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Vehicular Design and Resource Allocation Policies for Equitable Road Safety

Alyssa Ryan
University of Arizona

Vehicular Design and Resource Allocation Policies for Equitable Road Safety

TREC Friday Transportation Seminar

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Dr. Alyssa Ryan

Assistant Professor, Civil Engineering, University of Arizona

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TRANSPORTATION RESEARCH and EDUCATION CENTER

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Center for Applied Transportation Sciences

Overview

- Benefits of transportation systems are unevenly distributed *(Dodson et al., 2006)*
- Different levels of safety are experienced by individuals based on sex *(Kahane, 2013)*
- Different travel needs in different communities based on age, income, race, gender, ability, etc. *(Klein et al., 2018; Boarnet et al., 2020; Prescott et al., 2021; Corran et al., 2018)*

Two Primary Categories

Equitable resource allocation

Inclusive vehicular design

Vehicular Design – Motivation

Women are more likely than men to be killed or injured in crashes of equal severity *(Kahane, 2013)*

In comparable crashes, a belt-restrained female driver will sustain severe injuries 47% higher than a belt-retrained male driver *(Bose et al., 2011)*

Vehicular Design – Motivation

Females and males have different anthropometry *(Schneider et al., 1983)*

Crash test dummies used to test vehicles used in the US and Europe are only based on scaled 50th percentile male data *(Linder and Svedberg, 2019)*

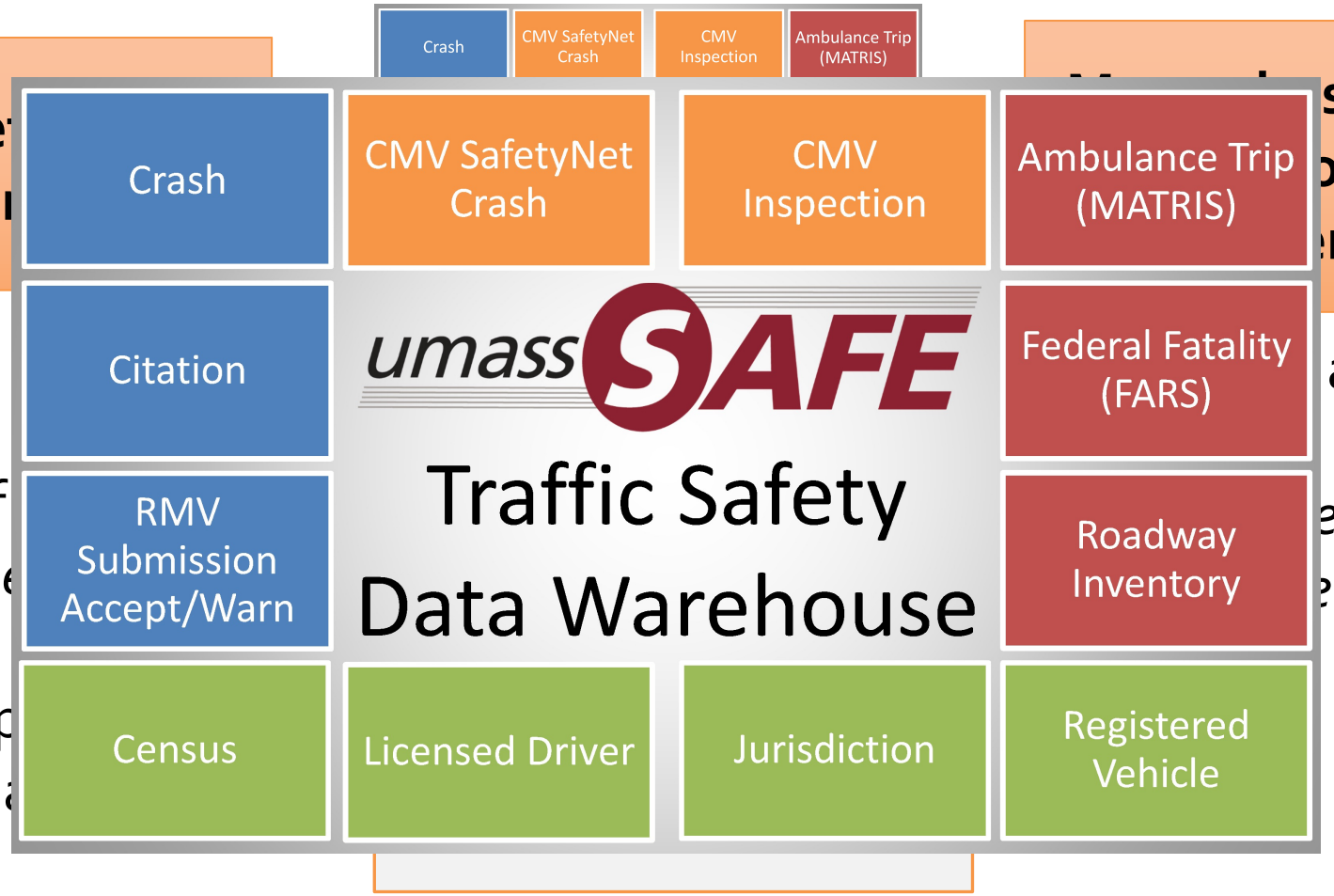
Female drivers are also naturally "out of position drivers" in the U.S. *(NHTSA, 2015)*

