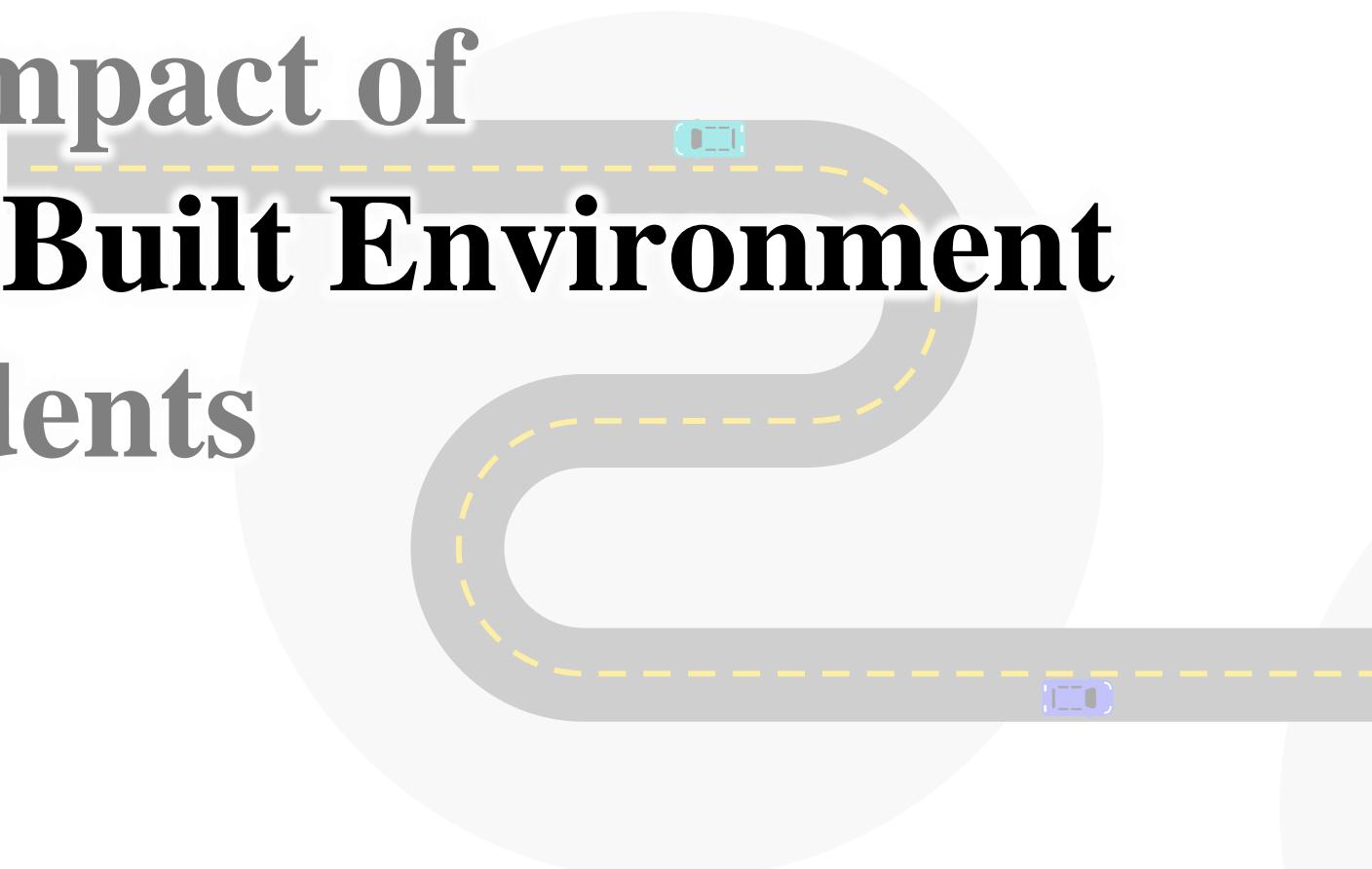
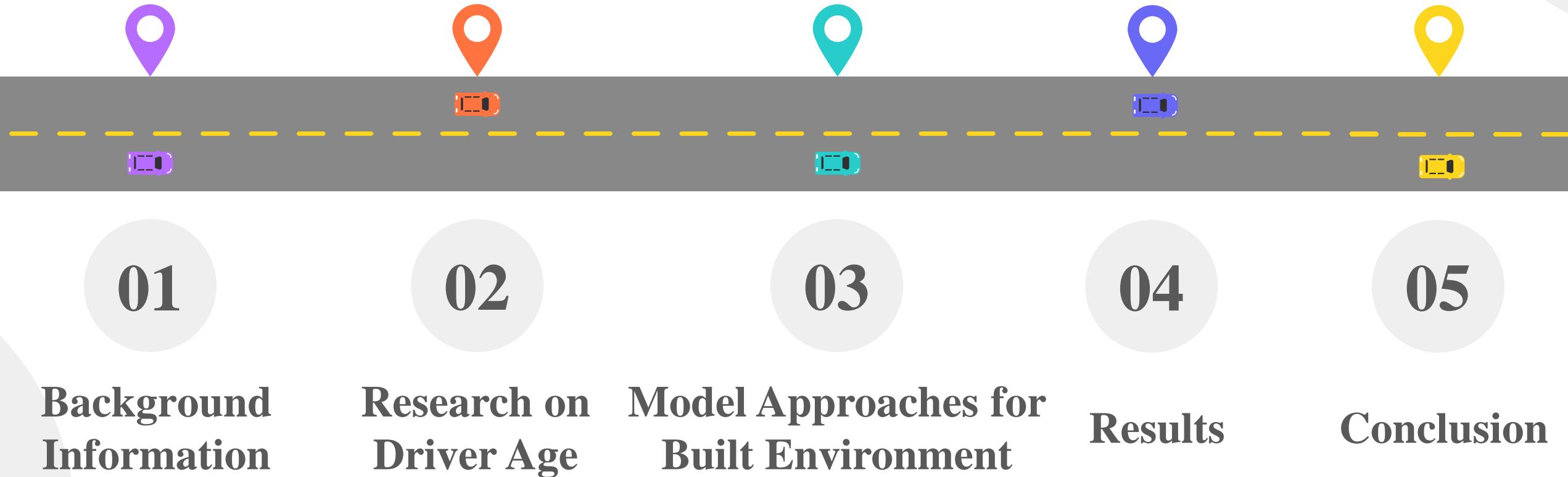


Exploring the Impact of Driver Age and Built Environment on Traffic Accidents

Group 1: Xinyi Deng, Junran Liang, Zhuojia Gan



CONTENT



01

Background Information

01 Background Information

(How about 20 years later?)

Think about how old our parents are?

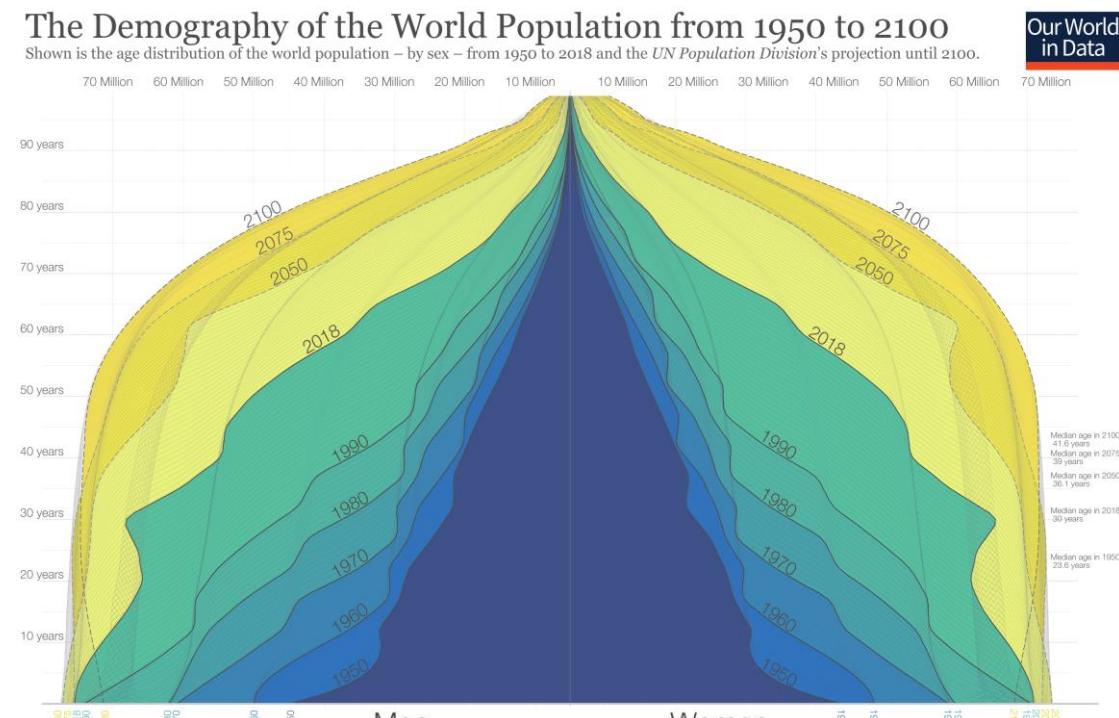
Do they Drive?

Are you concern about
this social phenomenon of elderly drivers?

01 Background Information

Population Aging :

The number of elderly population worldwide continues to grow.



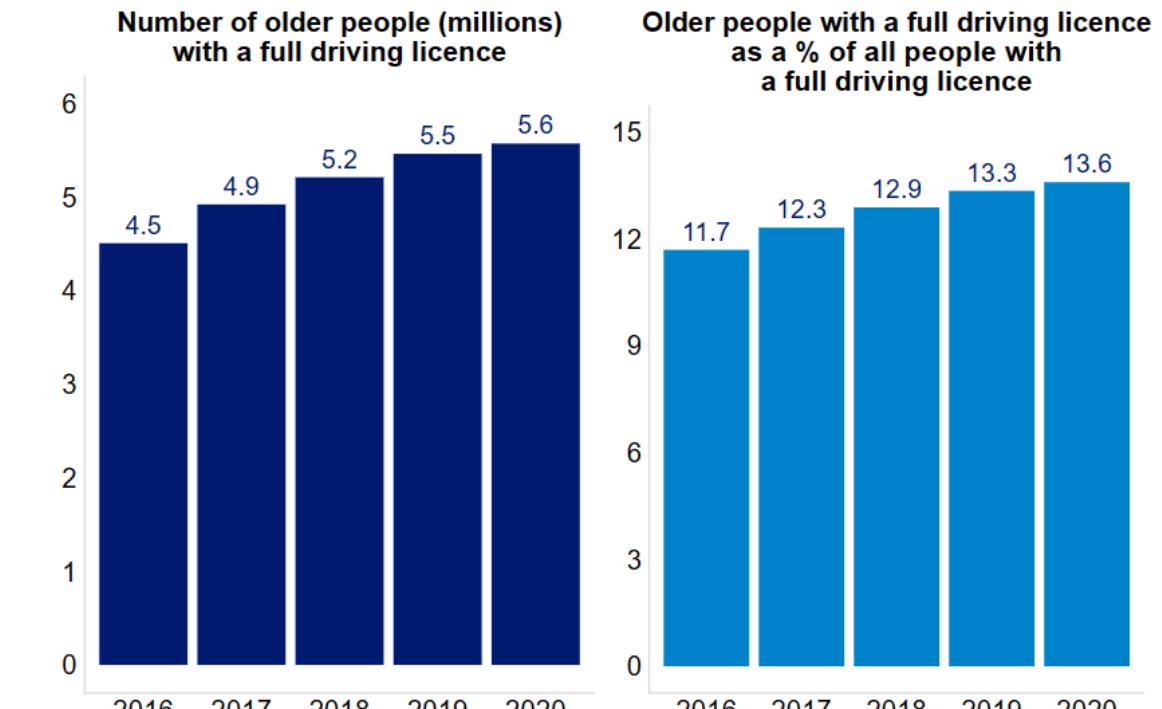
Data source: United Nations Population Division – World Population Prospects 2017; Medium Variant.

The data visualization is available at OurWorldInData.org, where you find more research on how the world is changing and why.

Licensed under CC-BY by the author Max Roser.

Elderly Drivers increasing:

The number of elderly drivers in the UK, climbed by 23.6% during the period of 2016 to 2020



*Older people: aged 70 and over

*Data from National statistics.(2022.May.25) .Reported road casualties Great Britain: older drivers factsheet 2020

01 Background Information



Population Aging and Increasing Number of Elderly Drivers
make this kind of news more frequent.

01 Background Information

The Aging Process

brings

Physical Health Problems

Impact

person's driving skills
and decision-making capabilities.

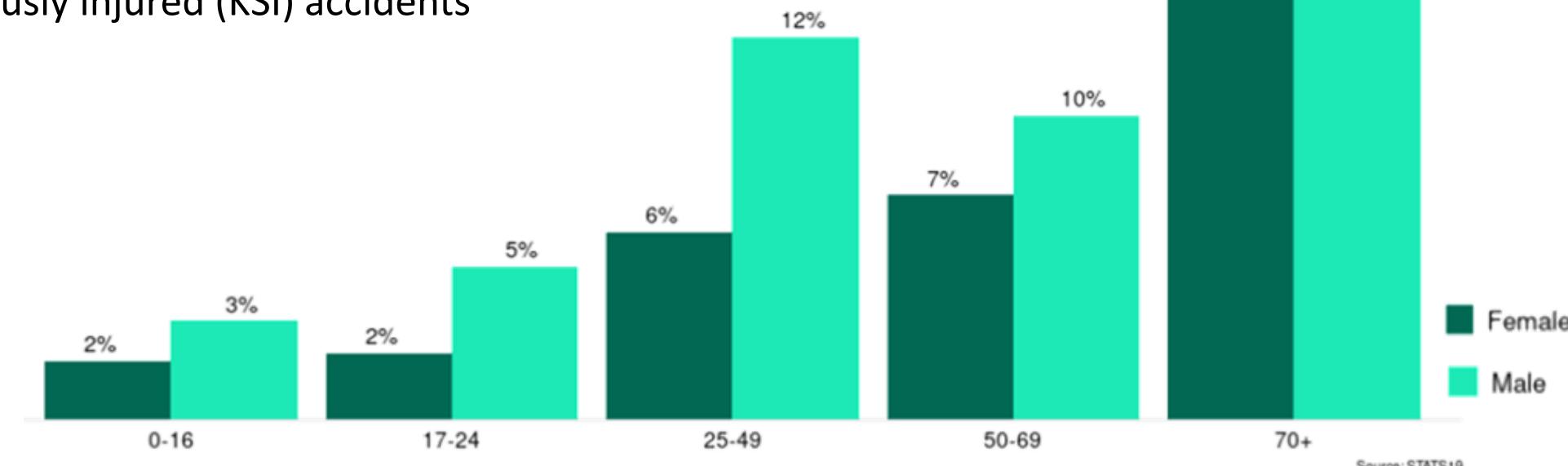
Elderly drivers are more likely to meet challenges on the road.

01 Background Information

Elderly drivers are more likely to be killed or seriously injured in collisions.

- Approximately **26%** of the casualties were **over 70 years old** in killed or seriously injured (KSI) accidents

Percentage of KSI casualties from collisions involving at least one older car driver, by sex and age, Great Britain: 2016 to 2021



01 Background Information

Research Question: **What is the relationship between Driver Age and Traffic Accidents?**

Research Area: London



02

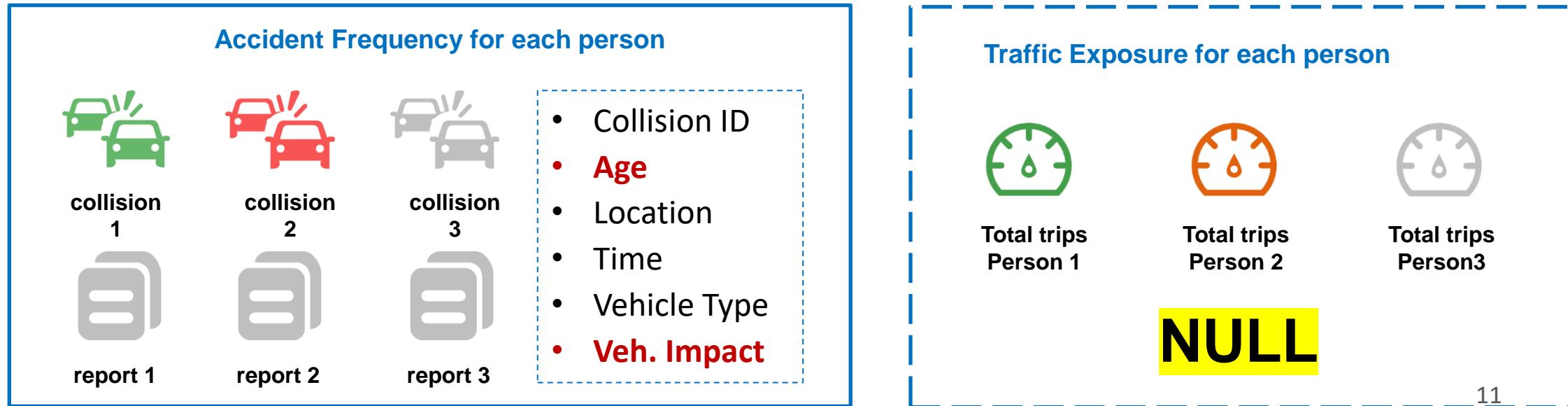
Research on Driver Age

Question: What is the relationship between driver age and traffic accidents?

