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Use of Official Municipal Demographics for the Estimation of Mortality in Cities Suffering from Heavy Environmental Pollution: Results of the First Study on All the Neighborhoods of Taranto from 2011 to 2020

Valerio Gennaro¹, Stefano Cervellera², Carlo Cusatelli³, Alessandro Miani^{4,5}, Francesco Pesce⁶, Gianluigi De Gennaro⁷, Alessandro Distante⁸, Luigi Vimercati⁸, Loreto Gesualdo⁶, Prisco Piscitelli^{4,9}

¹ Former Director of Liguria Region Mesothelioma Registry, IRCCS San Martino University Hospital, Genoa, Italy

² City Hall Bureau of Demographic Statistics, Municipality of Taranto, Taranto, Italy

³ Ionian Department, University of Bari “Aldo Moro”, Taranto, Italy

⁴ Italian Society of Environmental Medicine, SIMA, Milan, Italy

⁵ Department of Environmental Sciences and Policy, University of Milan, Milan, Italy

⁶ Department of Emergency and Organ Transplantation (DETO), School of Medicine, University of Bari “Aldo Moro”, Bari, Italy

⁷ Department of Biology, University of Bari “Aldo Moro”, Ionian Hub, Taranto, Italy

⁸ Division of Occupational Medicine, University of Bari “Aldo Moro”, Bari, Italy

⁹ Euro Mediterranean Scientific Biomedical Institute (ISBEM), Brindisi, Italy

Corresponding Author: Stefano Cervellera, Office of Statistics, Municipality of Taranto, City Hall
Tel/Fax +30 0994581223 – email: s.cervellera@comune.taranto.it

Background. In cities suffering from heavy environmental pressure or pollution, it is extremely important to rapidly access municipal demographics that can be used as indicators of population health status. Among those, mortality rates represent the most reliable data as they are officially retained and available to municipality with high level of details, thus allowing epidemiological comparison between different neighborhoods of the city across several years. Our study was aimed at validating and propose as universally applicable approach the use of municipal demographics as first-line tool to rapidly assess population health and drive health policies or urban planning in cities characterized by heavy environmental pressure. The case study of Taranto has been chosen due to the presence of the biggest European steel plant since 1960s resulting in heavy burden on environment and population health. **Methods.** We have performed an ecological study on general mortality data due to all causes, specific by gender, age groups and disaggregated at sub-municipal level (highest data granularity) into neighborhoods from 2011 to 2020 by using official demographics related to all people living in Taranto available at General Registry Office of the municipality. A preliminary analysis comparing data available at Municipality and those provided by the Italian National Institute of Statistics (ISTAT) was performed and confirmed the high level of reliability of the municipal source of data. For comparative analyses, we used Regional demographics and mortality from ISTAT. Indirect age-standardized mortality ratios (SMR; CI 90% and 95%), specific for gender and neighborhoods, were calculated in reference to the city of Taranto and Apulia Region; direct age-standardized and neighborhoods mortality rates were computed on city population. **Results.** The city of Taranto shows relevant inequalities in terms of mortality between the northern neighborhoods, closest to the industrial area (Paolo VI, Tamburi and Città Vecchia-Borgo), with excess mortality highlighted across 10 years described by SMRs always higher than those of the entire Apulia region, with peaks exceeding 50% between 2015 and 2017 both in women and men. The significant excesses of mortality have increased from 2011 to 2020 and progressively extended across several neighborhoods of Taranto city. Compared to the Apulia regional, we recorded a 68% mortality excess for men living in Paolo VI district during the year 2019. In the 3 Northern neighborhoods of the city were recorded 1020 excess deaths with confirmed statistical significance. **Conclusion.** The use of official mortality data allows a timely, reliable and costless assessment of population health in cities heavily impacted by environmental pollution like Taranto.

Keywords: Taranto; neighborhoods; mortality; demographics; health; environmental pollution.

Highlights

- Municipal mortality data are used for the first time to suggest their suitability for epidemiological purposes in cities suffering from heavy environmental pressure as timely indicator of intra-municipal discrepancies (at neighborhood level) in terms of overall mortality.
- The city of Taranto has been chosen as case study and this is the first time that official mortality data concerning all the neighborhoods and provided by the Municipality are used for epidemiological purposes.
- Our data are consistent with those of studies conducted in the context of national and regional surveys which highlighted increased mortality for all causes and for specific causes, as well as increased morbidity and incidences of tumor in the city of Taranto or in some neighborhoods (also characterized by high socioeconomic deprivation) close to the steel plant.

Introduction

In cities suffering from heavy environmental pressure or pollution, it is extremely important to rapidly access municipal demographics that can be used as indicators of population health status. Among those, mortality rates represent the most reliable data as they are officially retained and available to municipality with high level of details, thus allowing epidemiological comparison between different neighborhoods of the city across several years. Our study was aimed at validating and propose as universally applicable approach the use of municipal demographics as first-line tool to rapidly assess population health and drive health policies or urban planning in cities characterized by heavy environmental pressure. The case study of Taranto has been chosen due to the presence of the biggest European steel plant since 1960s resulting in heavy burden on environment and population health.

The city of Taranto has 199,561 inhabitants¹ distributed in six neighborhoods over 249.9 km² on Ionian Sea, with a population density of 798.7 inhabitants/km². The municipality is characterized by the presence of a large industrial area which includes: a coal-fired integral cycle steel plant (ex ILVA; current name: Arcelor Mittal) built up during the 1960s; a large petrochemical refinery operating since 1967; a cement production plant of and two thermoelectric plants (Edison and EniPower). These industrial activities are associated with an intense movement of huge quantity of imported carbon (namely 5-8 million tons per year) and raw materials in the docks of the port. In addition to the steel plant, the area of Taranto hosts factories for tires and plastic production, synthetic paints and glues. Finally, one of the few national sites identified for the temporary storage of nuclear wastes is located not far from the steel plant area.

The city of Taranto –has been included in the list of Italian areas "at higher risk of environmental crisis",²⁻⁴ and subsequently among the first block of the so called "sites of national interest" (SIN), which require

special environmental monitoring and land reclaim programs. Several environmental and biomonitoring studies¹³⁻¹⁶ carried out in Taranto area have assessed industrial emissions and their impact, confirming the high burden of air pollution originating mainly from the steel industry, with the diffusion of particulates, heavy metals, polycyclic aromatics hydrocarbons and organohalogen compounds. Environmental pollution has also determined a serious impact on people's health, as documented in several epidemiological studies conducted on the area. The first mortality studies carried out by the World Health Organization (WHO) for the periods 1980-1987¹⁷ and 1990-1994¹⁸ highlighted an excess of mortality concerning both all causes of death and neoplasms (lung, pleura and bladder cancer) compared to the regional figures of entire Apulia. In the first WHO study, such excesses were observed mainly in the male population, and associated with occupational risk factors.¹⁷

In the second study, excess mortality was observed also in women, suggesting a role of environmental exposures.¹⁸ The results of mortality analyses carried out for the period 1970-2004¹⁹ and a case-control study related to the years 2000-2002²⁰ highlighted an increasing trend in the risk of lung and pleural cancer, both in men and in women. During the period 1970-2004¹⁹, a decrease in general mortality was observed both in the municipality and at regional level. However, compared to region Apulia, men living in the city of Taranto showed excess in all-cause mortality as for all cancers since 1970, in particular for lung, pleura and bladder cancer.¹⁹ Excesses in mortality rates have also been observed among women, mainly due to diagnosis of ovarian/uterus cancers.¹⁹ A case-control study considering the years 2000-2002²⁰ showed an increased risk of cancer (lung, pleura, bladder and lymphoma or leukemia) directly associated with the distance from the main sources of environmental pollution. The impact of environmental risk factors on the health of people living in Taranto area was investigated in other two studies²¹ that took into account also the socio-economic status of the population through the use of tax data.²²

The use of dispersion models and environmental data²³⁻²⁴ based on SO₂ as tracer of industrial pollution found the highest levels of air pollutants in the neighborhoods close to the steel plant especially in case of winds blowing from the industrial area (the so called "wind days" when also schools remain closed).

