IAA Journal of Biological Sciences 13(1):1-8, 2025
©IAAJOURNALS
https://doi.org/10.59298/IAAJB/2025/13118
www.iaajournals.org
ISSN:2636-7254
IAAJB131

Community Health: Engineering Collaborations Across Disciplines

Odile Patrick Thalia

Faculty of Biological Sciences Kampala International University Uganda

ABSTRACT

The complexity of contemporary public health challenges exacerbated by globalization, climate change, urbanization, and socio-economic inequality requires a strategic departure from siloed responses toward interdisciplinary collaboration. This paper proposes a participatory action planning framework that leverages engineering innovation, co-design principles, and community engagement to address health disparities and systemic inefficiencies. By integrating insights from epidemiology, systems engineering, bioengineering, and public policy, this framework aims to support equitable health outcomes through collaborative problem-solving and technological advancements. We examine how engineering disciplines have contributed to solving real-world health issues from low-cost diagnostics in low-income regions to mobile health platforms and patient safety initiatives in clinical environments. The paper also explores models of interdisciplinary collaboration, the role of funding, and strategies for community engagement. Ultimately, this research presents a compelling case for the integration of engineering into the fabric of community health, offering new pathways for sustainable and inclusive health solutions.

Keywords: Community Health, Health Disparities Interdisciplinary Collaboration, Systems Engineering, Bioengineering, Participatory Design.

INTRODUCTION

Globalization, economic shifts, human migrations, and climate changes have made public health more complex in urban areas. While coordinated health actions have increased, they lack sufficient guiding knowledge and tools. Successful design-driven collaborative frameworks in other sectors have not been widely applied to public health. This article aims to develop a participatory action planning framework to support effective public health collaborations addressing complex adaptive and social contagion issues. Theoretical implications on knowledge integration in community health guide this effort. Health systems globally struggle to design and deliver effective services for communicable and non-communicable diseases amidst rapid urbanization and growing public distrust. Notably, population health declines when vulnerable groups cannot access needed services, leading to significant long-term costs from ignoring disparities. Strategies effective in other fields must be adopted in public health, which has relied on strategic design applications to influence social behavior from a systemic viewpoint. Co-design approaches that unite multidisciplinary teams have shown success in tackling social inclusion, homelessness, food insecurity, and public health issues but remain underutilized in public health. For instance, the sector often relies on formal policy tools for social behavior influence while maintaining a top-down communication approach. Such methods reflect a misunderstanding of public health metaphors and fail to harness necessary collaborative processes. Design principles and strategic planning have been successfully applied in other contexts, indicating the potential of participatory action planning frameworks in community engagement [1, 2].

The Role of Engineering in Community Health

In the United States, despite having advanced healthcare and numerous treatment options, health disparities (HD) among different populations are a growing issue. The Centers for Disease Control and Prevention define HD as variations in disease incidence and prevalence among socio-economically disadvantaged groups. These disparities arise from two key factors: the severity of illnesses can be higher in certain populations, and access to timely treatment can be significantly delayed. Systems engineering offers a way to address HD across public health by using modeling and optimization to uncover the

reasons behind disparities in access and disease impact. However, engineering alone isn't sufficient; integrating perspectives from other disciplines is essential to identify systemic flaws that contribute to or create disparities. Epidemiology can explore the biological mechanisms behind increased hypertension in African Americans or obesity in Native Americans, while economic theories can assess factors impacting access to prenatal care among Hispanics. Empowering frontline healthcare providers through participatory modeling can yield innovative approaches to treatment delivery that should be monitored closely. Insights from varied expert perspectives can clarify the complexities of health disparities, and mechanistic models can help to illustrate causative factors leading to observable disparities in population health [3, 4].

Interdisciplinary Collaboration Models

In developing this manuscript section for a cross-institution collaboration in engineering education, the aim is to discuss interdisciplinary collaborations related to engineering health partnerships. Future work plans will highlight various partnership models across disciplines and institutions. Collaboration across disciplines is a modern trend, supported by some funding sources that emphasize minority populations in research. While groups often form teams, achieving the end goal requires collaboration. Clear goals for each research period must be established, along with expectations for all participants, considering how credit for published work varies between fields. Collaboration may evolve as new techniques emerge. For instance, an interdisciplinary project in astronomy and computer engineering transformed a video digest of student learning into a new field of education research. Similarly, a bachelor's thesis on signal characterization in astrophysics became an algorithm focused on light distribution and image enhancement. In proposals, goals must remain specific and clearly communicated among team members. Many engineering careers focus on single disciplines, yet projects have shown how mechanical, civil, and microbiological engineers can collaboratively tackle global health issues through nutrition microsensors, enhancing both early-stage food detection and microfluidic sample preparation. These teams succeeded at their broad interface, reassessing and remodeling existing papers to suit various engineering journals and fostering interdisciplinary scholarship. Regular bi-weekly one-on-one and small group writing meetings can further sustain the writing process [5, 6].

