshjna & Miller, 2007

Many Real Crashes Are Not Reported to Police

Non-Police-Reported Crashes

But *all* crashes are *real*:
• Real consequences
• Defined externally by those consequences

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"Horizontal" Heterogeneity

• Within any severity strata, crash causes and other characteristics vary widely.
• Asleep-at-the-wheel (AATW) as LTCCS Critical Reason:
  – 19% of road departures
  – ≤1% of rear-end, sideswipe, & opposite direction crash involvements.
• Recognition failures as CR:
  – 65% of same-direction sideswipes
  – 14% of road departures
• Incidence correlation of 34 CRs between single-vehicle & multi-vehicle at-fault crashes: +0.18.

"Vertical" Heterogeneity:
Crash Characteristics Differ Across Severities

Characteristics, 2012 U.S. Truck Crashes:	PDO	Fatal
Nighttime	18.0%	35.9%
Undivided road	32.7%	53.0%
Front (of truck) impact	36.1%	58.6%
Head-on crash, passenger vehicle crossed center line	0.2%	17.7%
Pedestrian/bicycle	<0.1%	9.1%

General Causal Differences Across Crash Severity Levels

More Misbehavior

More "Garden Variety" Mistakes

More Impairment

Non-Police-Reported Crashes

"Vertical" Heterogeneity: Fatigue Incidence

Tefft (2014) estimates for % of drowsy drivers in Crashworthiness Data System passenger vehicle crashes:

- 15% of drivers in fatal crashes
- 8% of drivers in crashes with person hospitalized
- 3% of drivers in PDO crashes.

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ND SCEs: Overwhelmingly Non-Crashes

K A B / C / O / Non-Police-Reported Crashes

Non-Crash Events

SCE Crash Content

2011 Truck ND HOS Study (Blanco et al):
- 2,197 SCEs ("crashes, near-crashes, & crash-relevant conflicts")
- Crash criterion: "any contact"
- Number of crashes: 4 (0.2%)

100-Car ND Study (Dingus et al, 2006):
- 69 of 9,125 SCEs were crashes ("any impact")
- Of 69: 5 caused injuries + 7 other police-reported.
- Crash percentage: 0.8%
- Police-reported crash percentage: 0.1%

