Jul 11th, 9:50 AM - 10:10 AM

Health impact of air pollution on Italy: main findings of VIIAS and MED HISS projects

Antonio Piersanti
ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Laboratory of Atmospheric Pollution

Carla Ancona
Department Of Epidemiology, Lazio Regional Health Service

Giovanna Berti
Piedmont Regional Environmental Protection Agency

Ennio Cadum
Piedmont Regional Environmental Protection Agency

Luisella Ciancarella
ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Laboratory of Atmospheric Pollution

See next page for additional authors

Presenter/Author Information
Antonio Piersanti, Carla Ancona, Giovanna Berti, Ennio Cadum, Luisella Ciancarella, Ilaria D'Elia, Francesco Forastiere, and Gaia Righini

International Environmental Modelling and Software Society (iEMSs)
8th International Congress on Environmental Modelling and Software
Toulouse, France, Sabine Sauvage, José-Miguel Sánchez-Pérez, Andrea Rizzoli (Eds.)
http://www.iemss.org/society/index.php/iemss-2016-proceedings

Health impact of air pollution on Italy: main findings of VIIAS and MED HISS projects

Antonio Piersanti[a], Carla Ancona[b], Giovanna Berti[c], Ennio Cadum[c], Luisella Ciancarella[a], Ilaria D'Elia[a], Francesco Forastiere[b], Gaia Righini[a]
[a] *ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Laboratory of Atmospheric Pollution, Italy*
[b] *Department Of Epidemiology, Lazio Regional Health Service, Italy*
[c] *Piedmont Regional Environmental Protection Agency, Italy*

Abstract: The effects of air pollution on human health in Italy have been recently estimated in two different projects with complete national coverage, VIIAS and EU LIFE+ MED HISS. The projects share the methodological approach of the Health Impact Assessment (HIA) and the combined use of dispersion models and monitoring networks data, but differ on the exposure assessment and the overall objectives. VIIAS, using sub-municipal census data of population projected on the dispersion model grid, has estimated health outcomes on baseline years (2005 and 2010) and on three scenarios for 2020, in order to evaluate trends and effects of alternative policies. MED HISS involves 4 European countries and aims to assess the feasibility of a low-cost approach to surveillance of long-term health effects, based on linking resources such as air pollution prediction models, mortality and hospital admissions registries and National Health Interview Surveys. As the health data are available only at municipality level, exposure in MED HISS is calculated on municipalities. Here, we show and discuss the final outcomes of VIIAS, together with some preliminary results of MED HISS and we provide a first comparison of the two approaches.

Keywords*: air quality, health impact assessment, atmospheric dispersion modelling, population exposure*

1 INTRODUCTION

According the World Health Organization (WHO, 2015), air pollution is the largest environmental risk for human health, with estimates of 600000 premature deaths and 1.6 billion US$ of economic cost due to mortality and diseases in Europe in 2010 (WHO Regional Office for Europe, 2015). The assessment of the impacts of air quality on health is the endpoint of European and national cost-effective policies, which can be translated into emission reductions and control strategies. Therefore, there is a need for robust modelling tools that connect atmospheric dynamics, human response to air pollution and policy options, to optimize the use of dedicated resources and data, such as high performance computing and epidemiological cohort studies.
In Italy, two recent projects (VIIAS and EU LIFE+ MED HISS) estimated the health effects of air pollution on the national scale, following the Health Impact Assessment (HIA) scheme (Figure 1), based on existing estimates of the relative risk from previous epidemiological studies, which are applied to the specific exposure of the studied population.

