AGEING AND POLLUTION IN THE "TERRA DEI FUOCHI"

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Abstract. The term "Terra dei Fuochi" refers to that territory, between the provinces of Naples and the southwest of the Province of Caserta, characterized by a history of illegal disposal of toxic substances, waste often associated with their combustion with devastating consequences for the environment, ecosystem and human health of the population living there. This case of environmental devastation is known worldwide: the scientific journal Lancet Oncology (Mazza *et al.,* 2004) coined the term 'triangle of death', in a study on cancer mortality. Currently in Campania are 90 municipalities included in this area, of which 56 are in the Province of Naples and 34 in the Province of Caserta, with a population of 2,318,407 and 618,737 inhabitants respectively (ISTAT, 2022). A study by the Istituto Superiore di Sanità (ISS, 2020) identified 2,767 illegal landfills in 38 of the 90 municipalities; more than one citizen in three, 37 %, lives 100 meters from one of these sites. This article aims to investigate the relationship between pollution, aging, and mortality through cross-referencing data from different sources, such as ISS, ISPRA, ARPAC, Campania Region, and ISTAT demo-social surveys.

1. Introduction

Demographic aging is now endemic in advanced societies; we know that life expectancy is already very different around the world and is much higher in rich than poor nations (Christensen *et al.*, 2009).

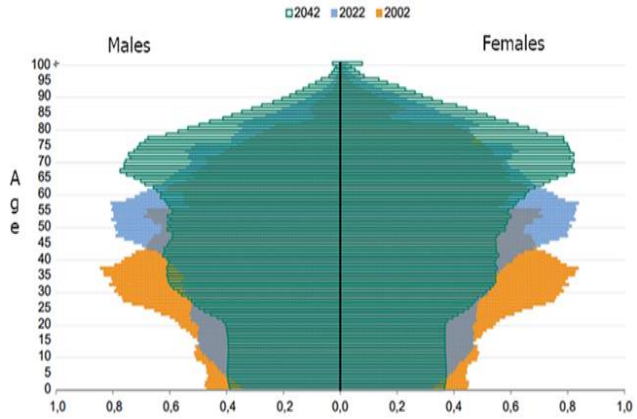
In recent years there has been an increase in average life expectancy and the main factors that can explain the gains in terms of longevity are socio-economic, physical, behavioral factors, and biomedical progress (Bartoli, 2023).

This work aims to check whether there is a relationship between pollution, aging, and mortality with a territorial focus from the national to the local level. A demographic analysis combined with an analysis of environmental data will be carried out on a small group of municipalities belonging to the "Terra dei Fuochi"

2. Ageing trends in Italy and in Campania

By comparing the distribution of the Italian resident population by gender and age group, as of 1 January 2002, 1 January 2022, and 1 January 2042[1], the change in population structure over the years can be observed, as a result of the evolution of birth, death, and migration phenomena. These demographic trends are progressively transforming the traditional population age pyramid (Figure 1).

Figure 1 – *Age pyramids in Italy at the 1st January 2002, 2022, and 2042 % values*



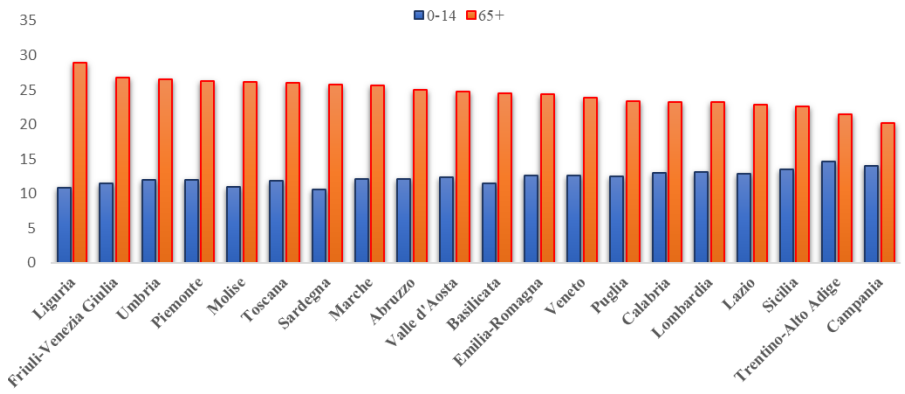
Source: ISTAT, Population by gender, age and marital status and Population and household forecasts, (b. 1.1.2021)

In developed countries, the classic pyramid shape has now disappeared due to the gradual decrease in births and hence the narrowing of the initial age classes and the shift of death to progressively older ages, with a simultaneous upward shift in the triangular shape. In the coming decades, there will be a further increase in the weight of Italy's elderly population due both to the increase in life expectancy and to the 'upward shift' (i.e. ageing) of the baby-boom cohorts, which are now in the middle age groups (ISTAT, 2022).