Within the SENTIERI Study, a national survey on all the Italian SInS ruled by the Italian Institute for Public Health (ISS), a first mortality analysis was carried out for the period 1995-2002^{25,26} with a subsequent extension up to 2003-2009²⁷ paying specific attention to the SIn of Taranto.²⁸

The results of the SENTIERI study confirmed the critical fiwith regard to the excesses of observed cancer incidence and mortality for respiratory and cardiovascular diseases as well as for different tumors, but reveled also a higher children mortality for all causes of death (with some warning about respiratory diseases and asthma) compared to the regional and national data.²⁷

A huge cohort study was conducted by Forastiere et al. to determine mortality and morbidity in terms of hospital admissions.²⁹ In particular, the occurrence of diseases associated with pollutants from industrial

emission sources present in the city (PM_{10} of industrial origin) was assessed for the period 1996-2010.²⁹ The study also contains an analysis on the short-term effects of PM_{10} dust on people living in the two most exposed districts of Taranto to the emissions of industrial origin: Borgo and Tamburi. As for mortality, the results revealed - for each increase of $10 \mu g/m^3$ of PM_{10} - an increase in the risk for overall mortality and hospitalizations, with a greater effect among the residents of the above mentioned two neighborhoods (specific for cardiovascular and respiratory diseases). Interestingly, data concerning mortality and hospital admissions were directly associated with the amount of industrial production and emissions from the steel plant.^{29,30}

These short-term effects are consistent with the literature, in particular with the findings of MISA study, an "Italian meta-analysis of studies about the short-term effects of pollution"³¹ and with the results of the international EpiAIR project.³²

The original findings from Forastiere et al. was that the observed excess in mortality was not limited to the neighborhoods adjacent to industrial areas but included also some districts located at far from the steel plant.^{29,30} However, this analysis must be supported by further investigations that consider the spatial trend of pollutants' dispersion, the impact of the socio-economic variables and the duration of residence of the citizens in the same neighborhood.³³

The objective of this study is to explore and validate the suitability of municipal demographic dataset, such as mortality data, as optimal tool to perform a rapid first-line monitoring for the assessment of population health status (mortality for all causes) in those areas characterized by heavy environmental pressure by using Taranto as "case study" for this purpose. Actually, this kind of reliable and official single source of population and mortality data is updated very quickly and frequently (almost daily), so that it is possible to make available data concerning the real-time situation. Furthermore, the municipal data source allows a disaggregation of the data at the sub-municipal level (neighborhoods), with high data granularity, which can provide important indications in very large cities (like Taranto) about the potential effects on human health of industrial pollutants.

Methods

The data of residents and deaths occurred in the city of Taranto from 2011 to 2020, disaggregated by gender, age and neighborhoods were provided by the Municipal Registry Office. Data concerning residents and deaths in Apulia region are available until 2019 and have been provided by the National Institute of Statistics (ISTAT). The attribution of the age at death is based on the difference between the year of death and date of birth. Population standardization was carried out by five-year age groups (0-4, 5-9, ..., 95+). The six neighborhoods of Taranto (located at different distances from the steel plant) were considered

using the administrative boundaries adopted at municipal level since 2004.

Standardized Mortality Ratios (SMRs) were calculated by using the indirect method, specific by gender and neighborhoods (high level of data granularity), assuming the entire Municipality and Apulia region as a reference. In addition, standardized annual rates were computed per 1.000 inhabitants, with reference to population of Taranto by year and gender. In the context of these analyses, the official source of general and cause-specific mortality data is represented by the National Institute of Statistics (ISTAT), for comparison and regional reference.³⁴

The main causes of death are deduced by official ISTAT forms and certified by a doctor of the local health authority for each death according to WHO ICD-9 and, more recently, to ICD-10 classification. Some misalignments between data provided by ISTAT at national level and the official municipal registers are always possible and might generate errors on the entire chain of data when used for epidemiological purposes. Therefore, we performed a preliminary assessment between different sources of data (ISTAT and tax data) in comparison to those directly available at Demographics Office of Taranto Municipality City Hall (digital registries available from 1992 to 2020). As reported in Figure 1, the results of this comparison show the strong misalignment of the two different data sources, which - if not considered - would cause remarkable errors in the determination of mortality indicators which are based on a ratio between deaths at numerator and population at denominator. It was also possible to determine the divergence or misalignment between the annual deaths data in the Municipal registry and that reported in the ISTAT sources. The variability between the two sources of mortality data in the period 1992-2020 was characterized for ISTAT deaths by a standard deviation of 263.6 with a range of variation of 1,133 while for the municipality the standard deviation was 133.3 with a range of variation of 555. Therefore, the municipal source, compared to ISTAT, is much less variable with a more stable and precise path. The graphs show the lower variability and greater smoothing of the data against a strong variability of ISTAT source, that finally tends to realign itself to the municipal data.

Statistical tests confirm a strong difference between the municipal demographics and ISTAT source, in particular for mortality quotients and population. Concerning the data on deaths, to verify the degree of dissimilarity between the two curves (the one of ISTAT and that of the Municipal registry office), the average of the absolute values of the differences between the data over the T years is calculated:

$$S = \frac{\sum_{t=1}^T |I_t - M_t|}{T}$$

The result $S=137.25$ indicates an average annual difference between the two sources of about 137 deaths: comparing them to the 1,923 deaths per year recorded on average by the Registry office (which detects the

information in real-time, thus providing more reliable data for our purpose), it results in an average error of ISTAT source estimated at 7.1%.

Figure 1. Comparison between Taranto Registry Office with ISTAT data concerning resident population (A) and number of deaths (B) in the city of Taranto by year (1992-2020).

The diversity of neighborhoods in terms of socio-deprivation was assessed by referring to the national deprivation index based on Caranci 2001,²² as modified by the Sentieri Study Group to take into account regional differences²⁶, according to five specific indicators:

- x1: % of population with an education equal to or below primary school leaving certificate (failure to reach compulsory schooling);
- x2: % of active unemployed population or looking for a first job;
- x3: % of occupied rented dwellings;
- x4: % of single-parent families with cohabiting dependent children;
- x5: population density (number of occupants per 100 m² in dwellings).

The index is a continuous variable and represents the deviation from the national average of deprivation characteristics: population quintiles for Italy as whole.

Using the 2011 data on census sections and sub-municipal areas, deprivation indices were obtained for each neighborhood, and were classified in the reference quintile on a regional basis (Tab.1). Four neighborhoods result in high socio-economic deprivation, one in medium-high deprivation and one in low deprivation.

Table 1. Socio-economic deprivation of neighborhoods, classification in quintiles of the Apulia region (SENTIERI Study)^{25,26}

Neighborhood	Position (distance to industrial area - mineral park)	Socio Economic Deprivation	
Paolo VI	Nord-Est (~ 4 km near industrial area - mineral park)	High Deprivation	
Tamburi-Lido Azzurro	Nord (< 500 mt near industrial area - mineral park)	High Deprivation	
Città Vecchia-Borgo	Central (~ 2 km near industrial area - mineral park)	Medium - High Deprivation	
Tre Carrare - Solito	Central-Est (~ 5 km near industrial area - mineral park)	High Deprivation	
Montegranaro - Salinella	Central-Sud (~ 5,5 km near industrial area - mineral park)	High Deprivation	
Talsano Lama S. Vito	Sud (~ 11 km near industrial area - mineral park)	Low Deprivation	
			0 1 2 3 4 5 Level Socio-Economic Deprivation ★

The specific mortality rates in neighborhoods, municipality and region were processed for each gender by relating the deaths of the specific age group to average population data. In case of missing data concerning deaths, they were distributed into age groups with the same frequency as the observed data. Actually, it has been verified that, even in the extreme case in which these deaths belonged to the most represented age group (in terms of absolute number of people divided by gender), the SMR under analysis would vary marginally both in males and females, up to a maximum of 0.1% for the entire period. Based on the analysis of ISTAT data misalignments, we used mortality data directly provided by the municipal registry source, both for population demographics and for deaths. Actually, the use of municipal registry data, as an alternative to ISTAT indicators, was able to mitigate inaccuracies and errors when computing mortality rates, due to the intrinsic characteristics and complex detection of deaths (numerator) and population (denominator), thus resulting in less distorted and more reliable results. Therefore, the determination of SMRs was based on municipal registry data, while for the comparisons towards the Apulia region, the ISTAT aggregate data of population and deaths of the period 2011-2019 were used. In accordance with the SENTIERI study²⁵⁻²⁸, we have set the statistical significance at 90% in the main analyses, to promptly identify the excess of mortality in the light of precautionary principle and population epidemiology. Additional analyses have been carried out by setting statistical significance at 95% in order to remarkably confirm the findings of the analyses and are presented in the supplementary materials to this paper. The 90% and 95% confidence intervals (CI) of significance were calculated by Byar's approximation method.³⁵⁻³⁷ We used the R software and the libraries “Stat”, “Stat4”, and “Epitools”. Tableau software was used for the simpler statistics and graphical representations.

Results

After having analyzed the population structure of the six Taranto neighborhoods in the period 2011-2020 (Fig. 2), we found that the total population passed from 207,457 to 192,386 inhabitants, with a reduction of 7.8% over the entire period, which is a value much higher than the regional average of 2.9%. In the younger age groups (0-39) there was a reduction of 20%, while the older population (80+) increased by about 30%.

