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Study of the excess mortality associated with the SARS-CoV-2 pandemic in the Local Health Authorities and Districts of the Autonomous Region of Sardinia - quinquennium 2017-2021

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Keywords: Mortality; excess mortality; old-age index; social and health services; re-modulating health interventions; Standardized mortality ratios: SMRs

Parole chiave: Mortalità; eccesso di mortalità; indice di vecchiaia;, servizi socio-sanitari; rimodulazione dei servizi sanitari; tassi standardizzati di mortalità

Abstract

Background. *Based on the indications of the Italian National Recovery and Resilience Plan and the Ministerial Decree n°77/2022, detecting specific populations' social-welfare needs is essential to reorganize the national and regional health service. The present analysis studies the impact of pandemic and pre-pandemic conditions in terms of mortality on Sardinian health service organizational subunits to indirectly investigate the need for specific social and health interventions.*

Design. *Retrospective observational mortality study on the Sardinian resident population, surveyed by the Italian National Institute of Statistics (Istat) from 2017 to 2021.*

Methods. *The database was built by crossing demographic data from the Istat divided into 21 five-year age groups (0-4 to 100+). Mortality and excess mortality were calculated with a focus on local health authorities and districts. The analysis were made considering three age groups (0-64, ≥ 65, 0-100+) and comparing the individual years 2020 and 2021 with the pre-pandemic triennium 2017-2019. To better understand the phenomenon of excess mortality, the old age index was calculated for the Local Health Authority and District for each year of the quinquennium considered.*

Results. *Standardized mortality ratios increased in the biennium of the SARS-CoV-2 pandemic compared to the baseline 2017-2019. A global increaseof the Standardized mortality ratios in all districts (2021) was measured, including those with Standardized mortality ratios already increasing in 2020. Notably, the Standardized mortality ratios (2020 and 2021) were often increased by the 0-64 age group. The regional excess mortality (0-100+) confirmed an increase in mortality compared to the baseline, with a slight decrease from 2020 to 2021.*

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List of abbreviations: ASDRs (age-specific mortality rates); CI (confidence interval); EM (excess mortality); ASLs (Local Health Authorities); D.M. (Ministerial Decree); MRR (mortality rate ratio); Istat (National Institute of Statistics); NRRP (National Recovery and Resilience Plan); SMRs (standardized mortality ratios); WHO (World Health Organization).

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Conclusions. *Sardinia presents peculiar demographic and geographical characteristics. Monitoring mortality rates and excess mortality confirms to be crucial to constantly re-modulating health interventions and planning of the supply of services, including the equitable allocation of resources based on actual health needs. Sardinia should embrace the concept of "age-friendly community" and create communities designed to promote active aging and social participation.*

Introduction

The institutional structure of the Regional Health Service has been changed with the Regional Law n. 24 of 2020 (1) and subsequent amendments (2, 3). It envisaged the creation of the Regional Agency of Health (4): one of the Healthcare Organizations in Sardinia, with legal personality under public law and administrative, patrimonial, organizational, technical, managerial, and accounting autonomy. The other organizations present on the territory are: eight Local Health Authorities (ASLs); three hospital companies; the Regional Agency of the Emergency and Urgency of Sardinia; the Zooprophylactic Institute of Sardinia.

The ASLs are organized into operating structures (districts) with managerial autonomy and, according to efficiency, effectiveness, rationality, and economy principles, guarantee i) collective healthcare prevention in living and working environments, ii) district assistance, iii) hospital assistance. Through a solid integration between health and social care interventions, district assistance ensures prevention, health education, diagnosis, treatment, and health promotion activities in the area, guaranteeing the essential levels of assistance (5).

A total of twenty-four social-health districts constitute the territorial articulation of the eight Sardinian ASLs (1), with the function of managing human, instrumental, and financial resources. Each district governs the health demand and organizes the primary assistance in a defined territorial context (6).

To be truly effective, health services must protect the entire population's health and not only those who actively request a health service. In this direction is the introduction of the Ministerial Decree (D.M.) 77/2022 (7, 8), which regulates the interventions envisaged in Mission 6 Component 1 of the Italian National Recovery and Resilience Plan (NRRP) (9) "Proximity networks, structures and telemedicine for territorial healthcare." The D.M. 77/2022 (7) is based on four key concepts: population medicine, active offer of healthcare, population stratification by risk profiles, and a general project of health assistance. The health project programming tool combines population stratification with the classification of health needs by identifying the essential standards of clinical responses (7). This approach would enable two levels of assessment of social welfare needs, management analysis, and evaluation of the outcome at individual and population level. These layers can be used for planning and verifying the results of healthcare services.

Expressing health information in quantitative terms is essential for studying phenomena within populations, proceeding with correct planning of the socio-economic development of a community, and rationalizing the use of resources.

Some phenomena of interest are not directly measurable due to non-uniform surveys and many confounding factors. This happened during the SARS-CoV-2 crisis: official statistics could not satisfy the Health Surveillance needs for managing the emergency. The pandemic outbreak has required new ways of producing and less time for disseminating data to obtain more timely information.

Estimates by the World Health Organization (WHO) showed excess mortality (EM) in the two-year period 2020-2021 of approximately 14.83 million, namely 2.7 times more than those notified as directly attributable to COVID-19 (10). Including all the causes of death, the EM allows searching for any other causes of this excess, including organizational, strategic, and managerial ones. In Italy, according to WHO (10), the excess deaths (directly or indirectly) attributable to SARS-CoV-2 were 160,802 deaths (biennium 2020-2021) compared to the 137,402 SARS-CoV-2 deaths notified by 31st December 2021. The Italian discrepancy estimated by WHO is alignable with other high-income countries. The accuracy of deaths from COVID-19 estimates in Italy was partly influenced by the impact of mortality due to the pressure suffered by the health services and hospitals in particular.

