



# PhD in MODELLI E METODI MATEMATICI PER L'INGEGNERIA / MATHEMATICAL MODELS AND METHODS IN ENGINEERING - 39th cycle

**PNRR 118 PA Research Field: IDENTIFYING SPATIO-TEMPORAL VARIABILITY IN DISEASE  
RISKS ASSOCIATED TO AIR POLLUTION**

**Monthly net income of PhDscholarship (max 36 months)**

**€ 1325.0**

In case of a change of the welfare rates during the three-year period, the amount could be modified.

## Context of the research activity

**Motivation and objectives of the research  
in this field**

Lombardy is one of the most polluted areas in Italy [1]. Many factors might be responsible: the high population density, a high level of urban and industrial areas, its geographic shape and climate. Particulate matter levels in the Po valley are determined by a high regional background, driven by specific meteorological conditions. Air pollution has adverse effects on total and cause-specific morbidity and mortality in the more advanced industrial countries [2] and in Lombardy [3]. However, quantifying and explaining spatiotemporal variation in disease risk associated to air pollution is vital to improving public health; this allows risk factors to be highlighted to the general public and for informed decisions about the future allocation of health resources. The environmental epidemiology literature has focused on studying the effect of a single exposure on a single health outcome so far, though the real biological and chemical interaction is much more complex [4].

The goal of this project is the identification of spatial or spatiotemporal variability in disease risks associated to air pollution and the proposal of statistical models to assess the joint effect of multiple exposures.

The objective consists in developing innovative statistical models

(i) to identify spatial-temporal variability of total and cause-specific morbidities and mortalities, for understanding the



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|                                                                                                | <p>role of the air pollution driving factors worsening health conditions of citizens of Milano metropolitan area and the whole Lombardy;</p> <p>(ii) to estimate the effect of multi-pollutant mixtures or multiple correlated exposures on human health.</p> <p>The objective might make available to the institution of local governance knowledge and tools for better understanding features and evolution of health outcomes related to air pollution. We would strengthen the administrative capacity in relation to the formulation and design of public policies, by developing diagnostic skills and helping in the identification of solutions, decisions and implementation.</p> <p>In summary, the research activity aims at bringing a significant development of the knowledge in the areas of interest of the PNRR. The research activity is in collaboration with ATS Milano, Unità di Epidemiologia and ARPA Lombardia, U.O. Qualità dell'Aria. Data and expertise about air pollution will be provided by the latter, while the former will be the public administration (PA) with expertise of epidemiology of air-pollution morbidities and mortalities.</p> |
| <p><b>Methods and techniques that will be developed and used to carry out the research</b></p> | <p>We aim at using innovative statistical models, possibly Bayesian, to understand spatial variation for morbidities and mortality of health outcomes related to air pollution in the metropolitan area of Milano or in the whole Lombardy. We will also consider identifying high-risk subregions (clusters) for focused action. This could be accomplished proposing new models for clustering areal data or boundary detection [5]. The total area of study is partitioned into a finite number of nonoverlapping areal units. Generalizations of this model might consider data for multiple time periods or for multiple competing diseases for a single time period (multivariate or competing risks modeling as in [6]).</p> <p>As a last line of research for this topic, we could also consider causal inference approaches, very popular now in the most recent literature on adverse health outcomes of air pollution. They have been proposed as a valid alternative to more traditional survival models [7]. Causal</p>                                                                                                                                             |



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|                               | <p>inference aims to estimate causal relationships, as opposed to statistical associations, between putative risk factors and study outcomes. In environmental epidemiology, the task becomes especially challenging, because risk factors are environmentally determined (and therefore usually impossible to randomize), and the studies are observational in nature. However, there are new methods in this context [8]. Theoretical work must be done to adjust them using Bayesian causal inference [9], which could account for model uncertainty in propensity score modelling for instance.</p> <p>Bibliography</p> <p>[1] EEA: Air quality in Europe - 2019 Report: Technical Report. Tech.rep., European Environmental Agency (EEA) (2019)</p> <p>[2] Dockery (2022). Synergy of Biostatistics and Epidemiology in Air Pollution Health Effects Studies. International Statistical Review.</p> <p>[3] Murtas, Russo (2019). Effects of pollution, low temperature and influenza syndrome on the excess mortality risk in winter 2016?2017. BMC Public Health.</p> <p>[4] Stafoggia et al. (2017). Statistical approaches to address multi-pollutant mixtures and multiple exposures: the state of the science. Current environmental health reports.</p> <p>[5] Gianella, Beraha, Guglielmi (2023). Bayesian boundary detection for densities of income areal data. Manuscript.</p> <p>[6] van den Boom, De Iorio, Qian, Guglielmi (2023). The Multivariate Bernoulli detector: change point detection in discrete survival analysis. arXiv:2308.10583</p> <p>[7] Dominici et al. (2022). Assessing Adverse Health Effects of Long-Term Exposure to Low Levels of Ambient Air Pollution: Implementation of Causal Inference Methods. Res Rep Health Eff Inst.</p> <p>[8] Pearce et al. (2019). Causal inference in environmental epidemiology: old and new. Epidemiology.</p> <p>[9] Li et al. (2023). Bayesian causal inference: a critical review. Philosophical Transactions of the Royal Society A.</p> |
| <b>Educational objectives</b> | The PhD student will have the opportunity to increase                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |



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|                                          | his/her abilities as a biostatistician or an epidemiologist or a data scientist, with strong expertise in statistical learning for healthcare and air pollution. In particular the student will study, develop and apply innovative statistical techniques for spatial survival analysis, time series and clustering, in order to identify spatio-temporal variability of total and cause-specific morbidities and mortalities, useful for understanding the role of the air pollution driving factors worsening health conditions of citizens of Milano metropolitan area and the whole Lombardy. |
| <b>Job opportunities</b>                 | The program will allow the student to find a job as a biostatistician or an epidemiologist. Moreover, the expertise in spatio-temporal statistical is nowadays a key methodological factor in many applicative industrial fields such as 5G/6G telecom networks, IoT applications (smartcity, public utility), manufacturing and logistics, climatic studies, and for all new technologies allowing for "data everywhere and everytime". Hence, the program also allows for a data scientist job.                                                                                                  |
| <b>Composition of the research group</b> | 1 Full Professors<br>0 Associated Professors<br>0 Assistant Professors<br>3 PhD Students                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Name of the research directors</b>    | Prof. Alessandra Guglielmi                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |

| <b>Contacts</b>                |
|--------------------------------|
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| <b>Additional support - Financial aid per PhD student per year (gross amount)</b> |    |
|-----------------------------------------------------------------------------------|----|
| <b>Housing - Foreign Students</b>                                                 | -- |
| <b>Housing - Out-of-town residents (more than 80Km out of Milano)</b>             | -- |

| <b>Scholarship Increase for a period abroad</b> |         |
|-------------------------------------------------|---------|
| <b>Amount monthly</b>                           | 662.5 € |
| <b>By number of months</b>                      | 6       |

| <b>National Operational Program for Research and Innovation</b>                       |                                                                |
|---------------------------------------------------------------------------------------|----------------------------------------------------------------|
| <b>Company where the candidate will attend the stage (name and brief description)</b> | ATS, Città Metropolitana di Milano, UOC Unità di Epidemiologia |
| <b>By number of months at the company</b>                                             | 6                                                              |



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| <b>Institution or company where the candidate will spend the period abroad (name and brief description)</b> | to be defined |
| <b>By number of months abroad</b>                                                                           | 6             |

**Additional information: educational activity, teaching assistantship, computer availability, desk availability, any other information**

Educational activities (purchase of study books and material, funding for participation to courses, summer schools, workshops and conferences): financial aid per PhD student per year

1st year: max 1.800,47 euros

2nd year: max 1.800,47 euros

3rd year: max 1.800,47 euros

The PhD students are encouraged to take part in activities related to teaching, within the limits allowed by the regulations. 1 individual PC per student + several shared PC. Access to one cluster with 32 processors and 384 GB RAM, and to several multi-processor servers.

Study and research period visiting "Pubbliche Amministrazioni": 6 months at ATS, Città Metropolitana di Milano, UOC Unità di Epidemiologia

Study and research period abroad: 6 months at a university abroad

The PhD project will promote the use of research results and guarantee the protection of intellectual property, ensuring open access to the public to research results and related data, in the shortest time and with the least possible limitations, according to the principles "Open science" and "FAIR Data".

Principles of PNNR will be guaranteed. In particular our research program is aimed at the integrated development of one or more of the following knowledge and skills (from Decreto Ministeriale 351 relativo al PNRR - dottorati per la Pubblica Amministrazione):

- potenziare la capacità amministrativa in relazione alla formulazione e al disegno delle politiche pubbliche, sia sviluppando capacità diagnostica sia assumendo la responsabilità del coordinamento del ciclo di policy per quanto concerne la fenomenologia delle problematiche possibili nelle fasi di definizione dei problemi e individuazione delle soluzioni, di decisione, di implementazione e di valutazione (strengthen the administrative capacity in relation to the formulation and design of public policies, both by developing diagnostic skills and by taking responsibility for coordinating the policy cycle as regards the phenomenology of possible problems in the phases of problem definition and identification of solutions, decisions, implementation and evaluation);
- partecipare al governo, all'organizzazione e alla direzione strategica di amministrazioni pubbliche (sia al livello nazionale che regionale e locale) attraverso l'attuazione di innovative strategie fortemente orientate agli utenti e all'efficacia delle azioni poste in essere, nonché alla valorizzazione delle risorse (participate in the governance, organization and strategic management of public administrations (both at national and regional and local level) through the



implementation of innovative strategies strongly oriented towards users and the effectiveness of the actions implemented, as well as the valorisation of resources).

Missions of the PNRR involved in this research: (a) M1C1, (b) M2C4, (c) M6C2.