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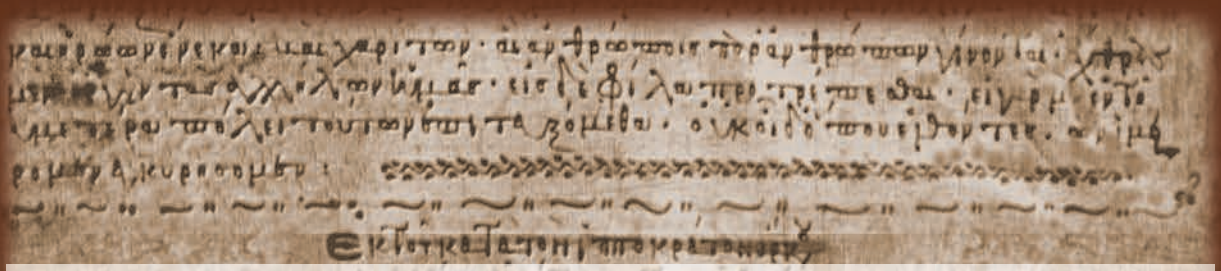
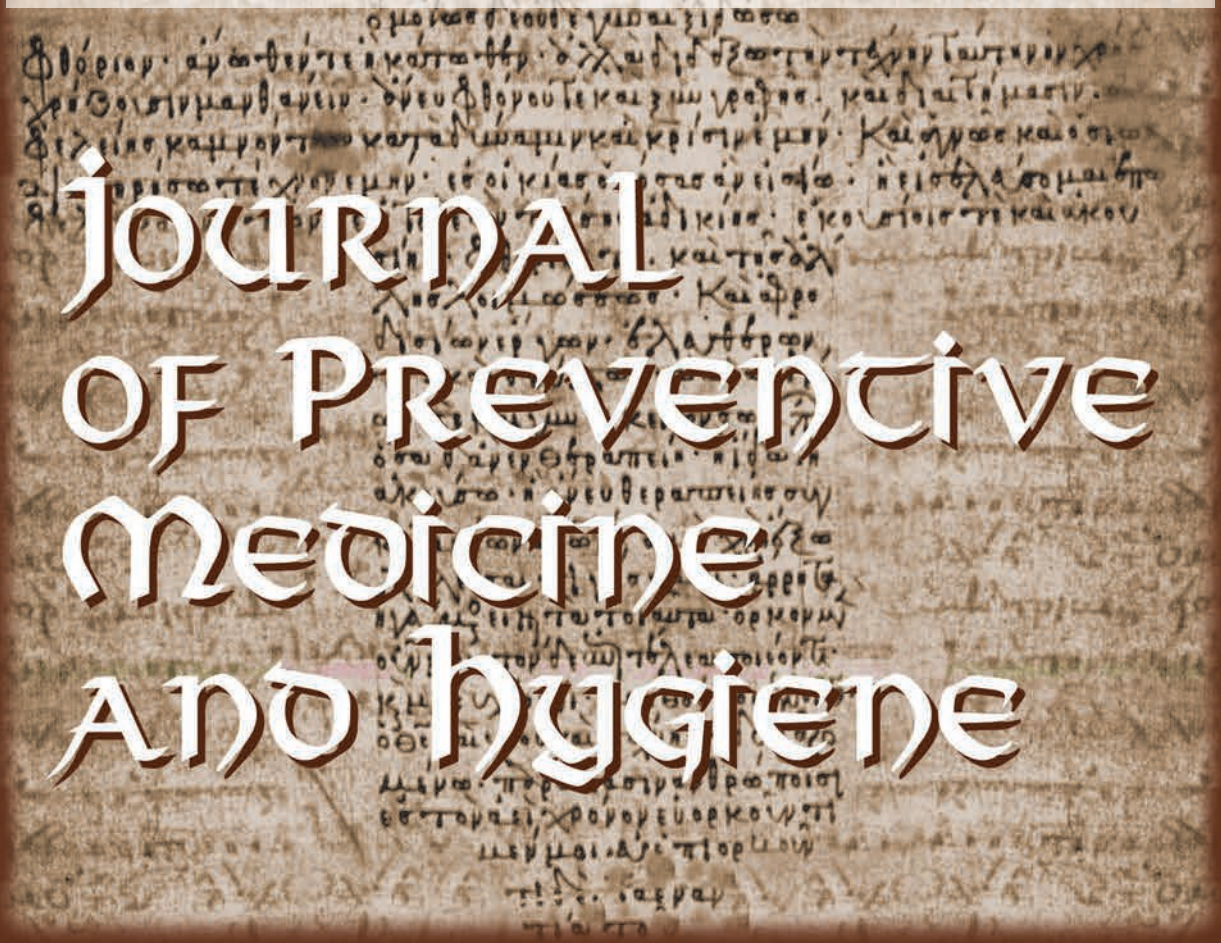


Supplement 2

Influenza vaccination coverage in the elderly and socio-economic inequalities in Italy

How local deprivation indices can help to improve the prevention of influenza in specific population sub-groups



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How local deprivation indices can help to improve the prevention of influenza in specific population sub-groups

PREFACE

Influenza vaccination coverage in the elderly and socio-economic inequalities in Italy

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Every year, seasonal influenza epidemics affect about 5-15% of the world's population, resulting in 3-5 million serious cases and 290,000-650,000 deaths [1]. The WHO defines seasonal influenza as a year-round disease burden, causing illnesses that ranges in severity and sometimes leads to hospitalization and death [1]. Some frail subjects, such as the elderly, are considered at high risk of complications, hospitalization and death [2-4].
Routine annual vaccination is the most effective means of avoiding influenza illness, reducing the associated complications and, consequently, reducing the impact of epidemics, and is strongly recommended by many health authorities worldwide [1, 5, 6]. Italy has a national influenza vaccination programme which identifies specific categories, such as subjects with chronic conditions, pregnant women, healthcare workers and those over 65 years old, which can benefit from free vaccination [7]. Despite this health opportunity, the influenza coverage rate in Italy does not reach the minimum recommended threshold of 75% and is far from the optimum target of 95% [8]. Indeed, a downward trend in coverage in the elderly has been observed since the 2009-2010 season; the average national coverage rate fell from 65.6% in 2009-2010 to 49% in 2014-2015 (its lowest value); a slight upward trend was recorded in the 2016-2017 and 2017-2018 seasons, when coverage reached 52.6% and 52.7%, respectively [4, 8].
This unsatisfactory level of coverage results in excessive recourse to Emergency Departments and in an increase in hospital accesses and hospitalization for complications in the elderly during epidemic peaks, causing organizational strain and increasing healthcare costs [5, 6]. Some interventions could improve coverage rates among the elderly, such as "tailor-made" information campaigns using innovative communication strategies and healthcare worker training. It is crucial to implement communication strategies that take into account the needs of the elderly population, while also involving elderly people's associations in awareness-raising activities. Moreover, strengthening the role of general practitioners in promoting influenza vaccination is fundamental.
Several international studies have shown that socio-economic conditions and deprivation play an important role in the lack of adherence to vaccination [9-12]. Specifically, studies investigating the role of socio-economic status (SES) have highlighted the correlation between deprivation and low vaccination coverage among groups at risk, such as the elderly. Indeed, SES is one of the main determinants of health, and affects the subject's ability to fully comply with preventive measures and healthcare prescriptions. Moreover, it assumes great relevance with regard to age and non-compliance with influenza vaccination [10].
In order to implement efficacious interventions to promote vaccination, it is important to understand the reasons behind non-compliance. This aspect could be investigated by implementing a model based on the intention to vaccinate, and adapting this to older people [13-15].
In this context, we designed and developed a project aimed at evaluating the association between vaccination coverage and socio-economic health inequalities in the elderly. The study was carried out in 10 Italian areas: Genoa, Ferrara, some cities in Veneto, Sassari, Cagliari, Rome, Florence, Siena, Foggia and Palermo. In order to better identify sub-groups of the population who do not comply with vaccination, we used socio-economic indicators that are able to detect the multidimensional aspects of social stratification. Indeed, indices of SES enable us to identify and evaluate the relationship between socio-economic inequalities and health outcomes. As these indices yield a geographical description of the population's health conditions and approximate the individual SES to that of the area of residence, they have already proved able to identify populations at risk of late diagnosis and/or under-treatment for chronic/degenerative diseases [16-19]. This information could be used to guide "tailor-made" interventions to promote health and vaccination in Italy. Furthermore, in support of this methodology, a specific WHO programme [20] encourages precisely this type of action, which must be adapted to the peculiarities of the specific areas.
Finally, the need to improve vaccination coverage in the elderly should be considered in the current and future demographic context. Given the ageing of the population, the demand for health care will increase in the coming years and, consequently, a greater burden will be placed on economic resources. Preventive action to promote "healthy ageing" is therefore fundamental, and vaccinations fall within this perspective.

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ORIGINAL ARTICLE

The local Socio-Economic Health Deprivation Index: methods and results

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Keywords

Health disparities • Socio-economic inequalities • Deprivation index • Public health

Summary

Introduction. *A socio-economic (SE) deprivation index is a measure that aims to provide an indication of SE hardship and disadvantage in the population. Our aim was constructing 10 Socio-Economonic and Health Deprivation Indexes (SEHDI) by means of the same method. This particular method enables these indexes to be used to investigate the relationships between SE inequalities and aspects of health and prevention in the population.*
Materials and Methods. *Data on the demographic and SE situation of the populations were taken from the 2011 Census at the Census Tract (CT) level (2001 for Rome municipality). To construct the SEHDIs, variables displaying a statistically significant correlation with the SMRs of overall mortality were subjected to a tolerance test of linearity, in order to eliminate collinear variables. The variables selected underwent PCA factor analysis, in order to obtain the factors to be linearly combined into the SEHDI. The final values were scaled from minimum to maximum deprivation, and the quantitative scale was converted into five ordinal normalized population groups. The SEHDIs were validated at the SE level by comparing them with the trends of the main SE indexes used in the 2011 Census (2001 for Rome municipality), and at the health level by comparing them with the trends of some causes of death. Both comparisons were made by means of ANOVA.*
Results. *The 10 areas considered were: the municipalities of Cagliari, Ferrara, Florence, Foggia, Genoa, Rome, Palermo, Sassari, Siena, and the ULSS 7 Veneto area. For each one, a specific SEHDI was computed and the different variables comprising each index focused on particular aspects of SE and health deprivation at the area level. The SEHDIs showed good percentages of explained variance (from 72.2% to 49.1%) and a linear distribution of the main statistical SE indices and of overall mortality in each area; these findings were in line with the literature on the relationship between the SE condition and health status of the population. The distribution of cause-specific mortality across the SEHDIs deprivation clusters is analyzed in other articles, which deal with the findings of the study in each area.*
Conclusions. *The SEHDIs showed good ability to identify the elements of SE inequalities that impact on the health conditions of populations; to depict the distribution of causes of death that are sensitive to SE differences concerning aspects of the social and family support structure. From a public health perspective, these results are relevant because they enable interventions of health promotion and prevention to be implemented on the basis of the characteristics that define deprivation groups.*

Introduction

A socio-economic deprivation index is a measure that aims to provide an indication of socio-economic hardship and disadvantage through a synthetic value [1, 2]. It generally refers to the living conditions of the inhabitants of a given geographical/administrative area, which may be defined topographically and/or normatively (e.g., the municipality or the Census Tract) [3-6]. As the index can be calculated by means of the same methodology in different areas, the population clusters obtained constitute analogous segments of different populations. Thus, comparisons can be made between the conditions of populations residing in different areas.
Deprivation indexes are usually computed in order to achieve general and specific objectives. The general objective is to describe relative deprivation within a population, while specific objectives may regard many aspects of economic, social, health or political issues.
As the present study focused on public health, the specific objectives can be summarized as follows:

- to obtain relative deprivation measures in order to identify critical points in the territory;
- to study the association between deprivation and health outcomes;
- to correct epidemiological evaluations of the association between other environmental factors and health outcomes.

The socio-economic health deprivation indexes used in this project were constructed in accordance with a specific methodology that makes them particularly suitable for investigating the relationships between socio-economic inequalities and aspects of health and prevention in the population, as verified by their use in previous studies [7-9].
Our aim was to compute a specific Socio-Economic and Health Deprivation Index (SEHDI) for each of the 10 areas involved in the study by using the same methodology, in order to precisely identify the elements that characterized specific socio-economic and health differences in different populations.

Materials and methods

Materials

Data on the demographic and socio-economic situation of the populations involved in the study were taken from the 2011 ISTAT Census of Population and Housing (2001 for Rome municipality).
We considered all variables made available publicly by ISTAT on its website [10] (a total of 152), plus a set of variables made available ad hoc for this study (a total of 24). The complete list is presented in Table S1, in the Supplementary Materials section of this article.
For the 10 geographical areas participating in the study (municipalities of Cagliari, Ferrara, Florence, Foggia, Genoa, Rome, Palermo, Sassari, Siena, and the ULSS 7 Veneto area) all the variables were considered at Census Tract (CT) level.
The maps used to produce a geographical representation of the indexes were taken from the ISTAT website in shapefile format; the reference system for representing the coordinates is the ED 1950 UTM Zone 32n [10].
To select the ISTAT variables composing the SEHDIs, we collected data on observed deaths due to all causes, at the CT level, in the 5-year period centered around 2011 (year of the Census; 2001 for Rome municipality), i.e. the period 2009-2013.
To validate the SEHDIs, we collected data on observed deaths (again at the CT level), broken down according to the main causes and to causes concerning the respiratory system (particularly relevant for the study) in the 5-year period 2009-2013. The complete list is shown in Table I, in which the observation periods and any local changes in these (depending on local updating of mortality data) are also indicated.
Collection of mortality data was enabled by collaboration among Municipalities, Regional Statistical Offices and, where present, Regional Mortality Registries. In some areas, ICD-9 codes were assigned to mortality data; these codes were then translated into ICD-10 codes. Table I also reports the correspondence between the two coding revisions.
Some Operating Units adopted slightly different observation periods, depending on the availability of the data. However, it was deemed that these differences would not compromise the reliability of the final result, as they were always close to the period in which the demographic and socio-economic data of the Census were gathered.

Methods

To construct the SEHDI, a consolidated method was implemented in every area [4]; this used a combination of bivariate and multivariate statistical techniques [11].
The variables from the Census were first examined in order to eliminate any outliers in the data; they were then converted into percentages of the total population. Subsequently, all the percentages obtained were correlated with the general mortality rate in each area, standardized by age on a regional basis (Standard Mortality Rates - SMR). Correlations were computed by means of the Pearson correlation index, with the statistical significance of the correlation being set at $p < 0.05$.
After this procedure, only the variables that were statistically significantly correlated with the SMRs were considered. A tolerance test of linearity was applied (statistical significance at $p < 0.05$), in order to eliminate all the ISTAT variables that were excessively collinear (level of tolerance $p < 0.001$) [11].
A Principal Component factor Analysis (PCA) was then carried out on the variables selected (with varimax rotation of the components, in order to orthogonalize them and make them independent of each other). Only components with eigenvalues ≥ 1 were considered [11]. These components expressed a substantial part of the variance, i.e. the variability of the distribution of the socio-demographic characteristics of the population observed, and were therefore the basic elements for the final computation of the SEHDI.
The SEHDI was calculated as a linear combination of factors coming from the PCA. The variable obtained was

Tab. I. Causes of death and observation periods in the study.

Causes of deaths (observation period: 2009-2013[1])	ICD-10	ICD-9
All causes	A00-Y89	001.0-E999.9
Cardiovascular system	I00-I99	390.0-459.9
Respiratory system	J00-J99	460.0-519.9
Flu and pneumonia	J10-J18	480.0-487.9
COPD	J40-J47	490.0-496.9
Digestive system	K00-K93	520.0-579.9
Diabetes	E10-E14	250.0-250.9
All cancers (except non-melanoma skin cancers)	C00-C43, C46-C95	140.0-172.9,176.0-208.9
Upper aero-digestive tracts cancers	C00-C15	140.0-150.9
Stomach cancers	C16	151.0-151.9
Colorectal and intestinal cancers, not otherwise specified	C18-C21, C26.0	153.0-154.9, 159.0
Lung cancers	C33-C34	162.0-162.9
Female breast cancers	C50	174.0-174.9
Prostate cancers	C61	185

[1] Different periods for the following areas: Cagliari: 2013-2015 Palermo: 2009-2016; Ferrara: 2010-2015 Sassari: 2013-2015.

then recalculated by applying values from 0 (= maximum deprivation) to 100 (= minimum deprivation). The index was obviously computed at the CT level for each of the 10 areas involved in the study.
The quantitative SEHDI was then converted into an ordinal variable that expressed deprivation in the population groups. To maintain the criterion of the normal distribution of inequality in the population [12, 13], the Agnelli, Cadeiras, Tabak, Turner and Vander-Eijden algorithm [14] was applied. By this classification, the deprivation groups presented an almost normally distributed number of people across the groups (statistical significance at $p < 0.05$). These groups were: 1 = high deprivation; 2 = medium-high deprivation; 3 = medium deprivation; 4 = medium-low deprivation; 5 = low deprivation.
The ordinal index thus obtained was validated: i) at the socio-economic level, by comparing it with the trends of the synthetic socio-economic indexes used in the 2011 Census (old-age index, structural dependency index, turnover index, activity rate, employment and unemployment rates; the same 2001 indexes for Rome municipality); and ii) at the health level, by comparison with the available data on causes of death.
In both comparisons, One-Way ANOVA was used with the F test and linearity test ($p < 0.05$) [11], in order to assess whether the trends yielded by the ordinal version of the index corresponded adequately to what is known in the literature on the relationships between socio-economic inequalities and causes of death. In addition to obtaining an adequate validation of all the indices, this procedure also yielded a fairly detailed evaluation of the state of health of the populations involved in the study.
The statistical analyses were conducted by means of SPSS 19.0 and STATA 13.0 software.

Results

For the 10 areas considered, a specific SEHDI was computed. In accordance with the methodology used, each local index comprised variables that focused on specific aspects of socio-economic and health deprivation at the local level. Table II reports the composition of each index.
On PCA, all the indices showed a good percentage of explained variance (from 72.2% to 49.1%), indicating an adequate ability to describe the distribution of deprivation in the population studied. Moreover, in every area, the validation procedures showed a good linear distribution of the main ISTAT socio-economic indexes and of overall mortality; this is in line with the hypothesis underlying this computation method and with the scientific literature on the relationships among the deprivation, general socio-economic condition and health status of a population (Tabs. IIIa, IIIb).
Several analyses were carried out in order to investigate the association between the SEHDI and cause-specific mortality, mainly as a validation tool. In some cases, the findings were discussed in detail by some of the other groups participating in the study (data not shown).
Finally, Table IV reports the distribution of the population in deprivation clusters in every area.

Discussion and conclusions

The indexes calculated in this study cannot be considered "pure" socio-economic deprivation indexes, because they use standardized general mortality as the very first tool for the selection of the Census variables.
Indeed, only variables that correlated with overall mortality were included in the indexes. However, they enabled SE inequalities across the different deprivation groups to be assessed, even though connected to their health status.
For example (Tab. II), some aspects that are common to every area distinguish subjects mainly on the basis of their need for social and practical support, and thus, the family structure that may help or hinder prevention or care patterns and the implementation of a healthy lifestyle [15-17]. Other characteristics, such as educational level and/or housing conditions, display a differential impact on stratification by socio-economic conditions from area to area (i.e., they express more or less variance) according to the specific situation of the labor market, of the housing market etc.
These peculiarities makes the SEHDI particularly suitable for studying the relationship between socio-economic and health aspects (of care, prevention, etc.) in a population (which was exactly the objective of this project). They are therefore indexes that could be defined as "purpose-built" [3-6].
Another important feature that enables them to describe the peculiarities of a specific area efficiently is their territorial detail: the Italian CTs are usually small in demographic terms (around 800 people on average). This characteristic allows us to consider the smallest available area of officially validated demographic and socio-economic information and, at the same time, an area small enough to be able to describe the reference context attributable to individual patients [5, 6], i.e. every person can be described by the demographic and socio-economic characteristics of his/her CT of residence, with a low risk of ecological bias [5, 6].
Starting from these latter considerations, the SEHDI showed:

- good descriptive ability to identify the relevant elements of socio-economic inequalities that impact on the health conditions of the different populations involved in the study;
- good ability to describe health problems related to some causes of death that are particularly relevant to socio-economic differences, in which the aspects of family and social support structure are also relevant;
- good description of the characteristics that underlie the differences in VC across the different deprivation groups.

Tab. II. Composition of the SEHDI in each area, by 2011 (2001 for Rome municipality) Census variables. SEHDI factors and explained variance.

Area	Factors				
Cagliari (56.4%)[1]	1 = 24.5%	2 = 16.7%	3 = 15.1%		
	Average no. of people per family Average no. of people per occupied dwelling % 3-member families	% housing with drinking water % housing with kitchen % married % students	% belonging to labor force % men		
Ferrara (62.3%)[1]	1 = 29.8%	2 = 19.8%	3 = 12.7%		
	% earners from labor or capital income % widowers/widows Index of structural dependence Old-age index % single-member families 65+ % primary school diploma	% 2-member families	% residential buildings in mediocre state of conservation % housing with kitchenette		
Florence (60.7%)[1]	1 = 30.9%	2 = 16.6%	3 = 13.2%		
	Average no. of people per family Average no. of people per occupied dwelling % 4-member families % married	% rented homes % foreigners and stateless persons residing in Italy	% widowers/widows % belonging to labor force % lower secondary school		
Foggia (68.9%)[1]	1 = 38.1%	2 = 16.1%	3 = 14.6%		
	% single-member families 65+ % widowers/widows % single-member families Average no. of people per family Old-age index	% separated and divorced % primary school diploma or no qualification	% housing with bathtub or shower		
Genoa (72.2%)[1]	1 = 21.2%	2 = 21.2%	3 = 16.0%	4 = 13.8%	
	Index of structural dependence Old-age index % widowers/widows	% single-parent families % single-parent families with children <15 years	% married % 2-member families	% rented homes % lower secondary school	
Palermo (64.3%)[1]	1 = 28.2%	2 = 21.9%	3 = 14.2%		
	% earners from labor or capital income Old-age index Index of structural dependence	Average no. of people per family % primary school diploma or no qualification	% single-parent families with children < 15 years		
Rome (59.3%)[1]	1 = 18.6%	2 = 13.8%	3 = 9.6%	4 = 9.5%	5 = 7.7%
	% widowers/widows Index of structural dependence Old-age index % men Average no. of people per family	% primary school diploma % employed in industry	Replacement index	% separated and divorced % rented homes	% family helpers % employed in agriculture % students
Sassari (56.5%)[1]	1 = 21.8%	2 = 20.5%	3 = 14.2%		
	Average no. of people per family Average no. of people per occupied dwelling % 3-member families % married % students	% housing with drinking water % housing with kitchen	% belonging to labor force % men		
Siena (63.5%)[1]	1 = 26.4%	2 = 18.6%	3 = 18.5%		
	% widowers/widows % women Old-age index Index of structural dependence	Employment rate Activity rate	% unemployed looking for new jobs % 3-member families		
ULSS7 - Veneto (49.1%)[1]	1 = 26.5%	2 = 22.6%			
	Unemployment rate % other employment status	% housewives % married Old-age index			

[1] Total explained variance.

Tab. IIIa. SEHDI general validation.

Area	Deprivation groups	SMR - Overall mortality	Replacement index	Old-age index	Index of structural dependence	Activity rate	Employment rate	Unemployment rate
Cagliari	High deprivation	1.93	271.98	566.28	106.07	43.26	60.79	11.59
	Medium-high deprivation	1.48	265.22	372.47	61.41	49.30	59.23	12.53
	Medium deprivation	1.20	219.61	301.22	54.49	52.59	60.55	11.32
	Medium-low deprivation	0.76	206.15	242.88	50.81	54.19	59.25	12.40
	Low deprivation	0.33	127.10	100.38	40.40	60.40	63.03	10.02
	Total	**1.16**	**223.78**	**311.50**	**58.08**	**51.99**	**60.13**	**11.77**
	Trend	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***NS***	***NS***
Ferrara	High deprivation	2.25	243.49	633.07	144.78	40.02	68.52	6.99
	Medium-high deprivation	1.46	271.62	404.00	78.28	47.32	69.71	6.65
	Medium deprivation	1.07	251.50	310.70	61.97	52.94	71.61	5.41
	Medium-low deprivation	0.82	219.24	229.42	50.72	58.12	72.52	4.67
	Low deprivation	0.47	152.62	104.97	34.08	68.09	75.57	3.83
	Total	**1.20**	**236.09**	**332.27**	**70.21**	**53.28**	**71.57**	**5.49**
	Trend	***p<0.05 L***	***p<0.05 NL***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***
Florence	High deprivation	1.22	152.46	292.92	70.39	52.59	66.21	7.01
	Medium-high deprivation	1.04	167.14	230.77	64.89	52.16	68.14	5.58
	Medium deprivation	1.10	203.88	253.72	66.32	52.22	70.77	4.60
	Medium-low deprivation	1.13	262.18	274.88	64.17	53.39	72.32	4.53
	Low deprivation	1.00	271.15	273.66	54.19	57.80	74.28	4.61
	Total	**1.09**	**211.38**	**259.99**	**63.98**	**53.45**	**70.75**	**4.99**
	Trend	***p<0.05 NL***	***p<0.05 L***	***p<0.05 NL***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***
Foggia	High deprivation	1.59	185.4	383.1	71.7	41.3	52.7	8.9
	Medium-high deprivation	1.19	155.7	215.0	60.0	42.4	47.8	10.2
	Medium deprivation	0.83	139.3	135.4	53.3	44.7	45.5	11.1
	Medium-low deprivation	0.77	102.3	97.2	51.6	44.7	41.6	11.5
	Low deprivation	0.20	92.1	83.2	60.1	46.9	45.3	11.0
	Total	**.95**	**139.7**	**177.3**	**57.8**	**43.8**	**46.3**	**10.6**
	Trend	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***NS***	***NS***
Genoa	High deprivation	3.40	256.3	606.0	84.7	43.6	60.0	7.7
	Medium-high deprivation	1.10	208.0	346.4	72.8	46.2	64.9	6.6
	Medium deprivation	1.02	203.3	261.3	69.8	49.4	65.9	5.7
	Medium-low deprivation	0.85	196.7	212.7	59.3	53.4	68.7	4.9
	Low deprivation	0.79	178.4	140.6	54.2	58.6	68.9	5.4
	Total	**1.10**	**203.8**	**279.9**	**67.8**	**49.8**	**66.2**	**5.9**
	Trend	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***

L = linear trend; NL = non-linear variation; NS = not statistically significant; NA = not available. Replacement Index = [(Pop. 60-64 yrs) / (Pop. 15-19 yrs)*100]; Old-age Index = [(Pop. 65+ yrs) / (Pop. 0-14 yrs)*100]; Structural Dependency Index= [(Pop. 0-14 yrs + Pop. 65+ yrs) / (Pop. 15-64 yrs)*100]; Activity Rate = [(Work Force 15-64 yrs / Pop. 15-64 yrs) * 100]; Employment Rate = [(Employed 15+ yrs / Pop. 15+ yrs) *100]; Unemployment rate = [(Unemployed 15+ yrs / Work Force 15+ yrs) *100].

Tab. IIIb. SEHDI general validation.

Area	Deprivation groups	SMR - Overall mortality	Replacement index	Old-age index	Index of structural dependence	Activity rate	Employment rate	Unemployment rate
Palermo	High deprivation	1.02	132.62	234.06	90.61	38.70	41.12	13.24
	Medium-high deprivation	1.04	127.95	173.27	60.86	43.48	42.11	12.10
	Medium deprivation	1.02	125.02	143.57	51.31	47.43	46.48	10.71
	Medium-low deprivation	0.93	122.47	115.85	41.47	51.30	48.49	10.02
	Low deprivation	0.96	115.38	100.44	29.98	58.37	54.28	9.55
	Total	**1.00**	**124.52**	**142.80**	**50.72**	**48.16**	**46.52**	**10.82**
	Trend	***p<0.05 NL***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***
Rome	High deprivation	1.53	296.98	323.60	61.02	44.75	53.14	10.53
	Medium-high deprivation	1.23	236.64	217.12	53.37	49.69	58.20	8.17
	Medium deprivation	1.05	176.50	163.71	48.17	51.71	58.65	7.26
	Medium-low deprivation	0.88	129.21	122.97	41.94	53.82	58.23	6.35
	Low deprivation	0.67	92.96	110.51	31.74	53.29	54.89	5.46
	Total	**1.08**	**184.10**	**176.48**	**47.96**	**51.27**	**57.75**	**7.42**
	Trend	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***NS***	***p<0.05 L***
Sassari	High deprivation	NA	138.21	284.73	94.86	43.54	48.89	14.34
	Medium-high deprivation	NA	163.46	245.58	56.59	50.26	54.75	13.54
	Medium deprivation	NA	184.64	249.63	51.95	51.63	56.66	12.82
	Medium-low deprivation	NA	152.84	148.52	40.16	57.86	58.52	12.10
	Low deprivation	NA	150.81	182.59	39.86	63.15	65.78	10.06
	Total	**NA**	**172.04**	**242.04**	**57.24**	**51.56**	**56.08**	**12.88**
	Trend	***NA***	***p<0.05 NL***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***
Siena	High deprivation	1.29	189.7	524.6	70.1	61.7	83.0	7.8
	Medium-high deprivation	1.25	271.8	336.6	67.8	55.2	73.8	6.4
	Medium deprivation	0.98	249.6	317.4	65.0	53.0	72.1	3.8
	Medium-low deprivation	0.92	203.3	264.7	66.9	50.5	69.0	2.8
	Low deprivation	0.80	220.2	165.2	60.3	49.7	61.4	1.2
	Total	**1.02**	**237.3**	**317.6**	**65.9**	**53.5**	**71.9**	**4.3**
	Trend	***p<0.05 L***	***p<0.05 NL***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***	***p<0.05 L***
ULSS 7 - Veneto	High deprivation	1.02	133.8	133.5	53.8	56.1	67.9	6.2
	Medium-high deprivation	1.01	114.0	121.9	52.7	57.5	69.2	5.2
	Medium deprivation	0.97	135.1	146.1	56.2	54.0	67.5	4.9
	Medium-low deprivation	0.90	144.1	194.8	60.5	51.5	66.6	5.8
	Low deprivation	0.87	142.2	157.6	55.4	54.5	69.0	4.1
	Total	**0.96**	**131.5**	**142.1**	**55.2**	**55.0**	**68.1**	**5.1**
	Trend	***p<0.05 L***	***p<0.05 NL***	***p<0.05 L***	***NS***	***p<0.05 NL***	***NS***	***p<0.05 L***

L = linear trend; NL = non-linear variation; NS = not statistically significant; NA = not available. Replacement Index = [(Pop. 60-64 yrs) / (Pop. 15-19 yrs)*100]; Old-age Index = [(Pop. 65+ yrs) / (Pop. 0-14 yrs)*100]; Structural Dependency Index= [(Pop. 0-14 yrs + Pop. 65+ yrs) / (Pop. 15-64 yrs)*100]; Activity Rate = [(Work Force 15-64 yrs / Pop. 15-64 yrs) * 100]; Employment Rate = [(Employed 15+ yrs / Pop. 15+ yrs) *100]; Unemployment rate = [(Unemployed 15+ yrs / Work Force 15+ yrs) *100].

Tab. IV. Population distribution by SEHDI cluster.

