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Preliminary analysis of the Respiratory Disease, based on Hospital Discharge Records, in the Province of L'Aquila, Abruzzo, Italy

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Key words: Respiratory disease, Hospital Discharge Records, Standardized Hospitalization Rates, Earthquake
Parole chiave: Patologie respiratorie, Schede di Dimissione Ospedaliera, Tassi standardizzati di ospedalizzazione, Terremoto

Abstract

Background. *The hospital discharge records (HDRs), integrated by other electronic health archives, besides some contra, can be a valuable and low-cost tool for monitoring public health.*
Methods. *Throughout a retrospective cohort study, we analyzed all hospitalizations in ordinary regime from the HDRs database of the residents in the province of L'Aquila, with the exception of day hospital, rehabilitation and long-hospital stay between 2008 and 2013, with a principal diagnosis of respiratory disease of 460 to 519, according to the ICD-9-CM. We calculated number and standard hospitalization rate (SHR) for respiratory diseases in groups of diagnoses: Pneumonia, Asthma, COPD and Respiratory Insufficiency, Other diseases in the general population in the pediatric population and the over 65s, in the Province of L'Aquila and in the three areas of L'Aquila, Marsica and Peligno-Sangrina.*
Results. *We observed different trends in SHRs in the different areas and for some of the different groups.*
Conclusions. *Diverse possible causes of the different trends are discussed, with a specific focus on a possible relation with the earthquake of the 6th April 2009, since coherent with the related scientific literature.*

Introduction

Hospital discharge records (HDRs) are a large and useful source of information regarding healthcare. HDRs are maintained by hospitals primarily for management and accounting purposes, but they are currently used nowadays also for epidemiological research (1, 2). The use of HDRs in epidemiology has strengths, limitations and may introduce biases (3, 4). The most important strengths are that data already exist, are large and are collected independently from research purposes. The limitations are instead that data are pre-collected by non-researchers, with a low or unknown quality. Biases may be also introduced, like misclassification as the result of unclear or erroneous clinical documentation, or like the fact

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that expensive medical procedures are usually documented better than those less costly (3, 4). Finally, underestimation and misclassification of actual cases are other important limitations, which may affect the estimate of a disease (5).

The paper reports on the use of HDRs to investigate respiratory health in the territorial area of the ASL 1 (Local Health Unit 1) of the Abruzzo Region, in the period 2008-2013. The territorial area extends to the southwest of the Region and includes 108 municipalities, 37 of which related to the macro-area "L'Aquila" (AQ), 35 belonging to the macro-area "Marsica" (AZ) and 36 to the area "Peligno-Sangrina" (SU) (6). It is worth remarking that it was impossible to extend the period of analysis to newer data without incurring into biases, since the data regarding the year 2014 are still incomplete of active and passive mobility because of disagreements between Regions.

Respiratory diseases involve millions of people around the World, in particular COPD and asthma the most frequent, and affect around 5% of the global population (7). Several multicenter studies provide data of COPD prevalence in the adult population and the elderly (8, 9) integrated more recently with prevalence and incidence data in the youth population. (10-11). The international multicenter studies ISAAC (12) and ECRHS (13) showed a wide range of asthma prevalence - 2-36% in the age group 6-7 years the first and 4-32% the second. Pneumonias are in Europe a cause of hospitalization and death with highly variable incidence rates (from 1.7% in Italy to 11, 6% in Finland), (13, 14) and hospitalization is increasing both in the Northern and in Southern Europe, up to a 34% increase in the UK (15).

The use of HDRs to study respiratory health is an accepted method in the Italian context (16, 17), while effective surveillance systems, e.g., of COPD and asthma based on health data archives are being used since many years in other European countries and in the USA (18, 19).

In detail, the paper reports on the number of hospitalizations per year in the areas of L'Aquila, Marsica and Peligno-Sangrina, as well as on the Standardized Hospitalization Rates (SHRs) in the Abruzzo Region, the Province of L'Aquila, and the aforementioned areas. The paper ends with a discussion about the findings and the possible causes of the differences found.