By focusing on the Autonomous Region of Sardinia, the present mortality analysis, conducted on the 2017-2021 quinquennium, aims: i) to evaluate how much the pandemic and the deployment of health, economic and organizational resources impacted the regional health service in its organizational subunits (ASLs

and corresponding districts); ii) to draw attention on the need of specific socio-sanitary interventions aimed at tackling some demographic phenomena (e.g., patchy aging) or potential shortcomings of the Regional Health System (e.g., EM in the youngest segment of the population clustered in specific territories).

Sardinia is likely to have characteristic health needs linked to its specific territory and population. The allocation of resources cannot disregard the consideration of the aging of Sardinians. Therefore, we estimated the mortality rate for the triennium 2017-2019 and the years 2020 and 2021, the EM in 2020 and 2021, and the old age index for each of the years of the quinquennium (2017-2021).

Materials and methods

1. Database

The database was built by crossing national and regional demographic data derived from the National Institute of Statistics (Istat) (11, 12). The data collected related to the resident population in Italy and Sardinia on the 1st of January of each year and to the total number of deaths that occurred by the 31st of December (same year). The data were divided into 21 five-year age groups (0-4 to 100+). The number of residents and deaths relating to Sardinia was collected with detail from the Municipality of residence. The resident population in each Municipality, necessary for establishing the database divided by socio-sanitary districts and ASLs, referred to the 1st of January of each year considered. Therefore, in calculating the average resident population in the triennium 2017-2019, the resident population of the 1st of January 2020 was considered to be sufficiently similar to that of the 31st of January 2019. The populations and deaths relating to the districts and Local Health Authorities were reconstructed using Excel (13).

2. Statistical analysis

To investigate mortality patterns, given the small numbers in some areas, age-standardized mortality ratios (SMRs) and related 95% confidence intervals (CI) were calculated for each district, ASL, and the Region of Sardinia, using the Italian population as standard (year 2020 and 2021, and triennium 2017-2019). Standardized rates referred to the age range 0-100+ and to the subgroup analysis 0-64 and ≥ 65. For an example of how we calculated the SMRs, see the Excel file kept available for online consultation[1].

Using the direct method of standardization, the age-standardized death rate of Sardinia and related 95% CI were calculated by applying to the standard Italian population the weights obtained from Sardinia population for 2020 and 2021, and 2017-2019 triennium. ASLs' age-standardized death rate and related 95% CI were calculated by applying to the Sardinian standard population the weights obtained from each ASL population for the same year/period.

The mortality rate ratios (MRRs) of the ASLs and related 95% CI were calculated for the triennium (2017-2019), 2020 and 2021, considering as a reference the ASL with the lowest mortality rate.

The triennium 2017-2019 was used as a baseline to manage the fluidity of seasonal mortality and limit the effect of any unexpected peaks during that period. These factors, on the contrary, may affect a shorter baseline.

The old age index was calculated individually for each year of the five-year period (2017-2021) with details for the Region of Sardinia, ASLs, and corresponding districts to better evaluate the phenomenon's trend over time. The data relating to the national old age index were extracted from Istat (11, 12).

We estimate the EM of ASLs and districts for 2020 and 2021 considering as baseline the Sardinian mortality for the triennium 2017-2019. The same approach was used for the sub-analysis on 0-64 and ≥ 65 age classes.

Several statistical models (10, 14-17) estimated the EM for the years of the pandemic 2020-2021, compared to the average of the period 2011-2019 or of the five-year period 2015-2019. Eurostat (18), instead, identified the baseline as the average of the number of deaths that occurred in each month in the period 2016-2019, making it possible to compare the EMs of different European countries, eliminating confounders.

Following the Eurostat approach, but on annual basis, we considered a 3-year baseline, assuming that this could reduce the distortions related to the

[1] https://docs.google.com/spreadsheets/d/1PrEAeZx1bItP9vDh7xYTqduQqjMg3bt8/edit?usp=sharing&ouid=106693069713588801899&rtpof=true&sd=true; authors and copyright owners: Sara Maria Pani, Federica Cadoni, Luigi Minerba. Data administrator: Sara Maria Pani, saramariapani@gmail.com; Department of Medical Sciences and Public Health, University of Cagliari, asse didattico E, SS 554 bivio Sestu, 09042 Monserrato (CA), Italy.

asynchronous aging of the Sardinian population compared to that of Italy.

Results

1. Standardized Mortality Ratios

The photograph of the geographic variability emerging from our analysis highlights territorial patterns, some of which recurrent, in the comparison between the pre-pandemic triennium and the years 2020 and 2021. The results showed an overall increase in SMRs (0-100+) in 8 districts in 2020 and all 24 districts in 2021, compared to the triennium 2017-2019. In 2021 there was an overall increase in SMRs in all ASLs and districts, including those with SMRs already increased in 2020 (vs baseline) (see Supplemental Materials, Table 1).

Despite a trend of increased mortality for the year 2021, the ASL of Cagliari showed a constant pattern of lower mortality, with the Area Vasta district having the lowest SMR (0-100+) in all the years considered.