Area	Deprivation groups	2011 resident population	%	Area	Deprivation groups	2011 resident population (2001 for Rome municipality)	%
Cagliari	High deprivation	4369	2.9	Palermo	High deprivation	17705	2.7
	Medium-high deprivation	28603	19.1		Medium-high deprivation	104476	15.9
	Medium deprivation	79276	53.0		Medium deprivation	299408	45.6
	Medium-low deprivation	35009	23.4		Medium-low deprivation	213778	32.6
	Low deprivation	2405	1.6		Low deprivation	20783	3.2
	Total	*149662*	*100.0*		*Total*	*656150*	*100.0*
Ferrara	High deprivation	14986	11.3	Rome	High deprivation	211082	8.4
	Medium-high deprivation	30682	23.1		Medium-high deprivation	602638	24.0
	Medium deprivation	49151	37.1		Medium deprivation	1016130	40.4
	Medium-low deprivation	27858	21.0		Medium-low deprivation	569461	22.7
	Low deprivation	9868	7.4		Low deprivation	112879	4.5
	Total	*132545*	*100.0*		*Total*	*2512190*	*100.0*
Florence	High deprivation	33471	9.4	Sassari	High deprivation	9486	7.7
	Medium-high deprivation	59143	16.5		Medium-high deprivation	15782	12.8
	Medium deprivation	181077	50.6		Medium deprivation	75391	60.9
	Medium-low deprivation	50414	14.1		Medium-low deprivation	13374	10.8
	Low deprivation	33849	9.5		Low deprivation	9736	7.9
	Total	*357954*	*100.0*		*Total*	*123769*	*100.0*
Foggia	High deprivation	10721	7.3	Siena	High deprivation	2599	5.0
	Medium-high deprivation	47794	32.7		Medium-high deprivation	9324	18.0
	Medium deprivation	57617	39.5		Medium deprivation	27126	52.4
	Medium-low deprivation	20288	13.9		Medium-low deprivation	9914	19.2
	Low deprivation	9591	6.6		Low deprivation	2762	5.3
	Total	*146011*	*100.0*		*Total*	*51725*	*100.0*
Genoa	High deprivation	17380	3.0	ULSS 7 - Veneto	High deprivation	19016	8.8
	Medium-high deprivation	168228	28.7		Medium-high deprivation	49180	22.7
	Medium deprivation	268861	45.9		Medium deprivation	99721	46.1
	Medium-low deprivation	120169	20.5		Medium-low deprivation	34428	15.9
	Low deprivation	11542	2.0		Low deprivation	14072	6.5
	Total	*586180*	*100.0*		*Total*	*216417*	*100.0*

From a public health perspective, these results are very relevant, as they enable interventions of health promotion and prevention to be oriented on the basis of the characteristics that define the deprivation groups.

However, there are two limits to this procedure. The first is the potential ecological bias, albeit reduced owing to the small dimensions of the Italian CTs [2, 6]. Indeed, studies that apply synthetic multi-factorial descriptions of small geographical areas to single individuals must be evaluated in the light of good knowledge of the areas considered, in order to avoid mis-attribution of peculiarities and, consequently, any misdirected health and social policy. From this point of view, it must be remembered that local indicators, such these, are tools useful only to local policy-makers, who should have a good knowledge of the area they administer.

The second limit is more of a characteristic of these indexes than a flaw: in interpreting the territorial descrip-

tion yielded by this method, it must be borne in mind that the concept of deprivation extends to social and health aspects, and does not only concern mere material deprivation [4, 7-9]. This implies that the interpretation must consider aspects linked to the social support and cultural resources that people can count on in order to understand messages, specifically prevention messages, to adopt good practices and correct lifestyles, early terapeutic actions in charge etc.
Bearing in mind these two limitations can improve the role of these local indices in guiding interventions and using resources more efficiently.

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Conflict of interest statement

None declared.

Authors' contributions

RL developed method, data organization, quality check and analyses. MV performed text revision and references. Both the authors contributed to the text writing.

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ORIGINAL ARTICLE

Analysis of influenza vaccination coverage among the elderly in Genoa (Italy) based on a deprivation index, 2009-2013

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Keywords

Influenza vaccination • Vaccine coverage • Deprivation • Elderly

Summary

Introduction. *The elderly suffer the most influenza-related complications, and 90% of deaths due to influenza occur in older subjects. Consequently, the elderly are among the main targets of influenza vaccination campaigns. The use of deprivation indexes can help to identify subgroups with lower vaccination uptake. This study analyzed influenza vaccination coverage in elderly persons living in Genoa (Italy) in relation to a local Index of Socio-Economic and Health Deprivation (SEHDI) in order to identify population subgroups needing specific intervention to improve vaccination coverage.*

Methods. *The study targeted subjects aged ≥ 65 years living in Genoa in the period 2009-2013. Information on vaccination coverage was provided by general practitioners and Local Health Units. A combination of linear regression, factor analysis and cluster analysis was used to construct the SEHDI at Census Tract (CT) level, on the basis of data from the 2011 Italian census.*

Results. *In 2011, people aged ≥ 65 years accounted for the 27.7% of the population of Genoa. Most elderly subjects were assigned to either the medium (45.3%) or medium-high (32%) deprivation groups, while the percentages in the extreme tails were low (3.6% high deprivation; 1.3% low deprivation). Significant, non-linear ($p < 0.05$ NL) relationships were observed in both sexes with regard to mortality due to all respiratory diseases (RD) and chronic obstructive pulmonary disease (COPD), with the highest Standardized Mortality Ratio (SMR) values in women in the high deprivation group of women (1.81, $p < 0.05$ RD; 1.79, $p < 0.05$ COPD). The SMRs for influenza and pneumonia showed a positive linear trend in women ($p < 0.05$) with the highest value in the high deprivation group (1.97, $p < 0.05$), while in men the trend was NL ($p < 0.05$). A positive linear trend ($p < 0.05$) was found with regard to vaccination coverage, which grew weakly as deprivation increased, up to the medium-high deprived group (from 34.6% to 44.4%). However, the high deprivation group showed the lowest value (33.3%).*

Conclusions. *The results revealed a relationship between deprivation and influenza vaccination coverage in the elderly. This finding should be taken into account in the organization of vaccination campaigns and should prompt differentiated intervention in each local area.*

Introduction

Socio-economic status (SES) is a composite concept that includes material and social deprivation [1, 2]. SES indexes are used to capture the various aspects of deprivation in a single number [3, 4] and to explore the relationships between SES and health outcomes. With regards to influenza, every year about 8% of the population is infected [5]. Among the elderly, incidence rates are low (in 2017, in Italy around 0.46 per 1,000; in Liguria 0.67 per 1,000) [6]. Although less affected by the disease, older people suffer more disease-related complications and 90% of deaths due to influenza and its complications occur in the elderly [5, 7]. For this reason, this age group is among the main targets of vaccination campaigns. As the risk of all-cause and cause-specific mortality is higher in unvaccinated elderly subjects than in those who are vaccinated [8], vaccination is strongly recommended. In 2003, the World Health Organization [9] recommended increasing influenza vaccination coverage among all high-risk subjects and attaining 75% coverage among the elderly by 2010. Subsequently the Italian National Health Plan set this target. The 2017-2019 Italian National Immunization Plan [10], in addition to the prevention and control of influenza recommendations for the 2017-2018 season [11] have set the minimum coverage target at 75% and the optimal goal at 95% [10, 11]. Nevertheless, after a peak of 74.1% in 2006-2007, coverage declined to 49.5% in 2014-15, and the subsequent increase has been scant, reaching a level of 51% [12].

The decrease in vaccination coverage has determined a significant rise in the number of cases [13] and an excess in overall mortality since December 2016 in Europe (particularly in the elderly) [14]. In Italy, from 2012 to 2015, a + 13% of excess mortality was documented in winter, largely as a result of influenza [15].

SES plays a major role in determining adherence to anti-influenza immunization programs, particularly in the elderly [16, 17]. Influenza vaccination coverage shows

local variations [18, 19] and often appears to be lower among individuals of low SES [18-20].
The measurement of SE deprivation takes into consideration the multidimensional aspects of social stratification. Therefore, the use of deprivation indexes is a useful strategy for measuring health disparities at the population level, and hence for distinguishing non-vaccinating groups [21].
The aim of this study was to identify groups of subjects aged ≥ 65 years with lower vaccination coverage in Genoa (Italy). To this end we applied a specific deprivation index based not only on the SE characteristics of the population, but also on its specific health needs, the ultimate goal being to guide specific interventions aimed at increasing influenza vaccination compliance.

Methods

The study focused on subjects aged ≥ 65 years living in Genoa from 2009 to 2013. Genoa, the regional capital of Liguria, is situated on the coast of the Ligurian sea and extends for more than 27 km. It has almost 590,000 inhabitants (2011 Census) and one of the oldest populations in Italy (65+ years old, 27.7%). As the terrain is mostly hilly, urban development on the landward side has created steep narrow streets. The central and western parts host the city's port, shipyards and steel mills, while the eastern part is residential and richer.
The numbers of observed and expected deaths due to all causes and to specific causes were obtained from the National Statistics Institute (ISTAT) through the Liguria Region Statistics Office. Collaboration between the Regional Statistics Office and the Municipal Statistics Office enabled these data to be stratified by gender and Census Tract (CT), as of the 2011 national census.
Data on influenza vaccination coverage were provided by the Liguria Regional Health Agency and the Department of Health Sciences of the University of Genoa, which collected and validated data from all general practitioners (GPs) working in the city. These data covered the influenza seasons from 2014 to 2016 and were accompanied by the street addresses of GPs' ambulatories. The addresses were geo-coded by CT, again by the Statistics Office of Genoa.
A composite Socio-Economic and Health Deprivation Index (SEHDI) was computed in accordance with a previously experimented method [22]. The unit of observation was the CT, for each of which the index was calculated on the basis of the variables recorded in the Genoa municipality during the 2011 Italian National Census of Population and Households. Mortality trends were analyzed by means of one-way analysis of variance (ANOVA) and the relationship between vaccination coverage and the deprivation index was analyzed by means of a Pearson bivariate correlation [23].

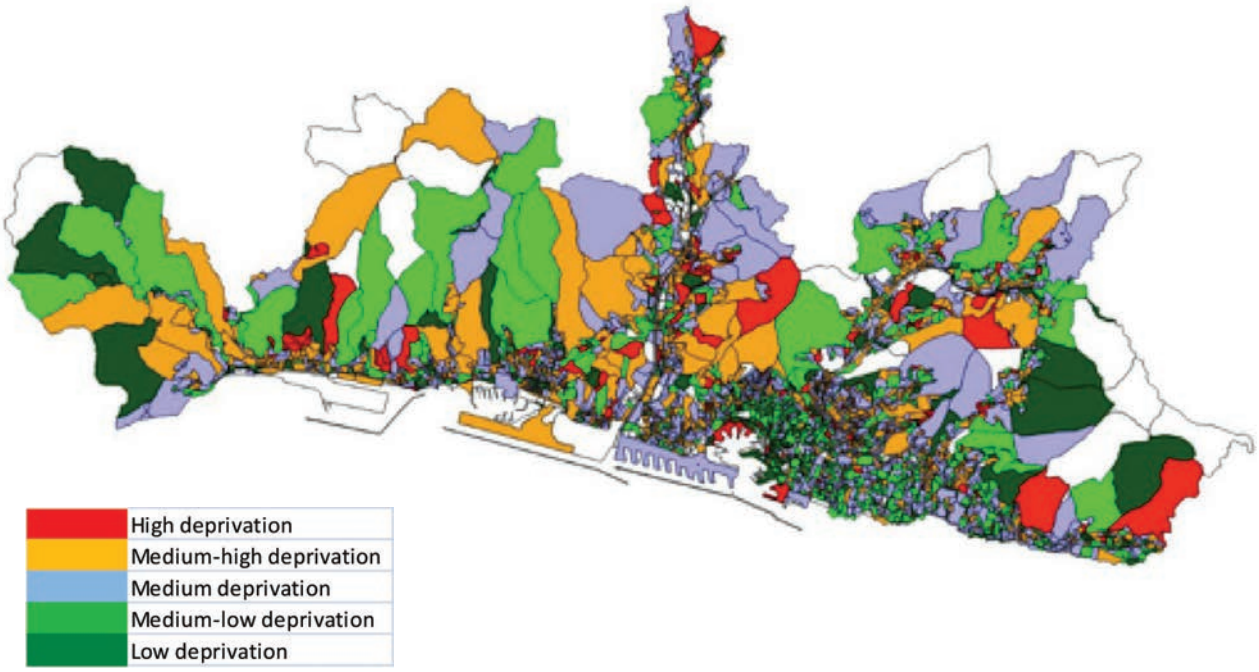
Results

According to the analysis of the factors used to construct the SEHDI, the contribution of the 1st factor (comprising the structural dependence index, the old-age index, the % of widowers/widows) to the explanation of the whole variance was 21.2%. The 2nd factor (% of single-parent families, % of single-parent families with children < 15 years) contributed 21.8%, and the 3rd factor (% of married, % of 2-members families) accounted for 16%. The 4th factor (% of rented homes, % of lower secondary school) contributed 13.8% (Tab. I).
In 2011, subjects aged 65+ years accounted for 27.7% of the population of Genoa. The percentages of the whole population and of the elderly who were in a condition of medium deprivation were similar (45.9% vs. 45.3%); medium-low deprivation was more frequent in the overall population than among the elderly (20.5% vs. 17.8%), while medium-high deprivation was more frequent in the elderly (32% vs 19.4%). At the extreme tails (both ends of the deprivation scale), the percentages were low. Only 3% of the whole population and 3.6% of elderly fell into the high deprivation group, and 2% and 1.3% belonged to the low deprivation group, respectively.
Mapping was performed in order to produce a visual depiction of the spatial distribution of SEHDI clusters in the city; the distribution of index values in the various CTs is shown in Figure 1. SES was higher in the central and eastern coastal areas than in the rest of the city. By contrast, there was a greater concentration of subjects belonging to high and medium-high deprivation groups in the two valleys, in the historical center and in the western industrial areas (Fig. 1).
Table II reports the Standardized Mortality Ratio (SMR) for all respiratory diseases, chronic obstructive pulmonary disease (COPD), influenza and pneumonia by sex, age (0-64 years and 65+ years) and SEHDI deprivation group.
In the younger subjects of both sexes, all trends were non-significant, while in the elderly statistically significant non-linear relationships [$p < 0.05$ non-linear trend (NL)] between SEHDI values and the SMRs of all res-

Tab. I. Composition of the SEHDI in Genoa, by 2011 Census variables (total explained variance 72.2%). SEHDI factors and explained variance.

Factor 1 = 21.2%	Factor 2 = 21.2%	Factor 3 = 16.0%	Factor 4 = 13.8%
Index of structural dependence	% single-parent families	% married	% rented homes
Old-age index	% single-parent families with children <15 years	% 2-members families	% lower secondary school
% widowers/windows			

Fig. 1. Map of Genoa showing the spatial distribution of SEHDI by census tract.



piratory diseases and COPD were observed in both sexes. In men, higher SMRs of all respiratory diseases were seen in the extreme tails groups, though the confidence intervals (CI) were not significant (low deprivation 1.24; high deprivation 1.15). The intermediate groups presented SMRs less than 1, which declined to a protective effect in the medium deprivation group (0.90, $p < 0.05$). Also in women, higher SMRs were found in the extreme groups, the highest value being seen in the high deprivation group (1.81, $p < 0.05$); from low deprivation to medium-high deprivation, the SMRs declined to protective values in the latter (0.81, $p < 0.05$).

A similar pattern was noticed with regard to COPD SMRs in both sexes ($p < 0.05$ NL trend). In men, higher SMRs were seen in the extreme categories (high deprivation 1.44, not significant [NS]); low deprivation 1.18, NS), while the intermediate groups presented SMRs less than 1, with a protective value in the medium deprivation group (0.88, borderline $p < 0.05$). In women, too, the higher SMRs were in the extreme tails, with the highest value in the high deprivation group (1.79, $p < 0.05$), while the intermediate groups presented SMRs less than 1, which decreased until a protective effect was reached in the medium deprivation group (0.88, $p < 0.05$).

The SMRs for influenza and pneumonia showed a linear positive trend in women ($p < 0.05$), with the highest SMR in the highly deprived (1.97, $p < 0.05$) and the lowest value in the low deprivation group (0.53, NS). In men, the trend was not linear ($p < 0.05$; low deprivation group SMR 2.46, NS; high deprivation group SMR 1.11, NS), while the other SMRs decreased from the medium-low deprivation group to the medium-high group.

Figure 2 shows the vaccination coverage (%) among the elderly in Genoa by deprivation group.

In the elderly, influenza vaccination coverage was lower at both ends of the scale (33.25% in the high deprivation group and 34.67% in the low derivation group). In the intermediate groups a positive linear trend ($p < 0.05$) was found, which grew slightly from the medium-low deprivation group (41.74%) to the medium-high deprivation group (44.36%).

Vaccination coverage decreased as the percentages of singles/unmarried and families with more than 4 members decreased; whereas it increased with the percentages of earners from labor or capital income, of 2-member families and of employees increased. Singularly, in the high deprivation cluster, vaccination coverage improved as the percentages of people belonging to the labor force, of rented homes and of 5-members families increased, but worsened as the percentage of owned homes rose. In the medium-high deprivation group, coverage rose as single-member families increased, and diminished as 3 to 5-member families and the average numbers of people per dwelling or per family grew. In the medium deprivation group, coverage rose with the increase in 3-member families and in the average number of people per dwelling, but declined as the percentage of single-member families increased. In the medium-low deprivation group, coverage improved as the percentage of single-member families and of employees rose, but decreased as the percentages of housewives and the average number of people per dwelling or per family grew. In the low deprivation group, vaccination coverage decreased with the growth of the percentages of foreigners and stateless

Tab. II. Standardized mortality ratios in Genoa for all respiratory diseases, COPD, pneumonia & influenza for the period 2009-2013.

Deprivation groups	*Respiratory 0-64 M*				*Respiratory 0-64 F*				*Respiratory 65+ M*				*Respiratory 65+ F*			
	OBS	SMR	95% CI		OBS	SMR	95% CI		OBS	SMR	95% CI		OBS	SMR	95% CI	
			Low	Up			Low	Up			Low	Up			Low	Up
High deprivation	2	1.43	0.00	3.42	3	3.08	0.00	6.56	55	1.15	0.84	1.45	85	1.81	1.43	2.20
Medium-high deprivation	26	1.80	1.11	2.50	14	1.44	0.69	2.20	416	0.91	0.82	1.00	316	0.81	0.72	0.90
Medium deprivation	19	0.78	0.43	1.13	14	0.86	0.41	1.31	584	0.90	0.83	0.98	529	0.96	0.88	1.04
Medium-low deprivation	5	0.44	0.05	0.82	9	1.19	0.41	1.97	246	0.97	0.84	1.09	219	1.01	0.87	1.14
Low deprivation	2	1.64	0.00	3.91	0	0.00	0.00	0.00	24	1.24	0.74	1.73	16	1.10	0.56	1.64
Total	**54**	**1.02**	**0.75**	**1.30**	**40**	**1.14**	**0.78**	**1.49**	**1325**	**0.93**	**0.88**	**0.98**	**1165**	**0.95**	**0.90**	**1.01**
Trend	*NS*				*NS*				*p<0.05 NL*				*p<0.05 NL*			
Deprivation groups	*COPD 0-64 M*				*COPD 0-64 F*				*COPD 65+ M*				*COPD 65+ F*			
	OBS	SMR	95% CI		OBS	SMR	95% CI		OBS	SMR	95% CI		OBS	SMR	95% CI	
			Low	Up			Low	Up			Low	Up			Low	Up
High deprivation	1	1.56	0.00	4.61	2	4.18	0.00	9.97	39	1.44	0.98	1.89	38	1.79	1.22	2.36
Medium-high deprivation	9	1.35	0.47	2.24	8	1.68	0.52	2.84	228	0.88	0.77	1.00	160	0.91	0.77	1.05
Medium deprivation	8	0.71	0.22	1.21	9	1.13	0.39	1.87	345	0.94	0.84	1.04	219	0.88	0.76	0.99
Medium-low deprivation	4	0.76	0.02	1.51	5	1.35	0.17	2.53	133	0.92	0.76	1.08	106	1.08	0.87	1.29
Low deprivation	0	0.00	0.00	0.00	0	0.00	0.00	0.00	13	1.18	0.54	1.83	10	1.52	0.58	2.47
Total	**22**	**0.90**	**0.53**	**1.28**	**24**	**1.39**	**0.83**	**1.94**	**758**	**0.94**	**0.87**	**1.01**	**533**	**0.96**	**0.88**	**1.05**
Trend	*NS*				*NS*				*p<0.05 NL*				*p<0.05 NL*			
Deprivation groups	*Influenza & pneumonia 0-64 M*				*Influenza & pneumonia 0-64 F*				*Influenza & pneumonia 65+ M*				*Influenza & pneumonia 65+ F*			
	OBS	SMR	95% CI		OBS	SMR	95% CI		OBS	SMR	95% CI		OBS	SMR	95% CI	
			Low	Up			Low	Up			Low	Up			Low	Up
High deprivation	1	3.80	0.00	11.24	0	0.00	0.00	0.00	10	1.11	0.42	1.79	24	1.97	1.18	2.76
Medium-high deprivation	7	2.57	0.67	4.47	2	1.68	0.00	4.01	77	0.90	0.70	1.10	63	0.62	0.47	0.77
Medium deprivation	5	1.09	0.13	2.04	1	0.50	0.00	1.49	115	0.94	0.77	1.12	166	1.15	0.98	1.33
Medium-low deprivation	0	0.00	0.00	0.00	0	0.00	0.00	0.00	61	1.27	0.95	1.59	62	1.10	0.82	1.37
Low deprivation	1	4.34	0.00	12.85	0	0.00	0.00	0.00	9	2.46	0.85	4.08	2	0.53	0.00	1.26
Total	**14**	**1.40**	**0.67**	**2.14**	**3**	**0.69**	**0.00**	**1.48**	**272**	**1.01**	**0.89**	**1.13**	**317**	**1.00**	**0.89**	**1.11**
Trend	*NS*				*NS*				*p<0.05 NL*				*p<0.05 L*			

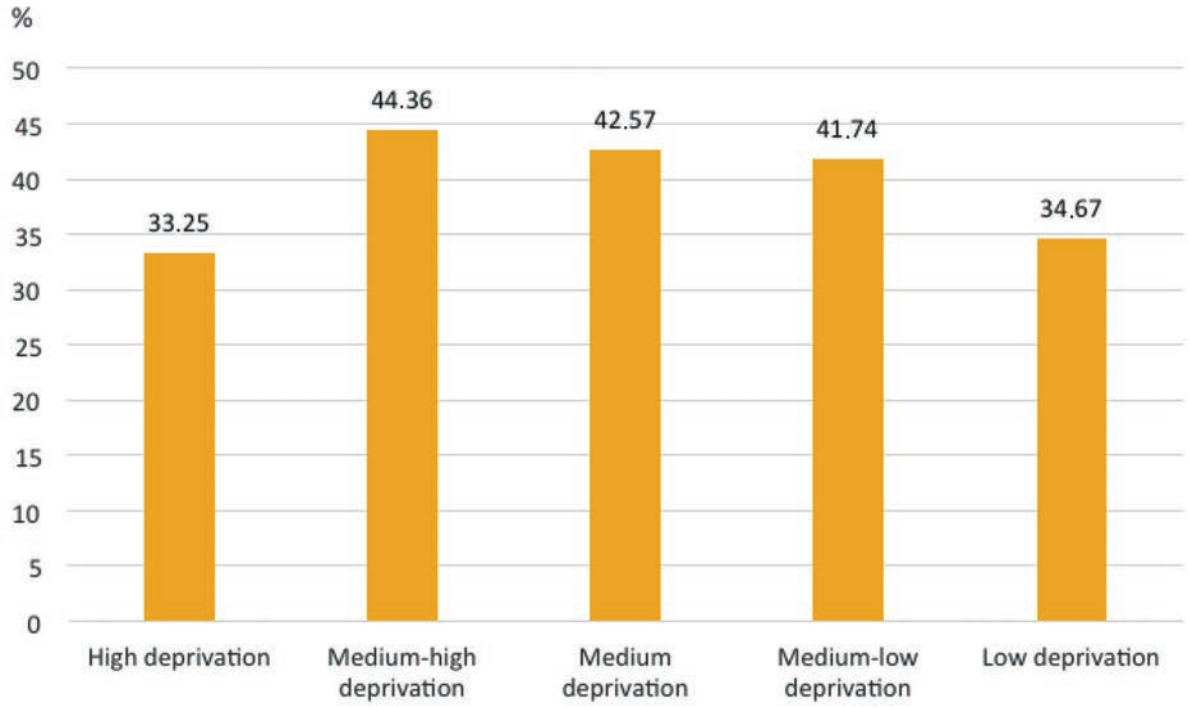
OBS: Observed death; SMR: Standardized Mortality Ratio; 95% CI: Confidence Intervals at 95% level; Low: lower interval; Upp: upper interval; L: linear trend; NL: not linear trend; NS: not significant trend.

persons residing in Italy and of single-parent families with children aged less than 15 years.

Discussion and conclusions

The population of Genoa has one of the highest aging indexes in the world, especially among women. Accordingly, the proportion of young people is declining. As a result, the population is fragile from the SE point of view. In particular, the intermediate age-class is shrinking markedly, which has substantially reduced the family support necessary to enable the elderly to cope with serious diseases and other health problems (e.g., disability) [24, 25]. Furthermore, with the decline of the city's traditional industrial and commercial activities, Genoa has tried to develop the sectors of tourism and advanced tertiary services [26]. Unfortunately, however, the SE structure still remains mainly based on savings and retirement income, rather than on the success of local business [27]. Moreover, the impervious nature of the territory creates logistical difficulties in the provision of social and health services.

Fig. 2. Vaccination coverage (%) among the elderly in Genoa by deprivation group - period 2014-2016.



In Genoa, the SEHDI was able to explain 72.2% of the total variance of the deprivation in the population. Indeed, the four component factors closely reflect the fragility of the Genoese population. The 1st factor (Tab. I), which concerns aging, loneliness and the increasing SE dependence of the elderly, summarizes this situation. The second factor brings out another type of poverty, that of the youngest families, who have little or no social support. This situation mostly involves foreigners who assist elderly Genoese residents living alone, given the low birth rate that has characterized the native population for many decades. These families (often Latin Americans) are mostly composed of unaccompanied women with dependent children, whose income does not allow family reunification and, thus, mutual family support; at times, the children of these families also have problems of social integration. This aspect is highlighted on the map by the fact that the CTs with high percentages of foreign residents coincide with the CTs with the highest SE disadvantage. The third factor reiterates the concept of the first two, emphasizing the importance of mutual support in the family. Finally, the fourth factor underlines the importance of home ownership in determining SES; at the same time, it reveals the relevance of the level of education in improving SES situation, and, from a health point of view, in understanding preventive messages and adhering preventive strategies.

With regard to the distribution of socio-health deprivation, the study showed that more than a third of the elderly population belonged to medium-high and high deprivation groups, and almost half to the medium deprivation group. This underlines the increasing socio-health problems of the city due to the high percentage of elderly persons in the population (27.7%), as already revealed by the traditional ISTAT summary indicators (old age, structural dependence, replacement indices).

The SMRs for respiratory diseases and COPD in the elderly display non-linear behaviors, with highest values in the two extreme clusters. Moreover, in women these SMRs seem to increase as deprivation increases, highlighting a worse socio-health situation. Considering the SMRs for influenza and pneumonia, the trend is not linear in men, while it is positive in women, owing to the very high value in the highly deprived. The result seen in men may be justified by the inverse relationship that was found between vaccination coverage and deprivation, with people belonging to the low deprivation group showing the lowest coverage (almost two percentage points less than in the high deprivation group). By contrast, in women, the socio-health disadvantages tend to affect the deprived more than the less deprived; thus mortality due to influenza and pneumonia increases in this group, as also does mortality due to the other respiratory diseases.

Our findings on the relationship between deprivation and mortality are in line with those from similar studies conducted in other European cities [28-30]. A study carried out in 15 European cities showed SE inequalities at the area level in concomitance with many main causes of death. Specifically, SMRs for influenza and pneumonia in women were directly associated with SE deprivation in three cities and inversely associated in one, while among men a direct association was observed in all cities [28]. Moreover, Italian studies have also found higher mortality rates in more deprived areas, with sig-

nificantly higher rates being recorded among the more deprived elderly both men and women [29, 30].

Regarding the association between vaccination coverage and deprivation, most studies conducted in the elderly have reported higher influenza vaccination uptake in the low deprivation groups [14, 15, 31]. Two studies [32-33], however, found that the less deprived elderly had lower influenza vaccination coverage than those in the lower and middle deprivation classes. We found that influenza vaccination coverage was lower at both ends of the scale. The low level seen in the low deprivation group could be the consequence of anti-vaccination campaigns [34], which have recently grown in Italy; these may have induced an exaggerated and distorted perception of potential vaccine risks [33] more frequent in the higher SE classes. The highest vaccination coverage was found in the medium-high deprivation group. In this group, it is possible that chronic and co-morbid conditions were more common, and that these subjects were therefore more likely to visit health care facilities where vaccination is encouraged and provided [32].

The present study has some limitations, the main one being that the observation unit was not the individual but the CT. This choice, while unavoidable, obliges caution in making inference about causal associations, as the ecological fallacy (namely, the error arising when the characteristics of a reference area, such as the CT, are assumed to apply to every individual in that area) cannot be ruled out [2, 3, 22]. Another limit may concern the possible under-reporting of vaccination coverage by GPs and, therefore, the incompleteness of data. On the other hand, one of the main strengths of the study lies in its use of validated administrative data, which makes the analysis transparent and repeatable. Moreover, it must be underlined that the different method of constructing the SEHDI could have given rise to differences from the literature results, as the associations observed in each individual investigation are linked to the distribution of the population into deprivation groups that are individuated by each single index. Indeed, "deductive" indexes – i.e. those based on the choice "a priori" of SE variables, each one of which is thought to be the best possible indicator of poverty – might not be the best method of constructing the best deprivation index to use for health purposes.

In conclusion, this study allowed us to describe the situation of deprivation of the elderly living in Genoa and to detect the main critical points concerning influenza vaccination. These findings should be taken into account in the organization of vaccination campaigns and should prompt differentiated actions in each local area.

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Conflict of interest statement

None declared.

Authors' contributions

RG and DP conceived and designed the study. LA, FZ, AB, LS and AM collected data. MV and RL performed statistical analysis and interpretated resultes. RL, MV, DA and DP participated in drafting the article or revising it critically for important intellectual content. All authors gave their final approval of the manuscript.

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ORIGINAL ARTICLE

Application of socio-economic-health deprivation index, analysis of mortality and influenza vaccination coverage in the elderly population of Tuscany

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Keywords

Deprivation index • Mortality • Influenza vaccination • Elderly • Tuscany (Italy)

Summary

Objective. *The aim of this paper is to describe the results obtained from the application of a specific local deprivation index, to general and cause-specific mortality and influenza vaccination coverage among elderly people in the municipality of Florence.*

Methods. *General and cause-specific mortality data (2009-2013) and influenza vaccination coverage data (2015/16 and 2016/17) were collected for subjects aged ≥ 65 years residing in the municipality of Florence (Tuscany), at the 2011 Census section level. A Socio-Economic and Health Deprivation Index (SEHDI) was constructed and validated by means of socio-economic indicators and mortality ratios.*

Results. *Half of the population of Florence belonged to the medium deprivation group; about 25% fell into the two most deprived groups, and the remaining 25% were deemed to be wealthy. Elderly people mostly belonged to the high deprivation group. All-cause mortality and cause-specific mortality (cancer and respiratory diseases) reached their highest values in the high deprivation group. Influenza vaccination coverage (VC) was 54.7% in the 2015/16 and 2016/17 seasons, combined. VC showed a linear rising trend as deprivation increased and appeared to be correlated with different factors in the different deprivation groups.*

Conclusions. *As socio-economic deprivation plays an important role in health choices, application of the SEHDI enables us to identify the characteristics of the main sub-groups of the population with low adherence to influenza vaccination. The results of the present study should be communicated to General Practitioners, in order to help them to promote influenza vaccination among their patients.*

Introduction

Tuscany, an Italian Region with a population of 3,742,437 [1], is composed of 10 Provinces and 276 Municipalities. Florence, the capital city of Tuscany, is situated in the north of the Region and is the most populous city. In the municipality of Florence, the population grew from 358,079 in 2011 [2] to 382,258 in 2017 [1]. Elderly people, i.e. aged ≥ 65, account for about a quarter of the whole population (25.5% in 2011 and 25.8% in 2017) [1]. The age pyramid shows that people older than 80 years are more frequently widows or widowers, a condition that is more frequent among women [3]. With regard to the structural indicators of the population, in 2017 the ageing index was 214.8 and the old-age dependency ratio was 41.5 [4].

According to 2001 Census data, the areas with the highest percentages of deprived and highly deprived people are those on the western side of Florence and the area south of the River Arno. By contrast, the north-eastern area of the city has the lowest percentage of deprived and highly deprived people [5]. In a recent analysis performed in 2012, the percentage of people living in deprived or highly deprived areas of the city was 37.2%, lower than the average Tuscan value (40%) [5].

The main causes of death are cardiovascular diseases (36.1%) and cancer (28.9%). Other significant causes of death are respiratory tract diseases, nervous system diseases, injuries and gastrointestinal diseases. Cumulatively, the six above-mentioned leading causes of death account for more than 87% of all deaths [5].