Material and Methods

Data regarding the hospitalizations of citizens from the Province of L'Aquila of the Abruzzo Region, both in public and private accredited institutes, was gathered from file A of the HDRs, and relates to the period starting from 01/01/2008 and ending to 31/12/2013. HDRs were collected from the Management Service of Information Flows and Health Statistics of ASL 1 Avezzano-Sulmona-L'Aquila. In 2008-2009 the healthcare system of the Abruzzo Region had a structure made up of 6 different ASLs, while - starting from the year 2010 - the former ASL 1 Avezzano-Sulmona and ASL 4 L'Aquila were merged into the actual ASL 1 Avezzano-Sulmona-L'Aquila (6). Accordingly, the data came from heterogeneous sources in the period before the year 2010 and from a unique data source in the following period. Consequently, before the data analysis, it was necessary at the beginning to implement a record linkage and a data integration procedure.

In particular, we included all HDRs that reported as the primary diagnosis code between 460 and 519, according to ICD 9-CM system, and all hospitalizations in ordinary regime, with the exception of treatments occurred in outpatient care, the rehabilitation and long term care.

Furthermore, in our analyses, we grouped the ICD9-CM codes into larger groups as follows:

• *Pneumonia*: ICD9-CM codes [480-489], to investigate cases in both the general population and in particular in childhood (0 to 14 years);

• *Asthma*: ICD9-CM codes [493], to investigate cases in both the general population and in particular in childhood (0 to 14 years);

• *COPD and respiratory failure*: codes ICD9-CM [490-492, 518], to investigate both cases in the general population and in particular in the elderly (aged over 65);

• *Other*: all other codes not included in the previous list.

The methodology of analysis focused on both the number of hospitalizations and the SHR, as follows:

- as for hospitalization, we analysed the number of hospitalizations by year, by area, and by group, in terms of both descriptive (i.e., absolute frequencies) and inferential (i.e., if an association exists between the groups and either the areas or the years) analyses. The results about SHRs are reported in subsection 1 of section Results;

- as for the SHRs, the analysis consisted in depicting the SHRs trends and in the application of a linear regression model with SHR as a dependent variable, the year as an independent variable, for all areas and for the previously mentioned groups. The source for population data - needed to compute the SHRs - was the Regional Statistical Office, which provided the number of residents in the province divided by municipality, by area of reference (L'Aquila, Marsica, Peligno- Sangrina) and by age group, for each year of the period between 01/01/2008 and 31/12/2013. The results about SHRs are reported in subsection 2 of section Results.

The inferential analyses were considered strongly statistically significant when $p < 0.01$ (highlighted with a ** sign), statistically significant when $0.01 \leq p < 0.05$ (highlighted with a * sign), marginally significant when $0.05 \leq p < 0.10$ (highlighted with a sign) and not significant when $p \geq 0.10$. The software used for the analyses was R version 3.3.0 for Linux.

Results

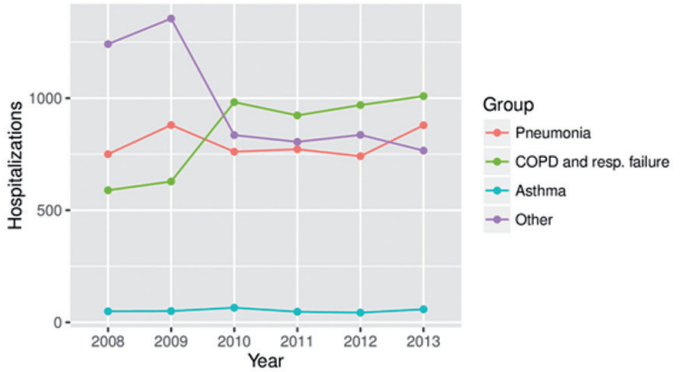
1. Total Number of Hospitalizations

Table 1 summarizes the total number of hospitalizations for respiratory diseases in the ASL 1, by year, splitted into the aforementioned groups.

