tcg crest

(Deemed to be University u/s 3 of UGC Act, 1956)

Distinct Category - Research

TCG CREST

School of Health, Environment & Sustainability Studies

Ph.D. Programme

Academic Session: August 2026

Focused Research Areas & Detailed Syllabus

Syllabus

Research Area: Public health policy & Sustainability

SECTION A: Foundations of Public Health (Core Concepts)

1. Epidemiology & Population Health

- Measures of disease frequency & Modes of disease transmission
- Demographic changes
- Disease control, elimination, eradication, reproduction rate
- Screening & diagnostic test evaluation
- Social determinants of health
- Burden of disease and intervention effect comparison (DALY, QALY)

2. Global Health Systems & Governance

- Health systems framework (WHO building blocks)
- Health care under humanitarian conditions
- Role of multilateral agencies (e.g., WHO, World Bank, Global Fund, UNITAID)
- Civil society response: community organisation

3. Health human resources planning methods

- Task shifting, Digital health and AI based health care

4. Health Economics

- Need, Demand and supply of healthcare
- Market failure for health products and market shaping
- Cost-effectiveness analysis (CEA)

SECTION B: Public Policy & Governance

1. Policy Process & Analysis

- Policy cycle (agenda-setting to evaluation)
- Stakeholder mapping and analysis
- Evidence-informed policymaking
- Policy implementation frameworks

2. Governance & Institutions

- Federalism & decentralization
- Regulatory frameworks in health
- Community organisations, NGOs, INGOs
- Public-private partnerships (PPP)

3. Law, Ethics & Rights

- Right to health
- Health equity - justice and marginalisation
- Gender and intersectionality
- Ethics and Bioethics

SECTION C: Sustainability & Development

1. Sustainable Development Frameworks

- Sustainable development theory
- Planetary health
- Climate change & health, Environmental health risks

2. Rural & Community Systems

- Community participation
- Social capital, Livelihood systems & health linkages
- Indigenous knowledge systems

SECTION D: Research Methods (Quantitative & Qualitative)

1. Quantitative Methods

2. Qualitative Methods

- Ethnography, Thematic analysis, Grounded theory, Mixed-methods research

3. Monitoring & Evaluation (M&E)

- Logic models & theory of change
- Process vs outcome evaluation
- Implementation research
- Realist evaluation

SECTION E: Contemporary Public Health Challenges

- Pandemic preparedness & resilience, antimicrobial resistance, non-communicable diseases
- Mental Health, Food systems & nutrition policy
- Digital health governance
- Health inequities & marginalized populations

Syllabus

Research Area: Health data-science & modelling

1. Mathematical Foundations

- Calculus (basic)
- Linear algebra
- Differential equations (especially ODEs; PDEs desirable)
- Basic probability theory

1.1. Statistical Skills

- Statistical inference
- Regression models
- Likelihood-based methods
- Bayesian methods
- Familiarity with uncertainty quantification

1.2. Computational Skills

- Programming (R / Python / MATLAB)
- Simulation techniques
- Numerical methods
- Data handling and cleaning

2. Epidemiology & Public Health Knowledge

- Basic epidemiological measures (incidence, prevalence, R0)
- Compartmental models (SIR, SEIR)
- Surveillance data structure
- Transmission dynamics
- Concepts like herd immunity, vaccine effectiveness

3. Research Preparation

- Modelling or data analysis
- Experience with infectious disease data
- Familiarity with real-world datasets

4. Machine Learning & AI for Health

4.1. Supervised Learning

- k-Nearest Neighbors
- Decision Trees
- Random Forests
- Support Vector Machines
- Neural Networks

4.2. Unsupervised Learning

- Clustering algorithms
- Dimensionality reduction

4.3. Deep Learning

- Convolutional Neural Networks (CNNs)
- Recurrent Neural Networks (RNNs)
- Model evaluation metrics

4.4. Model Validation

- Cross-validation
- Bias-variance trade-off
- Overfitting & regularization

5. Health Informatics

- Electronic Health Records (EHR)
- Data standards (HL7, FHIR)
- Data privacy and ethics (HIPAA/GDPR concepts)

6. Clinical Trials & Biostatistics

- Trial phases
- Randomization techniques
- Power analysis
- Interim analysis

Syllabus

Research Area: Frugal healthtech innovation, including assays and sensors

SECTION A: Research Aptitude

1. **Research Methodology**

- Hypothesis formulation
- Experimental design
- Clinical validation concepts
- Controls and reproducibility
- Bias and Confounding
- Statistical foundations: Probability and Statistical inference
- Data visualization

2. **Scientific Communication**

- Scientific reporting standards and research metrics, ethics
- Intellectual property considerations in research

3. **Innovation & Translation**

- Principles of frugal innovation
- Design thinking
- Reverse engineering
- Cost optimization models
- Technology readiness levels (TRL)
- Regulatory pathways (CDSCO, FDA overview)

SECTION B: Core Syllabus

1. **Biomolecular Foundations**

- Fundamentals of Cell biology
- Immunology fundamentals
- Enzyme kinetics
- Molecular diagnostics (PCR, RT-PCR, CRISPR diagnostics)
- Biomarkers and disease pathways
- Basics of Microbiology