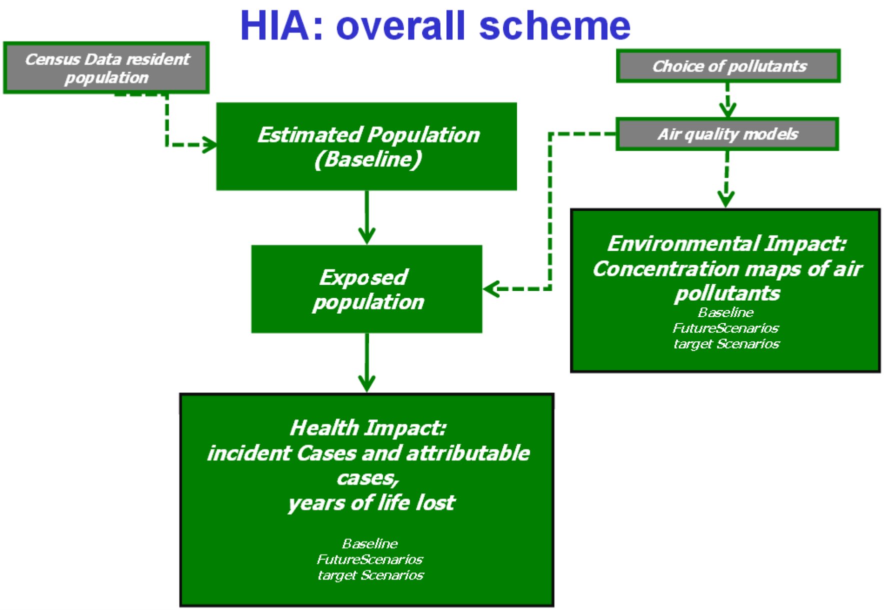

Figure 1. Air quality Health Impact Assessment scheme.

The use of a reference national air quality model (MINNI), combined with monitoring data, allowed the coverage of the whole territory and thus the use of national population data for a comprehensive calculation of exposure and health outcomes. The paper shows selected main findings from the two projects, highlighting strengths and limitations.

2 TWO HIA PROJECTS ON ITALY: VIIAS AND MED HISS

VIIAS (Integrated Assessment of the Impact of Air Pollution on the Environment and Health, 2013-2015; Ancona, 2015) project was funded by the Centre for Disease Control of the Italian Ministry of Health and coordinated by the Department of Epidemiology of the Lazio Region Health Service. VIIAS estimated the mortality (from respiratory disease, cardiovascular disease, lung cancer and total) and the months of life lost due to exposure to air pollution. Estimations were carried out both on Italy as a whole and on the 20 Member Regions individually. Health effects of PM2.5, NO_2 and O_3 were quantified.

To quantify the health gains of Italian population following changes in targets and policies, VIIAS carried out a baseline assessment on years 2005 and 2010. Using model projections on different scenarios (current legislation scenario - CLE, compliance with EU and Italian air quality standards – CLE + Target 1, CLE concentrations reduced by 20% - CLE + Target 2) an estimate of health population for 2020 was produced for future evaluation.

Both the national concentration maps of the analyzed pollutants and the future emission scenarios were provided by the MINNI model system (www.minni.org), funded by the Italian Ministry of Environment, which runs an atmospheric modeling system (AMS, Mircea et al., 2014) and an integrated assessment model (GAINS-Italy, D'Elia et al., 2009). The AMS performances have been assessed against measured concentrations in Italy for several simulation years (Mircea et al., 2014, 2016; Ciancarella et al., 2016).

The population data (people aged 30 and over) used for the exposure assessment are related to the year 2005 and were obtained by interpolation of the official national censuses of 2001 and 2011. The concentration of pollutants was provided by the model on a 4x4 km^2 grid, while population data were available on sub-municipal census zones. Therefore, for the calculation of exposure, population data were aggregated on the model grid.

The population exposure was associated with health outcomes by using concentration-response functions (CRFs), which put in relation air pollutants concentrations and health damages. A CRF provides an estimate of the relative risk, i.e. the increment of a health effect associated with a single-unit increment of the ambient concentration of the pollutant. CRFs are site specific, being obtained from observational epidemiological studies. In VIIAS, the WHO guidelines have been applied, using CRFs for mortality and coronary events taken from the WHO HRAPIE review conducted in 2013

(WHO, 2013). Pollutant-specific CRFs on single health outcomes were used. Thresholds of 10 μg/m^3 for PM2.5, 20 μg/m^3 for NO_2 and 70 μg/m^3 for O_3 were applied in the assessment, following WHO recommendations on the HIA procedure. The adult population (age 30 years and more) was taken into account following HRAPIE recommendations, as most of the evidence on PM2.5 long term effects an mortality comes from studies that focused on populations around 30 years of age and above.
VIIAS provided both national aggregated figures and results on 3 geographic areas (North, Center, South and Islands), 20 Member Regions, 2 macro areas (urban, non-urban). A summary of the results at the national level are presented in the following table.