"What You Can Do," NHTSA, 2015

Methodology

Massachuse
Data Syste

- Age
- Sex
- Manner of
  - *Rear-*
  - *etc.*
- Airbag dep
- Vehicle ye
- Etc.



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ord Information
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anatomic injury

e primary injury
ected per patient

Results – Injury Differences

	Odds Ratios	2.5 %	97.5 %
No Injury/NA	0.76**	0.71	0.82
Abdomen Injury	1.97**	1.64	2.39
Back Injury	0.75**	0.69	0.81
Chest Injury	1.29**	1.17	1.42
Global/General Injury	0.92*	0.86	0.97
Head Injury	-	-	-
Lower Extremity Injury	1.27**	1.16	1.40
Neck Injury	1.17**	1.09	1.27
Upper Extremity Injury	1.06	0.98	1.00

Note: Ref. = Male †p<0.1; *p<0.05; **p<0.01

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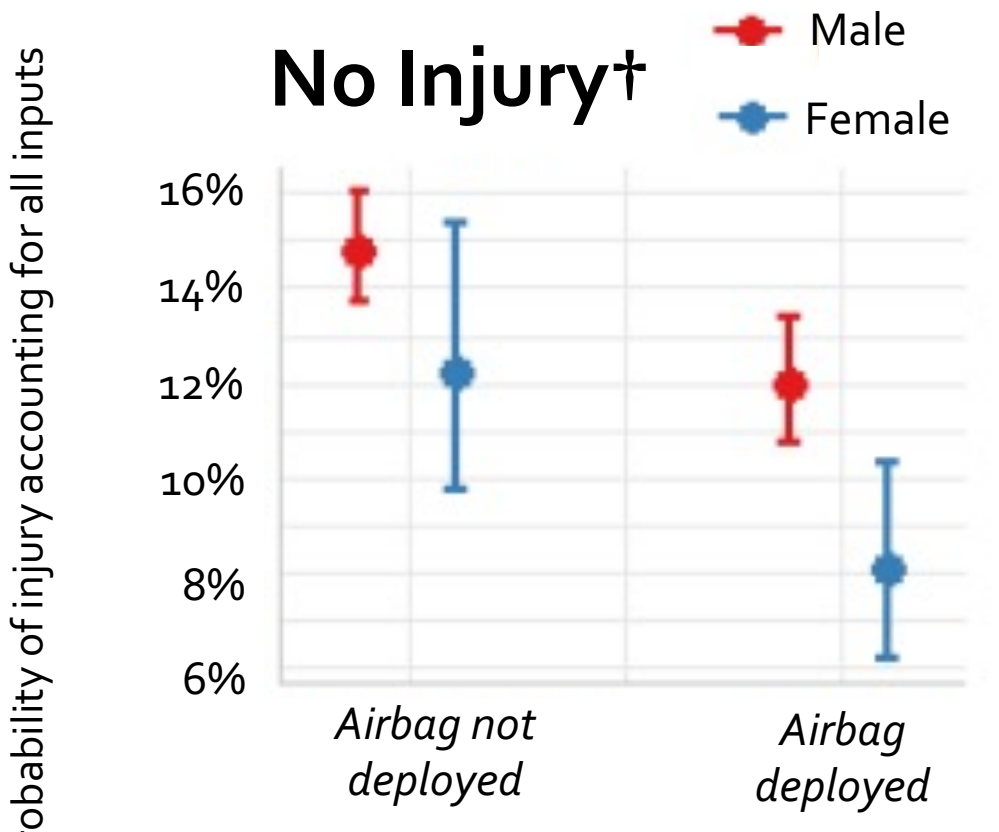
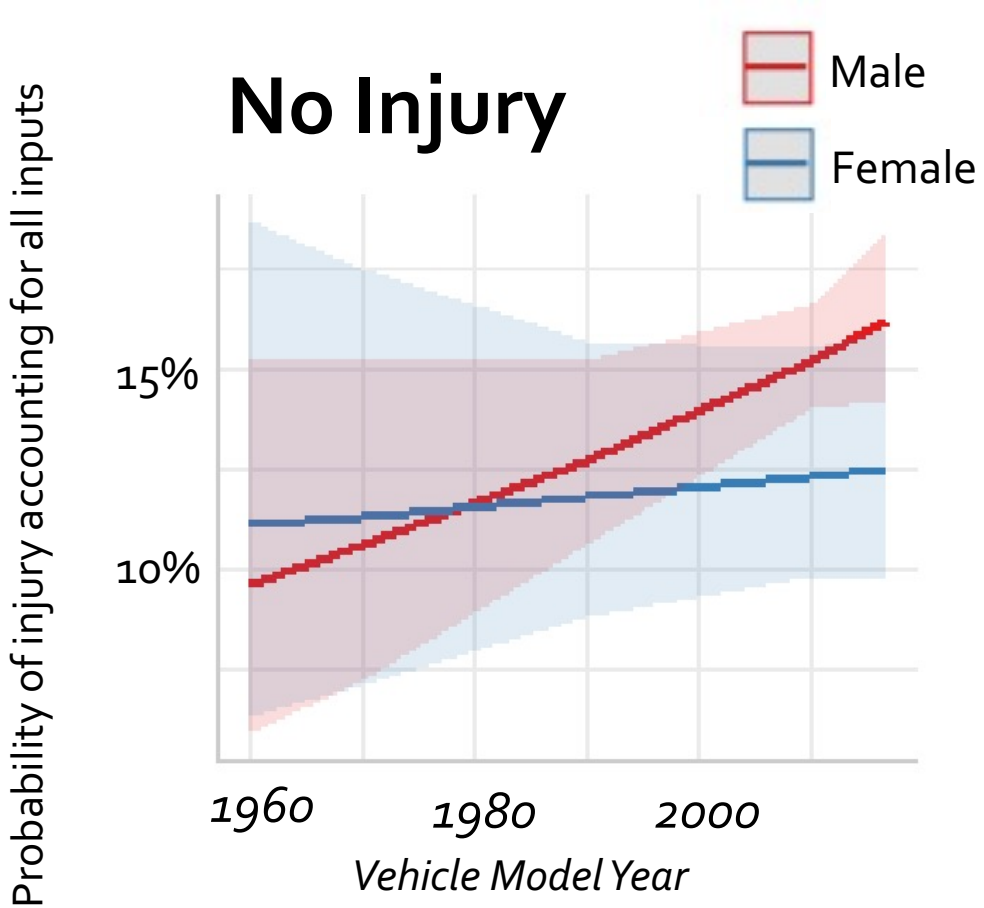
Results – Airbag Deployment



- Aligns with previous literature
- Suggests there is a need for airbag development based on occupant's specific anthropometric characteristics (sex, height, weight)