We need to calculate the **Probability of traffic accident** in different age groups:

$$POA_{(x)} = \frac{\sum \text{Number of accident for each person in the } x^{\text{th}} \text{ age group}}{\sum \text{Total Exposure for each person in the } x^{\text{th}} \text{ age group}}$$

Higher POA  More propensity to be involved in traffic accidents



Question: What is the relationship between driver age and traffic accidents?

Key Point of Replacement:

$$POA_{(x)} = \frac{\sum \text{Number of accident for each person in the } x^{\text{th}} \text{ age group}}{\sum \text{Total Exposure for each person in the } x^{\text{th}} \text{ age group}}$$

1. The distribution of **unresponsible drivers** closely mirrors the distribution of **all drivers exposed to accident hazard**.
2. The **distribution of ROA** in different age groups shows a similar **distribution of POA** in different age groups.

We can calculate the **Risk of traffic accident** in the x^{th} age group:

$$ROA_{(x)} = \frac{\text{Number of responsible drivers in accidents in the } x^{\text{th}} \text{ age group}}{\text{Number of Unresponsible drivers in the } x^{\text{th}} \text{ age group}}$$

- $ROA_{(x)}$ refers to the risk of traffic accident that actively caused by age group $_{(x)}$.

Question: What is the relationship between driver age and traffic accidents?

$$ROA_{(x)} = \frac{\text{Number of responsible drivers in accidents in the } x^{\text{th}} \text{ age group}}{\text{Number of Unresponsible drivers in the } x^{\text{th}} \text{ age group}}$$

Data selection:

Field	Example	Description
Collision_ID	1180080971	accident references, can be duplicated (refers to an unique accident)
Location(epsg:27700)	(529150, 182270)	Point in geometry
Vehicle Type	Taxi	Type of vehicle
Vehicle Impact	'Front Hit First'	First Point of impact in acc.
Driver Age	65	Age of driver
...



More than 3,500,000 records



Range from 2005-2022

Vehicle Type

- Remove non-motorized vehicles (eg: Pedals)

Age

- Remove drivers under 16 (Legal driving age in the UK)

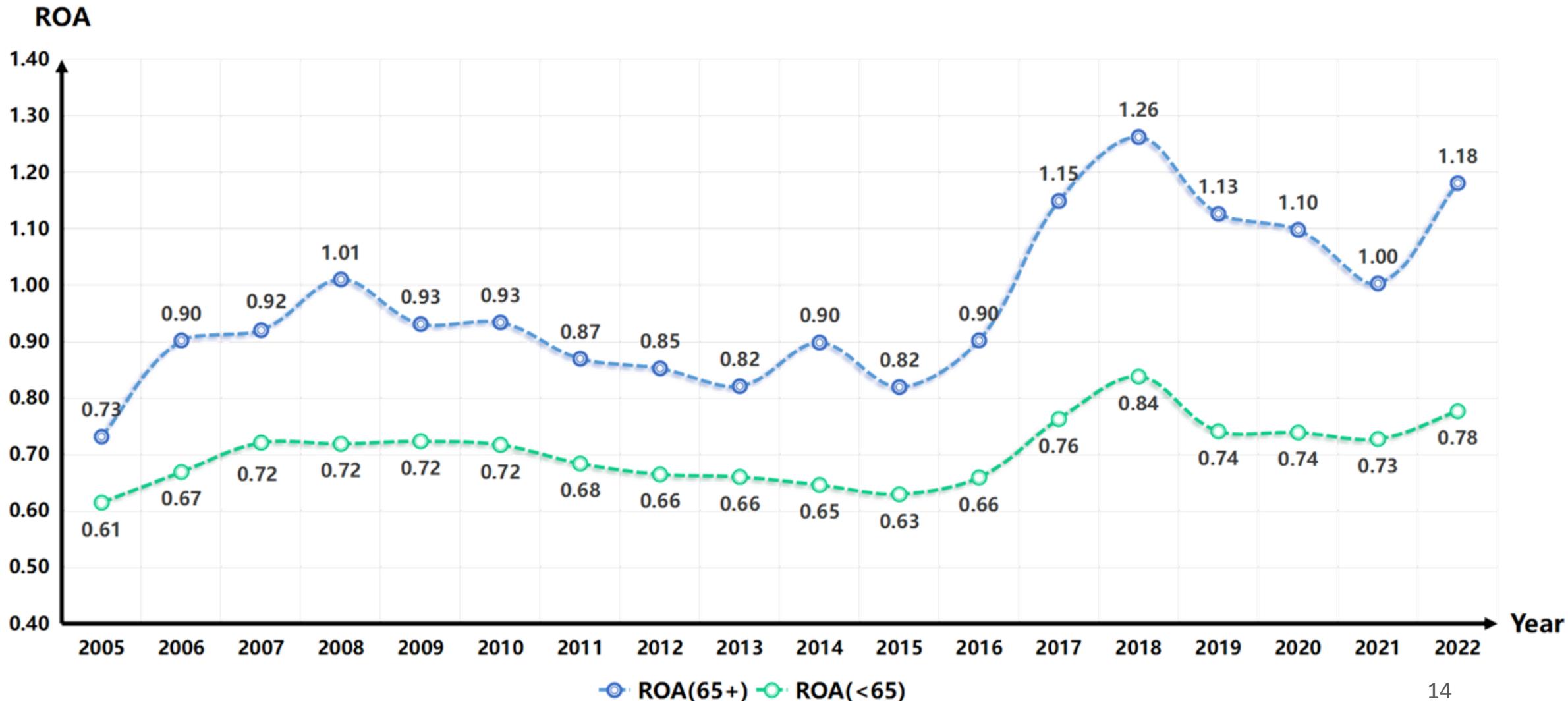
Resonsible & Unresponsible

"In rear-end accidents, the driver in the back is reliable for the damaged caused in most of states."

- Responsible drivers: **'Front Hit First'** in vehicle Impact.
- Unresponsible drivers: Other vehicle Impact type. (eg. 'End Hit First')

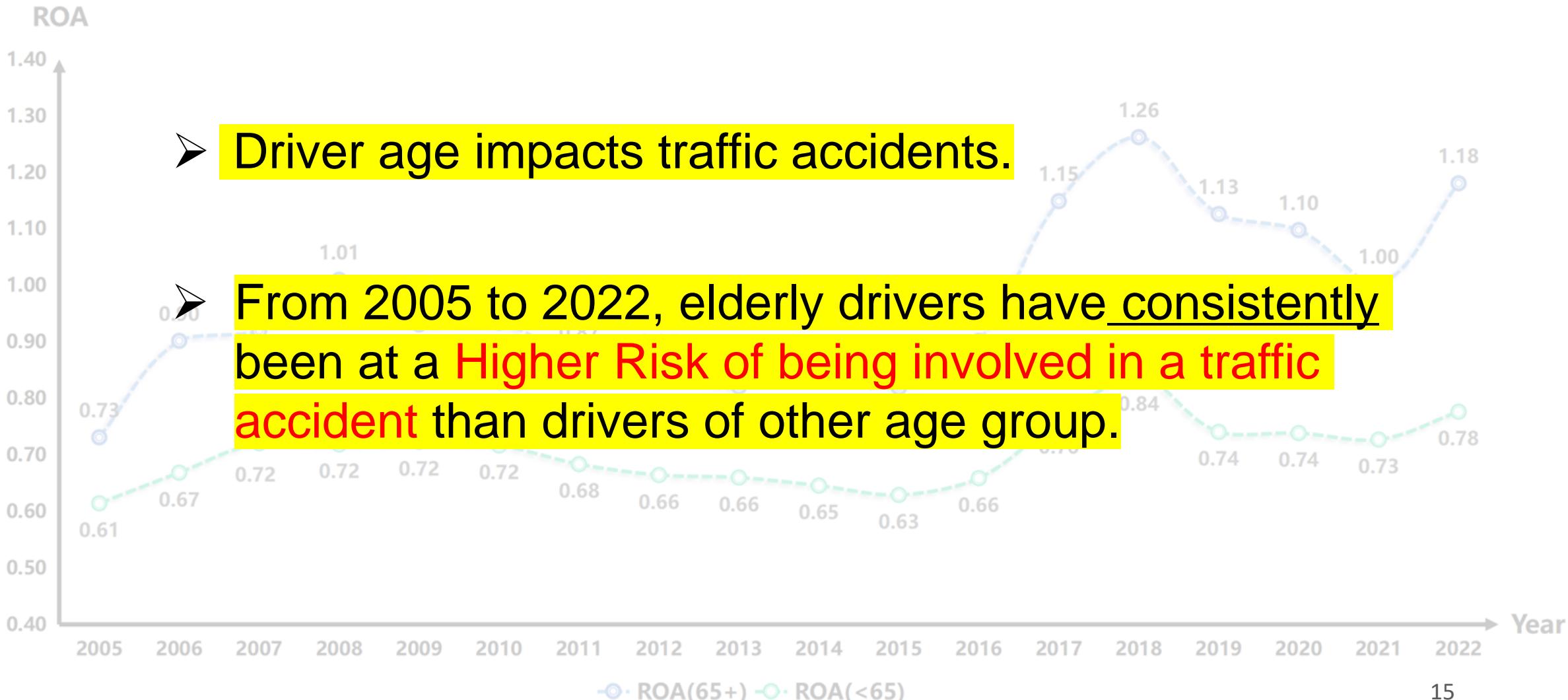
Question: What is the relationship between driver age and traffic accidents?

Conduct a **Long-Term Analysis** to capture the dynamic change of the relationship between age and traffic accident, as our society's demographic evolves.



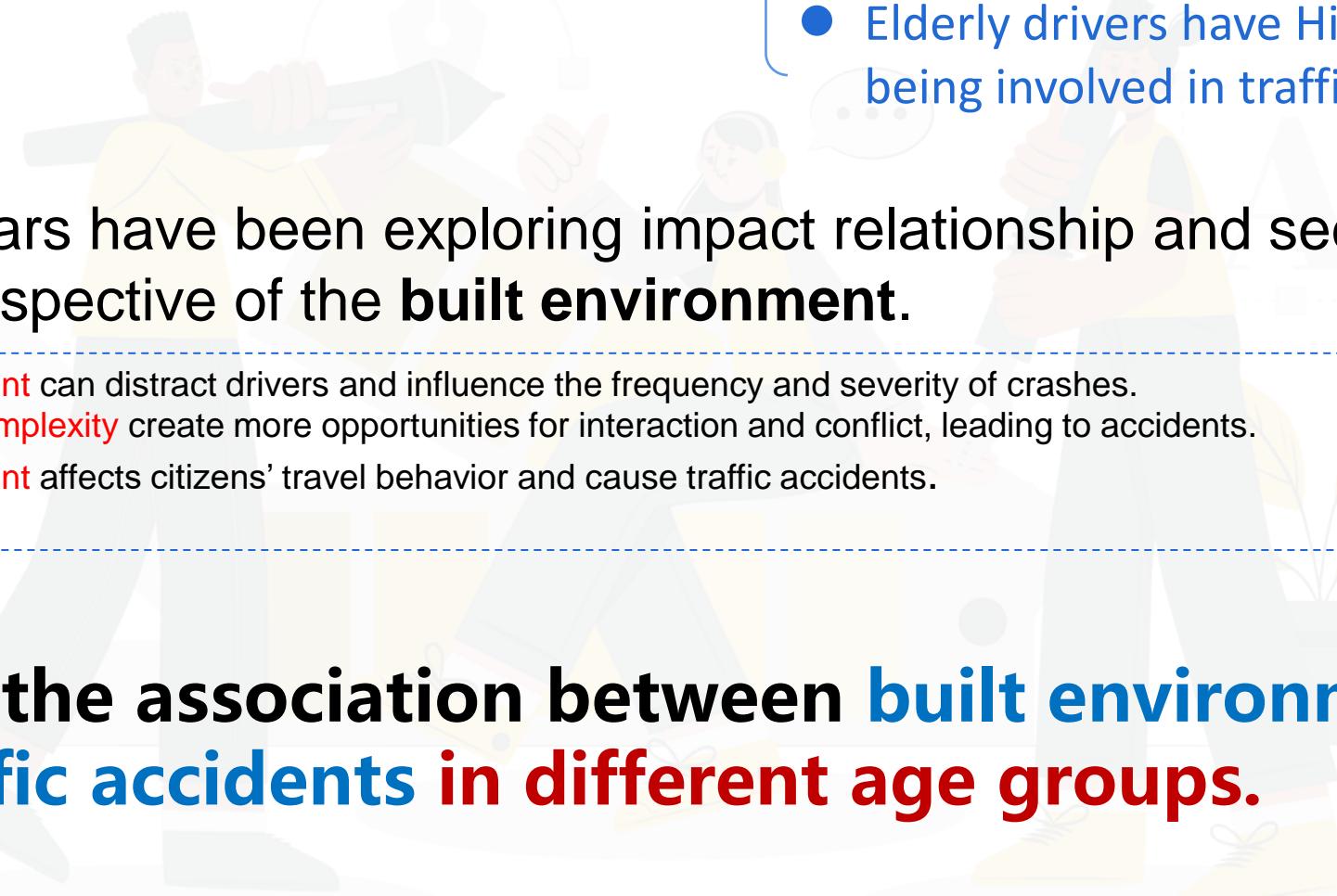
Question: What is the relationship between driver age and traffic accidents?

Result: $\text{ROA}_{(65+)} > \text{ROA}_{(< 60)}$





Noticing these social conditions

- 
- Population Aging
 - Increasing Number of Elderly Drivers
 - Driver age impacts traffic accidents
 - Elderly drivers have Higher Risk of being involved in traffic accidents

Some scholars have been exploring impact relationship and seeking solutions from the perspective of the **built environment**.

- Built environment can distract drivers and influence the frequency and severity of crashes.
- Density and complexity create more opportunities for interaction and conflict, leading to accidents.
- Built environment affects citizens' travel behavior and cause traffic accidents.

...



Analyze the association between built environment and traffic accidents in different age groups.



What is the relationship between **Built Environment** and traffic accidents in elderly drivers?

