



The Role of A.I in Cell Signaling pathway: The Use of Artificial Intelligence Models to Simulate and Predict Cellular Response

KAZI NAFISUL BASHAR¹

¹ St. Joseph Higher Secondary School (e-mail: kazinafisul@gmail.com)

ABSTRACT Programming and introducing A.I in CSC research can bring about a revolution in our medical sector. Although countries like Bangladesh are producing talented doctors and researchers, the numbers are not sufficient. The use of A.I in CSC research will not be a replacement for experts in this field. It is a tool to increase the number of people in our medical and research faculties. To use A.I in CSC research we must know what kind of role can it play in the cell signaling pathway and how can we actually use it in simulating and predicting cellular response. To do so, we must know if A.I can create cell pathway models and if it does how accurately we can make it work. To ensure maximum accurate results, many interviews must be held with experts. whether or not the A.I can be trusted in this particular job must be understood.

INDEX TERMS A.I, CSC research, cancer stem cell, Pathway modeling, cellular response

I. INTRODUCTION

THE smallest unit that can live on its own and that makes up all living organisms and the tissues of the body is called a cell. Cellular Mutation is any change in the DNA sequence of a cell. Mutations may be caused by mistakes during cell division, or they may be caused by exposure to DNA-damaging agents in the environment. Mutations can be harmful, beneficial, or have no effect. Cell signaling pathways are how cells communicate with each other to conduct their functions [3]. There are distinct types of cell signaling pathways, but they all share a few common features. Signals are classified into three main groups based on the distance they travel. We have three major transmembrane receptor classes: G protein coupled receptors, enzyme-coupled receptors, and ion channel receptors [3]. When a molecule that is part of a cell signal binds to a receptor, it triggers a series of reactions inside the cell that ultimately lead to the desired outcome [3]. There are four basic categories of chemical signaling found in multicellular organisms: paracrine signaling, autocrine signaling, endocrine signaling, and signaling by direct contact [3]. The proper functioning of normal stem cells is an absolute necessity to sustain life [1]. The specific properties that define a stem cell include the ability to self-renew and to generate the multitude of differentiated cellular progeny required to

populate a tissue [1], [4]. In the case of cAMP signaling, the enzyme adenylate cyclase AC is activated, converting ATP to cyclic AMP [3].

These hallmarks have been well established through >50 years of research in hematopoiesis [1]. While continually maintaining their own stem cell pool for the entirety of adult life, hematopoietic stem cells in the bone marrow give rise to increasingly lineage-restricted progenitor cells, which ultimately types produce 10 distinct of daughter cells [1].

Established cellular differentiation pathways may not be exclusive and alternate pathways between various multipotent progenitors and differentiated progeny may also exist [1], [2]. This research proposes to use A.I in addressing cancer stem cell signaling pathways and simulate as well as predict cellular responses but the real research is to see if A.I can make pathway models correctly.

II. RESEARCH OBJECTIVES

1. To evaluate the role of A.I in cell signaling pathway and CSC research [1], [3], [5]
2. To highlight the pros and cons of A.I in pathway modeling [2], [6]
3. To highlight the prospect of doctors and researchers of using A.I in CSC research [1], [2], [3], [7]

III. LITERATURE REVIEW

A. RECENT RESEARCH ON CANCER STEM CELL SIGNALING PATHWAY:

Mounting evidence supports CSCs as the possible cells of origin in the development of many cancers [1]. Although no one CSC model will be sufficient to explain how all cancers develop, or even to explain how different cancers develop within the same tissue, common to many of these hypothetical models is the dysregulation of key signaling pathways [1], [4]. Further understanding how CSCs and their signaling pathways function may lead to the development of new therapeutic approaches [1], [5]. Communities, research groups and database developers got involved in the pathway reconstruction by collating experimental observations from published literature and thus numerous types of biochemical pathways were successfully mapped [2]. Various databases with interactive user-friendly interfaces are now developed to facilitate several operations, such as pathway data retrieval, sharing and storing process [2]. This in turn helps to store these enormous amounts of constructed pathway data in a proper format and to retrieve easily across the internet [2]. As biology begins to move into the "postgenomic" era, a key emerging question is how to approach the understanding of how complex biomolecular networks function as dynamical systems [3]. Prominent examples include multimolecular protein "machines," intracellular signal transduction cascades, and cell-cell communication mechanisms [3].

