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Development and Representation of Health Indicators with Thematic Maps

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Abstract. Italian Local Health Care Agencies (ASLs) have the role of managing the public healthcare resources in their area of competence. To this end, the ASL of Pavia has implemented a data warehouse, which collects and integrates health data of more than 500,000 people since 2004. We have exploited such data repository to compute a variety of yearly health indicators, which have been represented on thematic maps of the area. Thanks to a Web-based application, the ASL decision-makers can monitor the area with a fine-grained spatial detail, dissecting the epidemiological, economical and pharmaceutical factors underlying citizens' health and patients' care. The implemented tool is currently up-and-running and has been evaluated with a usability questionnaire on a small number of users.

Keywords. Health Indicators, Maps, Public Health, Age Standardization, Smoothing

Introduction

The Italian National Health Service (Servizio Sanitario Nazionale, SSN) is a universal system that covers the healthcare needs for all eligible Italian residents. The national healthcare funds collected by taxation are transfered to each Italian Region, which redistributes them to the so-called Local Healthcare Agencies (Azienda Sanitaria Locale, ASL). Each ASL has to manage the supply, demand and costs of healthcare services for a population, which typically accounts for more than 400,000 people. It is therefore relevant for each ASL to know its demographic and epidemiological features, as well as the needs and the healthcare expenditure of its citizens. For this reason it's very useful to compute synthetic indexes able to represent the health phenomena of interest.

The ASLs collect administrative data related to the services delivered by the SSN to the citizens. The ASL of Pavia, in northern Italy collects these data in electronic form since 2004 using a data warehouse that yearly collects around 160,000 hospital admissions, 5M drug prescriptions and 9M outpatient services, related to about 530,000 people. This large amount of available data needs to be properly processed and presented to decision makers to be fully exploited. To this end, we have derived a wide range of health indicators that we have then graphically represented on thematic maps.

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1. Methods

The data warehouse of the ASL of Pavia collects (and update every month) the administrative data related to all health care services delivered to residents by the SSN. For a laboratory test, for example, the laboratory, the type, the cost (€), the date, the anonymous patient id and so on are reported, although the clinical outcome is not recorded. Relying on the ASL data warehouse, we have defined and computed 90 yearly health indicators that measure a variety of health care phenomena. Such indicators have been computed by grouping the data of the citizens living in the same town, thus obtaining a value for each of the 190 towns of the ASL area. Such values have been then represented on a Choropleth map. As concerns the data discretization, we chose a quantiles-based approach, which is widely used in epidemiology [1]. In order to choose the chromatic scale [2], we resorted to the ColorBrewer software [3] and we used a five-colors scale from green to red.

Besides the "ordinary" version of indicators, obtained from the raw data, we computed two others variants: the "standardized" one designed to remove the distortion due to different age distributions among the towns, and the "smoothed" one, in order to obtain a more homogeneous color distribution on the maps. The "standardized" indicators have been obtained by applying the so-called indirect age standardization technique [4, 5], which is widely used to compare mortality rates among different populations [6]. This method compares a study population, in our case the citizens of each of the 190 towns of the ASL area, with a standard population, chosen to be equal to the whole population of the area. The "smoothed" indicators have been derived to obtain a homogeneous distribution of the map colors, which would make the maps easier to be interpreted. In this case we applied a moving average Gaussian smoothing technique [7]. The value of an indicator for each town is computed as the weighted average of the indicator of all the towns, where the weights are obtained according to a Gaussian function centered on each town. Using this method the smoothed indicator of one town takes into account the values of the other towns, with weights decreasing when their distance increases.

Since the ASL data warehouse is based on SAS® technology, we designed a reusable procedure based on a series of SAS® macros to derive the three different kinds of indicators. We developed a Web-based application designed to browse, navigate and describe the thematic maps. We designed the procedure and the application in order to obtain an easily expandable and scalable tool, which makes easy to modify and expand its contents. We evaluated the application usability using the System Usability Scale (SUS) [8] that gives a global view of subjective assessments of usability of Web-applications in a reliable, simple and economic way [9]. The SUS questionnaire is composed of 10 items (the odds related to positive concepts and the evens to negative ones) and the resulting scores range from 0 to 100, where high values represent good usability. We asked a sample of 9 potential users of the ASL, large enough to detect most of the problems [10, 11], to use the application and fill the SUS questionnaire.