In the Local Health Unit of Florence, the standardized mortality ratio in the years 2013-2015 was 8.7/1000: specifically, 10.9/1000 in males and 7.2/1000 in females. The standardized PYLL (potential years of life lost) rate was 33.03 (32.8-33.3) and the age-standardised avoidable mortality rate was 176.3/100,000 (166.7/100,000-185.8/100,000) [6].

With regard to socio-economic aspects, in 2017 the total unemployment rate in the Province of Florence stood at 6.8% [7]. This value has shown an increasing trend over the last ten years, but it remains lower than the regional Tuscan unemployment rate. The highest values are those among young people aged 15-24, whose unemployment rate was 16.4% in 2017. The employment rate of the 15-64 age-group was 69.3% in 2017 [7, 8].

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Here, we report the results obtained from the application of the deprivation index to mortality and influenza vaccination coverage among people over 65 years of age according to the 2011 Census data on the municipality of Florence.

Methods

The study was approved by the Local Ethics Committee in September 2016, and data collection was authorized to start in October 2016. Moreover, in order to enable the analysis of coverage data collected by General Practitioners (GPs) in Florence in October 2017, a scientific collaboration agreement between the Local Health Unit of Central Tuscany and the Department of Health Sciences (University of Florence) was approved. The study population comprised subjects aged ≥ 65 years residing in the municipality of Florence (Tuscany) who had undergone influenza vaccination by their GPs.
The work was carried out according to the following phases:

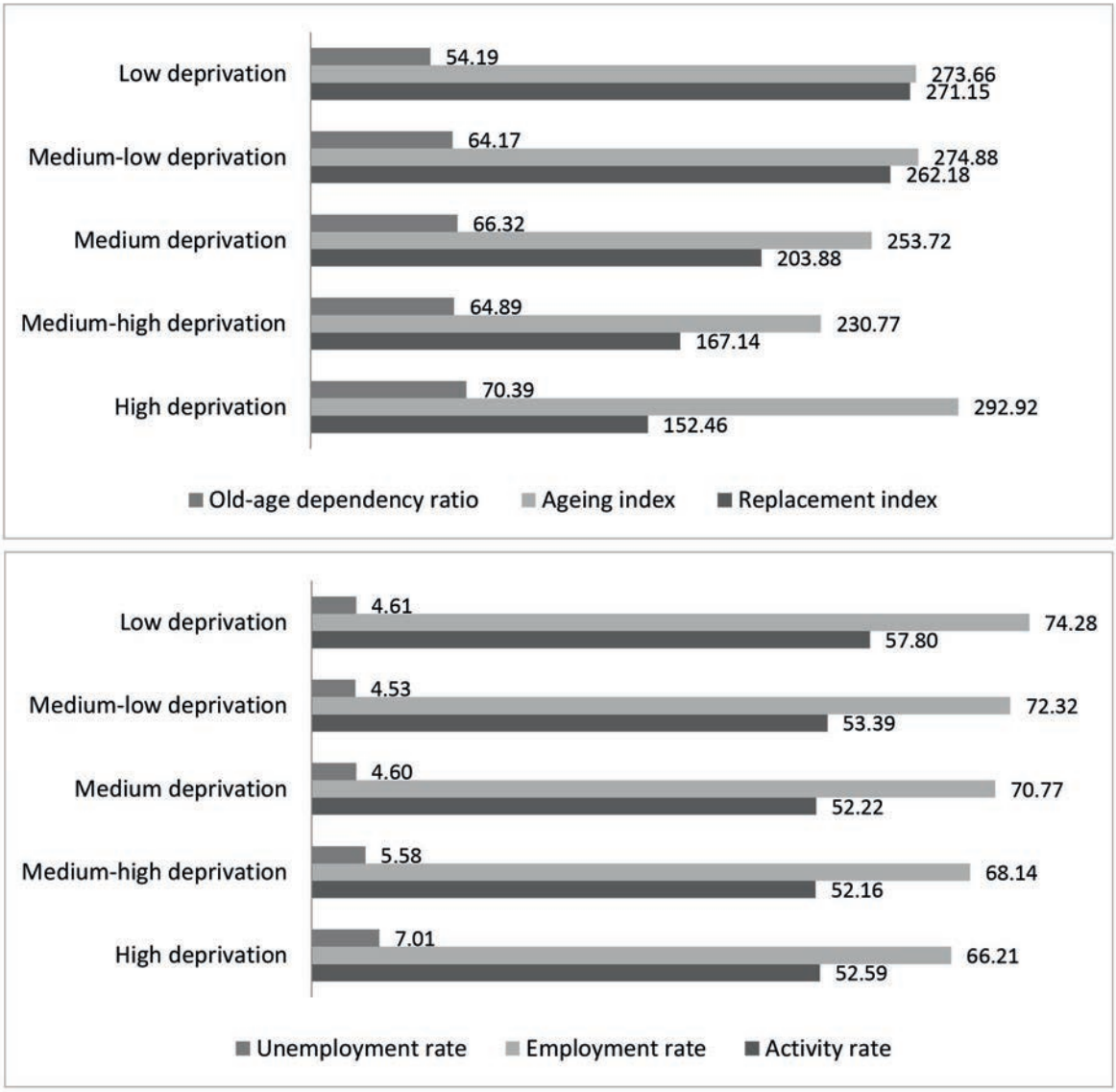
- *Phase 1: collection of mortality data.*
  General and cause-specific mortality data were obtained from the Regional Mortality Registry (RMR) for the years 2009-2013, by gender and by two age-groups (0-64y and over 65y). A shared procedure of data exchange was established between the Municipal Statistical Office and the RMR, in order to assign each deceased person to the corresponding 2011 Census section. In this first phase of the data collection, the following steps were followed:
  - the RMR provided the Florence Municipal Statistical Office with a list of names (name, surname, date of birth and fiscal code, accompanied by an identifier code constructed ad hoc for the study) of all the residents of the Municipality of Florence who had died in the period 2009-2013;
  - the Florence Municipal Statistical Office assigned each subject on the list provided by the RMR to a census section by using two linkages, one for the name and date of birth and one for the fiscal code. The Statistical Office then sent a file containing only the following information to the RMR: the identifier code and the census section to which the subject had been assigned;
  - the RMR then provided the mortality data regarding the variables listed above: all causes and specific causes of death, by sex, two age-classes (0-64; 65+), year and census section. This information was then transmitted by the RMR to the local study manager and, in aggregate form, to the Project Coordinator.
- *Phase 2: collection of influenza immunization coverage data.*
  During the second phase, the following steps were followed:
  - collection of the number of subjects aged ≥ 65 years vaccinated during the 2015/16 and 2016/17 influenza vaccination campaigns by each GP in Florence. These data were obtained through the computer files containing the list of vaccinated patients, available at the Florence Health District;
  - identification of the address of the main outpatient clinic served by each GP. This information was used as a proxy of the geographical area of each GP, and was obtained from the database containing information on all GPs in Florence;
  - the address of each GP's main clinic was linked to the corresponding census section (geocoding), after the list of all the addresses and their corresponding 2011 Census sections had been obtained from the Statistical Service of the Municipality of Florence;
  - calculation of the vaccination coverage (VC) in each census section. The total number of patients aged ≥ 65 years vaccinated by each GP was obtained from the database containing information on all GPs in Florence.

The total number of GPs was 260 in the 2015/16 season and 266 in the 2016/17 season. The difference between the two years was due to the different numbers of GPs retiring and of those starting work.
A local Socio-Economic and Health Deprivation Index (SEHDI) was developed according to the methodology proposed by Lillini et al. [9]. Three main factors made up the index and provided the best profiles of socio-economic-health inequalities in Florence; these factors explained 60.7% of the total variance.
To test the accuracy of the SEHDI, a validation procedure using socio-economic indicators and mortality ratios was performed [9].

Results

Regarding the socio-economic validation of the SEHDI, Figure 1 shows the main socio-economic status indexes for each deprivation group.
Half of the population of Florence belonged to the medium deprivation group. About 25% fell into the two most deprived groups, and the remaining 25% were deemed to be wealthy. The least deprived groups were seen to live in the city centre area, while the north-western area of the city had the highest percentage of deprived residents. Elderly people mostly belonged to the high deprivation group, which showed the highest ageing index value (292.92).
The unemployment rate varied from 4.53 to 7.01, with the highest value in the high deprivation group. Accordingly, the employment rate was highest (74.28) in the low deprivation group, as was the activity rate (57.80).
Concerning mortality ratios, Table I shows the general and cause-specific mortality ratios in each deprivation group. Cause-specific mortality was analysed with regard to the following diseases: cancer (general and sex-specific) and respiratory tract diseases (including pneumonia and COPD).

Fig. 1. Distribution of socio-economic status indexes in the five deprivation groups.



The RMR recorded a total of 22,563 deaths among residents of the municipality of Florence in the period 2009-2013. Of these, 22,032 deaths were linked to the 2011 census sections and included in the analysis; this figure, which corresponded to 97.6% of the total number of deaths, was obtained after electronic and manual cross-check and data validation.

All-cause mortality and cancer-related mortality showed a non-linear trend, with the highest values in the high deprivation group; the respiratory disease-specific mortality rate displayed a linear trend, with the highest value in the high deprivation group.

Regarding the distribution of the SEHDI by census section, the analysis showed that high deprivation was concentrated mainly on the western side of the city. The central area (north and south of the river) was the least deprived (Fig. 2).

After application of the "linkage procedure" between the census section and the VC of each GP's main outpatient clinic, the overall average VC was calculated to be 54.7% in the 2015/16 and 2016/17 seasons, combined; specifically: 57.3% in the 2015/16 season and 53.8% in 2016/17.

The results showed a linear rising trend in VC as deprivation increased (Fig. 3A-3C), which means that elderly subjects in the highly deprived group were more likely to be vaccinated than those in the least deprived group.

Concerning the 2015/16 season, a positive correlation emerged between VC and the percentage of married people, of people with lower secondary education, and of 2-member families. By contrast, a negative correlation was seen between VC and the percentage of singles/unmarried, of unemployed people looking for new jobs, of foreigners and stateless persons residing in Italy, of 1-member families and of unemployment.

Tab. I. Rates of general and cause-specific mortality in each deprivation group.

A) General and cause-specific mortality rates (respiratory tract diseases)				
Deprivation group	**General mortality SMR(95%CI)**	**Respiratory tract SMR(95%CI)**	**Pneumonia/Flu SMR (95%CI)**	**COPD SMR(95%CI)**
High deprivation	1.22(1.17-1.27)	1.51(1.29-1.74)	2.06(1.49-2.62)	1.29(0.99-1.29)
Medium-high deprivation	1.04(1.00-1.07)	1.08(0.94-1.22)	1.23(0.90-1.56)	1.10(0.89-1.30)
Medium deprivation	1.10(1.08-1.12)	1.25(1.16-1.34)	1.79(1.56-2.02)	1.08(0.97-1.20)
Medium-low deprivation	1.13(1.09-1.16)	1.22(1.06-1.39)	1.39(1.02-1.77)	1.04(0.82-1.25)
Low deprivation	1.00(0.96-1.05)	1.08(0.89-1.26)	1.36(0.90-1.81)	1.05(0.78-1.32)
Total	**1.09(1.08-1.11)**	**1.23(1.17-1.29)**	**1.63(1.47-1.78)**	**1.10(1.01-1.18)**
Trend	*p<0.05 n.l.*	*p<0.05 l.*	*p<0.05 l.*	*p<0.05 l.*
B) Cause-specific mortality rates (cancer)				
Deprivation group	**All cancers SMR(95%CI)**	**Stomach SMR(95%CI)**	**Colorectal SMR(95%CI)**	**Lung SMR(95%CI)**
High deprivation	1.20(1.09-1.30)	1.50(1.06-1.95)	1.26(0.94-1.58)	1.77(1.48-2.05)
Medium-high deprivation	1.02(0.95-1.09)	1.08(0.80-1.37)	1.30(1.05-1.54)	1.24(1.06-1.42)
Medium deprivation	1.05(1.01-1.09)	0.99(0-83-1.14)	1.40(1.26-1.55)	1.12(1.02-1.22)
Medium-low deprivation	1.11(1.03-1.19)	1.19(0-86-1.51)	1.52(1.23-1.81)	1.21(1.01-1.40)
Low deprivation	0.88(0.79-0.97)	0.95(0.60-1.30)	1.00(0.71-1.28)	0.89(0.68-1.09)
Total	**1.05(1.02-1.08)**	**1.08(0.96-1.19)**	**1.35(1.25-1.45)**	**1.19(1.12-1.26)**
Trend	*p<0.05 n.l.*	*p<0.05 l.*	*p<0.05 l.*	*p<0.05 l.*
C) Breast cancer and prostate cancer mortality rates				
Deprivation group	**Breast cancer (F) SMR(95%CI)**		**Prostate cancer (M) SMR(95%CI)**	
High deprivation	1.35(0.93-1./8)		1.36(0.83-1.98)	
Medium-high deprivation	1.04(0-75-1.33)		1.03(0-68-1.38)	
Medium deprivation	1.13(0.96-1.29)		1.03(0.83-1.22)	
Medium-low deprivation	1.27(0.93-1.61)		0.92(0.57-1.28)	
Low deprivation	1.14(0.72-1.55)		0.68(0.30-1.07)	
Total	**1.16(1.03-1.28)**		**1.01(0.87-1.15)**	
Trend	*p<0.05 n.l.*		*p<0.05 l.*	

n.l.: non-linear trend; l.: linear trend; F = females; M = males.

In the 2016/17 season, a positive correlation was observed between VC and the percentage of married people, of 2- and 4-member families, and the average number of people per occupied dwelling. VC displayed a negative correlation with the percentage of separated and divorced people, of people belonging to the labour force, of unemployed people looking for new jobs, of term contract workers, and of temporary jobs.
Finally, in the whole period (2015/17), a positive correlation emerged between VC and the percentage of married people and of 2- and 4-member families, and the average number of people per dwelling. A negative correlation was seen between VC and the percentage of divorced people, of people belonging to the labour force, of unemployed people and of temporary jobs.
On examining the individual census variables, it emerged that VC correlated with different factors in the different deprivation groups (Tab. II).

Discussion

Using census data to quantify socio-economic deprivation is a generally well-accepted method of identifying populations with poorer health outcomes [10]. In particular, since influenza immunization among the elderly is an important public health intervention to prevent unnecessary hospitalizations and premature death, the use of socio-economic deprivation indexes has been proposed in order to identify non-vaccinating subgroups [11].
In recent years, the age structure of the Florentine population has shown a reduction in the central age-groups and a steady increasein the elderly population. In particular, the percentage of older women living alone increases with age, and these subjects constitute a group at high risk of social isolation and poverty [3, 4, 12].
In the present study, a specific deprivation index, the SE-HDI, was drawn up and validated at the local level, in order to obtain a better estimation of health inequalities associated with environmental factors.
Regarding validation of the SEHDI, the present study confirmed, as expected, that elderly people are more likely to belong to the most deprived group. With regard to health-related validation, mortality was clustered by both overall and cause-specific mortality in this study. The results showed that increasing deprivation is significantly associated with all-cause and cause-specific mortality. The association with socio-economic deprivation is less clear with regard to mortality due to colorectal cancer, which showed higher values in the medium-low, medium and medium-high deprivation groups. These results are consistent with those of previous studies, which

Fig. 2. Distribution of deprivation indexes in the Municipality of Florence, by census section.

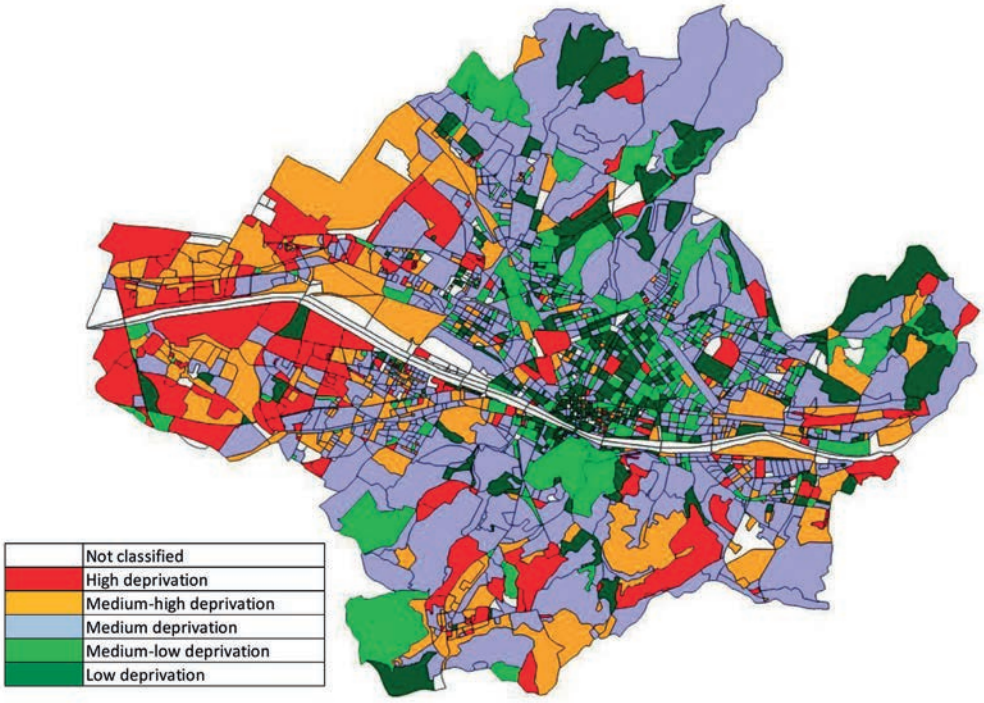
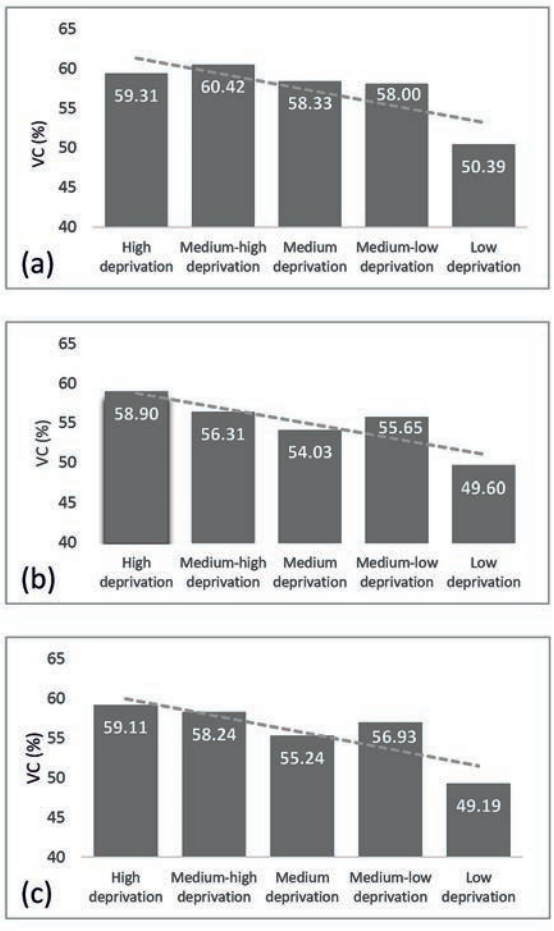


Fig. 3: Influenza vaccination coverage (%) in the different deprivation groups:
a): Season 2015/16; **b):** Season 2016/17; **c):** Seasons 2015/16 and 2016/17 combined.



Tab. II. Factors influencing vaccination coverage in each deprivation group (with correlation values and statistical significance).

Season 2015/16	Pearson correlation	P value
High deprivation		
% singles/unmarried	-1.000	0.020
% upper secondary school	0.997	0.046
% earners from labor or capital income	0.998	0.042
% 2-member families	-0.999	0.026
% single-parent families with children under 15 years	-0.998	0.042
% single-member families 65+	0.999	0.031
Medium-high deprivation		
% 3-member families	0.597	0.011
Medium deprivation		
% singles/unmarried	-0.408	0.007
% married	0.342	0.025
% foreigners and stateless persons residing in Italy	-0.329	0.031
% rented homes	-0.351	0.021
% owned homes	0.323	0.034
% employees	0.311	0.043
% temporary job	-0.329	0.031
Medium-low deprivation		
% belonging to labor force	-0.572	0.032
% employed	-0.541	0.046
% not belonging to the labor force	0.662	0.010
% students	0.548	0.042
% earners from labor or capital income	0.601	0.023
% employees	-0.638	0.014
Average area of homes occupied	0.542	0.045
Activity rate	-0.635	0.015
Low deprivation		
No correlation		
Season 2016/17	**Pearson correlation**	**P value**
High deprivation		
% lower secondary school	0-.995	0.043
% unemployed looking for new jobs	-0.999	0.033
% employed	-0.999	0.026
% self employed	0.994	0.041
Activity rate unemployed looking for new jobs	-0.998	0.039
Unemployment rate	-1.000**	0.006
Medium-high deprivation		
% 3-member families	0.458	0.044
Medium deprivation		
% divorced	-0.292	0.048
% primary school diploma	-0.279	0.041
% unemployed looking for new jobs	-0.355	0.024
% self-employed	0.355	0.025
% single-parent families with children under 15 years	-0.314	0.048
Unemployment rate	-0.315	0.048
Medium-low deprivation		
% housewives	-0.566	0.044
% 3-member families	0.617	0.025
Low deprivation		
% married	0.476	0.025
% separated	-0.380	0.041
% rented homes	-0.379	0.082
% 2-member families	0.447	0.037
% 3-member families	-0.405	0.041
% term contract workers	-0.403	0.043
% temporary job	-0.659*	0.001

Tab. II. Factors influencing vaccination coverage in each deprivation group (with correlation values and statistical significance).

Seasons 2015/16 and 2016/17 combined	Pearson correlation	P value
High deprivation		
% upper secondary school	0.992	0.049
% not belonging to the labor force	0.997	0.043
% other employment status	-0.998	0.041
% earners from labor or capital income	0.992	0.042
% entrepreneurs	0.996	0.049
% self-employed	0.995	0.045
% single-parent families with children under 15 years	-0.992	0.042
Medium-high deprivation		
% 3-member families	0.586	0.013
Medium deprivation		
% married	0.326	0.024
Medium-low deprivation		
% primary school diploma	-0.510	0.063
% 3-member families	0.503	0.067
% employees	-0.718	0.004
Low deprivation		
% 2-member families	0.450	0.031
% 3-member families	-0.422	0.045

*= $p < 0.05$; ** = $p < 0.01$.

have demonstrated that people living in more deprived areas have higher mortality rates than those living in less deprived areas [13-16].

From the analysis of the distribution of deprivation in the municipality of Florence, it emerges that the most deprived area is the western suburb, where the poorest people live. By contrast, the central area of the city appears to be the least deprived, although it does contain some deprived quarters. This could be due to the fact that not only economic but also familial and social factors (such as living alone, less access to health services) are involved in deprivation.

Vaccination coverage in the two flu-seasons proved to be low and did not meet the goal of 75% uptake among older people, which is the national minimum target set for people over 65y [16]; indeed, VC values were below 65%, which is very far from the optimal national target of 95%.

Application of the SEHDI to elderly people in the municipality of Florence revealed that adherence to influenza vaccination was greatest in the sub-group with the highest level of deprivation. These results differ from some previous findings. Indeed, a systematic review conducted in 2017, which investigated the association between deprivation indexes and anti-influenza vaccination coverage in the elderly population, found that elderly subjects belonging to the least deprived group were significantly more likely to be vaccinated than those in the most deprived group [11]. Moreover, Anu Jain et al. [18] reported that seasonal influenza vaccination uptake was modestly lower (7-11%) amongst those living in the most deprived areas.

On examining the individual Census variables, it is possible to identify some characteristics that further define the sub-groups of population with lower vaccination uptake. The results showed a positive correlation between immunization coverage and the percentage of married people and the average number of family members. By contrast, a negative correlation emerged between vaccination coverage and the percentage of divorced/single/unmarried people (probably living alone) and unemployed people.

Vaccination coverage also appears to be correlated with different factors in the different deprivation groups, confirming that socio-economic status plays an important role in health choices. Thus, the data on vaccination coverage in the municipality of Florence, when integrated with the index of territorial deprivation, allow us to identify specific sub-groups of the older population that do not sufficiently adhere to seasonal influenza vaccination advice.

The present study has some limitations. Firstly, mortality data and immunization coverage data refer to different periods; this is due to the unavailability of the most recent mortality data in the period of data collection. Secondly, vaccination coverage was calculated only for the two most recent influenza seasons (2015/16 and 2016/17), since digital data on previous years were not available (data from 2009/10 to 2013/14 were available only on paper). Moreover, influenza vaccination coverage data could be affected by possible bias regarding the correspondence between the address of each GP's outpatient clinic and the census section of the Municipality of Florence. Indeed, citizens in Tuscany can choose their GP from among all those who work in the area that includes their municipality of residence. Consequently, a resident of Florence may have chosen a GP whose outpatient clinic was on the opposite side of the city, or even in another municipality in the same area. The same applies to residents of other municipalities in the same area, who may have chosen a GP from the municipality of Florence, although they did

not reside in this municipality. Moreover, a GP may have several clinics in the same municipality.

Conclusions

In order to increase vaccination uptake and to understand the factors that influence immunization coverage, deprivation indexes can constitute a useful tool to share with the GPs in the territory. The results of the present study should be communicated to GPs, in order to help them to promote influenza vaccination among their patients, particularly those patients who are less likely to be vaccinated and who are at higher risk of death.
Continuing medical education, even in the form of distance learning, could constitute a useful application of the Project.

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Conflict of interest statement

None declared.

Authors' contributions

AB and FP made substantial contributions to the conception and design of the study, and/or to data acquisition (FP, PF, EB, AM, LB), analysis and interpretation (AB, FP, GD, FC, TS). SB and PB participated in drafting the article or revising it critically for important intellectual content. All authors give their final approval of the version to be submitted and any revised version.

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ORIGINAL ARTICLE

The Socio-Economic Health Deprivation Index and its association with mortality and attitudes towards influenza vaccination among the elderly in Palermo, Sicily

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Keywords

Socio-Economic Deprivation Index • Influenza vaccination coverage • Elderly • Social determinants of health

Summary

Introduction. *Socio-economic status (SES) seems to be a determinant of health and is associated with vaccination coverage among older and at-risk populations. The aim of this study was to evaluate trends in health outcomes and the Socio-Economic and Health Deprivation Index (SEHDI) among elderly people in the city of Palermo.*
Methods. *In the 2015 CCM project, the Palermo Unit collected mortality data for use in validating the SEHDI. Italian census data from 2009 to 2015 on overall mortality and causes of death were used. The outcome used to validate the SEHDI was vaccination coverage from the 2009-2010 to 2014-2015 influenza seasons among the elderly in Palermo.*
Results. *The SEHDI correlated significantly with all-cause mortality ($p < 0.05$), though this correlation displayed a decreasing trend. Regarding mortality due to influenza or pneumonia, however, the significant correlation ($p < 0.05$) showed an increasing trend. A linear trend was observed in the inverse correlation between the SEHDI and vaccination coverage rates ($p < 0.05$), with an overall 27% vaccination coverage among older people. Elderly subjects living in a census district with more regular immigrants, divorced people and single-parent families were more reluctant to undergo influenza vaccination.*
Conclusions. *This study allowed us to identify subgroups of elderly people who are less likely to adhere to influenza vaccination, and to whom health promotion interventions could be addressed in order to facilitate "healthy aging".*

Introduction

Vaccination is the most effective means of reducing influenza disease both among at-risk subjects and in the general population [1, 2]. The Italian Preventive Plan envisions free-of-charge influenza vaccination for over 65-year-old subjects and those at risk [3]. Nevertheless, in Italy almost 8 million cases of influenza-like illness (ILI) occur every year, imposing a heavy burden in terms of hospitalization and mortality [4-6]. Vaccination coverage in Italy is below the recommended level of 75% and has shown a decreasing trend in recent years (52.6% among subjects over 65 years old during the 2016-17 influenza season). Consequently, direct medical costs have risen, owing to the increase in Emergency Department and hospital admissions [7]. Literature data have shown that socio-economic status and deprivation play a major role in vaccination adherence [8-11]. Indeed, an association has been seen between income level and vaccination coverage among older and at-risk subjects. This has prompted the hypothesis that Socio-Economic Status (SES) is a determinant of health status and the ability to comply with preventive recommendations and healthcare indications. In this regard, low SES has been associated with low vaccination coverage in Spain, France and the UK [10]. By contrast, influenza vaccination coverage in Italy is reported to be higher among older people of lower SES [12, 13]. The same association has been observed among people with comorbidities who have a higher risk of acquiring influenza [14].

The Department of Science for Health Promotion and Mother-Child care of Palermo University contributed to the 2015 CCM project financed by the Ministry of Health. This project was called "Influenza vaccination among older people: developing a deprivation index of SES characteristics and informative/educational needs in order to increase vaccination coverage, so as to reduce influenza-related Emergency Department access and hospitalization". The purpose of the project was to validate a new socio-economic health-status deprivation index with a view to evaluating preventive strategies and health outcomes in the city of Palermo.

The main aim of the present study was to evaluate the trend in health outcomes and the socio-economic health-status deprivation index among subjects aged over 65 years in Palermo. The secondary objective was to evaluate the multidimensional features of SES, in order to identify groups of people at higher risk of refusing influenza vaccination.

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Methods

In the 2015 CCM project, the Palermo Unit dealt with collection of mortality data for use in validating the local deprivation index. The 2011 Italian census data on the city of Palermo were used to depict demographic characteristics. Data on overall mortality and causes of death from 2009 to 2016 were extracted by applying the ICD9 classification to the registry of causes of death, which is managed by the Sicilian Regional Health Authority [15]. Observed and expected deaths (n = 39,831), stratified by age and sex, were correlated with geographic information on the over 650,000 people living in Palermo.

All the demographic and socio-economic variables from the 2011 Italian Census of Population and Households were used to compute the Socio-Economic and Health Deprivation Index (SEHDI) for the municipality of Palermo, at Census block (or Census tract) territorial level. The SEHDI was computed according to the studies conducted by Lillini and Vercelli on local deprivation indexes as a tool for evaluating health inequalities in a population [16]. The values of the SEHDI were classified into five levels of deprivation (high, medium-high, medium, medium-low, and low).

The SEHDI was then used to study the vaccination coverage distribution from the 2009-2010 to 2014-2015 influenza seasons among Palermo residents. For each influenza season, vaccination coverage in each Census tract was evaluated. This was calculated by recording vaccination adherence among subjects aged over 64 years; these data were then linked to each Census block by plotting the geographical distribution of the offices of the subjects' general practitioners. Demographic, economic, housing and mortality variables were used to carry out a principal-component factor analysis, in order to draw up the deprivation index. The distribution of vaccination coverage according to the SEHDI was evaluated by ANOVA, using the F-test and the test of linearity for trend. Pearson's test was used to evaluate bivariate correlations between vaccination coverage and demographic characteristics (divorced, secondary school education level, percentage of retired people or schoolchildren, students, regular migrants and the frequency of single-parent families with at least one child < 15 years old) stratified by deprivation index. In all analyses, a two-tailed significance level was applied ($p < 0.05$).