B. RESEARCH ON CANCER STEM CELL SIGNALING PATHWAY:

As the cure of cancer has not been invented yet, doctors advise treating cancer properly and try to prevent it if possible. But the supervision on cancer stem cells is never enough [1]. Many institutes are using A.I in cancer stem cell signaling pathways. CSC (cancer stem cell) research has increased at a prominent level; A.I is being used in predicting drug target interactions [6], single-cell analysis [7], and pathway modeling [1], [2]. This research is going to be targeting the pathway modeling. A.I is used to simulate CSC signaling pathways to predict how changes in specific genes or proteins affect pathway dynamics [2], [3], [5]. A.I can also be used to evaluate hypothetical interventions in silico [3], [6].

C. GAPS IN PRIOR RESEARCH:

The studies certainly show the perfect data on cancer stem cell signaling pathway [1], [2], [3], but the accuracy of the pathway model should have been prioritized [4], [5]. The gap in this field is proposed to be filled in this research.

D. IMPLICATIONS FOR RESEARCH DESIGN AND FOCUS:

This literature review only focuses on the deepest use of A.I. in pathway modeling of CSC [1], [2], [3], [5].

IV. RESEARCH METHODOLOGIES

This research shall represent analyzed data on the merits and demerits of the use of A.I in modeling CSC pathways [1], [2], [3].

A. QUALITATIVE PHASE:

Interviews with researchers and doctors has been held. The research questions has been asked and the answers has been analyzed thoroughly. How A.I can be used in modeling pathways has been discussed deeply [2], [3] and why did not the previous researchers prioritize pathway modeling has been discussed [1], [2], [5].

B. QUANTITATIVE PHASE:

A small survey of 100 people has been conducted including doctors, biologists, genetic engineers, medical students, specialized A.I engineers, professors and people from various fields. .

V. RESULTS AND DISCUSSIONS

A. POSITIVE OVERVIEW

A.I can actually be used in pathway modeling and CSC research [1], [2], [3], [4], [5]. Many physicians seek the help of an A.I in diagnostics [8]. Most of the users were intern doctors who used A.I to know the side effects of certain medicines to prescribe the patients their medication properly [8]. Some of the general people who joined our survey mentioned verifying their symptoms with diseases using A.I [8]. This concludes that people of Bangladesh are starting to trust A.I more than before and this may be the new radiance towards the use of A.I in Bangladesh Medical Sector. article graphicx

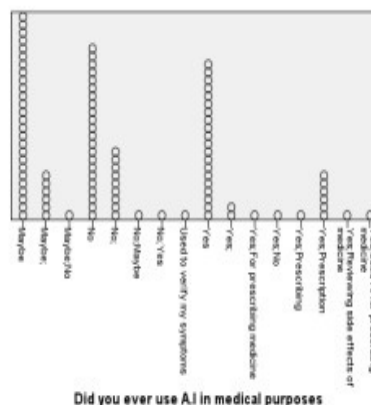


FIGURE 1. The simple dotted column graph shows reviews of people from various sectors.

B. POTENTIAL ISSUES AND CONCERNS

1. Reviews by Experts

For better analysis we used an A.I generated Pathway model and asked them about the details accuracy [2], [5]. Sadly, most of the researchers gave it a bad rating and most of the professors remained neutral. In our Qualitative Phase we interviewed many professors and researchers and some of them gave A.I a positive potential but most of the reviews were neutral or negative. We asked them why they did or did not prefer the A.I generated model. They mentioned the relevance of visual elements to be accurate and they found errors in the generated texts [2], [3]. As the survey included A.I or IT experts, their overall view was that the color balance, contrast, alignment and symmetry was good. But the Biologists exclaimed that there was a clarity of the message being conveyed and surprisingly they mentioned the completeness of information [2]. The overall review of the A.I in pathway modeling was 3.47 stars. All of the people were experienced in their own field.

2) Reviews by Students

After seeing reviews from experts, most of the students claimed that A.I will be able to generate more accurate models [1], [3], [6]. When they were questioned why they thought so, they compared the development of A.I throughout the years. A.I has been developed on a potential level for this. A.I can already generate images and can write down research papers based on the input [2], [3]. The students participated in this cross-sectional survey are the future doctors and biologists studying among the most reputed institutions in Bangladesh.

3) Overall Review

This concludes that A.I is yet to be fully trusted in CSC research and cell pathway modeling [1], [2], [3]. But it can be said that in the better future A.I has the enough potential to work hand to hand with researchers in Cancer stem cell research [1], [4], [5] and doctors in Cancer treatment [1], [7], [8].

