Pedagogical Pathways to Strengthen Interdisciplinary Readiness for the Data-Driven Future of Health

Tiffiny Shockley
PhD, MBA, CPHIMS, CHES, HITCM-PP, Queens University of Charlotte
profshockley@yahoo.com; ORCID 0000-0003-1378-6033

ABSTRACT: The rapid digital transformation of healthcare elevates the importance of building a workforce with strong interdisciplinary competence and advanced data literacy. Through strengthening these capabilities, organizations can ensure that digital health innovations promote equity, enhance public trust, and improve the overall effectiveness of health systems. This perspective paper explores innovative pedagogical strategies to strengthen interdisciplinary readiness for the data-driven future of health. Traditional health education models often operate within disciplinary silos, limiting students' ability to engage with complex, real-world challenges that require integrated knowledge across the health sciences, law, technology, data analytics, and social determinants of health. To address these limitations, the paper examines how curriculum redesign, applied learning, and interprofessional collaboration can break down disciplinary barriers. The proposed framework introduces four key pillars that include critical data literacy, applied ethics and anticipatory governance, cultural and contextual competence, and global regulatory fluency. These interconnected areas serve as a foundation for transforming education to meet the demands of a digitally integrated health landscape.

KEYWORDS: interdisciplinary readiness, pedagogical strategies, health data systems

Introduction

In today's data-centric health landscape, the ability to work across disciplines is no longer optional; it is foundational to building effective, ethical, and equitable health systems (Frenk et al., 2010; Veinot et al., 2018). Digital technologies are transforming every facet of care, from diagnostics to public health interventions, creating new opportunities while also introducing novel risks and deepening existing inequities (Vayena et al., 2018; Kostkova et al., 2021). Successfully responding to the evolving demands of digital health requires more than integrated coursework.

Traditional health education, however, often falls short. Programs remain constrained by disciplinary silos that limit students' readiness to address the complex, interconnected challenges they will encounter in practice (Morley et al., 2020). Emerging roles in health informatics, AI governance, and digital ethics call for interdisciplinary fluency, cultural awareness, and systems-level thinking. To meet these demands, future health leaders must cultivate adaptive competencies

that allow them to navigate ethical, regulatory, and technological uncertainty with confidence (Leslie et al., 2021).

Educators play a key role in reshaping learning environments to ensure the next generation of health professionals is equipped to lead in this increasingly complex, data-driven world (Frenk et al., 2010; Kukutai & Taylor, 2016). This paper focuses on four essential, interconnected pillars of interdisciplinary readiness: critical data literacy, applied ethics and anticipatory governance, cultural and contextual competence, and global regulatory fluency. Figure 1 illustrates the four pillars that serve as the conceptual framework for this analysis.
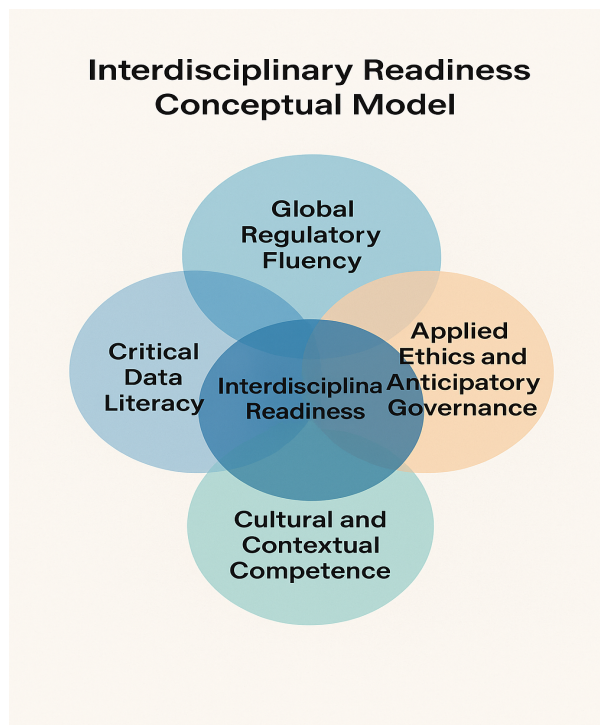