03

Model Approaches for Built Environment

Question: How to discover factors that have contribution on old drivers

Question: How to discover factors that have contribution on old drivers

Modeling: Capture the relationship between X and y

$$y \sim \{X\}: y = aX_1 + bX_2 + C \quad R^2: 100\% \quad (\text{ideal})$$

Question: How to discover factors that have contribution on old drivers

Modeling: Capture the relationship between X and y

$$y \sim \{X\}: y = aX_1 + bX_2 + C \quad R^2: 100\%$$

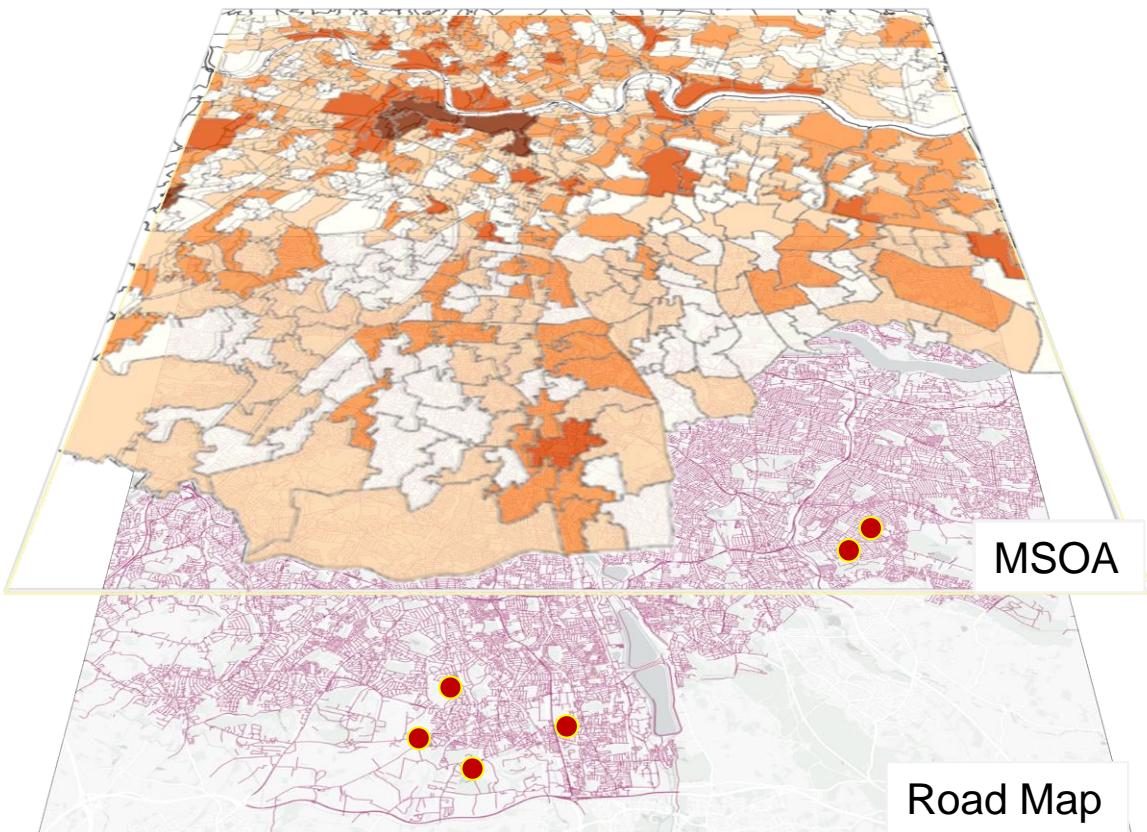
a:Contribution of X_1

b:Contribution of X_2

1. Define X and y
2. Find a mathematical statistic model to capture the relationships

Question: How to discover factors that have contribution on old drivers

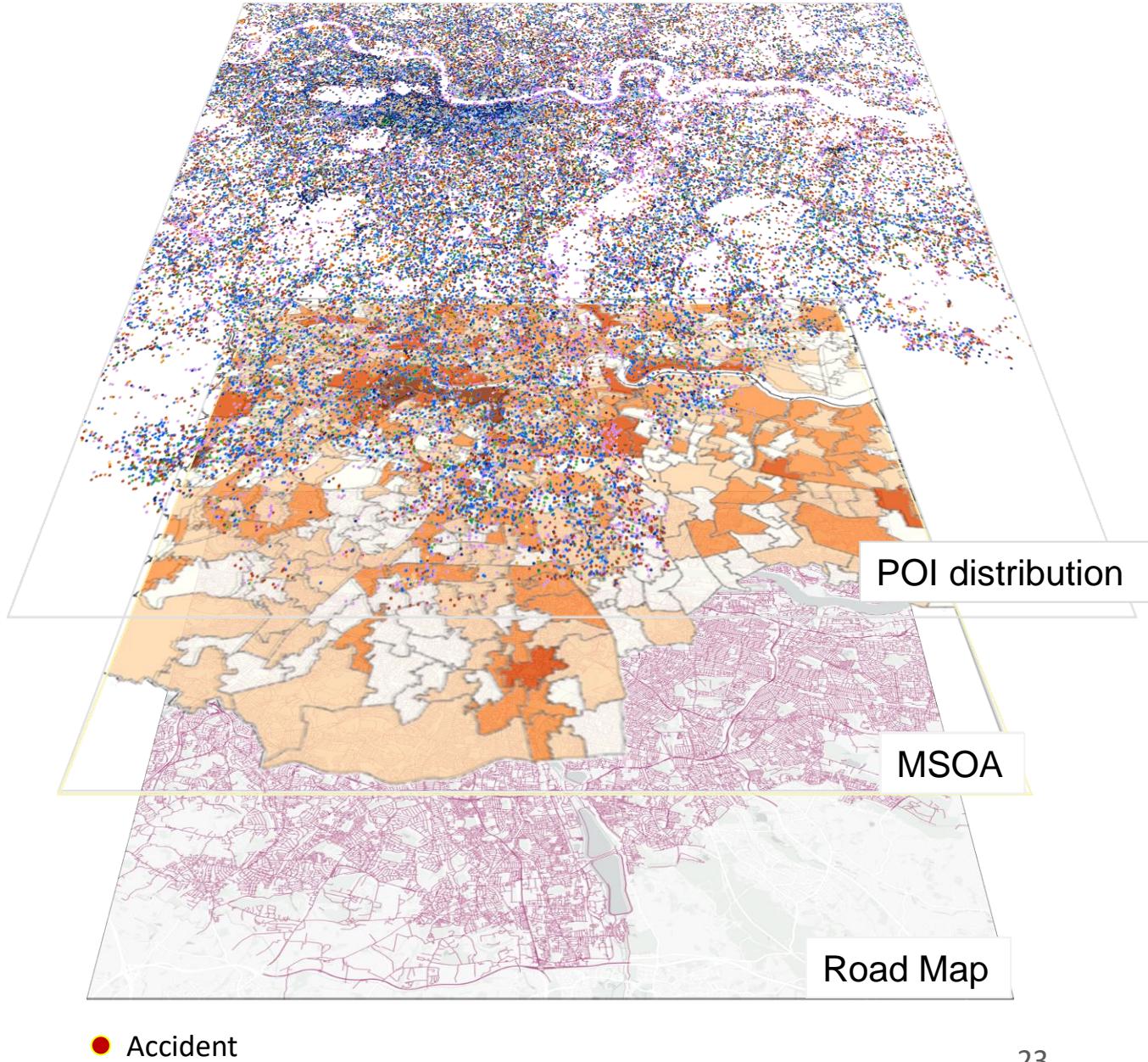
Count



Spatial Unit - MSOA(Middle Super Output Area)

Y - Accident Number

Question: How to discover factors that have contribution on old drivers



Spatial Unit - MSOA(Middle Super Output Area)

Y - Accident Number

In urban computing, **POI** is a commonly used proxy for built-environment in most researches

- Accom. & Food
- Attractions
- Commercial
- Education & Health
- Construction
- Administration
- Retail
- Sport & Entertainment
- Transport

Fan, Z., Zhang, F., Loo, B. P. Y., & Ratti, C. (2023). Urban visual intelligence: Uncovering hidden city profiles with street view images. *Proceedings of the National Academy of Sciences*, 120(27), e2220417120.
<https://doi.org/10.1073/pnas.2220417120>

Question: How to discover factors that have contribution on old drivers

Table 1: Data Format for $Y \sim \{POI\}$

MSOA	Accident Number	Accom. & Food	Attraction	Commercial	...	Retail
E02000001	121	1169	360	4786	...	528
E02000002	64	330	4	41	...	130
...
E02006931	40	96	67	133	...	37

The diagram illustrates the data structure. A red bracket labeled 'Y' spans the 'Accident Number' column, indicating it is the dependent variable. A blue bracket labeled 'X' spans the 'Attraction' column, indicating it is one of the independent variables.

Data Shape:(983,13)

Question: How to discover factors that have contribution on old drivers

Model Selection

Question: How to discover factors that have contribution on old drivers

Model Selection

Shortage

- **Non-Spatial Linear Model:** Multiple Linear Regression\ Lasso Regression

$$y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \epsilon$$

- **Spatial Effect**
Hypo: location effect
- **Interactions between X**
Hypo: Time & lamp?

- **Spatial Statistical Model:** Multiscale GWR \ Spatial Lag Model

$$y_i = \beta_0(u_i, v_j) + \sum_{j=1}^p \beta_j(u_i, v_j)x_{ij} + \dots + \epsilon$$

- **Spatial Effect**
- **Interactions between X**

Question: How to discover factors that have contribution on old drivers

Model Selection

The screenshot shows a research article page. At the top, there are buttons for "View PDF" and "Download full issue". Below that is the Elsevier logo and the journal title "Computers, Environment and Urban Systems" with the volume information "Volume 96, September 2022, 101845". The main title of the article is "Extracting spatial effects from machine learning model using local interpretation method: An example of SHAP and XGBoost". Below the title, the author's name is Ziqi Li, followed by "Show more" and "Add to Mendeley", "Share", and "Cite" buttons. The DOI is https://doi.org/10.1016/j.compenvurbsys.2022.101845. The article is under a Creative Commons license and is marked as "open access". A "Highlights" section lists the following points:

- Local interpretable methods (e.g. SHAP) enable the extraction of spatial effects from machine learning model of spatial data.
- Simulation results suggest that spatial effects modelled by XGBoost are similar to the parameters in SLM and MGWR.
- An example of ride-hailing demand in Chicago is presented to demonstrate the use of local interpretable machine learning.

Inspiration

- Spatial effect can be **captured and explicitly explained** (With SHAP)
- **Interactions** between X can also be **captured and explicitly explained** (With SHAP)
- Machine Learning can **performed as well as traditional statistic models** without assumption to the model specification and data distribution.

Li, Z. (2022). Extracting spatial effects from machine learning model using local interpretation method: An example of SHAP and XGBoost. *Computers, Environment and Urban Systems*, 96, 101845.
<https://doi.org/10.1016/j.compenvurbsys.2022.101845>

Question: How to discover factors that have contribution on old drivers

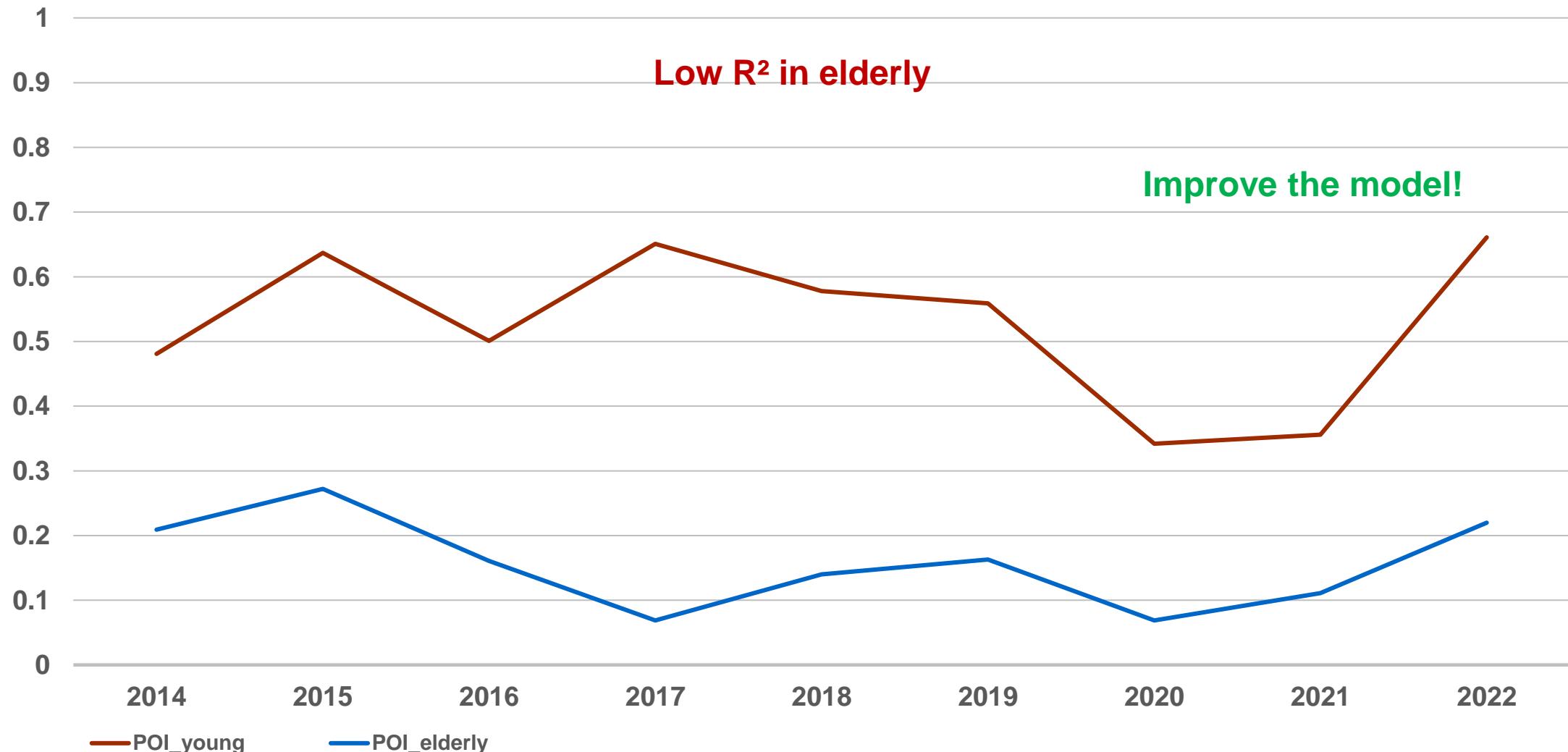
Model Performance

{Accident Num} ~ {POI},
XGBoost

Question: How to discover factors that have contribution on old drivers

Model Performance

R^2 of $Y \sim \{\text{POI}\}$ in 2014-2022 for both young & elderly



Question: How to discover factors that have contribution on old drivers

Model Selection

The screenshot shows the PNAS website interface. At the top, there are navigation links: ARTICLES ▾, FRONT MATTER, AUTHORS ▾, and TOPICS +. Below this, the title of the article is displayed: "RESEARCH ARTICLE | SOCIAL SCIENCES | 8 Urban visual intelligence: Uncovering hidden city profiles with street view images". The authors listed are Zhuangyuan Fan, Fan Zhang, Becky P. Y. Loo, and Carlo Ratti. The article was edited by Richard Shearmur from McGill University, received on November 30, 2022, and accepted on May 18, 2023. The DOI is https://doi.org/10.1073/pnas.2220417120. The article has 6,281 views. A sidebar on the left is titled "Significance" and lists other sections: Abstract, Results, Discussion, Materials and Methods, Data, Materials, and Software Availability. A note at the bottom states: "We use cookies on this site to enhance your user experience. By using this website, you are giving your consent for us to set cookies. Find out more" and provides a link to the cookie policy.

Inspiration

- **POI** mainly stands for **urban function-based measures**, while **Streetview images** stands for **visual perception measures**.
- Urban Features extracted from StreetView images can better estimate the hidden SES compared to POI.

Fan, Z., Zhang, F., Loo, B. P. Y., & Ratti, C. (2023). Urban visual intelligence: Uncovering hidden city profiles with street view images. Proceedings of the National Academy of Sciences, 120(27), e2220417120.
<https://doi.org/10.1073/pnas.2220417120>

Question: How to discover factors that have contribution on old drivers

Data: StreetView Images(SVI)



Google Maps Platform



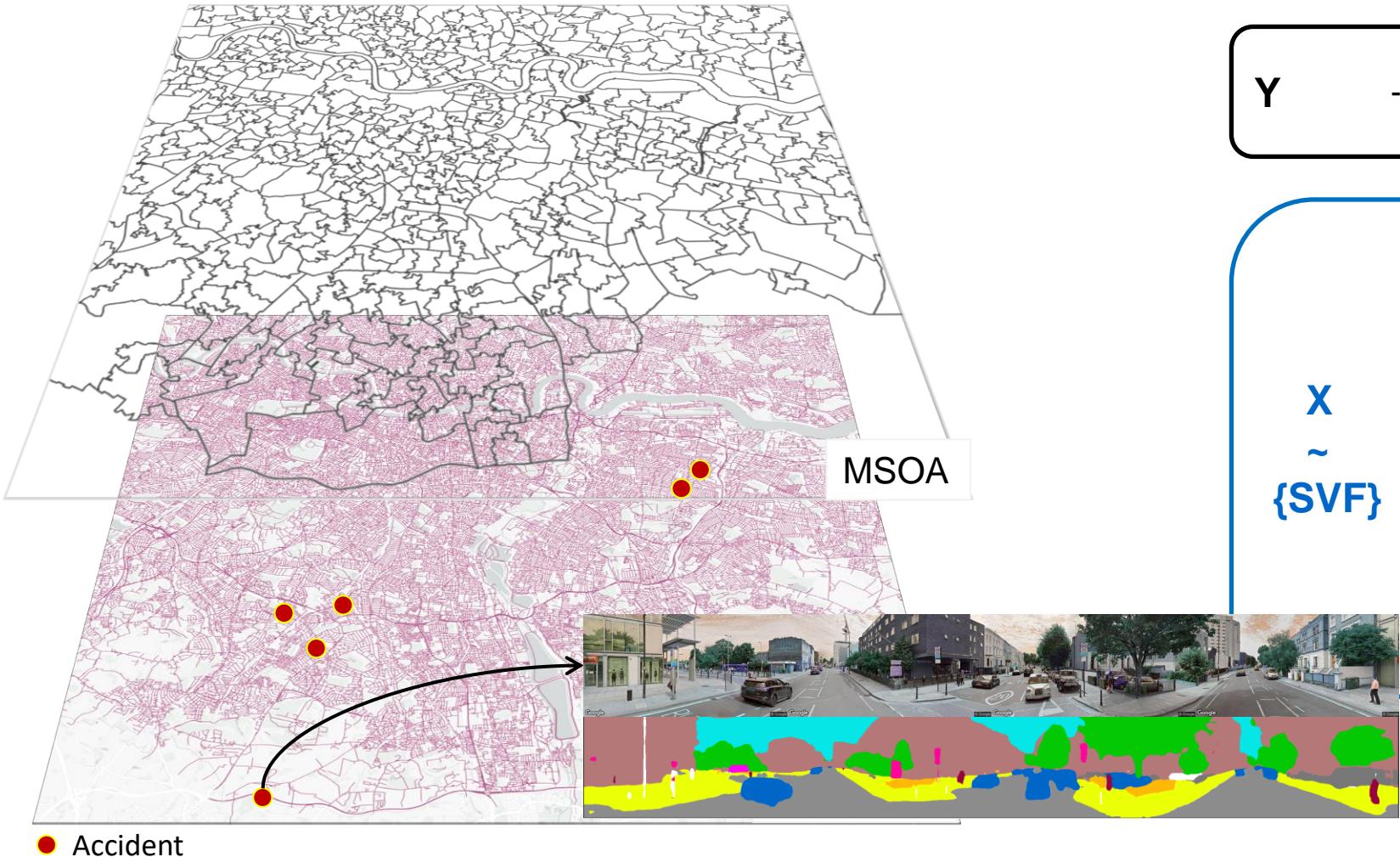
Visual Perception have their counterparts: Tree, Wall, Sky...



