

# Irene Balelli

Ph.D.

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## Summary

After a training in Mathematics carried out in Italy, Spain and France, and a Master's degree dedicated to *Mathematics applied to biological and medical sciences* (UPMC, Paris), I received my Ph.D. from **University Paris 13** (2013-2016, LAGA Laboratory, Sorbonne Paris Cité). My thesis project, embedded in the frame of the **laboratory of excellence Inflammex**, aimed to establish an appropriate graph-based mathematical framework to define and study simplified evolutionary models inspired by antibody affinity maturation (AAM), a biological process that enables the development of a specific antibody response against pathogens attacking our organism. In January 2017 I joined the **SISTM team** (INSERM U1219 Bordeaux Population Health and INRIA) for a post-doc as part of the **EBOVAC project**, launched under the European Innovative Medicines Initiative (**IMI**) **Ebola+** program, to support the development, by the pharmaceutical company **Janssen**, of a prophylactic vaccine against Ebola virus disease. I developed and refined mechanistic models of the immune response to the envisaged vaccination strategies, and confronted them with clinical trial data. In 2019 I have integrated the **Epione team** (Inria Center of University Côte d'Azur) as a post-doctoral researcher in the context of the **ANR FedBioMed project**, where I mainly focused on federated learning for the analysis of decentralized heterogeneous multimodal biomedical data. In 2021 I was awarded with an **ISFP (Inria Starting Faculty Position)**, a permanent research position, in the Epione team, with a research project on *Causal machine learning: from imaging to in silico trials*. I am currently involved in both **international projects** (EU H2020 SimCardioTest), **national projects** (such as in particular the upcoming RHU TALENT project) and with **local partners** (ExactCure company, Nice CHU).

Throughout my research career, I have had the opportunity to investigate several questions from both a theoretical and a medical perspective, acquiring a broad view of the interactions between Mathematics, Statistics and Medicine, whose potential is increasingly recognized and which involves challenges and issues in each of these fields, as well as at their intersections. Since my PhD, I have focused on mathematical and statistical modeling applied to biomedical sciences, with a very **multidisciplinary approach** (I have been led to collaborate with immunologists, physicians, biologists and clinicians throughout my career), seeking a hierarchical, modular and interpretable definition of the developed models. I have had the opportunity to publish my results in **journals** (e.g. *Mathematical Biosciences*, *MELBA*) and in **conferences** (including the prestigious peer reviewed IPMI, whose proceedings are published in the Springer series *Lecture Notes on Computer Science*). I presented my work in several occasions, both nationally and internationally. Finally, I have served as a **reviewer** for several journals (e.g. *Vaccine Journal*, *MedIA*), and I have always been involved in **teaching** activities (bachelor's and master's degrees, thematic schools). I am currently in charge of the **pedagogical organization** of the AI for Health track of the Data Science&AI Master 2 (University Côte d'Azur). I am currently **supervising students** from Master 2 up to post-doc.

## Biographical Information

Birth **November 3, 1988**, in Forlimpopoli - Italy.  
Citizenship **Italian and French**.  
Family **Under PACS. Two children** (2015 and 2018).  
situation

## Research Interests

Modeling/  
Statistics Bayesian Statistics. Latent variable models. Generative models. Mixed effects models. Identifiability analysis. Sensitivity analysis. Parameter estimation with population approach. Expectation Maximization. PK/PD. In-silico trials. Meta-modeling.

ML & Data governance	Federated learning. Distributed learning. Causal learning. Differential privacy. Large-scale heterogeneous biomedical data. Missing data.
Biomedical Applications	<i>Immunology</i> : Immune response dynamics. Immune system. Antibody affinity maturation. B-cells. Immune memory. Vaccination. <i>Cardiology</i> : Drugs' cardiac safety. Pro-arrhythmic risk. <i>Neurodegenerative diseases</i> : Alzheimer's Disease, Parkinson's Disease, Brain Imaging data.
Applied Probability	Random walks on graphs. Markov chains. Graph theory. Galton-Watson processes. Evolutionary landscapes

## Current Position

2021–now **Research scientist (ISFP) in mathematical modeling for computational biomedicine**, EPIONE team - Inria Center of University Côte d'Azur, Valbonne - France.

## Experience

2020–2021 **Post-doctoral research fellowship in federated statistical learning for new generation meta-analyses of large-scale and secured biomedical data**, EPIONE team - Inria Center of University Côte d'Azur, Valbonne - France.