Table 1. Average population exposure, attributable deaths for PM2.5, NO_2 and O_3, and months of life lost for PM2.5, in Italy. Results of the VIIAS project.

			2005	**2010**	**2020 CLE**	**2020 CLE - Target1**	**2020 CLE - Target2**
PM2.5	general mortality	population exposure (μg/m³)	20.1	15.8	18.1	16.2	14.5
		attributable deaths (95% confidence interval)	34552 (20608-43215)	21524	28595	23170	18511
		months of life lost	9.7	5.5	7.7	5.9	4.2
NO_2	general mortality	population exposure (μg/m³)	24.7	17.9	16.6	16.1	13.3
		attributable deaths (95% confidence interval)	23387 (21514-50283)	11993	10117	9021	5247
O_3	mortality for respiratory diseases	population exposure (μg/m³)	105.1	108.2	97	-	-
		attributable deaths (95% confidence interval)	1707 (622-2861)	1858	1320	-	-

Total figures in 2005 evidence the relevant impact of PM2.5 and NO_2 on mortality, ranging from 23000 to 34000 attributable deaths. The average exposure of the population to PM2.5 is 20.1 μg/m^3, very close to the EU limit value of 25 μg/m^3. Remarkable differences were found among the 20 Member Regions, with Northern Italy showing a higher number of deaths from PM2.5 (22485) and NO_2 (14008), and between urban and non-urban areas, with deaths attributable to NO_2 being more than doubled (16736 versus 6651) and PM2.5 deaths only slightly higher in urban areas (19358 versus 15194), confirming the different dispersion pattern and main sources (road traffic and residential heating for NO_2, secondary aerosol formation for PM2.5).
The different 2020 scenarios provide a forecast of prevented deaths according to different targets. As an example, attaining the EU limits could save 11000 lives on PM2.5 and 14000 on NO_2. The health gains are dependent on the geographical area, as emission reductions are different between Member Regions. It is worth noting that the 2020 CLE scenario shows higher exposure and effects for PM2.5 in 2020 than in 2010, due to an increase in PM2.5 emissions. This growth is caused by the large spread of wood combustion for residential heating, due both to climate change mitigation policies (encouraging carbon-neutral fuels such as biomasses) and to persistent effects of the economic crisis (leading people to use self-provided wood for heating). This growth overcomes scenario mitigation measures, resulting in an increase of PM2.5 concentrations and population exposure.
Results were obtained on the MINNI geographical reference, providing national maps of health outcomes, e.g. death rates per 100000 inhabitants from PM2.5 (Figure 1). Large zones in Northern Italy, Tuscany, Rome and Naples show significant death rate values in 2005, with peaks above 250. A decreasing trend is observed between 2005 and 2020, with can be attributed to the growing efficacy of policy mitigation options. Although compliance with the current EU legislation would have a large impact on the health of Italian residents, there is a large scope for further improvement.