Figure 2. Taranto city: neighborhoods and industrial area

Table 2 shows the population structure in the 6 neighborhoods of Taranto city in 2011 and 2020, including information about the level of socio-economic deprivation (as elaborated by the ID-SENTIERI model on 2011 tax data)^{22,26}.

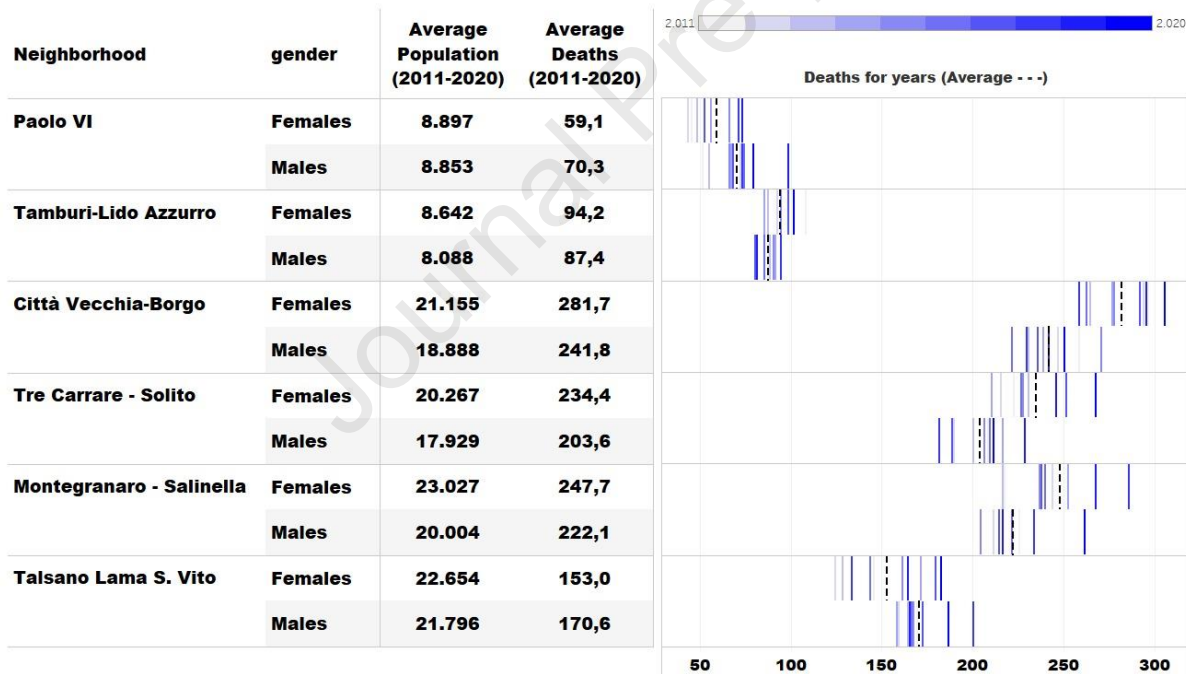
Table 2. Population structure, by age and gender, of the resident population in the 6 Taranto neighborhoods (years 2011 and 2020); the level of socio-economic deprivation is elaborated by the ID-SENTIERI model (2011 census data)^{22,26}

gender	age class	year	Paolo VI	Tamburi-Lido Azzurro	Città Vecchia-Borgo	Tre Carrare - Solito	Montegrano - Salinella	Talsano Lama S. Vito
Females	0-14	2011	2.189	1.959	3.735	3.265	3.870	4.698
		2020	1.816	1.649	3.177	2.680	3.166	3.833
	20-39	2011	2.544	2.319	5.032	4.778	5.406	6.079
		2020	1.920	1.855	3.872	3.665	3.907	4.648
	40-64	2011	2.947	2.837	7.517	7.689	8.632	8.498
		2020	3.157	2.801	7.599	6.940	7.995	8.473
	65-79	2011	1.143	1.206	3.631	3.701	4.275	2.869
		2020	1.181	1.251	3.469	4.125	4.376	3.849
Males	0-14	2011	174	670	2.188	1.693	1.770	871
		2020	473	629	2.074	1.973	2.405	1.364
	20-39	2011	2.349	2.062	3.918	3.391	3.933	4.947
		2020	1.934	1.782	3.260	2.791	3.196	4.082
	40-64	2011	2.629	2.325	5.150	4.816	5.205	6.122
		2020	2.065	1.918	4.352	3.659	3.895	4.564
	65-79	2011	2.921	2.762	7.001	6.740	7.612	8.046
		2020	3.163	2.695	6.962	6.061	6.890	7.995
	80 +	2011	1.012	882	2.562	3.033	3.301	2.748
		2020	939	1.108	2.953	3.423	3.554	3.567
		2011	120	322	980	891	944	548
		2020	347	308	968	1.256	1.426	951

The structural dynamics of the neighborhoods' population can be paired into three clusters with the following matches: Paolo VI with Talsano, Montegrano with Tre Carrare, and Old City with Tamburi. In the whole reference period (2011-2020) a total of 20659 deaths were classified: 51.8% (n=10701) were females and 48.2% (n=9958) were males (Table 3). At the neighborhood level, only in Paolo VI and Talsano the deaths of males were more than those observed for females (54.3% and 52.7%, respectively). The trend of deaths at the neighborhood level, by gender and by age, shows higher annual growth rates in all ages for females living in Montegrano and Tre Carrare, as well as in the age group 40-64 for Talsano and also Paolo VI (in this latter both for females and males). Table 4 resumes the average population and average number of deaths across the study period.

Table 3. Total deaths per age groups occurred in the resident populations from 2011 to 2020

gender	age class	Paolo VI	Tamburi-Lido Azzurro	Città Vecchia-Borgo	Tre Carrare - Solito	Montegranaro - Salinella	Talsano Lama S. Vito	Total
Femal..	0-14	3	3	9	6	6	7	<u>34</u>
	20-39	5	5	16	8	7	12	<u>53</u>
	40-64	85	66	208	155	164	144	<u>822</u>
	65-79	204	212	526	492	524	405	<u>2.363</u>
	80 +	294	656	2.058	1.683	1.776	962	<u>7.429</u>
	Total	<u>591</u>	<u>942</u>	<u>2.817</u>	<u>2.344</u>	<u>2.477</u>	<u>1.530</u>	<u>10.701</u>
Males	0-14	7	4	15	6	7	10	<u>49</u>
	20-39	13	18	33	23	20	20	<u>127</u>
	40-64	137	153	399	232	255	241	<u>1.417</u>
	65-79	290	260	739	681	746	646	<u>3.362</u>
	80 +	256	439	1.232	1.094	1.193	789	<u>5.003</u>
	Total	<u>703</u>	<u>874</u>	<u>2.418</u>	<u>2.036</u>	<u>2.221</u>	<u>1.706</u>	<u>9.958</u>
Total		<u>1.294</u>	<u>1.816</u>	<u>5.235</u>	<u>4.380</u>	<u>4.698</u>	<u>3.236</u>	<u>20.659</u>

Table 4. Average population and average deaths per each Taranto neighborhood (2011-2020), with graph deaths distribution across the study period.

It is very clear from data summarized in Table 5 – which present the intra-municipal assessment of the six different neighborhoods – that the districts located in the Northern part of the city closest to the industrial area of the steel plant, present $SMR > 1$ for almost the entire period (with the only exception of males in 2011, where the recorded value is 0.94). The peaks in the SMR values showing statistical significance were reached in Paolo VI district in 2015 and 2016 for females (1.52 and 1.49, respectively) and in 2019 for men (1.56). In Tamburi district the highest statistically significant values of SMR were recorded in

2012 for females (1.27) and in 2010-2020 for males (1.33 and 1.23, respectively). The neighborhood of Città Vecchia/Borgo showed statistically significant SMR values for males in 2015 (1.34) and in more recent years (1.17 in 2017, 1.18 in 2019, and 1.20 in 2020). The differences in comparison with the three Southern city districts is remarkable, thus showing relevant inequalities in terms of mortality across the same city which follow the distance from the steel plant.

Table 5. Standardized Mortality Rate (SMR) by neighborhood, sex and year, compared to indirectly standardized mortality rates by age and sex, using Taranto city as reference population (2011-2020); the excess of mortality with statistical significance (CI 90%) are highlighted in red.