Table 1. Standardized Death Rate and Mortality Rate Ratio – ASLs

SR and MRR - Sardinian ASLs								
2017-2019[a]								
	SR	SE	CI		MRR	SE	CI	
ASL	proportion X 1000		Min	Max			Min	Max
Cagliari	8.96	0.13	8.71	9.22	1.00			
Carbonia	9.83	0.27	9.30	10.09	1.10	0.09	0.92	1.27
Sanluri	10.63	0.32	10.01	10.89	1.19	0.03	1.13	1.24
Lanusei	9.89	0.40	9.10	10.14	1.10	0.03	1.05	1.15
Oristano	10.22	0.24	9.76	10.48	1.14	0.01	1.12	1.16
Nuoro	10.40	0.25	9.91	10.66	1.16	0.03	1.11	1.22
Sassari	9.88	0.17	9.54	10.13	1.10	0.02	1.07	1.14
Olbia	10.24	0.28	9.69	10.49	1.14	0.06	1.03	1.25
2020								
	SR	SE	CI		MRR	SE	CI	
ASL	proportion X 1000		Min	Max			Min	Max
Cagliari	9.75	0.14	9.48	10.01	1.00			
Carbonia	11.42	0.30	10.84	11.69	1.17	0.10	0.98	1.36
Sanluri	11.77	0.34	11.11	12.04	1.21	0.03	1.15	1.26
Lanusei	10.39	0.42	9.57	10.66	1.07	0.03	1.01	1.12
Oristano	11.91	0.26	11.40	12.17	1.22	0.01	1.20	1.24
Nuoro	12.21	0.28	11.67	12.48	1.25	0.03	1.19	1.31
Sassari	11.51	0.19	11.14	11.77	1.18	0.02	1.14	1.22
Olbia	11.46	0.29	10.89	11.73	1.18	0.06	1.06	1.29
2021								
	SR	SE	CI		MRR	SE	CI	
ASL	proportion X 1000		Min	Max			Min	Max
Cagliari	9.87	0.14	9.60	10.14	1.00			
Carbonia	11.75	0.30	11.16	12.02	1.19	0.10	1,00[b]	1.38
Sanluri	12.26	0.35	11.57	12.53	1.24	0.03	1.19	1.30
Lanusei	12.11	0.46	11.21	12.38	1.23	0.03	1.17	1.28
Oristano	12.17	0.26	11.65	12.44	1.23	0.01	1.21	1.25
Nuoro	12.43	0.28	11.87	12.70	1.26	0.03	1.20	1.32
Sassari	11.06	0.19	10.70	11.33	1.12	0.02	1.08	1.16
Olbia	11.49	0.29	10.91	11.76	1.16	0.06	1.05	1.28

SR= Standardised death Rate; MRR= Mortality Rate Ratio; SE= Standard Error; CI= Confidence Interval

[a]For the triennium: population calculated as the average between the population on 01/01/2017 and 01/01/2020; ASL deaths calculated as average deaths of 2017-2019 period.

[b] value 0,997

This phenomenon is driven mostly by the age group ≥65. For details see Supplemental Materials, Tables 2 and 3. It should be observed that the SMR fluctuations of the individual ASL were influenced by the trend of the SMRs of its districts, which sometimes presented a substantial discrepancy between them already in the three years preceding the pandemic.

The results of the subgroup analysis showed that it is often the weight of the 0-64 age group that increases the global SMR (0-100+) in the years 2020 and 2021 (Supplemental Materials, Table 1 and 2). The ASL of Gallura represents an exception with a decreased mortality in 2021 driven mainly by the 0-64 age group. For a graphical representation of districts' SMRs, see Figure 1.

2. Standardized rates and mortality rate ratio

The regional standardized rate showed an increase in mortality in 2020 and a slight decrease in 2021. The ASL of Cagliari showed the lowest mortality rate and this was considered as a reference for MRRs calculation. All the ASLs showed a significant difference from the references confirmed by the CI of the MRRs, except for the ASL of Sulcis. See Table 1 and Supplemental Material Table 4 for details.

3. Excess mortality

The EM analysis for 2020 and 2021 confirmed what already emerged from the other results. The regional data (0-100+) indicated an increase in mortality compared to the baseline, with a slight

Table 2. Excess Mortality

EXCESS MORTALITY													
		0-100+				age group 0-64				age group ≥ 65			
		2020		2021		2020		2021		2020		2021	
		EM	%	EM	%	EM	%	EM	%	EM	%	EM	%
CAGLIARI													
	Area Vasta	167	8.1%	119	5.8%	1	0.3%	2	0.6%	166	9.5%	117	6.7%
	Area Ovest	116	11.9%	161	16.6%	1	0.4%	-3	-2.0%	115	14.4%	164	20.5%
	Quartu-Parteolla	48	5.4%	72	8.0%	14	9.0%	21	13.7%	34	4.6%	51	6.9%
	Sarrabus-Gerrei	16	6.0%	28	10.5%	3	8.2%	-8	-25.8%	13	5.7%	36	15.5%
	Sarcidano - Barbagia di Seulo e Trexenta	8	1.5%	17	3.2%	11	17.1%	0	-0.5%	-3	-0.6%	17	3.7%
	TOTAL ASL	354	7.5%	396	8.4%	29	3.9%	11	1.5%	326	8.2%	386	9.7%
CARBONIA													
	Carbonia	115	19.3%	98	16.5%	21	28.0%	-1	-1.3%	94	18.1%	99	19.0%
	Iglesias	57	12.3%	108	23.2%	-19	-25.3%	7	10.0%	76	19.3%	101	25.7%
	Isole San Pietro e Sant'Antioco	15	6.0%	9	3.7%	0	0.0%	6	24.0%	15	6.6%	3	1.4%
	TOTAL ASL	187	14.2%	215	16.4%	2	1.3%	12	7.1%	185	16.2%	203	17.8%
SANLURI													
	Sanluri	36	7.0%	59	11.4%	-6	-10.0%	13	21.7%	42	9.2%	46	10.1%
	Guspini	63	10.6%	64	10.7%	11	12.1%	9	9.9%	52	10.3%	55	10.9%
	TOTAL ASL	99	8.9%	123	11.1%	5	3.3%	22	14.6%	94	9.8%	101	10.5%
LANUSEI													
	Tortoli	5	0.9%	96	15.6%	3	4.3%	15	20.0%	2	0.4%	81	14.9%
	TOTAL ASL	5	0.9%	96	15.6%	3	4.3%	15	20.0%	2	0.4%	81	14.9%
ORISTANO													
	Oristano	124	15.8%	89	11.4%	26	27.5%	13	13.6%	98	14.3%	76	11.1%
	Ales-Terralba	58	11.0%	89	16.9%	10	16.5%	11	18.1%	48	10.3%	78	16.7%
	Ghilarza-Bosa	67	11.5%	74	12.7%	9	16.2%	20	35.3%	57	11.0%	53	10.2%
	TOTAL ASL	249	13.2%	252	13.3%	45	21.2%	44	20.7%	203	12.1%	207	12.4%
NUORO													
	Nuoro	135	15.1%	97	10.8%	8	6.2%	-3	-2.0%	127	16.6%	100	13.1%
	Macomer	7	2.6%	41	14.7%	-10	-28.4%	5	12.8%	18	7.2%	37	14.9%
	Siniscola	62	20.2%	61	19.9%	-1	-2.1%	11	22.9%	63	24.3%	50	19.3%
	Sorgono	35	15.1%	32	13.8%	-3	-10.7%	3	10.7%	38	18.6%	29	14.2%
	TOTAL ASL	240	14.0%	232	13.5%	-6	-2.4%	16	6.5%	246	16.7%	216	14.7%
SASSARI													
	Sassari	357	18.2%	188	9.6%	12	3.8%	19	6.0%	345	20.9%	169	10.3%
	Alghero	63	7.2%	69	7.8%	-23	-20.3%	-20	-17.6%	86	11.1%	89	11.5%
	Ozieri	78	21.4%	19	5.1%	9	23.9%	6	15.6%	69	21.1%	13	4.0%
	TOTAL ASL	498	15.5%	276	8.6%	-2	-0.5%	5	1.0%	500	18.2%	271	9.9%
OLBIA													
	Olbia	146	15.7%	111	11.9%	39	27.8%	16	11.5%	107	13.5%	95	12.0%
	Tempio	21	6.1%	26	7.6%	-5	-10.9%	-9	-19.6%	26	8.8%	35	11.9%
	La Maddalena	-5	-4.3%	22	20.6%	3	23.5%	1	5.9%	-7	-7.5%	22	22.3%
	TOTAL ASL	162	11.8%	159	11.6%	37	18.6%	8	4.0%	125	10.6%	151	12.8%
REGIONAL		1794	11.3%	1749	11.0%	113	5.0%	133	5.9%	1681	12.3%	1616	11.8%

