## **Project 3** (Dr. Ehsanul Hoque Apu)

**Title: Computational Strategies for Real-Time Biomechanical Prediction in Craniofacial Injuries Using Physics-Informed Neural Networks: A Mini-Review.**

**Abstract:**
Traditional assessment of complex craniofacial trauma lacks the quantitative accuracy needed for optimal treatment planning. While the Finite Element Method (FEM) provides high-fidelity biomechanical analysis, its computational cost limits clinical use in time-sensitive situations. Physics-based machine learning overcomes this by creating efficient surrogate models that incorporate the governing laws of mechanics, allowing near real-time prediction of fracture patterns and post-operative outcomes with high physical accuracy. This paper discusses key computational methods for combining FEM and physics-informed machine learning (ML), presenting a schematic for a clinical workflow and examining the current limitations of this approach. This work emphasizes a crucial step toward translating advanced computational tools from research into personalized, real-time surgical planning.

**Project PI:** Dr. Ehsanul Hoque Apu, Dept. of Biomedical Sciences, BCOD, Northeast Ohio Medical University (E: ehoqueapu@neomed.edu)
**Project Co-PI:** Dr. Nazeeba Siddika, Dept. of Specialty Dentistry, BCOD, Northeast Ohio Medical University (E: nsiddika@neomed.edu)

**Other NEOMED Faculty Investigators:**
- Dr. Ahmed Abdelkarim, Dept. of Specialty Dentistry, BCOD, NEOMED.
- Dr. Mohammad Ansari, Assistant Professor of Anatomy and Neurobiology

**The specific aims are to:**
1. Search and analyze existing literature.
2. Identify and categorize the computational models, Finite Element Analysis (FEA), Multiphysics Simulation and Machine Learning.
3. From literature, we will evaluate the models, particularly regarding their capacity to predict the progression of hard and soft tissue injuries.
4. Draft a review manuscript and plan for an original study based on the findings.

**What is the specific research question being addressed by the research project?**
- What is the current evidence on variations of existing computational models for predicting the progression of hard and soft tissue injuries.