BIOGRAPHICAL SKETCH

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NAME: **Dr. SAIKAT BATABYAL**

eRA COMMONS USER NAME (credential, e.g., agency login): sbatabyal2074

POSITION TITLE: **ASSISTANT PROFESSOR**

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	END DATE MM/YYYY	FIELD OF STUDY
Visva Bharati, Santiniketan, West Bengal	BS	05/2013	Mathematics
Visva Bharati, Santiniketan, West Bengal	MS	05/2015	Mathematics
SRM Institute of Science and Technology, Kattankulathur, Tamilnadu	PHD	12/2022	Applied Mathematics

A. Personal Statement

I am working on developing models for within-host dynamics of pathogens and investigating the progression from Mycobacterium tuberculosis (Mtb) infection to Tuberculosis (TB). This involves creating epidemiological models to understand the protective effects of prior Mtb infection and identifying individuals who would benefit most from preventative treatments. My research also explores T cell dynamics and the integration of experimental data into model construction, using techniques like R, Python for model fitting. I am dedicated to advancing TB control through simulations that evaluate public health interventions, such as vaccination and treatment adherence programs. I aim to integrate mathematical modeling with biomedical science to enhance Translational Research, ultimately benefiting societal health outcomes.

1. Saikat Batabyal, Kevin Urdahl, Vitaly V Ganusov: Potential limitations of community-wide strategy to treat Mycobacterium tuberculosis infection. (Communicated soon…)
2. *Saikat Batabyal, *Chakraborty, D Ganusov, V.: A brief overview of mathematical modeling of the within-host dynamics of Mycobacterium tuberculosis. Frontiers in Applied Mathematics and Statistics, 10, (2024). DOI: https://doi.org/10.3389/fams.2024.1355373. (*Authors have equal contributions).

B. Positions, Scientific Appointments, and Honors

Positions and Scientific Appointments

2026 – Present: **Assistant Professor,** Ramaiah University of Applied Sciences, Dept. of Biotechnology, Faculty of Life and Allied Health Sciences, Bengaluru, India
2023 – 2026: **Postdoctoral Scientist,** Texas Biomedical Research Institute, San Antonio, TX, USA
2023: **Postdoctoral Research Associate,** University of Tennessee, Knoxville, TN, USA
2021 – 2023: **Young Policy Professional,** Indian Institute of Science, Bangalore, India
2017 – 2018: **Senior Scientist**, Alpen Adria University, Klagenfurt, Austria
2015: **Visiting Researcher,** Jacobs University of Bremen, Germany

Honors

2026: Adjunct Faculty, Theoretical Immunology Laboratory, Texas Biomedical Research Institute, San Antonio, USA.
2025: IN-TRAC Travel Grant, Texas Biomedical Research Institute, San Antonio, USA.
2021– 2023: Member, National Mission on Interdisciplinary Cyber-Physical Systems, Ministry of Science & Technology, Government of India.
2024: Landhal Travel Award, Society for Mathematical Biology.
2022: Member Secretary, Uttar Pradesh Council of Science & Technology (UPCST)-DST, Govt. of India.
2017: Modeling Simulation Optimization, Alpen Adria University, Austria.

C. Contributions to Science

1. Quantitative Modeling of Tuberculosis Epidemiology: We have analyzed whether prior infection delays the onset of active disease based on nursing student cohorts exposed to TB patients, from Boston Medical College (Badger et al. 1948). Approximately 10% of TST individuals progress to TB within one to three years, while TST+ individuals show slower progression, suggesting partial protection. To quantify this effect, we will develop an epidemiological model that incorporates varying levels of MTBI-induced protection and evaluates the potential drawbacks of widespread prophylactic treatment, including reduced natural immunity. In future research work, we will construct an agent-based model (ABM) to simulate individual-level interactions, transmission dynamics, and healthcare access across diverse populations. The ABM will be used to assess the impact of vaccination, targeted screening, and treatment adherence programs on TB transmission and disease outcomes. We will apply our expertise in quantitative modeling to investigate how prior *Mycobacterium tuberculosis* infection (MTBI) confers protection upon re-exposure and how prophylactic treatment of MTBI individuals may alter population-level TB incidence. This expertise is demonstrated by my previous work and the following representative publications:

Key contribution: This study aims to improve understanding of how prior *Mycobacterium tuberculosis* (Mtb) infection influences disease progression and TB control strategies. Using longitudinal data from nursing student cohorts exposed to TB patients.

