



# Age-It: Ageing Well in an Ageing Society

Una nuova alleanza per progettare soluzioni socioeconomiche, biomediche e tecnologiche per un'Italia inclusiva verso tutte le generazioni

# Measuring housing and health vulnerability among older people in Italy: a multidimensional perspective

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# The «VAI» project

(Vulnerabilità degli Anziani in Italia)

- **Period:** October 2024-October 25
- **Funding:** AGE-IT - Ageing well in an ageing society, Spoke 1 - The demography of ageing
- **Management:** DiSES (Department of Economic and Social Sciences, UNIVPM)
  - DICEA (Department of Civil, Building and Architecture Engineering, UNIVPM);
  - DISCLIMO (Department of Clinical and Molecular Sciences, UNIVPM);
  - + IRES Emilia-Romagna, Institute of Economic and Social Research

People involved: 18 people (UNIVPM Researchers, consultants, administrative staff)

## We studied...

### WHAT:

- Housing vulnerability of older people (VAA)
- Health vulnerability of older people (VAS)

Focus on combinations of critical conditions (threat/coping)

### HOW:

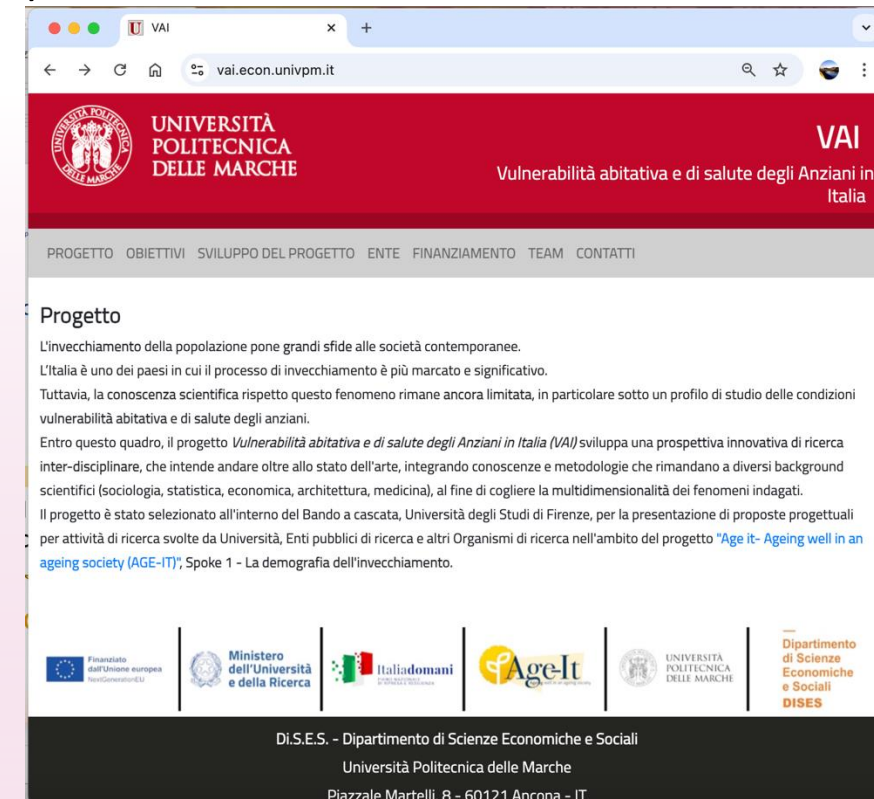
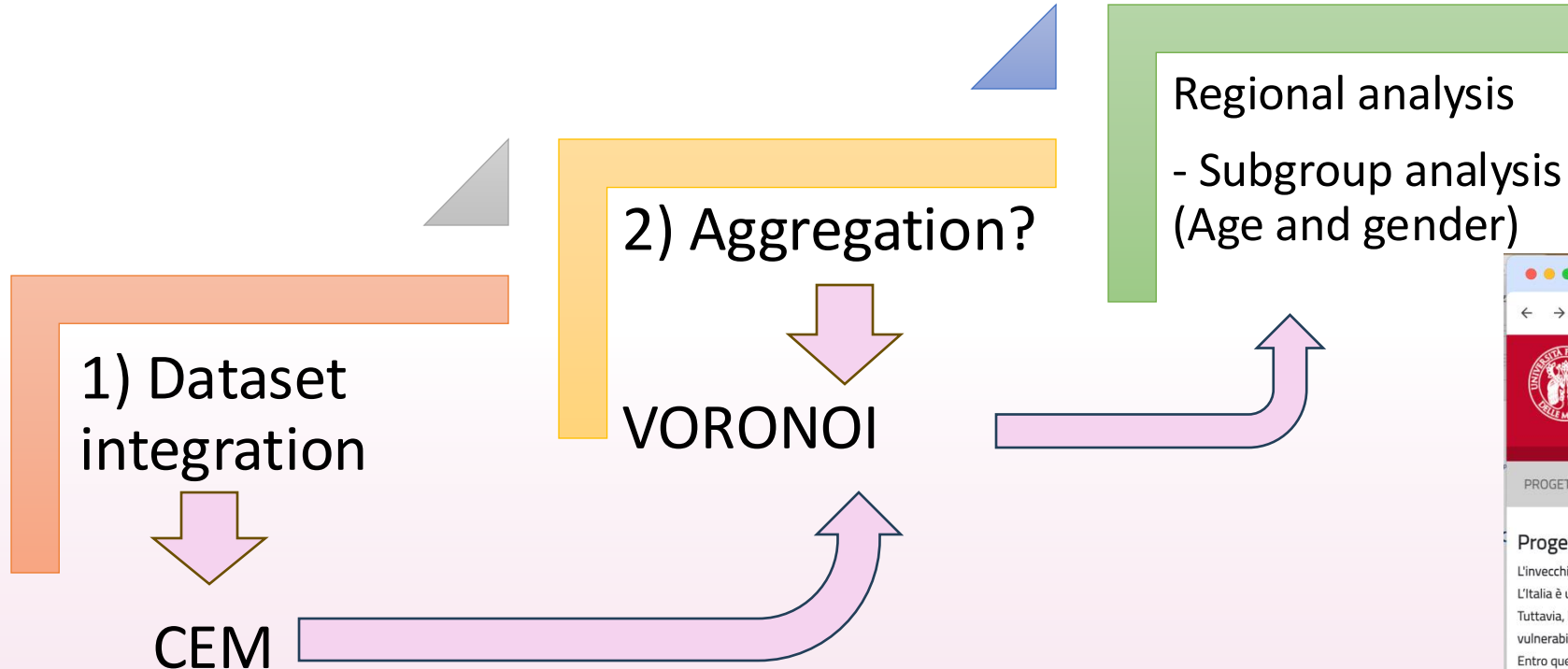
- Alkaire/Foster (AK) method: deprivation/poverty study; size identification (K); definition of the critical threshold (cut-off) for each dimension;
  - $H \rightarrow$  % of people with critical conditions (incidence)
  - $A \rightarrow$  average value of critical conditions (intensity)
  - $MPI \rightarrow H \cdot A$