As far as the gender composition is taken into account, it is evident that, in the older ages, it is strongly unbalanced towards women, who enjoy a higher survival rate. Analyzing the age groups 0-14 and over 65 of the resident population on 1 January 2022 by region, it emerges that Campania is the second region after Trentino Alto Adige to have a high percentage of population in the youth group (0-14) and is also the region with the lowest percentage of population over 65. Therefore, the Campania is a young region, or better, the youngest in Italy.

[1] Data for 2042 are estimated.

Figure 2 – *Resident population 0-14 years and 65 years and over by region (% 2022)*



Source: elaboration on data from demo.istat.it database

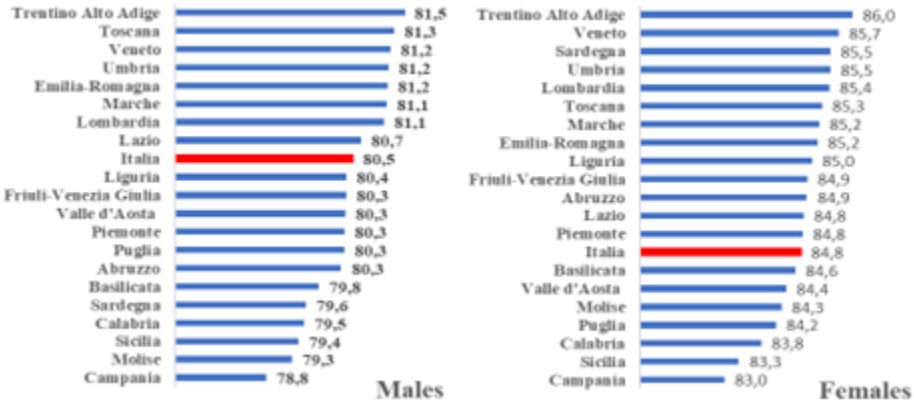
In 2022, Italy's life expectancy at birth is estimated at 80.5 years for men and 84.8 years for women; (Figure 3).

There is a significant increase for men of about 2.5 months compared to 2021.

For women, on the other hand, the value of life expectancy at birth remains unchanged from the previous year.

Campania region has life expectancy values of 78.8 years for men and 83.1 for women, making it the region where life expectancy is lowest (ISTAT, 2023).

Figure 3 – *Life expectancy at birth by gender and region (year 2022)*



Source: ISTAT, Resident Population Mortality Tables (2021) and Demographic Indicator Nowcasting System (2022)

3. The “Terra dei Fuochi”

The “Terra dei Fuochi” is the territory between Naples and Caserta, characterized by a history of illegal disposal of toxic waste (Fariello, 2019) associated with its burning, with devastating consequences for the environment, the ecosystem and the health of the population living there. This territory is a quadrilateral that covers approximately 800 square kilometers (Ministero dell’Interno, 2018); an area strongly compromised due to the high and massive presence of pollutants (Altavista *et al.*, 2004), so much so that it is considered a case of environmental devastation, now known worldwide.

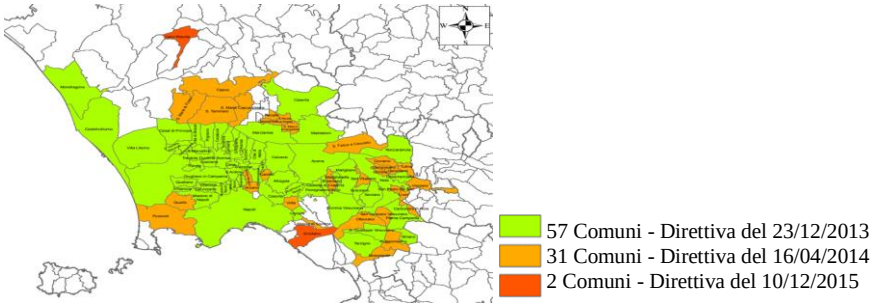
Since this is a set of illegal practices carried out in such a vast territory, we cannot identify a precise date to indicate the beginning of this phenomenon: we know that the expression "Terra dei Fuochi" was used for the first time in 2003 in the Ecomafie report (Legambiente, 2003). Then, in September 2004, the scientific journal Lancet Oncology, in a study on cancer mortality, coined the term 'triangle of death' to indicate an area between the municipalities of Acerra, Nola, and Marigliano, sadly known for the sharp increase in cancer mortality of the local population, mainly due to the illegal disposal of toxic waste (Mazza *et al.*, 2004).