†p<0.1; *p<0.05; **p<0.01

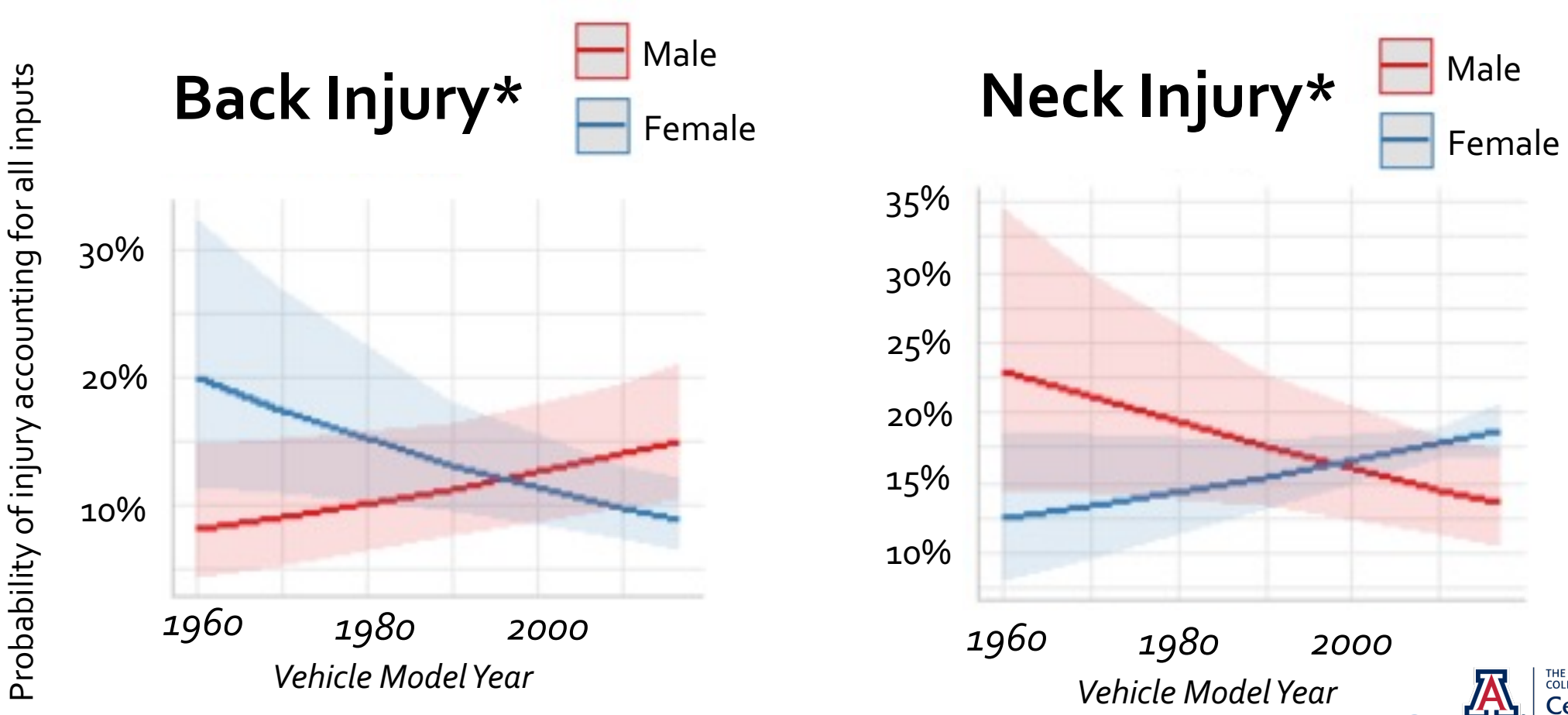
Results – Vehicle Model Year



- Not statistically significant, but less of a change for female drivers than male drivers over time
- Less predictable injury occurrence for female drivers

†p<0.1; *p<0.05; **p<0.01

Results – Vehicle Model Year



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Significant Takeaways & Applications

Female drivers are **more likely** than male drivers to **sustain an injury** in comparable crash conditions, and specifically, **neck, chest, and abdomen injuries**

Vehicle designs, testing, and safety technology should **consider injury locations** for varying crash scenarios

Further research should examine **why certain injuries occur more frequently** for female drivers

Safety programs/agencies should investigate specific injury disparities **to create safer environments for female drivers**, including in regards seat design, airbag design and placement, etc.

Local Resource Allocation - Motivation

3.6 times higher fatal crash rate on local roads compared to interstates & arterials (FHWA, 2019)

- 77% of US roads are owned by local governments *(FHWA, 2018)*
- Municipal roadways have increased safety challenges as small governments:
  - lack financial resources *(Brown, 1980; Landes, 2009)*
  - more likely to reduce expenditures than create revenue *(MacManus & Pammer, 1990)*
  - require more mobility options on a smaller budget

	Funding & Resources		*Level of Safety*
Region 1	$ $	→	* * *
Region 2	$ $	→	* *

	Funding & Resources		*Level of Safety*
Region 1	$ $	→	* * *
Region 2	$ $ $	→	* * *