## Data mapped

	Year	Geographic representation	VAA			VSA			Total
			Threat	Coping	Total	Threat	Coping	Total	
EHIS	2019	Regional	4	2	6	9	2	11	17
AVQ	2019	Regional	4	2	6	4	2	6	12
SHARE	2022	Macro-area	4	2	6	7	4	11	17
EU-SILC	2019	Macro-area	4	1	5	4	1	5	10
Total			16	7	<b>23</b>	24	9	<b>33</b>	<b>56</b>

Total variables mapped according to analytical scheme: 1,360

## Methodological approach adopted



# PART 1.

# CEM METHODOLOGY:

# DATASET INTEGRATION



## Why ? Double problem



### Problem 1: Peculiarities of the datasets

The available datasets capture different aspects.

**Objective :** Maximize the information present in the different datasets so as not to lose information.

### Problem 2: Aggregate Data

In general, official statistical surveys release aggregate data only at the **macro-regional** (North, Center, South) or national level. This aggregation **does not reflect territorial specificities** and risks homogenizing very different risk and vulnerability profiles, limiting the effectiveness of local policies.

**Objective :** Obtain **disaggregated knowledge** to improve territorial planning and enable an accurate assessment of regional risk profiles.



## How?



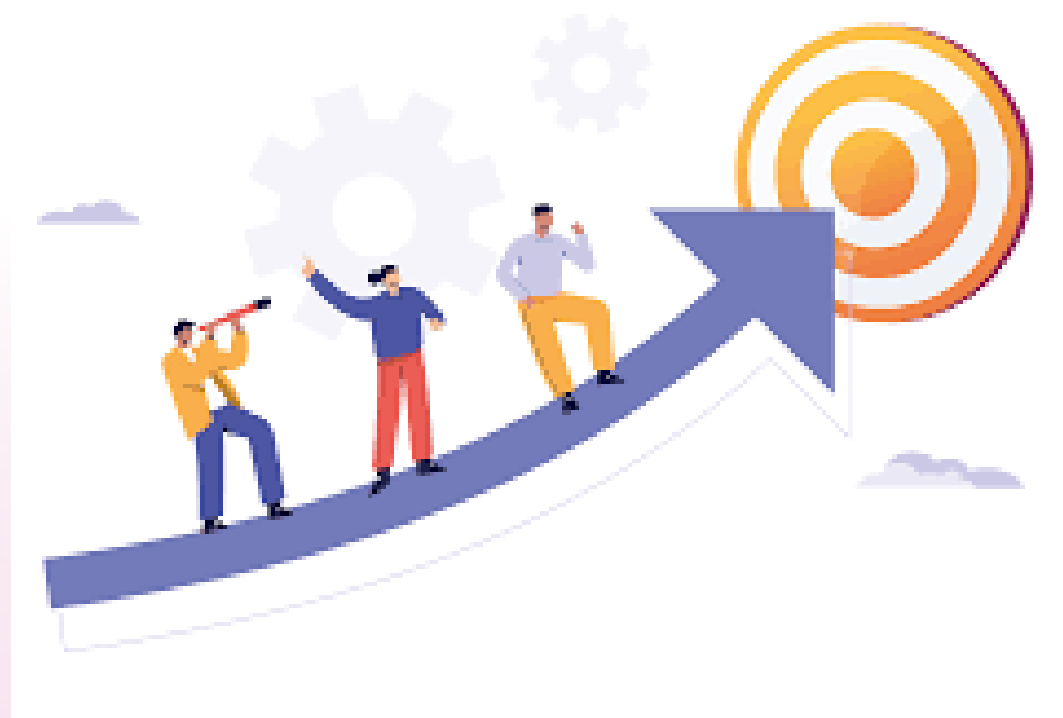
### Methodological Approach: Inferential and imputation statistics.

Statistical imputation generates **plausible regional estimates** from macroeconomic data.

### Specific Technique:

**Coarsened Exact Matching (CEM)**, a robust technique based on direct distribution balancing, is adapted for dataset integration, serving as a *record linkage* based on feature similarity in the absence of an explicit common key.

## Advantages



### **Transfer variable:**

The method allows you to merge datasets that do not have a common key .

### **Reduction of distortions in data sets**

The CEM reduces distortions balancing covariate distributions between data sets heterogeneous .

### **Estimates regional improved**

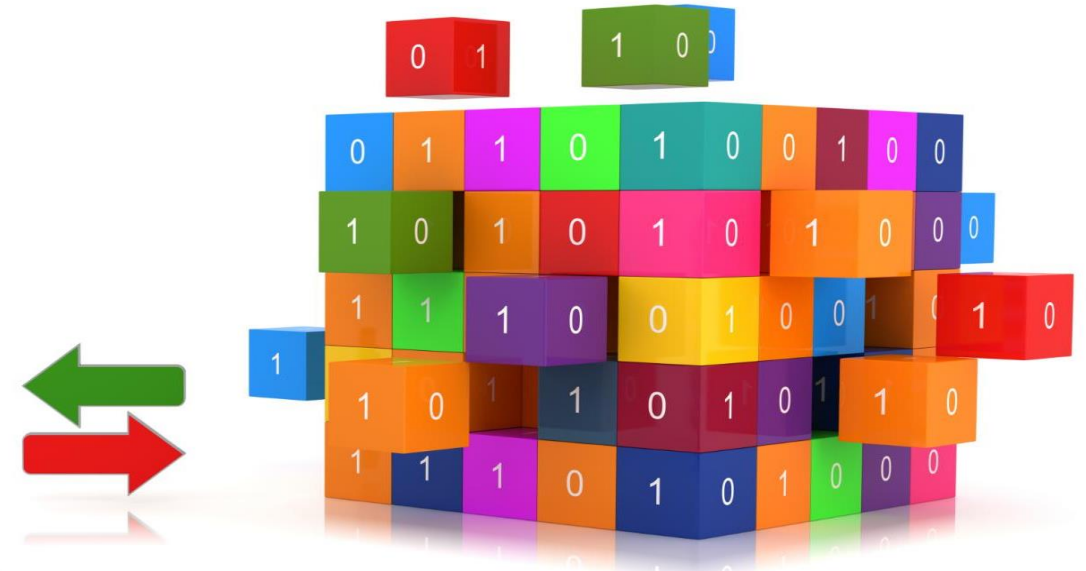
The CEM allows analysis at regional level.