2017–2019 **Post-doctoral research fellowship in modeling of the immune response to Ebola vaccine**, SISTM team - Inserm U1219 Bordeaux Population Health, Bordeaux - France.

## Education

2017 **Qualification**, CNU section 26: Applied mathematics and applications of mathematics.

2013–2016 **PhD in Applied Mathematics with teaching activities**, LAGA - University Paris 13, Villetaneuse - France.

**Title**: *Mathematical foundations of antibody affinity maturation*.

**Supervisors**: Vuk Milišić, Gilles Wainrib, Hatem Zaag.

**Defense date**: November 30, 2016.

2011–2013 **Master Degree in Mathematics Applied to Biology and Medicine**, *Master thesis*: A mathematical model of somatic hypermutation (*Supervisors*: V. Milišić, G. Wainrib), University Paris 6, Paris - France.

2010–2011 **Erasmus Program**, Universidad Complutense, Department of Mathematics, Madrid - Spain.

2007–2010 **Bachelor degree in Mathematics**, *Bachelor thesis*: Bressloff and Cowan's model: visual hallucinations as stable states of cortical activation (*Supervisor*: G. Citti), University of Bologna, Bologna - Italy.

## Papers, Book Chapters and Preprints → ;

†S. Al-Ali, J. Llopis-Lorente, M. T. Mora, M. Sermesant, B. Trénor, **I. Balelli**, *A causal discovery approach for streamline ion channels selection to improve drug-induced TdP risk assessment*, Accepted for publication in CinC 2023 [[hal-04105144](https://hal.archives-ouvertes.fr/hal-04105144)].

†F. Cremonesi, M. Vesin, S. Cansiz, Y. Bouillard, **I. Balelli**, L. Innocenti, S. Silva, S.S. Ayed, R. Taiello, L. Kameni, R. Vidal, F. Orhac, C. Nioche, N. Lapel, B. Houis, R. Modzelewski, O. Humbert, M. Onen, and M. Lorenzi, *Fed-BioMed: Open, Transparent and Trusted Federated Learning for Real-world Healthcare Applications*, [[hal-04081557](https://hal.archives-ouvertes.fr/hal-04081557)].

†**I. Balelli**\*, A. Sportisse\*, F. Cremonesi, P.A. Mattei, M. Lorenzi, *Fed-MIWAE: Federated Imputation of Incomplete Data via Deep Generative Models*, In preparation, [[hal-04069795](https://hal.archives-ouvertes.fr/hal-04069795)].

Q. Clairon, C. Pasin, **I. Balelli**, R. Thiébaud, M. Prague, *Parameter estimation in nonlinear mixed effect models based on ordinary differential equations: an optimal control approach*, Accepted for publication in Computational Statistics ([COST](https://www.computational-statistics.com)), [arXiv: 2102.11543].

M. Lorenzi, M. Deprez, **I. Balelli**, A. L. Aguila, A. Altmann, *Integration of Multimodal Data*, Springer Nature 2023, Book Chapter, In press.

† **I. Balelli**, S. Silva, M. Lorenzi, *A Differentially Private Probabilistic Framework for Federated Heterogeneous Multi-View Datasets Variability*, *Journal of Machine Learning for Biomedical Imaging (MELBA)*. 2022:012.

† **I. Balelli**, S. Silva, M. Lorenzi, *A Probabilistic Framework for Modeling the Variability Across Federated Datasets of Heterogeneous Multi-View Observations*, *International Conference on Information Processing in Medical Imaging (IPMI)*. Springer, Cham, 2021. p. 701-714.

M. Prague\*, J. Gerold\*, **I. Balelli**, C. Pasin, J. Li, D. Barouch, J. Whitney, A. Hill, *Viral rebound kinetics following single and combination immunotherapy for HIV/SIV*, [[bioRxiv 700401](#)].

**I. Balelli**, C. Pasin, M. Prague, F. Crauste, T. Van Effelterre, V. Bockstal, L. Solforosi, R. Thiébaud, *A model for establishment, maintenance and reactivation of the immune response after vaccination against Ebola virus*, *Journal of Theoretical Biology*, 2020, DOI: 10.1016/j.jtbi.2020.110254.

C. Pasin, **I. Balelli**, T. Van Effelterre, V. Bockstal, L. Solforosi, M. Prague, M. Douguih, R. Thiébaud, *Dynamics of the humoral immune response to a prime-boost Ebola vaccine: quantification and sources of variation*, *Journal of Virology*, 2019, DOI: 10.1128/JVI.00579-19.