More than 16,000 total hospitalizations were taken into account, with an average around 2,600 per year. The largest part of hospitalizations were due to "other diagnoses", followed by COPD and respiratory failure, then Pneumonia and Asthma. The use of the HDR as the only information source is very likely the cause of an underestimation of asthma cases in a population, given that their hospitalization is usually an infrequent outcome (20). A strongly significant association exists between the group and the year (χ^2=536.1, df=15, p=0.000 **). The

Table 1 - Total number of hospitalizations for respiratory diseases, by year

Group	2008	2009	2010	2011	2012	2013	Total
Pneumonia	750	880	761	772	741	879	4783
COPD and resp. failure	589	628	982	923	969	1009	5100
Asthma	49	50	65	47	43	58	312
Other diagnoses	1241	1355	835	805	836	766	5838
Total	2629	2913	2643	2547	2589	2712	16033



	R^2	p		m
Pneumonia	−0.201	0.707		6.829
COPD	0.683	0.026	*	87.543
Asthma	−0.248	0.940		0.171
Other	0.608	0.042	*	−113.200

Figure 1 - Graph of the total number of hospitalizations for respiratory diseases, by year, and details of the regression analysis

meaning for this association is discussed in Section 4 below.

Figure 1 places the numbers of hospitalization reported in Table 1 in a graphical format, accompanied by the related regression analysis. The linear regression analysis shows the following. A statistically significant increase in terms of hospitalizations is present for COPD (p=0.028, R^2=0.683), while a statistically significant reduction trend characterizes the other respiratory pathologies (p=0.042, R^2=0.608). A possible explanation for these trends is discussed in the next section.

Table 2 instead summarizes the total numbers of hospitalization for respiratory diseases, by area, split into the groups mentioned in Materials and Methods.

Hospitalizations took place with the highest frequency in the AZ area, then in AQ and finally in SU. A strongly significant association exists between the group and the area (χ^2=621.8, df=6, p=0.000 **). The meaning for this association is discussed in the next section.

Besides these results, the next Subsection analyses respiratory health in terms of SHR, that allows for a comparison of local to provincial and regional rates, while adjusting for the difference in population and age structure between the geographic areas.

2. Standardized Hospitalization Rates

The results concerning the SHRs are split into two subsections. The first reports on the trends for the Abruzzo Region, the Province of L'Aquila and the aforementioned areas (Subsect. 2.1). The second subsection instead details the analysis in terms of the aforementioned groups (Subsect. 2.2).

Table 2 - Total number of hospitalizations for respiratory diseases, by area

Group	AQ	AZ	SU	Total
Pneumonia	1984	1896	903	4783
COPD and resp. failure	1030	2864	1206	5100
Asthma	60	193	59	312
Other	1517	2877	1444	5838
Total	4591	7830	3612	16033

2.1. Trends for Abruzzo, Province of L'Aquila and Areas

Figure 2 shows the trend of the SHRs for all the respiratory diseases from 2008 to 2013, in the three different macro areas as well as for the Province of Aquila and the Abruzzo Region, and the results of the corresponding linear regression analyses. Note that a direct comparison between the trends is not possible, because the data about the areas only concern ordinary hospitalizations and do not include other types of hospitalizations that are instead considered for the Province of L'Aquila and for the Abruzzo Region.

The figure and the linear regression analysis (summarized on the right) show the following. In the Abruzzo Region, a statistically significant reduction trend is present (last row). The reduction for the Province of L'Aquila, on the contrary, is not statistically significant. Marginally significant reductions are shown in the AZ and SU area, while - on the other hand - a strong statistically growing trend regards the AQ area ($p=0.002$, $R^2=0.902$).

Next Subsection details the analysis for the three areas with regard to the groups introduced in Section 2.

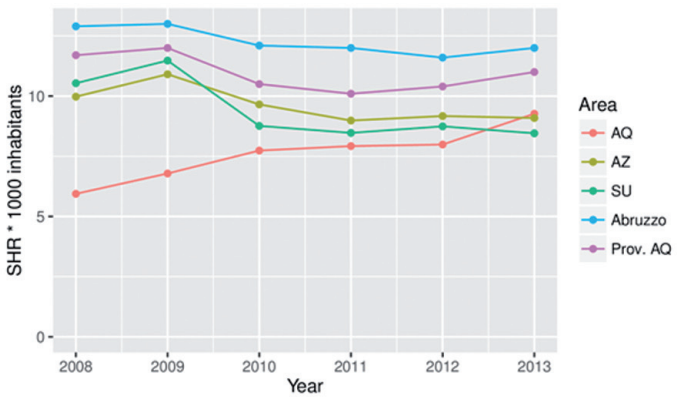
2.2 Trends for Areas and Groups

The graphs included in Figure 3 show, for all the respiratory pathologies and for the groups introduced in Section 2:

• on the left, the trends for SHR, by year, by area;

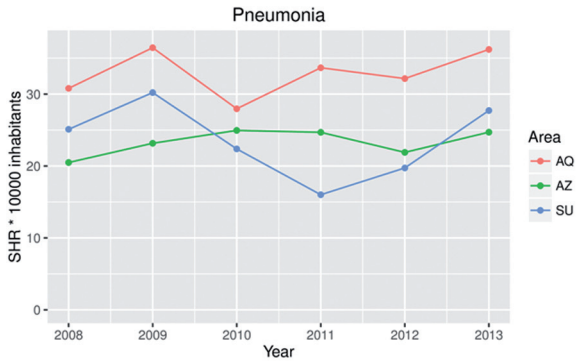
• on the right, the details of the linear regression analyses.

The figure suggests the following. There was no statistically significant trend for pneumonia (Figure 3.a.1), not even in childhood, with the exception of a marginally significant decrease in the SU area (Figure 3.a.2). In relation to asthma, we can notice a statistically significant decreasing trend in AZ, and a growing trend in AQ area, only marginally significant (Figure 3.b.1). The trend in AZ is not replicated for the pediatric situation, while it is in the AQ area (Figure 3.b.2). Finally, for COPD and respiratory failure, the analyses present a statistically significant growing trend in the areas of AQ and AZ, but not in the SU area (Figure 3.c.1). The trend becomes more pronounced when investigated in the elderly in the AQ area, whereas it becomes only marginally significant in the AZ area (Figure 3.c.2).



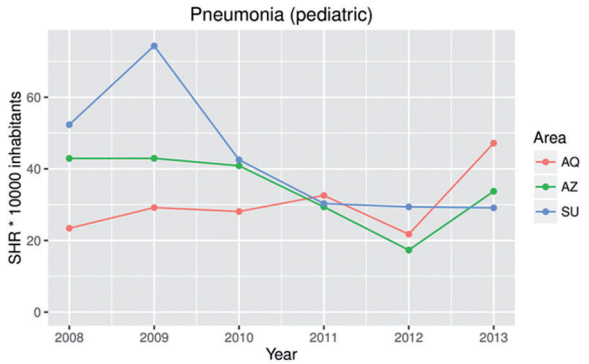
	R^2	p		m
AQ	0.902	0.002	**	0.584
AZ	0.461	0.083	.	−0.294
SU	0.528	0.062	.	−0.540
Prov. AQ	0.217	0.197		−0.249
Abruzzo	0.640	0.035	*	−0.251

Figure 2 - SHRs for respiratory diseases in the Region, the Province and by area (from our processing and from ASR Abruzzo, Regional Health Agency) (21).



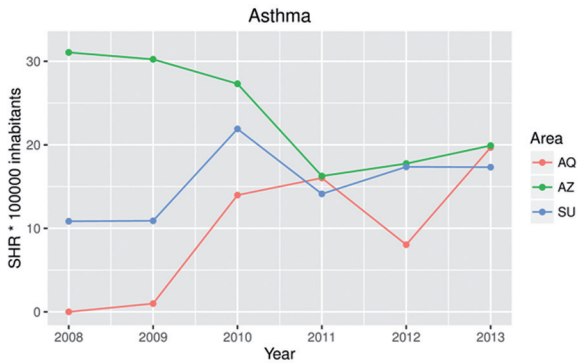
	R^2	p		m
AQ	−0.118	0.530		0.568
AZ	0.063	0.312		0.486
SU	−0.170	0.629		−0.707

(a.1)