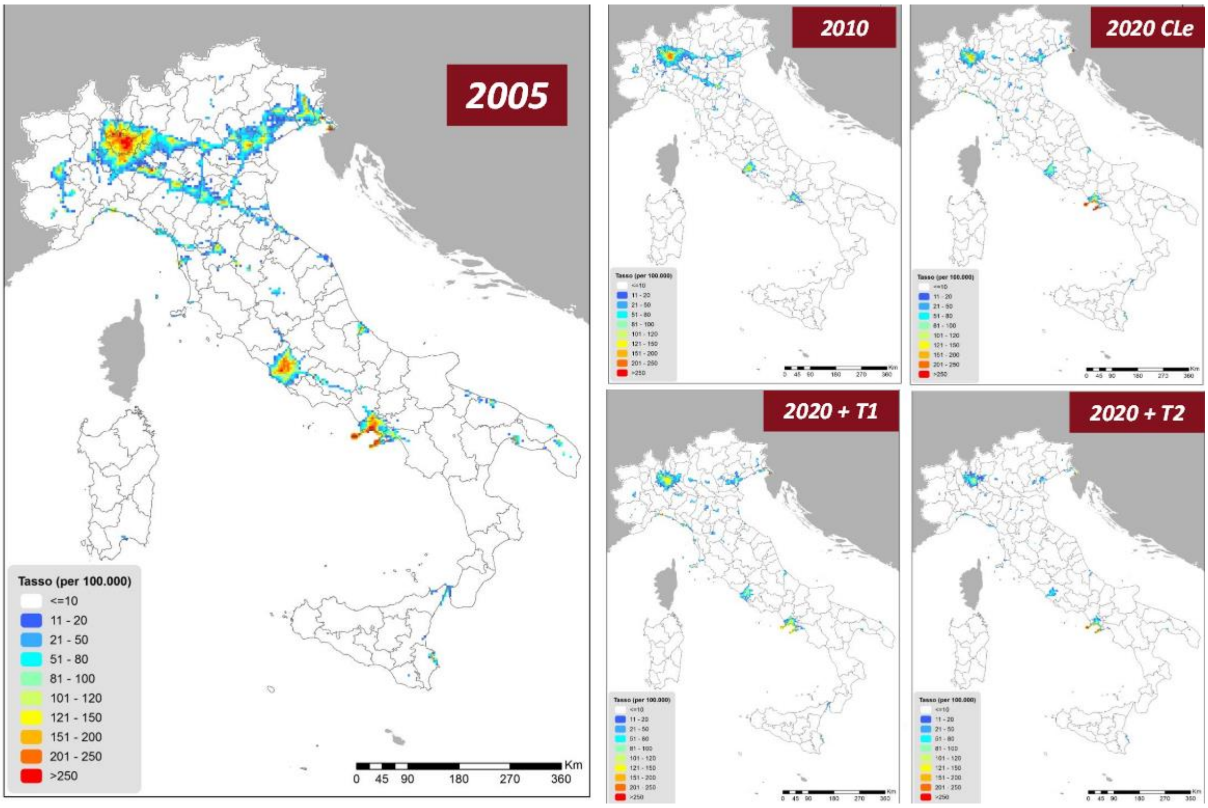

Figure 2. Death rates attributable to PM2.5 each 100000 inhabitants in the 5 case studies. Results of the VIIAS project.

The 2005 model concentrations have been previously compared to concentrations measured by official monitoring networks in Italy (Mircea, 2014), showing performances in line with similar national-scale modeling systems. The fractional bias indicator is reported in Table 2, indicating a good reproduction of O_3 and underestimations on NO_2 and PM. Therefore, average population exposure to NO_2 and PM2.5 is likely to be even higher, suggesting the need of improving model estimates, e.g. by assimilation of measured data. On the other hand, concentration-response functions are provided with uncertainty as well, i.e. 95% confidence intervals (Table 1), which show a significant uncertainty (quantified as statistical margin of error, in percentage). This is structurally embedded in the CRFs methodology. Such uncertainties have to be carefully taken into account when using mortality results for planning health policies.

Table 2. Uncertainty of model concentrations and mortality in 2005 for PM2.5, NO_2 and O_3. Results of the VIIAS project.

	model concentrations, annual average	general mortality, annual deaths
uncertainty indicator	fractional bias $\frac{Model - Observation}{\frac{Model+Observation}{2}}$	margin of error $\frac{\frac{95\%\ confidence\ interval}{2}}{average\ value} * 100$
PM2.5	-0.55*	32.7%
NO_2	-0.45	40.2%
O_3	0.12	65.7%

* calculated for PM10

Other uncertainties are present in the health outcomes results (synergies and antagonisms between pollutants were not quantified), in the concentration-response functions (conclusions of epidemiological studies conducted in different conditions and populations are extrapolated to Italy) and in the model outputs (coarse resolution for NO_2, scenario assumptions are realistic but subjected to periodical revisions).