Reliable regional estimates help identify vulnerable areas in housing and health, enabling targeted interventions

- This approach values differences and allows for better allocation of public resources and design of effective interventions

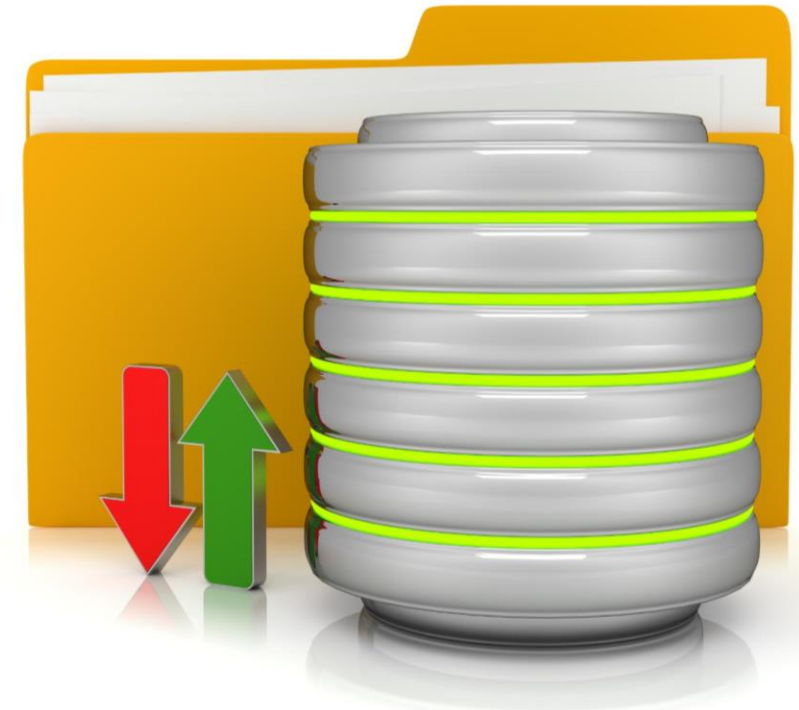
## The Coarsened Exact Matching Process (CEM): How does it work ?

- **Coarsening** Phase : Continuous variables are divided into discrete classes to facilitate the exact one correspondence in the CEM process.
- **Initial Matches:** Matches (bin matching) are created between profiles in the datasets using **Coarsened Exact Matching (CEM)**.
- **Exact** Matching Process (**within** of the bins):  
The **exact correspondence** comes performed within each container for coupling carefully the units belonging to the two dataset.



## The Coarsened Exact Matching Process (CEM): How does it work ?

- **Problem with Standard Imputation:** The standard CEM procedure involves randomly assigning the variable to be transferred into the receiving "bin", but this **does not guarantee** that the transferred variable would have a behavior (a distribution) similar to the original one.
  - **Adopted Solution:** To ensure a distribution as similar as possible between the "receiving bin" and the "donor bin", the donation of the dichotomous variables was carried out **maintaining the same proportion** of cases.
- **Relative Loss Calculation and Loss Minimization:** The loss relative is the percentage of unmatched units and must to be maintained low to ensure quality of integration :
  - To minimize unmatched units, an iterative procedure was performed



Initial dataset	Integrated dataset	Transferred variables	Variables for “bins” (the number of classes is in brackets)	Starting numbers	% match
EHIS	AVQ	<ul style="list-style-type: none"> <li>Housing context (a4_contesto_abitaz)</li> <li>Mental Health Index-5 (MHI-5) (s4_mhi5)</li> </ul>	<ul style="list-style-type: none"> <li>Gender (2)</li> <li>Educational Qualification (5),</li> <li>Macroarea (4),</li> <li>Region (20),</li> <li>Working Condition (6),</li> <li>Age (2).</li> </ul>	13720  With weights: 13575593	97.91%
EHIS+AVQ	SHARE	<ul style="list-style-type: none"> <li>social_connectedness (sn_scale_dic)</li> </ul>	<ul style="list-style-type: none"> <li>Gender (2),</li> <li>Educational Qualification (5),</li> <li>Macroarea (4),</li> <li>Working conditions (6),</li> <li>Age (2),</li> <li>Income (5).</li> </ul>	13433  With weights 13298337	94.63%
EHIS+AVQ+ SHARE	EUSILC	<ul style="list-style-type: none"> <li>Difficulty in sustaining housing costs (a3_cost_prob_EUSILC),</li> <li>Condition of under-occupancy of the dwelling (a4_under_occ2_EUSILC),</li> <li>Waiver of specialist medical care (s3_no_med_treat2_EUSIL),</li> <li>Degree of urbanization (UrbDeg).</li> </ul>	<ul style="list-style-type: none"> <li>Gender (2),</li> <li>Educational Qualification (5),</li> <li>Macroarea (4),</li> <li>Working conditions (4),</li> <li>Age (2),</li> <li>Income (5).</li> </ul>	12712 With weights 12439808	99.46%
EHIS+AVQ+SH ARE+EXPENSES	EXPENSES	<ul style="list-style-type: none"> <li>No air conditioning (Vabi_cond)</li> <li>Absolute Poverty (povassc)</li> <li>Relative Poverty (poor)</li> </ul>	<ul style="list-style-type: none"> <li>Gender (2),</li> <li>Educational Qualification (3),</li> <li>Region (20),</li> <li>Working conditions (4),</li> <li>Age (2),</li> <li>Income (5).</li> </ul>	12,644 with weights 12361236	95.63%