[1]Reference: average observed deaths in the triennium 2017-2019 (Regional - ASLs - Districts); percentage calculated based on the difference with reference.

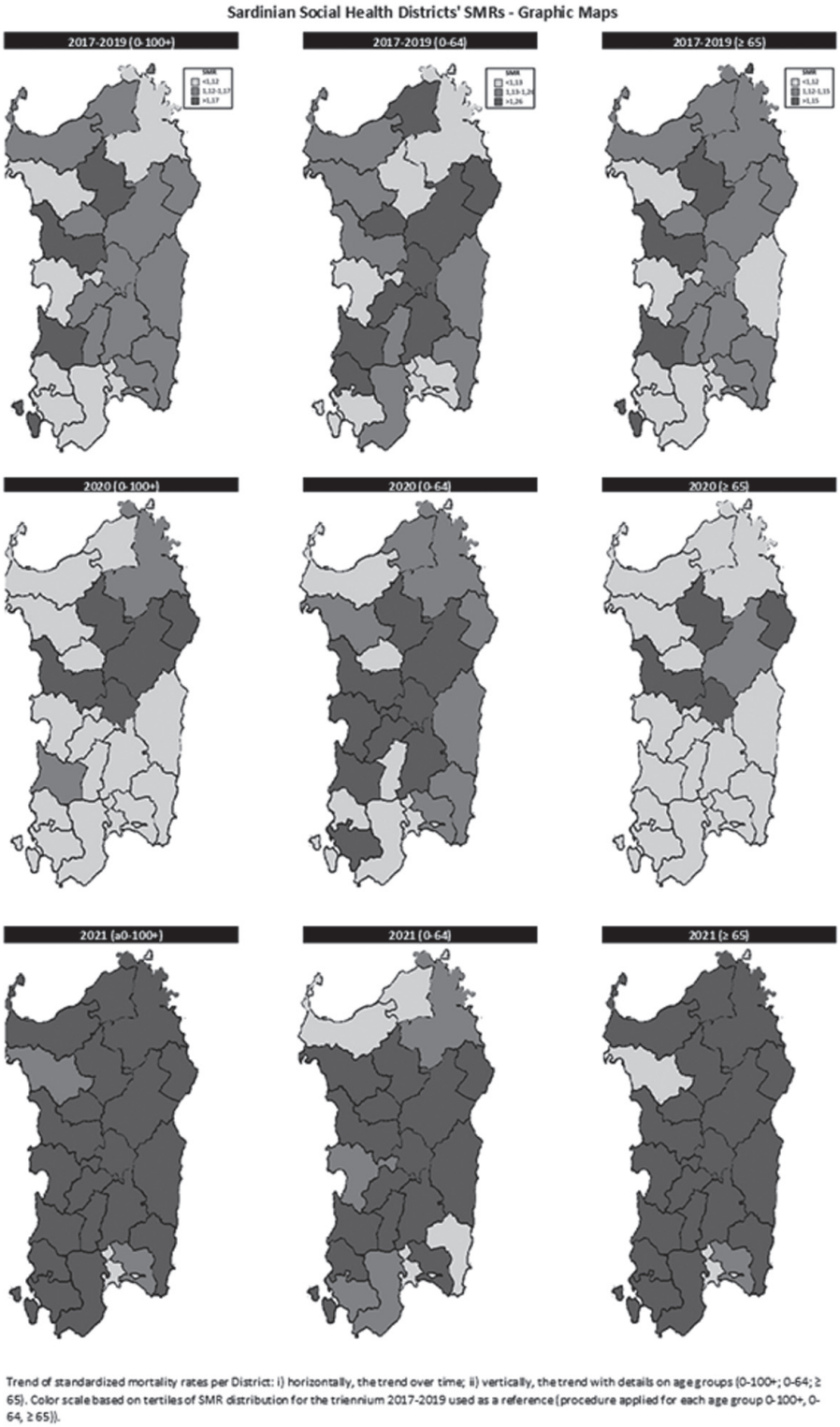

Figure 1 - Standardized mortality ratios - Graphic Maps

Table 3. Old Age Index

		OLD AGE INDEX				
ASL	DISTRICTS	2021	2020	2019	2018	2017
CAGLIARI						
	Area Vasta	245.7	237.2	227.7	218.0	211.3
	Area Ovest	182.0	172.0	163.4	153.4	146.3
	Quartu-Parteolla	185.3	175.7	165.9	156.2	149.1
	Sarrabus-Gerrei	279.7	271.2	257.2	244.2	234.5
	Sarcidano - Barbagia di Seulo e Trexenta	259.4	252.7	243.3	235.7	228.2
	TOTAL ASL	219.1	210.2	200.8	190.8	183.7
CARBONIA						
	Carbonia	318.3	302.0	285.0	270.0	253.5
	Iglesias	283.7	269.8	253.4	240.3	227.3
	Isole San Pietro e Sant'Antioco	316.4	308.7	294.4	283.0	273.7
	TOTAL ASL	304.9	290.9	274.6	260.9	246.9
SANLURI						
	Sanluri	278.2	267.9	256.2	246.5	235.4
	Guspini	252.0	243.1	232.0	222.3	215.0
	TOTAL ASL	263.3	253.7	242.4	232.8	223.9
LANUSEI						
	Tortolì	215.3	207.9	198.3	192.1	188.3
	TOTAL ASL	215.3	207.9	198.3	192.1	188.3
ORISTANO						
	Oristano	269.5	257.8	245.3	233.4	224.0
	Ales-Terralba	300.8	287.4	276.1	263.9	255.6
	Ghilarza-Bosa	295.6	290.0	281.8	273.8	266.5
	TOTAL ASL	284.5	274.0	262.9	251.8	243.3
NUORO						
	Nuoro	223.4	212.9	203.6	194.3	186.5
	Macomer	300.3	285.5	268.9	261.8	252.8
	Siniscola	182.3	175.0	167.0	160.5	156.1
	Sorgono	321.3	308.2	295.2	278.6	266.1
	TOTAL ASL	231.1	221.0	211.1	202.2	194.8
SASSARI						
	Sassari	218.6	209.5	199.6	190.1	183.4
	Alghero	262.2	251.8	241.6	232.8	226.2
	Ozieri	237.9	229.2	220.2	209.8	203.7
	TOTAL ASL	230.1	220.7	210.8	201.4	194.8
OLBIA						
	Olbia	159.7	153.0	147.6	140.6	135.5
	Tempio	252.6	243.2	234.6	225.3	221.4
	La Maddalena	247.8	235.9	224.4	211.6	205.8
	TOTAL ASL	179.1	171.8	165.7	158.1	153.2
REGIONAL		**231.5**	**222.2**	**212.4**	**202.7**	**195.5**
NATIONAL		**182.6**	**179.3**	**174**	**168.9**	**165.3**

decrease from 2020 to 2021. The data broken down by ASL showed that, although they share a similar excess of deaths over the years 2020 and 2021, the decrease in the regional mortality was driven mostly by 3 out of 8 ASLs. In all the 5 ASLs that show an increase from 2020 to 2021 the ≥65 age class was impacted, however, the 0-64 age class was the one to drive the EM in 3 out of 5 (Carbonia, Sanluri and Lanusei).

The EM analysis per district confirmed a remarkable heterogeneity of the mortality phenomenon between districts, even within the same ASL. Being the EM calculated with respect to the average of the baseline for each district, it was possible to observe the behavior of the single district over time (Table 2).

4. Old age index

Sardinia showed a significantly higher regional old-age index than the national one, with an initial difference (2017) of 30 absolute points, which progressively grows to 48.9 points in 2021. The data showed, in consecutive years, a progressive increase of the old age index in all districts, more pronounced in some geographic areas. The districts of Sorgono, Carbonia, Isole San Pietro and Sant'Antioco, Macomer, and Ales-Terralba, which already had very high old-age indexes as early as 2017, showed a greater increase than the other districts in the quinquennium considered. The Olbia district was the youngest one, and together with the districts of Siniscola, Quartu-Parteolla, and Area Ovest, they were the only ones with old age indexes below the national value. For all details, see Table 3.