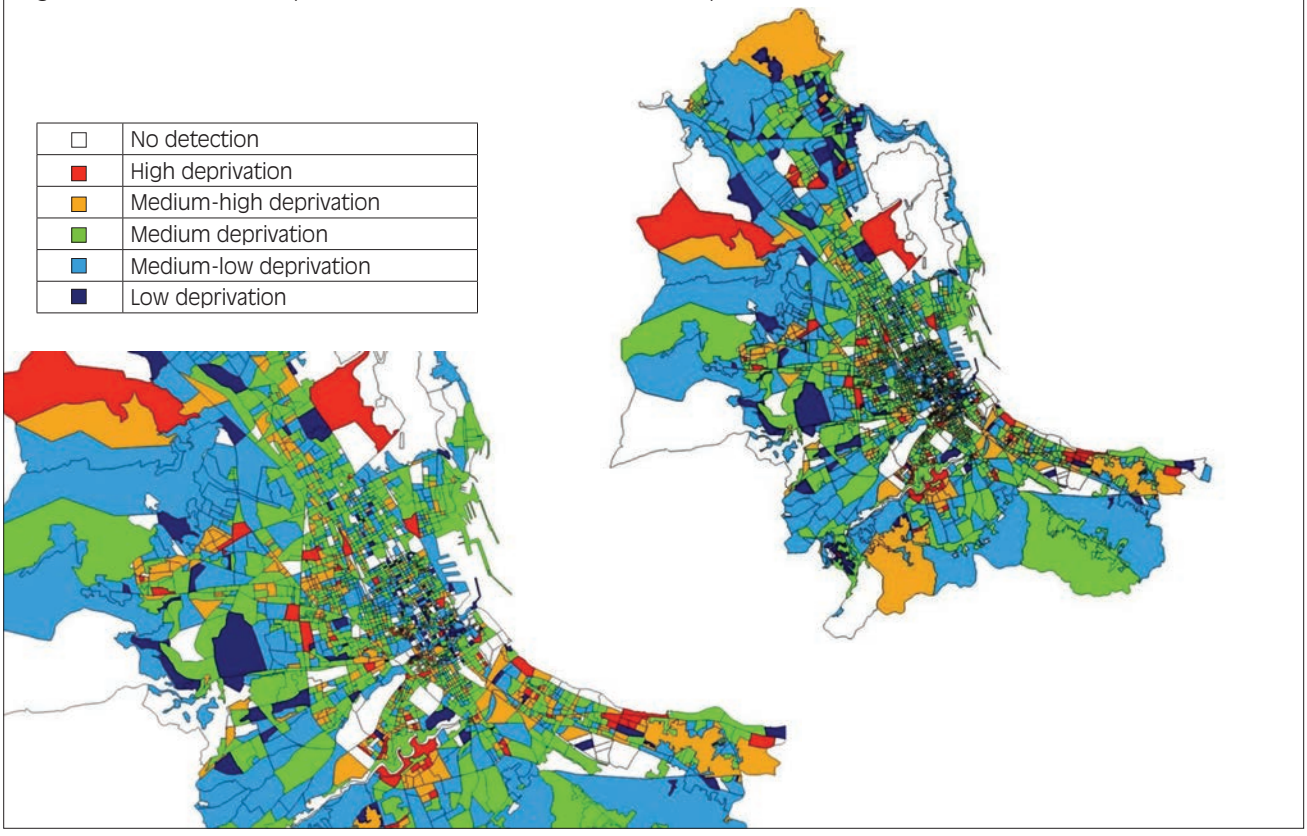
Results

SEHDI and health outcomes of the elderly population in Palermo

The distribution of the population living in the city of Palermo, in terms of the different SEHDI groups, was quite homogeneous, since almost half of the population (46%) was classified as having a "medium deprivation" level. Moreover, the extreme groups of SEHDI accounted for only a small proportion of the general population. Figure 1 shows the distribution of the SEHDI by Census tract; the SEHDI distribution in the historical center of the city is shown in detail.

Through factor analysis, three main groups of variables responsible for 64% of the variability of the SEHDI were

Fig. 1. Distribution of SEHDI by Census tract in Palermo and focus on its city center.



Tab. I. Factor analysis of SEHDI demographic, economic and housing variables.

	Factor 1 (socio-economic) = 28.2%	Factor 2 (socio-cultural) = 21.9%	Factor 3 (family-related deprivation) = 14.2%
SEHDI variables	% earners from labor or capital income	Mean number of people per family	% single-parent families with at least one child < 15years old
	Old age index	% primary school diploma	
	Index of structural dependence	% literate subjects	
		% illiterate subjects	
Total explained variance = 64.3%			

Tab. II. Trend in overall mortality and mortality due to influenza or pneumonia and SEHDI among the elderly population of Palermo.

SEHDI level	Overall deaths observed 65+ M	Overall mortality SMR 65+ M	95% CI		Overall deaths observed 65+ F	Overall mortality SMR 65+ F	95% CI	
High	363	1.12	1.01	1.24	393	0.90	0.81	0.99
Medium-high	1640	1.05	1.00	1.10	1980	1.00	0.96	1.05
Medium	3729	1.04	1.00	1.07	4484	1.02	0.99	1.05
Medium low	1964	0.89	0.85	0.93	2306	0.97	0.93	1.01
Low	148	0.86	0.72	1.00	201	1.16	1.00	1.32
Total	**7844**	**1.00**	**0.98**	**1.02**	**9364**	**1.00**	**0.98**	**1.02**
Trend		*p < 0.05 L*				*p < 0.05 NL*		
SEHDI level	**Influenza and pneumonia deaths observed 65+ M**	**Influenza and pneumonia mortality SMR 65+ M**	**95% CI**		**Influenza and pneumonia deaths observed 65+ F**	**Influenza and pneumonia mortality SMR 65+ F**	**95% CI**	
High	12	1.57	0.68	2.46	5	0.65	0.08	1.23
Medium-high	33	0.90	0.59	1.20	25	0.72	0.44	1.01
Medium	86	1.01	0.80	1.23	88	1.14	0.90	1.38
Medium low	52	1.00	0.73	1.27	42	1.01	0.70	1.32
Low	2	0.49	0.00	1.17	2	0.66	0.00	1.58
Total	**185**	**1.00**	**0.85**	**1.14**	**162**	**0.99**	**0.84**	**1.14**
Trend		*p < 0.05 L*				*p < 0.05 NL*		

M: male; F: female; SMR: Standardized Mortality Rate; SEHDI: Index of deprivation in Palermo; L: Linear trend; NL: Non-Linear trend.

identified (Tab. I). In detail, the socio-economic group accounted for almost 1/3 (28%) of the general population variability, followed by socio-cultural factors (22%) and deprivation related to the family context (14%). As shown in Table II, the analysis of all-cause mortality, according to the SEHDI within the city of Palermo stressed a linear distribution in the old men (decreasing at deprivation decreasing, $p < 0.05$), not in old women, where a non-linear association as found ($p < 0.05$). Table II also shows a significant correlation between mortality due to influenza or pneumonia and higher deprivation indexes ($p < 0.05$). On stratifying the results of the mortality analysis by gender, an increasing trend in mortality due to influenza or pneumonia was found among elderly men as the deprivation index increased ($p < 0.05$). By contrast, a decreasing trend in mortality and was observed in elderly women as the deprivation index increased ($p < 0.05$).

SEHDI and vaccination coverage among the elderly population in Palermo

Average influenza vaccination coverage among people aged more than 64 years and resident in Palermo between the 2009-2010 and 2014-2015 influenza seasons was 27%. On comparing vaccination coverage with deprivation levels, a linear trend in the correlation between coverage rate increase and deprivation index decrease ($p < 0.05$) was observed, with 29% coverage in the "medium deprivation" group (Tab. III).

The Pearson bivariate correlation between vaccination coverage and socio-economic variables showed that elderly subjects in Palermo were more reluctant to undergo influenza vaccination if they lived in census districts with more immigrants, divorced people and single-parent families. Conversely, influenza vaccination coverage was higher among the elderly living in census districts with more people of a higher educational level (at least high school degree) or students, retired people and school-children (not working population) (Tab. IV).

Discussion

Social and economic disadvantage is a predictor of mortality, not only in Italy but also worldwide, as reported in several studies [17-22]. However, no standardized concise indicators that appropriately describe the variability of socio-economic status are available. Accordingly, this study

aimed to draw up a new deprivation index which would include all-cause mortality as a health indicator and to apply this to the socio-economic context of the various districts of the city of Palermo. A further aim was to validate a tool that could identify sub-groups of elderly people who are most likely not to undergo influenza vaccination.

The SEHDI deprivation index did not show a wide range of distribution, with a large part of the general population belonging to the "medium deprivation" level. This distribution could suggest that the deprivation index of the residents of Palermo is determined predominantly by socio-economic and cultural factors rather than by variables concerning the family context. This consideration seems to fit into the general social framework observed in Southern Italy, where productivity is lower than in Northern and Central Italy [18].

The correlation of SEHDI with all-cause and specific mortality rates among the elderly revealed a higher risk of mortality in the most disadvantaged population groups in men and a higher risk of mortality among less socio-economically disadvantaged groups in women. These data are quite different from those that emerged from a previous study conducted in Sicily, in which higher mortality rates were observed among the elderly in the most disadvantaged population groups [17].

Regarding the specific mortality rates due to influenza or pneumonia, a similar difference between men and women was observed. Specifically, the mortality was increasing at increasing deprivation in old men, while among old women lower mortality rates correlated with lower deprivation. This effect could be attributable to different attitudes towards disease prevention according to gender, as shown by a recent Sicilian study on adhesion to Pap smear testing [23].

Assessment of influenza vaccination coverage rates among the elderly in Palermo during five consecutive influenza seasons showed a linear trend in the correlation between higher deprivation groups and lower vaccination adherence, as previously reported in other studies [8, 10, 24]. This trend was different from that reported in other Italian Regions involved in the 2015 CCM project and in other studies, in which lower influenza vaccination adherence was related with a lower deprivation index [10, 12, 13].

On analyzing influenza vaccination coverage in relation to deprivation clusters, it emerged that a large proportion of elderly people lived in areas of higher deprivation, where variables most frequently associated with "hard-to-reach" subjects (divorce, lower level of education, foreigners) are encountered [25, 26].

Tab. III. Vaccination coverage and SEHDI of Palermo city from 2009/2010 to 2014/2015.

SEHDI	Vaccination coverage 65+ 2009/10-2014/15 (%)
High deprivation	19.05
Medium-high deprivation	24.64
Medium deprivation	28.68
Medium-low deprivation	26.81
Low deprivation	27.25
Overall	**27.12**
Trend	***p < 0.05 L***

L: Linear trend.

Conclusions

By correlating this socio-economic and health deprivation index with influenza vaccination coverage in the city of Palermo, we were able to identify those subgroups of elderly people who were most likely to adhere to influenza vaccination. The present study therefore contributes to identifying population subgroups for which health promotion interventions could be organized, in order to facilitate "healthy aging" of the elderly population.

Acknowledgements

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Conflict of interest statement

None declared.

Tab. IV. Correlation between vaccination coverage and demographic characteristics.

		Vaccination coverage 65+ 2009/10-2014/15 (%)
% divorced	β-coefficent	-0.095
	p-value	0.042
% upper secondary school	β-coefficent	0.131
	p-value	0.016
% not belonging to the labor force	β-coefficent	0.095
	p-value	0.043
% students	β-coefficent	0.132
	p-value	0.016
% foreigners and stateless persons residing in Italy	β-coefficent	-0.131
	p-value	0.016
% single-parent families with children under 15 years	β-coefficent	-0.106
	p-value	0.053

Authors' contributions

VR reviewed literature, interpreted data, checked data validity and wrote first draft of the paper. AC coordinated and supervised data collection, built figure, checked data validity, performed statistical analysis and revised the manuscript. IS and SP designed the data collection instruments and collected the data. CC reviewed literature, interpreted data and revised the manuscript. AC conceptualized and designed the study, interpreted data and revised the manuscript. All authors have read and approved the final manuscript.

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ORIGINAL ARTICLE

Analysis of influenza vaccination coverage among the elderly living in Rome, based on a deprivation index, 2009-2013

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Keywords

Influenza vaccination • Vaccine coverage • Deprivation • Elderly

Summary

Introduction. *Elderly people are more likely to develop influenza-related complications. However, despite the recommendations, the optimal vaccination coverage is not reached. The use of deprivation indexes can help to identify subgroups with lower vaccination uptake. We analyzed vaccination coverage among elderly subjects living in the city of Rome on the basis of their socioeconomic characteristics by using a local deprivation index.*
Methods. *We focused on the population aged ≥ 65 years living in the city of Rome from 2009 to 2013. Information on vaccination coverage was collected from general practitioners. A combination of multivariate techniques, including multiple linear regression, factor and cluster analysis, was used to construct a composite area-based Index of Socio-Economic and Health Deprivation (SEHDI). The index was calculated for each census tract on the basis of data from the 2001 Italian census.*
Results. *The majority of elderly subjects living in Rome belonged to the medium (40.4%) and medium-high (24%) deprivation groups; only 4.5% of the population was in the low-deprivation group. An inverse relationship was found between influenza vaccination coverage and the deprivation index: elderly subjects in the low-deprivation group displayed lower coverage (55.45%) than those in the high-deprivation group (57.59%). Specifically, vaccination coverage decreased with the increase of replacement index, employment rate and the percentage of: single and divorced individuals; university and high-school graduates; employees, entrepreneurs and freelancers, family assistants, students; foreigners and stateless persons residing in Italy; families consisting of one person.*
Conclusions. *Our results show an inverse relationship between deprivation and vaccination coverage and may help to identify subgroups that could benefit from targeted initiatives to increase vaccination coverage.*

Introduction

Influenza is a common infectious disease, affecting around 8% of the entire population during the winter season each year [1]. Incidence rates reach the lowest values among the elderly, with peaks ranging from a minimum of 1.78 per 1,000 to a maximum of 8.55 per 1,000 in the last nine seasons. In the last influenza season, the overall incidence of influenza among the elderly was 0.46 per 1,000 in Italy and 0.39 per 1,000 in the Lazio Region [2]. Although less frequently affected by the disease, elderly people are more likely than other age-groups to develop influenza-related complications, which may even be fatal. Indeed, 90% of deaths due to influenza occur among the elderly [1, 3].
Because of these clinical characteristics, elderly people are among the targets of influenza vaccination campaigns each year. The risk of all-cause and cause-specific mortality has been shown to be higher in the unvaccinated elderly subjects than in their vaccinated counterparts [4]. Indeed, vaccination has been strongly recommended for the elderly since the National Health Plan 1998-2000 was formulated, which set the minimum vaccination coverage goal at 75% [5]. Furthermore, the last two National Immunization Plans indicated 95% as the optimal goal of vaccination coverage [6, 7]. Nonetheless, neither goal has been achieved since the 1999/2000 season. A peak coverage of 68.3% among the elderly was observed in 2005/2006. Thereafter, a steady decrease ensued, until the lowest value of 48.6% was reached in 2014/2015; the last two seasons, however, have seen an increase to values around 52% [8].
The decline in vaccination coverage has led to a significant increase in cases of influenza-like illness [9]. Furthermore, since December 2016, an excess in all cause-mortality, primarily explained by influenza, has been observed throughout Europe, particularly among elderly people [10]. In Italy, analysis of seasonal mortality from 2012 to 2015 showed a 13% increase in mortality among the elderly in the 2015 winter season, which seemed to be due to the peak in influenza [11].
It has been demonstrated that socioeconomic conditions play quite an important role in determining adherence to immunization programs against influenza, particularly

in the elderly population [12, 13]. Indeed, influenza vaccination coverage shows local variations [14, 15] and is considerably lower among individuals from socioeconomically deprived areas [14, 16]. Our recent systematic review also concluded that individuals from different groups at risk for influenza were less likely to be vaccinated if they lived in more deprived areas in comparison with those from affluent areas, regardless of the vaccine type (seasonal or pandemic) [17]. Deprivation indexes are measures of the level of deprivation in an area that take into consideration the multidimensional aspects of social stratification; their implementation at the population level could be a useful strategy for measuring health disparities and distinguishing non-vaccinating groups [18].

The aim of our study was to identify groups of subjects aged ≥ 65 years with lower vaccination coverage, living in the city of Rome, on the basis of their socioeconomic characteristics. To this end, we constructed and applied a local deprivation index.

Methods

Study population

The study focused on elderly subjects ≥ 65 years old living in the city of Rome from 2009 to 2013. Rome is located in the central part of Italy, in the Lazio region, has a population of about 2.5 million and a surface area of 1,290 km^2. Elderly people constitute 21.5-22.4% of the entire population of the city, a percentage that is in line with the national figures [19].

To ascertain vaccination coverage, all general practitioners (GPs) working in the city of Rome were considered.

Data sources

Data on influenza vaccination coverage were provided by the Lazio Health and Social Policy Directorate, which collects and validates data from the GPs. The data covered the influenza seasons from 2009-10 to 2013-14 and included the street addresses of GPs' offices. These latter were georeferenced in terms of census tract by the Statistics Office of the city of Rome.

Demographic and socioeconomic characteristics of the study population were collected from the National Institute for Statistics, whereas the number of observed deaths due to all causes and to specific causes were obtained from the Department of Epidemiology of the Regional Health Service of the Lazio region. The data obtained were stratified by gender and census tract, as per the 2001 national census. The ICD-10 codes were converted into ICD-9 codes for the query.

Statistical analysis

A composite area-based Index of Socio-Economic and Health Deprivation (SEHDI) was constructed by using a combination of multivariate techniques, including multiple linear regression, factor and cluster analysis for the local population, as reported elsewhere [20]. In calculating the index, each census tract was used as the unit of observation. Standardized Mortality Ratios (SMRs) were calculated on the basis of expected deaths, computed at the regional level, in order to validate the index with respect to the relationship between deprivation and the causes of death, as reported in the literature [19], and to describe the health condition of the population considered. SMRs were computed as the ratio between observed and expected mortality. Expected cases were computed on the basis of expected regional mortality (overall and for each specific cause, by gender and age-group). SMR values higher than 1 indicated a risk of mortality higher than the regional one, while SMR values lower than 1 indicated a risk of mortality lower than the regional one.

The relationship between the SEHDI and vaccination coverage was analyzed by means of one-way analysis of variance (ANOVA) (statistical significance at $p < 0.05$) in order to evaluate the trend among the deprivation groups. A Pearson bivariate correlation, with statistical significance threshold at $p < 0.05$, was used to test the association between single specific socioeconomic and demographic census variables and the vaccination coverage in order to identify peculiar characteristics that could influence vaccination uptake.

The relationship between the SEHDI and mortality due to all causes and to specific causes was tested through ANOVA (statistical significance at $p < 0.05$) [19]. SMR and the results of ANOVA were reported for all-cause mortality and two causes of deaths, namely cardiovascular and respiratory diseases, as well as for influenza and pneumonia. These choices were supported by the fact that the calculation of influenza-associated deaths generally takes into consideration respiratory and circulatory diseases as underlying causes of death.

Results

During the study period, the population ranged from a minimum of 554,028 to a maximum of 590,603 elderly people, with men accounting for between 40.8% and 40.9% [21-23].

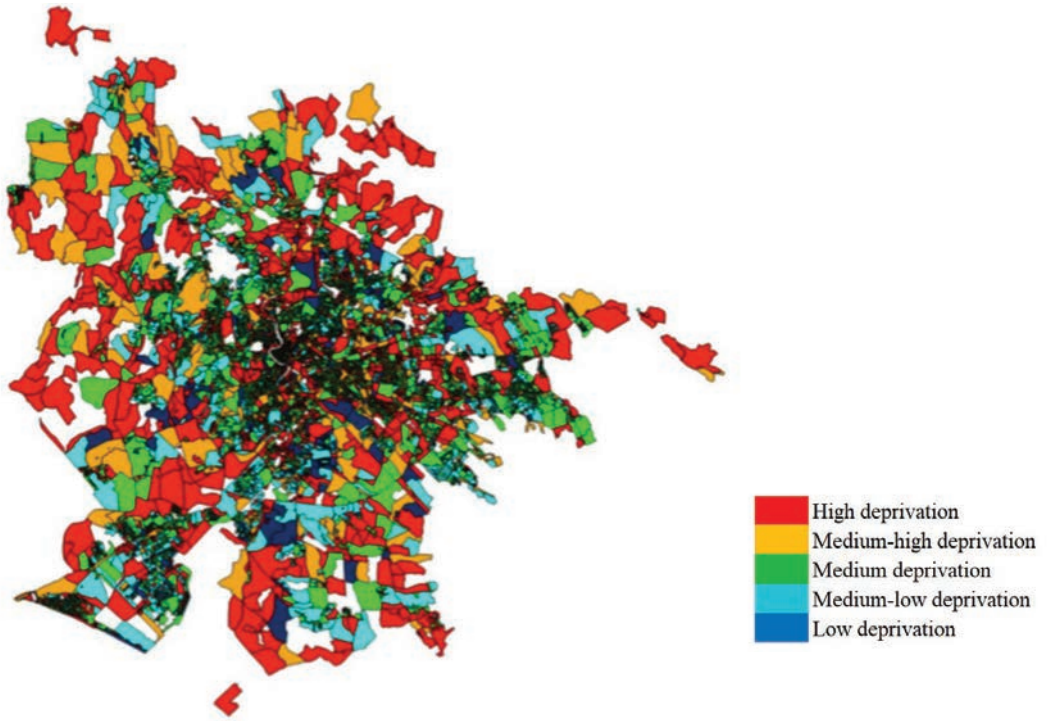
According to the factor analysis for the construction of the SEHDI, the contribution of the first factor to the explanation of the whole variance was 18.6%; this factor comprised the following variables: percentage of widows/widowers, percentage of males, old-age index, index of structural dependence, and average number of members of households. The contribution of the second factor was 13.8%; the third and fourth factors contributed 9.6% and 9.5%, respectively, while the last factor had a value of 7.7% (Tab. I).

According to results, the category of medium deprivation comprised the highest percentage (40.4%) of elderly people living in the city of Rome; 22.7% were classed as medium-low deprived while about 1/3 belonged to the categories medium-high (24%) or high (8.4%) deprivation. The low-deprivation group accounted for only 4.5%. Mapping was performed in order to show the

Tab. I. Factors used for constructing the deprivation index and their corresponding contribution values.

Factor 1 = 18.6%	Factor 2 = 13.8%	Factor 3 = 9.6%	Factor 4 = 9.5%	Factor 5 = 7.7%
% widows / widowers	% primary school diploma	Replacement index	% divorced	% family helpers
Index of structural dependence	% employed in industry		% separated	% employed in agriculture
Old-age index			% rented homes	% students
% men				
Average number of household components				
Total variance explained = 59.3%				

Fig. 1. Map of Rome showing the spatial distribution of the deprivation index by census tract. Some census tracts (20.1%), comprising 1.3% of the entire population of Rome, were not analyzed owing to data incompleteness.

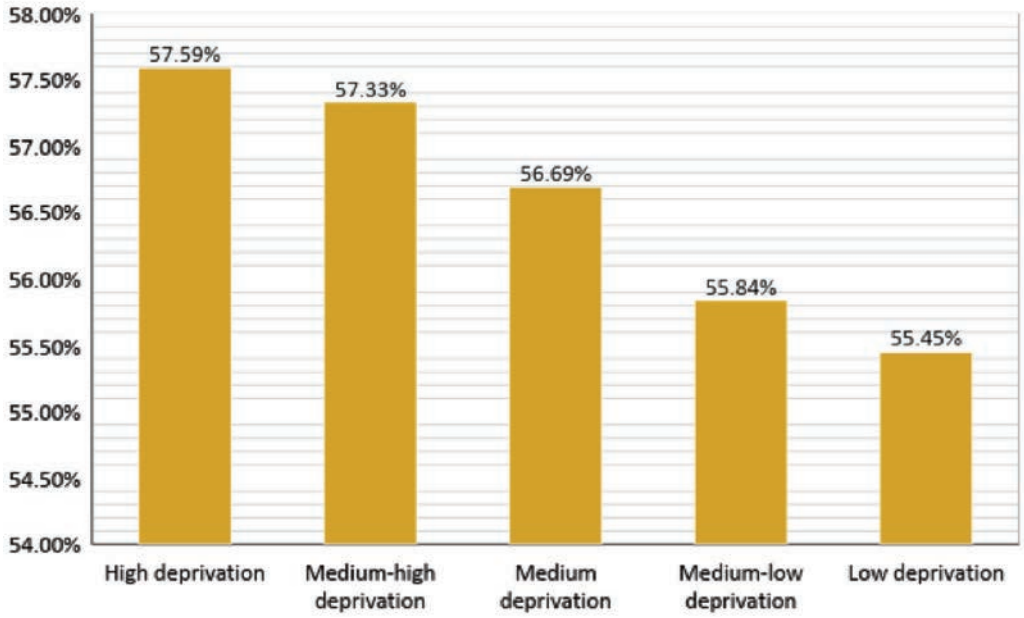


spatial distribution of the various groups in the city; the distribution of census tracts, with their assigned index value, is shown in Fig. 1. The population of the historical center of Rome has a higher socioeconomic position than the rest of the city. A greater concentration of subjects belonging to high and medium-high deprivation groups can be seen in the peripheral quarters of the city, particularly in the eastern, north-western and southern areas (Fig. 1).

A significant linear trend was found in the correlation between vaccination coverage and the deprivation index, with coverage increasing slightly as deprivation increases: from 55.45% in the low-deprivation group to 57.59% in the high-deprivation group (Fig. 2). Specifically, vaccination coverage decreased as the following variables increased: replacement index, employment rate and the percentages of: singles, divorced; graduates and higher school graduates; employees, entrepreneurs and freelancers, family assistants, students; foreigners and stateless persons residing in Italy; one-person families.

We observed a nonlinear significant relationship between the deprivation index and mortality due to all causes and cardiovascular diseases, with high, medium-low and low deprivation groups showing the highest SMRs. Specifically, with regard to all-cause mortality, the highest SMRs were seen in the low deprivation group among men (SMR = 1.17, 95% CI: 1.11-1.24), women (SMR = 1.36, 95% CI: 1.29-1.43) and the total population (SMR = 1.26, 95% CI: 1.22-1.31). Analogously, the highest SMRs for cardiovascular diseases were observed in low deprivation groups (SMR = 1.17, 95% CI: 1.07-1.27 in men; SMR = 1.23, 95% CI: 1.14-1.33 in women; SMR = 1.20, 95% CI: 1.13-1.27 in the total population). A significant linear trend was observed in males with respect to mortality due to respiratory diseases, with the highest SMRs being recorded in high deprivation groups (SMR = 1.14, 95% CI: 1.03-1.24) and the lowest in low deprivation groups (SMR = 0.86, 95% CI: 0.67-1.05). A significant nonlinear trend was observed in women and the total population, with the highest SMR in the high deprivation group (SMR = 1.27, 95% CI: 1.16-1.38 in

Fig. 2. Vaccination coverage (%) among the elderly by deprivation group in the period 2009-2013.



women and SMR = 1.21, 95% CI: 1.13-1.28 in the total population).

The SMR due to influenza and pneumonia showed a linear inverse correlation in men (high deprivation group: SMR = 0.66, 95% CI: 0.48-0.85; low deprivation group: SMR = 1.41, 95% CI: 0.87-1.95) and in the total population (high deprivation group: SMR = 0.76, 95% CI: 0.63-0.89; low deprivation group: SMR = 1.08, 95% CI: 0.73-1.42), while the trend was non-linear in women (low deprivation group: SMR = 0.71, 95% CI: 0.31-1.12; medium-low deprivation group: SMR = 1.05, 95% CI: 0.88-1.23) (Tab. II).

Discussion

Our study showed that more than half of the elderly population living in the city of Rome in the period 2009-2013 belonged to the medium, medium-high and high deprivation groups, and that there was an inverse relationship between influenza vaccination coverage and the SEHDI, with people in the low deprivation group showing the lowest coverage (more than two percentage points less than the high deprivation group). A linear relationship was observed between deprivation and mortality due to influenza and pneumonia in the total population and among men, with higher SMRs in low deprivation groups. By contrast, women in the low deprivation group showed the lowest SMR. The highest SMRs due to all-cause and cardiovascular disease mortality were also observed in low deprivation groups.

Socioeconomic position is a multidimensional concept and must be interpreted with caution, since different factors have been considered for its evaluation in the literature [24]. Nonetheless, our results are in concordance with those of published studies regarding the city of Rome. Indeed, the areas that displayed high deprivation in our analysis mostly correspond to those with low average income [25], low socioeconomic position [26] and a high index of social disadvantage [27].

In Rome, people belonging to medium/high social classes mainly reside in the prestigious central areas of the city, while those of lower social class tend to live in the peripheral areas. Using the socioeconomic position (SEP), Cesaroni et al. [26] found a similar distribution of socioeconomic inequalities in Rome and reported that the peripheral areas of the city (especially eastern and northern parts) had a low SEP, while the city center had a high SEP.

A recent report by the statistical office of the city of Rome concluded that the central area (municipalities I and II) and the northern part of the city had the highest economic welfare [25], while the municipalities located in the eastern part (municipality V and VI) had lower average incomes. The municipalities with the highest average income were those that displayed low or medium-low deprivation in our analysis (municipality I, II, XV) [25]. The same report also revealed that the percentage of elderly people living in conditions of economic difficulty (under € 11,000 gross a year) was higher in the eastern municipalities, particularly municipalities V and VI (32.5% and 37.5% of the total population aged ≥65 years, respectively) [25].

With regard to the association between vaccination coverage and deprivation, our findings are not in line with those of most studies. Indeed, most studies con-

Tab. II. Standardized mortality due to all causes and to cardiovascular and respiratory diseases, pneumonia and influenza in the period 2009-2013.

	All causes 65+ M				*All causes 65+ F*				*Total all causes 65+*			
Deprivation groups	Observed	SMR	95% CI		Observed	SMR	95% CI		Observed	SMR	95% CI	
			Lower	Upper			Lower	Upper			Lower	Upper
High deprivation	5912	1.13	1.10	1.16	7670	1.22	1.20	1.25	13582	1.18	1.16	1.20
Medium-high deprivation	13800	1.07	1.05	1.09	17469	1.16	1.14	1.18	31269	1.12	1.11	1.13
Medium deprivation	20156	1.06	1.05	1.07	24656	1.16	1.15	1.17	44812	1.11	1.10	1.12
Medium-low deprivation	9599	1.14	1.12	1.17	10552	1.24	1.21	1.26	20151	1.19	1.17	1.21
Low deprivation	1451	1.17	1.11	1.24	1515	1.36	1.29	1.43	2966	1.26	1.22	1.31
Total	**50918**	**1.09**	**1.08**	**1.10**	**61862**	**1.18**	**1.18**	**1.19**	**112780**	**1.14**	**1.13**	**1.15**
Trend		*p<0.05 n.l.*				*p<0.05 n.l.*				*p<0.05 n.l.*		
	Cardiovascular diseases 65+ M				*Cardiovascular diseases 65+ F*				*Total Cardiovascular diseases 65+*			
Deprivation groups	Observed	SMR	95% CI		Observed	SMR	95% CI		Observed	SMR	95% CI	
			Lower	Upper			Lower	Upper			Lower	Upper
High deprivation	2100	1.17	1.12	1.22	3288	1.15	1.11	1.19	5388	1.16	1.13	1.19
Medium-high deprivation	5072	1.15	1.12	1.18	7544	1.10	1.08	1.13	12616	1.12	1.10	1.14
Medium deprivation	7185	1.10	1.07	1.12	10796	1.12	1.10	1.14	17981	1.11	1.09	1.13
Medium-low deprivation	3318	1.15	1.11	1.19	4417	1.14	1.11	1.17	7735	1.14	1.12	1.17
Low deprivation	497	1.17	1.07	1.27	623	1.23	1.14	1.33	1120	1.20	1.13	1.27
Total	**18172**	**1.13**	**1.11**	**1.15**	**26668**	**1.12**	**1.11**	**1.14**	**44840**	**1.13**	**1.12**	**1.14**
Trend		*p<0.05 n.l.*				*p<0.05 n.l.*				*p<0.05 n.l.*		
	Respiratory diseases 65+ M				*Respiratory diseases 65+ F*				*Total Respiratory diseases 65+*			
Deprivation groups	Observed	SMR	95% CI		Observed	SMR	95% CI		Observed	SMR	95% CI	
			Lower	Upper			Lower	Upper			Lower	Upper
High deprivation	447	1.14	1.03	1.24	521	1.27	1.16	1.38	968	1.21	1.13	1.28
Medium-high deprivation	1004	1.04	0.97	1.10	1093	1.11	1.04	1.18	2097	1.07	1.03	1.12
Medium deprivation	1440	1.01	0.96	1.06	1611	1.16	1.10	1.22	3051	1.08	1.04	1.12
Medium-low deprivation	668	1.06	0.98	1.14	704	1.26	1.17	1.36	1372	1.15	1.09	1.22
Low deprivation	80	0.86	0.67	1.05	83	1.14	0.90	1.39	163	0.98	0.83	1.14
Total	**3639**	**1.04**	**1.00**	**1.07**	**4012**	**1.17**	**1.14**	**1.21**	**7651**	**1.10**	**1.08**	**1.13**
Trend		*p<0.05 l.*				*p<0.05 n.l.*				*p<0.05 n.l.*		
	Influenza and pneumonia 65+ M				*Influenza and pneumonia 65+ F*				*Total Influenza and pneumonia 65+*			
Deprivation groups	Observed	SMR	95% CI		Observed	SMR	95% CI		Observed	SMR	95% CI	
			Lower	Upper			Lower	Upper			Lower	Upper
High deprivation	52	0.66	0.48	0.85	80	0.84	0.66	1.03	132	0.76	0.63	0.89
Medium-high deprivation	135	0.70	0.58	0.82	202	0.89	0.76	1.01	337	0.80	0.72	0.89
Medium deprivation	217	0.76	0.66	0.87	272	0.85	0.75	0.95	489	0.81	0.74	0.88
Medium-low deprivation	94	0.75	0.60	0.90	136	1.05	0.88	1.23	230	0.90	0.79	1.02
Low deprivation	26	1.41	0.87	1.95	12	0.71	0.31	1.12	38	1.08	0.73	1.42
Total	**524**	**0.75**	**0.69**	**0.81**	**702**	**0.89**	**0.82**	**0.95**	**1226**	**0.82**	**0.78**	**0.87**
Trend		*p<0.05 l.*				*p<0.05 n.l.*				*p<0.05 l.*		

SMR: Standardized Mortality Ratio; M: male; F: female; l.: linear; n.l.: non-linear.

ducted in elderly populations across different seasons and countries have reported higher influenza vaccination uptake in low deprivation groups [14, 15, 28]. Only two studies, conducted in Colombia [29] and Germany [30], had findings similar to ours, and reported that elderly people from higher social classes had lower influenza vaccination coverage than those from lower and middle classes. We hypothesize that our findings might be the consequence of anti-vaccination campaigns [31], which have grown in Italy, and of the increased perception of the potential risks of vaccination [32], as people from higher socioeconomic classes may be more susceptible to both influences. Another possible explanation is that, in the high deprivation groups, people with chronic and/or co-morbid conditions are more likely to visit health-care facilities and have vaccination advised and given [29].