**Starting number: 13722 corresponding to 13576875**

**Number of integrated DB: 12092 corresponding to 11934162**

**Data loss rate: 11.88%**

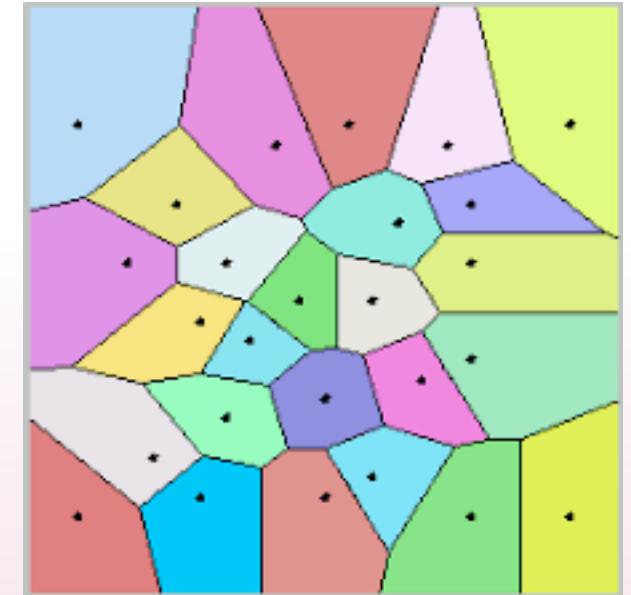
# PART 2.

# THE VORONI METHOD



## Voronoi Method : Introduction

- **Post-Integration Objective: Develop an in-depth analysis of the housing and health vulnerability** conditions of older people using the integrated dataset, going beyond the results emerging from a simple aggregate analysis.
- **Limitation of Traditional Classification Methods:** Classical methods (such as weighted averages or lexicographical orderings) are often **insufficient** to classify entities based on **multiple criteria** and do not solve the problem when **there is no clear dominance** (i.e., when rankings based on different criteria do not coincide).
  - **Innovative Method Proposed:** Mariani et al., 2024 .



# Voronoi Method : Introduction

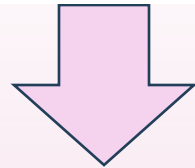
Social Indicators Research (2024) 175:989–1005  
<https://doi.org/10.1007/s11205-023-03192-9>

ORIGINAL RESEARCH



## Two in One: A New Tool to Combine Two Rankings Based on the Voronoi Diagram

Francesca Mariani<sup>1</sup> · Mariateresa Ciommi<sup>1</sup> · Maria Cristina Recchioni<sup>1</sup>



- **How the Method Works:** This approach uses an iterative scheme that exploits the Voronoi diagram in a two-dimensional space at each step it orders the points based on their distances (Pareto Dominance + Euclid).
- **Advantage:** The Voronoi dominance and partition approach is more sophisticated but intuitive.
  - It not only determines the absolute "best" elements, but **also ranks the "non-dominant" elements** based on their proximity to the leaders.

## Voronoi Method : some technical details

Voronoi method is used to order or classify entities (regions, individuals, firms, etc.) when you have two indicators and you do not want to construct a composite indicator. Each unit is represented as a point in the two-dimensional plane  $[0,1]^2$ , with normalized coordinates between 0 and 1.

The procedure is based on an iterative algorithm that combines:

- Pareto dominance, which establishes when one point is better than another (A dominates B if it is equal or better in both dimensions and better in at least one);
- Voronoi partitions, which divide space into cells based on the Euclidean distance from reference points (“pivots”).