Neighborhood	gender	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Paolo VI	Females	1,18	1,12	1,26	1,30	1,52	1,49	1,08	1,38	1,27	1,17
	Males	0,94	1,34	1,03	1,17	1,11	1,25	1,16	1,18	1,56	1,20
Tamburi-Lido Azzurro	Females	1,27	1,12	1,12	1,01	1,11	1,05	1,13	1,12	1,14	1,14
	Males	1,11	1,16	1,20	1,22	1,21	1,20	1,17	1,33	1,13	1,25
Città Vecchia-Borgo	Females	1,03	1,06	1,01	1,01	1,01	1,02	1,05	0,97	1,10	1,09
	Males	1,13	1,13	1,08	1,09	1,24	1,08	1,17	1,10	1,18	1,20
Tre Carrare - Solito	Females	0,96	0,94	1,04	0,87	0,93	0,98	0,99	1,00	1,00	1,01
	Males	0,93	0,88	0,95	0,97	0,92	0,96	0,89	0,79	0,99	0,86
Montegranaro - Salinella	Females	0,88	0,99	0,90	0,98	0,90	0,95	0,86	1,04	0,93	0,93
	Males	0,94	0,91	0,92	0,93	0,84	0,92	0,91	0,94	0,85	0,96
Talsano Lama S. Vito	Females	1,03	0,89	0,94	1,12	1,06	0,93	1,08	0,80	0,83	0,86
	Males	0,97	0,93	0,98	0,88	0,91	0,91	0,95	1,04	0,81	0,88

Tables 5 and 6 show how the 3 districts (Paolo VI, Tamburi and Città Vecchia-Borgo) suffer from excess mortality (SMR>1), with the excess of mortality that worsens across almost the entire study period, reaching a very high level of 68% mortality excesses for men in Paolo VI during the year 2019 when compared to regional figures, with a standardized mortality rate of 16.5 deaths per 1000 inhabitants (Table 6). The regional comparison shows that in these neighborhoods there is still an excess of mortality, which remains significant for almost the entire period, with a more pronounced increase in men (Table 6). Table 7 shows that in the 3 neighborhoods closest to the steel plant (Tamburi, PaoloVI and Città Vecchia/Borgo) it has been recorded an excess of 1020 deaths. Figure 3 and Figure 4 show how the significant excesses of mortality have increased from 2011 to 2020 and progressively extended across several neighborhoods of Taranto city.

The statistical significance of excess mortality did not differ when determining confidence intervals (IC) at 90% (according to the methodology of SENTIERI study in the perspective of precautionary principle) or 95%. Specifically, when passing from SMR with 90% IC to SMR with 95% IC (using as reference population the entire Region Apulia) we lose statistical significance only for men living in Paolo VI district in the single year 2014 and for male residents in Tamburi for the two years 2011-2012. All the other statistically significant SMR reported in the Tables and Figures of the present study with 90% IC remained significant

also when setting confidence intervals at 95% (Tables and Figures with 95% IC calculations are available in Supplemental Materials published with this paper).

Table 6. Standardized Mortality Rate (SMR) by neighborhood, sex and year, compared to indirectly standardized mortality rates of Apulia region reference population by sex and age (2011-2020); the excess of mortality with statistical significance (CI 90%) are highlighted in red.

Neighborhood	gender	2011	2012	2013	2014	2015	2016	2017	2018	2019
Paolo VI	Females	1,23	1,12	1,23	1,38	1,47	1,53	1,08	1,37	1,41
	Males	1,05	1,43	1,07	1,28	1,18	1,38	1,17	1,24	1,68
Tamburi-Lido Azzurro	Females	1,35	1,15	1,15	1,09	1,10	1,07	1,15	1,13	1,26
	Males	1,22	1,21	1,29	1,35	1,30	1,31	1,16	1,41	1,21
Città Vecchia-Borgo	Females	1,09	1,08	1,05	1,09	1,02	1,03	1,07	0,98	1,21
	Males	1,23	1,18	1,16	1,21	1,34	1,17	1,16	1,17	1,25
Tre Carrare - Solito	Females	1,02	0,96	1,07	0,94	0,93	0,99	1,00	1,01	1,10
	Males	1,02	0,92	1,01	1,08	0,98	1,05	0,88	0,84	1,05
Montegranaro - Salinella	Females	0,93	1,00	0,92	1,05	0,90	0,96	0,86	1,05	1,02
	Males	1,04	0,96	0,98	1,04	0,89	1,01	0,90	0,99	0,90
Talsano Lama S. Vito	Females	1,09	0,90	0,94	1,21	1,04	0,96	1,10	0,80	0,95
	Males	1,08	1,00	1,03	0,97	0,97	0,99	0,94	1,09	0,88

Table 7. Observed (Dx Oss.) and expected deaths in the six neighborhoods (IC 90%) compared to indirectly standardized mortality rates by age and sex on Apulia region reference population (2011-2020). Red bullet points refer to significant excess of mortality (IC 90%)

gender	years	Neighborhood	Dx Oss.	IC90	Expected	
Females	2011-12-13	Paolo VI	136	(117 - 156)	114	●
		Tamburi-Lido Azzurro	287	(259 - 316)	236	●
		Città Vecchia-Borgo	853	(805 - 902)	792	●
		Tre Carrare - Solito	667	(625 - 711)	657	
		Montegranaro - Salinella	676	(633 - 720)	709	
		Talsano Lama S. Vito	397	(364 - 431)	406	
	2014-15-16	Paolo VI	188	(166 - 212)	128	●
		Tamburi-Lido Azzurro	264	(237 - 292)	243	
		Città Vecchia-Borgo	815	(768 - 863)	779	
		Tre Carrare - Solito	663	(621 - 706)	697	
		Montegranaro - Salinella	727	(683 - 772)	750	
		Talsano Lama S. Vito	475	(439 - 512)	445	
	2017-18-19	Paolo VI	196	(173 - 220)	151	●
		Tamburi-Lido Azzurro	290	(262 - 319)	245	●
		Città Vecchia-Borgo	844	(796 - 893)	779	●
		Tre Carrare - Solito	747	(702 - 793)	722	
		Montegranaro - Salinella	789	(743 - 836)	807	
		Talsano Lama S. Vito	476	(440 - 513)	500	
Males	2011-12-13	Paolo VI	178	(156 - 201)	150	●
		Tamburi-Lido Azzurro	262	(235 - 290)	211	●
		Città Vecchia-Borgo	734	(690 - 780)	617	●
		Tre Carrare - Solito	597	(557 - 638)	606	
		Montegranaro - Salinella	647	(605 - 690)	651	
		Talsano Lama S. Vito	492	(456 - 530)	475	
	2014-15-16	Paolo VI	207	(183 - 232)	162	●
		Tamburi-Lido Azzurro	266	(239 - 294)	201	●
		Città Vecchia-Borgo	729	(685 - 775)	587	●
		Tre Carrare - Solito	631	(590 - 673)	609	
		Montegranaro - Salinella	650	(608 - 693)	664	
		Talsano Lama S. Vito	491	(455 - 529)	501	
	2017-18-19	Paolo VI	239	(214 - 266)	175	●
		Tamburi-Lido Azzurro	255	(229 - 282)	202	●
		Città Vecchia-Borgo	705	(661 - 750)	591	●
		Tre Carrare - Solito	597	(557 - 638)	647	
		Montegranaro - Salinella	663	(621 - 706)	712	
		Talsano Lama S. Vito	537	(499 - 576)	553	

Table 8. Standardized mortality rates by sex and year in the six neighborhoods of Taranto, with mortality rates directly standardized by age and sex on Taranto city reference population (2010-2020).

Neighborhood	gender	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Paolo VI	Females	15,0	12,3	9,0	12,8	13,6	15,6	15,0	11,5	13,9	15,0	13,0
	Males	10,8	9,7	11,6	9,3	11,4	12,5	14,0	12,2	12,6	16,3	15,0
Tamburi-Lido Azzurro	Females	10,0	12,1	10,6	10,7	9,9	11,3	10,2	12,1	12,3	13,0	13,7
	Males	12,8	11,4	11,6	11,4	12,8	12,6	12,3	11,8	14,6	12,7	14,5
Città Vecchia-Borgo	Females	10,0	9,9	10,1	9,3	10,1	10,2	10,1	11,3	10,5	12,5	13,2
	Males	10,4	11,8	11,5	10,5	11,4	13,5	11,3	11,9	11,9	13,0	14,1
Tre Carrare - Solito	Females	8,9	9,2	8,9	9,4	8,7	9,3	9,6	10,6	10,6	11,4	12,2
	Males	8,1	9,4	8,7	9,2	10,1	9,6	9,9	8,9	8,4	10,9	10,1
Montegranaro - Salinella	Females	8,8	8,4	9,4	8,2	9,8	9,1	9,2	9,1	11,1	10,5	11,3
	Males	8,2	9,5	9,0	9,0	9,7	8,8	9,4	9,1	10,2	9,4	11,3
Talsano Lama S. Vito	Females	8,8	9,8	8,3	8,6	11,4	10,7	9,4	12,0	8,8	9,8	10,6
	Males	7,8	9,8	9,5	9,8	9,4	9,8	9,3	9,7	11,5	9,1	10,5