Figure 1. Conceptual Framework: Four Pillars of Interdisciplinary Readiness for a Data-Driven Health Future

The proposed conceptual framework, illustrated in Figure 1, outlines four essential competencies that are foundational to preparing learners for the data-driven future of health. Each domain addresses a core readiness area that students must develop in order to navigate complex and evolving digital health systems. Critical data literacy emphasizes the importance of understanding how data is collected, who controls it, and how it shapes health outcomes and equity. Applied ethics and anticipatory governance equip learners to proactively assess the social and moral implications of emerging technologies. Cultural and contextual competence centers the lived experiences of diverse populations and the importance of trust in digital health ecosystems. Lastly, global regulatory fluency ensures that students understand and can operate within a wide range of international legal and policy environments. Taken together, these pillars provide a roadmap for integrating interdisciplinary values into digital health education.

The Limits of Traditional Interdisciplinarity

Academic programs in medicine, public health, law, and information science have made important strides in cross-disciplinary training. However, simply combining siloed content from different fields does not adequately prepare students to confront real-world dilemmas where legal mandates, data constraints, and human outcomes intersect (Kostkova et al., 2021). For example, health informatics professionals may be trained in data management but lack the legal literacy needed to interpret privacy regulations like the Health Insurance Portability and Accountability Act (HIPAA) or the General Data Protection Regulation (GDPR) in practice, while clinicians may encounter digital tools without understanding their algorithmic biases or limitations (Vayena et al., 2018; Leslie et al., 2021).

What is needed is a deliberate shift toward integrative, systems-level thinking which is an approach that encourages individuals to see health challenges not as isolated problems, but as interconnected issues shaped by policies, technologies, institutions, and social dynamics (Frenk et al., 2010; Sweeney & Van Dyk, 2022). This perspective enables future professionals to anticipate how decisions in one area, such as algorithm design or data sharing, can ripple through the broader healthcare ecosystem (Reddy et al., 2020). Systems-level thinking creates space for ethical reflexivity, prompting learners to continually question not only what can be done with digital tools, but what *should* be done (Floridi, 2019). It also supports critical inquiry by encouraging the examination of underlying assumptions, power structures, and unintended consequences. These skills are vital for identifying and addressing inequities embedded within digital health systems (Benjamin, 2019; Eubanks, 2018). These competencies remain underdeveloped in traditional education models that emphasize narrow specialization over interdisciplinary collaboration and reflection (Hoffman et al., 2021). Though many programs currently offer interdisciplinary exposure, they often do so through fragmented or parallel tracks rather than cultivating truly integrated understanding. As a result, students may lack the ability to synthesize diverse perspectives, interrogate underlying assumptions, or anticipate the systemic consequences of their decisions.

Complex health challenges such as AI-driven clinical decision-making, the responsible deployment of digital surveillance tools, and tensions between patient autonomy and public health mandates demand more than baseline disciplinary knowledge. These challenges are multi-dimensional and fast-evolving, requiring professionals to move beyond compliance-driven mindsets and instead develop adaptive expertise. This includes the capacity to evaluate emerging risks, navigate regulatory ambiguities, and lead with cultural humility and ethical foresight.

To meet these demands, education must actively equip students to connect legal, technological, clinical, and societal domains. A pedagogy grounded in interdisciplinary integration can foster the systems-thinking required to build

equitable, technology-enabled health systems capable of responding to both innovation and inequity (Frenk et al., 2010; Morley et al., 2020).

Nuanced Knowledge: A New Competency Set

Future healthcare professionals must be equipped to assess what is legal and what is just. They need to be able to assess what is innovative and what is equitable. For example, while meeting HIPAA requirements may satisfy baseline legal obligations, understanding how algorithmic bias in clinical decision tools perpetuates structural racism requires deeper engagement with concepts like data justice and sociotechnical systems (Veinot et al., 2018).

This level of readiness demands a new set of nuanced competencies. At the core is *critical data literacy*, which requires a deeper engagement with concepts like data justice, a framework focused on the fairness of how individuals are made visible, represented, and treated through data (Taylor & Chilufya, 2023). This involves questioning who controls health data, how it is collected, and what sociopolitical power that data enables or suppresses. It goes beyond technical proficiency, asking future health leaders to understand that data are never neutral. The infrastructure, ownership, and context of health data systems actively shape patient outcomes, public trust, and health policy decisions.