Limits

Due to their nature, some phenomena of interest are not directly measurable. To respond to the needs related to Health Surveillance for managing the SARS-CoV-2 pandemic emergency, data were produced timely but piecemeal, due to the non-uniform surveys and the high number of confounding factors.

The dissemination of daily mortality data for all Italian municipalities required an extraordinary effort from Istat and local operators. The data about the daily deaths of Sardinian municipalities refer to those published by Istat on 02 March 2022. As this information is revised with each update, there may be differences between our data and those published afterwards by Istat.

Considering the standardization techniques used on the data of the Sardinia Region, it is necessary to highlight that the calculations relating to the expected deaths in the indirect standardization depend on the age-specific mortality rates (ASDRs) of the standard population (Italian population). Therefore, the ASDRs are affected by the substantial increase in mortality linked to the pandemic phenomenon recorded in the Peninsula since the first wave of COVID-19 in 2020.

It is also necessary to consider the objective limits to results' interpretation deriving from the, sometimes, subtle differences between the SMRs and related wide CIs.

Discussion and Conclusions

In this analysis of the quinquennium 2017-2021, we photographed indirectly the socio-sanitary conditions of the resident Sardinian population by analyzing old age index, mortality rates trends, and EM of ASLs and districts areas.

Regarding the impact of SARS-CoV-2 pandemic in Sardinia, it would have been reasonable to expect, based on national data, an increase in mortality in the biennium 2020-2021, with a greater impact on the elderly population group (≥ 65), especially in the first year of the pandemic (pre-vaccine era). The trend of the regional standardized rate showed an increase in mortality in 2020 and a slight decrease in 2021, as confirmed by the analysis of EM. However, unlike what one might expect if Sardinian mortality had followed the country's trend for the year 2020, the global increase in SMRs would seem to be driven mostly by the 0-64 age class. This phenomenon could result from an asynchronous wave of the pandemic due to the insularity condition of Sardinia combined with the timely lockdown measures, or it could be an apparent phenomenon linked to the use of national ASDRs year by year. The calculation of expected Sardinian deaths is, in fact, influenced by the Italian Peninsular phenomenon, where in 2020, the first wave was more impactful. The peak of mortality recorded in the first wave was not homogeneous throughout the national territory, mainly concerning some areas of northern Italy, such as Cremona and Bergamo, where the EM was 50% higher than in the pre-pandemic period.