### Main steps

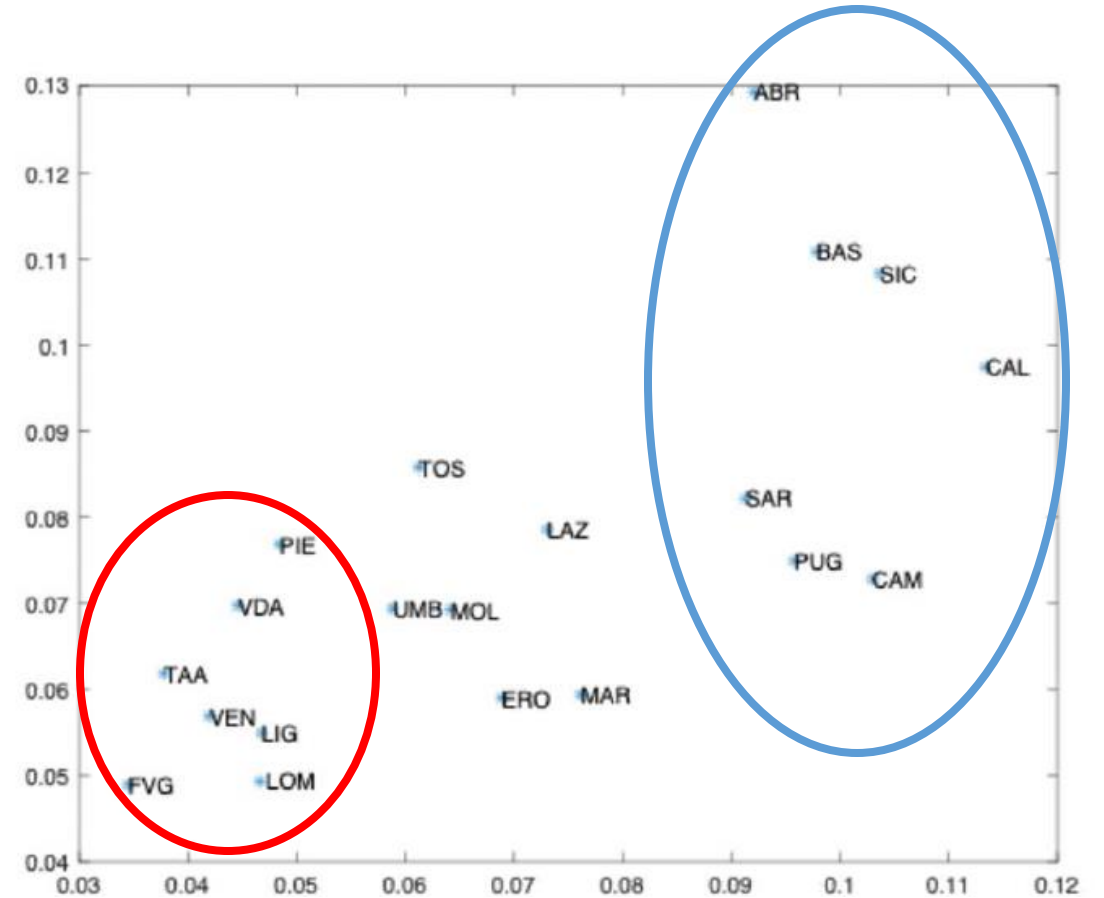
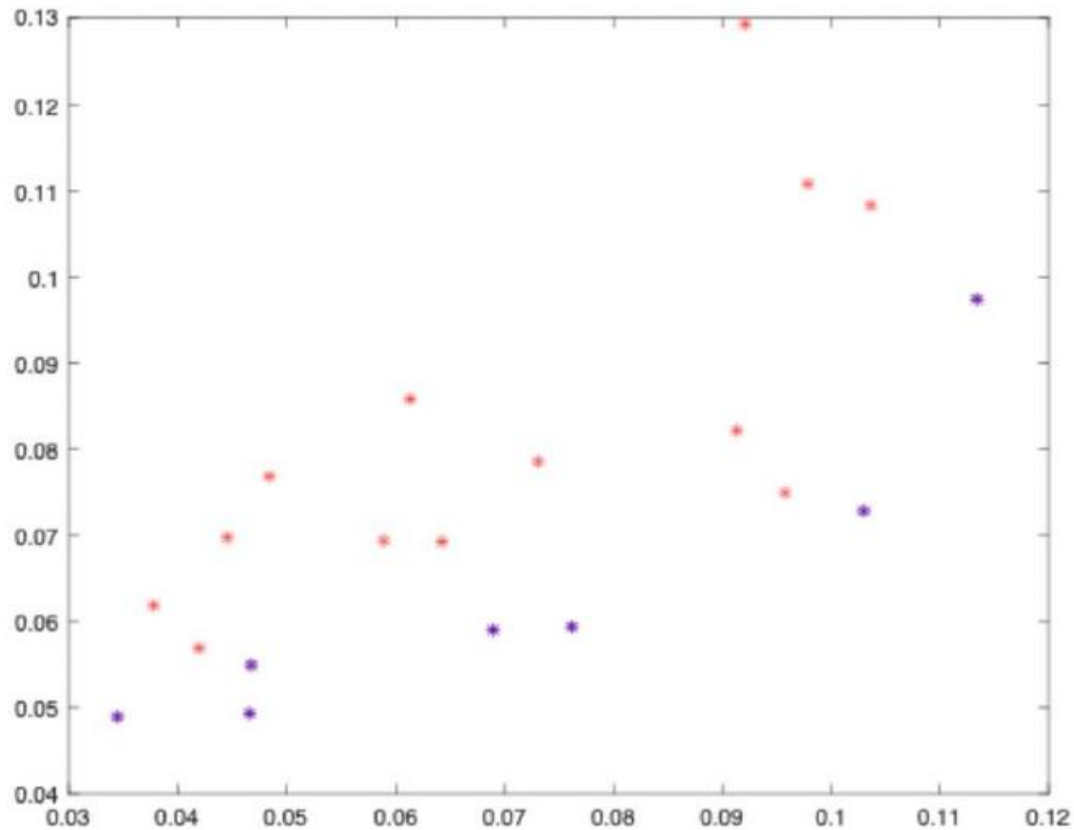
1. Selection of the initial set ( $O_0$ ): the “dominant” points (not surpassed by others in both dimensions) are identified through two sortings:
  - *row-wise* (based on the first coordinate, filtering out non-increasing values of the second);
  - *column-wise* (based on the second coordinate, filtering out non-increasing values of the first).The largest group is chosen: this represents the initial Pareto frontier.
2. Voronoi Iterations :
  - Voronoi partition on the space  $[0,1]^2$  is constructed using the pivots of the current set;
  - points not yet sorted are assigned to the closest cell;
  - in each cell the point closest to the pivot is selected;
  - the point is inserted into the ranking according to dominance or distance relationships;
  - the pivot set is updated.

The algorithm stops when there are no more changes, producing a complete ranking.

# SOME RESULTS: POLICY IMPLICATIONS

## Voronoi Method : Results

- X-axis → VSA (health vulnerability) -  $k = 7$  of 14 variables.
- Y-axis → VAA (housing vulnerability) -  $k = 5$  of 11 variables.



Pareto-ordered “blue” points.

## Classification

Regione	Codice	Ranking_VAA	Ranking_VSA	Ranking_Voroni
13	ABR	20	15	18
17	BAS	19	17	19
18	CAL	17	20	20
15	CAM	11	18	16
8	ERO	5	11	7
6	FVG	1	1	1
12	LAZ	14	12	12
7	LIG	3	6	6
3	LOM	2	5	2
11	MAR	6	13	13
14	MOL	8	10	10
1	PIE	13	7	9
16	PUG	12	16	14
20	SAR	15	14	15
19	SIC	18	19	17
4	TAA	7	2	4
9	TOS	16	9	11
10	UMB	9	8	8
2	VDA	10	4	5
5	VEN	4	3	3

Considering the ranking produced by Voroni, the elements of strong differentiation are confirmed, from the Southern regions to those of the North (passing through those of the Centre), with a more significant presence of *combinations of critical conditions*, at the housing and health level, in the **South of the country**.