Afterward, in 2007, the World Health Organisation (WHO) highlighted that a specific effect on the population was observed for dioxins due to exposure to the burning of illegal waste. Later on, in 2011, a report released by the Regional Agency for the Environmental Protection of Campania (ARPAC) showed that an area of 3 million square meters was seriously compromised due to the high and massive presence of toxic waste.

In 2016, the Campania Region launched a project in collaboration with the Zooprophylactic Institute to carry out environmental and demographic analyses on exposure to pollutants. Thereafter, in 2019, another international scientific journal 'The Journal of Cellular Physiology' published the data from the pilot study that demonstrated the high concentration of metals in the blood of patients from municipalities particularly affected by landfills and illegal spills. Finally, in 2020, the ISS published a report in which it was revealed that some serious cancer diseases are linked to the illegal disposal of waste (ISS, 2020).

Currently, in the Campania region, there are 90 municipalities included in this area (Figure 4), of which 56 are in the province of Naples and 34 in the province of Caserta, with a population of 2,926,181 inhabitants, resident population at first of January 2020.

Figure 4 – *Map of "Terra dei Fuochi" (Land of fires)*

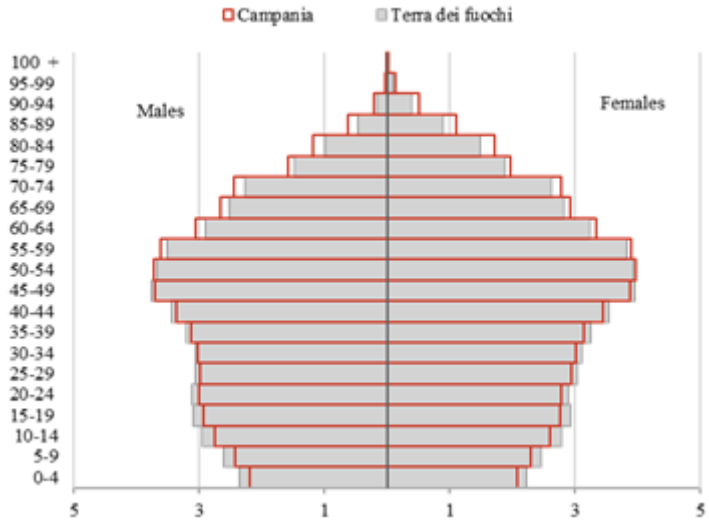


Source: Processing on Arpac data 2016

Comparing the age pyramid of the population residing in Campania with that of the population that lived in the "Terra dei Fuochi" in 2020, it can be seen that the population in the younger age groups is greater in the "Terra dei Fuochi" than in the region as a whole; from the age of 50 onwards it is the opposite.

As far as the gender composition is taken into account, it is evident that, in the older ages, it is strongly unbalanced towards women, both in Campania and in "Terra dei Fuochi", who enjoy a higher survival rate (Figure 5).

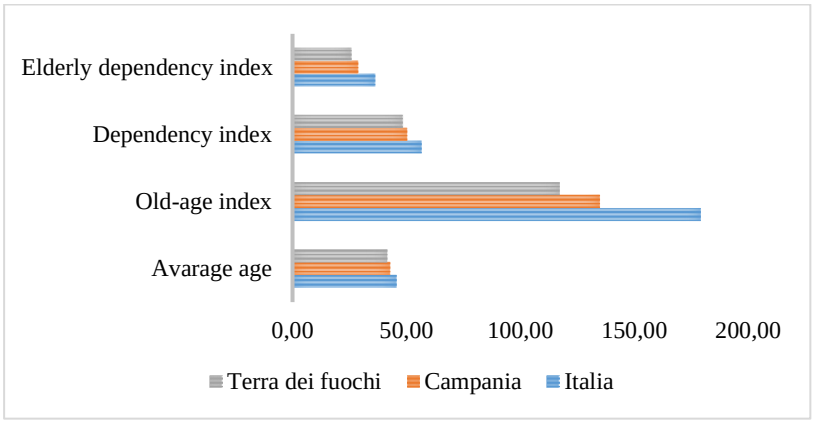
Figure 5 – *Age pyramid of the resident population, Campania and "Terra dei Fuochi", year 2020 % values*