Figure 3. *Standardized Mortality Rates by sex and year in the six neighborhoods of Taranto, with mortality rates directly standardized by age and sex on Taranto city reference population (2011-2020 presented as two year-intervals).*

Figure 4. *Standardized Mortality Rates by sex and year in the six Taranto neighborhoods, with mortality rates directly standardized by age and sex on Apulia Region reference population (2011-2018 presented as two year-intervals; 2019 presented as single year due to unavailable data about 2020).*

Our study is aimed at proposing a universal model/approach applicable to any city suffering from heavy environmental pressure, based on the analysis of general mortality preferably computed for each different neighborhood and for age groups. The specific objective was to explore and validate the suitability of official mortality data maintained at municipal and updated almost daily as reliable tool to rapidly monitor population health status referring as “case study” to a city characterized by well known environmental threats such as Taranto. By using this first-hand and real-time updated data source, there is no need to wait for expensive research protocols or long-lasting processes of data collection at national level (often misaligned and resulting in underestimations, as showed by our preliminary comparative assessment between the municipal and ISTAT data sources in Italy).

Moreover, the use of municipal data allows a disaggregation of data at neighborhoods level (high data granularity), which can provide important indications for health and urban planning policies. Actually, it must be kept in mind that mortality analyses are never an endpoint in itself but they always need comparative assessments as well as territorial or temporal evaluations to verify how the phenomenon varies geographically or over an adequate time. On our side, having accessed to data from 2011 to 2020 has granted us to work on an adequate interval including very recent data, while the analysis of standardized mortality rates (SMRs) by neighborhoods gave us the opportunity to specifically investigate the static and dynamic mortality of the city of Taranto, highlighting differences and inequalities in terms of mortality between the six neighborhoods. A number of studies³⁹⁻⁴³ and health impact assessments have address environmental threats of Taranto, and the city was also included in those analyzed by SENTIERI study under the supervision of health authorities.²³⁻³³ Specifically, the association between exposure to PM₁₀ and the negative health effects was investigated in relation to some neighborhoods of Taranto city by Forastiere et al. in the frame of a judiciary prosecution, with estimations of hazard ratios for each unit of increase in dust concentration of industrial origin.²⁹ The study also conducted an assessment of the socioeconomic status which allowed for the identification of a wide social variability: greater health problems were observed in the most deprived areas of Taranto city closer to the industrial area (Paolo VI and Tamburi which includes Isola e Porta Napoli sub-areas, both in males and females, associated with exposure to PM₁₀). In particular, critical figures were observed in Isola e Porta Napoli sub-areas, and Lido Azzurro, when taking into account the social differences, environmental and occupational exposures that characterize these areas.

The observed excesses refer in particular to oncological, cardiovascular and respiratory diseases in terms of both mortality and hospitalization.²⁹ In 2016, a study conducted at sub-municipal/district level³³ was carried out by using the cohort investigated by Forastiere and colleagues (2012),²⁹ with the aim of explaining the spatial variability of mortality observed in the city of Taranto. The exposure of the population to pollution sources was assessed as a function of both the distance between the central point

of the industrial site and the center of each district, SO₂ and PM₁₀ values were estimated in each sub-municipal area. Mortality was analyzed with the integration of socio-economic data disaggregated by tax data provided by ISTAT.²² The results of this latter study reported a high variability in mortality observed for both sexes, explained both by environmental indicators and by socioeconomic variables.³³ In particular, higher mortality was observed both in association with the highest concentrations of PM₁₀ in the neighborhoods closer to the industrial area (namely those more deprived) and in association with the highest SO₂ values recorded in neighborhoods far from the steel plant (i.e. Paolo VI area).³² Therefore, using PM₁₀ and SO₂ as tracers of other pollutants of industrial origin and integrating socioeconomic deprivation data, the study suggests two different exposure patterns of residents of the city of Taranto: a closest pattern and a distal pattern in relation to the distance from the steel plant. The first refers to exposure to PM₁₀ related to the health risks for citizens living nearby the industrial site; the second refers to exposure to SO₂ associated with health risks for people who live further away from polluting emissive sources of industrial origin.⁴¹

Despite the typical limitations of any ecological study, our results largely confirms the results of the epidemiological report performed by Forastiere et al.²⁹, which in the period of enrolment of the cohorts (1898-2010) estimates the excesses of general mortality (for all causes) in the Northern neighbourhoods of the City: + 12% in males and + 9% in females living in Tamburi (reaching statistical significance only in males); and + 27% for males and + 28% for females (both sexes statistically significant).

The epidemiological and environmental evidence available for the Taranto area shows a health and environmental picture with multiple critical aspects, claiming for primary prevention interventions and continuous monitoring of the health status of the population.³⁴² This would require a feasible tool to rapidly perform a preliminary assessment of population health status every year, preferably based on official data provided by the same municipality and able to allow epidemiological comparison between different years, age groups, gender and neighborhoods. Municipal mortality data have been here used for the first time and their suitability for epidemiological purposes is analyzed to provide timely indicators of intra-municipal mortality for each neighborhood. Our results are consistent with those of the studies already conducted in the context of national and regional projects, which have highlighted an increase in general mortality in particular in the northern districts of Taranto city, closer to the industrial area and mineral parks.⁴¹⁻⁴³ In our preliminary methodological test, we have shown that the mortality and demographic data of the municipal register can be used more reliably than official ISTAT source, and avoids divergences or misalignments between the real data and those transferred to national level. The municipal registry data therefore appear as a source of first choice data as, on the one hand, greater accuracy and timeliness in the study of mortality, on the other hand to carry out this study at the sub-municipal level of the districts, with respect to municipal and provincial aggregate ISTAT data.

This analysis allows us to highlight the excess mortality of specific neighborhoods, which otherwise would not have emerged by limiting ourselves to the analysis of the average mortality of the entire municipality, also made for single causes of death ICD-10. Furthermore, it comes out that the analysis of the standardized mortality rate (SMR) at the municipal and sub-municipal level shows that for medium-large cities it is necessary to analyze the mortality at the neighborhood level, given that the higher mortality in the entire municipality (as in the analysis of this study) is essentially attributable to a significant excess of mortality among residents in some neighborhoods. This could be particularly true in cities that suffer from severe environmental pressures that are not widespread but located in specific areas of the city such as the large steel plant in the north-western part of Taranto. The values of SMR are very high in both men and women of the 3 neighborhoods (Paolo VI, Tamburi and Città Vecchia/Borgo) closer to the steel plant, showing a constant but significantly higher trend for women, while for men the increasing trend presented even very high peaks (>50%) in recent years (1.56 vs municipality 1.68 vs region in 2019), with significant excesses (IC: 90%) in many years and with a strong worsening trend if compared with Apulia regional data, thus confirming the very strong health inequalities suffered by the citizens of these neighborhoods. Statistical significance has been set at 90% confidence intervals in accordance to that of SENTIERI study, but the analyses have been performed also considering 95%CI, showing almost no differences.

Thus, a strong concern emerges about the inequalities of mortality found in the City of Taranto, for the significant excesses detected in the Northern 3 districts vs. the others, as well as for the excessively positive trend in deaths of males in Paolo VI neighborhood, further worsened in recent years. The significant excesses of mortality have increased from 2011 to 2020, resulting in a total of 1020 deaths. It is important to highlight that the excess of mortality progressively extended across several neighborhoods of Taranto city starting from the one closest to the steel plant (Tamburi) and then involving also Paolo VI and Città Vecchia/Borgo. In the frame of an emerging need for a careful assessment of environmental data in relation to people's health, this paper calls for population studies able to investigate the general population health status by using specific biochemical, molecular, and epigenetic biomarkers in the perspective of Precision and Gender Medicine.⁴⁴⁻

Conclusions.

The use of municipality data can be considered a methodological approach that allows a timely, reliable and costless first-line assessment of the population status and drive urban planning policies in cities suffering from heavy environmental pressures. The significant excesses of mortality have increased and progressively extended from 2011 to 2020 across several neighborhoods of Taranto city. Specifically, our study on overall mortality in Taranto confirmed a greater health risks in all the 3 neighborhoods close to the steel plant

(namely PAOLO VI, Tamburi-Lido Azzurro and Città Vecchia-Borgo), resulting in a total of 1020 excess deaths from 2011 to 2020.