Public Health Challenges Addressed by Engineering

In lower-income countries, public health problems including high prevalence of infectious diseases, malnutrition, and reduced access to healthcare, are often viewed as social problems that require social solutions. In the engineering sector, biotechnology and distributed wireless technology present opportunities to address these public health challenges with innovative, cost-effective solutions. However, in lower-income countries, public health problems are typically not framed as technical questions requiring engineering solutions. Early adoption of technologies, unless accompanied by behavior modification, surveillance, and enforcement, are unlikely to bring about behavioral change or improve public health outcomes. Implementation science that includes coaching, problem solving, and a focus on how to make new behaviors sustainable is critical. Bioengineering tools such as low-cost diagnostics for detection of STDs at the point-of-care, computerized surveillance for real-time community detection of waterborne diseases, and compact membrane bioreactors for decentralized treatment of wastewater, represent science and engineering advances that stand to reduce poor health in lower and lower-middle income countries. Extension and dissemination of bioengineered tools requires partnerships with engaged public health professionals. Global public health problems in lower and lower-middle income countries receive little attention on most engineering campuses. Such problems require engineered solutions, but engineering faculties are unaware of them, and huge multidisciplinary engineering teams are needed to address them. Therefore, it is important to develop links between engineering laboratories and lower and lower-middle income country institutions. Furthermore, mechanisms for support are needed to bring public health professionals and engineering scientists together. Engineering and science students brought early-stage bioengineering tools go to developing countries, but they need training in technology dissemination, and patience in the face of inevitable failures. Community use of bioengineering tools requires local ownership and design-in flexibility. Technology adoption requires methodologies to understand social norms and design-in breadth of use. Capacity development of engineers trained in these disciplines is needed in lower and lower-middle income countries. Public health students and experts tend to see problems in social terms, whereas engineering students viewing problems in scientific terms. This gulf in perceptions currently exceeds mechanisms to bridge it and goes unaddressed [7, 8].

Technological Innovations in Community Health

Recent years have seen tremendous interest in technological innovation to address societal needs such as health. Access to standard medical care and pharmaceuticals varies considerably between high-income and low-income regions, leading to health disparities. This paper highlights the role that glaring differences in most aspects of life have on health. Addressing the pressing needs of communities can go well beyond health. But these needs act as a powerful driver for developing innovative solutions. In addition to fascinating physics, mathematics, and engineering problems, health challenges also require meticulous real-life testing and prototyping in the field. Recently, community members have been trained and engaged to help understand the issues of concern, discover existing solutions, co-generate new ideas for improvement, and develop technical solutions. Technological innovations alone will not resolve health disparities, but they can help redress imbalances, if ethically developed with particular emphasis on power relationships as well as the good that can be generate. A wealth of solutions can be documented across technologies, industries, and applications, leading to improved performance, efficiency, and quality. Patterning and micro-manufacturing of paradigms and devices found in nature offers opportunities for spiritual reinforcement solutions. Asset and production management solutions arising out of the finance and energy sectors may provide robust yet flexible approaches for improved forecasting and epidemic modeling. Large-scale longitudinal studies of populations to evaluate cost-effectiveness and identify chronic population health trajectories, combined with low-cost wearable sensors to measure risk factors and gene transmission, are critical for better prevention and management of infectious diseases. Interventions can make use of a wealth of mobile telephony solutions for monitoring, communicating, and financial transactions that are universally applicable. Solutions developed by a venture capital portfolio are questioned as those designed to address affordability issues in addition to durability and quality [9, 10].