Our finding of an association between vaccination coverage and deprivation is to some extent corroborated by the relationship between deprivation and mortality. Indeed, in our study, both all-cause SMRs and SMRs for cardiovascular diseases and for influenza and pneumonia showed the highest values in low deprivation groups, although the SMRs for respiratory diseases displayed the opposite trend. Nevertheless, the evidence on the specific topic of influenza-associated mortality and socio-economic condition is still contrasting. A recent cross-sectional ecological study conducted in 15 European cities showed that SMRs for influenza and pneumonia in women were directly associated with socioeconomic deprivation in London, Rotterdam and Kosice and inversely associated in Madrid, while in men a direct association was found in all 15 cities [33].

Our study has some limitations. The main one is that it did not allow us to make inferences about causal association, as the observation unit was the census tract. Indeed, the ecological fallacy could not be ruled out. Another limit may be connected with the possible under-reporting of vaccination coverage by GPs and, therefore, the possible incompleteness of the data. On the other hand, one of the main strengths of the study lies in its use of validated administrative data, which makes the analysis transparent and repeatable.

Conclusions

In conclusion, our study allowed us to robustly depict the situation of deprivation of elderly people living in the city of Rome and to ascertain that people from low deprivation groups showed lower vaccination coverage. These results should be taken into account in the organization of vaccination campaigns and should prompt differential intervention according to the local area.

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Conflict of interest statement

None declared.

Authors' contributions

RL and CdW designed the study. FA and FC collected the data, RL performed the statistical analysis and CdW and VV contributed to data interpretation. VV and CdW drafted the manuscript and RL, FA and FC critically revised it. All authors have read and approved the final manuscript and agreed to be accountable for all aspects of the work.

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ORIGINAL ARTICLE

Identifying Ferrara's elderly people with low influenza immunization rates: the contribution of a local socio-economic deprivation index

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Keywords

Elderly • Influenza • Immunization • Deprivation index

Summary

Influenza immunization coverage rates remain far below the optimal value recommended by the World Health Organization, even in groups considered at high risk, such as the elderly. A possible explanation for this suboptimal vaccination uptake may be deprivation. A specifically developed local deprivation index was proposed for the classification of residents in the municipality of Ferrara in order to evaluate the characteristics of subjects over 65 years of age who accepted/refused influenza immunization (2010-2015). The variables building this deprivation index were primarily related to demographic aspects, such as age, widow/widower status, education, family composition and housing characteristics. Influenza immunization coverage rates were unsatisfactory in all categories of deprivation. A statistically significant decreasing trend in coverage rates was observed with decreasing deprivation in the general population and in males, but not in females. In addition to factors composing the local deprivation index, being separated, living in a family of three members and independent contractor were features that hindered immunization among very deprived elderly.

Introduction

Influenza is a major public health burden. Complications, including deaths, are more common in the elderly and in children younger than one year of age [1]. Vaccination against influenza is safe and effective, and large cohort studies have shown that it can prevent morbidity and mortality in those population groups that suffer the main complications of the disease [2]. The World Health Organization (WHO) has set a vaccination coverage target of at least 75% in the elderly population and among risk groups. However, although the vast majority of countries recommend vaccination of the elderly population, coverage of this group is still low, both worldwide and in European countries [3].

Situated in the east of the Emilia-Romagna Region, in north-eastern Italy, the Province of Ferrara had 353,481 residents at the time of the 2011 census (23.7% over 65 years old). The area of the province corresponds to that of the Local Health Unit. There are three hospitals and one university hospital. Healthcare services are also provided by six "Case della Salute" – which are facilities that provide social and healthcare services for the population of the catchment area (municipalities or large areas inside a municipality) – and about 250 General Practitioners (GPs). The main city is Ferrara (132,545 residents in 2011, about 27.4% over 65 years old). As observed at the national level, influenza immunization coverage rates among elderly people are far below the recommended target of 75%, and suffered a sharp decrease in recent years, from 66.9% in the 2010-2011 season to 53.6% in the 2014-2015 season [4].

In the period 2015-2017, a national project (sponsored by the Italian Center for Disease Prevention and Control) was implemented, in order to determine whether, and how, socio-economic inequalities can influence compliance with flu vaccination in subjects aged ≥ 65 years in Italy. In this framework, we investigated the characteristics that were able to promote or to hinder influenza immunization among subjects over 65 years old living in the municipality of Ferrara. To this end, we measured levels of deprivation by means of a specifically developed local deprivation index.

Methods

The study was part of a national project funded by the Italian Center for Disease Prevention and Control (CCM); it involved 10 cities/areas in Italy, and was conducted under the supervision of the Department of Health Sciences of the University of Genoa.

Ethical aspect

The research was approved by the Ethics Committee of the Liguria Region in May 2016 and, later, by the Ethics Committee of Ferrara Province in September 2016, in

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order to ensure compliance with current regulations on the protection of personal data.

Population

The study population comprised the entire population resident in the territory of the Municipality of Ferrara. As the local Socio-Economic and Health Deprivation Index (SEHDI) was calculated on the basis of variables recorded in the last census (2011), persons resident in the period 2010-2015 were considered. Each individual was assigned to his/her own census unit by geo-referencing the address and street number. The population was stratified according to gender and age (0-64 and ≥ 65 years old).

Mortality data collection

Selected causes of death, as recorded in the deaths register of the Local Health Unit (LHU) of Ferrara in the period 2010-2015, were investigated. The list, according to ICD-10, was as follows: all causes (A00-Y89), diseases of the circulatory system (I00-I99), diseases of the respiratory system (J00-J99), influenza and pneumonia (J10-J18), chronic obstructive pulmonary disease (J40-J47), diseases of the digestive system (K00-K93), diabetes (E10-E14), neoplasms (C00-C43, C46-C95), malignant neoplasms of the lip, oral cavity and pharynx (C00-C15), malignant neoplasms of the stomach (C16), malignant neoplasms of the colon (C18-C21, C26), malignant neoplasms of the trachea, bronchus and lung (C33-C34), malignant neoplasms of the breast (C50), and malignant neoplasms of the prostate (C61). A separate database for each cause of death was set up according to the 1,875 census units of the Ferrara municipality. Data on observed mortality were acquired by means of a record link between the LHU deaths register and the census unit. Expected mortality was calculated by multiplying Emilia-Romagna Region's mortality rates by the number of individuals living in each census unit, thereby obtaining the number of expected deaths in 2010-2015.

Assessment of the local deprivation index

The local socio-economic and health deprivation index (SEHDI) of the Municipality of Ferrara was calculated for each census unit according to the method described in Lillini et al. [5]. Variables resulting from the 2011 ISTAT census were considered. The population of the Ferrara municipality was divided into five groups according to the level of deprivation: from high to low. The deprivation index underwent socio-economic validation and healthcare validation by analysis of variance (ANOVA) with F-test and linearity test. Statistical significance was set at $p < 0.05$. Variables evaluated for socio-economic validation were: dependency ratio, old-age dependency ratio, turnover of active population, employment and unemployment rates. For the healthcare validation, data on all-cause mortality and on the above-mentioned selected causes of death were evaluated.

Influenza immunization coverage

Data on influenza immunization in subjects over 65 years old in the period 2010-2015 were collected from the LHU's vaccination register, which records all vaccinations carried out in Public Health clinics, and from a regional information database (SOLE), which stores records of vaccinations carried out by General Practitioners. Each subject immunized was assigned to the corresponding census unit by geo-referencing his/her address and street number.

Statistical analysis

Influenza immunization coverage rates in the various groups of deprivation were analyzed by means of ANOVA with F-test and linearity test (statistical significance at $p < 0.05$). The correlation between immunization coverage rates and single variables within groups of deprivation was investigated by means of Pearson bivariate correlation (statistical significance at $p < 0.05$). Statistical analysis was performed by means of SPSS 19.0 and Stata 13.0.

Results

The variables contributing to the SEHDI in the Ferrara municipality are reported in Table I. The factors involved were able to explain 62.3% of the total variance, and were primarily related to demographic aspects, such as age, widowhood, education, family composition and housing characteristics. The deprivation index underwent socio-economic and healthcare validation, showing a significant correlation both with demographic variables, such as old-age dependency ratio, and standard

Tab. I. Variables contributing to Ferrara's local deprivation index (organized into factors by analyzing the main components).

Factor 1	Factor 2	Factor 3
% earners from labor or capital income	% 2-member families	% residential buildings in mediocre state of conservation
% widower/widow		% residences with kitchenette
index of structural dependence		
Old-age index		
% single-member families 65+		
% primary school diploma		
Total variance explained=62.3%		

Fig. 1. Composition of Ferrara municipality's population according to local deprivation index.

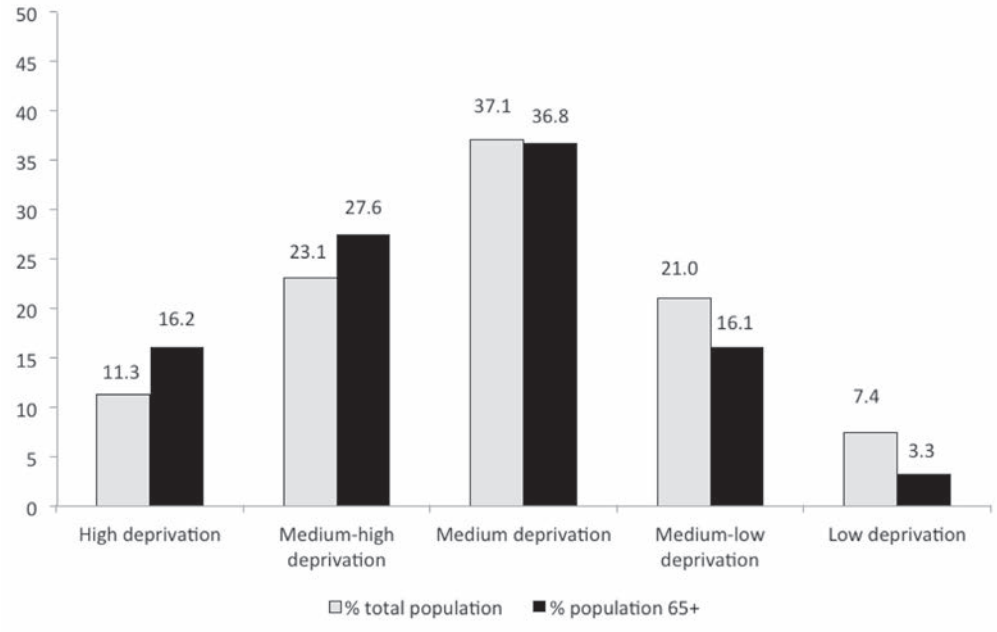
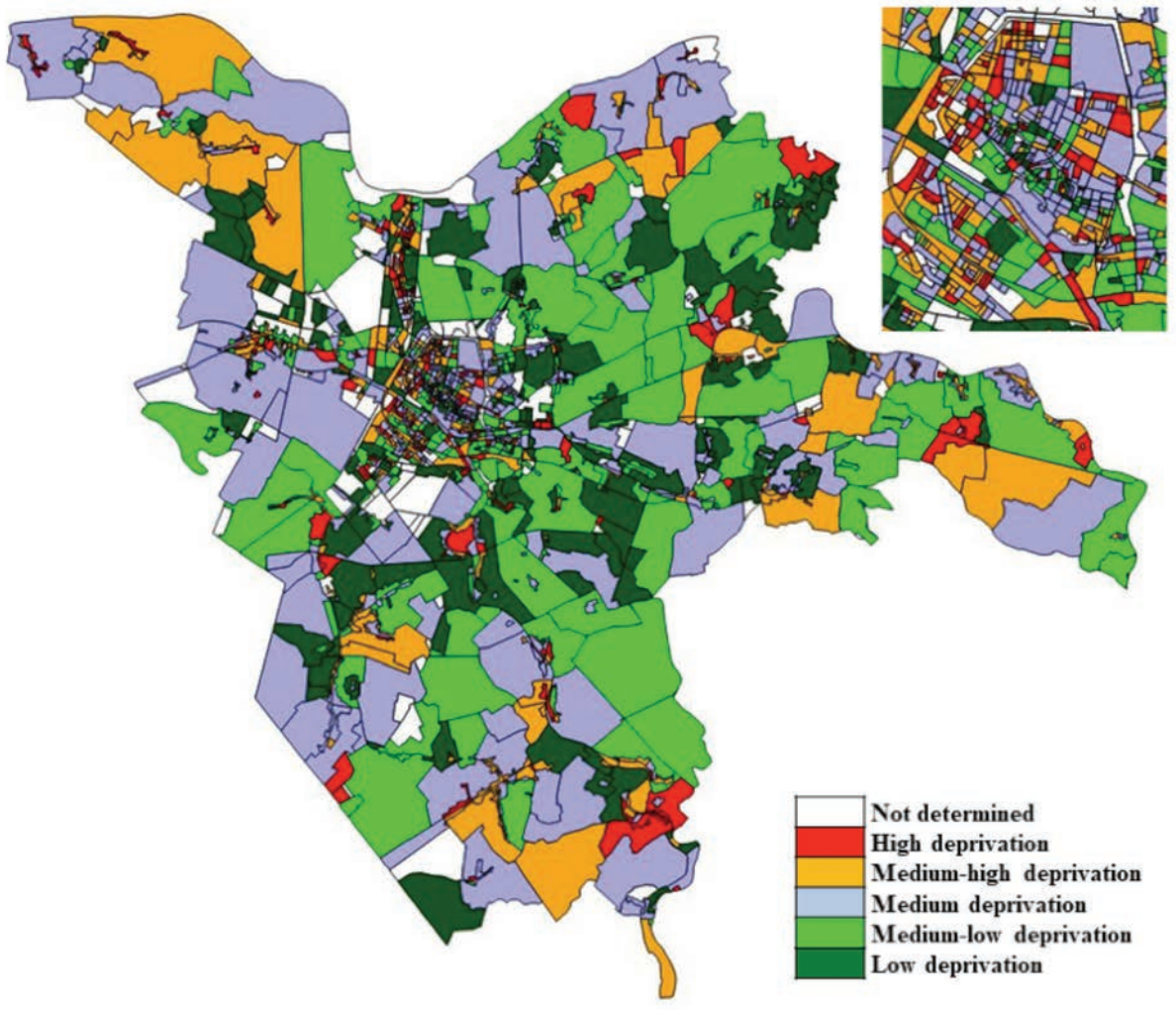


Fig. 2. Map of the municipality of Ferrara according to local deprivation index. On the top right, a focus on the center of the city.



mortality ratio; this revealed that the standard mortality ratio increased as deprivation increased.

Figure 1 shows the classification of the population into five groups according to the SEHDI. As expected, the distribution of the general population approached a normal distribution, with the majority of inhabitants displaying medium deprivation (the middle group) and only a small percentage of individuals in the groups of high or low deprivation. A normal distribution was also observed when only subjects over 65 years of age were considered, with almost 44% in the two highest deprivation groups.

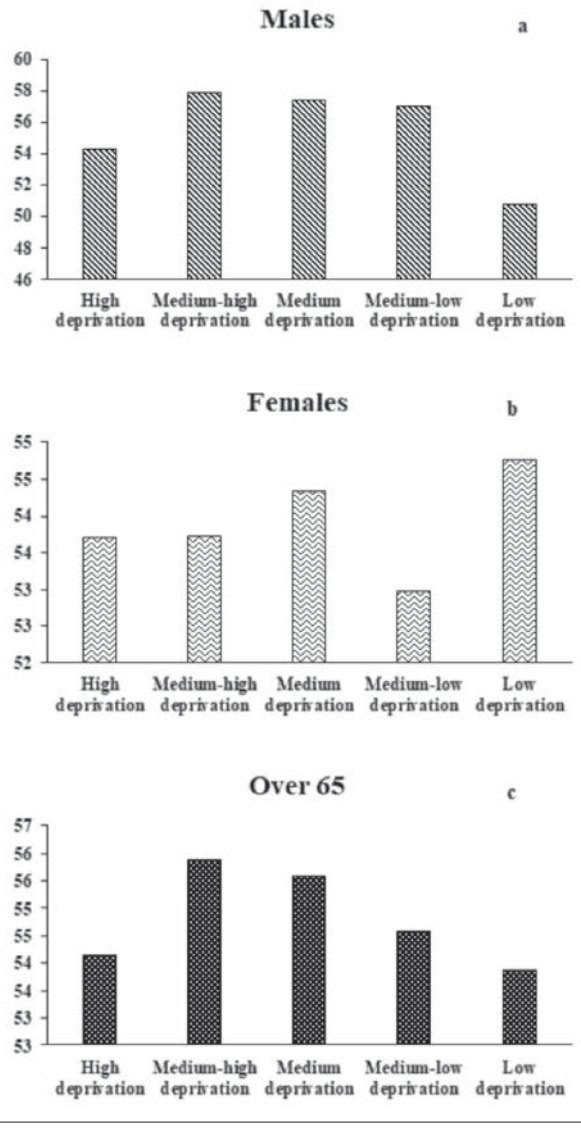
Figure 2 shows a map of the municipality of Ferrara: census units are shown in different colors, according to the degree of deprivation. White areas were not classified, as they corresponded to unpopulated, open spaces. The majority of the territory consisted of large areas of medium-low and low deprivation, especially in the eastern part of the municipality. Zones of medium-high deprivation were located at the edge of the municipal area, while small areas of high deprivation were located both in the outer sectors of the municipality (rural areas) and in the city centre, inside the ancient walls.

The average influenza immunization coverage rate among the over-65s living in the municipality of Ferrara in the period 2010-2015 was 55.7%. Coverage rates according to deprivation showed unsatisfactory levels in all categories of deprivation (Fig. 3). The lowest coverage rates were recorded among low-deprivation males (50.7%) and medium-low-deprivation females (53.0%), while the highest values were observed in low-deprivation females (54.8%) and medium-high-deprivation males (57.9%). In the general population, and in males but not in females, a statistically significant decreasing trend in coverage rates was observed as deprivation decreased.

In addition to the factors composing the deprivation index, socio-economic variables able to favor or to hinder influenza immunization were assessed according to gender (Tab. II). In males, being unmarried, having a high school diploma and being a foreign resident were factors hindering immunization, while widowhood and being a salaried worker were factors promoting vaccination. Among females, poor education (illiteracy and primary school diploma), unemployment, living in a family with four members and being a house-owner were variables that hindered immunization, whereas being a foreign resident, being a salaried worker, and living in a single-parent family with children under 15 years of age favored compliance with influenza vaccination.

The SEHDI was applied in order to identify specific features favouring or hindering influenza immunization (Tab. III). In the highly deprived group, only factors hindering the vaccination were observed: being separated, living in a family with three members and working as independent contractor. Being unmarried seemed to favor adherence to vaccination, while being married or widowed were factors that hindered immunization among subjects in the medium-high, medium and medium-low categories of deprivation. Among the least deprived, owning one's home impacted negatively on immunization, while being a salaried worker had a positive effect.

Fig. 3. Vaccination coverage rates among subjects aged ≥ 65 years, according to gender and local deprivation index.



Discussion

The socio-economic inequalities underlying health differences in Ferrara are mainly due to the age composition of the population, the family structure and the living conditions (more specifically, the characteristics of the building).

Indeed, the first factor composing the index is almost totally defined by variables which stress the role of age and of an aging population. This aspect underlines the need for support and specific means of ensuring good health conditions for the elderly population.

The second factor is completely defined by only one variable, which concerns the family structure: the percentage of 2-member families. This factor reveals that, in

Tab. II. Socio-economic variables influencing immunization rates among subjects aged ≥65 years, according to gender.

Socio-economic variables with Pearson coefficient (p value)					
Males		**Females**		**General population**	
% unmarried	-0.071 0.005)	% primary school diploma	-0.069 (0.006)	% unmarried	0.047 (0. 041)
% widower/widow	0.063 (0.014)	% illiterate	-0.063 (0.013)	% married	-0.047 (0.048)
% upper secondary school diploma	-0.058 (0.023)	% not belonging to the labor force	-0.047 (0. 045)	% upper secondary school diploma	-0.046 (0.061)
% foreigners and stateless persons residing in Italy	-0.055 (0.033)	% foreigners and stateless persons residing in Italy	0.076 (0.003)	% owned homes	-0.067 (0.007)
% employees	0.055 (0.033)	% owned homes	-0.074 (0.003)	% 4-member families	-0.067 (0.007)
		% 4-member families	-0.084 (0.001)	% 5-member families	-0.057 (0.023)
		% employees	0.136 (< 0.0001)	% employees	0.124 (< 0.0001)
		% entrepreneurs	-0.057 (0.025)	% single-parent families	0.073 (0.003)
		% single-parent families	0.052 (0.039)		
		% single-parent families with children < 15 yrs.	0.047 (0.044)		

Tab. III. Socio-economic variables influencing immunization rates among subjects aged ≥65 years, according to clusters of deprivation (p value).

Socio-economic variables with Pearson coefficient (p value)									
High deprivation		**Medium-high deprivation**		**Medium deprivation**		**Medium-low deprivation**		**Low deprivation**	
% separated	-0.177 (0.008)	% unmarried	0.161 (0.003)	% unmarried	0.082 (0.071)	% unmarried	0.122 (0.026)	% employees	0.279 (< 0.001)
% 3-member families	-0.141 (0.035)	% married	-0.135 (0.012)	% married	-0.089 (0.051)	% widower/ widow	-0.108 (0.050)	% owned homes	-0.157 (0.018)
% self-employed	-0.127 (0.048)	% graduated	0.156 (0.004)	% 2-member families	-0.109 (0.016)	% lower secondary school diploma	0.146 (0.008)		
		% upper secondary school diploma	-0.107 (0.046)	% 4-member families	0.107 (0.019)	% belonging to labor force	0.156 (0.004)		
		% housewives	0.123 (0.023)	% employees	0.116 (0.010)	% employed	0.169 (0.002)		
		% owned homes	-0.102 (0.059)	% single-parent families	0.099 (0.029)	% not belonging to labor force	-0.206 (< 0.001)		
		% 2-member families	0.192 (< 0.001)			% foreigners and stateless persons residing in Italy	0.106 (0.045)		
		% 4-member families	-0.331 (0.001)			% self-employed	0.170 (0.002)		
		% self-employed	-0.136 (0.012)						
		% single-parent families	0.182 (0.001)						

the context of an aging population, a family made up of (only) two members can give rise to health inequalities, probably owing to difficulties in providing social support (on the role of social and family support in reducing health inequalities, see also Lillini et al. [5], Vercelli et al. [6], Casanova et al. [7, 8]).

Finally, the third factor introduces the material element of socio-economic inequalities, as reflected by housing conditions. In Ferrara, old, run-down buildings and small dwellings (those with only a kitchenette) identify an economic condition that could lead to health problems and inequalities.

Overall, in Ferrara the SEHDI revealed that old age, small families and poor housing were the main predictors of health problems and inequalities. This is not an uncommon situation in areas with an aged population but quite a solid economic background, and underlines the specific need for social support in order to improve health prevention and to take care of people when a disease breaks out [7, 9-11].

Most findings showed that, even when the potential effect of clinical confounding factors is taken into account, a socio-economic gradient exists in vaccination coverage among the elderly; specifically, the lower the social position of the individual (as measured by several different

indicators), the lower is the likelihood of being immunized against seasonal flu [12]. In the literature, studies conducted in the US, UK, Canada, Germany and Spain have confirmed that higher income, education and better housing conditions are predictors of vaccination against influenza [13-18]. In contrast, we recorded generally lower coverage rates in medium-low and low deprivation classes. Indeed, Italy has already proved to be an exception, in that the available evidence suggests that in Italy, unlike other countries, the lower socio-economic classes are more likely to receive influenza vaccination [19-20]. Our data indicated that living in a large family (more than 4 members) reduced the likelihood of vaccination uptake. By contrast, a recent review [20] revealed a higher uptake among individuals who did not live alone, while a survey conducted in France [21] reported that the number of individuals in the household had no statistically significant impact on seasonal influenza immunization.

The influence of being in employment on vaccination uptake seems to differ according to the degree of professional autonomy. In high and medium-high deprivation categories, being self-employed reduced uptake, whereas being an employee proved to be a factor that increased uptake. Employment is a variable not often considered in studies that examine socio-economic determinants of influenza immunization coverage rates. However, income, which can be considered a proxy, albeit not completely adequate, has not been unequivocally associated with either reduced or increased influenza immunization [22].

The influenza immunization uptake among the elderly living in the Ferrara municipality in the years 2010-2015 was inadequate, being far from the goal of 75% fixed by the WHO and also adopted by the 2017-2019 Italian National Immunization Plan [23]. Nevertheless, having evaluated several social and demographic aspects of the elderly population, the present study suggests that compliance with common prevention practices in general, and with vaccination in particular, varies to some degree among different categories of people.

Conclusions

Detailed analysis of the social and demographic features of population subgroups who do not adhere to preventive practices, as highlighted by the deprivation index, can contribute to establishing targeted interventions aimed at involving these subjects through specific strategies of communion and organization.

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Conflict of interest statement

The authors declare no confict of interest of this project.

Authors' contributions

AS, RL, SF and GG concepted and designed the study; GM, PP, GM and FB collected the data; RL, AS, SL and SF analysed and interpreted the data; AS and SL drafted the article; RL,SF and GG revised it critically; all authors gave final approval of the version to be submitted and any revised version.

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ORIGINAL ARTICLE

Social deprivation indexes and anti-influenza vaccination coverage in the elderly in Sardinia, Italy, with a focus on the Sassari municipality

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Keywords

Vaccines • Influenza •Social Deprivation Indexes • Elderly • Italy

Summary

The aim of the present study was to evaluate the relationship between social deprivation indexes and anti-influenza vaccination coverage in the elderly population (over 65 years old) in Sardinia. This relationship was first observed in a regional context. An already-known deprivation index was used, and its trivial relationship with anti-influenza vaccination coverage was evaluated. Secondly, the same relationship was assessed in the homogeneous area of the Municipality of Sassari. This required the adoption of an ad hoc deprivation index, which allowed us to stratify the population into deprivation groups and to correlate vaccination coverage with socio-economic variables.

The results showed that regional anti-influenza vaccination coverage increased linearly as deprivation decreased. This trend was confirmed in the Municipality of Sassari. Pearson's analysis highlighted factors that significantly correlate with vaccination coverage.

In Sardinia, the relationship between anti-influenza vaccination coverage and socio-economic status is consistent with the international panorama, and highlights the necessity to implement interventions to promote vaccination coverage among the elderly.

Introduction

Socio-economic status and social deprivation influence adherence to health prevention programs, particularly those regarding vaccination [1-7].

The Italian Region of Sardinia participated in a project financed by the Italian Ministry of Health – (National Center for Disease Control and Prevention – CCM 2015: "Indici di deprivazione socioeconomica sanitaria e coperture vaccinali antinfluenzali negli anziani", as stated by Article 4, paragraph 7 of the collaboration agreement), with the aim of assessing the relationship between socio-economic inequalities and low anti-influenza vaccination coverage among subjects aged over 65 years. To this end, characteristics of socio-economic status were examined in order to study their relationship with vaccination coverage and thus enable vaccination promotion strategies to be implemented on the basis of real needs [7-10].

The present study, which focused on the 2015 and 2016 seasonal influenza periods, was conducted in different phases: firstly, the trivial relationship between social deprivation and anti-influenza vaccination coverage in adults aged over 65 years was observed at the regional level among macro areas by means of an already known social index (IDMS) [8]. Secondly, the same relationship was evaluated by means of an ad hoc social index (SEHDI) for the homogeneous area of the Municipality of Sassari, in order to check for possible biases which could affect the trivial analysis.

Methods

Relationship between IDMS index and anti-influenza vaccination coverage in adults aged over 65 years in Sardinia

According to the distribution of the population (1,658,138 inhabitants in 2016 in Sardinia), the regional territory is organized into 8 homogeneous areas (AO): 2 metropolitan areas, 5 aggregated communities, and 1 small geographically-isolated community. Each AO includes a Local Social-Health Area (ASSL), which is part of the Territorial Health Protection Agency (ATS), as stated by Regional Law [10]. The organization of the healthcare network is related to various territorial features, such as insularity, conformation, progressive depopulation of rural areas, and population and road distribution [11, 12]. On account of these features, Sardinia has already proved to be an excellent model for epidemiological studies [13].

In order to evaluate the coverage of anti-influenza vaccination offered to over-65s by the 8 ASSLs, data provided by the Regional Health Department referring to two influenza seasons (2015-2016) were analyzed [14]. Furthermore, the relationship between the percentage of vaccination coverage and the Index of Sardinian Multiple Deprivation (IDMS) index [8], an index already available at the macro-area level, was evaluated by applying a simple linear regression model.

Relationship between SEHDI and anti-influenza vaccination coverage in over-65s in Sassari

The homogeneous area of Sassari includes its municipal territory, which covers an area of 547.03 km² and has a density of 233.1 inhabitants per km². The municipal territory is divided into 998 census areas, based on common economic, social and/or environmental characteristics.

The relationship between social deprivation status and anti-influenza vaccination coverage in the over-65s was studied with regard to the specific urban and peri-urban area of the Municipality of Sassari. To this end, an ad hoc Socio-Economic Health Deprivation Index (SEHDI), developed by Lillini and Vercelli, was used. This enabled the population to be stratified into groups of deprivation. The methods used to develop the SEHDI and to define different deprivation groups were taken from the previous studies by Lillini and Vercelli on the development of local socio-economic deprivation indexes aimed at identifying health inequalities in the population on the basis of socio-economic stratification [15, 16].

The anti-influenza vaccination coverage rates among over-65s within the various deprivation groups were compared by means of the ANOVA with F-test and linearity test. Vaccination coverage data provided by General Practitioners (GPs) working in local clinics/polyclinics were obtained from the Municipal Social-Health District database.

Finally, the relationship between coverage and the SEHDI was elaborated by applying a linear regression model. All of the data collected were processed by means of Excel (Microsoft Corp.) and STATA (STATA Corp). The datasets are available from the corresponding author on reasonable request.

Results

In recent years (2013-2016), a very low average anti-influenza vaccination coverage (around 40%) was recorded among over-65s in Sardinia, with high variability between areas and municipalities. In the 2015-2016 season, analysis per AO showed an inversely proportional relationship between anti-influenza coverage and the IDMS deprivation index (y = - 12.36x + 50.74; R^2 = 0.15), with the highest coverage observed in Ogliastra (Lanusei) (58%) and the lowest in Cagliari (28%) (Fig. 1).

The survey of the urban and peri-urban areas of the Municipality of Sassari involved the local populations of 998 census areas, which amounted to 127,525 of the 334,103 residents of all ASSLs (74,349 adults over 65) during the survey period [12]. Of these, 111,437 were registered at 119 clinics, served by 96 GPs. Adults aged over 65 years numbered 27,496, of whom 23,943 constituted the sample under study.

On the basis of the SEHDI, the population was divided into 5 groups of deprivation: High Deprivation (7%), Medium-High Deprivation (13%), Medium Deprivation (61%), Medium-low Deprivation (11%) and Low Deprivation (8%).

The study area and the distribution of the SEHDI are depicted in Figure 2; as shown, it is not possible to identify a homogeneous territorial trend.

Figure 3 shows the population of over-65s in Sassari, stratified according to the 5 above-mentioned SEHDI categories, in relation to anti-influenza vaccination coverage. A growing trend was observed as wealth increased (y = 1.2223x + 28.662; R^2 = 0.8735). Indeed, vaccination coverage was seen to vary from 30% in high deprivation areas to 34% in low deprivation areas, the difference being statistically significant (ANOVA (F); $p < 0.05$).