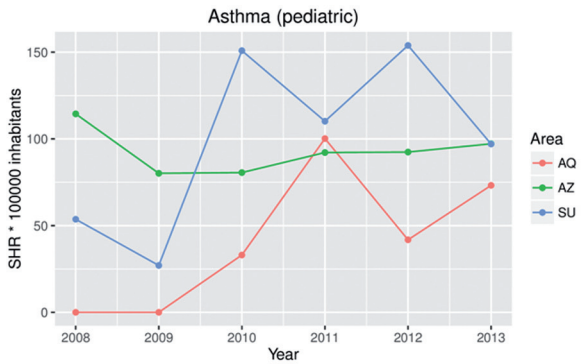
	R^2	p		m
AQ	0.187	0.216		2.887
AZ	0.388	0.111		−3.836
SU	0.518	0.065	.	−7.519

(a.2)



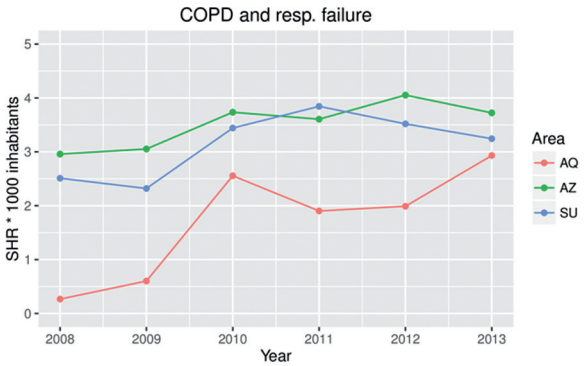
	R^2	p		m
AQ	0.549	0.056	.	3.474
AZ	0.653	0.032	*	−2.980
SU	0.123	0.262		1.256

(b.1)



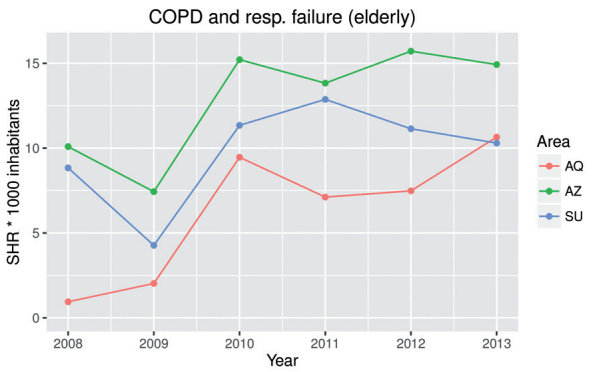
	R^2	p		m
AQ	0.450	0.087	.	15.961
AZ	−0.218	0.761		−1.083
SU	0.174	0.225		15.908

(b.2)



	R²	p		m
AQ	0.648	0.033	*	0.481
AZ	0.628	0.037	*	0.191
SU	0.330	0.136		0.219

(c.1)



	R²	p		m
AQ	0.647	0.033	*	1.788
AZ	0.473	0.079	.	1.361
SU	0.091	0.288		0.841

(c.2)

Figure 3 - Trend of the SHRs for groups, by year, area, age group and details of the regression model. For readability purposes, please note that the scale of the ordinates is different with regard to the different groups.

Discussion

As shown above, the results emerging from the preliminary analyses of the HDRs for the LHU1 Avezzano-Sulmona-L'Aquila highlight the following aspects:

• in terms of numbers of hospitalization (Subsection 3.1), a statistically significant association exists between:

-groups and years, meaning that the type of hospitalization for respiratory diseases changed during the years. Such an association can be explained by the fact that - in view of a substantial stable number of hospitalizations per year - we observe an increase for COPD and respiratory failure, accompanied by a decrease for "other diagnoses" (see Table 1);

- groups and areas, meaning that the type of hospitalizations for respiratory diseases was different between the areas. Such an association is very likely due to the highest frequencies for AZ with regard to AQ and SU, in relation to all other respiratory diseases rather than Pneumonia (see Table 2).

Furthermore, a growing trend for COPD and a reducing trend for other respiratory disease is also shown. A possible explanation of such a finding may be the introduction of the integrated information system, as recalled in Section Materials and methods (22). This claim is supported by the scientific literature

that points out that the introduction of health information technology has been shown to improve data quality by increasing adherence to guidelines, enhancing disease surveillance, and decreasing medical errors (2).