2. Results

We exploited and combined the large amount of administrative data stored in the data warehouse of the ASL of Pavia, in order to compute 90 health indicators in the three different versions, obtaining about 300 hundred maps. The indicators, computed for the year 2010, cover a wide range of health phenomena grouped into 4 categories of interest:

1. “demography and epidemiology”, reporting features of the general population, such as demographic information and epidemiological information, like the prevalence of the most important pathologies (e.g. chronic diseases);
2. “healthcare costs”, including healthcare services costs for people affected by specific pathologies, costs related to particular ATC (Anatomical Therapeutic Chemical) drug prescriptions (e.g. Statins) and costs related to the main healthcare services (e.g. hospital admissions);
3. “healthcare consumptions”, reporting the amount of the main health services (e.g. drug prescription) or the extent of specific phenomena (e.g. percentage of people with at least one disease-specific cost exemption);
4. “marketing”, including information about the management of the healthcare resources, like the percentage of prescription of generic drugs (e.g. PPIs) or the percentage of admission in the hospitals of the area of Pavia.

The Web-based application consists of two panels, as we can see in Figure 1. The left panel contains both a “summary menu”, with the list of the links to each group and subgroup in which the indicators have been divided, and a “complete menu” with the list of all the available indicators. The right panel changes its contents during the navigation. After starting the application, it shows the homepage, with the description of the tool, while after the indicator selection, it shows its smoothed thematic map. The indicator page visualizes, from top to bottom, its short description, one of its maps, the year the data refers to, the map version visualized, a menu to change the map version and the equation used to compute the indicator.

As previously mentioned, the usability of the Web-based application has been evaluated relying on the SUS scale [8]. The average score (n=9) was 82.8 with a median of 87.5, a minimum of 57.5 and a maximum of 97.5.

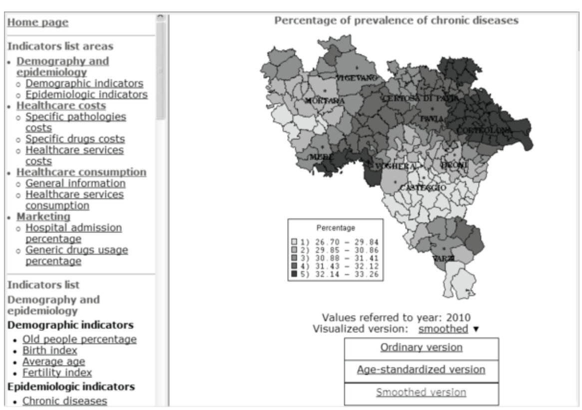

Figure 1. Screenshot of the maps management Web-based application

3. Discussion

Thematic maps are already being used widely to produce health atlases [12, 13] describing specific phenomena (e.g. mortality, cancer) on a territory (e.g. nations, regions). The growing diffusion of Web-based e-atlases [14-16] served as a major help in the diffusion of this tool by letting users to interactively "explore" the territory.

The goal of this work was to provide the decision-makers of the ASL of Pavia a procedure to compute and represent on thematic maps a large variety of yearly health indicators therefore obtaining an electronic health atlas of the Pavia area. The peculiarities making it different from what's already widespread are (i) the variety of the indicators and (ii) the possibility to analyze the indicators by different and complementary viewpoints useful for the many governance activities of the ASL.

The web-based application developed to manage the thematic maps, in fact, allows both browsing the health indicators by resorting to a hierarchical table of content (which is much handier than a flat slideshow) and by viewing the different variants choosing them on the dedicated menu.

The "ordinary" version represents the "raw" indicator and is useful to detect what are the areas requiring improvements to the healthcare services, but may be affected by the different age distributions of the areas. For instance, we can see that the raw distribution of prevalence of chronic diseases, in Figure 2, is very similar to the age distribution, in Figure 3: the high values on the southernmost area is probably due to the presence of elderly people and not to a higher disease probability.