**I. Balelli**, V. Milišić, G. Wainrib, *Multi-type Galton-Watson processes with affinity-dependent selection applied to antibody affinity maturation*, *Bulletin of Mathematical Biology*, 2019, vol. 81, no 3, p. 830-868.

**I. Balelli**, V. Milišić, G. Wainrib, *Random walks on binary strings applied to the somatic hypermutation of B-cells*, *Mathematical Biosciences*, 2018, vol. 300, p. 168-186.

**I. Balelli**, V. Milišić, G. Wainrib, *Branching random walks on binary strings for evolutionary processes in adaptive immunity*, [[arXiv: 1607.00927](#)].

† This paper is listed within the 3IA Côte d'Azur collection.

## Conferences, Meetings and Seminars

- 2023 **Innovaheart 2023**, *Invited talk*, Bordeaux.
- 3IA Seminar**, *Invited talk*, Sophia Antipolis.
- 2022 **Inria-DFKI workshop 2022**, Bordeaux.
- BoostUrCareer Doctoriales 2022 – AI in HEALTHCARE**, *Invited talk*, Nice.
- 2021 **Information Processing in Medical Imaging (IPMI) 2021**, Online event.
- 2020 **3IA Scientific Days**, Nice - France.
- Sophi.A Summit 2020**, Sophia Antipolis - France.
- 2019 **4<sup>th</sup> EBOVAC1/2 Annual meeting**, *Invited talk*, Nairobi - Kenya.
- VRI Annual meeting**, *Invited talk*, Paris - France.
- 2018 **IMI 10<sup>th</sup> Anniversary Scientific Symposium**, [3<sup>rd</sup> committee prize “best presentation”](#), Brussels - Belgium.
- CROI 2018**, *Poster (J.M. Gerold, C. Pasin, I. Balelli, S. Lim, C. Osuna, J.B. Whitney, D.H. Barouch, M. Prague, A.L. Hill)*, Boston - United States.
- 3<sup>rd</sup> EBOVAC1/2 Annual meeting**, *Invited talk (with C. Pasin)*, Amsterdam - Nederland.
- 2017 **Systems Immunology and Vaccine design**, Heidelberg - Germany.
- 2016 **Probabilities and Statistics seminar (LAGA)**, *Invited talk*, Villetaneuse - France.
- 1<sup>st</sup> Challenges in inflammation meeting**, Florence - Italy.
- Les probabilités de demain**, *Invited talk*, IHÉS - Bures-sur-Yvette - France.
- Summer school: “PDE and Probability for Life Sciences”**, CIRM - Marseille - France.
- 2015 **EDP-Normandie**, Havre - France.

- 2014 **InflaConf: Mathematical modeling in immunology and inflammation**, *invited talk*, Paris - France.  
**CANUM 2014**, Carry-le-Rouet - France.  
**Inflamex day**, *Invited talk*, CIEP Sèvres - France.
- 2013 **GDR Métice: Inflammation and Treatment Resistance**, *invited talk*, Lyon - France.

## Thematic schools: contribution

- 2022 **AI4Health Winter School**, *Workshop (teaching materials and presentation)*: Fed-BioMed, an open source framework for federated learning in real world healthcare applications, Online event.
- 2021 **AI4Health Winter School**, *Workshop (teaching materials and presentation)*: Handling heterogeneity in the analysis of biomedical information, Online event.
- First Inria-DFKI European Summer School on Artificial Intelligence**, *Workshop (teaching materials and presentation)*: Federated learning methods and frameworks for collaborative data analysis, Online event.

## Supervision activities

- Post-Doc **S. Al-Ali**, *Causal data analysis of in-silico trials*, Projet SimCardioTest, Since Oct. 2022 (100% supervision).
- PhD **E. Gaymard**, *Innovative mathematical methodologies in pharmacometric meta-modeling from highly heterogeneous sources*, industrial PhD (CIFRE) with [Exact-Cure](#), co-directed with M. Sermesant, Since Nov. 2022 (50% supervision)<sup>‡</sup>.
- Master 2 **B. Ramudu Manam**, *PPCA-based disease progression modeling*, Since Apr. 2023 (50% supervision).  
**A. Senacheribbe**, *Longitudinal PPCA*, Sept. 2020 - Feb. 2021 (50% supervision).  
**M. Alexandre**, *Mechanistic modeling applied to vaccinology*, Feb. 2019 - Aug. 2019 (20% supervision).

<sup>‡</sup> I am committed with the doctoral school [ED STIC](#) and the University Côte d'Azur to defend my HDR (*habilitation à diriger des recherches*) by 2025.