• in terms of SHRs (Section 2 of the Results), the results that showed differences are the following:

- for the respiratory disease in general, there was a growing trend in L'Aquila area, associated with a marginal decrease in all other areas;
- for asthma, there was an increase in AQ area, while in the AZ area a decrement;
- for COPD and respiratory failure, we found a statistically significant increase for AQ and AZ, but not for SU.

The differences in SRHs trends, in the different areas, may have been caused by different factors, as discussed below.

1. Repayment Plan

For the purpose of a correct interpretation of the results, it is necessary to consider the possible influence of the deficit repayment plan which affected the Abruzzo Region, signed on 6/3/2007 (23), which required a strong reorganization of the hospital network, with the conversion of some of the main ones, requalification of home care, containment of the pharmaceutical expenditure and the reduction of the number of beds. Accordingly, in 2013, all Abruzzo hospitals registered -41.0% of hospitalizations for all diseases with regard to the year 2007. Furthermore, in the early 2000's, the Abruzzo Region was the Italian region with the highest SHR, but the regional average value of 2013 of c.a 178 hospitalizations per 1,000 inhabitants became closer to the national average (i.e., c.a 164 hospitalizations per 1,000 inhabitants). Also hospital beds are now significantly below the national average: in the public hospital of Avezzano the number of beds decreased markedly (-32%) in the period 2005-2013, in parallel with the reduction of hospitalizations (22).

Besides that, the general reduction forced by the repayment plan can be considered the main reason of the decreasing trend in the Abruzzo Region (see Figure 2), but the differences found between the different areas might have been caused by different factors.

2. Different Implementation of Community Care

For many respiratory diseases, the implementation of community care is a valuable method for reducing hospitalization and SHR. Therefore, a different trend in the different areas could be caused by a stronger or a weaker implementation of such practices.

In our case, since the three areas belong to the same ASL at least from the organizational viewpoint, community care should have had, during the period under investigation, a similar application. Therefore, even if plausible, a different implementation of community care might not be the cause of the different trends in the different areas. Nonetheless, a study about this factor is worth to be carried out.

3. Inappropriate Hospitalizations

Hospitalizations for asthma are identified as at high risk of inappropriateness and therefore they are normally discouraged. This situation is very likely to be the cause of the different trend in AZ area for asthma, compared to both the general population and the children, most probably indicating the decrease in inappropriate hospitalizations (Figures 2.b.1 and 2.b.2).

4. Earthquake, April 2009

As known, on April 6th 2009 the city of L'Aquila was hit by a strong earthquake that caused about 300 deaths, mainly as the consequence of the collapse of many buildings. The increase in the number of hospitalizations for respiratory disease due to environmental disasters is documented

by several studies. A retrospective study on the similarities that have affected large earthquakes occurred in the past decade 2000-2010 (Bam in Iran, Sichuan in China, Port-au-Prince in Haiti, Pakistan, Kashmir and Ica in Peru), showed that respiratory infections of the upper and lower tract, especially bronchitis and pneumonia, have been the most frequent pathologies (24).

In the Kashmir earthquake, the 3.6% of hospitalizations was represented by lower respiratory tract infections/asthma in the first three weeks after the earthquake (25). In the first 15 days after the Hanshin (Japan) earthquake, Pneumonia represented the largest number of hospitalizations for pathology, particularly in the elderly, and in the fourth place Asthma, in a broader age range (26). In the great earthquake of Sendai and Tohoku (Japan) in March 2011 the number of patients hospitalized for respiratory disease in the month following the earthquake was 2.7 times higher than in the same period of 2010, including all age sections (27).

In the study of Yamanda et al., in the two months following the Tohoku earthquake of 2011, Pneumonia was the most frequent cause of hospitalization for respiratory illness, followed by acute exacerbation of COPD, asthma attacks and progression of lung cancer (28). The main difference of the Japanese studies compared to ours is that they examined hospitalizations for respiratory disease, but only in the aftermath of the earthquake and not in a longer span of time.