Authors' contribution: Valerio Gennaro, Stefano Cervellera, Carlo Cusatelli, Alessandro Miani, Francesco Pesce, Gianluigi De Gennaro, Alessandro Distante, Luigi Vimercati, Loreto Gesualdo, Prisco Piscitelli conceived the study, prepared, wrote, and approved the manuscript. Stefano Cervellera, Valerio Gennaro, Carlo Cusatelli and Prisco Piscitelli performed and revised the analyses.

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Figure 1. Comparison between Taranto Registry Office with ISTAT data concerning resident population (A) and number of deaths (B) in the city of Taranto by year (1992-2020).

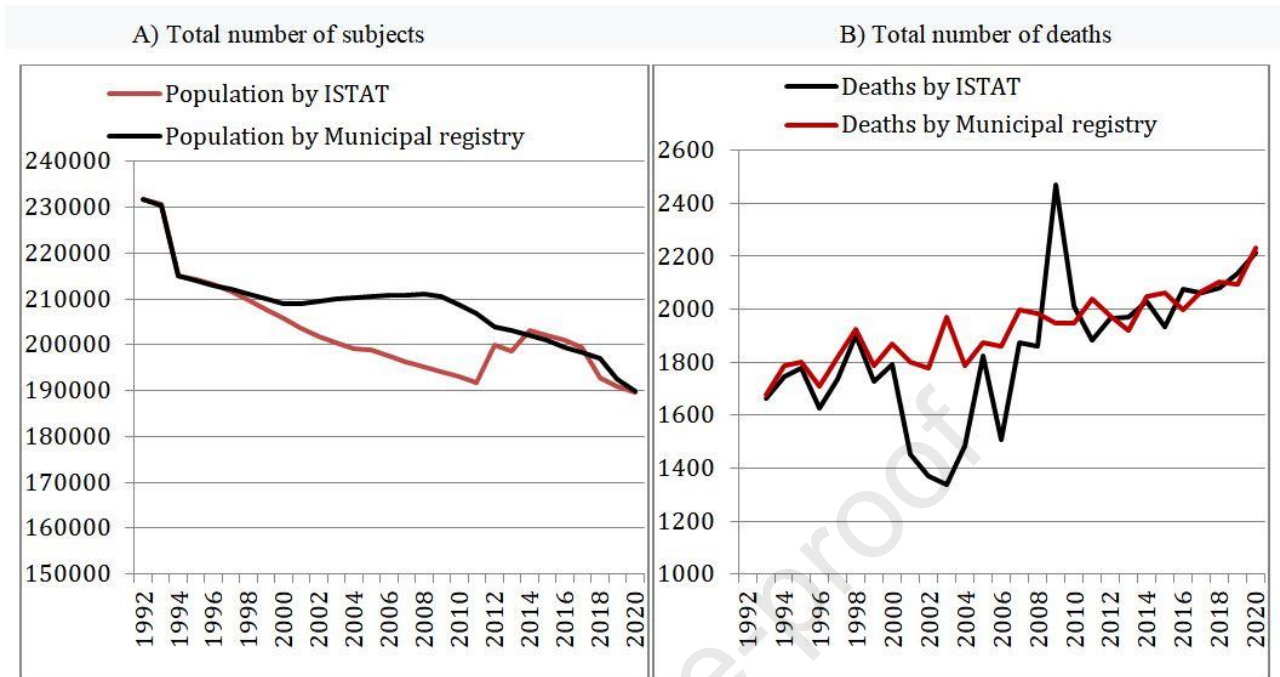


Figure 2. Taranto city: neighborhoods and industrial area

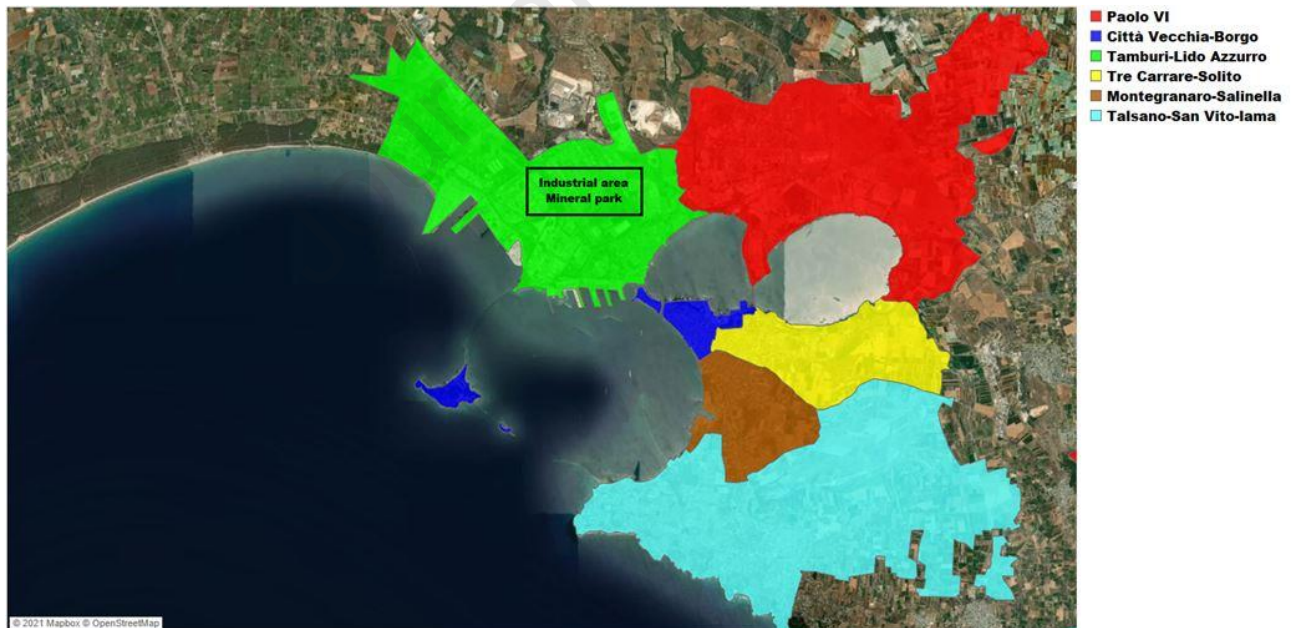


Figure 3. Standardized Mortality Rates by sex and year in the six neighborhoods of Taranto, with mortality rates directly standardized by age and sex on Taranto city reference population (2011-2020 presented as two year-intervals).