MED HISS (Mediterranean Health Interview Surveys Studies: long term exposure to air pollution and health surveillance) is an on-going EU LIFE+ Pilot project (2013-2016) involving four countries (Italy, France, Slovenia and Spain). MED HISS is aimed to set up a surveillance system of long term effects of air pollution, based on the common availability of routine air quality and health data. Three main information sources were used: 1) the National Health Interview Surveys (NHIS, Hupkens et al., 1999), available in all countries, representative of the total population and covering both urban and rural areas; 2) mortality and hospital admissions registries; 3) air pollution models.
The use of NHISs data already available, which include individual information on main potential confounders (smoking, BMI, occupation, education, etc.), allows the recruiting of retrospective cohorts, with a remarkable saving of resources, that are normally allocated on building the information on the observed population. Furthermore, NHISs data on entire national populations tries to overcome the existing limitations on the health effect of air pollution, historically based on cohort studies from outside EU, or conducted in Europe, but with restrictions on age or location.
Cohorts are being followed-up for mortality and morbidity, and each subject will be assigned a level of exposure to air pollution (PM10, PM2.5, NO_2, O_3), derived from national-scale dispersion models. As population and health data are available at municipality level, a dedicated work package up-scaled the model gridded concentrations on municipalities, using a weighted block averaging procedure (Ignaccolo, 2012) that accounts for built-up surface percentages collected from CORINE LAND COVER data (http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2006-raster-3). MED HISS cohorts are representative of all populations and areas of residence (urban, rural, metropolitan) and long term effect will be evaluated for a wide range of diseases.
MED HISS id developing a new methodological proposal and has already shown several practical issues.
Data availability is different in the 4 countries, both generated by air quality models (in France-CHIMERE, in Italy-MINNI, in Slovenia-ARSO and in Spain-CALIOPE) and for health data. Model datasets are inhomogeneous because available on different years, due to differences in the national practices and non-mandatory use of models for regulatory purposes (e.g., MINNI model data on Italy required assimilation of measured data, to be comparable to the other countries).
Inhomogeneous anonymization and linkage procedures and schemes of NHIS questionnaires are in force across Europe. The individual linkage between NHIS sampled subjects and mortality/morbidity data was not possible in Spain and Slovenia for preserving privacy and was substituted with an ecological approach based on aggregated data.
Health impact assessment is ongoing and here we have provided some preliminary findings. Long term effects of air pollution on mortality and hospital admissions (the latter rarely assessed in epidemiological studies) were calculated for Italy with the 1999-2000 NHIS, with different follow-up periods and number of cohort members using the Cox proportional hazard model (Cox, 1972), with pollutants and age time-varying variables, adjusting for other variables. Hazard ratios related to 10 $\mu g/m^3$ of increase of PM2.5 and NO_2 are in line with other cohort studies, both for mortality (natural, lung cancer and lower respiratory tract infection) and hospital admissions (circulatory system, stroke, lung cancer and neoplasm). A stronger and more robust association between mortality and PM10 was found in Spanish rural areas compared to urban areas.

3 CONCLUSIONS AND RECOMMENDATIONS

VIIAS and MED HISS are the first comprehensive evaluations of health effects of air quality in Italy, bringing together physical modelling and field measurements, as well as scenario evaluation of mitigation measures and epidemiology. VIIAS established a reference health impact assessment on national basis, to be further refined with local data from dispersion models and epidemiological studies and with updated future emissions scenarios, based on policy management of air quality. MED HISS is showing that there is a need to homogenize anonymization and linkage procedures and to standardize NHIS questionnaires across Europe. When linkage between air pollution model data and georeferenced NHISs is possible, existing resources can be used to obtain results that are similar to those obtained in large expensive cohort studies. Therefore, this tool could become very useful for health surveillance purposes.

ACKNOWLEDGMENTS

VIIAS (www.viias.it, in Italian) was funded by by the Centre for Disease Control of the Italian Ministry of Health. MED HISS (www.medhiss.eu) is a LIFE+ project funded by the European Commission, grant number LIFE12 ENV/IT/000834. The computing resources and the related technical support used in MINNI have been provided by CRESCO/ENEAGRID High Performance Computing infrastructure and its staff (Ponti et al., 2014). CRESCO/ENEAGRID High Performance Computing infrastructure is funded by ENEA, the Italian National Agency for New Technologies, Energy and Sustainable Economic Development and by Italian and European research programmes, see http://www.cresco.enea.it/english for information. The working teams and partners of VIIAS and MED HISS are acknowledged.