An example of this is the 2024 controversy surrounding the U.K.'s NHS Federated Data Platform (FDP). Developed in partnership with private technology companies, including Palantir Technologies, the FDP was positioned as a major advancement to centralize patient data across the National Health Service and improve analytics and decision-making (Downey, 2024). Despite being promoted as a tool to enhance population health and operational efficiency, the initiative raised significant ethical and legal concerns regarding data ownership, patient consent, and corporate access to sensitive health information.

Public backlash quickly grew, fueled by a lack of transparency in procurement processes and the perception that patient data were being commodified without adequate control or oversight. Advocacy groups questioned whether patients were meaningfully informed about how their information would be shared, particularly with private corporations known for their roles in surveillance and defense sectors. This episode reinforced the risks of concentrating data power in the hands of a few unaccountable actors, a dynamic that can erode public trust and undermine efforts toward equitable innovation.

Similar tensions have emerged globally. For example, in Kenya, the government's digital ID initiative intended to streamline access to health and social services faced heavy criticism for failing to account for marginalized populations who were excluded due to documentation barriers, deepening health inequities in already vulnerable communities (Privacy International, 2021)

Additionally, debates continue around the European Union's Artificial Intelligence Act, which aims to set global standards for the ethical use of AI, yet faces scrutiny over enforcement gaps, particularly regarding health applications (European Parliament, 2024). These cases reflect a growing need for health professionals to move beyond surface-level compliance and engage with anticipatory governance that addresses unintended consequences before they are embedded in policy or technology.

Applied Ethics and Anticipatory Governance: Proactive Oversight Before Harm

Although stronger data literacy is essential, it is not sufficient on its own. The ethical implications of deploying digital tools must be addressed proactively, not reactively. In today's rapidly evolving digital health landscape, applied ethics must be embedded into the design and implementation of technologies from the outset. Health professionals must embrace an anticipatory governance approach, which is one that evaluates the potential social, clinical, and ethical consequences of digital health innovations before deployment, rather than responding only after harms emerge.

Applied ethics in this context involves grappling with complex, high-stakes questions: What are the consequences when an AI model makes a diagnostic error in critical care? How should informed consent be reimagined when wearable devices passively collect health data beyond clinical environments? And how do we balance innovation with privacy, especially in underserved communities where mistrust of health institutions may already be high?

A case in point is the 2023 incident involving Woebot Health, an AI-powered mental health chatbot designed to deliver conversational therapy through mobile platforms. Even as Woebot showed early promise, ethical concerns were raised when it became clear that adolescent users, some under age 18, were not adequately protected from psychological harm. This included a lack of live clinician oversight during episodes of suicidal ideation, sparking public debate about the regulatory gray zones surrounding digital therapeutics and the ethical responsibilities of companies deploying AI in sensitive health domains (McKinney & Tseng, 2023).

Critics also raised alarms that Woebot collected sensitive emotional data without full transparency about how that information would be stored, shared, or monetized. The case triggered a public debate about the ethical obligations of digital therapeutics companies and the regulatory gray zone that still surrounds mental health AI tools. As a result, the FDA faced renewed pressure to re-evaluate oversight mechanisms for digital mental health products, and Woebot voluntarily paused its expansion to adolescent markets.

This example illustrates why health leaders and informatics professionals must apply ethical foresight. Anticipatory governance calls for scenario planning, stakeholder engagement, equity impact assessments, and cross-sector consultation before rolling out new tools. It also demands that organizations establish clear accountability structures so that they appropriately respond when things go wrong and ensure that technologies are designed from the outset to respect autonomy, dignity, and justice.

Cultural and Contextual Competence: Building Trust in Data Systems

As digital health tools become more embedded in care delivery, cultural and contextual competence has emerged as a critical, yet often overlooked, skill set for health professionals. Trust in data systems does not develop uniformly across all communities; it is shaped by historical experiences, cultural values, and systemic inequities that influence how individuals engage with health technologies.