Community Engagement Strategies

Leveraging the right intellectual capacity with community-based academics is crucial to genuinely understand the community for tech interventions. Community engagement aims to grasp the needs of potential users in health domains, focusing on qualitative evidence regarding users' unmet needs, barriers, and motivators. This engagement aids in digitalizing manual, culturally-competent health solutions tailored to target communities. It serves as a preliminary step to explore diverse community needs and determine the necessary digital formats/content to communicate effectively. Technologies in accessible formats will be promoted through community development and health agency engagement. Phase two focuses on deeper engagement with community partners. When tech-enabled platforms are ready, it's vital to identify and empower partners committed to culturally-appropriate digital health solutions. CE partners should be large regional firms with a presence in affected areas, ensuring accessibility and cultural competence. They can promote app usage by driving behavior change through advocacy forums, particularly targeting community partners involved in CE Phase-1. This setup fosters amicable collaboration for future phases. In phase two, advancing knowledge among amateur community workers at partner levels is essential. Understanding their domain knowledge aids in data sharing and coding, addressing often overlooked challenges. To enhance health intervention engagement in this phase, it's crucial to define effective strategies for building partnerships with local institutions and hospitals, establishing ambassador tools, and implementing tech-enabled health solutions in demo-centers or workshops to support health campaigns and advocacy, as well as collaborating with tele-health networks for on-demand services throughout the campaign [11, 12].

Policy and Regulation in Community Health Engineering

Engineers often want to consult on policies related to their work and may seek to influence regulations or team up with those who are more established in public policy. Involving experts from the design community who have experience in creating policy strategies can enhance engineer-led efforts. Policy experts can provide insights on the relationships and interests that affect initiatives and advice on communication. Legal experts can help consider types of legal precedents and enforcement. The intersection of health engineering, research, and public policy can blur, especially during the innovation phase, but established systems typically attract public health oversight. Veteran public health experts can guide how to present cases to authorities and influence public health regulations. An interdisciplinary research community is devoted to global health issues, but financial and institutional investments are essential for improving the quality and quantity of engineers in health engineering. Innovative collaborations across disciplines may address funding challenges. Pilot programs that link institutions in high-income nations with those in low-income areas could supplement local fellowships. Partnerships

with development initiatives may foster new health engineering projects aligned with local regulations, enhancing expertise. By aligning with health stakeholders' interests, engineers can pinpoint areas for significant impact. There are vast opportunities in health engineering for the development of analytical tools and technologies, which can lead to competitive grants discussions. Funded pilot efforts can create effective, practical pathways for developing local partnerships critical for sustained implementation [13, 14].

Funding and Resource Allocation

Having adequate resources is essential for successful collaborations in engineering and clinical teamwork aimed at improving patient care. Continuous emphasis on resource allocation can enhance collaboration sustainability. Key priorities include securing a permanent program manager to oversee operations, ensuring longitudinal financial support, and distributing funding widely to successful institutions. A program manager can alleviate barriers related to logistics and recruitment costs. Continuous funding is vital for structured projects, as many initiatives currently rely on independent, temporary funding sources. Addressing specific needs of engineers, clinicians, and patients is crucial for effective collaborations. Clinical hosts stress the importance of understanding engineering principles within their context, necessitating resources such as established communication channels, clinician participation at events, user-friendly online manuals, and institution-specific resources. Engineers face challenges in collaborating with non-engineers due to differing thought processes. Potential solutions include sharing design concepts, allowing clinicians to thoroughly explain their methodologies, and structuring collaboration groups to optimize specialties. Furthermore, engineers should engage directly in patient care settings to grasp real-world challenges, which could involve sending successful collaboration team members to medical facilities for discussions and evaluations. Furthermore, inviting engineers to patient safety committee meetings can deepen their understanding of patient care issues. Implementing these strategies aims to foster innovative collaborations that address health disparities and enhance patient care [15, 16].

Evaluation and Impact Assessment

Evaluation and Impact Assessment: Engineering collaborations addressing hospital patient safety problems. Health care practitioners often pinpoint safety issues in hospitals that engineering collaborations can effectively tackle, potentially exposing future health care engineers to significant clinical challenges. A pilot project integrated students from the Department of Biomedical Engineering into hospitals to work alongside health care professionals on these patient safety issues. Through a needs-based selection, students formed teams with clinical staff to prioritize and resolve pressing safety concerns. Each team dedicated two days a week for 8 weeks to their assigned site, concluding with weekly progress presentations. After data collection and analysis, teams proposed recommendations for cultural and systemic changes to enhance patient safety. At the conclusion, teams produced comprehensive reports and presented their findings, while both students and site leaders conducted mid- and final evaluations. Feedback indicated the necessity for improved training to enhance students' success in patient care engineering. There were calls for better alignment on expectations and commitment, as engagement varied among host clinicians. Faculty oversight was identified as a limit, with students unclear on success measures and the credibility of their findings. Many students requested additional training in ethnographic methods, which they found challenging to implement within the limited project timeline. Despite these challenges, initial evaluation results indicated success in meeting the program's objectives. A follow-up survey revealed that 71% of students believed the course could influence their career paths, suggesting potential growth in interest for clinician-engineering collaboration. Even students doubting future collaboration noted shifts in their perspectives. Clinical hosts echoed similar sentiments, with 71% acknowledging their organizations were acting on student findings and 86% reporting changed views on the projects. Both hosts and students recognized the need for improvements but advocated for the program's continuation and expansion for future cohort [17-20].