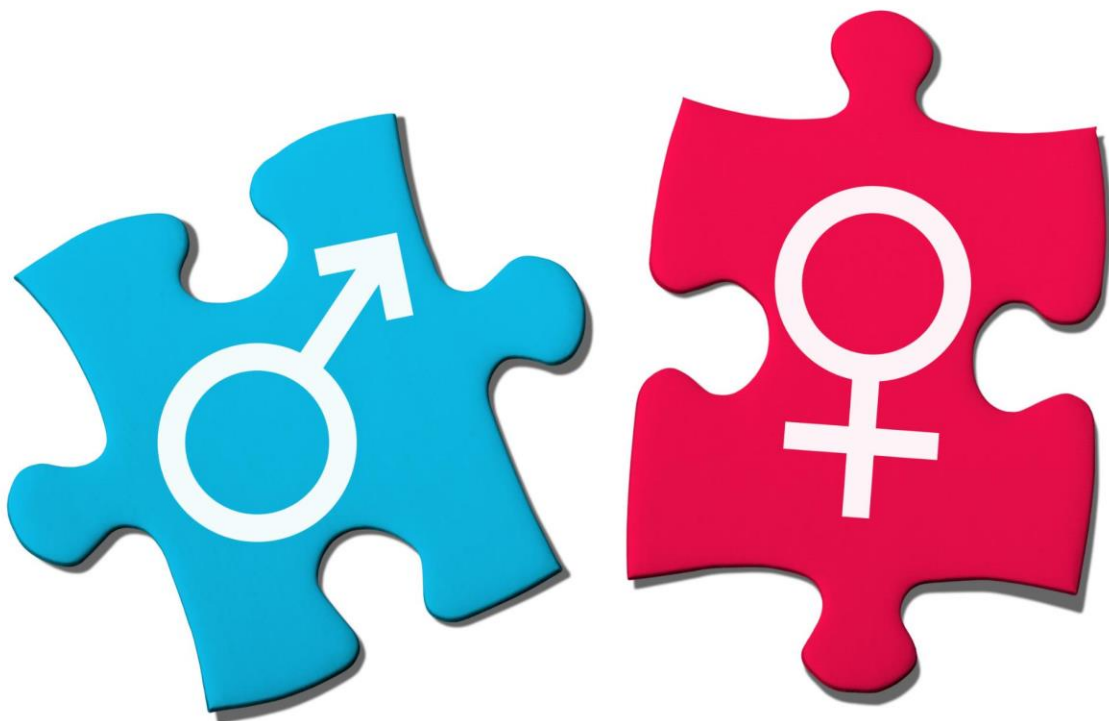
However, further aspects also emerge, which concern not only the differences in the system, considering the VAA and VSA values separately (see Emilia-Romagna, Marche, Piedmont, Tuscany) but also – through the consideration of the Voroni ranking – elements of internal differentiation within the macro-areas (see the cases of Molise and Umbria).

1 = less vulnerable

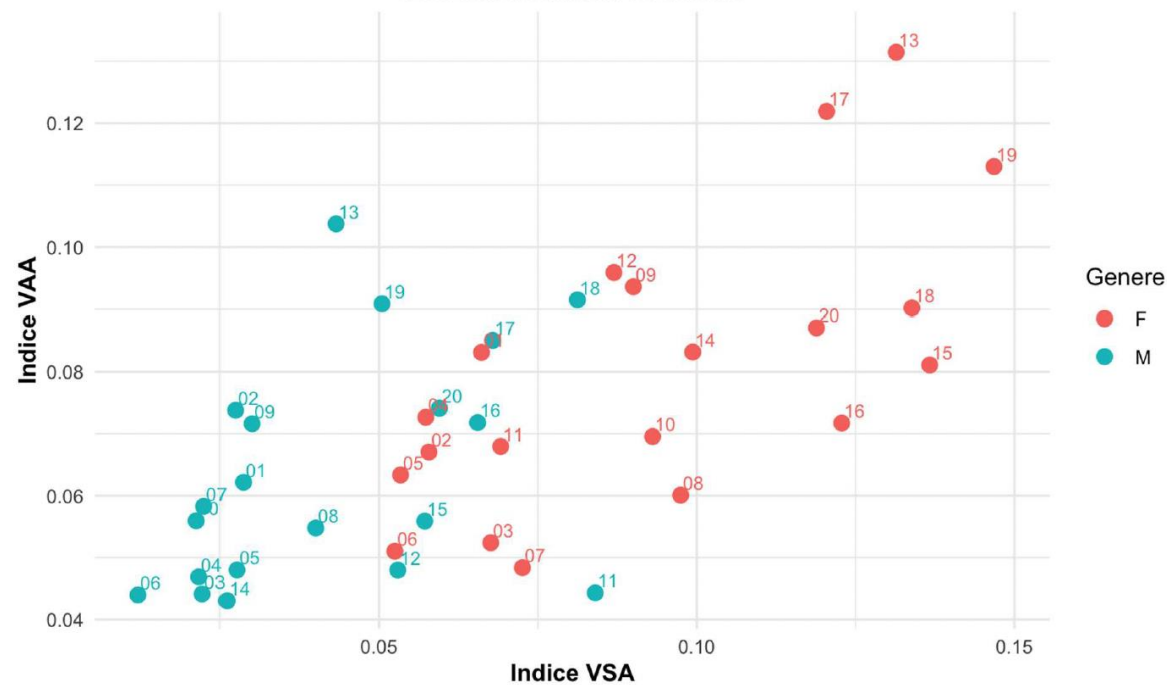
Nota: da 1 a 5; da 6 a 10; da 11 a 15; da 16 a 20