REFERENCES

Ancona, C., Golini, M. N., Ciancarella, L. Demaria, M., Badaloni, C., Cesaroni, G., Cadum, E., Forastiere, F., 2015. Health impact assessment of PM2.5 and NO_2 in Italy. The VIIAS National Study. In: Environmental Health Perspectives - Abstracts of the 27th Conference of the International Society of Environmental Epidemiology (ISEE)., n. 1912.

Ciancarella, L., Adani, M., Briganti, G., Cappelletti, A., Ciucci, A., Cremona, G., D'Elia, I., D'Isidoro, M., Mircea, M., Piersanti, A., Righini, G., Russo, F., Vitali, L., Zanini, G., 2016. La simulazione nazionale di AMS-MINNI relativa all'anno 2010. Simulazione annuale del Sistema Modellistico Atmosferico di MINNI e validazione dei risultati tramite confronto con i dati osservati. Technical Report RT/2016/12/ENEA, ENEA, ISSN 0393-3016 (in Italian).

Cox, D., 1972. Regression models and life-tables. Journal of the Royal Statistical Society, Series B 34 (2), 187–220.

D'Elia, I., Bencardino, M., Ciancarella, L., Contaldi, M., Vialetto, G., 2009. Technical and Non-Technical Measures for air pollution emission reduction: The integrated assessment of the regional Air Quality Management Plans through the Italian national model. Atmospheric Environment 43, 6182-6189.

Hupkens, CLH., van den Berg, J.; van der Zee, J., 1999. National health interview surveys in Europe: an overview. Health Policy 47 (2), 145-168.

Ignaccolo, R., Ghigo, S., Bande, S., 2012. Functional zoning for air quality. Environmental and Ecological Statistics 20 (1), 109-127.

Mircea, M., Ciancarella L., Briganti G., Calori G., Cappelletti A., Cionni I., Costa M., Cremona G., D'Isidoro M., Finardi S., Pace G., Piersanti A., Righini G., Silibello C., Vitali L., Zanini G., 2014. Assessment of the AMS-MINNI system capabilities to simulate air quality over Italy for the calendar year 2005. Atmospheric Environment 84, 178-188.

Mircea, M., Grigoras, G., D'Isidoro M., Righini G., Adani, M., Briganti G., Ciancarella L., Cappelletti A., Calori G., Cionni I., Cremona G., Finardi S., Larsen, B. R., Pace G., Perrino, C., Piersanti A., Silibello C., Vitali L., Zanini G., 2016. Impact of grid resolution on aerosol predictions: a case study over Italy. Aerosol and Air Quality Research 16, 1253–1267.

Ponti, G., Palombi, F., Abate, D., Ambrosino, F., Aprea, G., Bastianelli, T., Beone, F., Bertini, R., Bracco, G., Caporicci, M., Calosso, B., Chinnici, M., Colavincenzo, A., Cucurullo, A., Dangelo, P., De Rosa, M., De Michele, P., Funel, A., Furini, G., Giammattei, D., Giusepponi, S., Guadagni, R., Guarnieri, G., Italiano, A., Magagnino, S., Mariano, A., Mencuccini, G., Mercuri, C., Migliori, S., Ornelli, P., Pecoraro, S., Perozziello, A., Pierattini, S., Podda, S., Poggi, F., Quintiliani, A., Rocchi, A., Scio, C., Simoni, F., Vita, A., 2014. The role of medium size facilities in the HPC ecosystem: The case of the new CRESCO4 cluster integrated in the ENEAGRID infrastructure. In: proceedings of the 2014 International Conference on High Performance Computing and Simulation, HPCS 2014, n. 6903807, 1030-1033.

WHO Regional Office for Europe, 2013. Review of evidence on health aspects of air pollution – REVIHAAP Project. Technical Report. Copenhagen: WHO Regional Office for Europe.

WHO, 2015. Landmark Resolution on "Health and the Environment: Addressing the health impact of air pollution". 68th World Health Assembly, 26 May 2015, Geneva, Switzerland.

WHO Regional Office for Europe, 2015. Economic cost of the health impact of air pollution in Europe: Clean air, health and wealth. Copenhagen: WHO Regional Office for Europe.