Semantic Segmentation: Deep-Learning Model

- Open-Source Semantic Segmentation Model trained on MIT ADE20K
- ResNet18dilated + PPM_deepsup
- **Be able to classify each pixel to different types of urban entity**
- **Calculate the percentage of each type as the values of visual perception**

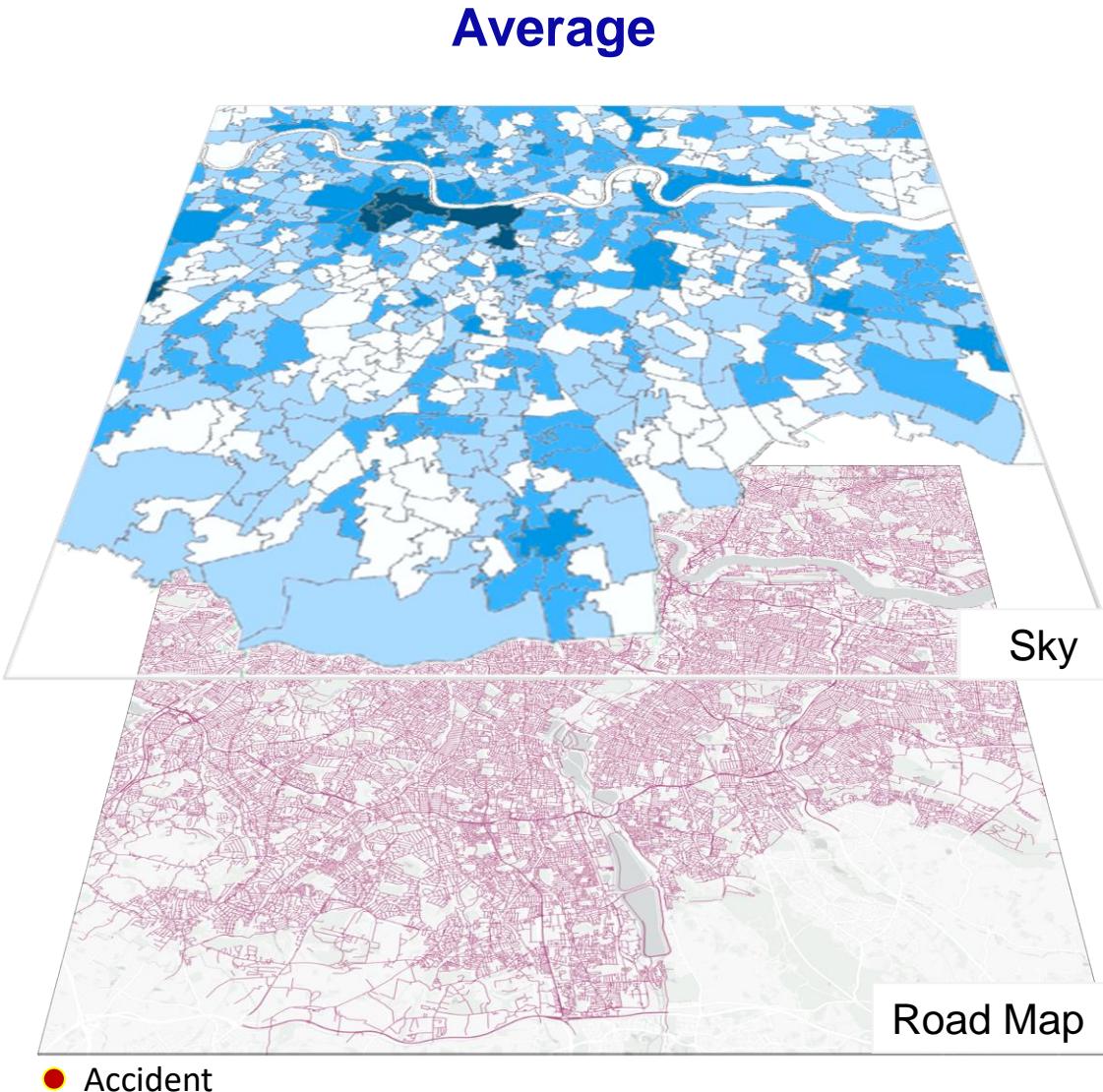
Question: How to discover factors that have contribution on old drivers



Spatial Unit - MSOA(Middle Super Output Area)

Y - Accident Number

Question: How to discover factors that have contribution on old drivers



Spatial Unit - MSOA(Middle Super Output Area)

Y - Accident Number

X
~
{SVF}

- Sky
- Building
- Tree
- Wall
- Sidewalk
- Light Vehicle
- People
- Street Furniture
-(13 types)

SVF: Street View Features

Question: How to discover factors that have contribution on old drivers

Table 2: Data Format for $Y \sim \{SVF\}$

MSOA	Accident Number	Person(%)	Road(%)	StreetFurniture(%)	...	GreeneryTree (%)
E02000001	121	1.25	18.80	5.00	...	3.00
E02000002	64	1.00	29.50	1.00	...	7.00
...
E02006931	40	2.43	20.50	2.43	...	11.50

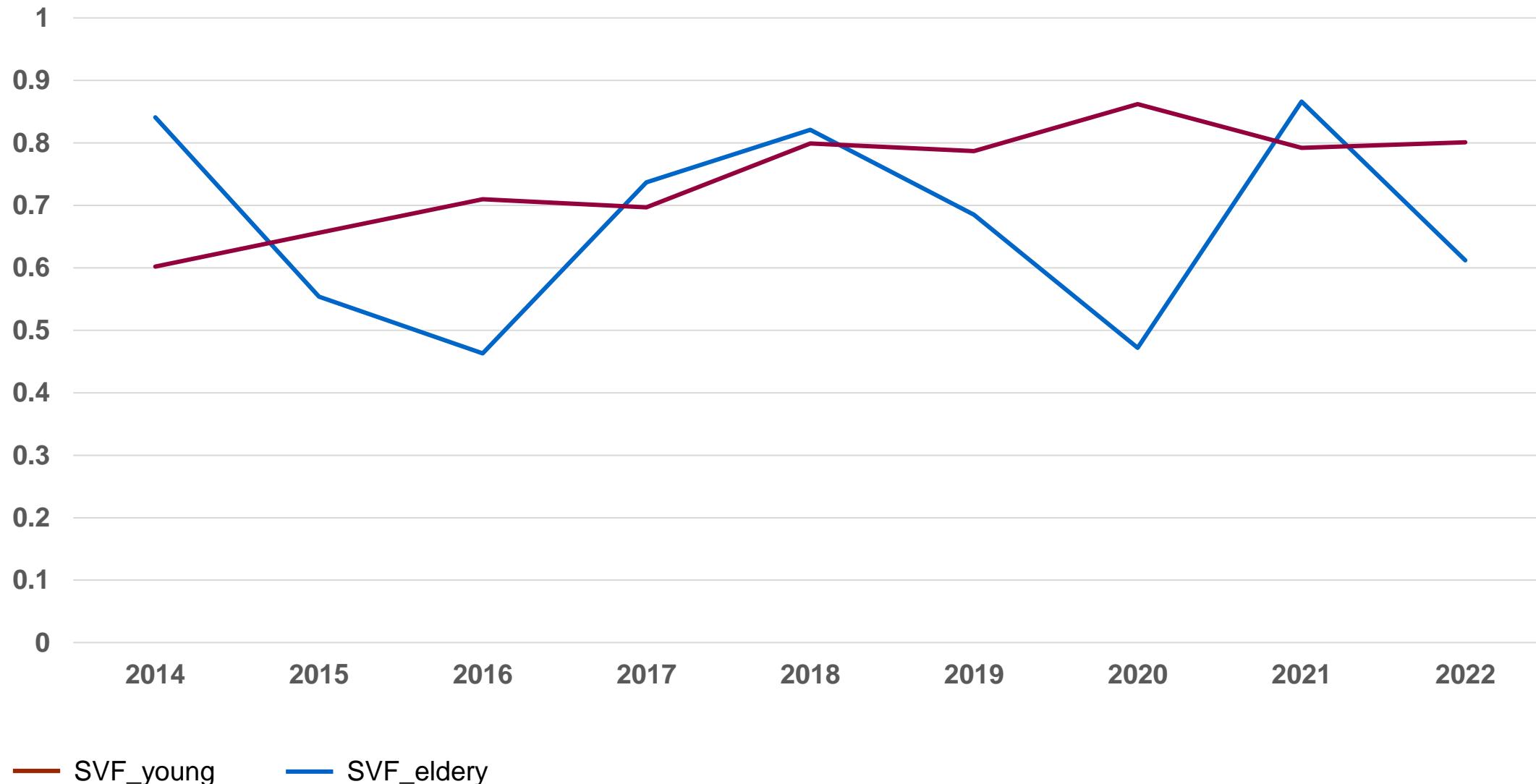


Data Shape:(983,17)

Question: How to discover factors that have contribution on old drivers

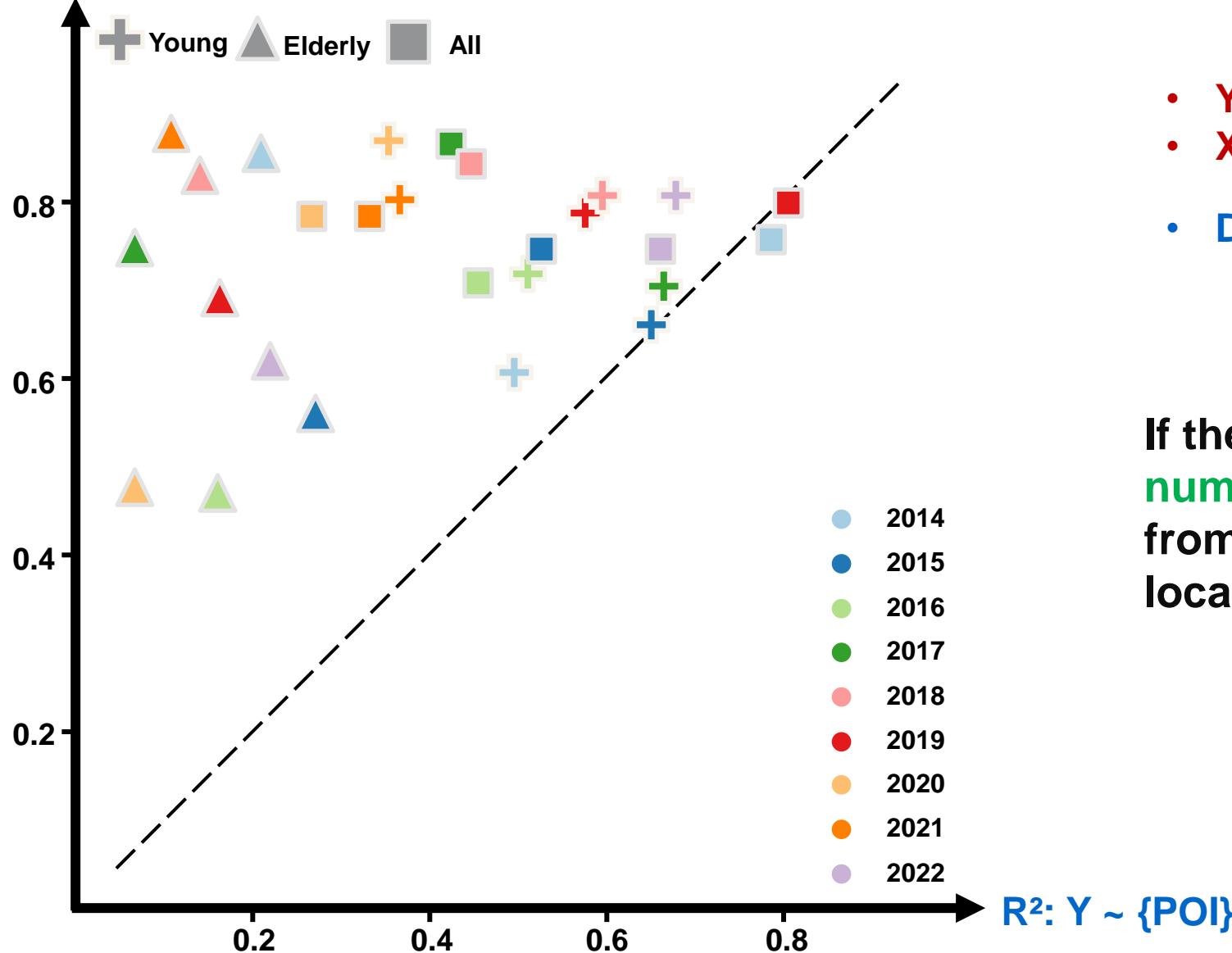
Model Performance

R^2 of $Y \sim \{SVF\}$ in 2014-2022 for both young & elderly



Question: How to discover factors that have contribution on old drivers

$R^2: Y \sim \{SVF\}$

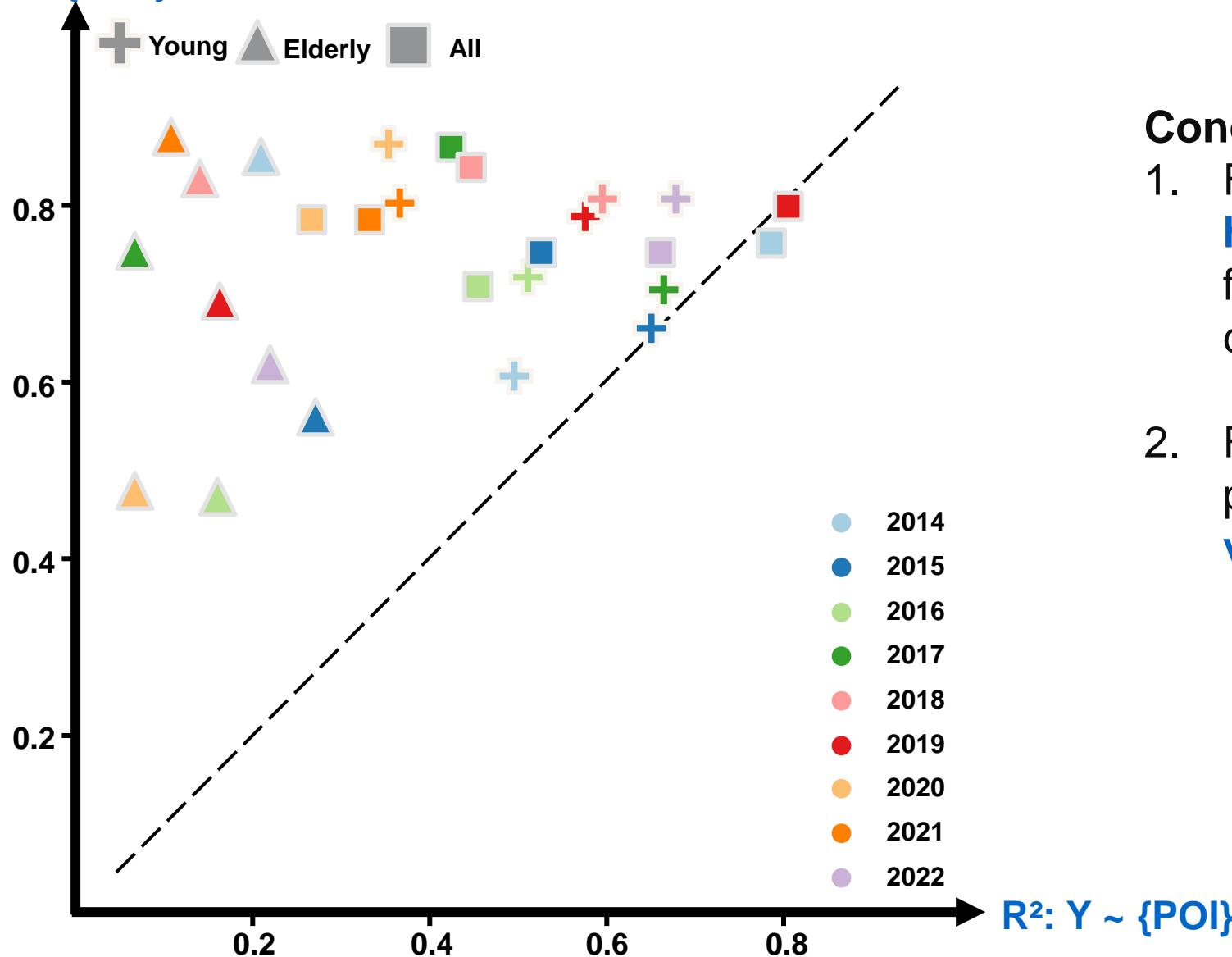


- Y axis: the R^2 of $Y \sim \{SVF\}$
- X axis: the R^2 of $Y \sim \{POI\}$
- Data Points: R^2 for each year