For marginalized populations, particularly those who have faced discrimination or exploitation by health institutions, assurances of privacy, security, and ethical use of data often fall short without culturally responsive engagement. In the United States, studies have shown that Black and Indigenous communities' express greater skepticism toward data-sharing initiatives, rooted in well-documented histories of medical racism and data misuse (Kraft et al., 2018; Kukutai & Taylor, 2016).

Efforts to expand precision medicine and digital health interventions that fail to account for these histories risk reinforcing disparities rather than closing them. A notable illustration of this is seen in the controversy surrounding the All of Us Research Program, which aimed to enroll over one million diverse participants to build one of the most robust biomedical datasets in the world. Despite its promise, community advocates raised concerns that data governance structures lacked adequate representation from communities most affected by health inequities (Mello et al., 2018).

Critics questioned whether benefits from the research would be equitably distributed and whether participation might expose individuals to privacy risks without sufficient safeguards (Kraft et al., 2018; Veinot et al., 2018; Vayena et al., 2018). These tensions demonstrate the importance of cultivating cultural and contextual competence as a soft skill, and as a foundation for ethical, inclusive, and trusted digital health systems (Benjamin, 2019; Taylor & Chilufya, 2023).

Global Regulatory Fluency: Navigating an Evolving Legal Landscape

In the era of globalized digital health, regulatory fluency is a required specialized skill. It is an essential competency for health professionals, informaticians, and leaders alike. As technologies transcend national borders, understanding the

complexities of regional, national, and international data governance frameworks is vital to ensure ethical, lawful, and culturally appropriate health innovation.

One of the most influential examples is the European Union's General Data Protection Regulation (GDPR), which has set a global benchmark for data privacy, consent, and individual rights (European Commission, 2016). Yet, GDPR compliance represents just one layer of an increasingly fragmented legal environment. Health professionals must also grapple with emerging legislation, such as the EU's Artificial Intelligence Act, which introduces new accountability standards for AI used in healthcare, and the OECD's principles for trustworthy digital governance, which emphasize inclusion, transparency, and human rights protections (European Parliament, 2024; OECD, 2023).

The failure to anticipate regulatory differences across borders can stall innovation or expose organizations to legal and reputational risks. For example, in 2022, a U.S.-based telehealth company faced penalties after expanding services into the European market without aligning its data collection practices with GDPR standards, leading to regulatory action and the suspension of services (Johnson, 2022).

Similar tensions have emerged in low- and middle-income countries, where rapid digital health deployment often outpaces the development of adequate legal protections, creating environments vulnerable to exploitation or inequitable access (Taylor & Chilufya, 2023).

Recommendations for Building Interdisciplinary Readiness Through Curriculum Innovation

To meet the evolving demands of a data-driven health system, academic programs must move beyond fragmented, discipline-specific instruction and foster integrated learning environments that reflect the complexity of real-world health challenges. One promising approach is the design of dedicated courses or embedded modules that operationalize the four pillars of interdisciplinary readiness. These pillars include critical data literacy, applied ethics and anticipatory governance, cultural and contextual competence, and global regulatory fluency, all woven into a cohesive pedagogical framework.

A model course, for example, might be titled *"Ethics, Equity, and Data in Digital Health Systems"* and be structured around interdisciplinary inquiry and problem-based learning. The course could begin with a focus on critical data literacy, prompting students to analyze health datasets to assess how data is collected, who controls it, and how it shapes clinical decisions and public policy (Taylor & Chilufya, 2023). Case studies such as the NHS Federated Data Platform and algorithm-driven triage tools would serve to highlight the social and political dimensions of data use (Downey, 2024).

Subsequent modules could explore applied ethics and anticipatory governance through scenario-based learning, where students anticipate and evaluate ethical dilemmas in emerging digital health tools, and develop foresight briefs to guide decision-making (McKinney & Tseng, 2023; Vayena et al., 2018). In parallel, students would develop cultural and contextual competence by engaging with frameworks like community-based participatory research (CBPR) and learning directly from guest speakers representing historically marginalized communities (Kukutai & Taylor, 2016; Kraft et al., 2018). These discussions would be grounded in issues of trust, inclusion, and justice in digital health implementation.