Methodology

Demographic and population data

United States® Census Bureau

Distance from urbanized region

NEW YORK STATE

MASS GIS

Municipal highway expenditure data

DLS
DIVISION OF LOCAL SERVICES
MA DEPARTMENT OF REVENUE

Local mileage data

NEW YORK STATE OF OPPORTUNITY.
Department of Transportation

Moving Massachusetts Forward.
massDOT

Methodology

Municipal survey data

Cornell Local Roads Program
New York LTAP Center

UMassAmherst
College of Engineering
UMass Transportation Center

qualtrics XM

Municipal road crash data

DMV

IMPACT

+

Demographic and population data

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DIVISION OF LOCAL SERVICES
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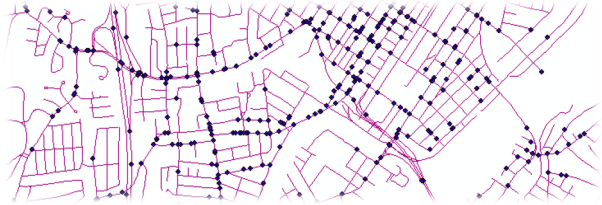
Data Envelopment Analysis Description

$$

Given Annual Municipal Highway Funding

System efficiency



Decrease Annual Municipal Crashes

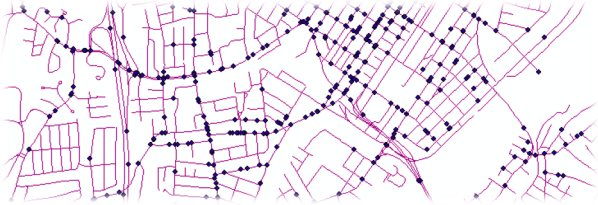
Data Envelopment Analysis study description

$$

Given Annual Municipal Highway Funding

System efficiency

- Location
- Number of local miles
- Population
- Number of local highway staff
- Road Safety Audits
- % population white
- % population older
- % population in poverty
- etc.



Decrease Annual Municipal Crashes

	MA with weighting method			NY with weighting method			NY with cost method		
	Coefficient	Confidence Interval		Coefficient	Confidence Interval		Coefficient	Confidence Interval	
Variable	(β)	2.5%	97.5%	(β)	2.5%	97.5%	(β)	2.5%	97.5%
Intercept	18690*	1360	24784	-18192*	-33606	-26361	-11886*	-23869	-17813
Ctr_mi	1005*	888	1302	1023*	1236	1625	1280*	1586	1937
Pop	1218*	855	1331	1171*	656	1007	977*	469	795
Eng	67.4*	12.2	156	-60.9*	-108	-36.1	-43.5*	-74.4	-5.34
Hwy_eng	-30.5	-114	47	-357*	-466	-310	-396*	-567	-410
RPO/cnty	-54.9*	-113	-12.7	136*	168	218	109*	131	180
Consult	7.56	-34.5	84.4	34.8*	14.0	72.4	18.6	-3.04	55.6
Staff	200*	101	406	466*	693	813	385*	642	766
Civil	18.3	-48.6	85.6	141*	76.0	187	65.4	-14.5	95.7
RSA	115*	66.4	177	195*	231	332	300*	411	504
Mi_50+	-749*	-978	-685	-1213*	-2034	-1876	-1166*	-2024	-1874
%white	170*	86.5	305	99.8*	35.6	157.9	-42.5*	-190	-74.3
%pov	59.7	-15.0	254	-480.7*	-743	-582	-504*	-824	-670
%older	-68.7	-215	86.8	-424*	-741	-599	-414*	-745	-605
	n = 500			n = 1043			n = 1043		

*p-value <0.05

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EPDO = (property damage only crashes)*W1 + (injury crashes)*W2 + (fatal crashes)*W3

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Significant Takeaways & Applications

At the municipal level:

- Increase # of highway maintenance staff

- Increase Road Safety Audits

At the state/region level:

- Increase support/funding for rural communities

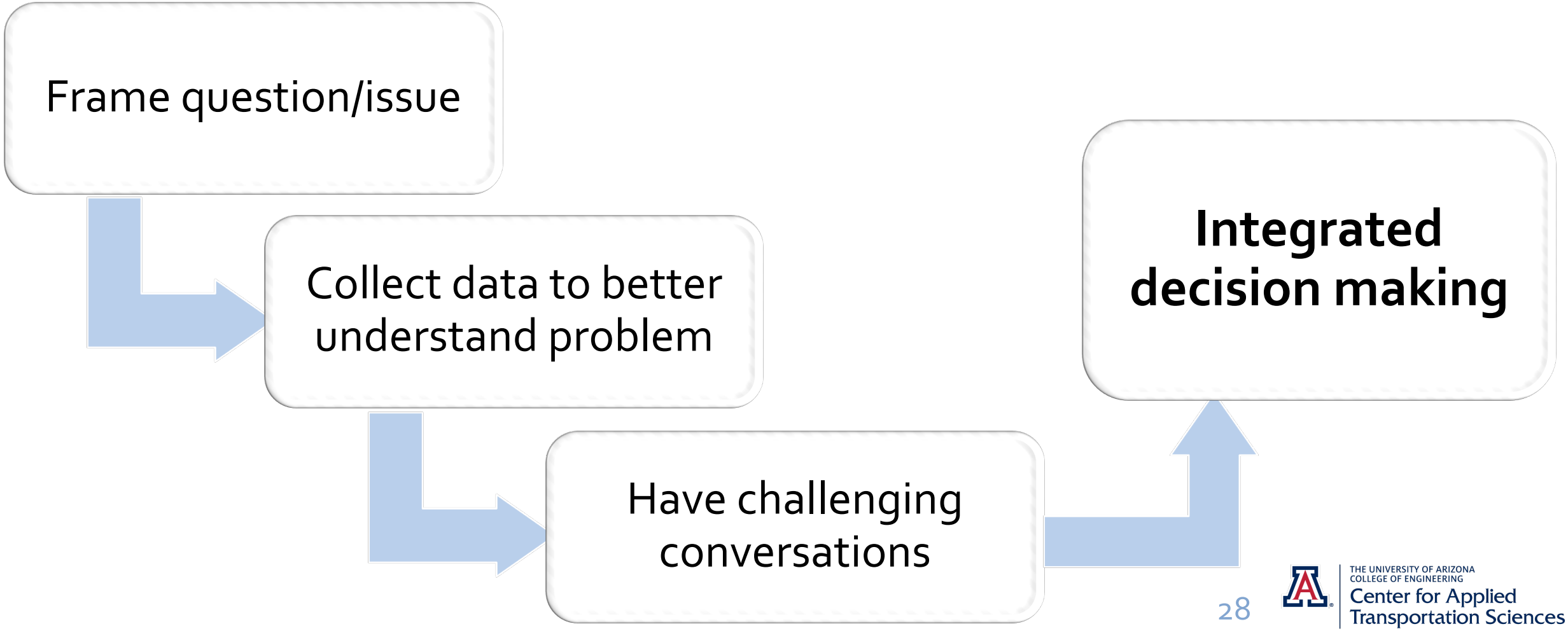
- Increase support/funding for racial minority communities

Data envelopment analysis effective and useful for regional efficiency and equity studies

Equivalent Property Damage Only (EPDO) calculations impact outcome

There is a need to prioritize investment ***based on risk*** at both the community and individual levels to create ***safe and equitable mobility for all.***

Implementing Change for Equitable Safety



Contact:

Dr. Alyssa Ryan
alyssaryan@arizona.edu
https://alyssaryan.co/

Ryan Research Group

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Relevant works:

- Ryan, A., Tainter, F., Fitzpatrick, C., Gazzillo, J., Riessman, R., and Knodler, M. (2020) "The impact of sex on motor vehicle crash injury outcomes," Journal of Transportation Safety & Security. doi: 10.1080/19439962.2020.1834478.
- Ryan, A., Barchers, C., Christofa, E., and Knodler, M. (2021) "Equitable resource allocation for municipal safety: A data envelopment analysis," Transportation Research Part D: Transport and Environment, 97, 102926. doi: 10.1016/j.trd.2021.102926.
- Ryan, A., Christofa, E., Barchers, C., and Knodler, M. (2021) "The relationship between municipal highway expenditures and socio-demographic status: Are safety investments equitably distributed?" Transportation Research Interdisciplinary Perspectives, 9, 100321. doi: 10.1016/j.trip.2021.100321.
- Ryan, A. and Knodler, M. (under 2nd review) "Influential crash conditions leading to injury differences experienced by female and male drivers," Journal of Transport & Health.

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