# IarcoSubmission - Mohi C..pdf

*by* Mr Adnan

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IARCO RESEARCH PROPOSAL

Full Legal Name: Mohima Chakraborty

Institution: East Delta University

Category: Senior

Class/Grade/Year: BSc

Country: Bangladesh

Major (if senior): Electrical & Electronics Engineering

Submission Date: September 30, 2025

Registered Email Address: mohic84@gmail.com

Research Topic: Designing a Biochip Swarm System; An In-Silico Exploration of Swarm Intelligence and Nanotechnology to Neutralize Metastatic Cancer Cells Beyond Existing Therapies to Advance Nanomedicine in Directions Yet Underexplored by Oncology for Detecting, Blocking, and Neutralizing Metastasis Before It Spreads

Title

Designing a Biochip Swarm System; An In-Silico Exploration of Swarm Intelligence and Nanotechnology to Neutralize Metastatic Cancer Cells Beyond Existing Therapies to Advance Nanomedicine in Directions Yet Underexplored by Oncology for Detecting, Blocking, and Neutralizing Metastasis Before It Spreads

Research Problem

Metastasis, the movement of cancer cells from the primary tumor into distant organs, is what causes over 90% of cancer deaths around the world. Although conventional approaches such as surgery, chemotherapy, radiotherapy, and immunotherapy can reduce primary tumor burden, they remain insufficient in preventing or intercepting metastatic progression [2]. Existing nanomedicine and targeted drug-delivery systems show two major weaknesses: (i) they do not support continuous, real-time surveillance of circulating tumor cells (CTCs) and exosome-mediated interactions, both vital for metastasis [4]; and (ii) they display inadequate selectivity, often mistaking normal cells for malignant ones, leading to collateral toxicity and false positives [5]. While biochips and nanoparticle-based drug carriers have demonstrated promising results in either biomarker detection or therapeutic delivery, existing technologies do not provide integrated functionality for real-time surveillance, interception of metastatic signals, and on-demand therapeutic neutralization within the human body [7]. Consequently, there is an urgent need for a multifunctional swarm-like biochip system that can dynamically track metastatic routes, capture and filter CTCs, block exosome communication, and simultaneously release neutralizing agents with embedded safety mechanisms — a gap that remains unaddressed in current oncology and nanotechnology research [10].

Existing Literature

Scientists have made significant progress in technologies to fight metastasis, but some areas still need improvement. For example, Gupta & Lee (2021) created nanoparticles with tumor-specific tags and intelligent release systems to deliver therapies more accurately. Park et al., 2024 developed stimuli-responsive coatings for environment sensitive drug delivery. But these systems still lack real-time adaptability. Li et al. (2023) developed liquid biopsy and microfluidic CTC platforms that can detect cancer at the single-cell level and also created early wearable chip prototypes. But these external chips cannot continuously monitor metastasis inside the body. Zuan et al. (2023) developed liquid biopsy and microfluidic CTC platforms that can detect cancer at the single-cell level and created early wearable chip prototypes. Anwar & Shahid (2022) has found that CRISPR and RNAi are now more accurate, but safe delivery inside the body is still a problem. Lab-on-chip devices can now detect many disease markers at once and use AI to help analyse results (Kumar et al., 2023), but they still work only outside the body. Tiny robots can move using magnets and show early signs of working together

(Torres et al., 2024), but they still can't reliably talk to each other or carry out treatments inside the body in a coordinated way.

## Research Question

The central research question of this proposal examines how a smart swarm of biochips can be developed to safely and accurately detect and stop metastatic cancer cells as they travel through the bloodstream. To answer this, the study focuses on three main areas. First, it studies how well biochips can detect signals of metastasis in real time, such as circulating tumor cells, exosomes, and specific gene markers. Second, it investigates whether different functional modules—such as GPS-like tracking chips, CRISPR-based gene silencers, exosome blockers, and artificial microenvironments—can be effectively integrated to work as a coordinated swarm that targets metastasis without damaging healthy tissues. Third, it focuses on building strong safety features like backup swarms, error filters, and doctor controls to keep the system safe and accurate. This research question is clear and can be tested using computational models, in-silico experiments, and AI simulations. It matters because it combines known technologies in nanomedicine, gene editing, microfluidics, and exosomes into a novel swarm framework to intercept metastasis in real time safely.

## Methodology

This study will be performed entirely in silico using computational models to create a proof of concept. It will use a mix of simulations, real biomedical datasets, and AI/ML algorithms to design and evaluate a swarm of biochips for intercepting metastasis. First, data from TCGA, GEO, and CTC sources will build a digital twin of the bloodstream. This simulation will model blood flow, tumor cell release, exosome communication, and nanoparticle–biochip interactions and generate synthetic data such as ctDNA and antigen levels. Second, machine learning models will be trained to recognize cancer-related signals. Their performance will be explained using SHAP and LIME, and evaluated using standard metrics like sensitivity, specificity, precision, recall, and ROC-AUC. Third, intervention modules—including nanoparticle “GPS chips,” exosome blockers, CRISPR silencers, decoy organ traps, and CTC filters—will be modelled, with a reinforcement learning or rule-based controller coordinating swarm behavior (detection, attack, verification) inspired by natural systems. Finally, the platform will be evaluated on detection accuracy, reduction of simulated metastatic nodules, and response time, with robustness tested under noisy data conditions and safety ensured by verifier swarms, false-positive filters, and human-in-the-loop overrides.

## Research Topic

This project plans to create a swarm of tiny smart chips that stop cancer from spreading. Each chip has a different job—tracking tumor cells, blocking signals, turning off genes, catching harmful cells, trapping cells in decoys, and using AI to deliver medicine only where needed—working together like bees in a hive [13]. This approach tackles one of the biggest problems in cancer treatment: metastasis, which causes almost 90% of cancer deaths worldwide but is still hard to control because current therapies mainly focus on the original tumor. Instead of just reacting to cancer after it spreads, this research aims to stop it early, which could save lives and improve patient outcomes [11]. By combining nanomedicine, microfluidics, and AI-based decision-making, the proposed biochip swarm brings together the latest technologies in a way that is both innovative and increasingly realistic. Metastasis is one of the toughest challenges in cancer, and our idea of a swarm of tiny agents doing different jobs is new and exciting [12]. By using proven science to turn this imagination into a system that stops cancer in real time, this project could change the way we fight cancer and fits perfectly with IARCO's goals of creativity and high impact [14].

Quality of Writing

This proposal is clear, concise, and understandable, with technical words explained simply. The sections follow a logical sequence, and short paragraphs, lists, and headings make the writing easy to follow while keeping it scientifically accurate. The proposal explains complicated topics, such as swarm biochips and exosome inhibition, with analogies (biochips as bees with different roles) so both technical and non-technical readers can follow. Measurable outcomes, such as ≥90% sensitivity and ≥50% metastasis reduction, make the methodology transparent and testable. The writing is clear, polished, and professional.

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