In line with ours, studies conducted after the collapse of the World Trade Center on September 11 2001, report that, after massive exposure to smoke and dust over a long period (29, 30), children and adolescents are the most likely to have a worsening or a new diagnosis of respiratory symptoms. Szema (31) report the exacerbation of asthma in children in the fall after the September 11 disaster, but a much higher prevalence of asthma in the age group of 2 to 4 years (16%) than that estimated by the US National Health Information System, up to two to three years after the 11 September (32).

Exposures might cause exacerbation of respiratory symptoms in children with greater genetic susceptibility, supposedly linked to a still incomplete lung development (33). Another result of our study is the increase of hospitalization for COPD and respiratory failure, in subjects > 65 years, also confirmed by studies of Yamanda et al, in which COPD exacerbations after an environmental disaster were more frequent in the elderly patients (28).

As previously said in our study, we took into account hospitalizations that mention the respiratory disease as the primary diagnosis. This choice involves the loss of cases in which respiratory disease is annotated in HDRs as a complication or an underlying medical condition. Compared to the exposure, eventually connected to the earthquake, these cases may be very numerous. An example is pneumonia, that frequently takes place in the course of cardiovascular or metabolic chronic diseases: in a study conducted in the US by Fry et al. (34), pneumonias not mentioned as a first diagnosis are about 30% of the total; another study in the Veneto Region, Italy, that shows an hospitalization rate of the same order of magnitude as measured by us (25.63 / 10,000), reports a comorbidity in 46.4% of patients (35). A further study investigating the possible effect of concurrent diagnoses, or that includes them, may be worthy of attention.

Therefore, in summary, the effects of earthquake may be one of the possible causes of the increased SHRs in the AQ area both in general (Figure 2) and for asthma, COPD and respiratory failure (Figures 2.b.1, 2.b.2, 2.c.1, 2.c.2) compared to the other areas.

Conclusions

HDRs may be a very valuable information source for epidemiological purposes. Compared to the unique contribution of

the single information source of file A of ASL 1, a more accurate estimate of the phenomenon could be achieved by applying a data integration approach between different electronic medical sources, e.g., HDRs database, Pharmaceutical Prescriptions Register.

Besides that, the paper summarized - in terms of both hospitalizations and SHRs - the respiratory health in the Province of L'Aquila, and discussed the possible factors that may have caused the differences found in the different areas.

Among the possible factors, a specific discussion was reported about a possible relation with the L'Aquila's 2009 earthquake, since our analyses, even if with some differences, seem to be in-line with the relevant literature. Nonetheless, for a deeper investigation, possible approaches could be to set up a medium/long-term surveillance system for respiratory diseases and to investigate in deeper details the application of community care in the different areas.

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Riassunto

Analisi Preliminare della patologia respiratoria, basata sui dati delle schede di dimissione ospedaliera, nella Provincia dell'Aquila, Abruzzo, Italia

Premessa. Le schede di dimissione ospedaliera (SDO), integrate da altri archivi sanitari elettronici, malgrado pro e contro, possono costituire uno strumento prezioso e a basso costo per il monitoraggio della salute pubblica.

Metodi. Tramite uno studio retrospettivo di coorte, sono stati analizzati tutti i ricoveri in regime ordinario dal database SDO dei residenti nella provincia dell'Aquila, con l'eccezione dei ricoveri in regime di day hospital, riabilitazione e lungodegenza, tra il 2008 e il 2013, con una diagnosi principale di malattie respiratorie da 460 a 519, secondo l'ICD-9-CM. Abbiamo calcolato il numero e il tasso standardizzato di ospedalizzazione (SHR) per le malattie respiratorie in gruppi di diagnosi: polmonite, asma, BPCO e insufficienza respiratoria, altre malattie respiratorie, nella popolazione generale, nella popolazione pediatrica e over 65 anni, nella provincia dell'Aquila e nelle tre aree L'Aquila, Marsica e Peligno-Sangrina.

Risultati. Abbiamo osservato trend differenti per SHR nelle tre diverse aree e per alcuni dei diversi gruppi.

Conclusioni. Sono discusse le diverse possibili cause dei diversi trend, con un focus specifico su una eventuale relazione con il sisma del 6 aprile 2009, in quanto coerenti con la correlata letteratura scientifica.

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