The final component would cultivate global regulatory fluency by comparing legal frameworks such as HIPAA, the GDPR, and Kenya's Data Protection Act, and conducting mock compliance reviews of health technologies across jurisdictions (European Commission, 2016; Privacy International, 2021). Interprofessional collaboration would be emphasized throughout, encouraging students from diverse backgrounds such as public health, informatics, law, and social sciences that can help to co-create solutions to complex digital health challenges. Course deliverables might include policy briefs or prototype digital tools addressing equity and ethics in health innovation.

Some academic institutions have already begun to model this integrated approach. Johns Hopkins University's Bloomberg School of Public Health includes coursework in informatics that bridges policy, ethics, and technical content through cross-listed, interdisciplinary instruction (Johns Hopkins University, 2024). At the University of Toronto, the Institute for Health Policy, Management and Evaluation offers a course on AI and health equity that challenges students to examine data governance and ethical impacts together (University of Toronto, 2023). Similarly, Stanford University's Center for Biomedical Ethics hosts seminars where students critically analyze the intersections of law, ethics, and digital medicine (Stanford University, 2023). These initiatives exemplify a broader shift toward pedagogy that treats ethics, equity, law, and technology as deeply interconnected dimensions of contemporary health leadership.

To scale these efforts, academic institutions should embed critical data literacy across all health disciplines, ensuring students gain both technical proficiency and the ability to interrogate the structural and political dimensions of data use (Veinot et al., 2018). Ethics and anticipatory governance must be integrated into core curricula, not relegated to elective courses or compliance checklists. Likewise, cultivating cultural and contextual competence is essential for building trust, especially among communities that have historically been marginalized by health systems (Kukutai & Taylor, 2016; Kraft et al., 2018). Given the global reach of digital health technologies, regulatory fluency must extend beyond domestic frameworks to include international policies such as the

GDPR, the OECD's principles for digital governance, and region-specific AI standards (European Commission, 2016; OECD, 2023).

Finally, academic institutions must engage stakeholders beyond the classroom. This will include community leaders, policymakers, technology developers, and advocacy organizations to co-create learning experiences that reflect both global standards and local realities. Only through such integrated and collaborative approaches can health education produce leaders capable of advancing equity, ethics, and innovation in a rapidly evolving digital health landscape.

Conclusion: Shaping a Workforce for an Equitable, Data-Driven Health Future

Preparing students for this environment requires more than content integration; it demands a deliberate shift toward adaptive, interdisciplinary competence grounded in critical inquiry, cultural awareness, applied ethics, and global regulatory understanding. Without these capacities, health innovations risk reinforcing existing disparities and undermining public trust.

Building these competencies goes beyond an educational imperative as they are a prerequisite for ensuring health systems remain equitable, trustworthy, and responsive to the complexities of the digital era. Through intentional, stakeholder-informed pedagogy, health education can produce leaders capable of advancing justice, equity, and innovation in an increasingly data-driven health future.

References

Benjamin, R. (2019). *Race after technology: Abolitionist tools for the new Jim code.* Polity.

Downey, A. (2024, February 15). NHS data platform: Palantir's role raises privacy concerns. *The Guardian.* https://www.theguardian.com/society/2024/feb/15/nhs-data-platform-privacy-palantir

European Commission. (2016). General Data Protection Regulation (GDPR) (Regulation (EU) 2016/679). *Official Journal of the European Union.* https://eur-lex.europa.eu/eli/reg/2016/679/oj

European Parliament. (2024). *Artificial Intelligence Act.* https://artificialintelligenceact.eu/the-act/

Eubanks, V. (2018). *Automating inequality: How high-tech tools profile, police, and punish the poor.* St. Martin's Press.