VALUES FROM THE SURVEY

topic	Values
Total participation of experts	302
Rating of A.I pathway Model	3.47
Used A.I in Medical purpose	45 people
Prefer using A.I in pathway modeling	45 percent

VI.CONCLUSION

This research has successfully interviewed experts and analyzed data from previous research papers [1], [2], [3]. Hoping the A.I will take a better role in CSC research as well as pathway modeling [2], [4], [5] and medical treatment [1], [7], [8], this research is concluded here. This research may inspire others to discover more on the use of A.I in CSC research [1], [2], [3], [6].

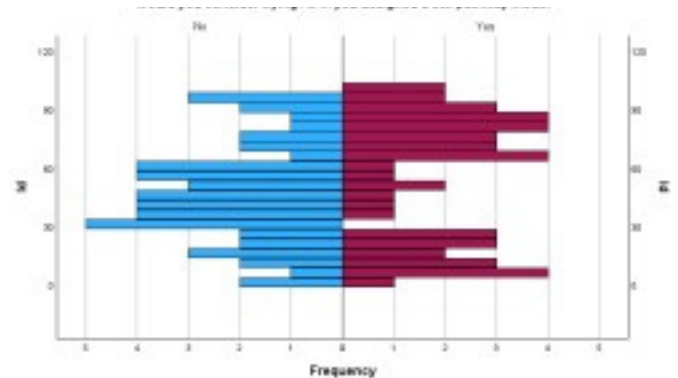


FIGURE 2. This indicates that most of the experts won't even consider using A.I in call pathway modeling . Blue is positive response and red is negative

REFERENCES

- [1] W. H. Matsui, "Cancer stem cell signaling pathways," *Medicine*, vol. 95, no. 1S, pp. S8–S19, 2016.
- [2] S. Chowdhury and R. R. Sarkar, "Comparison of human cell signaling pathway databases—evolution, drawbacks and challenges," *Database*, vol. 2015, p. bau126, 2015.
- [3] D. A. Lauffenburger, "Cell signaling pathways as control modules: complexity for simplicity?," *Proceedings of the National Academy of Sciences*, vol. 97, no. 10, pp. 5031–5033, 2000.
- [4] X. Huang et al., "Single-cell multi-omics and machine learning for dissecting stemness in cancer," *Briefings in Bioinformatics*, vol. 26, no. 5, p. bbaf566, 2025.
- [5] K. Takasawa et al., "Single-cell analysis using machine learning techniques and its application to medical research," *Biomedicine*, vol. 9, no. 11, p. 1513, 2021.
- [6] V. R. Umapathy et al., "Perspective of artificial intelligence in disease diagnosis: a review of current and future endeavours in the medical field," *Cureus*, vol. 15, no. 9, p. e45684, 2023.
- [7] A. Ramović Hamzagić et al., "Machine learning model for prediction of development of cancer stem cell subpopulation in tumors subjected to polystyrene nanoparticles," *Toxics*, vol. 12, no. 5, p. 354, 2024.
- [8] V. Kulkarni et al., "Artificial intelligence in healthcare diagnostics: a literature review," *Open Access Library Journal*, 2025.

VII. ABOUT AUTHOR

[Kazi Nafisul Bashar] is a Bangladeshi student researcher, youth organizer, and aspiring genetic engineering researcher with interests in biotechnology, genetics, astronomy, computer science, philosophy, and interdisciplinary research. He is the CEO of Silvane, founder of "Orion Hatch" and co founder of the Josephite News Portal. Nafis received a Gold Award in The Queen's Commonwealth Essay Competition and a Bronze Honor in International Astronomy and Astrophysics Competition . He was also a finalist in both International Computer Science Competition and International Academic Research Competition . He serves as a leader of BioDams, a biology-focused initiative connected to his growing interest in genetics, biotechnology, and research. He completed the Winter Research Program organized by YRJ , where he developed skills in academic writing and research methodology. He is continuing his research on CSC, Biotechnology, AI. At St. Joseph , Nafis served as the Vice President of the Josephite IT Club, Asst. General Secretary of Josephite Math Club, Co-Author at Josephite Writers' Forum and participated actively in Olympiads, STEM programs, and student leadership initiatives. Through Orion Hatch and collaborative student teams, he hosted the International Aurora Research Challenge and the Astro Essay Challenge, initiatives aimed at encouraging research culture, scientific curiosity, and youth participation in STEM and writing. Alongside his scientific interests, Nafis is also involved in creative writing and philosophical studies exploring psychology, existentialism, and human behavior. He is a karate practitioner with a brown belt. Nafis aims to pursue higher education and research in Chemical Biological engineering and biotechnology while continuing his work in research, youth leadership, and science outreach.