Relevance: Together, these modeling approaches will provide mechanistic and population-level insights into how prior infection and intervention strategies shape TB epidemiology, guiding more effective prevention and control policies.

Representative publication:

a. Saikat Batabyal, Kevin Urdahl, Vitaly V Ganusov: Potential limitations of community-wide strategy to treat Mycobacterium tuberculosis infection. (Communicated soon…)

2. Quantitative Within-host Modeling of Tuberculosis Immunity: My research has focused on developing mathematical and computational frameworks to understand how prior *Mycobacterium tuberculosis* (Mtb) infection influences disease progression and TB control strategies. Using longitudinal cohort data and mathematical modeling, I have investigated how latent Mtb infection provides partial protection upon re-exposure and how prophylactic treatment affects long-term TB incidence. This work integrates compartmental and agent-based models to quantify population level effects of vaccination, screening, and adherence interventions. The results contribute to a more nuanced understanding of natural immunity and intervention outcomes, providing a foundation for evidence-based TB prevention and control policies.

Key contribution: Established a dual modeling approach to evaluate the balance between MTBI-induced protection and the epidemiological consequences of preventive therapy, informing future public health strategies for TB control.

Relevance: This work advances the field of infectious disease modeling by linking individual immune protection mechanisms to population-level disease outcomes, aligning with NIH priorities in systems epidemiology and global health.

Representative publication:

a. *Saikat Batabyal, *Chakraborty, D Ganusov, V.: A brief overview of mathematical modeling of the within-host dynamics of Mycobacterium tuberculosis. Frontiers in Applied Mathematics and Statistics, 10, (2024). DOI: https://doi.org/10.3389/fams.2024.1355373. (*Authors have equal contributions).

3. Dynamic Modeling of COVID-19 Transmission and Seasonal Perturbations: During the COVID-19 pandemic, I contributed to understanding the nonlinear dynamics of SARS-CoV-2 spread using mathematical modeling and chaos theory. I demonstrated how external perturbations and seasonal forcing can transition epidemic trajectories from chaotic to stable regimes. By integrating real-time infection data and theoretical dynamics, this study provided new insights into how interventions, behavioral changes, and environmental factors modulate disease stability.

Key contribution: Introduced a novel framework based on perturbation and stability analysis to characterize transitions between chaotic and stable epidemic states, revealing how seasonality and control measures shape epidemic persistence.

Relevance: This work offered predictive insights into COVID-19 transmission dynamics, illustrating the importance of nonlinear feedback and seasonality in epidemic forecasting principles that also inform my current TB modeling research.

Representative publication:

a. Saikat Batabyal: COVID-19: Perturbation dynamics resulting chaos to stable with seasonality transmission. Chaos, Solitons & Fractals, (SCI, Scopus, ISSN: 0960-0779, IF: 9.922), 110772, (2021).
b. Saikat Batabyal, Batabyal, A.: Mathematical computations on epidemiology: A case study of the novel coronavirus (SARS-CoV-2). Theory in Biosciences, (SCI, SCIE, Scopus, Online ISSN: 1611-7530, IF: 1.315), 140(2), 123-138, (2021).
c. Saikat Batabyal, Batabyal, A.: Public Healthcare System Capacity During COVID-19: A Computational Case Study of SARS-CoV-2. Health Science Reports, (PubMed, PubMed Central Scopus, Online ISSN: 2398-8835), Article DOI: 10.1002/hsr2.305, (2021).

4. Mathematical Modeling in Ecology (Predator–Prey Dynamics and Pattern Formation): I applied nonlinear dynamical systems theory to ecological modeling, focusing on predator–prey interactions, mutualism, and pattern formation in spatio-temporal domains. My work examined how mutualistic relationships influence system stability and whether such interactions can restrain blow-up phenomena in predator populations. I also investigated the effects of diffusion-driven instabilities on the emergence of spatial patterns, demonstrating how ecological and behavioral factors contribute to system complexity. Using analytical and numerical methods, I explored how changes in functional responses and diffusion parameters shape ecological stability and self-organization. This research provided new insights into the mechanisms driving coexistence, oscillatory behavior, and spatial heterogeneity in ecological systems.