The Sardinian districts' magnitude of the health crisis has been studied with the EM, which, including all the causes of death (free from confounding linked to the attribution of the specific cause of death (19, 20), allows searching for any other organizational, strategic, and managerial causes of this excess. The annual Sardinian EM detected may indicate a local condition pre-existing the pandemic since the sub-analysis showed a percentage discrepancy of 5% (2020) and 5.9% (2021) compared to the baseline for the 0-64 age class. This phenomenon suggests that pre-pandemic heterogeneous factors could have played an important role, contributing to the impact on Sardinian districts.

Sardinia has the second highest Italian aging index (2022; Istat), with uneven dynamics across the districts. Despite a progressive regional global increase, demographic aging is more pronounced in some areas, depicting a leopard spot pattern throughout Sardinia. This scenario of a progressively aging society challenged the welfare schemes during the pandemic and will heavily impact healthcare and social security costs in the near future. Our results highlight that

the Region of Sardinia, by virtue of its demographic characteristics, should embrace the concept of "age-friendly community" and work to create communities with policies, services, and physical and social structures specifically designed to allow and promote active aging and social participation, despite any illnesses and disabilities (21-23).

In light of the challenges associated with the NRRP (7) and the D.M. 77/2022 (8), in particular, according to the key concepts of Population Medicine and the 'Health Project' planning tool, it would be desirable to monitor old age index, mortality rates, and EM in the years to come. These and other periodic measures would make it possible: i) to photograph the trend of demographic phenomena in the various social and health areas, ii) to stratify the population based on the risk profile, iii) to constantly re-modulate the interventions of health promotion and planning of the supply of social and welfare services, including the equitable allocation of resources based on actual health needs.

Following the structural changes envisaged by the regional Law n. 24/2020 (1), detecting specific social-welfare needs of ASLs and districts' resident population is essential to efficiently reorganizing the Regional Health Service on the Sardinian territory.

Riassunto

Studio degli eccessi di mortalità legati alla pandemia da SARS-CoV-2 nelle ASL e Distretti della Regione Autonoma della Sardegna – quinquennio 2017-2021

Premessa. Sulla base delle indicazioni del Piano Nazionale di Ripresa e Resilienza e del Decreto Ministeriale n°77, la rilevazione dei fabbisogni socio-assistenziali specifici delle popolazioni è fondamentale per la riorganizzazione del Servizio Sanitario Nazionale e di quelli regionali. La presente analisi studia l'impatto di condizioni pandemiche e pre-pandemiche, in termini di mortalità, sulle subunità organizzative del Servizio Sanitario sardo allo scopo di indagare indirettamente la necessità di specifici interventi socio-sanitari.

Design. Studio di mortalità sulla popolazione residente sarda, censita dall'Istituto Nazionale di Statistica dal 2017 al 2021.

Metodi. La base dati è stata costruita utilizzando i dati demografici dell'Istituto Nazionale di Statistica divisi in 21 gruppi di età quinquennali (da 0-4 a 100+). La mortalità e l'eccesso di mortalità sono stati calcolati per ASL e relativa articolazione distrettuale. Le analisi sono state effettuate considerando tre gruppi di età (0-64, ≥ 65, 0-100+), e comparando singolarmente gli anni 2020 e 2021 con il triennio pre-pandemico 2017-2019.

Per meglio comprendere il fenomeno dell'eccesso di mortalità, è stato calcolato l'indice di vecchiaia per ASL e Distretto per ogni anno del quinquennio considerato.

Risultati. I tassi di mortalità standardizzati sono aumentati nel biennio della pandemia da SARS-CoV-2 rispetto al triennio di confronto 2017-2019. Nel 2021 è stato misurato un aumento globale dei tassi di mortalità standardizzati in tutti i distretti, compresi quelli con tassi di mortalità standardizzati già in aumento nel 2020. In particolare, l'incremento dei tassi di mortalità standardizzati (2020 e 2021) è spesso a carico della fascia di età 0-64 anni. L'eccesso di mortalità regionale negli anni 2020 e 2021 (0-100+) ha confermato un aumento della mortalità rispetto alla baseline (triennio), con una leggera diminuzione dal 2020 al 2021.

Conclusioni. La Sardegna presenta caratteristiche demografiche e geografiche peculiari. Il monitoraggio dei tassi di mortalità e dell'eccesso di mortalità si conferma fondamentale per rimodulare costantemente gli interventi sanitari e la programmazione dell'offerta dei servizi, anche attraverso un'equa allocazione delle risorse sulla base delle effettive esigenze sanitarie. La Sardegna dovrebbe abbracciare il concetto di "age-friendly community" e creare comunità progettate per promuovere l'invecchiamento attivo e la partecipazione sociale.