Source: elaboration on data from demo.istat.it database

The analysis of the age structure of "Terra dei Fuochi" shows that it is a young land, as there is a lower percentage of people over 65 than the national average. The Orta di Atella municipality for example is the youngest in Italy, with more than 20% (21.6%) of the population in the 0-14 age group. All other demographic indicators are influenced by the age structure of the population in these municipalities. The old-age index[2] and the dependency index[3] of "Terra dei Fuochi" are lower than the national and regional figures (Figure 6).

Figure 6 – *Structural indicators, Italia, Campania and "Terra dei Fuochi", year 2020 % values*



Source: elaboration on data from demo.istat.it database

As in line with regional and national data, the "Terra dei Fuochi" also shows a steady decline in the birth rate[4], with 2020 registering a birth rate of -0.83 compared to 2014 (Table 1).

An analysis of the mortality rate from 2014 to 2020 shows that it is fluctuating, peaking in 2020, caused probably by the pandemic. As we know, Covid-19 has accentuated the process of demographic decline that had already begun in 2015, as it has impacted all the components of demographic dynamics (excess mortality,

[2]It is a synthetic indicator of the degree of ageing of the population It is obtained by comparing the amount of the population aged 65 years and over and that of children 0-14 years

[3]It is the percentage ratio between the population of non-working age (0-14 years and 65 years and over) and the working population (15-64 years); it calculates how many individuals there are of non-working age for every 100 of working age, indirectly providing a measure of the sustainability of a population structure. This ratio expresses the theoretical social and economic burden of the working-age population: values above 50 % indicate a situation of generational imbalance

[4] The birth rate is the ratio between the number of live births in the year and the average amount of the resident population, multiplied by 1,000.

declining births, halving of marriages, shrinking migration flows), in according to the study of Rosina (2020).

Table 1 – *Demographic statistics of the "Terra dei Fuochi"[a], year 2014-2020*

Demographic statistics	2014	2015	2016	2017	2018	2019	2020
birth rate	9,44	9,44	9,29	9,30	9,01	8,72	8,61
mortality rate	8,20	8,97	8,32	8,91	8,50	8,51	9,67
total migration rate	-1,01	-0,83	-2,14	-1,02	-2,88	-2,68	-2,32
old-age index	93,61	97,33	100,82	104,79	108,14	112,26	117,26
Elderly dependency index	22,70	23,26	23,71	24,23	24,63	25,17	25,91
Dependency index	47,60	47,77	47,82	47,91	47,93	48,06	48,47
average age	39,78	40,09	40,38	40,72	41,01	41,35	41,70

Source: elaboration on data from Istat database "a misura di comune"
Notes: [a]the rates of the "Terra dei Fuochi" are the result of the weighted average of the 90 municipal rates (the weight is the resident population as of 12/31/2020).

Moving on to analyze each of the 90 municipalities in the "Terra dei Fuochi" in the year 2020, it can be observed that the standard deviation with the highest value occurs for the Old Age Index, so for this variable, there is greater variability between observations (Table 2).

Table 2 – *Descriptive statistics[a], "Terra dei Fuochi", year 2020*

Statistics	Birth rate	Mortality rate	Total migration rate	Old-age index	Elderly dependency index	Dependency index
observation number	90	90	90	90	90	90
Minimum	4,08	5,21	-11,39	43,25	13,51	40,76
Maximum	14,45	13,98	26,19	186,59	39,29	62,20
first quartile	7,93	7,96	-4,28	83,44	20,21	43,89
Median	9,21	8,81	-0,80	98,00	22,46	45,90
Third quartile	10,21	9,90	2,55	124,97	26,32	48,29
Medium	9,06	8,93	0,02	105,89	23,60	46,46
Variance (n)	3,04	2,55	44,22	890,01	21,56	11,61
Standard deviation (n)	1,74	1,60	6,65	29,83	4,64	3,41

Source: elaboration on data from ISTAT database "a misura di commune"
Notes: [a]the average value is the result of the simple average of the 90 municipal rates.