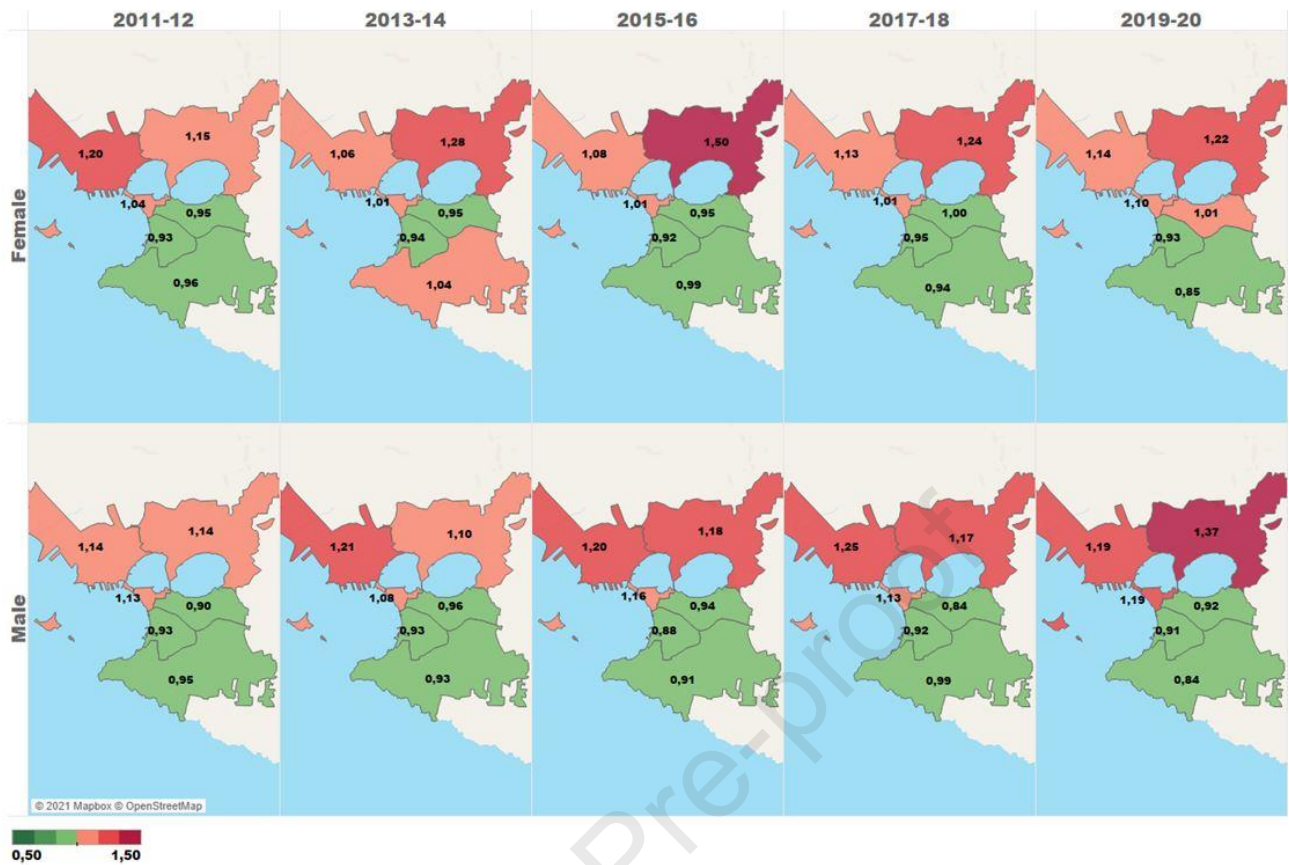


Figure 4. Standardized Mortality Rates by sex and year in the six Taranto neighborhoods, with mortality rates directly standardized by age and sex on Apulia Region reference population (2011-2018 presented as two year-intervals; 2019 presented as single year due to unavailable data about 2020).

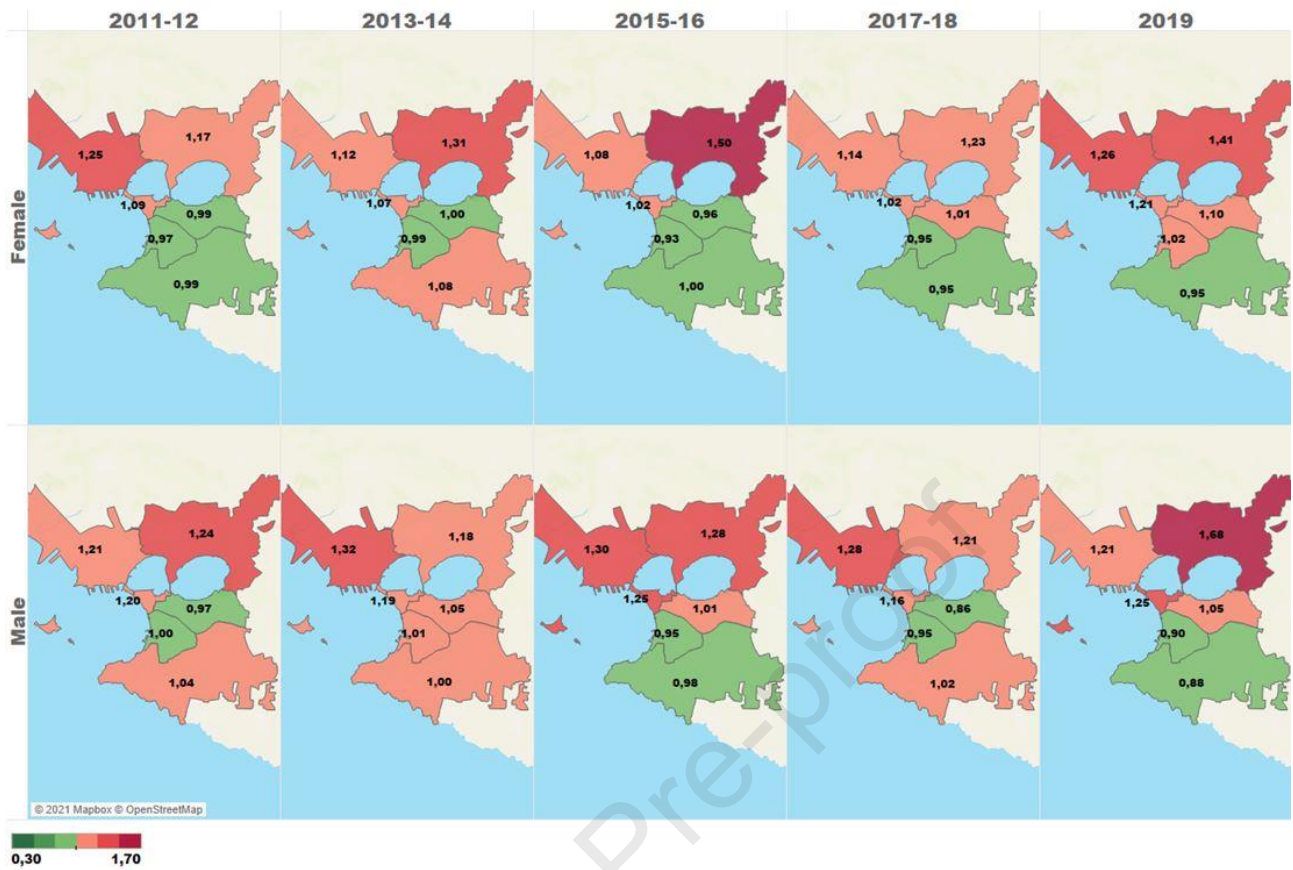


Table 1. Socio-economic deprivation of neighborhoods, classification in quintiles of the Apulia region (SENTIERI Study) 25,26

Neighborhood	Position (distance to industrial area - mineral park)	Socio Economic Deprivation
Paolo VI	Nord-Est (~ 4 km near industrial area - mineral park)	High Deprivation
Tamburi-Lido Azzurro	Nord (< 500 mt near industrial area - mineral park)	High Deprivation
Città Vecchia-Borgo	Central (~ 2 km near industrial area - mineral park)	Medium - High Deprivation
Tre Carrare - Solito	Central-Est (~ 5 km near industrial area - mineral park)	High Deprivation
Montegranaro - Salinella	Central-Sud (~ 5,5 km near industrial area - mineral park)	High Deprivation
Talsano Lama S. Vito	Sud (~ 11 km near industrial area - mineral park)	Low Deprivation

Table 2. Population structure, by age and gender, of the resident population in the 6 Taranto neighborhoods (years 2011 and 2020); the level of socio-economic deprivation is elaborated by the IDSENTIERI model (2011 census data)^{22,26}

gender	class age	year	Paolo VI	Tamburi-Lido Azzurro	Città Vecchia-Borgo	Tre Carrare - Solito	Montegranaro - Salinella	Talsano Lama S. Vito
Females	0-14	2011	2189	1959	3735	3265	3870	4698
		2020	1816	1649	3177	2680	3166	3833
	20-39	2011	2544	2319	5032	4778	5406	6079
		2020	1920	1855	3872	3665	3907	4648
	40-64	2011	2947	2837	7517	7689	8632	8498
		2020	3157	2801	7599	6940	7995	8473
	65-79	2011	1143	1206	3631	3701	4275	2869
		2020	1181	1251	3469	4125	4376	3849
	80 +	2011	174	670	2188	1693	1770	871
		2020	473	629	2074	1973	2405	1364
Males	0-14	2011	2349	2062	3918	3391	3933	4947
		2020	1934	1782	3260	2791	3196	4082
	20-39	2011	2629	2325	5150	4816	5205	6122
		2020	2065	1918	4352	3659	3895	4564
	40-64	2011	2921	2762	7001	6740	7612	8046
		2020	3163	2695	6962	6061	6890	7995
	65-79	2011	1012	882	2562	3033	3301	2748
		2020	939	1108	2953	3423	3554	3567
	80 +	2011	120	322	980	891	944	548
		2020	347	308	968	1256	1426	951

Table 3. Total deaths per age groups occurred in the resident populations from 2011 to 2020

gender	class age	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Females	0-14	2	3	2	2	2	4	6	6	5	2	34
	20-39	7	4	4	10	4	3	5	7	5	4	53
	40-64	73	87	77	86	64	105	84	85	87	74	822
	65-79	252	233	212	225	231	231	237	225	257	260	2363
	80 +	699	683	678	727	760	678	776	769	788	871	7429
	Total	1033	1010	973	1050	1061	1021	1108	1092	1142	1211	10701
Males	0-14	3	8	4	2	12	6	3	4	6	1	49
	20-39	16	14	19	13	9	19	9	9	10	9	127
	40-64	165	153	138	142	135	138	145	129	138	134	1417
	65-79	361	345	296	336	339	329	330	334	361	331	3362
	80 +	453	444	491	502	508	484	470	534	514	603	5003
	Total	998	964	948	995	1003	976	957	1010	1029	1078	9958
Total F + M		2031	1974	1921	2045	2064	1997	2065	2102	2171	2289	20659

Table 4. Average population and average deaths per each Taranto neighborhood (2011-2020), with graph deaths distribution across the study period.