## Teaching Activities

- 2020-2023 **Bayesian learning**, *Lectures and tutorials (10h/year)*, M2 MSc Data Science & Artificial Intelligence, University Côte d'Azur, Sophia Antipolis - France.  
**Modeling of biological systems**, *Lectures and tutorials (10h/year)*, M2 BIM, University Côte d'Azur, Nice - France.  
**Analysis and Modeling**, *Tutorials (20h/year)*, 1st year bachelor's degree, University Côte d'Azur, Nice - France.  
**Statistics and Modeling**, *Tutorials (24h/year)*, 3rd year bachelor's degree, University Côte d'Azur, Nice - France.
- 2013-2016 **Teaching mission proposed to PhD students (Monitorat - Tutorials 64h/year)**.  
**Probability and Statistics 2**, *Tutorials*, 2nd year bachelor's degree in Mathematics and MIEF, University Paris 13, Villetaneuse - France.  
**Probability and Statistics 1**, *Tutorials*, 2nd year bachelor's degree in Mathematics, University Paris 13, Villetaneuse - France.  
**Probability and Statistics**, *Tutorials*, 1st year Engineering degree (Apprentissage énergétique), Engineering School Sup Galilée, Villetaneuse - France.  
**Statistics**, *Tutorials*, 1st year Engineering degree MACS (Mathématiques Appliquées et Calcul Scientifique), Engineering School Sup Galilée, Villetaneuse - France.  
**Probability**, *Tutorials*, 2nd year IUT-Info, University Paris 13, Villetaneuse - France.  
**Inferential statistics**, *Tutorials*, 2nd year DUT-GEA, University Paris 13, Bobigny - France.

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## Review Activities

2020-2023 Vaccine (Elsevier), Medical Image Analysis (Elsevier), Neuroimage (Elsevier), SMAI J. of Computational Mathematics

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## Softwares

[Fed-BioMed](#) Open-source federated learning framework: participation to research and development.  
[Fed-mv-PPCA](#) Bayesian framework for federated multi-view heterogeneous datasets assimilation based on Probabilistic PCA: design and code.

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## Responsibilities and Management

**Administration** In charge of the pedagogical organization of the AI for Health track of the [Data Science&AI](#) Master 2, Université Côte d'Azur, Sophia Antipolis - France  
Part of the Data Science&AI Master 2 jury (M2 recruitment panel and end-of-semester/end-of-year evaluation jury) for the 2023-2024 academic year.

**Projects** WP leader in the EU H2020 project SimCardioTest and in the upcoming RHU project TALENT.

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## National & International Projects and Collaborations

2021–now [SimCardioTest](#), *EU H2020 programme*, 10 organizations, 6 EU countries and USA.  
**Academic:** Center for Research and Innovation in Bioengineering (Ci2B), [Universitat Politècnica de València](#) (Spain).  
**Industry:** [InSilicoTrials](#) (Italy).  
2018–2019 [DYNAM-HIC](#), *Inria Associate team*, France and USA.  
**Academic:** [Harvard Program for evolutionary Dynamics](#) (USA).  
2017–2019 [Ebovac](#), *IMI Ebola+ programme*, 6 partners, EU, UK, Sierra Leone, Burkina Faso.  
**Academic:** [Oxford Vaccine Group](#) (UK).  
**Industry:** [Janssen Vaccines & Prevention B.V.](#) (Belgium).  
**Clinic:** Vaccine Research Institute ([VRI](#), France).  
2013–2016 [Inflamex](#), *Laboratory of Excellence (LabEx)*, France.  
**Clinic:** Inserm UMR-U978 Signaling Adapters in Hematology ([ASIH](#), France).

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## Outreach activities

2022 [1 scientifique 1 classe: Chiche!](#), to encourage the pursuit of scientific studies and explain research activities to high school students. 3 classes, Lycée Tocqueville, Grasse.

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## Computer Skills

Programming Languages	<b>Python, Matlab, R</b>	Parameter estimation softwares	<b>Monolix, NIMROD</b>
Others	<b>IdentifiabilityAnalysis (Mathematica), DAISY (Reduce3.8)</b>		

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## Languages

Italian	<b>Mother tongue</b>	English	<b>Fluent</b>
French	<b>Bilingual</b>	Spanish	<b>Fluent</b>

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## Misc

Editing & Office	<b>OpenOffice, Office, L<sup>A</sup>T<sub>E</sub>X</b>	Operating Systems	<b>Mac OSX, Linux, Windows</b>
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