K A B / C / O / Non-Police-Reported Crashes — **SCEs**

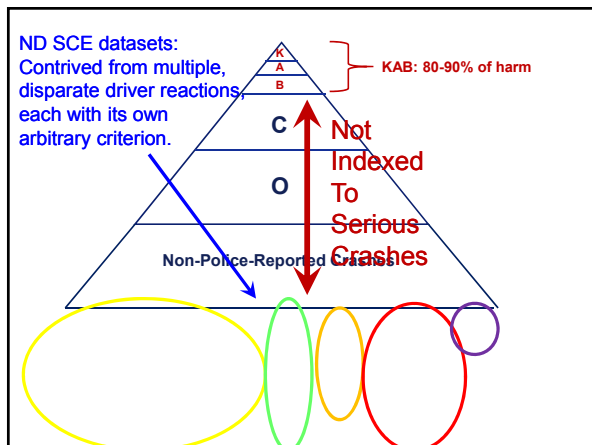---

K A B / C / O / Non-Police-Reported Crashes — **SCEs**
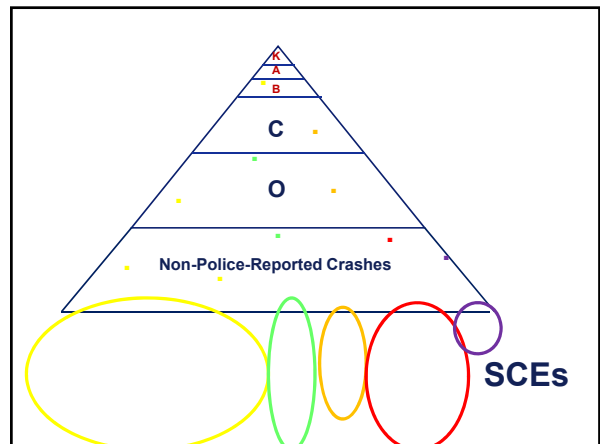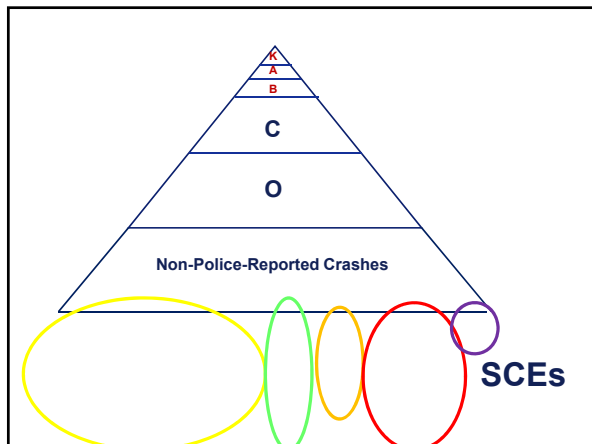
SCEs ≠ Crashes

- SCEs are abrupt or aberrant driver avoidance maneuvers or other reactions: e.g., hard-braking, swerves, lane deviations.
- Truck ND study (Hickman et al; 2005): Only 1.5% of SCEs had no truck avoidance maneuver.

- Crashes are impacts or other consequences.
- LTCCS: 44% of truck crash involvements had no avoidance maneuver.

Rear-End Scenarios (% of All Events)

Scenarios:	Event Type: SCEs	LTCCS Crashes
Rear-end, truck would have been/was *striking*	43.1%	12.3%
Rear-end, truck would have been/was *struck*	0.5%	5.7%

ND SCE datasets: Contrived from multiple, disparate driver reactions, each with its own arbitrary criterion.

KAB: 80-90% of harm

Not Indexed To Serious Crashes

Non-Police-Reported Crashes

SCE Database Composition [Simplified]

Trigger Type	Criterion	Hanowski (2008) % (~800 total)	Blanco (2011) % (2,197 total)
Hard Braking	Decel > |0.35g| + Speed > 15 mph	No break-down provided	49%
Short Time-to-Collision	TTC ≤ 1.85 seconds + Range ≤ 150 feet + Target speed ≥ 5 mph + Yaw rate < |4 degrees/second| + azimuth < |8 degrees|		No further break-down provided
Swerve	"Swerve value ≥ 3" + Speed > 15 mph		
ULD	Truck center to lane edge < 44"	NA	51%

"Validation": Near-Crashes as Surrogates for Crashes in 100-Car Study (Guo et al, 2010)

- *Post hoc* comparison of 69 crashes & 830 near-crashes from the 100-Car Study.
- Easiest ND validation test imaginable: two adjacent categories from the same dataset.
- Near-perfect associations (R^2):
  - Weather: +0.99
  - Road Alignment: +0.99
  - Lighting: +0.97
  - Driver Age: +0.91
- Not-so-perfect associations (R^2):
  - Conflict type (single vehicle, lead vehicle, etc.): +0.19
  - Precipitating factors (object in road, crossing vehicle, etc.): +0.03.

Guo et al (2010) Validation Study (Continued)

Characteristic	Near-Crashes	Crashes
Single-vehicle scenario	8%	54%
Low traffic conditions	32%	59%
Driver reacted to crash threat	95%	66%