Future Directions in Community Health Engineering

Traditionally, global health has been viewed purely as a public health domain. Additions of other disciplines, including engineering, have rarely been made. Constraints have also existed regarding the abilities of engineers to effectively frame public health challenges as engineering challenges. Simultaneously, engineers have not systemically included the topic into the educational curriculum, and the global health research community has neglected the topic. Until this gap is bridged, it will be impossible to enact a shift toward stronger disciplinary inclusion, and public health challenges will not be sufficiently addressed. A vastly different vision of the academic community in which engineers are deeply

engaged in the design, development, and implementation of robust tools goes unfulfilled. To truly embrace the challenges of global health research, a plan for engaging consideration of public health challenges as engineering challenges is proposed. In the near term, participants must be educated about the nature of this problem, the various considerations that must be pondered, and the opportunities for new avenues of inquiry. On a broader time horizon, there is a need for structured opportunities for interdisciplinary collaboration to grow from public health challenges, along with an ongoing academic community that has an eye toward the inclusion of engineers in the engineering side of this collaboration. It follows that a set of solid fundamental principles is required for conversations across disciplines. The goal of this section is to frame the nature of the current problem, provide recommendations for a participatory workshop aimed at creating new directions, and explore the long-term implications of this effort [21-23].

CONCLUSION

As global health threats grow more interconnected and complex, the need for interdisciplinary collaboration becomes more urgent. This paper has highlighted the transformative potential of integrating engineering into public health through participatory frameworks, co-design, and technological innovation. By uniting engineers, clinicians, community stakeholders, and policymakers, we can develop adaptive solutions that are culturally competent, technically sound, and socially impactful. The challenges of global and community health cannot be addressed through public health expertise alone; rather, they require the collective intelligence of diverse disciplines. Institutional support, funding mechanisms, and educational reforms must align to promote these collaborative efforts. Bridging the disciplinary divide is not merely a strategic advantage, it is a necessity for building resilient, equitable, and sustainable health systems. Future directions should focus on establishing long-term academic and institutional partnerships that support scalable, locally-tailored engineering solutions in global and community health contexts.

REFERENCES

1. Vazquez M. Engaging biomedical engineering in health disparities challenges. Journal of community medicine & health education. 2018 Mar 5;8(2):595.
2. Andrawes L, Johnson T, Coleman M. Complexity in health: can design help support interdisciplinary solutions?. Global Health: Science and Practice. 2021 Nov 29;9(Supplement 2):S217-25.
3. Le DD, Leon-Gonzalez R, Giang TL, Nguyen AT. Socio-economic-related health inequality in non-communicable diseases among older people in Viet Nam. Ageing & Society. 2021 Jun;41(6):1421-48.
4. Karran EL, Grant AR, Lee H, Kamper SJ, Williams CM, Wiles LK, Shala R, Poddar CV, Astill T, Moseley GL. Do health education initiatives assist socioeconomically disadvantaged populations? A systematic review and meta-analyses. BMC Public Health. 2023 Mar 8;23(1):453. springer.com
5. Dusdal J, Powell JJ. Benefits, motivations, and challenges of international collaborative research: a sociology of science case study. Science and Public Policy. 2021 Apr 1;48(2):235-45.
6. Ingale KK, Paluri RA. Financial literacy and financial behaviour: A bibliometric analysis. Review of Behavioral Finance. 2022 Mar 2;14(1):130-54.
7. Daher-Nashif S. In sickness and in health: The politics of public health and their implications during the COVID-19 pandemic. Sociology Compass. 2022 Jan;16(1):e12949.
8. Passet-Wittig J, Bujard M. Medically assisted reproduction in developed countries: Overview and societal challenges. Research Handbook on the Sociology of the Family. 2021 Jun 11:417-38. elgaronline.com
9. Ugwu CN, Ugwu OP, Alum EU, Eze VH, Basajja M, Ugwu JN, Ogenyi FC, Ejemot-Nwadiaro RI, Okon MB, Egba SI, Uti DE. Medical preparedness for bioterrorism and chemical warfare: A public health integration review. Medicine. 2025 May 2;104(18):e42289.
10. Wells JC, Sharma S, Del Paggio JC, Hopman WM, Gyawali B, Mukherji D, Hammad N, Pramesh CS, Aggarwal A, Sullivan R, Booth CM. An analysis of contemporary oncology randomized clinical trials from low/middle-income vs high-income countries. JAMA oncology. 2021 Mar 1;7(3):379-85. jamanetwork.com