If the R^2 of POI and SVF are numerically similar, data points from different years would be located on the 45° diagonal

Question: How to discover factors that have contribution on old drivers

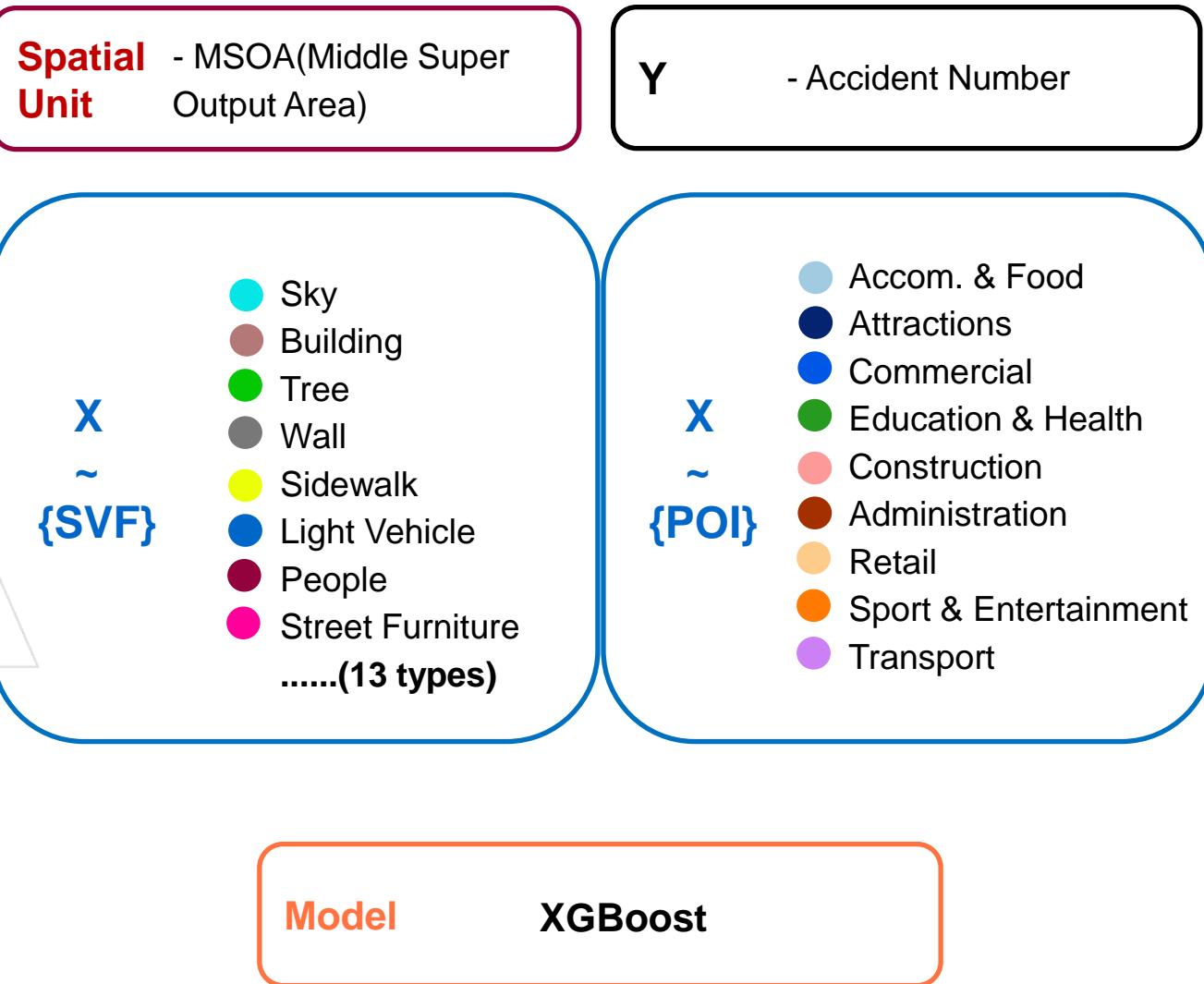
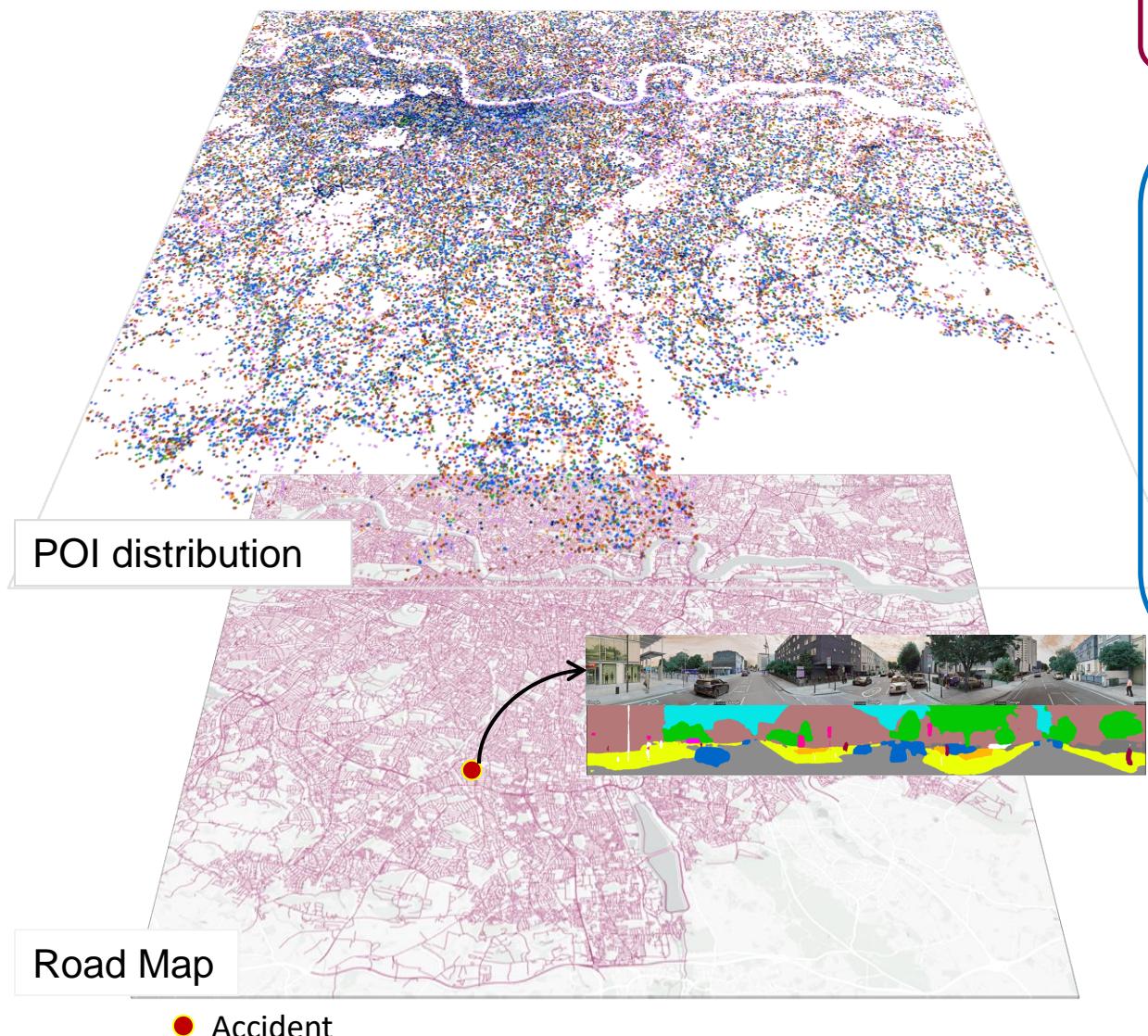
$R^2: Y \sim \{SVF\}$

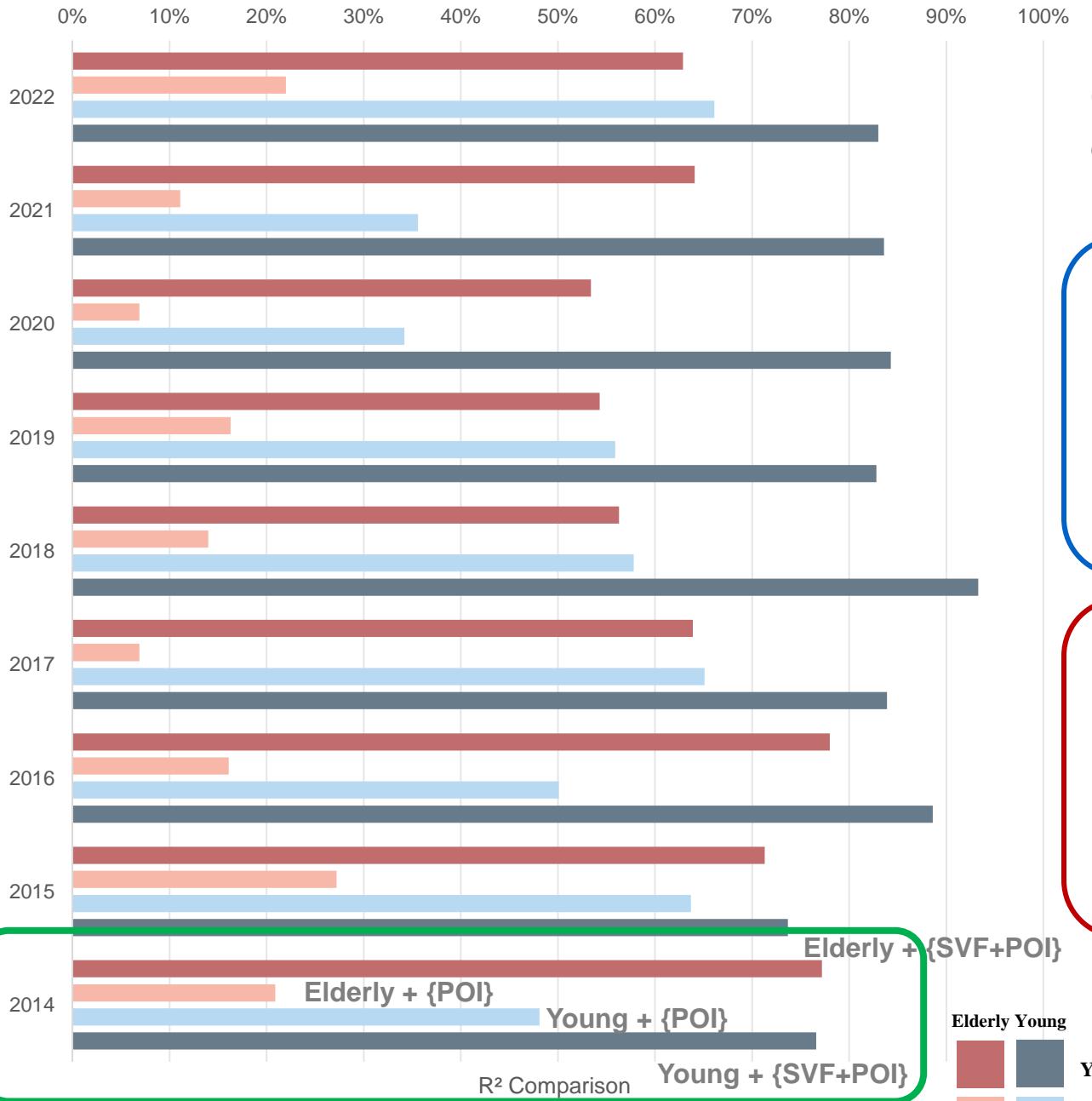


Conclusion:

1. For elderly, **visual perception have more information** than function-based measure on collision.
2. For the young, both data performs relatively similar, but **visual perception a bit better**.

Question: How to discover factors that have contribution on old drivers

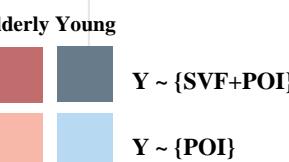


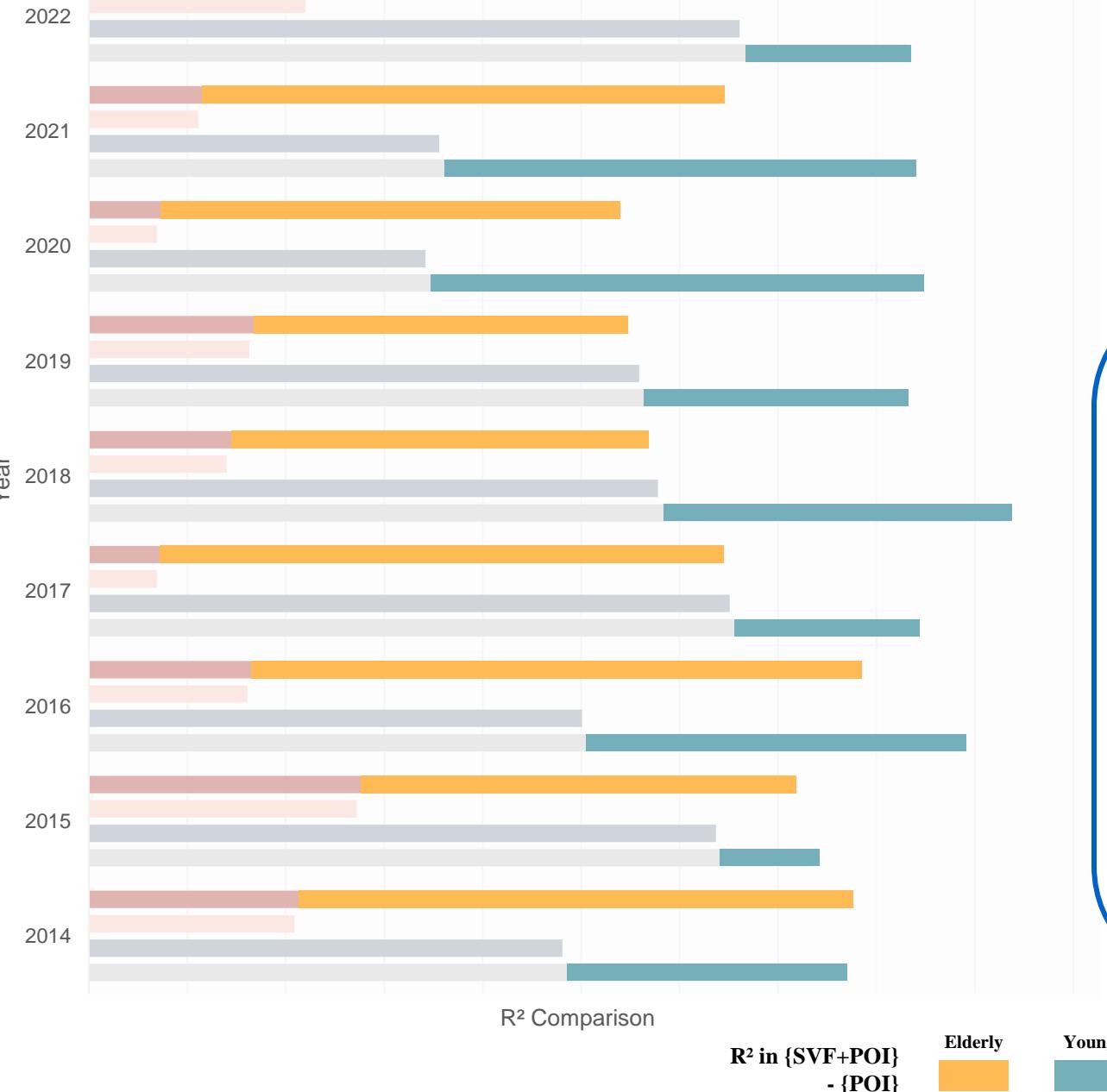


Question: How to discover factors that have contribution on old drivers

- For both elderly and the young, using POI+SVF always perform **much better** than using POI alone