## Insight 1: Gender Differences



Relazione tra Indici VSA e VAA per Regione  
Confronto tra Maschi e Femmine



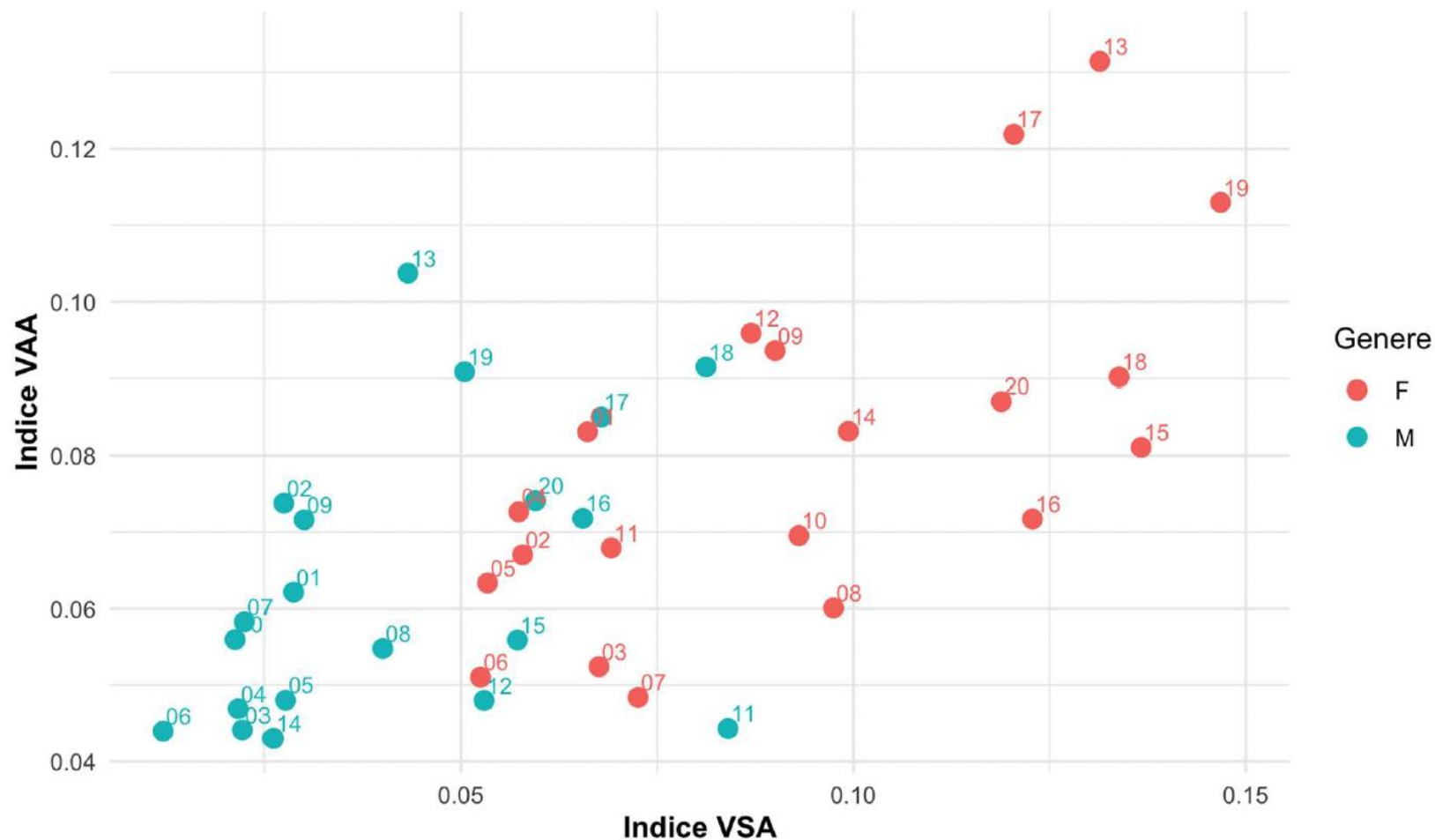
## Insight 1: Gender Differences

**Greater vulnerability for women.**

They show levels of vulnerability more high, in particular in the regions southern and in the islands, with values high VAA and VSA.

### Relazione tra Indici VSA e VAA per Regione

Confronto tra Maschi e Femmine



## Insight 1: Gender Differences

Tabella 6: Ordinamento secondo Voronoi, dal meno vulnerabile al più vulnerabile, per genere Femminile

Posizione	1	2	3	4	5	6	7	8	9	10
Regione	FVG	LIG	LOM	VEN	VDA	MAR	TAA	PIE	TOS	UMB
Posizione	11	12	13	14	15	16	17	18	19	20
Regione	ERO	MOL	LAZ	SAR	PUG	CAL	CAM	SIC	BAS	ABR

### Correlation Between housing and health

Exists a correlation stronger between housing and vulnerability health among women compared to men .

Tabella 7: Ordinamento secondo Voronoi, dal meno vulnerabile al più vulnerabile, per genere maschile

Posizione	1	2	3	4	5	6	7	8	9	10
Regione	FVG	LOM	MOL	TAA	VEN	UMB	LIG	ERO	LAZ	MAR
Posizione	11	12	13	14	15	16	17	18	19	20
Regione	CAM	PIE	TOS	VDA	SIC	PUG	SAR	BAS	CAL	ABR