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Supplementary Materials

Table SM 1. Standardized Mortality Ratio

STANDARDIZED MORTALITY RATIO										0-100+
		2017-2019 triennium			2020			2021		
ASL	DISTRICTS	SMR	CI		SMR	CI		SMR	CI	
			min	max		min	max		min	max
CAGLIARI										
	Area Vasta	0.87	0.83	0.90	0.82	0.78	0.85	0.90	0.86	0.94
	Area Ovest	1.10	1.04	1.18	1.07	1.01	1.14	1.23	1.16	1.31
	Quartu-Parteolla	1.12	1.05	1.20	1.03	0.96	1.09	1.15	1.08	1.22
	Sarrabus-Gerrei	1.13	1.00	1.27	1.05	0.94	1.18	1.24	1.11	1.39
	Sarcidano - Barbagia di Seulo e Trexenta	1.17	1.07	1.27	1.04	0.96	1.13	1.21	1.11	1.32
	TOTAL ASL	0.99	0.97	1.02	0.93	0.91	0.96	1.05	1.02	1.08
CARBONIA										
	Carbonia	1.04	0.96	1.13	1.10	1.02	1.18	1.20	1.11	1.29
	Iglesias	1.11	1.01	1.21	1.08	0.99	1.17	1.33	1.22	1.44
	Isole San Pietro e Sant'Antioco	1.18	1.04	1.33	1.10	0.97	1.24	1.22	1.08	1.37
	TOTAL ASL	1.09	1.03	1.15	1.09	1.04	1.15	1.25	1.19	1.31
SANLURI										
	Sanluri	1.15	1.05	1.25	1.08	0.99	1.17	1.29	1.18	1.39
	Guspini	1.20	1.11	1.30	1.16	1.07	1.25	1.31	1.21	1.42
	TOTAL ASL	1.18	1.11	1.25	1.12	1.06	1.19	1.30	1.23	1.37
LANUSEI										
	Tortolì	1.12	1.03	1.21	0.99	0.91	1.07	1.28	1.19	1.38
	TOTAL ASL	1.12	1.03	1.21	0.99	0.91	1.07	1.28	1.19	1.38
ORISTANO										
	Oristano	1.10	1.02	1.18	1.11	1.04	1.18	1.20	1.12	1.28
	Ales-Terralba	1.14	1.05	1.24	1.11	1.02	1.20	1.33	1.23	1.44
	Ghilarza-Bosa	1.20	1.11	1.31	1.19	1.10	1.29	1.39	1.28	1.49
	TOTAL ASL	1.14	1.09	1.19	1.13	1.09	1.18	1.29	1.24	1.34
NUORO										
	Nuoro	1.16	1.08	1.23	1.17	1.10	1.24	1.27	1.19	1.35
	Macomer	1.17	1.04	1.31	1.06	0.94	1.18	1.36	1.21	1.51
	Siniscola	1.17	1.05	1.31	1.22	1.10	1.35	1.39	1.25	1.54
	Sorgono	1.17	1.02	1.32	1.19	1.05	1.34	1.37	1.21	1.54
	TOTAL ASL	1.16	1.11	1.22	1.16	1.11	1.22	1.32	1.26	1.38
SASSARI										
	Sassari	1.06	1.01	1.10	1.09	1.04	1.13	1.14	1.09	1.19
	Alghero	1.13	1.06	1.21	1.07	1.00	1.14	1.22	1.14	1.30
	Ozieri	1.18	1.07	1.31	1.27	1.15	1.39	1.28	1.16	1.41
	TOTAL ASL	1.09	1.05	1.13	1.10	1.06	1.14	1.18	1.14	1.22
OLBIA										
	Olbia	1.11	1.04	1.18	1.12	1.05	1.18	1.20	1.13	1.28
	Tempio	1.17	1.05	1.30	1.08	0.97	1.20	1.24	1.11	1.37
	La Maddalena	1.15	0.94	1.37	0.96	0.78	1.15	1.31	1.10	1.55
	TOTAL ASL	1.13	1.07	1.19	1.09	1.04	1.15	1.22	1.16	1.28
REGIONAL		**1.08**	**1.07**	**1.10**	**1.05**	**1.04**	**1.07**	**1.18**	**1.17**	**1.20**

SMR= Standardized Mortality Ratio = expected death / observed death. Per 1000 inhabitants.
CI= Confidence interval

Table SM 2. Standardized Mortality Ratio – age group 0-64

STANDARDIZED MORTALITY RATIO										age group 0-64
		2017-2019 triennium			2020			2021		
ASL	DISTRICTS	SMR	CI		SMR	CI		SMR	CI	
			min	max		min	max		min	max
CAGLIARI										
	Area Vasta	1.05	0.94	1.17	1.00	0.90	1.12	1.09	0.98	1.22
	Area Ovest	1.15	0.98	1.33	1.09	0.93	1.26	1.15	0.98	1.33
	Quartu-Parteolla	1.11	0.94	1.30	1.15	0.98	1.34	1.29	1.10	1.49
	Sarrabus-Gerrei	1.20	0.82	1.64	1.22	0.85	1.66	0.92	0.59	1.32
	Sarcidano - Barbagia di Seulo e Trexenta	1.30	1.00	1.64	1.44	1.13	1.79	1.34	1.03	1.69
	TOTAL ASL	1.11	1.03	1.19	1.09	1.02	1.17	1.16	1.08	1.24
CARBONIA										
	Carbonia	1.07	0.84	1.33	1.34	1.09	1.62	1.15	0.90	1.42
	Iglesias	1.26	0.99	1.56	0.90	0.68	1.16	1.47	1.17	1.81
	Isole San Pietro e Sant'Antioco	1.08	0.69	1.54	1.03	0.66	1.47	1.40	0.95	1.94
	TOTAL ASL	1.14	0.98	1.32	1.12	0.96	1.29	1.31	1.13	1.51
SANLURI										
	Sanluri	1.17	0.89	1.49	1.00	0.75	1.29	1.49	1.17	1.85
	Guspini	1.47	1.19	1.79	1.59	1.29	1.91	1.71	1.39	2.06
	TOTAL ASL	1.34	1.13	1.56	1.32	1.12	1.54	1.61	1.38	1.86
LANUSEI										
	Tortolì	1.18	0.93	1.46	1.17	0.93	1.45	1.48	1.20	1.80
	TOTAL ASL	1.18	0.93	1.46	1.17	0.93	1.45	1.48	1.20	1.80
ORISTANO										
	Oristano	1.05	0.85	1.27	1.27	1.06	1.51	1.24	1.01	1.49
	Ales-Terralba	1.26	0.97	1.59	1.39	1.09	1.73	1.56	1.23	1.94
	Ghilarza-Bosa	1.25	0.95	1.59	1.38	1.07	1.74	1.78	1.41	2.20
	TOTAL ASL	1.16	1.01	1.32	1.33	1.18	1.50	1.46	1.29	1.64
NUORO										
	Nuoro	1.37	1.15	1.62	1.40	1.18	1.64	1.42	1.19	1.68
	Macomer	1.46	1.03	1.98	1.01	0.66	1.43	1.77	1.27	2.35
	Siniscola	1.32	0.97	1.71	1.21	0.89	1.59	1.68	1.28	2.13
	Sorgono	1.50	0.99	2.10	1.28	0.82	1.82	1.75	1.19	2.42
	TOTAL ASL	1.39	1.22	1.57	1.29	1.13	1.46	1.56	1.38	1.75
SASSARI										
	Sassari	1.20	1.07	1.34	1.18	1.05	1.31	1.32	1.18	1.47
	Alghero	1.20	0.99	1.44	0.91	0.73	1.11	1.03	0.83	1.25
	Ozieri	1.08	0.76	1.46	1.28	0.93	1.68	1.32	0.95	1.75
	TOTAL ASL	1.19	1.08	1.30	1.12	1.02	1.23	1.25	1.14	1.37
OLBIA										
	Olbia	1.03	0.87	1.21	1.24	1.06	1.43	1.17	1.00	1.36
	Tempio	1.34	0.98	1.76	1.14	0.81	1.51	1.12	0.79	1.51
	La Maddalena	0.87	0.44	1.45	1.02	0.56	1.63	0.96	0.49	1.57
	TOTAL ASL	1.08	0.93	1.23	1.20	1.06	1.36	1.15	1.00	1.31
REGIONAL		**1.17**	**1.12**	**1.22**	**1.17**	**1.12**	**1.22**	**1.29**	**1.24**	**1.34**