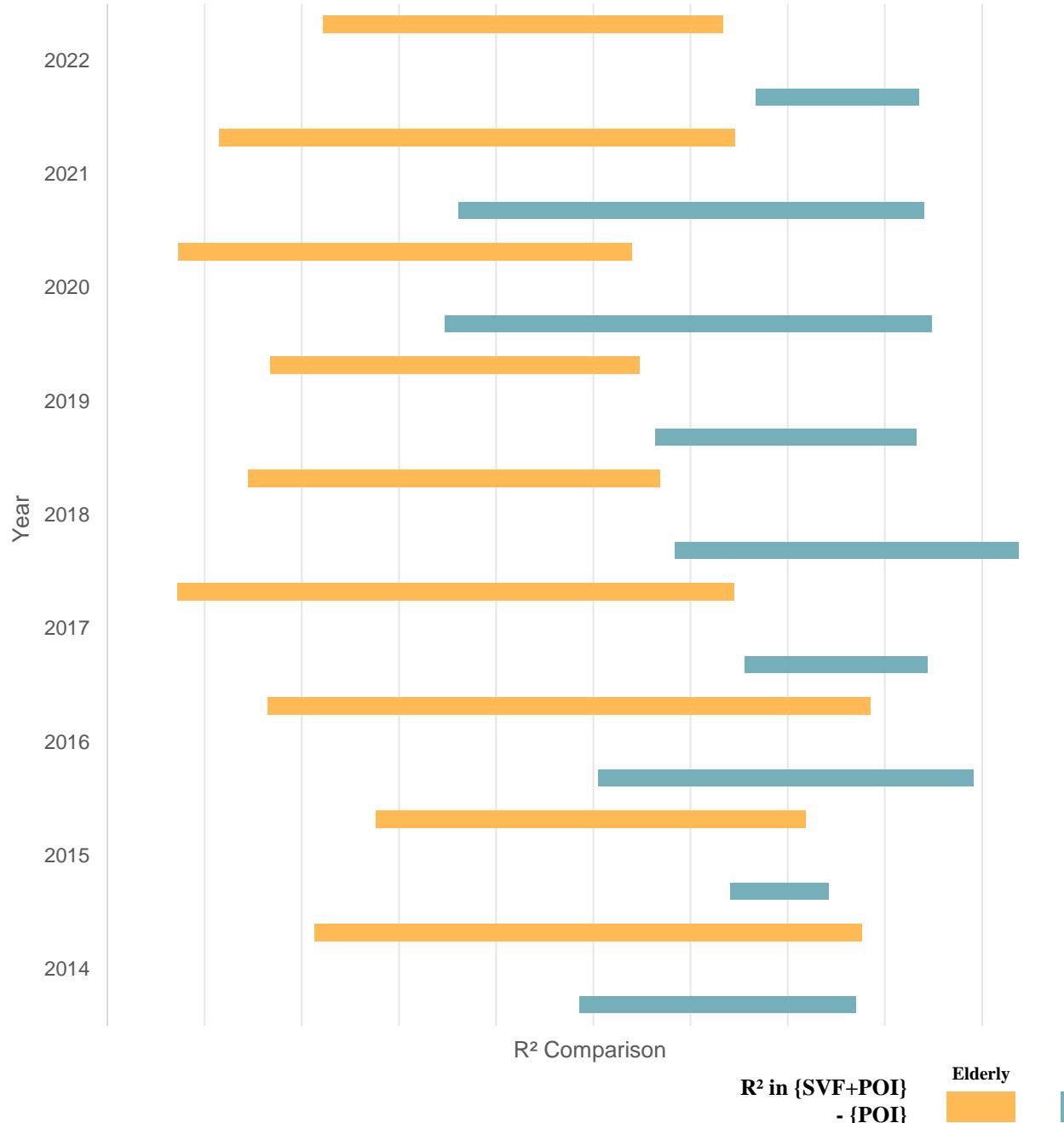
- Compared to POI, **to what extent** does SVF provide **extra information?**





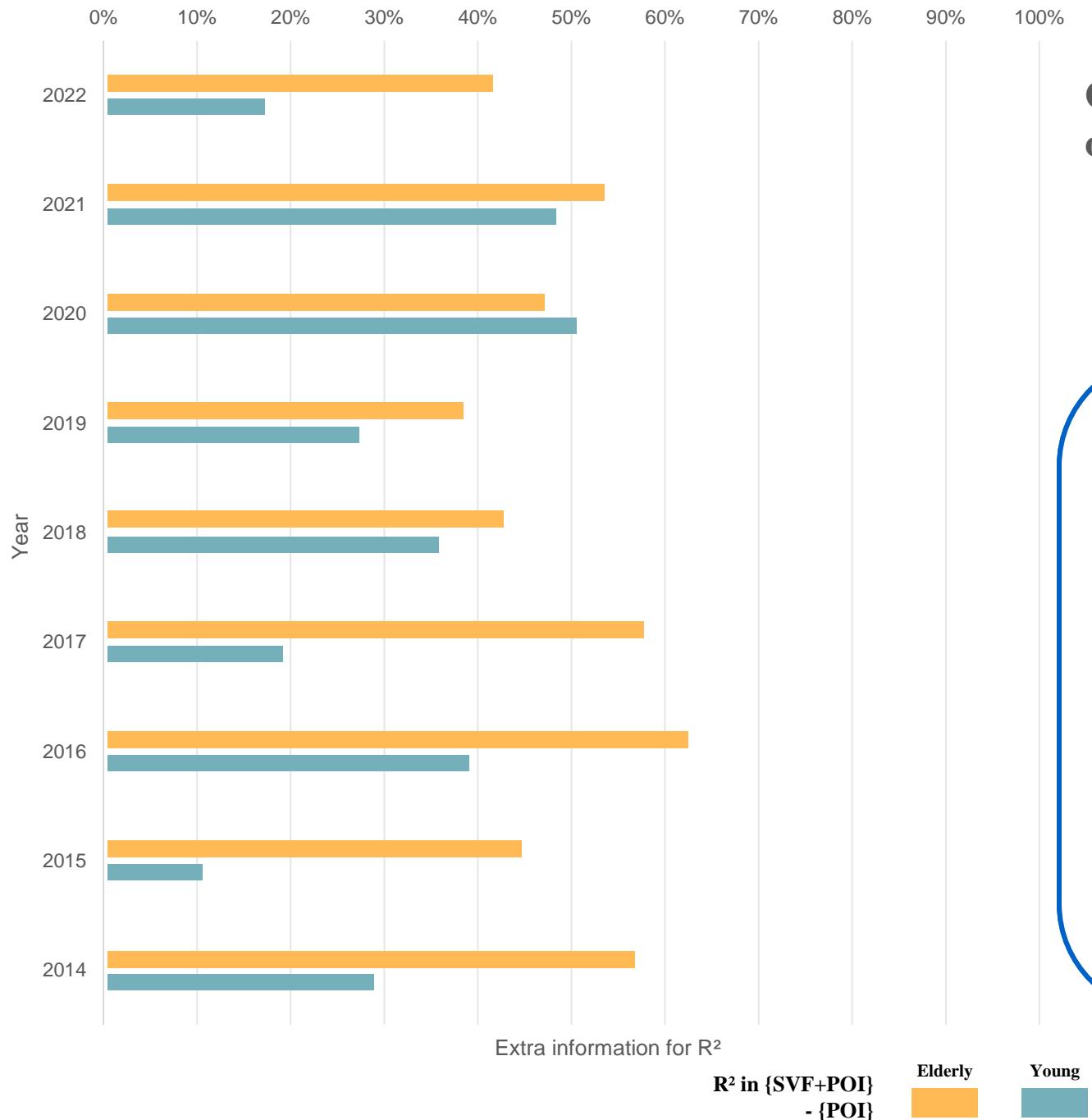
Question: How to discover factors that have contribution on old drivers

- For each year, we **extract the increment of R^2 in $\{\text{SVF+POI}\}$** compared to $\{\text{POI}\}$ for both young and elderly
- The increment stands for the **extra information** provided by $\{\text{SVF}\}$ in this modelling



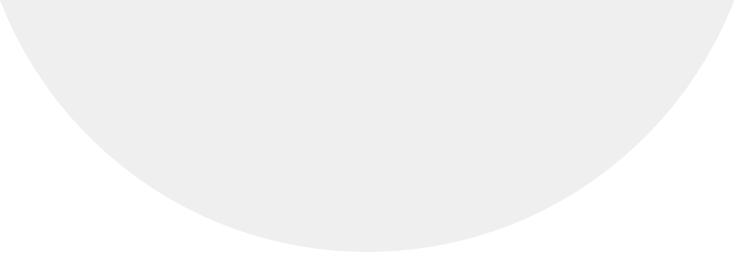
Question: How to discover factors that have contribution on old drivers

- Compare the **extra information** provided by **{SVF}**



Question: How to discover factors that have contribution on old drivers

- Compare the **extra information** provided by **{SVF}**



Question: How to discover factors that have contribution on old drivers

Summary

Question: How to discover factors that have contribution on old drivers

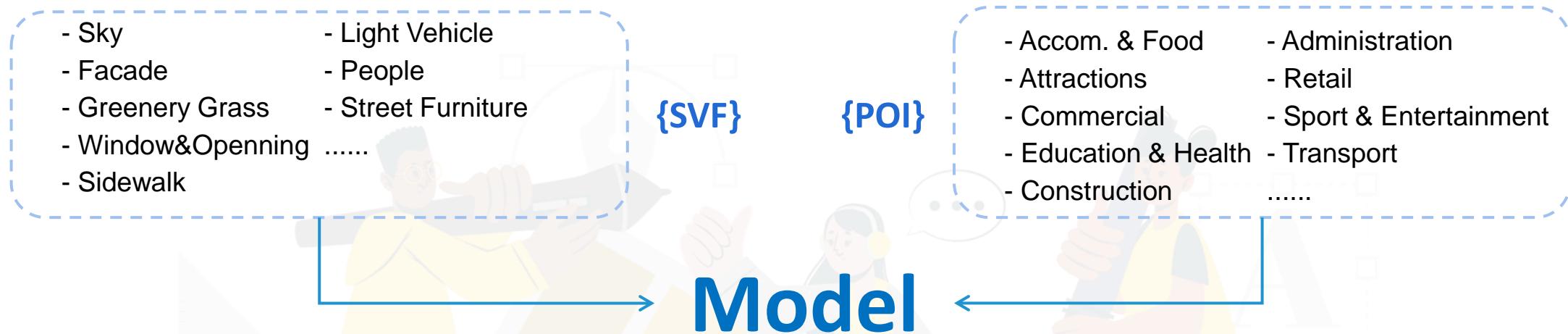
- **Mathematical Statistic Model** : XGBoost
- **Spatial Unit**: MSOA (Middle Super Output Area)
- **Dependent Var (Y)** : Accident Number
- **Independent Vars. (X)** : Street View Features + POI
- **Date Range**: 2014 - 2022

- **Inspiration in global modelling**: The elderly are much affected by Visual Perception

- **Further Step**: Which counterparts of SVF and POI have more contributions (impacts)?

04

Results



➤ What is the relationship :
between built environment and traffic accidents in elderly drivers?

SHAP

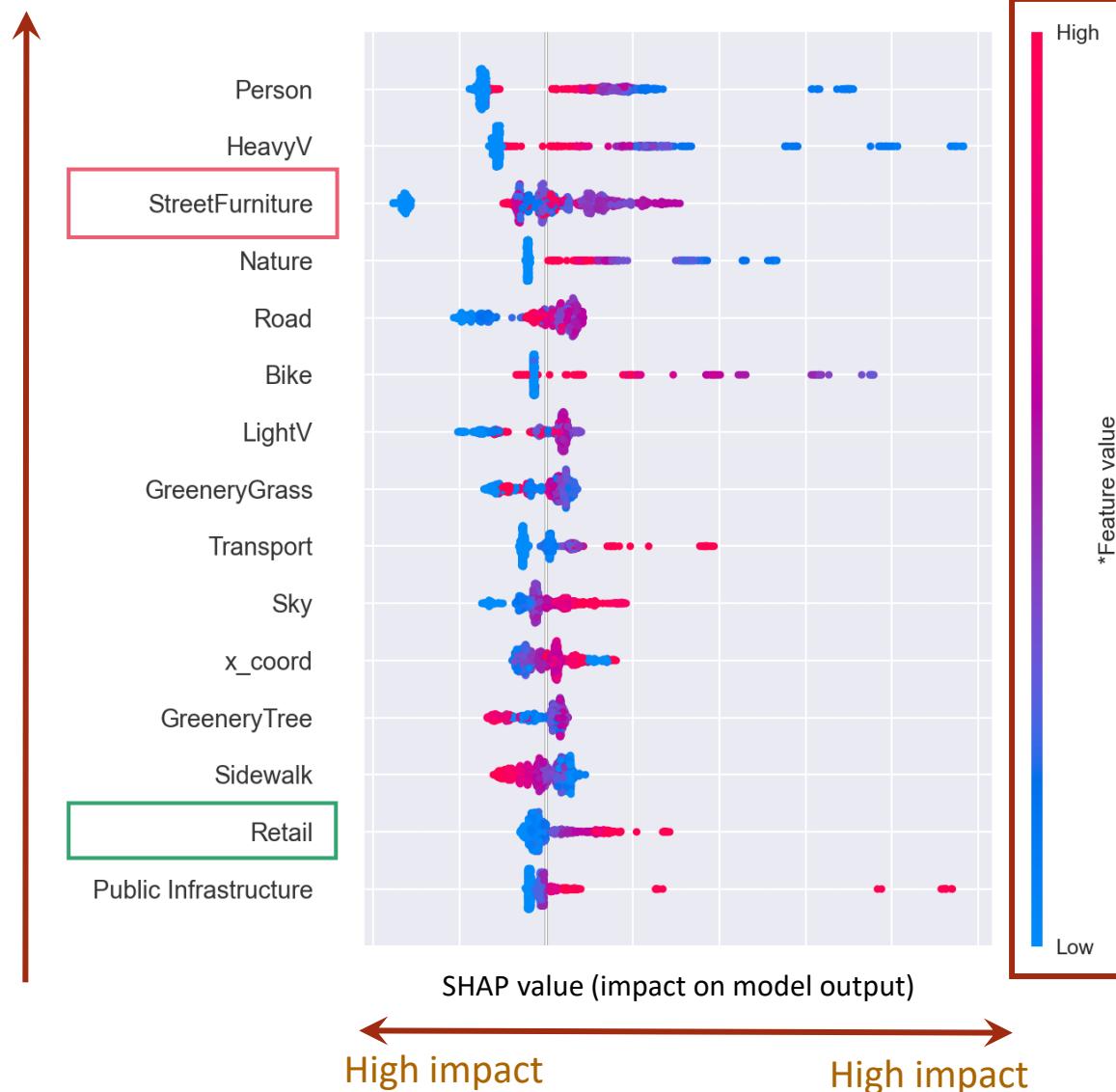
(Shapley Additive exPlanations)

What is the relationship between built environment and traffic accidents in elderly drivers?

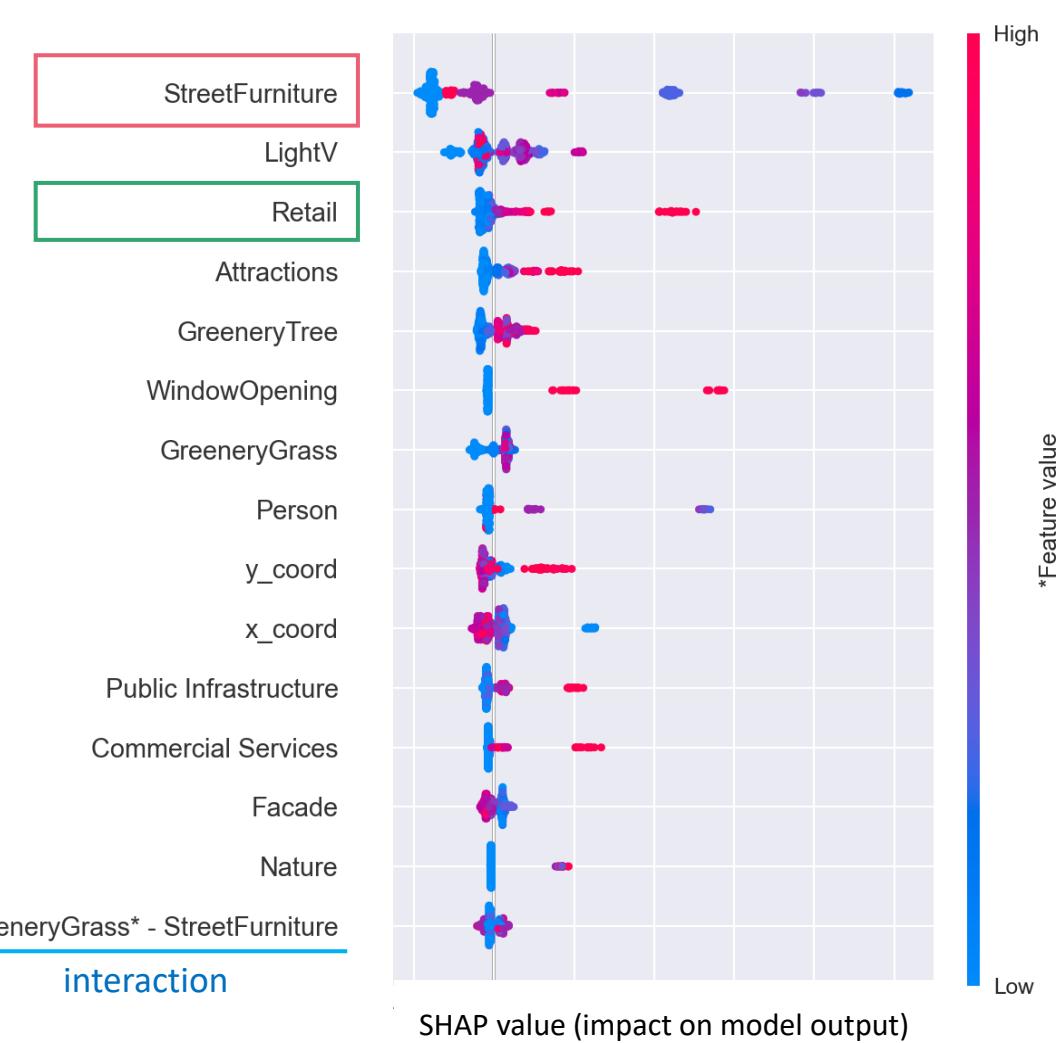
Cross-sectional result in 2019

High contribution

SHAP - value (Young)