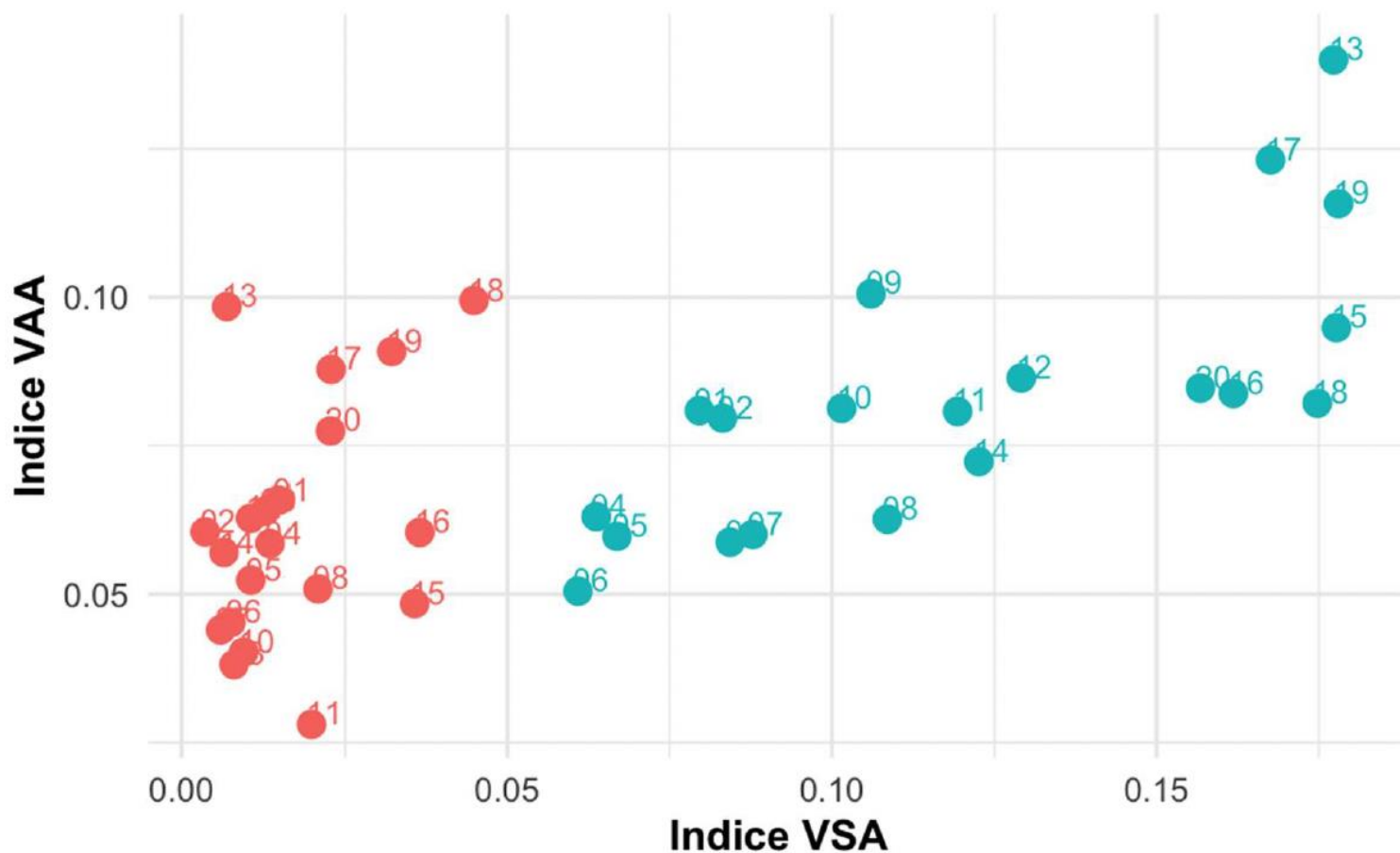
### Regional differences for gender

Regions such as Molise and Valle d' Aosta show significant gender disparities in the vulnerability rankings .

Figura 22: Scatter plot le regioni Italiane per entrambe le fasce di età.

## Relazione tra Indici VSA e VAA per Regione

Confronto tra Classe di età



## Insight 2: Age Differences



Età

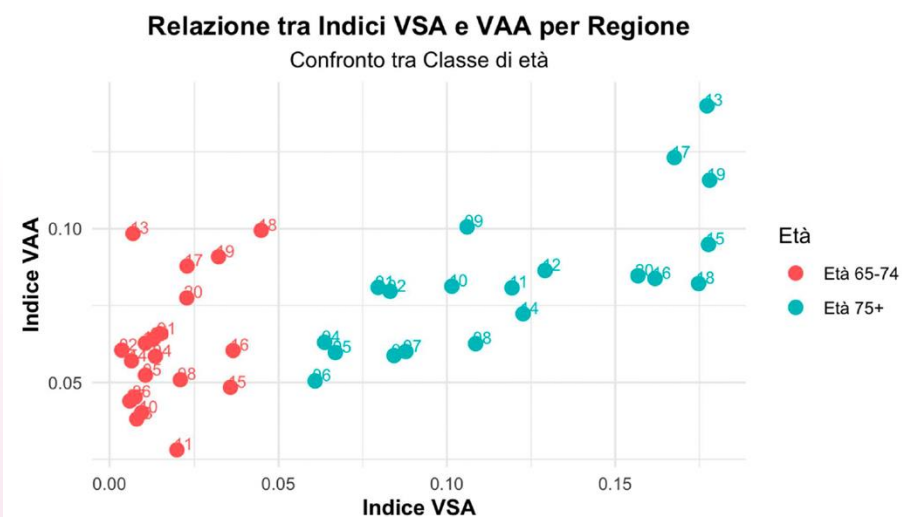
- Età 65-74
- Età 75+

## Age groups comparisons

The study compares health and vulnerability housing Between 65 to 74 years old and 75+ , highlighting the increase of the risks with age .

## Insight 2: Age Differences

Figura 22: Scatter plot le regioni Italiane per entrambe le fasce di età.





## Insight 2: Age Differences

Tabella 31: Ordinamento secondo Voronoi, dal meno vulnerabile al più vulnerabile, individui tra i 65 e i 74 anni.

Posizione	1	2	3	4	5	6	7	8	9	10
Regione	MAR	LOM	LIG	FVG	UMB	CAM	VEN	VDA	MOL	ERO
Posizione	11	12	13	14	15	16	17	18	19	20
Regione	PUG	LAZ	TAA	TOS	PIE	SAR	ABR	BAS	SIC	CAL

Tabella 42: Ordinamento secondo Voronoi, dal meno vulnerabile al più vulnerabile, individui over 75.

Posizione	1	2	3	4	5	6	7	8	9	10
Regione	FVG	TAA	VEN	LOM	VDA	PIE	LIG	ERO	UMB	TOS
Posizione	11	12	13	14	15	16	17	18	19	20
Regione	MAR	MOL	LAZ	CAL	SAR	PUG	CAM	BAS	ABR	SIC

Interesting differences:

- E.g. Marche and Campania: very significant gap to the detriment of the older age group, compared to the “younger” one (in Marche it goes from rank 1 to rank 11; in Campania from rank 6 to rank 17);
- E.g. Piedmont and Trentino: the ranking is more favorable in the older age groups (in Piedmont it goes from rank 15 to rank 6; in Trentino from rank 13 to rank 2).



## Conclusions



**Effectiveness of CEM** CEM effectively complements investigations heterogeneous (in the absence of a key )

**Classification regional** The Voronoi method allowed a classification consistent and interpretable of the regions based on vulnerability .

**Implications policies** Gender and age differences highlight the need for policies differentiated to address vulnerabilities regional .

# THANK YOU FOR YOUR ATTENTION

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We acknowledge funding from **Next Generation EU** , in the context of the **National Recovery and Resilience Plan, Investment PE8 – Project Age-It: “Ageing Well in an Aging Society” [DM 1557 11.10.2022]** .

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This resource was co-financed by the Next Generation EU.