SMR= Standardized Mortality Ratio = expected death /observed death. Per 1000 inhabitants.
CI= Confidence interval

Table SM 3. Standardized Mortality Ratio – age group ≥ 65

STANDARDIZED MORTALITY RATIO										age group ≥ 65
		2017-2019 triennium			2020			2021		
ASL	DISTRICTS	SMR	CI		SMR	CI		SMR	CI	
			min	max		min	max		min	max
CAGLIARI										
	Area Vasta	0.84	0.80	0.88	0.79	0.76	0.83	0.87	0.83	0.91
	Area Ovest	1.10	1.02	1.17	1.07	1.00	1.14	1.25	1.17	1.33
	Quartu-Parteolla	1.12	1.04	1.21	1.00	0.93	1.08	1.12	1.05	1.20
	Sarrabus-Gerrei	1.12	0.98	1.27	1.03	0.91	1.17	1.28	1.14	1.44
	Saraidano - Barbagia di Seulo e Trexenta	1.15	1.05	1.26	1.00	0.91	1.09	1.20	1.09	1.31
	TOTAL ASL	0.98	0.95	1.01	0.91	0.88	0.94	1.03	1.00	1.07
CARBONIA										
	Carbonia	1.04	0.95	1.13	1.06	0.98	1.15	1.21	1.11	1.30
	Iglesias	1.08	0.98	1.19	1.11	1.01	1.21	1.31	1.20	1.43
	Isole San Pietro e Sant'Antioco	1.19	1.04	1.35	1.11	0.97	1.25	1.20	1.05	1.36
	TOTAL ASL	1.08	1.02	1.14	1.09	1.03	1.15	1.24	1.18	1.31
SANLURI										
	Sanluri	1.15	1.05	1.26	1.09	0.99	1.19	1.26	1.15	1.37
	Guspini	1.16	1.06	1.27	1.11	1.02	1.20	1.26	1.16	1.37
	TOTAL ASL	1.16	1.08	1.23	1.10	1.03	1.16	1.26	1.19	1.34
LANUSEI										
	Tortolì	1.11	1.02	1.20	0.97	0.89	1.05	1.26	1.16	1.36
	TOTAL ASL	1.11	1.02	1.20	0.97	0.89	1.05	1.26	1.16	1.36
ORISTANO										
	Oristano	1.11	1.03	1.19	1.09	1.01	1.17	1.19	1.11	1.28
	Ales-Terralba	1.13	1.03	1.24	1.08	0.99	1.17	1.31	1.20	1.42
	Ghilarza-Bosa	1.20	1.10	1.31	1.17	1.08	1.27	1.34	1.24	1.46
	TOTAL ASL	1.14	1.09	1.20	1.11	1.06	1.16	1.27	1.21	1.33
NUORO										
	Nuoro	1.12	1.05	1.21	1.14	1.06	1.21	1.25	1.17	1.33
	Macomer	1.14	1.00	1.28	1.06	0.94	1.20	1.31	1.16	1.47
	Siniscola	1.15	1.02	1.30	1.23	1.10	1.36	1.35	1.20	1.50
	Sorgono	1.13	0.98	1.29	1.18	1.04	1.34	1.34	1.17	1.51
	TOTAL ASL	1.13	1.08	1.19	1.15	1.09	1.20	1.29	1.23	1.35
SASSARI										
	Sassari	1.03	0.99	1.09	1.07	1.03	1.12	1.11	1.06	1.17
	Alghero	1.12	1.04	1.20	1.09	1.01	1.16	1.25	1.16	1.33
	Ozieri	1.20	1.07	1.33	1.27	1.15	1.40	1.28	1.14	1.42
	TOTAL ASL	1.07	1.03	1.12	1.10	1.06	1.13	1.17	1.12	1.21
OLBIA										
	Olbia	1.12	1.05	1.20	1.09	1.02	1.17	1.21	1.13	1.29
	Tempio	1.15	1.02	1.28	1.07	0.96	1.20	1.25	1.12	1.39
	La Maddalena	1.19	0.96	1.44	0.95	0.76	1.15	1.36	1.13	1.62
	TOTAL ASL	1.13	1.07	1.20	1.08	1.02	1.14	1.23	1.17	1.30
REGIONAL		**1.07**	**1.05**	**1.09**	**1.04**	**1.02**	**1.05**	**1.17**	**1.15**	**1.19**

SMR= Standardized Mortality Ratio: expected death / observed death. Per 1000 inhabitants.
CI= Confidence interval

Table SM 4.Standardized Death Rate - Sardinia

SR - SARDINIA				
	SR	SE	CI	
Period			Min	Max
2021	10.70	0.08	10.54	10.86
2020	10.84	0.08	10.68	10.99
2017-2019[a]	9.77	0.08	9.62	9.93

SR= Standardized death Rate; SE= Standard Error; CI= Confidence Interval

[a] For the triennium: population calculated as the average between the population on 01/01/2017 and 01/01/2020; Sardinian deaths calculated as average deaths for 2017-2019.