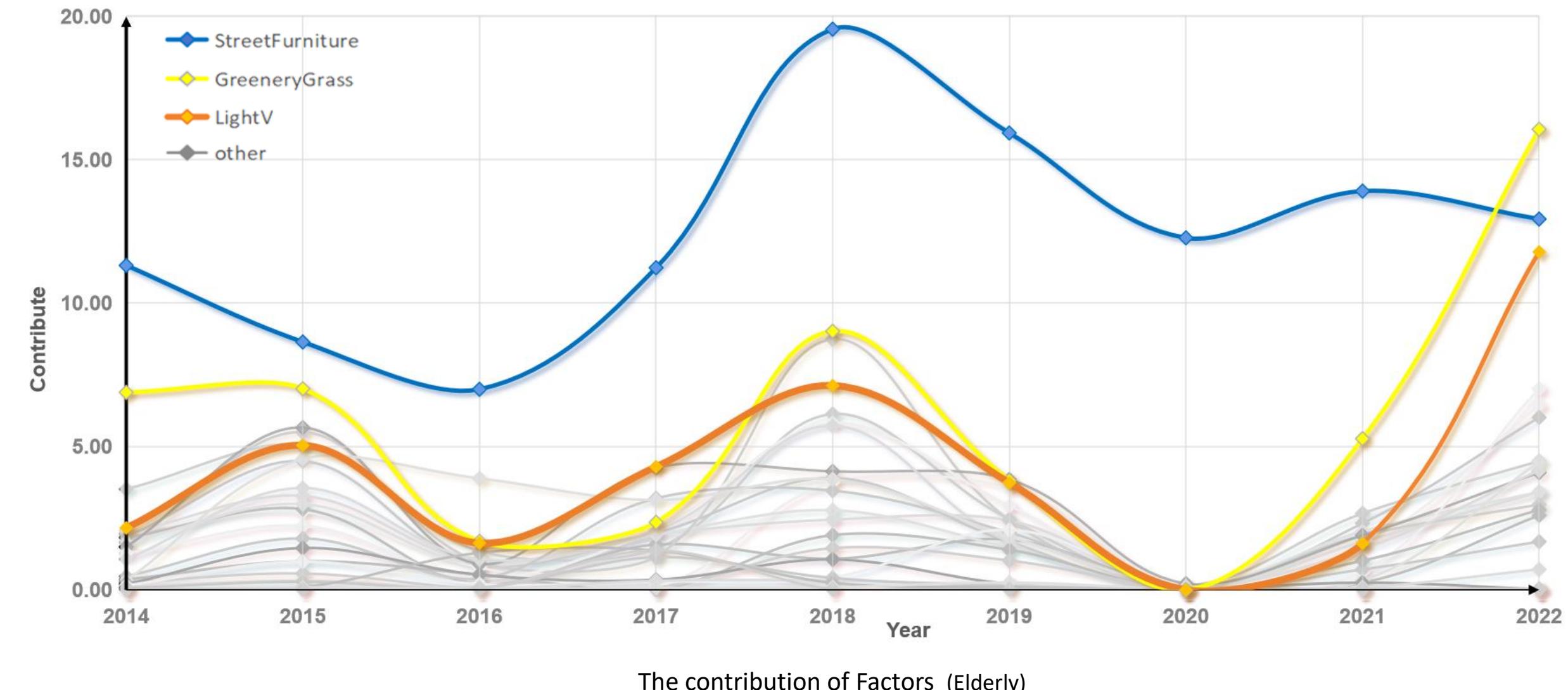


SHAP - value (Elderly)



GreeneryGrass* - StreetFurniture
interaction

What are the high contributing factors in elderly drivers?

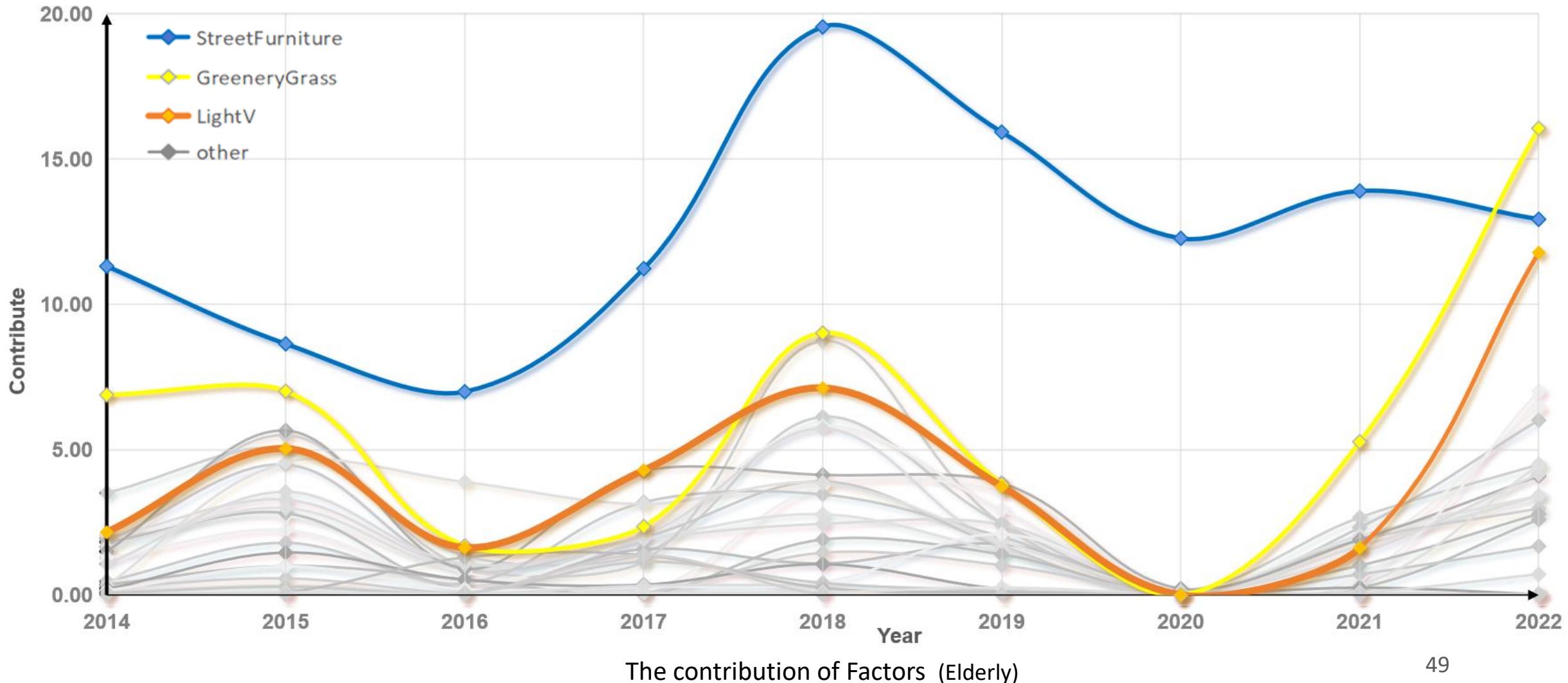


What are the high contributing factors in elderly drivers?

Streetlight, Bench, Chair, Seat, Awning, Booth, Sign

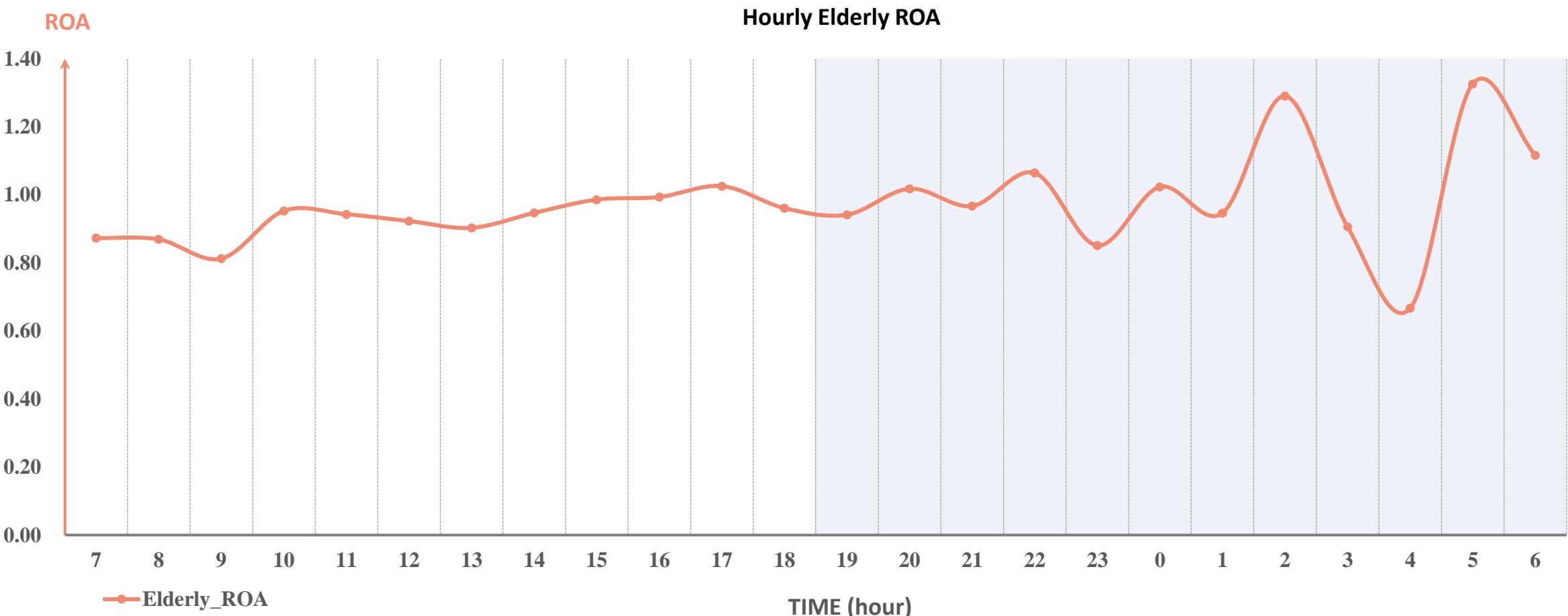
Grass, Plant, Flower
Van, Car, Bus

➤ In the time scale from 2014 to 2022, StreetFurniture always keep high in contribution.

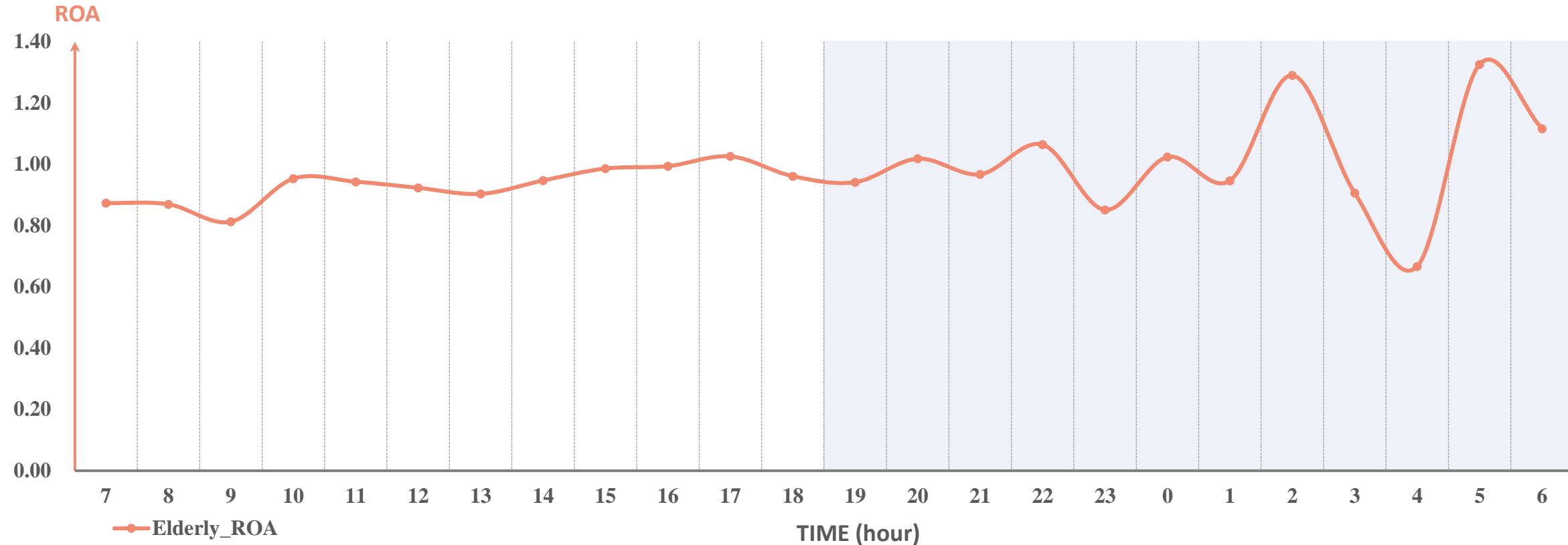


Is there any further relationship between time and traffic accidents in elderly driver ?

$$ROA_{(\geq 65)} = \frac{\text{Number of responsible drivers in accidents in the elderly group}}{\text{Number of Unresponsible drivers in the elderly group}}$$



Is there any further relationship between time and traffic accidents in elderly driver ?

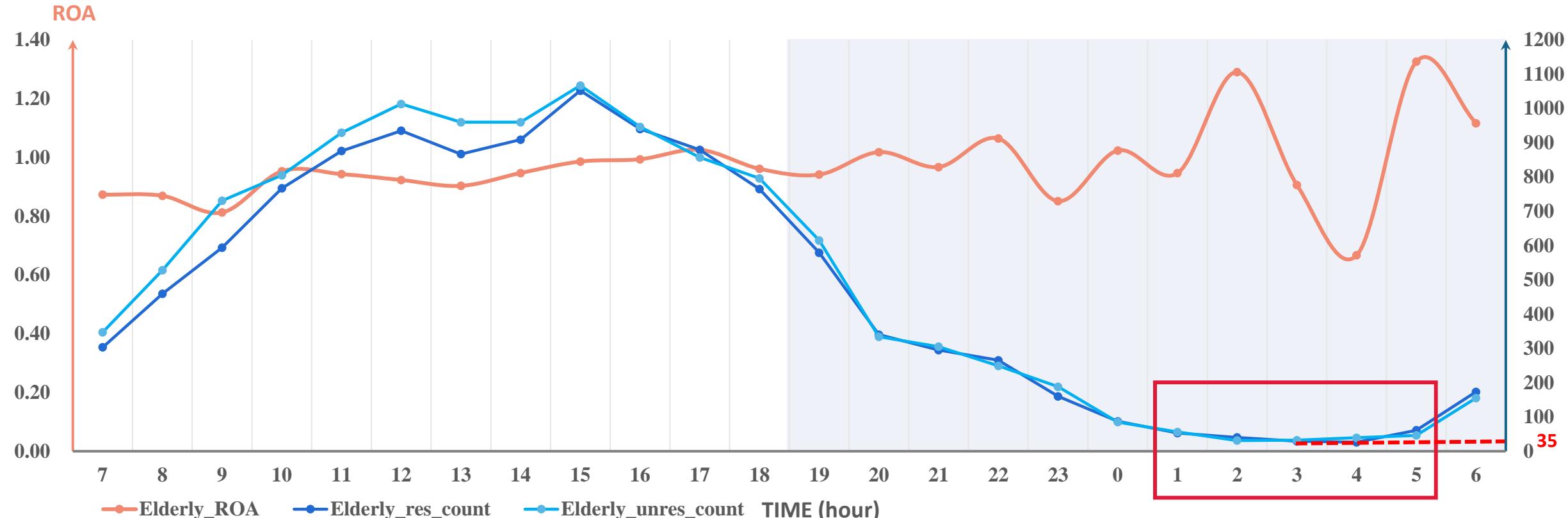


The index of elderly ROA fluctuates **during the night**:

Reaching **peak** around **2 am** and **5 am**, **lowest** at **4 am**.

$$ROA_{(65)} = \frac{\text{Number of responsible drivers in accidents in the elderly group}}{\text{Number of Unresponsible drivers in the elderly group}}$$

Is there any further relationship between time and traffic accidents in elderly driver ?



During the hours of **1am-5am**, the **number of recorded traffic accidents is significantly low**, any **small change** could have a **large impact** on the results.

$$ROA_{(65)} = \frac{\text{Number of responsible drivers in accidents in the elderly group}}{\text{Number of Unresponsible drivers in the elderly group}}$$

05

Conclusion

Question-1:

What is the relationship between driver age and traffic accidents?