4. Analysis of environmental data

The second part of the work focuses on the analysis of environmental data, to understand whether air pollution affects the lives of residents and in particular the over-65s. Data, available at municipal level, from *Istituto Superiore per la Protezione e la ricerca ambientale* (ISPRA) and ARPAC sources were analysed.

In this study, a sample of 7 municipalities belonging to the 'Terra dei Fuochi' was analyzed, because in these municipalities (Arpa Campania, 2022) air quality detection stations are installed.

An annual air quality index was calculated for each municipality from the annual mean value recorded by the monitoring station.

Based on the target value, an annual air quality assessment was made. The formula for the daily air quality index, as calculated by the ARPA agencies, was re-adjusted and an annual index was formulated.

The Annual Air Quality Index (IQA) is defined as the maximum of the three calculated sub-indices for the most critical pollutants: nitrogen dioxide (no2), particulates 10 (pm10), tropospheric ozone (o3):

$$IQA=\max [spm10; so3; sno2] \quad (1)$$

To develop the sub-index, for each of the 3 main pollutants, the annual average value (measured and validated by ARPAC) was compared with the limit value/annual target set by Legislative Decree 155/2010:

$$spm10 = (vpm10/vlpm10) *100 \quad (2)$$

$$so3 = (vo3/vlo3) *100 \quad (3)$$

$$sno2 = (vno2/vlno2) *100 \quad (4)$$

ISPRA calculated the parameters for a comparison with the limit values for the protection of human health established by the reference legislation (Legislative Decree 155/2010) and with the reference values for the protection of human health established by the WHO.

From the analysis of the data, we see that the municipality of San Vitaliano has the highest index of air quality (unhealthy air), followed by Casoria (Table 3).

[5] VLPM10 Limit value D. Lgs.155/2010 Civil year 40 µg/m3
VLNO2 Limit value D. Lgs.155/2010 Civil year 40 µg/m3
VLO3 Target value, Maximum daily average calculated over 8 hours (average over three years) 120 µg/m³

Table 3 – *Analysis of environmental data, year 2020*

Municipality	Average age	Old-age index	Dependency index	Elderly dependency index	Annual IQA	Outcome
Caserta	45,45	192,48	54,31	35,74	49,17	excellent
Casoria	41,26	116,47	51,24	27,57	85,00	fair
Maddaloni	41,22	114,25	49,09	26,18	57,50	good
Napoli	43,35	147,49	54,69	32,59	72,50	good
Napoli	43,35	147,49	54,69	32,59	58,33	good
Pozzuoli	43,03	142,37	51,50	30,25	65,00	good
San Felice a Cancello	41,26	111,88	51,33	27,10	72,50	good
San Vitaliano	40,32	95,79	48,99	23,97	127,50	unhealthy

Source: elaboration from demo.istat.it database and Ispra and Arpac database
Notes: There are 2 monitoring stations in the city of Naples

Analyzing the age structure of the population, in a sample of 7 municipalities, the municipality of San Vitaliano, which has higher pollution rates, has the lowest percentage of the population over 65 (Table 4).

Table 4 – *The population of the 7 municipalities by age, values %*

Municipality	Young inactive population 0-14 years		Active population 15-64 years		Young elders' inactive population 65-74 years		Great elders' inactive population 75-99 years		Centenarians 100++	
	F	M	F	M	F	M	F	M	F	M
Caserta	5,93	6,10	33,72	31,08	6,63	5,53	6,71	4,27	0,02	0,01
Casoria	7,61	8,04	33,81	32,31	5,71	4,89	4,49	3,13	0,00	0,00
Maddaloni	7,36	8,01	34,16	32,92	5,38	4,91	4,35	2,91	0,01	0,00
Napoli	6,93	7,35	33,10	31,55	6,18	5,15	6,04	3,68	0,02	0,01
Pozzuoli	6,76	7,26	33,84	32,16	5,84	5,42	4,99	3,71	0,01	0,00
San Felice a Cancello	7,77	8,24	33,15	32,93	5,05	4,60	4,80	3,46	0,01	0,00
San Vitaliano	7,96	8,84	34,17	32,95	4,61	4,30	4,38	2,79	0,00	0,00

Source: elaboration from demo.istat.it database

The standardized mortality rates[6] are calculated for the 7 municipalities of the focus and for the provinces of Naples and Caserta, they were elaborated using the standard population method; the reference population for standardization is the Italian resident population at 31 December 2020.