Fig. 1. Relationship between the IDMS social index and anti-influenza vaccination coverage among subjects aged over 65 years observed in the 8 Sardinian Local Social-Health Areas (ASSL) during the period 2015-2016.

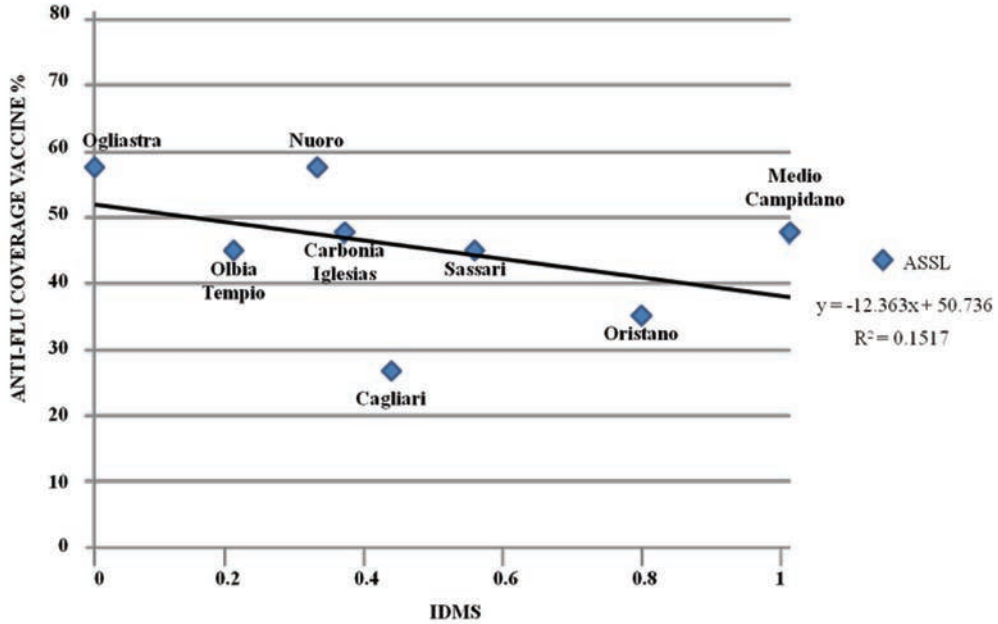


Fig. 2. Graphic representation of census areas of the Municipality of Sassari.

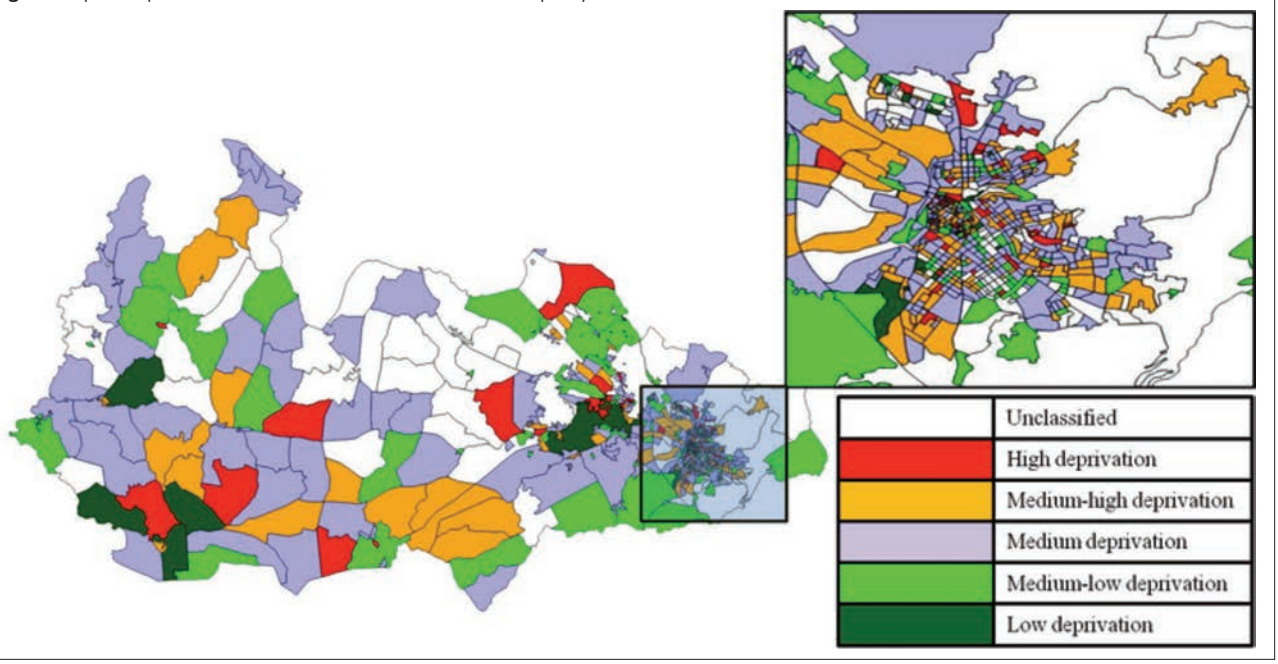


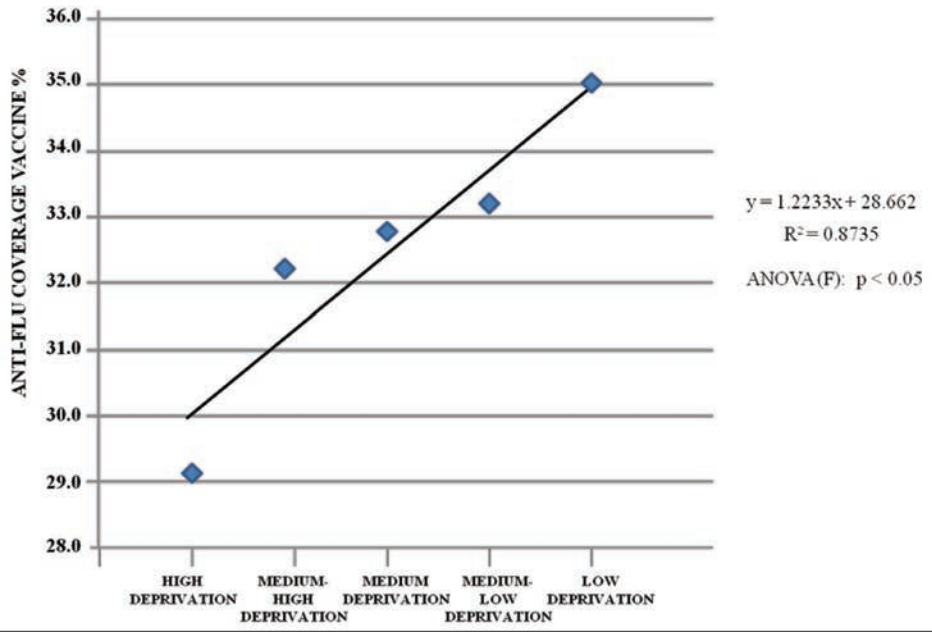
Table I shows the correlation between the percentage of vaccination coverage in the over-65s and the socio-economic variables by census areas.

On the one hand, vaccination coverage increased as the following variables increased: percentage of married people, percentage of home-owners, and average number of people per occupied dwellings; on the other, it decreased as the percentage of foreigners and stateless persons residing in Italy, rented homes and 1-member families increased.

The vaccination coverage observed in the high deprivation group increased as the percentage of 2-member families and the old-age index rose, whereas it decreased as the percentage of those working in temporary jobs increased.

In the medium-high deprivation group, vaccination coverage was higher among graduates, the self-employed, and employees. Furthermore, vaccination coverage in the medium deprivation group increased as the percentage of 4-member families and those with average

Fig. 3. Relationship between SEHDI groups of deprivation and anti-influenza vaccination coverage.



Tab. I. Correlation between socio-economic variables and vaccination coverage among residents aged over 65 years in the Municipality of Sassari, by deprivation group.

Population observed	Socioeconomic variables	Pearson correlation	P-value
Over-65s resident in the Municipality of Sassari	% married	0.120	0.032
	% foreigners and stateless persons residing in Italy	- 0.115	0.039
	% rented homes	- 0.109	0.051
	% owned homes	0.135	0.016
	% 1- member families	- 0.185	0.001
	Number of components per family	0.149	0.008
	Average number of people per occupied dwelling	0.129	0.019
Over-65s high deprivation	% 2- member families	0.405*	0.040
	% temporary job	- 0.389*	0.050
	Retirement index	0.446*	0.043
Over-65s medium-high deprivation	% degree or other academic qualification	0.391**	0.007
	% self-employed	0.402**	0.005
	Activity rate	0.293*	0.046
Over-65s medium deprivation	% rented homes	- 0.147*	0.034
	% 1- member families	- 0.248**	0.000
	% 4- member families	0.219**	0.001
	Average number of people per occupied dwelling	0.222**	0.001
	Average number of persons per family	0.233**	0.001
Over-65s, medium-low deprivation	% foreigners and stateless persons residing in Italy	- 0.594**	0.009
Over-65s, low deprivation	% single-parent families with children under 15 years	0.544*	0.013

*: $p < 0.05$; **: $p < 0.01$.

number of people per occupied dwellings, whereas it decreased as the percentage of tenants and 1-member families increased.

Vaccination coverage in the medium-low deprivation group increased as the percentage of foreigners and stateless residents in Italy rose. Finally, vaccination coverage in the low deprivation group rose as the percentage of single-parent families with children under 15 years old rose.

Discussion

Socio-economic deprivation in urban areas is closely associated with low vaccination coverage among high-risk groups, such as the elderly [3, 4, 17]. Indeed, socio-economic status is considered one of the main social determinants both of individuals' health and of their adherence to preventive measures [17, 18]. In particular elderly people's socio-economic status appears to play an important role in their compliance with anti-influenza vaccination [6, 7].

Low socio-economic status is usually correlated with low vaccination coverage, as reported in Spain, France and the United Kingdom [19]. In Italy, however, studies by Damiani and Chiatti [17, 20] seemed to suggest that the opposite was true, in that anti-influenza vaccination was found to be more widespread among elderly subjects belonging to more deprived social classes (65%) than among those from wealthier classes (57%).

The present study was conducted in various AOs throughout the Sardinia Region, though it focused on deprivation in the population of Sassari's. The aim was to determine the relationship between influenza vaccination coverage and deprivation in an at-risk age-group (over-65s). In the past, urban and peri-urban areas of Sassari have been the focus of various health investigations [21, 25]. To the best of our knowledge, however, this is the first study to focus on the relationship between socio-economic status and vaccination coverage.

Data from the entire Sardinian Region, which were obtained by means of the IDMS deprivation index, showed an inverse correlation between vaccination coverage and deprivation. This finding is similar to that observed in the literature, but opposite to that recorded in Italy. Indeed, in Sardinia, influenza vaccination coverage in adults aged 65 years and over appears to decrease as deprivation increases. This difference between Sardinia and the national context could be attributed to two main reasons: 1) the non-homogeneous vaccination offer among the different AOs, which does not depend on the IDMS used, but could be due to a possible different agreement between the ASSLs and the GPs, who strongly influence vaccination uptake among the over-65s; 2) a variable relationship between vaccination coverage and status, which may be attributable, on the one hand, to a linear pattern at low levels of coverage, as in Sardinia, and, on the other, to a non-linear pattern at higher levels of vaccination coverage, such as those found in other territorial contexts [14, 16].

In order to exclude the potential bias due to possible different agreements with GPs, which could occur regard-

less of socio-economic determinants, our study focused on the AO of Sassari. The SEHDI enabled us to identify and evaluate the relationship between socio-economic inequalities and health outcomes. As suggested by the literature data [26, 27], using a deprivation index is useful in the study of the health characteristics of the population, particularly those of sensitive groups (e.g., populations at risk of late diagnosis and/or undergoing therapy for chronic-degenerative diseases) [27, 31]. We observed that flu vaccination coverage depends on SEHDI at the AO level, too.

Moreover, we observed a direct proportional correlation between vaccination coverage in over-65s and various socio-economic variables (percentage of married people, average number of people per occupied dwellings, rented homes, and 1-member families). Conversely, a statistically significant inverse relationship was seen between coverage and the percentage of foreigners and stateless persons residing in Italy, of those in rented homes and of 1-member families. On the basis of these results, the present study confirms the role played by occupational and cultural factors in influencing adherence to anti-influenza immunization programs, as previously observed by several authors [6, 32, 33]. The relationship between influenza vaccination coverage and clusters of deprivation shows how cultural level and professional occupation positively influence adherence to flu vaccination among over-65s [6, 34].

Conclusions

In Sardinia, the relationship observed between low vaccination uptake and socio-economic status was consistent with that reported in the literature. The analysis of data on the Municipality of Sassari by means of an ad hoc deprivation index (SEHDI) confirmed the relationship seen at the regional level.

Our results emphasize the need to implement interventions for the promotion of vaccination [30, 35], especially in high- risk groups, such as the elderly, and to hone information on the main cultural and occupational factors observed.

List of abbreviations

CCM – National Centre for Disease Control and Prevention
AO – Homogeneous Area
ASSL – Local Social-Health Area
ATS – Territorial Health Protection Agency
IDMS – Index of Sardinian Multiple Deprivation
SEHDI –Socio-Economic Health Deprivation Index

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Conflict of interest statement

None declared.

Authors' contributions

PC conceived the study; MDM, ED and AAz collected the data; PC and AAr analyzed and interpreted the data; PC, MD and AAr wrote the paper; ED revised the manuscript. All authors have read and approved the final manuscript.

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ORIGINAL ARTICLE

Local deprivation status and seasonal influenza vaccination coverage in adults ≥ 65 years residing in the Foggia municipality, Italy, 2009-2016

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Keywords

Influenza vaccination • Deprivation index • Socioeconomic status • Elderly

Summary

Introduction. *In Italy, vaccination against seasonal influenza has been recommended for the elderly since 1980, but coverage is still far below the WHO minimum target level of 75%. Effective interventions to improve influenza vaccination should take into account socioeconomic determinants of inequalities in vaccine uptake. This study aimed to assess differences in vaccination coverage, by socioeconomic status, among people ≥ 65 years of age residing in the Foggia municipality, Italy.*
Methods. *A Socio-Economic-Health Deprivation Index (SEHDI) was constructed by using a multivariate analysis model. The resident population, for census block, was classified in 5 deprivation groups. Differences in demographic and socioeconomic indicators, the standardized mortality ratios (SMRs), and the average vaccination coverage among deprivation groups were evaluated with the linear F-test. The association between census variables and influenza vaccination coverage, in each deprivation group, was assessed using the Pearson bivariate correlation.*
Results. *The SEHDI allowed to identify factors related to ageing, housing, household size and composition, and education. Forty percent of people residing in the Foggia municipality lived in conditions of socioeconomic and health deprivation. Belonging to families with 3 or 4 members was associated with increased coverage rates. In the most deprived group, vaccination uptake was positively associated with the dependency ratio.*
Conclusions. *The results of this study have shown that there is still large room for improving influenza vaccination coverage among subjects belonging to the most deprived areas. Surveillance of trends in influenza vaccine uptake by socioeconomic groups is a feasible contribution to implementing effective, tailored to the frail older persons, vaccine utilization programs.*

Introduction

Seasonal influenza is an acute respiratory infection caused by influenza viruses which circulate in all parts of the world. Several studies have shown that, among individuals aged ≥ 65 years, influenza is associated with increased morbidity and mortality and excess hospitalizations, particularly in industrialized countries [1-4].
Vaccination is the most effective method to prevent infection and severe outcomes caused by influenza viruses [5]. Vaccination can reduce illness and lessen the severity of infection, particularly in groups at risk for complications of influenza, such as the elderly and subjects of any age with underlying diseases [6]. The World Health Organization (WHO) recommends annual influenza vaccination for pregnant women, children aged 6-59 months, the elderly, individuals with specific chronic medical conditions and healthcare workers [7]. In 2009, the Council of the European Union issued a recommendation on seasonal influenza vaccination with the aim of reaching a vaccination coverage (VC) rate of 75% among the older age-groups and risk groups, as recommended by the WHO. Member States were also encouraged to improve vaccination coverage among healthcare workers [8].

In Italy, since 1980, influenza vaccination has been recommended for people 65 years of age and older, those with chronic diseases, children under 12 years of age who are receiving long-term anti-inflammatory treatment with aspirin, and those who have frequent contact with high-risk groups [2, 9]. Vaccination coverage among the elderly population formerly showed an increasing trend, reaching 68.7% in the 2005-2006 season. Subsequently, the proportion of vaccinated elderly progressively declined and dropped below 50% during two of the latest influenza seasons [10]. During the 2017-2018 season, vaccination coverage was 52.7% [10, 11], still far below the minimum (75%) or optimal (95%) coverage targets set in the National Vaccination Plan (PNPV) 2017-2019 [11].
In the Apulia region, Southern Italy (≈ 4,000,000 inhabitants), in the first half of the 2000s, influenza vaccination coverage rates in people aged 65 years and over were stably above 68%; they then decreased from 57.2% in the 2012-2013 season to 48.6% in the 2014-2015 season. During the 2017-2018 season, the coverage rate rose to 59.4% [12], with the highest level recorded in the district of Foggia (61%) [13].
A systematic review published in 2013 showed that the access and adherence to seasonal influenza vaccination

among adults aged ≥ 65 years are influenced by social determinants of health, such as age, gender, marital status, education, ethnicity, socioeconomic status, social and cultural values, place of residence, lifestyle habits, social influences, previous vaccination experiences, perceived susceptibility, sources of information and perceived health status [14]. Also healthcare system-related factors, including accessibility, affordability, knowledge, attitudes towards vaccination, and physicians' advice, are important determinants of vaccination. Effective interventions to improve influenza vaccination should therefore take into account determinants that may cause inequalities in vaccine uptake, in order to identify the population groups to which targeted efforts must be addressed [14, 15].

Deprivation indexes have been proposed as useful measures for analyzing health inequalities by identifying and evaluating the relationships between socioeconomic status (SES) and health conditions. These indexes usually refer to geographical aggregations, and are used as a proxy of the individual's conditions according to the area of residence. They can be used to identify disparities in influenza immunization among the various high-risk groups, including the elderly [16, 17].

Because few studies have specifically focused on the role played by deprivation indexes in determining vaccine uptake [18-23], we aimed to assess differences in influenza vaccination coverage among people ≥ 65 years of age belonging to different socioeconomic groups and residing in the Foggia municipality (Apulia region, Italy), according to census district and the variables recorded [24].

Methods

Setting

The Foggia municipality is the administrative center of the homonymous district. Situated in the center of "Italy's granary", it is an important reference point for nearby rural areas [25]. In terms of population, Foggia is the third-largest Apulian municipality, after Bari and Taranto. It is the most densely populated municipality (299.3 inhabitants/sq km) in the Foggia district and has the second-largest territorial extension (507.80 sq km). On 1 January 2017, the population was estimated at 151,726 residents (51.8% women), 20.7% of whom were aged 65 years or older, 65% between 15 and 64 years and 14.3% under 15 years. Since 2012, the proportion of older persons in the total population has grown significantly (+ 4.6% of people aged ≥ 65 years) and the average age has increased by almost 5 years. The old-age-dependency ratio and the aging index have increased by 7.7% and 53.6%, respectively. In 2017, resident foreigners accounted for 4% of the total population (+3% compared with 2003) (Tab. I) [26, 27].

Calculation of the Socio-Economic-Health Deprivation Index (SEHDI)

Variables from the data warehouse of the 15th Italian General Censuses of Population and Housing 2011 were considered [24]. The SEHDI was calculated by using a multivariate analysis model as previously described by Lillini et al. [18]. Standardized mortality ratios (SMRs) for all-cause and some cause-specific mortality, by gender and age-group (0-64 years and 65+ years), were taken from the Apulian Causes of Death Registry for the period 2009-2013 (death certificates coded in accordance with the International Classification of Diseases 10th Revision - ICD10). The resident population, by census district, was classified in 5 deprivation groups: high deprivation, medium-high deprivation, medium deprivation, medium-low deprivation, low deprivation. The chart of the Foggia municipality was constructed by means of the ISTAT (Italian National Institute of Statistics) shapefile format [28].

Data on influenza vaccination uptake in adults aged ≥ 65 years in seven seasons (2009-2010 to 2015-2016) were retrieved from general practitioners' (GPs) medical records of subjects. GPs' offices (n = 124) were georeferenced and vaccination coverage was calculated for each census district.

Differences in the main demographic and socioeconomic indicators (dependency ratio, aging index, replacement index, activity rate, employment and unemployment rates), the SMRs, and the average vaccination coverage among the five deprivation groups were evaluated by means of the linear F-test ($p < 0.05$).

The association between census variables [24] and influenza vaccination coverage, in each deprivation group, was assessed by means of the Pearson bivariate correlation ($p < 0.05$).

Results

Table II shows the census variables composing the SEHDI for the Foggia municipality. The SEHDI allowed us to identify 3 main factors related to aging, housing, household size and composition, and education. Together, these accounted for 69% of the variance.

Forty percent of people residing in the Foggia municipality lived in conditions of socioeconomic and health deprivation (Fig. 1).

Among the main demographic and socioeconomic indicators, dependency ratio, aging index, and replacement index were higher in the most deprived groups ($p < 0.05$ l.), while activity rate was lower. The SMR was higher in the high deprivation group ($p < 0.05$ l.) (Tab. III).

Figure 2 shows the geographical distribution of the SEHDI by census district. The most deprived area was the old part of the city, traditionally inhabited by people of lower socioeconomic status and immigrants.

The SMRs for the period 2009-2013 were higher in the most deprived groups ($p < 0.05$ l.) (Tab. IV).

Tab. I. Main demographic indicators of Foggia municipality, Italy, years 2002-2017, January 1st.

Year	Population (n.)	Population aged 0-14 (%)	Population aged 15-64 (%)	Population aged ≥ 65 (%)	Mean age (years)	Dependency ratio (%)	Old-age-dependency ratio (%)	Aging index (%)	Resident foreigners (n.)
2002	155,188	17.7	66.3	16.1	38.8	50.9	24.2	91	-
2003	154,970	17.5	66.1	16.4	39.1	51.2	24.8	93.9	1,431
2004	154,792	17.2	66.1	16.7	39.4	51.3	25.2	96.9	1,955
2005	154,780	17.0	65.9	17.1	39.8	51.7	25.9	100.5	2,085
2006	153,650	16.8	65.8	17.5	40.1	52	26.5	104.2	1,837
2007	153,529	16.5	65.7	17.7	40.5	52.1	27	107.3	2,045
2008	153,469	16.2	65.9	17.9	40.7	51.8	27.2	110.2	2,732
2009	153,239	16.0	65.9	18.1	41	51.7	27.4	112.8	3,361
2010	152,959	15.9	65.9	18.2	41.3	51.7	27.2	114.9	3,857
2011	148,573	15.7	65.8	18.5	41.6	51.9	28.1	117.5	4,290
2012	147,045	15.5	65.7	18.9	41.9	52.3	28.8	122.2	2,803
2013	148,573	15.2	65.6	19.2	42.2	52.4	29.2	126	3,745
2014	153,143	15.1	65.3	19.6	42.4	53.1	30.0	129.7	5,113
2015	152,770	14.8	65.1	20.0	42.7	53.5	30.7	134.9	5,593
2016	151,991	14.6	65.1	20.4	43	53.7	31.3	139.4	5,612
2017	151,726	14.3	65.0	20.7	43.4	53.9	31.9	144.6	6,140

Tab. II. Census variables [24] composing the SEHDI for the Foggia municipality, Italy.

Factor 1 = 38.1%	**Factor 2 = 16.1%**	**Factor 3 = 14.6%**
Housing with bathtub or shower (%)	Housing with bathtub or shower (%)	Housing with bathtub or shower (%)
Widowers/widows (%)	Primary school diploma, illiterate (%)	
2-member families (%)		
Average number of people per family		
Aging index (%)		
Total variance explained = 68.9%		

Fig. 1. Distribution of population residing in the Foggia municipality, Italy, by deprivation group [24].

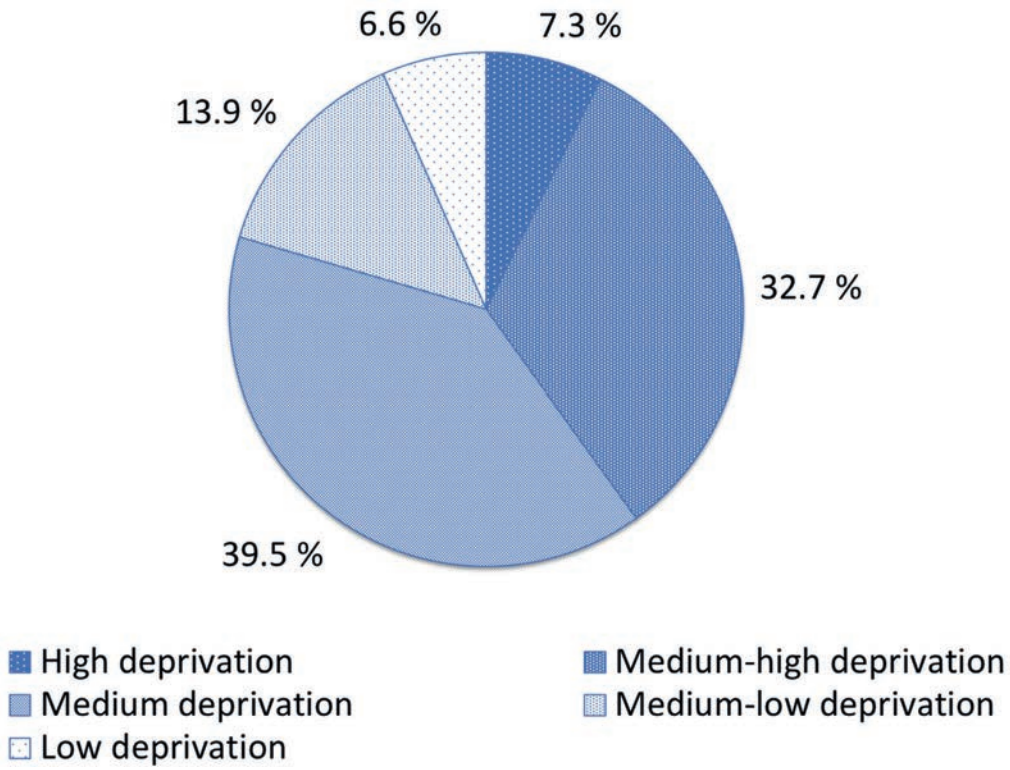
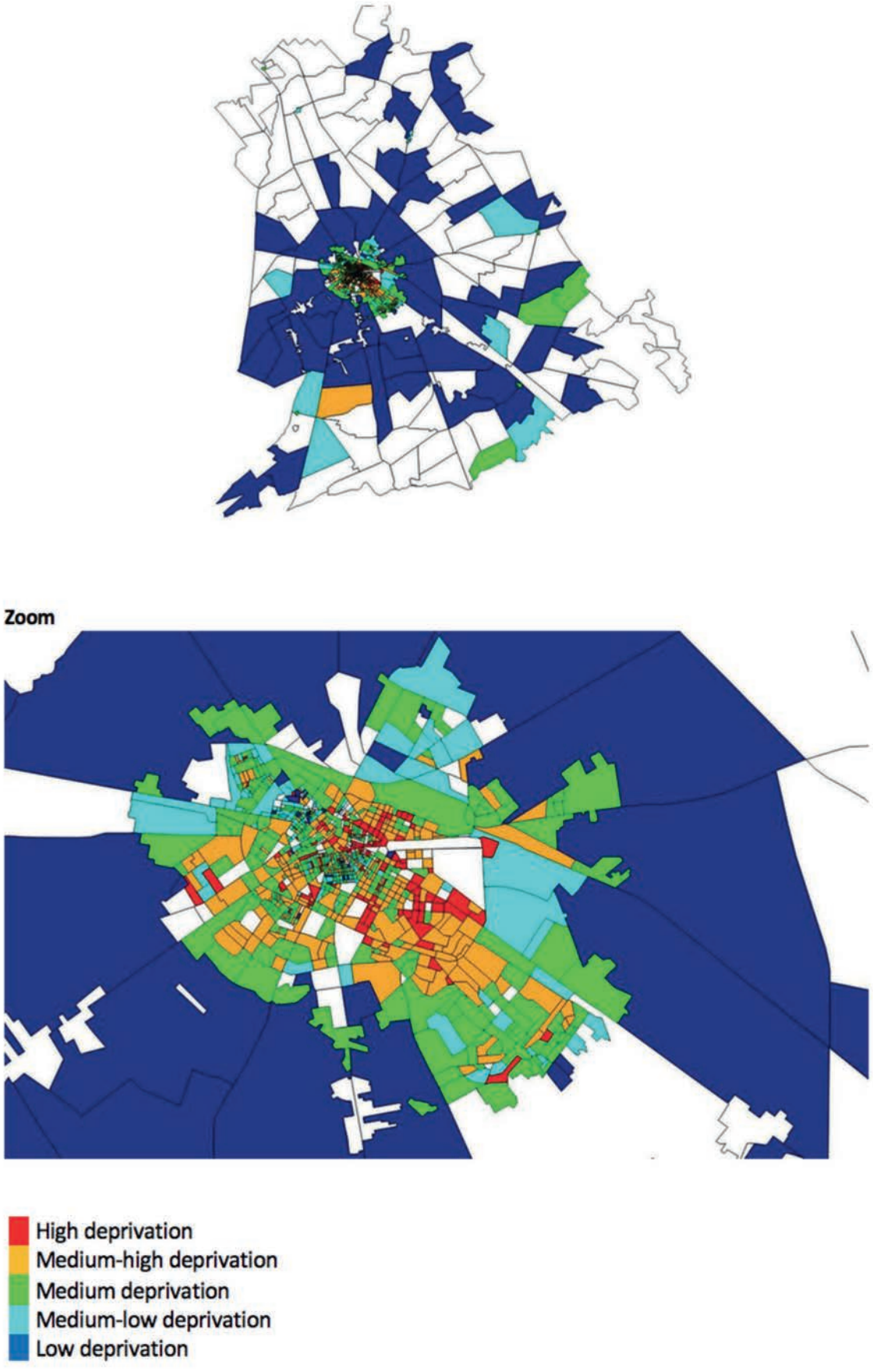


Fig. 2. Geographical distribution of the SEHDI in the Foggia municipality, Italy [24].



Tab. III. Main demographic and socioeconomic indicators[24], and SMRs[2009-2013] in the Foggia municipality, Italy, by deprivation group.

Deprivation group	Dependency ratio (%)	Aging index (%)	Replacement Index (%)	Activity rate (%)	Employment rate (%)	Unemployment rate (%)	SMR
High deprivation	71.7	383.1	185.4	41.3	52.7	8.9	1.14
Medium-high deprivation	60.0	215.0	155.7	42.4	47.8	10.2	0.83
Medium deprivation	53.3	135.4	139.3	44.7	45.5	11.1	0.63
Medium-low deprivation	51.6	97.2	102.3	44.7	41,6	11.5	0.82
Low deprivation	60.1	83.2	92.1	46.9	45.3	11.0	0.57
Total	**57.8**	**177.3**	**139.7**	**43.8**	**46.3**	**10.6**	**0.8**
Trend	*p < 0.05 l.*	*p < 0.05 l.*	*p < 0.05 l.*	*p < 0.05 l.*	*NS*	*NS*	*p < 0.05 l.*

Tab. IV. SMRs[2009-2013] for all-cause and some cause-specific mortality in the Foggia municipality, Italy, by deprivation group.