11. Ocran Mattila P, Ahmad R, Hasan SS, Babar ZU. Availability, affordability, access, and pricing of anti-cancer medicines in low-and middle-income countries: a systematic review of literature. Frontiers in Public Health. 2021 Apr 30;9:628744. frontiersin.org
12. Baines R, Bradwell H, Edwards K, Stevens S, Prime S, Tredinnick-Rowe J, Sibley M, Chatterjee A. Meaningful patient and public involvement in digital health innovation, implementation and evaluation: a systematic review. Health Expectations. 2022 Aug;25(4):1232-45. wiley.com
13. Ocloo J, Garfield S, Franklin BD, Dawson S. Exploring the theory, barriers and enablers for patient and public involvement across health, social care and patient safety: a systematic review of reviews. Health research policy and systems. 2021 Dec;19:1-21. springer.com
14. Wen J, Wang W, Kozak M, Liu X, Hou H. Many brains are better than one: the importance of interdisciplinary studies on COVID-19 in and beyond tourism. Tourism Recreation Research. 2021 Apr 3;46(2):310-3. deu.edu.tr
15. Ugwu CN, Ugwu OP, Alum EU, Eze VH, Basajja M, Ugwu JN, Ogenyi FC, Ejemot-Nwadiaro RI, Okon MB, Egba SI, Uti DE. Sustainable development goals (SDGs) and resilient healthcare systems: Addressing medicine and public health challenges in conflict zones. Medicine. 2025 Feb 14;104(7):e41535.
16. Calleja N, AbdAllah A, Abad N, Ahmed N, Albarracin D, Altieri E, Anoko JN, Arcos R, Azlan AA, Bayer J, Bechmann A. A public health research agenda for managing infodemics: methods and results of the first WHO infodemiology conference. JMIR infodemiology. 2021 Sep 15;1(1):e30979. jmir.org
17. Nwulu EO, Elete TY, Omomo KO, Akano OA, Erhueh OV. The importance of interdisciplinary collaboration for successful engineering project completions: A strategic framework. World Journal of Engineering and Technology Research. 2023;2(3):48-56. researchgate.net
18. Ongesa TN, Ugwu OP, Ugwu CN, Alum EU, Eze VH, Basajja M, Ugwu JN, Ogenyi FC, Okon MB, Ejemot-Nwadiaro RI. Optimizing emergency response systems in urban health crises: A project management approach to public health preparedness and response. Medicine. 2025 Jan 17;104(3):e41279.
19. Shaker MS, Oppenheimer J, Verdi M, Anagnostou A, Abrams EM, Blatman KH, Hand M, Spergel JM, Lang DM. Teamwork in clinical medicine. The Journal of Allergy and Clinical Immunology: In Practice. 2024 Dec 1;12(12):3261-8. [HTML]
20. Han J, Kelley T, Knowles JG. Factors influencing student STEM learning: Self-efficacy and outcome expectancy, 21st century skills, and career awareness. Journal for STEM Education Research. 2021 Sep;4(2):117-37.
21. Tavakoly Sany SB, Aman N, Jangi F, Lael-Monfared E, Tehrani H, Jafari A. Quality of life and life satisfaction among university students: Exploring, subjective norms, general health, optimism, and attitude as potential mediators. Journal of American College Health. 2023 May 4;71(4):1045-52. [HTML]
22. Jacobsen KH. Introduction to global health. Jones & Bartlett Learning; 2022 Oct 10.
23. Van Druten VP, Bartels EA, Van de Mheen D, De Vries E, Kerckhoffs AP, Nahar-van Venrooij LM. Concepts of health in different contexts: a scoping review. BMC health services research. 2022 Mar 24;22(1):389. springer.com

CITE AS: Odile Patrick Thalia (2025). Community Health: Engineering Collaborations Across Disciplines. IAA Journal of Biological Sciences 13(1):96-101.
https://doi.org/10.59298/IAAJB/2025/13196101