Question-2:

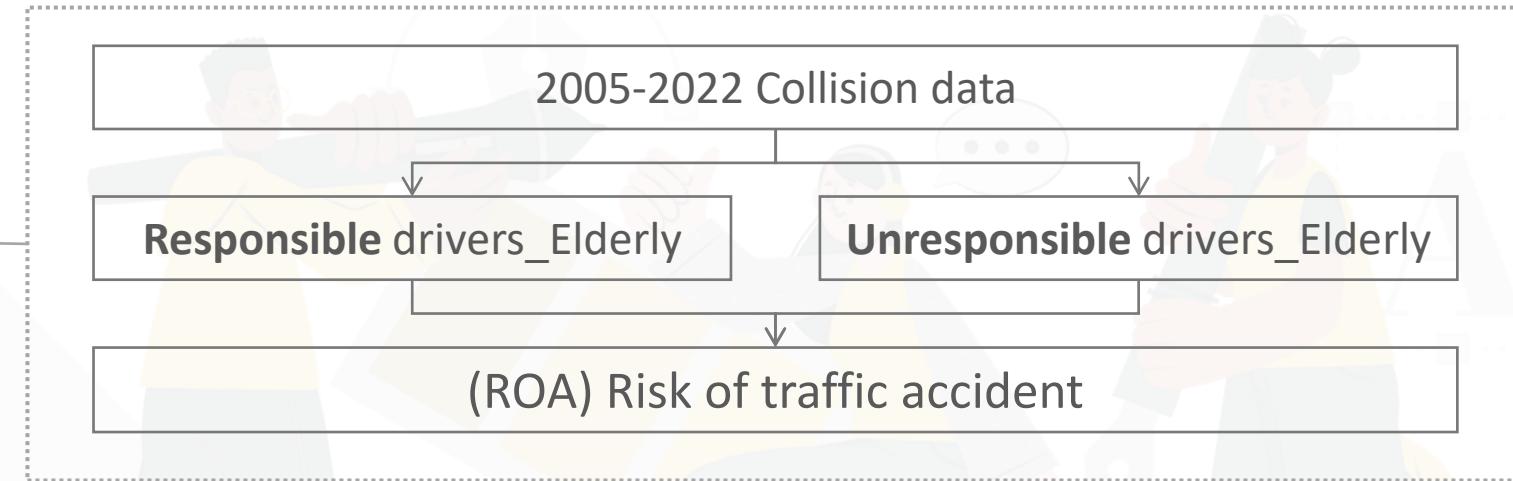
What is the relationship between
built environment and traffic accidents in elderly drivers?

Conclusion

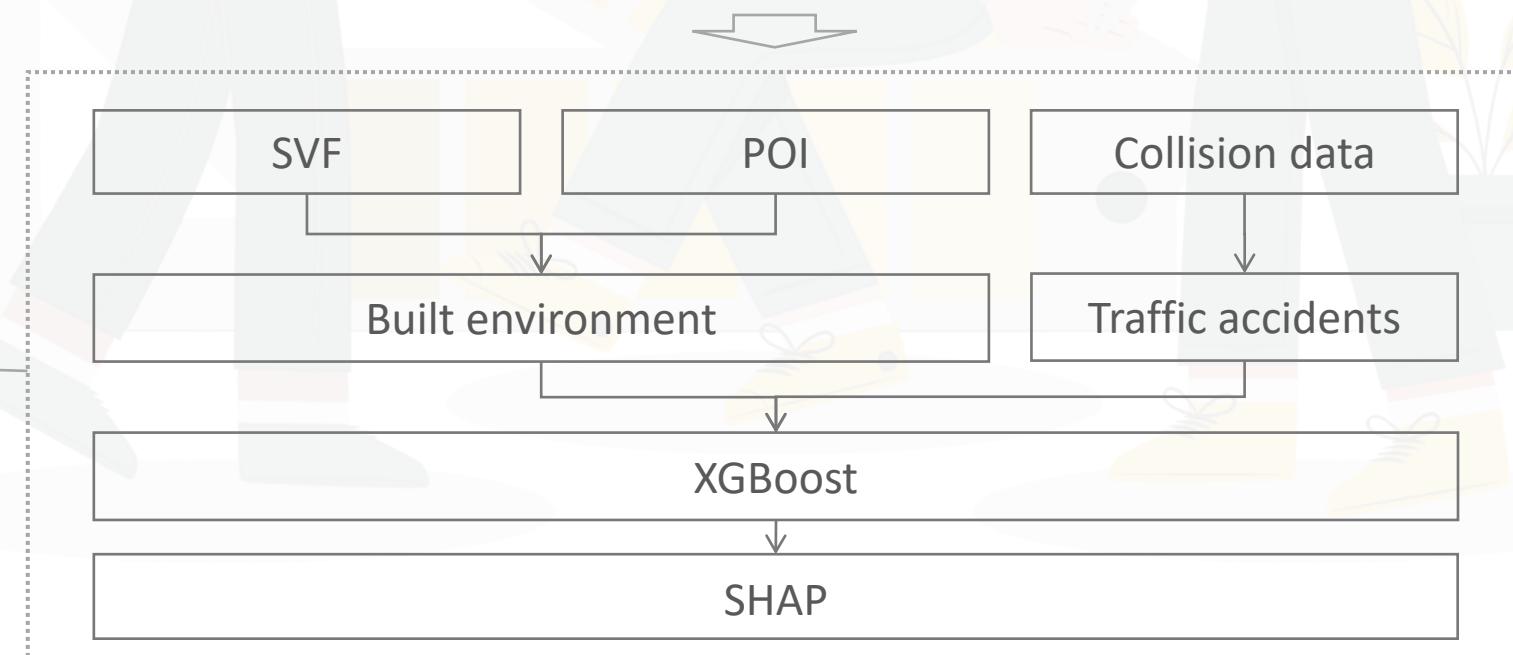
Question

No.1:
What is the relationship between driver age and traffic accidents?

Technological route



No.2:
What is the relationship between built environment and traffic accidents in elderly drivers?



Conclusion

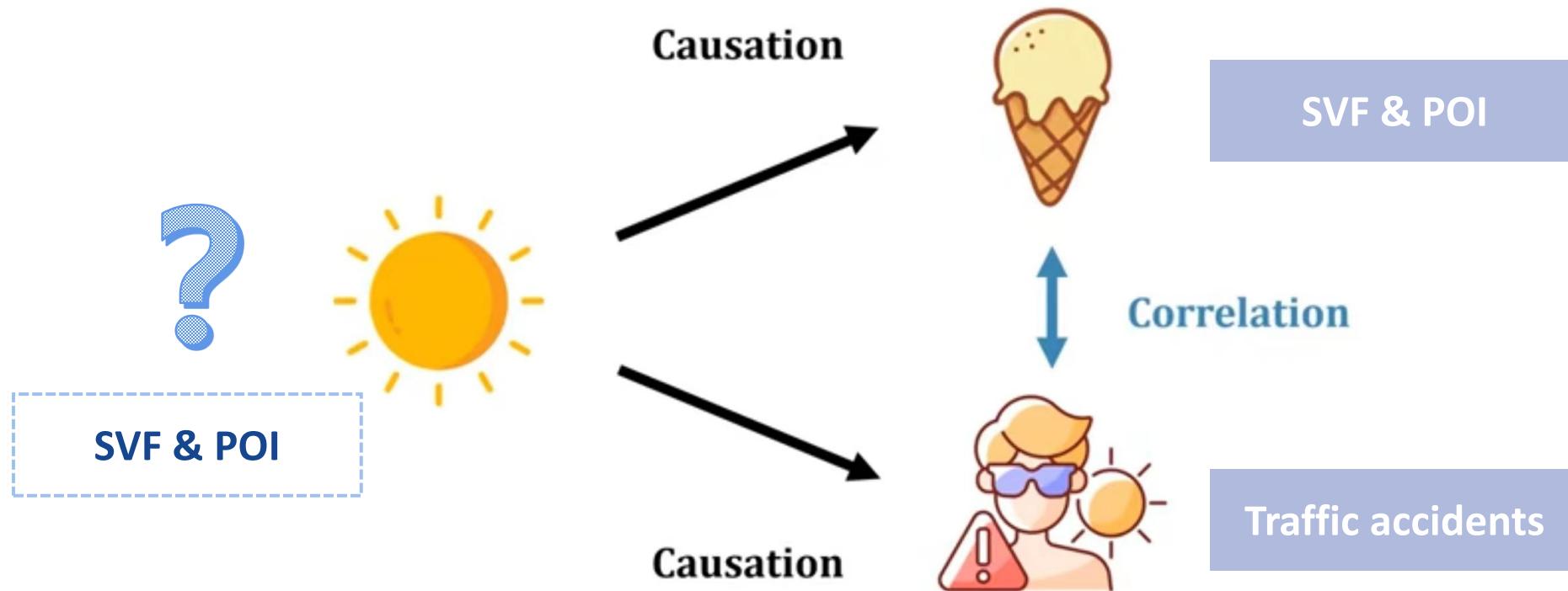
No.1:

- Driver age impacts traffic accidents.
- Elderly drivers have Higher ROA than other age groups.

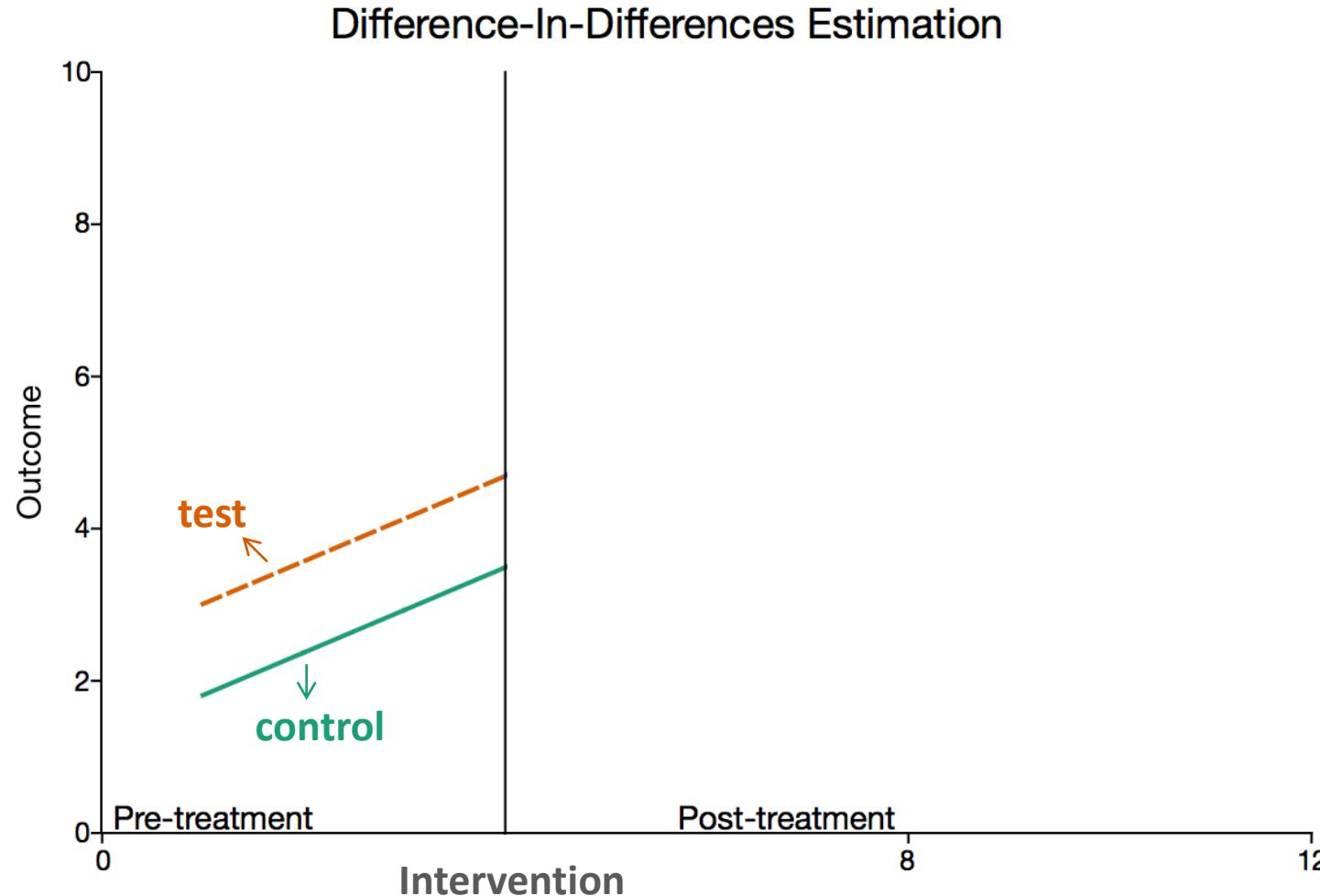
No.2:

- The elderly are much affected by Visual Perception.
- Some factors are correlation with traffic accident.
- And streetfurniture having a relatively high level of contribution.

Correlation ≠ Causation



If we want to find causal relationships, we need to design more precise experimental methods.



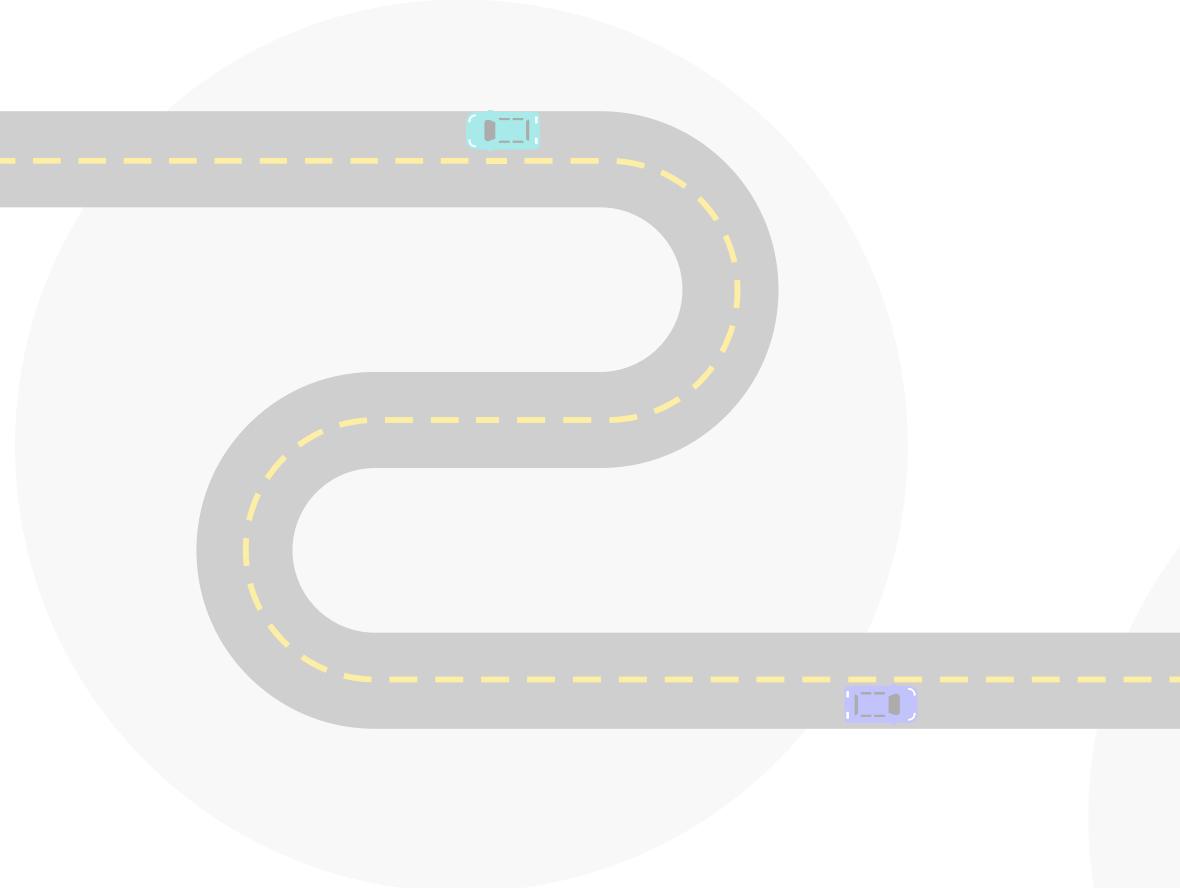
Problem:

1. strong domain knowledge to find proper x;
2. hard to set a control group.



Thank you

(^ ^)



Appendix A: Street view features

Street view features group	Detail
Street Furniture	Streetlight, Bench, Chair, Seat, Awning, Booth, Sign
Greenery Grass	Grass, Plant, Flower
Light V.	Van, Car, Bus
Facade	Wall, House, Building, Skyscraper, Hovel
Nature	Hill, Lake, Waterfal, Mountain, Water, River, Sea, Rock
HeavyV	Heavy Vehicle
Bike	Bike, MotorBike
Person	Person
WindowOpening	Window, Door
Road	Road
Sidewalk	Sidewalk
GreeneryTree	Tree, Palm
Sky	Sky

Appendix B: Data

Data	Source	Date range
Collision data	Transport for London	2005-2022
StreetView image	Google maps	2005-2022
POI	OpenStreetMap	2014-2022