Deprivation group	All-cause mortality	Diseases of the circulatory system	Diseases of the respiratory system	Diseases of the digestive system	Chronic Obstructive Pulmonary Disease (COPD)	Influenza and pneumonia
	SMR (95%CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)
High deprivation	1.59 (1.48-1.71)	1.67 (1.48-1.87)	1.45 (1.04-1.86)	1.28 (0.78-1.78)	1.04 (0.6-1.47)	4.12 (2.16-6.08)
Medium-high deprivation	1.19 (1.14-1.23)	1.19 (1.12-1.27)	1.04 (0.88-1.21)	1.55 (1.28-1.81)	0.69 (0.52-0.86)	2.13 (1.46-2.80)
Medium deprivation	0.83 (0.79-0.86)	0.83 (0.77-0.89)	0.81 (0.68-0.94)	0.90 (0.72-1.08)	0.63 (0.49-0.78)	1.68 (1.14-2.22)
Medium-low deprivation	0.77 (0.72-0.83)	0.75 (0.65-0.84)	0.81 (0.59-1.03)	0.89 (0.58-1.19)	0.72 (0.46-0.98)	1.55 (0.67-2.43)
Low deprivation	0.20 (0.16-0.24)	0.21 (0.14-0.29)	0.07 (0-1.16)	0.34 (0.07-0.61)	0.10 (0-0.24)	0 (0-0)
Total	**0.95 (0.93-0.97)**	**0.96 (0.92-1)**	**0.88 (0.80-0.97)**	**1.1 (0.97-1.23)**	**0.66 (0.56-0.75)**	**1.88 (1.52-2.24)**
Trend	*p < 0.05 l.*	*p < 0.05 l.*	*p < 0.05 l.*	*p < 0.05 l.*	*p < 0.05 l.*	*p < 0.05 l.*

Tab. V. SMRs[2009-2013] for all-cause and some cause-specific mortality in persons ≥65 years of age residing in the Foggia municipality, Italy, by deprivation group.

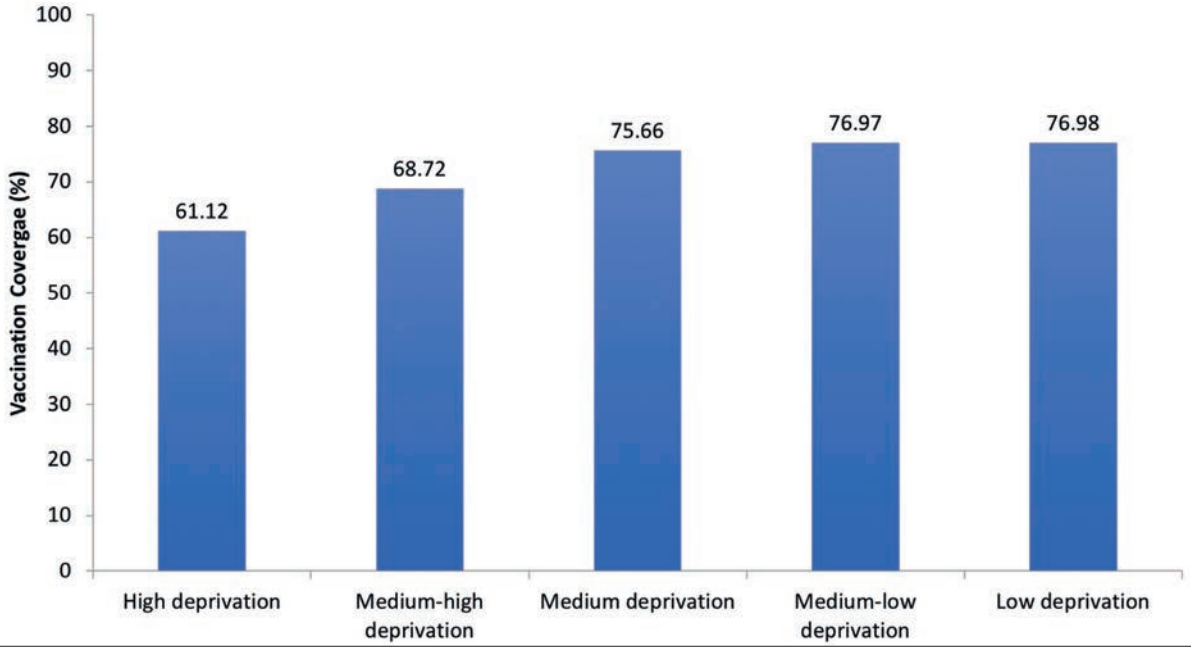
Deprivation group	All-cause mortality	Diseases of the respiratory system	Chronic Obstructive Pulmonary Disease (COPD)	Influenza and pneumonia
	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)	SMR (95% CI)
High deprivation	0.99 (0.91-1.06)	0.93 (0.67-1.20)	0.67 (0.39-0.95)	2.56 (1.30-3.81)
Medium-high deprivation	0.92 (0.88-0.96)	0.83 (0.70-0.97)	0.54 (0.41-0.68)	1.72 (1.16-2.27)
Medium deprivation	0.92 (0.88-0.97)	0.93 (0.77-1.09)	0.74 (0.57-0.91)	1.94 (1.28-2.60)
Medium-low deprivation	0.98 (0.90-1.07)	1.13 (0.81-1.44)	1.04 (0.67-1.41)	1.95 (0.74-3.15)
Low deprivation	0.29 (0.89-0.94)	0 (0-0)	0.10 (0-0.24)	0 (0-0)
Total	**0.91 (0.89-0.94)**	**0.87 (0.79-0.96)**	**0.65 (0.56-0.75)**	**1.85 (1.48-2.22)**
Trend	*p < 0.05 n.l.*	*p < 0.05 n.l.*	*p < 0.05 n.l.*	*NS*

A non-linear trend was observed in the SMRs for all-cause and some cause-specific mortality, except for Influenza and pneumonia, in the 65+ age-group (Tab. V). Mortality data, by sex, age and deprivation group, are shown in Table S1.

During seven influenza seasons (2009-2010 to 2015-2016), vaccination coverage in the elderly population residing in the Foggia municipality was 71.9% on average, with rates above the minimum (75%) coverage target recorded in the least deprived groups ($p < 0.05$ l.) (Fig. 3).

Residing in an area with a higher proportion of divorced persons or immigrants was associated with a lower vaccination uptake, while belonging to families with 3 or 4 members was associated with higher coverage rates (Tab. VI). In the most deprived group, vaccination uptake was positively associated with the dependency ratio (Tab. VII).

Fig. 3. Influenza vaccination coverage (averages in seven seasons: 2009-2010 to 2015-2016) in persons ≥65 years of age residing in Foggia municipality, Italy, by deprivation group.



Tab. VI. Associations between census variables[24] and influenza vaccine uptake in persons ≥65 years of age residing in the Foggia municipality, Italy.

Census variable	Pearson correlation coefficient	P value
3-member families (%)	0.156	0.014
4-member families (%)	0.167	0.012
Divorced (%)	-0.199	0.006
Foreigners and stateless persons residing in Italy (%)	-0.172	0.011

Tab. VII. Associations between census variables[24] and influenza vaccine uptake in persons ≥65 years of age residing in the Foggia municipality, Italy, by deprivation group.

Census variable	Pearson correlation coefficient	P value
High deprivation group		
Dependency ratio (%)	0.631	0.012
Employees (%)	-0.374	0.017
Foreigners and stateless persons residing in Italy (%)	-0.356	0.019
Medium-high deprivation group		
Unemployed (%)	0.210	0.017
Entrepreneurs (%)	-0.225	0.014
Unpaid family workers (%)	-0.200	0.019
Single-parent families (%)	-0.243	0.011
Medium deprivation group		
Married (%)	0.291	0.015
Replacement Index (%)	0.332	0.01
Divorced (%)	-0.475	0.014
Self-employed (%)	-0.429	0.029
Medium-low deprivation group	No association	
Low deprivation group	No association	

Discussion

Preventing serious complications of seasonal influenza among the elderly remains a public health priority and has a major economic and social impact.

Life expectancy considerably increased in most developed countries during the twentieth century, and by 2050 it is expected that 30% of Europeans will be aged > 60 years and at least 10% ≥ 80 years [29]. However, the increase in longevity (and in health) is very unevenly distributed across groups with different socioeconomic status [30], and health inequalities seem to be increasing over time [31].

In agreement with other studies [29], ours showed that the census variables composing the SEHDI for the Foggia

municipality, Italy, included aging and household size and composition, which are considered to be among the main determinants of the well-being of older adults.

Research on the relationship between health inequalities and social deprivation in older people is scant. Some studies have suggested that there is only a weak association between social deprivation and ill health, or that there is a lower mortality differential between older people living in affluent areas and those in deprived areas [32]. In the Foggia municipality, we found that some main demographic and socioeconomic indicators (such as dependency ratio, aging index, and replacement index) were higher in the most deprived groups.

Some authors claim that accessibility to healthcare facilities influences health service utilization [18, 31]; health outcomes may therefore be related to the spatial distribution of such services [31, 33]. In our study, the most deprived area was the old part of the city, farther from healthcare services and with more difficult access to public transport

Our results also support those of other studies, in that all-cause and cause-specific mortality was found to be higher among the most disadvantaged groups [18, 34]. A study of socioeconomic inequalities in health and mortality in 22 European countries showed that, in almost all countries, death rates were substantially higher in groups of lower socioeconomic status [35]. In particular, our results are consistent with the finding of that a lower mortality due to diseases of the respiratory and circulatory systems was associated with higher socioeconomic status [18, 36, 37].

We found excess deaths from influenza and pneumonia among the deprived groups. Zhao et al. showed that, during the 2009/2010 pandemic and the first post-pandemic influenza season in England, persons living in areas with the highest level of deprivation had a significantly higher risk of death following influenza A(H1N1)pdm09 than residents in areas with the lowest level, in both periods [38]. Khieu et al. found that people living in the most deprived areas experienced the highest estimated influenza-attributable all-cause mortality rate, which was 1.8 times greater than that found in the least deprived areas [39]. These findings support the notion that influenza vaccination should be targeted to the most vulnerable groups living in the most deprived areas.

Our study showed that a lower socioeconomic status of the elderly population residing in the Foggia municipality was associated with a lower influenza vaccination uptake. Other studies on socioeconomic disparities in influenza vaccination have reported similar results. For instance, Landi et al. found that the presence of economic problems was significantly associated with a reduced likelihood of being vaccinated [40]. Similarly, Norbury et al. found that people living in more deprived areas were less likely than their wealthier counterparts to be immunized over two different influenza seasons [41]. By contrast, Damiani et al. reported that socioeconomic inequalities in influenza vaccine uptake were present among adults but not among the elderly, perhaps because the National Health Service in Italy provides influenza vaccination for the elderly free of charge [19].

Finally, our finding of a positive association between vaccination uptake and household size and composition supports the hypothesis that social disadvantages, such as isolation and low income, may hinder access to the healthcare system among elderly people [40].

Conclusions

Although influenza vaccination coverage among the least deprived groups living in the Foggia municipality was above the objective of vaccinating at least 75% of the population aged 65 years or older, our study, like others, revealed that there is still ample room for improvement among subjects belonging to the most deprived groups. The surveillance of trends in influenza vaccination uptake by socioeconomic groups can contribute to reducing health inequalities and implementing effective vaccination programs that are tailored to frail older persons.

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Conflict of interest statement

None declared.

Authors' contributions

FF conceived the study, analyzed and interpreted the data, and drafted the manuscript. GI, AC, MDP, FVP, SC, and MDT contributed to data analysis and to drafting the manuscript. DM contributed to conceiving the study and revised the manuscript. RP provided important intellectual input in the various steps of the study and edited the manuscript. All authors have read and approved the final manuscript.

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Supplementary Materials

Tab. S1. SMRs[2009-2013] for all-cause and some cause-specific mortality in the Foggia municipality, Italy, by sex, age and deprivation group.

	All-cause mortality								
	Males aged 0-64	Females aged 0-64	Total population aged 0-64	Males aged ≥ 65	Females aged ≥ 65	Total population aged ≥ 65	Total, males	Total, females	Total population
Deprivation group	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**
High deprivation	1.25 (0.88-1.63)	1.86 (1.27-2.45)	1.48 (1.16-1.8)	1.01 (0.89-1.12)	0.97 (0.87-1.07)	0.99 (0.91-1.06)	1.59 (1.42-1.76)	1.59 (1.44-1.75)	1.59 (1.48-1.71)
Medium-high deprivation	1.18 (1.02-1.34)	1.16 (0.95-1.37)	1.17 (1.04-1.3)	0.92 (0.86-0.97)	0.92 (0.87-0.97)	0.92 (0.88-0.96)	1.24 (1.17-1.31)	1.13 (1.07-1.2)	1.19 (1.14-1.23)
Medium deprivation	0.95 (0.82-1.07)	1.04 (0.86-1.21)	0.98 (0.88-1.08)	0.85 (0.79-0.91)	1 (0.93-1.06)	0.92 (0.88-0.97)	0.83 (0.78-0.88)	0.83 (0.78-0.88)	0.83 (0.79-0.86)
Medium-low deprivation	1.03 (0.81-1.24)	0.93 (0.65-1.21)	0.99 (0.82-1.16)	0.87 (0.76-0.98)	1.1 (0.98-1.22)	0.98 (0.9-1.07)	0.76 (0.68-0.84)	0.79 (0.71-0.87)	0.77 (0.72-0.83)
Low deprivation	0.35 (0.17-0.53)	0.23 (0.03-0.42)	0.31 (0.17-0.44)	0.25 (0.16-0.34)	0.35 (0.23-0.48)	0.29 (0.22-0.37)	0.21 (0.15-0.27)	0.19 (0.13-0.25)	0.2 (0.16-0.24)
Total	**1 (0.92-1.08)**	**1.06 (0.94-1.17)**	**1.02 (0.95-1.09)**	**0.87 (0.84-0.91)**	**0.95 (0.91-0.99)**	**0.91 (0.89-0.94)**	**0.96 (0.92-0.99)**	**0.94 (0.91-0.98)**	**0.95 (0.93-0.97)**
Trend	*p<0.05 l.*	*p<0.05 l.*	*p<0.05 l.*	*p<0.05 l.*	*p<0.05 n.l.*	*p<0.05 n.l.*	*p<0.05 l.*	*p<0.05 l.*	*p<0.05 l.*
	Diabetes mellitus								
	Males aged 0-64	Females aged 0-64	Total population aged 0-64	Males aged ≥ 65	Females aged ≥ 65	Total population aged ≥ 65	Total, males	Total, females	Total population
Deprivation group	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**
High deprivation	1.1 (0-3.25)	0 (0-0)	0.71 (0-2.11)	0.95 (0.39-1.52)	0.17 (0-0.34)	0.43 (0.21-0.64)	1.43 (0.62-2.24)	0.28 (0.01-0.55)	0.7 (0.36-1.04)
Medium-high deprivation	0.44 (0-1.06)	0.84 (0-2)	0.58 (0.01-1.15)	0.71 (0.46-0.95)	0.43 (0.29-0.58)	0.53 (0.4-0.66)	0.85 (0.56-1.13)	0.56 (0.37-0.74)	0.67 (0.51-0.83)
Medium deprivation	0.98 (0.19-1.76)	1.6 (0.2-3)	1.19 (0.48-1.89)	0.65 (0.39-0.9)	0.73 (0.51-0.96)	0.7 (0.53-0.87)	0.61 (0.39-0.83)	0.65 (0.46-0.83)	0.63 (0.49-0.77)
Medium-low deprivation	1.32 (0-2.81)	0.91 (0-2.68)	1.18 (0.02-2.34)	0.8 (0.28-1.32)	0.7 (0.3-1.1)	0.74 (0.42-1.05)	0.68 (0.29-1.06)	0.52 (0.24-0.8)	0.59 (0.36-0.82)
Low deprivation	0 (0-0)	0 (0-0)	0 (0-0)	0.21 (0-0.62)	0 (0-0)	0.09 (0-0.28)	0.12 (0-0.34)	0 (0-0)	0.05 (0-0.15)
Total	**0.8 (0.35-1.25)**	**1.05 (0.32-1.77)**	**0.88 (0.5-1.27)**	**0.7 (0.54-0.86)**	**0.51 (0.4-0.61)**	**0.58 (0.49-0.67)**	**0.72 (0.57-0.87)**	**0.53 (0.43-0.64)**	**0.61 (0.52-0.69)**
Trend	*NS*	*NS*	*NS*	*p<0.05 n.l.*	*p<0.05 l.*	*p<0.05 l.*	*p<0.05 l.*	*p<0.05 l.*	*p<0.05 l.*
	Diseases of the circulatory system								
	Males aged 0-64	Females aged 0-64	Total population aged 0-64	Males aged ≥ 65	Females aged ≥ 65	Total population aged ≥ 65	Total, males	Total, Females	Total population
Deprivation group	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**
High deprivation	1.56 (0.64-2.49)	2.43 (0.63-4.23)	1.81 (0.98-2.65)	1.07 (0.86-1.27)	1 (0.85-1.15)	1.02 (0.9-1.15)	1.63 (1.33-1.93)	1.7 (1.45-1.95)	1.67 (1.48-1.87)
Medium-high deprivation	0.98 (0.65-1.31)	0.92 (0.42-1.42)	0.96 (0.69-1.24)	0.96 (0.86-1.06)	0.95 (0.87-1.03)	0.95 (0.89-1.02)	1.19 (1.07-1.31)	1.19 (1.09-1.29)	1.19 (1.12-1.27)
Medium deprivation	1.03 (0.74-1.32)	1.62 (1.04-2.21)	1.2 (0.93-1.46)	0.89 (0.79-0.99)	1.01 (0.91-1.1)	0.96 (0.89-1.03)	0.8 (0.71-0.89)	0.86 (0.78-0.94)	0.83 (0.77-0.89)
Medium-low deprivation	1.08 (0.6-1.57)	0.92 (0.18-1.66)	1.04 (0.63-1.44)	0.84 (0.66-1.03)	1.12 (0.94-1.31)	1 (0.87-1.14)	0.67 (0.54-0.81)	0.81 (0.68-0.94)	0.75 (0.65-0.84)
Low deprivation	0.11 (0-0.34)	0 (0-0)	0.08 (0-0.25)	0.3 (0.13-0.47)	0.48 (0.27-0.69)	0.39 (0.26-0.53)	0.18 (0.08-0.28)	0.24 (0.14-0.35)	0.21 (0.14-0.29)

Tab. S1. SMRs[2009-2013] for all-cause and some cause-specific mortality in the Foggia municipality, Italy, by sex, age and deprivation group.

	Diseases of the circulatory system								
	Males aged 0-64	Females aged 0-64	Total population aged 0-64	Males aged ≥ 65	Females aged ≥ 65	Total population aged ≥ 65	Total, males	Total, Females	Total population
Total	**0.99 (0.81-1.17)**	**1.24 (0.92-1.57)**	**1.06 (0.9-1.22)**	**0.91 (0.84-0.97)**	**0.98 (0.92-1.03)**	**0.95 (0.91-0.99)**	**0.92 (0.86-0.98)**	**0.99 (0.94-1.05)**	**0.96 (0.92-1)**
Trend	***p<0.05 n.l.***	***NS***	***p<0.05 l.***	***p<0.05 l.***	***p<0.05 n.l.***	***p<0.05 n.l.***	***p<0.05 l.***	***p<0.05 l.***	***p<0.05 l.***
	Diseases of the respiratory system								
	Males aged 0-64	Females aged 0-64	Total population aged 0-64	Males aged ≥ 65	Females aged ≥ 65	Total population aged ≥ 65	Total, males	Total, females	Total population
Deprivation group	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**
High deprivation	0 (0-0)	1.9 (0-5.62)	0.63 (0-1.85)	0.85 (0.5-1.2)	1.02 (0.61-1.43)	0.93 (0.67-1.2)	1.24 (0.73-1.75)	1.72 (1.05-2.39)	1.45 (1.04-1.86)
Medium-high deprivation	0.94 (0.12-1.77)	0.39 (0-1.15)	0.76 (0.15-1.37)	0.84 (0.66-1.01)	0.83 (0.63-1.04)	0.83 (0.7-0.97)	1.06 (0.84-1.27)	1.02 (0.77-1.27)	1.04 (0.88-1.21)
Medium deprivation	1.38 (0.53-2.24)	0.59 (0-1.41)	1.13 (0.49-1.77)	0.89 (0.69-1.08)	1 (0.74-1.26)	0.93 (0.77-1.09)	0.81 (0.64-0.97)	0.81 (0.6-1.02)	0.81 (0.68-0.94)
Medium-low deprivation	0.75 (0-1.78)	0.84 (0-2.48)	0.78 (0-1.65)	1.02 (0.64-1.41)	1.29 (0.75-1.82)	1.13 (0.81-1.44)	0.74 (0.47-1.02)	0.92 (0.54-1.29)	0.81 (0.59-1.03)
Low deprivation	1.51 (0-3.59)	0 (0-0)	1.05 (0-2.51)	0 (0-0)	0 (0-0)	0 (0-0)	0.11 (0-0.25)	0 (0-0)	0.07 (0-0.16)
Total	**1.08 (0.59-1.57)**	**0.61 (0.07-1.14)**	**0.93 (0.56-1.3)**	**0.84 (0.73-0.95)**	**0.93 (0.78-1.07)**	**0.87 (0.79-0.96)**	**0.86 (0.75-0.97)**	**0.92 (0.78-1.05)**	**0.88 (0.8-0.97)**
Trend	***NS***	***NS***	***NS***	***p<0.05 n.l.***	***p<0.05 n.l.***	***p<0.05 n.l.***	***p<0.05 l.***	***p<0.05 l.***	***p<0.05 l.***
	Influenza and pneumonia								
	Males aged 0-64	Females aged 0-64	Total population aged 0-64	Males aged ≥ 65	Females aged ≥ 65	Total population aged ≥ 65	Total, males	Total, Females	Total population
Deprivation group	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**
High deprivation	0 (0-0)	8.67 (0-25.66)	3.89 (0-11.5)	2.62 (0.52-4.71)	2.52 (0.96-4.08)	2.56 (1.3-3.81)	3.66 (0.73-6.59)	4.43 (1.81-7.04)	4.12 (2.16-6.08)
Medium-high deprivation	2.85 (0-6.8)	0 (0-0)	1.58 (0-3.77)	2.18 (1.2-3.15)	1.41 (0.76-2.06)	1.72 (1.16-2.27)	2.76 (1.58-3.94)	1.68 (0.9-2.46)	2.13 (1.46-2.8)
Medium deprivation	3.13 (0-6.68)	1.35 (0-4.01)	2.36 (0.05-4.67)	2.17 (1.1-3.23)	1.76 (0.92-2.6)	1.94 (1.28-2.6)	1.99 (1.09-2.88)	1.45 (0.78-2.12)	1.68 (1.14-2.22)
Medium-low deprivation	2.82 (0-8.35)	3.83 (0-11.35)	3.25 (0-7.76)	2.22 (0.27-4.17)	1.73 (0.21-3.25)	1.95 (0.74-3.15)	1.74 (0.35-3.14)	1.4 (0.28-2.52)	1.55 (0.67-2.43)
Low deprivation	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)
Total	**2.57 (0.51-4.63)**	**1.66 (0-3.54)**	**2.18 (0.75-3.6)**	**2.13 (1.51-2.74)**	**1.65 (1.19-2.11)**	**1.85 (1.48-2.22)**	**2.17 (1.58-2.76)**	**1.66 (1.22-2.11)**	**1.88 (1.52-2.24)**
Trend	***NS***	***NS***	***NS***	***NS***	***NS***	***NS***	***p<0.05 l.***	***p<0.05 l.***	***p<0.05 l.***
	Chronic Obstructive Pulmonary Disease (COPD)								
	Males aged 0-64	Females aged 0-64	Total population aged 0-64	Males aged ≥ 65	Females aged ≥ 65	Total population aged ≥ 65	Total, males	Total, females	Total population
Deprivation group	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**
High deprivation	0 (0-0)	0 (0-0)	0 (0-0)	0.61 (0.27-0.96)	0.74 (0.28-1.21)	0.67 (0.39-0.95)	0.92 (0.4-1.44)	1.23 (0.47-2)	1.04 (0.6-1.47)

Tab. S1. SMRs[2009-2013] for all-cause and some cause-specific mortality in the Foggia municipality, Italy, by sex, age and deprivation group.

	Chronic Obstructive Pulmonary Disease (COPD)								
	Males aged 0-64	Females aged 0-64	Total population aged 0-64	Males aged ≥ 65	Females aged ≥ 65	Total population aged ≥ 65	Total, males	Total, females	Total population
Medium-high deprivation	0.43 (0-1.26)	1.3 (0-3.84)	0.64 (0-1.53)	0.56 (0.39-0.73)	0.51 (0.3-0.72)	0.54 (0.41-0.68)	0.71 (0.5-0.92)	0.66 (0.39-0.93)	0.69 (0.52-0.86)
Medium deprivation	0.94 (0-1.99)	0 (0-0)	0.71 (0-1.52)	0.71 (0.51-0.92)	0.8 (0.49-1.1)	0.74 (0.57-0.91)	0.63 (0.45-0.81)	0.64 (0.39-0.89)	0.63 (0.49-0.78)
Medium-low deprivation	0 (0-0)	0 (0-0)	0 (0-0)	0.83 (0.43-1.24)	1.43 (0.68-2.18)	1.04 (0.67-1.41)	0.58 (0.3-0.87)	1 (0.48-1.53)	0.72 (0.46-0.98)
Low deprivation	3.39 (0-8.1)	0 (0-0)	2.63 (0-6.28)	0 (0-0)	0 (0-0)	0 (0-0)	0.15 (0-0.36)	0 (0-0)	0.1 (0-0.24)
Total	**0.77 (0.15-1.38)**	**0.41 (0-1.2)**	**0.68 (0.18-1.19)**	**0.62 (0.51-0.74)**	**0.7 (0.54-0.86)**	**0.65 (0.56-0.75)**	**0.63 (0.52-0.75)**	**0.7 (0.54-0.86)**	**0.66 (0.56-0.75)**
Trend	***NS***	***NS***	***NS***	***p<0.05 n.l.***	***NS***	***p<0.05 n.l.***	***p<0.05 l.***	***p<0.05 l.***	***p<0.05 l.***
	Diseases of the digestive system								
	Males aged 0-64	Females aged 0-64	Total population aged 0-64	Males aged ≥ 65	Females aged ≥ 65	Total population aged ≥ 65	Total, males	Total, females	Total population
Deprivation group	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**
High deprivation	0 (0-0)	3.82 (0-8.15)	1.04 (0-2.22)	0.65 (0.17-1.13)	0.94 (0.46-1.42)	0.82 (0.48-1.17)	0.76 (0.2-1.33)	1.73 (0.93-2.53)	1.28 (0.78-1.78)
Medium-high deprivation	1.84 (1.01-2.67)	1.04 (0.02-2.06)	1.62 (0.96-2.29)	1.27 (0.93-1.62)	1.17 (0.87-1.46)	1.21 (0.99-1.44)	1.67 (1.28-2.05)	1.43 (1.08-1.78)	1.55 (1.28-1.81)
Medium deprivation	1.13 (0.58-1.69)	0.8 (0.02-1.58)	1.05 (0.59-1.5)	0.78 (0.49-1.08)	1.24 (0.89-1.59)	1.02 (0.79-1.25)	0.8 (0.56-1.04)	1 (0.73-1.27)	0.9 (0.72-1.08)
Medium-low deprivation	1.53 (0.47-2.6)	2.25 (0.05-4.46)	1.72 (0.75-2.69)	1.05 (0.43-1.66)	0.86 (0.33-1.4)	0.95 (0.54-1.36)	0.98 (0.54-1.43)	0.78 (0.37-1.19)	0.89 (0.58-1.19)
Low deprivation	0.39 (0-1.14)	1.18 (0-3.48)	0.58 (0-1.39)	0.68 (0-1.45)	0.25 (0-0.75)	0.48 (0.01-0.95)	0.43 (0.01-0.84)	0.24 (0-0.58)	0.34 (0.07-0.61)
Total	**1.28 (0.9-1.66)**	**1.3 (0.67-1.94)**	**1.29 (0.96-1.61)**	**0.99 (0.79-1.18)**	**1.1 (0.91-1.29)**	**1.05 (0.92-1.18)**	**1.07 (0.9-1.25)**	**1.13 (0.95-1.31)**	**1.1 (0.97-1.23)**
Trend	***NS***	***NS***	***NS***	***p<0.05 n.l.***	***p<0.05 n.l.***	***p<0.05 l.***	***p<0.05 n.l.***	***p<0.05 l.***	***p<0.05 l.***
	Malignant neoplasms								
	Males aged 0-64	Females aged 0-64	Total population aged 0-64	Males aged ≥ 65	Females aged ≥ 65	Total population aged ≥ 65	Total, males	Total, females	Total population
Deprivation group	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**
High deprivation	1.34 (0.74-1.94)	1.89 (1.1-2.68)	1.59 (1.1-2.07)	1.07 (0.85-1.28)	1.13 (0.89-1.36)	1.09 (0.94-1.25)	1.58 (1.29-1.87)	1.82 (1.48-2.16)	1.69 (1.47-1.91)
Medium-high deprivation	1.1 (0.85-1.34)	1.35 (1.05-1.65)	1.21 (1.02-1.4)	1.04 (0.93-1.15)	0.87 (0.75-0.98)	0.97 (0.89-1.05)	1.28 (1.16-1.4)	1.14 (1.01-1.27)	1.22 (1.13-1.31)
Medium deprivation	0.88 (0.69-1.06)	0.99 (0.77-1.22)	0.93 (0.78-1.07)	0.96 (0.84-1.07)	0.93 (0.79-1.07)	0.95 (0.86-1.03)	0.85 (0.76-0.94)	0.83 (0.73-0.93)	0.84 (0.77-0.91)
Medium-low deprivation	0.62 (0.36-0.88)	0.76 (0.43-1.09)	0.68 (0.47-0.89)	0.96 (0.76-1.17)	1.16 (0.87-1.44)	1.04 (0.87-1.21)	0.7 (0.56-0.83)	0.82 (0.65-1)	0.75 (0.64-0.85)
Low deprivation	0.4 (0.1-0.69)	0.24 (0-0.51)	0.33 (0.13-0.54)	0.28 (0.11-0.45)	0.32 (0.06-0.57)	0.29 (0.15-0.43)	0.23 (0.12-0.34)	0.19 (0.07-0.31)	0.22 (0.13-0.3)
Total	**0.9 (0.77-1.02)**	**1.08 (0.93-1.23)**	**0.97 (0.88-1.07)**	**0.97 (0.91-1.04)**	**0.93 (0.85-1.01)**	**0.96 (0.91-1.01)**	**0.97 (0.91-1.03)**	**0.97 (0.9-1.04)**	**0.97 (0.93-1.02)**
Trend	***p<0.05 l.***	***p<0.05 l.***	***p<0.05 l.***	***p<0.05 l.***	***p<0.05 n.l.***	***p<0.05 l.***	***p<0.05 l.***	***p<0.05 l.***	***p<0.05 l.***

Tab. S1. SMRs[2009-2013] for all-cause and some cause-specific mortality in the Foggia municipality, Italy, by sex, age and deprivation group.