[6] The standardization of mortality rates by age makes it possible to eliminate the effect of ageing dynamics and the different age composition of populations.

The data show that the municipality of San Vitaliano, which has the highest pollution rates, also has the highest standardized mortality rate, for both men and women, followed by San Felice a Cancello, Casoria and Maddaloni (Table 5).

Table 5 – *Standardised mortaly rate, males and females, year 2020 values*

Municipality	Standardized mortality rate, males*10000	Standardized mortality rate, females*10000
Caserta	126,14	130,47
Casoria	141,65	133,75
Maddaloni	124,53	143,77
Napoli	149,73	146,21
Pozzuoli	129,56	132,25
San Felice a Cancello	147,40	146,33
San Vitaliano	150,88	171,09
Province of Napoli	135,30	133,33
Province of Caserta	136,80	138,20

Source: elaboration on data from demo.istat.it database

Then the correlations between the annual air quality index, the standardized mortality rate and the percentage of population over 65, by gender, in the 7 municipalities of the focus.

The correlations are all significant: negative correlations are those between IQA and population over 65, and positive correlations are those between IQA and mortality; so there is a strong relationship between the variables, but this does not allow us to say with certainty that the observed link is cause and effect or not (Table 6).

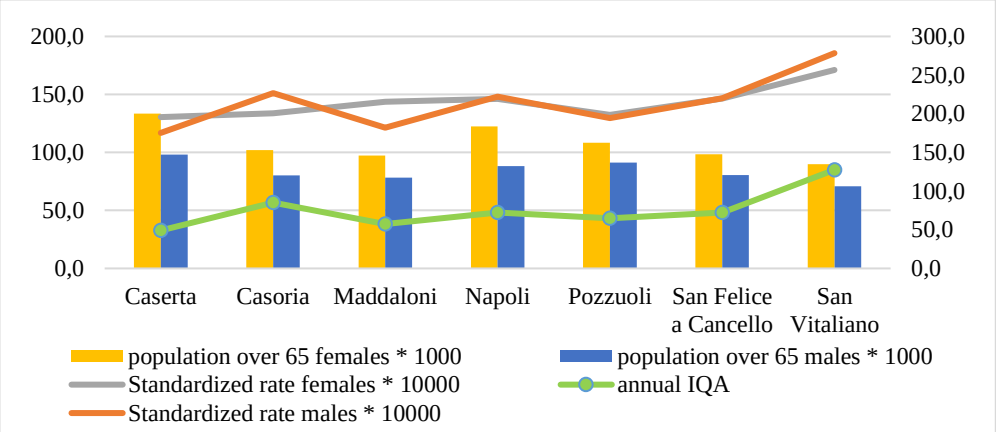
Table 6 – *Correlations between annual IQA and mortality and population over 65, year 2020 values*

	Standardized rate males * 10000	Standardized rate females * 10000	population over 65 females * 1000	population over 65 males * 1000
annual IQA	0,72	0,83	-0,63	-0,76

Source: elaboration from demo.istat.it database and Ispra and Arpac database

The data seem to show an inverse relationship between pollution and aging and a direct relationship between pollution and mortality (Figure 7).

Figure 7 – *Annual IQA and standardized mortality rates and population over 65 by gender, year 2020 values*



Source: elaboration from demo.istat.it database and Ispra and Arpac database

5. Conclusions

Despite the "Pact for the Terra dei Fuochi", in which the mayors of the municipalities concerned signed a document in which they committed themselves to take measures to combat the phenomenon of rubbish being left on roads and in public areas and to take measures for the prompt removal of rubbish, the "Terra dei Fuochi" is an area where aging is very troubled.

The analysis carried out on the 7 sample municipalities of the focus shows that there is a strong relationship between the annual air quality index, the mortality rate, and the percentage of over 65.

From data processing we see that there is an inverse relationship between pollution and aging and a direct relationship between pollution and mortality, in short, it seems that in "Terra dei Fuochi" mortality is higher, and aging is not as widespread as in Campania, Italy and Europe.

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