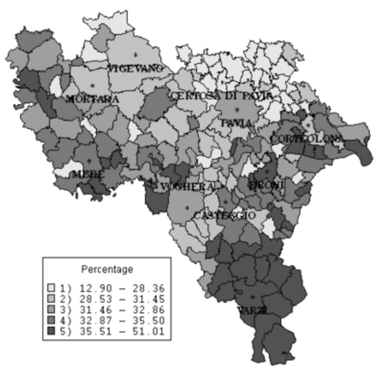

Figure 2. "Ordinary" map of prevalence of chronic diseases

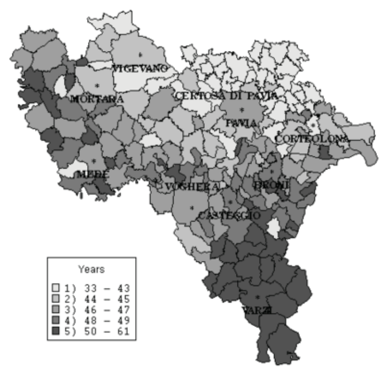

Figure 3. "Ordinary" map of average age

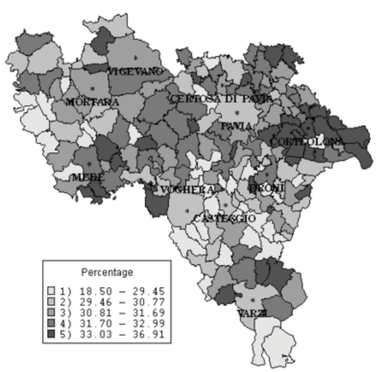

Figure 4. "Standardized" map of prevalence of chronic diseases

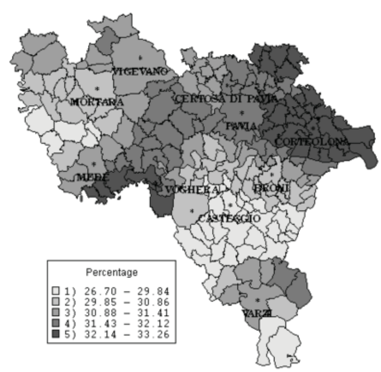

Figure 5. "Smoothed" map of prevalence of chronic diseases

The "standardized" version in Figure 4 shows that, by removing the age effect, the distribution of chronic diseases is higher in the northeastern region. This kind of representation is useful when programming prevention actions or to detect areas where studies about the possible impact of environmental factors should be carried on. The "smoothed" version, in Figure 5, allows both obtaining an intuitive and immediate interpretation of the phenomena distribution on the area and detecting areas with similar average behavior. To avoid wrong conclusion, when using this representation we have to keep in mind that it provide an overall view of phenomena but not its raw distribution.

The Web-application presented in the paper is currently used by ASL decision maker to monitor the health phenomena distribution in the area; some maps related to pathologies prevalence and costs have been presented in a local conference. The application turned out having a high subjective usability corresponding to a vote of "B" and "Good" in the graduate [17] and adjective [18] scales proposed to interpret the numeric score of the System Usability Scale. Moreover, the feedbacks of the users pointed out some possible improvements, such as to improve the tutorial and documentation. In the near future we are planning a further usability test with more users.

References

[1] Brewer CA, Pickle L. Evaluation of Method for Classifying Epidemiological Data on Choropleth Maps in Series. Annals of the Association Of American Geographers. 2002; 92(4): 662-681
[2] Brewer CA, MacEachren AM, Pickle LW, Herrmann D. Mapping Mortality: Evaluating Color Schemes for Choropleth Maps. Annals of the Association of American Geographers. 1997; 87(3): 411-438
[3] http://colorbrewer2.org (2011 October 26)
[4] Waller LA, Gotway CA. Applied spatial statistics for public health data. New Jersey: Wiley & Sons; 2004
[5] Colton T. Statistica in medicina. First Italian edition. Padova: Piccin editore; 1979
[6] Preston SH, Heuveline P, Guillot M. Demography: Measuring and modelling population process. Oxford: Blackwell Publishers Ltd; 2000
[7] Sangwine SJ, Horne REN. The color image processing handbook. Cambridge: Chapman & Hall; 1998
[8] Brooke J. SUS: A quick and dirty usability scale. In Jordan PW, Thomas B, Weerdmeester BA, &. McClelland AL (Eds.). Usability Evaluation in Industry. London: Taylor and Francis; 1996. pp 189-194
[9] Tullis TS, Stetson JN. A Comparison of Questionnaires for Assessing Website Usability. Usability Professionals Association (UPA) 2004 Conference; 2004 June 7-11; Minneapolis, USA
[10] Lewis JR. Sample Sizes for Usability Studies: Additional Considerations. Hum Fact, 1994; 36: 368-78
[11] Virzi R. Refining the Test Phase of Usability Evaluation: How Many Users is Enough? Hum Fact 1992; 34: 457–468
[12] World Health Organisation. Atlas of Mortality in Europe. WHO Regional Publications, European Series No.75. Geneva: WHO; 1997
[13] Kemp I, Boyle P, Smans M, Muir C (Editori). Atlas of Cancer in Scotland 1975-1980: Incidence and Epidemiological Perspective. IARC Scientific Publications No.72. Lyon: International Agency for Research on Cancer; 1985
[14] http://www.oshpd.ca.gov/General_Info/Healthcare_Atlas.html (2011 Oct 18)
[15] http://www.ncin.org.uk/cancer_information_tools/eatlas/ (2011 Oct 19)
[16] http://www.e-r-a.it/tacar/carfrm.php?uid=0 (2011 Oct 18)
[17] Bangor A, Kortum P, Miller J. Determining What Individual SUS Scores Mean: Adding an Adjective Rating Scale. Journal of Usability Studies 2009; 4(3): 114-123
[18] Bangor A, Kortum PT, Miller JT. An Empirical Evaluation of the System Usability Scale. International Journal of Human-Computer Interaction 2008; 24(6): 574-594