	Malignant neoplasms of lip, oral cavity and pharynx								
	Males aged 0-64	Females aged 0-64	Total population aged 0-64	Males aged ≥ 65	Females aged ≥ 65	Total population aged ≥ 65	Total, males	Total, females	Total population
Deprivation group	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**
High deprivation	0 (0-0)	0 (0-0)	0 (0-0)	1.24 (0-3.67)	0 (0-0)	0.79 (0-2.34)	0.64 (0-1.9)	0 (0-0)	0.45 (0-1.34)
Medium-high deprivation	2.1 (0.42-3.78)	1.68 (0-3.58)	1.94 (0.67-3.2)	1.63 (0.2-3.06)	0.67 (0-2)	1.32 (0.26-2.37)	1.52 (0.62-2.42)	1.07 (0-2.28)	1.39 (0.66-2.12)
Medium deprivation	1.03 (0.02-2.03)	1.28 (0-2.73)	1.12 (0.29-1.95)	0.77 (0-1.84)	0 (0-0)	0.54 (0-1.29)	0.66 (0.13-1.19)	0.61 (0-1.46)	0.65 (0.2-1.1)
Medium-low deprivation	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	5.98 (0-14.28)	1.78 (0-4.25)	0 (0-0)	1.78 (0-4.25)	0.45 (0-1.09)
Low deprivation	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	8.84 (0-26.18)	2.25 (0-6.67)	0 (0-0)	1.94 (0-5.74)	0.47 (0-1.4)
Total	**1.05 (0.4-1.71)**	**1.05 (0.21-1.89)**	**1.05 (0.54-1.57)**	**1.05 (0.32-1.78)**	**1.14 (0.02-2.26)**	**1.08 (0.47-1.69)**	**0.79 (0.43-1.16)**	**0.96 (0.29-1.62)**	**0.84 (0.51-1.16)**
Trend	***NS***	***NS***	***NS***	***NS***	***NS***	***NS***	***NS***	***p<0.05 l.***	***p<0.05 l.***
	Malignant neoplasm of stomach								
	Males aged 0-64	Females aged 0-64	Total population aged 0-64	Males aged ≥ 65	Females aged ≥ 65	Total population aged ≥ 65	Total, males	Total, females	Total population
Deprivation group	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**
High deprivation	0 (0-0)	0 (0-0)	0 (0-0)	1.21 (0.15-2.28)	1.33 (0.16-2.5)	1.27 (0.48-2.06)	1.45 (0.18-2.72)	1.75 (0.22-3.27)	1.58 (0.6-2.57)
Medium-high deprivation	1.06 (0.02-2.1)	0.78 (0-1.85)	0.95 (0.19-1.7)	0.96 (0.47-1.44)	0.58 (0.15-1.01)	0.79 (0.46-1.12)	1.19 (0.65-1.72)	0.65 (0.2-1.1)	0.95 (0.59-1.31)
Medium deprivation	0.97 (0.12-1.82)	0.89 (0-1.9)	0.94 (0.29-1.59)	1.13 (0.56-1.7)	1.54 (0.73-2.34)	1.3 (0.82-1.77)	0.99 (0.56-1.43)	1.05 (0.52-1.58)	1.02 (0.68-1.35)
Medium-low deprivation	2.1 (0.04-4.16)	3.36 (0.07-6.65)	2.58 (0.79-4.37)	1.24 (0.15-2.33)	0.73 (0-1.75)	1.04 (0.27-1.8)	1.24 (0.43-2.05)	0.61 (0.08-1.3)	0.98 (0.43-1.54)
Low deprivation	0 (0-0)	0 (0-0)	0 (0-0)	1.18 (0-2.82)	0 (0-0)	0.77 (0-1.83)	0.57 (0-1.35)	0 (0-0)	0.35 (-0.13-0.82)
Total	**1.04 (0.47-1.6)**	**1.09 (0.38-1.81)**	**1.06 (0.62-1.5)**	**1.08 (0.76-1.41)**	**0.98 (0.62-1.34)**	**1.04 (0.8-1.28)**	**1.09 (0.8-1.38)**	**0.84 (0.55-1.14)**	**0.99 (0.78-1.2)**
Trend	***NS***	***NS***	***NS***	***p<0.05 n.l.***	***NS***	***p<0.05 n.l.***	***p<0.05 n.l.***	***p<0.05 l.***	***p<0.05 l.***
	Malignant colorectal neoplasms								
	Males aged 0-64	Females aged 0-64	Total population aged 0-64	Males aged ≥ 65	Females aged ≥ 65	Total population aged ≥ 65	Total, males	Total, females	Total population
Deprivation group	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**
High deprivation	4.5 (0.9-8.09)	1.97 (0-4.7)	3.4 (1.05-5.76)	1.84 (0.94-2.74)	0.94 (0.33-1.55)	1.37 (0.83-1.9)	3.14 (1.83-4.46)	1.45 (0.55-2.35)	2.3 (1.5-3.1)
Medium-high deprivation	1.67 (0.68-2.65)	2.22 (0.91-3.53)	1.9 (1.11-2.7)	1.48 (1.07-1.89)	1.07 (0.7-1.43)	1.28 (1-1.56)	1.84 (1.38-2.31)	1.45 (1.01-1.88)	1.65 (1.34-1.97)
Medium deprivation	0.89 (0.27-1.5)	1.38 (0.48-2.29)	1.1 (0.58-1.62)	1.14 (0.75-1.54)	1.16 (0.72-1.59)	1.15 (0.86-1.44)	0.98 (0.68-1.28)	0.98 (0.65-1.32)	0.98 (0.76-1.21)
Medium-low deprivation	0.3 (0-0.89)	0.44 (0-1.29)	0.36 (0-0.85)	1.41 (0.61-2.21)	1.43 (0.54-2.32)	1.42 (0.83-2.01)	0.88 (0.4-1.36)	0.93 (0.38-1.47)	0.9 (0.54-1.26)

Tab. S1. SMRs(2009-2013) for all-cause and some cause-specific mortality in the Foggia municipality, Italy, by sex, age and deprivation group.

	Malignant colorectal neoplasms								
	Males aged 0-64	**Females aged 0-64**	**Total population aged 0-64**	**Males aged ≥ 65**	**Females aged ≥ 65**	**Total population aged ≥ 65**	**Total, males**	**Total, females**	**Total population**
Low deprivation	0 (0-0)	1.82 (0-4.33)	0.73 (0-1.73)	0 (0-0)	0 (0-0)	0 (0-0)	0 (0-0)	0.37 (0-0.88)	0.16 (0-0.38)
Total	**1.19 (0.73-1.64)**	**1.57 (0.96-2.19)**	**1.35 (0.98-1.72)**	**1.33 (1.08-1.58)**	**1.08 (0.84-1.32)**	**1.21 (1.04-1.39)**	**1.32 (1.1-1.54)**	**1.13 (0.91-1.35)**	**1.23 (1.07-1.39)**
Trend	*p<0.05 l.*	*NS*	*p<0.05 l.*	*p<0.05 l.*	*p<0.05 l.*	*p<0.05 n.l.*	*p<0.05 l.*	*p<0.05 l.*	*p<0.05 l.*
	Lung neoplasms								
	Males aged 0-64	**Females aged 0-64**	**Total population aged 0-64**	**Males aged ≥ 65**	**Females aged ≥ 65**	**Total population aged ≥ 65**	**Total, males**	**Total, Females**	**Total population**
Deprivation group	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**	**SMR (95% CI)**
High deprivation	1.13 (0.02-2.23)	0.55 (0-1.64)	0.93 (0.12-1.75)	0.97 (0.52-1.42)	1.5 (0.46-2.53)	1.09 (0.67-1.5)	1.2 (0.7-1.7)	2.04 (0.71-3.37)	1.36 (0.88-1.84)
Medium-high deprivation	1.14 (0.64-1.64)	1.47 (0.67-2.28)	1.25 (0.83-1.68)	1.03 (0.8-1.27)	1.04 (0.56-1.52)	1.03 (0.82-1.25)	1.09 (0.87-1.31)	1.47 (0.93-2.02)	1.16 (0.95-1.37)
Medium deprivation	1 (0.6-1.4)	1.21 (0.58-1.85)	1.07 (0.73-1.41)	1.17 (0.9-1.44)	0.92 (0.4-1.44)	1.13 (0.88-1.37)	0.88 (0.7-1.06)	0.95 (0.54-1.36)	0.89 (0.73-1.05)
Medium-low deprivation	0.45 (0.01-0.89)	0.74 (0-1.57)	0.54 (0.14-0.94)	0.77 (0.37-1.17)	1.03 (0.02-2.03)	0.81 (0.44-1.19)	0.47 (0.25-0.68)	0.79 (0.16-1.42)	0.52 (0.31-0.73)
Low deprivation	0.68 (0-1.45)	0.51 (0-1.51)	0.63 (0.01-1.25)	0.52 (0.01-1.04)	0 (0-0)	0.45 (0.01-0.89)	0.37 (0.1-0.65)	0 (0-0)	0.31 (0.08-0.55)
Total	**0.94 (0.69-1.19)**	**1.13 (0.74-1.53-)**	**1.01 (0.79-1.22)**	**1.02 (0.87-1.17)**	**1.03 (0.72-1.34)**	**1.02 (0.89-1.16)**	**0.87 (0.76-0.98)**	**1.13 (0.85-1.41)**	**0.92 (0.81-1.02)**
Trend	*p<0.05 n.l.*	*p<0.05 n.l.*	*p<0.05 n.l.*	*p<0.05 n.l.*	*p<0.05 l.*	*p<0.05 l.*	*p<0.05 l.*	*p<0.05 l.*	*p<0.05 l.*
	Malignant neoplasms of breast								
		Females aged 0-64			**Females aged ≥ 65**			**Total, females**	
Deprivation group		**SMR (95% CI)**			**SMR (95% CI)**			**SMR (95% CI)**	
High deprivation		1.39 (0.03-2.75)			1.08 (0.44-1.72)			1.47 (0.72-2.21)	
Medium-high deprivation		1.99 (1.25-2.72)			0.85 (0.54-1.17)			1.27 (0.94-1.6)	
Medium deprivation		1.36 (0.82-1.89)			1.01 (0.62-1.41)			0.98 (0.71-1.25)	
Medium-low deprivation		1.07 (0.28-1.87)			1.62 (0.7-2.54)			1.08 (0.59-1.56)	
Low deprivation		0 (0-0)			0.4 (0-1.18)			0.12 (0-0.37)	
Total		**1.42 (1.07-1.77)**			**0.99 (0.77-1.22)**			**1.07 (0.9-1.25)**	
Trend		*p<0.05 l.*			*p<0.05 n.l.*			*p<0.05 l.*	
	Malignant neoplasms of prostate								
	Males aged 0-64			**Males aged ≥ 65**			**Total, males**		
Deprivation group	**SMR (95% CI)**			**SMR (95% CI)**			**SMR (95% CI)**		
High deprivation	0 (0-0)			1.01 (0-41-1.61)			1.54 (0.63-2.45)		

Tab. S1. SMRs[2009-2013] for all-cause and some cause-specific mortality in the Foggia municipality, Italy, by sex, age and deprivation group.

	Malignant neoplasms of prostate								
	Males aged 0-64			**Males aged ≥ 65**			**Total, males**		
Medium-high deprivation	0.71 (0.2-11)			1.11 (0.79-1.43)			1.42 (1.01-1.82)		
Medium deprivation	1.04 (0-2.49)			0.89 (0.57-1.20)			0.79 (0.52-1.06)		
Medium-low deprivation	1.41 (0-4.18)			1.41 (0.70-2.12)			1.07 (0.54-1.59)		
Low deprivation	0 (0-0)			0.22 (0-0.66)			0.14 (0-0.4)		
Total	**0.86 (0.02-1.7)**			**1.02 (0.82-1.21)**			**1.04 (0.84-1.23)**		
Trend	***NS***			***p<0.05 l.***			***p<0.05 l.***		

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ORIGINAL ARTICLE

Influenza vaccination coverage and deprivation among the elderly in the municipality of Cagliari: results and perspectives

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Keywords

Influenza vaccination • Deprivation • Elderly • Fragility

Summary

Introduction. *The elderly are among the main targets of influenza vaccination campaigns. Previous studies have shown that socio-economic status influences compliance with influenza vaccination, particularly in the elderly. Deprivation indexes can therefore be useful in identifying population groups with lower vaccination uptake and guide targeted intervention to improve vaccination coverage. We analysed the correlation between influenza vaccination coverage and levels of socio-economic and health deprivation among the population of Cagliari, by means of an Index of Socio-Economic and Health Deprivation (SEHDI) specifically tailored to the city, in order to identify population subgroups needing specific intervention to improve vaccination coverage.*
Methods. *A combination of linear regression, factor analysis and cluster analysis was adopted in order to build the SEHDI at the Census Tract (CT) level; data were taken from the 2011 Italian Census. Mortality among subjects aged ≥ 65 years in Cagliari in the period 2013-2015 was used to select the SEHDI variables. On the basis of the SEHDI, his population was classified into five normalised deprivation groups. Information on vaccination coverage was provided by general practitioners and Local Health Units. Cause-specific mortality and information on vaccination coverage in the deprivation groups were analysed by means of ANOVA (F test at $p < 0.05$).*
Results. *Around 20% of the Cagliari population was seen to be living in disadvantaged conditions. The trends in Standard Mortality Rates (SMRs) for all causes and for respiratory diseases, chronic obstructive pulmonary diseases (COPD), influenza and pneumonia were analysed across the deprivation groups. Pneumonia and flu mortality rates displayed a non-linear trend in men and a positive linear trend in women. Flu vaccination uptake rates were low: 27%. Coverage proved to be lower in the two extreme categories and higher in the medium deprivation ones.*
Conclusions. *The correlation between low vaccination coverage and socio-economic deprivation not only underlines the important role of vaccination in safeguarding health, but also the fact that it can be considered a factor in ensuring the system's equality, thanks to its role in limiting health impacts on those living in the most problematic or disadvantaged circumstances. It also stresses the characteristics which contribute to low compliance. Therefore, this finding should be taken into account in the organization of vaccination campaigns and should prompt differentiated interventions in each local area.*

Introduction

Cagliari is the capital of the autonomous region of Sardinia, a large island of south-western Italy. Situated on the south tip of the island, the city looks out over the Gulf of Cagliari. The Metropolitan Area of Cagliari comprises the municipality of Cagliari and 16 neighbouring municipalities; some share borders and close urban connections with the capital, while others are located in the hinterland. According to statistics from 2016, the municipality of Cagliari has a population of 154,639 (smaller than those of other Italian region capitals), while the Metropolitan Area comprises 430,000 residents, around a quarter of the total population of Sardinia in just 5.2% of the island's surface area [1].
In the social context of the city, municipal borders are no longer significant. The municipalities are closely interconnected and the city's population moves frequently among them, sharing services, social spaces and working environments [2]. In this context, the city of Cagliari displays some unusual characteristics. For example, while the population of the Metropolitan Area is younger and more active than the Sardinian average, the population of the capital includes a very high percentage of elderly people: 26.5% are over 65 years of age, and the ageing index is 258.2 [1]. Indeed, the younger members of the population, even those who work in the capital, find it more economical to live in the surrounding municipalities.
In this specific context, the study of socio-economic status (SES), which is a composite concept that includes material and social deprivation [3-5], has both advantages and limits. On the one hand, it may be able to identify the needs of the elderly; on the other, however, it may partially overlook the needs of younger people who reside outside the municipality but make use of the city's public and social services for health purposes.
The target population of the study consisted of subjects aged ≥ 65 years; therefore, the effect of this demographic characteristic on the relationship between SES and

health needs and influenza vaccination coverage does not affect the reliability of the results. For an analysis of the health condition of the younger population, the study would have to be extended to the wider metropolitan area, but this is beyond the purpose of the study.

Every year, about 8% of the Italian population catch influenza [6]. Although the elderly are less frequently affected, they develop more complications after the disease and 90% of deaths due to influenza and complications occur in this age group [7]. As the mortality risk is higher in unvaccinated elderly subjects than in the vaccinated elderly [7], vaccination is strongly recommended.

The role of SES is crucial in determining adherence to immunization against influenza, particularly in the elderly [8]. The use of synthetic deprivation indexes is an effective strategy for measuring health disparities at the population level, and also for identifying non-vaccinating groups, not least because this method takes into account the aspect of social support, which is particularly relevant in elderly people [9].

The aim of this study was to identify population groups aged ≥ 65 years with lower vaccination coverage in Cagliari by means of a specific socio-economic and health deprivation index (SEHDI) based not only on the SE characteristics of the population but also on its specific health needs, with a view to orienting targeted interventions aimed at increasing compliance with influenza vaccination.

Materials and methods

As per the time-scale of the project, the first step was to develop the SEHDI in accordance with a previously tested method [10]. The SEHDI enabled us to classify the population into five deprivation categories (high deprivation, medium-high deprivation, medium deprivation, medium-low deprivation and low deprivation), and to normalize the population distribution by group [11].

Gathering mortality data on the whole population and information on flu vaccination coverage among the over-65's required close collaboration with the Public Health and Hygiene Service (SISP) of the Cagliari Socio-Health Prevention Department (ASSL Cagliari) of the Sardinian Health Protection Agency (ATS).

Mortality data, which were essential to calculating the SEHDI, were drawn from the RENCAM database at the individual level, and regarded the period 2013-2015. The working staff devoted particular attention to the addresses of residence, in order to verify their correspondence to the 2011 Census Tracts. Indeed, the geo-coded mortality data allowed us to select from the 2011 Italian Census the demographic and socio-economic variables used to built the SEHDI, in accordance with the method of Lillini et al. [10]. Subsequently, all respiratory causes of death (ICD10: J00-J99) were extracted; the following specific causes – COPD (ICD10: J40-J47) and Influenza and Pneumonia (ICD10: J10-J18) – were then analysed according to SEHDI groups of population, along with all respiratory diseases and overall mortality.

Mortality was analysed in terms of Standard Mortality Rates (SMR), computed by gender and age group (0-64, 65+ years), and regional mortality rates were used as the reference figures.

Influenza vaccination data were retrieved from two information sources: the vaccinations database at the two clinics at SISP's central site in Cagliari, and reports from general practitioners' vaccination certification records. In the year considered, the two databases were handwritten and archived in paper form at the SISP site.

Differences in SMRs and vaccination coverage across the SEHDI groups were analysed by means of ANOVA with F-test and linearity tests (statistical significance at $p < 0.05$), considering age groups (0-64, 65+) and gender [12]. The Pearson correlation test (statistical significance at $p < 0.05$) was used to evaluate the association between vaccination coverage and the single demographic and socio-economic variables, in order to better describe the population characteristics, and to determine where and how to focus specific intervention to improve vaccination compliance [12].

The analyses were performed by means of SPSS 19.0 and Stata 13.0 statistical software.

Results

In Cagliari, the SEHDI was based on three factors, and developed a total explained variance of 56.4% (Tab. I).

The three factors mainly concerned demographic aspects of the population, particularly the family structure, housing conditions and occupational status, mainly among males.

Validation according to the main synthetic ISTAT socio-economic and demographic indices confirmed the ageing of the population, with a linear increase in the old-age index, structural dependency index and replacement index as deprivation grew. By contrast, as expected, the activity rate decreased linearly as deprivation increased (Tab. II).

No statistically significant difference was seen in the employment and unemployment rates across the SEHDI

Tab. I. Composition of SEHDI by 2011 Census variables. SEHDI factors and explained variance.

Factor 1 = 24.5%	Factor 2 = 16.7%	Factor 3 = 15.1%
Average no. of people per family Average no. of people per occupied dwelling % 3-member families	% housing with drinking water % housing with kitchen % married % students	% belonging to labour force % men
Total variance explained by Cagliari SEHDI = 56.4%		

Tab. II. SEHDI general validation.

Deprivation groups	Replacement index	Old-age index	Index of structural dependence	Activity rate	Employment rate	Unemployment rate
High deprivation	271.98	566.28	106.07	43.26	60.79	11.59
Medium-high deprivation	265.22	372.47	61.41	49.30	59.23	12.53
Medium deprivation	219.61	301.22	54.49	52.59	60.55	11.32
Medium-low deprivation	206.15	242.88	50.81	54.19	59.25	12.40
Low deprivation	127.10	100.38	40.40	60.40	63.03	10.02
Total	***223.78***	***311.50***	***58.08***	***51.99***	***60.13***	***11.77***
Trend	***p<0.05 L↑***	***p<0.05 L↑***	***p<0.05 L↑***	***p<0.05 L↓***	***NS***	***NS***

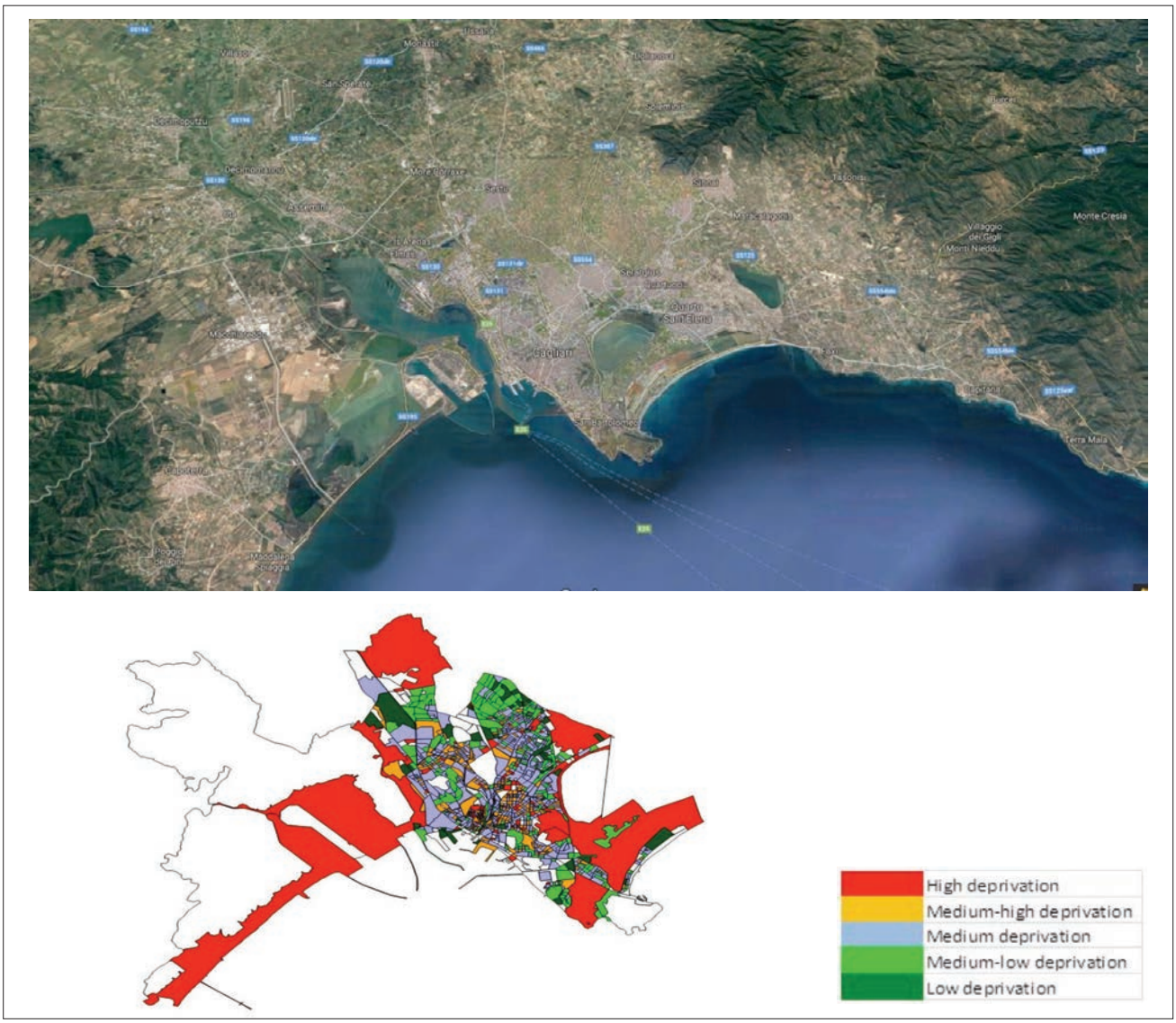
Trend: p<0.05 L↑ = linear positive; p<0.05 L↓ = linear negative; p<0.05 NL = not linear; NS = not significant.

groups, owing to the high presence of aged people, outside the labour market, as discussed above.

The SEHDI distribution revealed that at least 22% of the population lived in disadvantaged conditions, most of whom (53%) fell into the medium deprivation category; 25% displayed a socio-economic advantage. It is interesting that the extreme groups are really the tails of the population (2.9% of population in the high deprivation group, 1.6% in the low deprivation group).

Grouping the population of Cagliari according to the SEHDI allowed us to create a socio-economic map of the municipality, which can be compared with the Aerial photo of the area (Fig. 1).

Fig. 1. Aerial photo and map of Cagliari showing the spatial distribution of the SEHDI by census tract.



Low and medium-low deprivation were present in most parts of the historical centre and in the residential eastern areas, but also in areas where they might be less expected, such as working-class neighbourhoods in the southern districts. High and medium-high deprivation areas were more frequently located near the harbour and on the borders of the municipality, though they also appeared in middle-class neighbourhoods. It is noteworthy that the most deprived areas bordered on (and were part of) the industrial areas or were located close to the large ponds immediately around the city.

The overall mortality rates displayed a statistically significant linear increase as deprivation grew, with an almost double risk of death in the high deprivation group and only a third of risk in the low deprivation group.

Owing to the small dimensions of the city, deaths due to respiratory diseases were few However, an interesting (and statistically significant) difference emerged between the two genders in the elderly. Indeed, in women, all respiratory diseases displayed a linear increasing trend as deprivation increased, and similar variations for COPD, and pneumonia and influenza. In elderly men, however, the relationships were non-linear; this was strongly dependent on the distribution of COPD, which was more frequent among men (Tab. III).

According to the rates reported in the study, vaccination coverage among the over-65's in Cagliari stood at a very low level, 27%. The distribution of coverage across the five population categories was Gaussian. Vaccination coverage was lower at the two extremes of the index (Fig. 2). However, compliance was greater in the high deprivation group than in the low deprivation group.

Vaccination coverage was lower in contexts with more women, married and divorced couples, university or high school graduates, members of the workforce and salaried workers, 2- or 3-member families and over-65s living alone, and where the average number of people per household and per family, structural dependence index and employment rate were higher.

Discussion and conclusions

The study was aimed at analysing the link between vaccination coverage and the social, economic and health status of the population. It focused on how the use of a specific local deprivation index, the SEHDI, can help to identify the relationship between socio-economic inequalities and aspects of healthcare prevention in Cagliari.

The SEHDI refers not only to material deprivation (income factors or the ability to pay for goods or services, etc.), but also to social deprivation (for example, difficulty in accessing treatment or prevention if no one can provide help) and to the cultural/educational level (comprehension of healthcare information and correct use of services etc.) [3, 10]. Furthermore, the SEHDI yielded a detailed geographical description of the population's health conditions; for this reason, it could be used to improve the classification and description of the population and to guide public healthcare choices [13, 14].

Our results showed a close relationship between deprivation and overall mortality in the elderly. With regard to respiratory disease mortality and mortality due to flu and pneumonia, by contrast, the relationships were not linear when both genders were pooled. This was determined by the non-linear trends seen in men; in women, the trends were linearly positive, which testifies to their greater economic and social fragility.

Vaccination coverage among the over-65's in Cagliari was 27%; this rate is far below the ideal minimum level (75%) and the national (52%) and regional (41%) averages. The non-linear relationship between vaccination coverage and deprivation may be explained in two ways. First, coverage is lower in the groups at both ends of the deprivation scale; this suggests different responses to recommendations on prevention, probably as a result of different cultural levels. At the same time, the groups with the lowest coverage rates include more, among whom social fragility is more prevalent. Indeed, women more often live alone, and are therefore less likely to have adequate family support or easy access to healthcare or public social assistance.

Thus, vaccination is important not only in safeguarding health,; it is also a factor in ensuring the system's equality, owing to its role in limiting health impacts on those living in the most problematic or disadvantaged circumstances [15, 16]. This study lays down a framework for discussion regarding prevention through tools that can be adapted to the contexts in which adherence to vaccination is unsatisfactory. It does this through a verified methodology and a viewpoint that focuses, as far as possible, on the local perspective, and by adding further fuel to the debate on the need to tackle healthcare inequality efficiently and with specific weapons.

Although the sociological dimension would favour a study encompassing the entire Metropolitan Area, the lack of information systems and municipal databases made a project on this scale impractical; for this reason, the present study is currently limited to the Municipality of Cagliari.

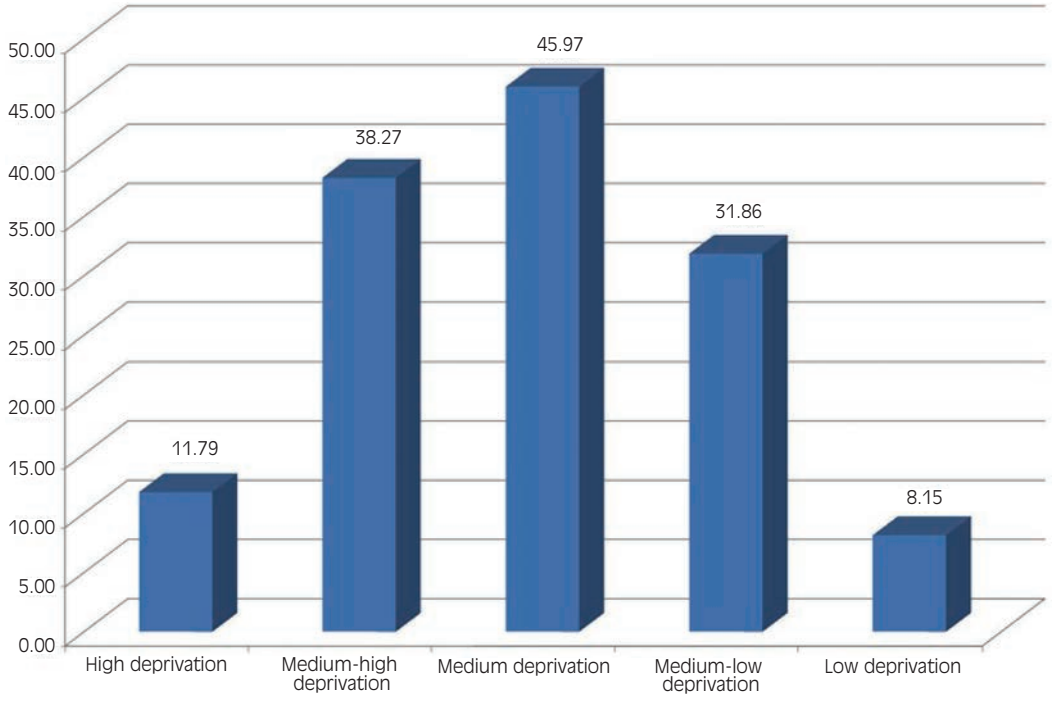
On 6th December 2018, a conference entitled "Fragility and the right to healthcare protection. Flu vaccination: criticality and opportunity in the face of healthcare inequalities" was held in Cagliari. On that occasion, the data that emerged from this study were presented and the relationship between socio-economic factors and access to prevention services in Cagliari was further examined, with a view to building on the present results through reflection and discussion with healthcare personnel. We hope this initiative will prompt a strong response from the health system in terms of improving strategies to promote vaccination.

Tab. III. Overall mortality and mortality due to respiratory diseases, influenza and pneumonia, and COPD in the elderly in Cagliari city, by gender and deprivation (period 2013-2015). Number of deaths (OBS), Standard Mortality Ratios (SMR) and statistical significance (p).

Cause	Deprivation groups	Males + females			Males			Females		
		OBS	SMR	p	OBS	SMR	p	OBS	SMR	p
Overall mortality	High deprivation	209	1.27	*	71	1.27		138	1.27	*
	Medium-high deprivation	1041	1.11	*	426	1.09		615	1.13	*
	Medium deprivation	2299	0.99		1063	0.98		1236	1.00	
	Medium-low deprivation	605	0.79	§	324	0.78	§	281	0.80	§
	Low deprivation	15	0.41	§	8	0.35	§	7	0.51	§
	Total	**4169**	**0.99**		**1892**	**0.96**		**2277**	**1.01**	
	Trend	***p<0.05 L↑***			***p<0.05 L↑***			***p<0.05 L↑***		
Respiratory system	High deprivation	17	1.48		4	0.87		13	1.90	
	Medium-high deprivation	59	0.88		22	0.68	§	37	1.08	
	Medium deprivation	169	1.01		99	1.11		70	0.90	
	Medium-low deprivation	34	0.60	§	18	0.52	§	16	0.73	
	Low deprivation	0	0.00	§	0	0.00	§	0	0.00	§
	Total	**279**	**0.92**		**143**	**0.88**		**136**	**0.96**	
	Trend	***p<0.05 NL***			***p<0.05 NL***			***p<0.05 L↑***		
influenza & pneumonia	High deprivation	5	2.04		1	1.23		4	2.44	
	Medium-high deprivation	24	1.72	*	6	1.05		18	2.19	*
	Medium deprivation	50	1.46	*	22	1.40		28	1.51	
	Medium-low deprivation	8	0.71		3	0.49		5	0.95	
	Low deprivation	0	0.00	§	0	0.00	§	0	0.00	§
	Total	**87**	**1.39**	*	**32**	**1.12**		**55**	**1.62**	*
	Trend	***p<0.05 NL***			***p<0.05 NL***			***p<0.05 L↑***		
COPD	High deprivation	4	0.69		1	0.38		3	0.93	
	Medium-high deprivation	23	0.67	§	12	0.65		11	0.68	
	Medium deprivation	81	0.93		53	1.05		28	0.77	
	Medium-low deprivation	23	0.77		15	0.77		8	0.77	
	Low deprivation	0	0.00	§	0	0.00	§	0	0.00	§
	Total	**131**	**0.83**	**§**	**81**	**0.88**		**50**	**0.75**	**§**
	Trend	***NS***			***p<0.05 NL***			***NS***		

Standard Mortality Rates were referred to those of the Sardinia Region. P = test F; p<0.05: * = significantly increased risk; § = significantly decreased risk. Trend: p<0.05 L↑ = linear positive; p<0.05 NL = not linear; NS = not significant.

Fig. 2. 2015-2016 vaccination coverage (%) among the elderly in Cagliari, by deprivation group.



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Conflict of interest statement

None declared.

Authors' contributions

AL and LM made substantial contributions to the conception and design of the study, and/or to data acquisition (AL, LP), analysis and interpretation (AL, LP, LC, LM, RL, MV). AL, RL and MV participated in drafting the article or revising it critically for important intellectual content. All authors give their final approval of the version to be submitted and any revised version.

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