Their conclusion: "There is no debate that crashes and near-crashes are two different types of events."
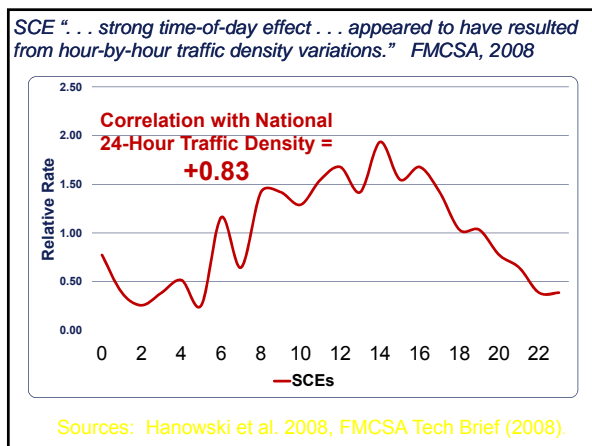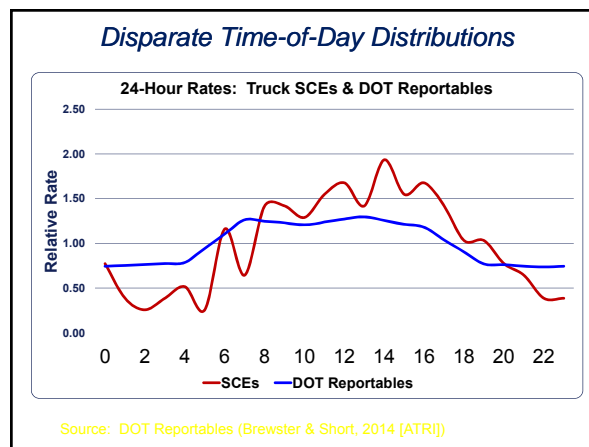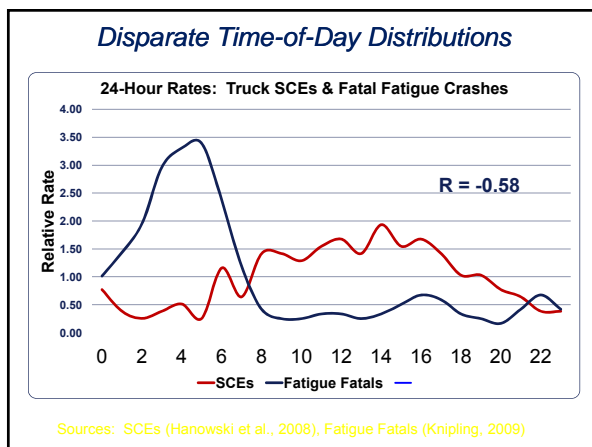
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SCEs ≠ Fatigue-Related Crashes

SCEs	Fatigue Crashes
Detected from *abrupt driver responses*	Driver is *non*-responsive
Lowest rate in early morning	*Highest* rate in early morning
Most likely in *heavy traffic*	Most likely on *lonely roads*
Most likely on *undivided* roads	Most likely on *divided* roads
Mostly *multi-vehicle*	Mostly *single-vehicle*
0.1% AATW* (1 of 915)	3.8% AATW**

*Hickman et al. 2005 large truck ND study
**Large Truck Crash Causation Study

Disparate Time-of-Day Distributions

24-Hour Rates: Truck SCEs & Fatal Fatigue Crashes

R = -0.58

Sources: SCEs (Hanowski et al., 2008), Fatigue Fatals (Knipling, 2009)

Disparate Time-of-Day Distributions

24-Hour Rates: Truck SCEs & DOT Reportables

Source: DOT Reportables (Brewster & Short, 2014 [ATRI])

SCE *". . . strong time-of-day effect . . . appeared to have resulted from hour-by-hour traffic density variations."* FMCSA, 2008