Key contribution: Established how mutualistic interactions and diffusion processes regulate blow-up phenomena and generate spatial patterns in predator-prey systems, linking mathematical theory to observable ecological dynamics.

Relevance: This work enhanced understanding of nonlinear population dynamics and spatio-temporal pattern formation, offering conceptual frameworks applicable to both ecological and epidemiological modeling.

Representative publication:

a. Saikat Batabyal, Jana, D., Upadhyay R. K.: Diffusion driven finite time blow-up and pattern formation in a mutualistic preys-sexually reproductive predator system: A comparative study. Chaos, Solitons & Fractals, (SCI, Scopus, Online ISSN: 0960-0779, IF: 9.922), 147C, 110929, (2021).
b. Saikat Batabyal, Jana, D., Parshad, R. D., Basheer, A., Upadhyay R. K.: Pattern Formation in an Explosive Food Chain Model: The case of "Apparent" Mutualism. Eur. Phys. J. Plus (SCI, SCIE, Scopus, Online ISSN: 2190-5444, IF: 3.758), 136, 448 (2021).
c. Saikat Batabyal, Jana, D., Lyu, J., Parshad, R.D.: Explosive predator and mutualistic preys: A comparative study. Physica A (SCI, Scopus, Online ISSN: 0378-4371, IF: 3.778), (2019).
d. Jana, D., Saikat Batabyal, Lakshmanan, M.: Self-diffusion-driven pattern formation in prey-predator system with complex habitat under fear effect. Eur. Phys. J. Plus (SCI, SCIE, Scopus, Online ISSN: 2190-5444, IF: 3.758), 135, (2020).

5. Policy Research on Science, Technology, and Innovation (STI) Governance: As a Policy Research Fellow at the Indian Institute of Science (IISc), Bangalore, I contributed to national level efforts to strengthen coordination and governance in India's Science, Technology, and Innovation (STI) ecosystem. My work focused on facilitating Centre-State and Inter-Ministerial partnerships aimed at promoting interdisciplinary research, innovation, and technology translation. I played an active role in developing policy frameworks under the National Mission on Interdisciplinary Cyber-Physical Systems (NM-ICPS), initiated by the Ministry of Science and Technology, Government of India. Through this fellowship, I gained hands-on experience in policy formulation, inter-agency coordination, and evidence-based evaluation of research and innovation programs. My contributions supported the design of mechanisms to enhance collaboration between academic institutions, industries, and government agencies, key components for building a sustainable innovation ecosystem.

Key contribution: Contributed to national STI policy design and coordination mechanisms that strengthened interdisciplinary collaboration and technology-driven innovation under the NM-ICPS mission.

Relevance: This experience broadened my perspective on how research, technology, and policy intersect, reinforcing my ability to align scientific modeling and data-driven research with strategic decision-making in public health and national innovation systems.

Representative publication:

a. Dey, D., Kumar, A., Pandey, P., Batabyal, A., Saikat Batabyal, Lingayat, D.: Role of STI in Sustainable Development: Towards food and nutrition security. Policy Brief, IISc, Bangalore, (2022).

6. Theoretical Research in Functional and Complex Analysis: My early academic work focused on the mathematical foundations of functional and complex analysis, with applications to variational regularization and the theory of entire functions. As a Senior Scientist on a project funded by Alpen-Adria-Universität, Austria, I investigated sparsity-promoting variational regularization methods for linear inverse problems. This work contributed to improving the stability and convergence properties of solutions in ill-posed systems, an area with broad applications in signal reconstruction and image processing. During my master's research, I explored the growth properties of entire functions. This work applied advanced concepts in complex analysis to characterize the comparative growth of composite analytic functions, enriching the theoretical understanding of function behavior in higher-order analytic systems.

Key contribution: Advanced the theoretical understanding of sparsity-based regularization for inverse problems and extended classical results in complex analysis on the growth of entire and composite functions.

Relevance: This foundational work strengthened my expertise in functional analysis and nonlinear dynamics, providing the mathematical rigor that underpins my later research in computational modeling, epidemiology, and systems biology.

Representative publication:

a. Banerjee, D., Saikat Batabyal: Hyper relative order (p, q) of entire functions. Annals of West University of Timisoara - Mathematics and Computer Science (Online ISSN: 1841-3307), 2, 65- 84, (2017)