Neighborhood	gender	Average Population (2011-20)	Average Deaths (2011-20)
Paolo VI	Females	8.897	59,1
	Males	8.853	70,3
Tamburi-Lido Azzurro	Females	8.642	94,2
	Males	8.088	87,4
Città Vecchia-Borgo	Females	21.155	281,7
	Males	18.888	241,8
Tre Carrare - Solito	Females	20.267	234,4
	Males	17.929	203,6
Monte granaro - Salinella	Females	23.027	247,7
	Males	20.004	222,1
Talsano Lama S. Vito	Females	22.654	153
	Males	21.796	170,6

Table 5. Standardized Mortality Rate (SMR) by neighborhood, sex and year, compared to indirectly standardized mortality rates by age and sex, using Taranto city as reference population (2011-2020); the excess of mortality with statistical significance (CI 90%) are highlighted in red.

Neighborhood	gender	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Paolo VI	Females	1,18	1,12	1,26	1,30	1,52	1,49	1,08	1,38	1,27	1,17
	Males	0,94	1,34	1,03	1,17	1,11	1,25	1,16	1,18	1,56	1,20
Tamburi-Lido Azzurro	Females	1,27	1,12	1,12	1,01	1,11	1,05	1,13	1,12	1,14	1,14
	Males	1,11	1,16	1,20	1,22	1,21	1,20	1,17	1,33	1,13	1,25
Città Vecchia-Borgo	Females	1,03	1,06	1,01	1,01	1,01	1,02	1,05	0,97	1,10	1,09
	Males	1,13	1,13	1,08	1,09	1,24	1,08	1,17	1,10	1,18	1,20
Tre Carrare - Solito	Females	0,96	0,94	1,04	0,87	0,93	0,98	0,99	1,00	1,00	1,01
	Males	0,93	0,88	0,95	0,97	0,92	0,96	0,89	0,79	0,99	0,86
Montegranaro - Salinella	Females	0,88	0,99	0,90	0,98	0,90	0,95	0,86	1,04	0,93	0,93
	Males	0,94	0,91	0,92	0,93	0,84	0,92	0,91	0,94	0,85	0,96
Talsano Lama S. Vito	Females	1,03	0,89	0,94	1,12	1,06	0,93	1,08	0,80	0,83	0,86
	Males	0,97	0,93	0,98	0,88	0,91	0,91	0,95	1,04	0,81	0,88

Table 6. Standardized Mortality Rate (SMR) by neighborhood, sex and year, compared to indirectly standardized mortality rates of Apulia region reference population by sex and age (2011-2020); the excess of mortality with statistical significance (CI 90%) are highlighted in red

Neighborhood	gender	2011	2012	2013	2014	2015	2016	2017	2018	2019
Paolo VI	Females	1,23	1,12	1,23	1,38	1,47	1,53	1,08	1,37	1,41
	Males	1,05	1,43	1,07	1,28	1,18	1,38	1,17	1,24	1,68
Tamburi-Lido Azzurro	Females	1,35	1,15	1,15	1,09	1,10	1,07	1,15	1,13	1,26
	Males	1,22	1,21	1,29	1,35	1,30	1,31	1,16	1,41	1,21
Città Vecchia-Borgo	Females	1,09	1,08	1,05	1,09	1,02	1,03	1,07	0,98	1,21
	Males	1,23	1,18	1,16	1,21	1,34	1,17	1,16	1,17	1,25
Tre Carrare - Solito	Females	1,02	0,96	1,07	0,94	0,93	0,99	1,00	1,01	1,10
	Males	1,02	0,92	1,01	1,08	0,98	1,05	0,88	0,84	1,05
Montegranaro - Salinella	Females	0,93	1,00	0,92	1,05	0,90	0,96	0,86	1,05	1,02
	Males	1,04	0,96	0,98	1,04	0,89	1,01	0,90	0,99	0,90
Talsano Lama S. Vito	Females	1,09	0,90	0,94	1,21	1,04	0,96	1,10	0,80	0,95
	Males	1,08	1,00	1,03	0,97	0,97	0,99	0,94	1,09	0,88

Table 7. Observed (Dx Oss.) and expected deaths in the six neighborhoods (IC 90%) compared to indirectly standardized mortality rates by age and sex on Apulia region reference population (2011-2020). Red bullet points refer to significant excess of mortality (IC 90%)

years	gender	Neighborhood	Expected Death	Observed Death	IC90%	Statistica Significance
2011-12-13	Females	Paolo VI	114	136	(117-156)	Yes
		Tamburi-Lido Azzurro	236	287	(259-316)	Yes
		Città Vecchia-Borgo	792	853	(805-902)	Yes
		Tre Carrare - Solito	657	667	(625-711)	No
		Montegranaro - Salinella	709	676	(633-720)	No
		Talsano Lama S. Vito	406	397	(364-431)	No
	Males	Paolo VI	150	178	(156-201)	Yes
		Tamburi-Lido Azzurro	211	262	(235-290)	Yes
		Città Vecchia-Borgo	617	734	(690-780)	Yes
		Tre Carrare - Solito	606	597	(557-638)	No
		Montegranaro - Salinella	651	647	(605-690)	No
		Talsano Lama S. Vito	475	492	(456-530)	No
2014-15-16	Females	Paolo VI	128	188	(166-212)	Yes
		Tamburi-Lido Azzurro	243	264	(237-292)	No
		Città Vecchia-Borgo	779	815	(768-863)	No
		Tre Carrare - Solito	697	663	(621-706)	No
		Montegranaro - Salinella	750	727	(683-772)	No
		Talsano Lama S. Vito	445	475	(439-512)	No
	Males	Paolo VI	162	207	(183-232)	Yes
		Tamburi-Lido Azzurro	201	266	(239-294)	Yes
		Città Vecchia-Borgo	587	729	(685-775)	Yes
		Tre Carrare - Solito	609	631	(590-673)	No
		Montegranaro - Salinella	664	650	(608-693)	No
		Talsano Lama S. Vito	501	491	(455-529)	No
2017-18-19	Females	Paolo VI	151	196	(173-220)	Yes
		Tamburi-Lido Azzurro	245	290	(262-319)	Yes
		Città Vecchia-Borgo	779	844	(796-893)	Yes
		Tre Carrare - Solito	722	747	(702-793)	No
		Montegranaro - Salinella	807	789	(743-836)	No
		Talsano Lama S. Vito	500	476	(440-513)	No
	Males	Paolo VI	175	239	(214-266)	Yes
		Tamburi-Lido Azzurro	202	255	(229-282)	Yes
		Città Vecchia-Borgo	591	705	(661-750)	Yes
		Tre Carrare - Solito	647	597	(557-638)	No
		Montegranaro - Salinella	712	663	(621-706)	No
		Talsano Lama S. Vito	553	537	(499-576)	No

Table 8. Standardized mortality rates by sex and year in the six neighborhoods of Taranto, with mortality rates directly standardized by age and sex on Taranto city reference population (2011-2020).

gender	Neighborhood	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Females	Paolo VI	12,32	8,98	12,76	13,62	15,55	14,96	11,55	13,88	15,00	13,04
	Tamburi-Lido Azzurro	12,15	10,62	10,70	9,92	11,29	10,19	12,07	12,26	13,04	13,73
	Città Vecchia-Borgo	9,86	10,14	9,32	10,12	10,25	10,12	11,35	10,47	12,50	13,24
	Tre Carrare - Solito	9,18	8,89	9,45	8,70	9,32	9,58	10,58	10,65	11,37	12,24
	Montegranaro - Salinella	8,35	9,38	8,18	9,79	9,08	9,23	9,10	11,11	10,54	11,28
	Talsano Lama S. Vito	9,84	8,30	8,59	11,39	10,74	9,42	11,98	8,83	9,76	10,57
Males	Paolo VI	9,68	11,60	9,31	11,36	12,50	14,01	12,17	12,61	16,32	15,00
	Tamburi-Lido Azzurro	11,42	11,60	11,41	12,84	12,58	12,29	11,78	14,60	12,65	14,50
	Città Vecchia-Borgo	11,83	11,47	10,52	11,37	13,47	11,31	11,91	11,86	13,02	14,06
	Tre Carrare - Solito	9,36	8,69	9,25	10,06	9,58	9,95	8,87	8,40	10,85	10,10
	Montegranaro - Salinella	9,50	9,02	9,00	9,67	8,77	9,42	9,14	10,17	9,39	11,26
	Talsano Lama S. Vito	9,84	9,46	9,80	9,43	9,84	9,31	9,73	11,45	9,12	10,50

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

On behalf of all authors

Dr Prisco Piscitelli