2. **Chemistry for Assay Development**

- Analytical chemistry principles
- Electrochemistry
- Surface chemistry
- Spectroscopy (UV-Vis, Fluorescence)
- Chromatography basics
- Miniaturization and Nanomaterials in diagnostics

3. Physics & Sensor Fundamentals

- Semiconductor and solid-state device principles
- Fundamentals of electromagnetics
- Optics and photonics
- Signal-to-noise ratio and Noise sources
- Transduction mechanisms
- Microfluidics physics

4. Biosensors & Diagnostic Platforms

- Enzymes, antibodies, aptamers
- Lateral flow assays
- ELISA principles
- Lab-on-chip systems
- Paper-based diagnostics
- Wearable biosensors
- Continuous monitoring devices
- Multiplex detection systems

5. Engineering for Frugal Medical Devices

- Embedded system architectures and Programming concepts
- Analog & digital signal conditioning principles
- IoT integration
- Power and Energy management
- System design and architectures for electromechanical systems
- Rapid prototyping methodologies for electromechanical systems

6. Data & Digital Health

- Basics of biomedical signal processing
- Filtering techniques
- Cloud integration

7. Materials & Manufacturing for Low-Cost Devices

- Partitioning of instrument and disposable
- Si in biosensors (hybrid vs integrated approach)
- Polymers for biomedical use
- Biocompatibility basics
- Low-cost fabrication techniques (hybrid vs integrated and thick vs thin film techniques)
- Different moulding processes

8. Clinical Translation & Validation

- Diagnostic performance metrics (sensitivity, specificity, predictive values, ROC analysis)
- Analytical performance parameters (Limit of detection)
- Clinical study design

Syllabus

Research Area: Biodesign

1. Fundamentals of Biological Systems

- Cell biology
- Biomolecules: Proteins, nucleic acids, lipids, carbohydrates
- Genetics and molecular biology: DNA replication, transcription, translation
- Basic microbiology and immunology
- Human physiology (organ systems, homeostasis)
- Systems biology concepts

2. Principles of Engineering for Biological Systems

- Biomechanics (statics, dynamics, mechanics of biological tissues)
- Biomaterials (metals, polymers, ceramics, composites; biocompatibility)
- Bioinstrumentation and sensors
- Signal processing in biological systems
- Embedded systems in healthcare devices
- Fluid mechanics in physiological systems
- Heat and mass transfer in biological applications
- Systems modelling of physiological processes

3. Design Thinking and Innovation in Healthcare

- Design thinking methodology
- User-centered and need-based design
- Clinical immersion process
- Problem identification and need validation
- Concept generation and prototyping
- Human factors engineering
- Usability and ergonomics
- Industrial and product design principles

4. Medical Devices and Diagnostics

- Classification of medical devices
- In-vitro diagnostics (IVD)
- Principles of image-based diagnostics (X-ray, Ultrasound, MRI, PET)
- Wearable health technologies
- Implantable devices
- Point-of-care diagnostics
- Digital health technologies

5. Translational Research and Regulatory Science

- Clinical trials (phases and study design)
- Good Laboratory Practices (GLP)
- Good Manufacturing Practices (GMP)
- Regulatory pathways and risk management
- Intellectual property rights
- Bioethics and research integrity

6. Quantitative Methods and Data Analysis

- Biostatistics (probability, hypothesis testing, regression)
- Experimental design
- Data acquisition systems
- Basics of machine learning in healthcare
- Modelling and simulation in biological systems

7. Biotechnology and Emerging Technologies

- Synthetic biology
- Tissue engineering and regenerative medicine
- Nanobiotechnology
- CRISPR and gene editing basics
- Biosensors and lab-on-chip systems
- AI in healthcare

8. Sustainability and Societal Impact

- Frugal innovation in healthcare
- Global health challenges
- Affordable medical technology design
- Ethical, social, and environmental considerations

Syllabus

Research Area: Assistive Technology

1. Fundamentals of Biological Systems

- Human physiology (organ systems, homeostasis)
- Systems biology concepts

2. Principles of Engineering for Biological Systems

- Biomechanics (statics, dynamics, mechanics of biological tissues)
- Biomaterials (metals, polymers, ceramics, composites; biocompatibility)
- Bioinstrumentation and sensors
- Signal processing in biological systems
- Embedded systems in healthcare devices
- Fluid mechanics in physiological systems
- Heat and mass transfer in biological applications
- Systems modelling of physiological processes

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7. Biotechnology and Emerging Technologies

- Synthetic biology
- Tissue engineering and regenerative medicine
- Nanobiotechnology
- CRISPR and gene editing basics
- Biosensors and lab-on-chip systems
- AI in healthcare

8. Assistive Technology Application Areas

- Prosthetics and orthotics
- Rehabilitation robotics
- Brain–computer interfaces
- Wearable health monitoring
- Accessible communication technologies
- Mobility and sensory assistance devices

9. Sustainability and Societal Impact

- Frugal innovation in healthcare
- Global health challenges
- Affordable medical technology design
- Ethical, social, and environmental considerations