Correlation with National 24-Hour Traffic Density = +0.83

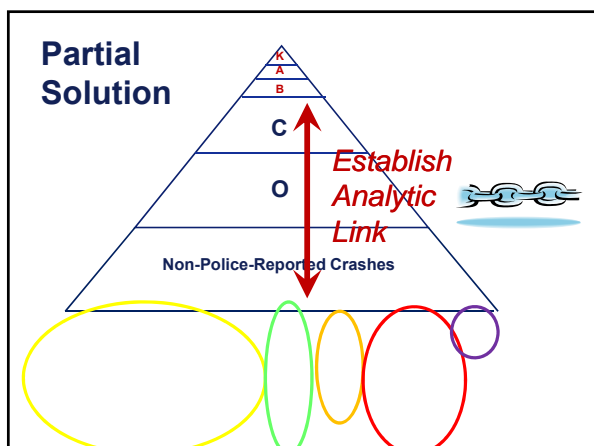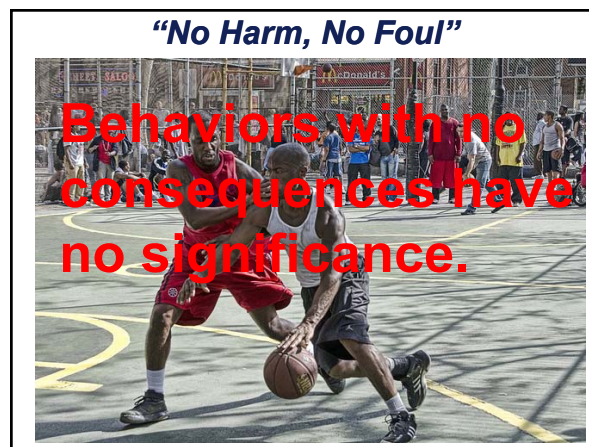Sources: Hanowski et al. 2008, FMCSA Tech Brief (2008).

Negative Construct Validity in Relation to Fatigue
- **2008 VTTI Study (Wiegand, 2008):** *Inverse* relationship between drowsiness & SCE involvement; baseline-to-SCE odds ratios:
  - Observer Ratings of Drowsiness (ORD): 1.9
  - Percent eye closure (PERCLOS): 1.7
- **Wiegand: SCEs most likely when drivers were most *alert*.**
- **Most SCEs are *distraction*-related (Olson, 2009)**
- **Distraction & drowsiness are *opposites* (Barr 2011):**
  - Distraction: driver active, looking around
  - Drowsiness: driver passive, tunnel vision.

Inverse Relation: SCE Likelihood & ORD

Relative SCE Likelihood vs. Observer Rating of Drowsiness (mid-points)

Source: Wiegand et al. (2008)
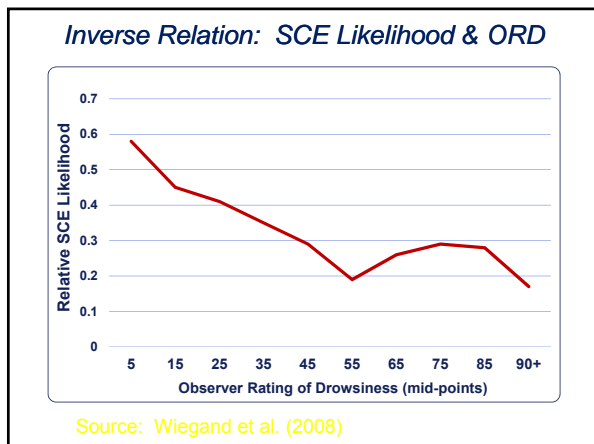
2008 → 2011 Change in SCE Mix

- 2008 (Hanowski et al) SCEs: hard-braking, swerves, short times-to-collisions
- 2011 (Blanco et al): added 1,118 unintended lane deviations (ULDs) to 1,079 of the above.
- Rationale: ULDs are "reliable indicator of fatigue"
- Scientific issues:
  - ULDs not a *specific* indicator of fatigue; 77.5% are distraction-related (Olson et al, 2009)
  - No crash-based rationale for SCE mix
- No analysis of SCEs to verify fatigue.

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"No Harm, No Foul"

Behaviors with no consequences have no significance.

Partial Solution

K
A
B
C
O

Non-Police-Reported Crashes

Establish Analytic Link

Crash-Indexed SCE Causation Analysis

- Profile serious (KAB) truck crashes in regard to key objective features; i.e., location type, scenario type, time-of-day. Source: GES
- Calculate "crash space" %s for each cell.
- Design ND SCE collection & sampling to best match crashes.
- Classify SCEs by same objective cells
- Weight SCE cell %s to match crash %s.
- Analyze SCE causal factors (e.g., Critical Reasons, ORD, PERCLOS, HOS factors).

Alternatively, use crash HARM percentages!

Thanks for your attention!

Ron Knipling
Safety for the Long Haul Inc.
& Motor Carrier Safety Associates
(703) 533-2895
rknipling@verizon.net
www.safetyforthelonghaul.com