Floridi, L. (2019). Establishing the rules for building trustworthy AI. *Nature Machine Intelligence, 1*(6), 261–262. https://doi.org/10.1038/s42256-019-0055-y

Frenk, J., Chen, L., Bhutta, Z. A., Cohen, J., Crisp, N., Evans, T., Fineberg, H., Garcia, P., Ke, Y., Kelley, P., Kistnasamy, B., Meleis, A., Naylor, D., Pablos-Mendez, A., Reddy, S., Scrimshaw, S., Sepulveda, J., Serwadda, D., & Zurayk, H. (2010). Health professionals for a new century: Transforming education to strengthen health systems in an interdependent world. *The Lancet, 376*(9756), 1923–1958. https://doi.org/10.1016/S0140-6736(10)61854-5

Hoffman, S. J., Røttingen, J. A., Bennett, S., Lavis, J. N., Edge, J. S., & Frenk, J. (2021). Aligning goals and roles in health education systems. *Global Challenges, 5*(1), Article 2000048. https://doi.org/10.1002/gch2.202000048

International Association of Privacy Professionals. (2022, July 15). Italian DPA fines health app €10 million over biometric data use. *IAPP.* https://iapp.org/news/a/italian-dpa-fines-health-app-10-million-over-biometric-data-use

Johns Hopkins University. (2024). *Health informatics program overview.* https://publichealth.jhu.edu/academics/ms-in-health-science-informatics

Kostkova, P., Brewer, H., de Lusignan, S., Fottrell, E., Goldacre, B., Hart, G., Koczan, P., Knight, P., Marsolier, C., McKendry, R. A., Ross, E. M., & Tooke, J. (2021). Who owns the data? Open data for healthcare. *Frontiers in Digital Health, 2,* Article 588454. https://doi.org/10.3389/fdgth.2020.588454

Kraft, S. A., Cho, M. K., Gillespie, K., Halley, M., Varsava, N., Ormond, K. E., & Juengst, E. T. (2018). Beyond consent: Building trusting relationships with diverse populations in precision medicine research. *American Journal of Bioethics, 18*(4), 3–20. https://doi.org/10.1080/15265161.2018.1439374

Kukutai, T., & Taylor, J. (Eds.). (2016). *Indigenous data sovereignty: Toward an agenda.* ANU Press. https://press.anu.edu.au/publications/series/centre-aboriginal-economic-policy-research/indigenous-data-sovereignty

Leslie, D., Mazanderani, F., & Tait, J. (2021). Ethical guidance for AI-based decision support systems in mental health care. *Nature Medicine, 27*(9), 1465–1466. https://doi.org/10.1038/s41591-021-01452-7

McKinney, M., & Tseng, E. (2023, June 12). Woebot Health's chatbot offers support to adolescents. But is it ethical? *STAT News.* https://www.statnews.com/2023/06/12/woebot-health-chatbot-adolescent-ethics/

Mello, M. M., Wolf, L. E., & Goodman, S. N. (2018). Clinical trial participants' views of the risks and benefits of data sharing. *New England Journal of Medicine, 378*(23), 2202–2211. https://doi.org/10.1056/NEJMsa1713259

Morley, J., Floridi, L., Kinsey, L., & Elhalal, A. (2020). From what to how: An initial review of publicly available AI ethics tools, methods and research to translate principles into practices. *Science and Engineering Ethics, 26,* 2141–2168. https://doi.org/10.1007/s11948-019-00165-5

OECD. (2024). *2023 OECD digital government index: Results and key findings.* OECD Publishing. https://doi.org/10.1787/1a89ed5e-en

Privacy International. (2021, January 21). *Kenya's Huduma Namba: Digital ID and exclusion.* https://privacyinternational.org/news-analysis/4392/digital-identity-kenya

Reddy, S., Fox, J., & Purohit, M. P. (2020). Artificial intelligence-enabled healthcare delivery. *Journal of the Royal Society of Medicine, 113*(1), 10–13. https://doi.org/10.1177/0141076819877552

Stanford University. (2023). *Center for Biomedical Ethics programs.* https://med.stanford.edu/bioethics.html

Sweeney, L., & Van Dyk, J. (2022). Ethical by design: A systems approach to responsible digital health innovation. *Journal of Medical Ethics, 48*(4), 238–243. https://doi.org/10.1136/medethics-2020-107156

Taylor, L., & Chilufya, H. (2023). Data colonialism in Africa and the decolonial imperative. *Patterns, 4*(3), Article 100744. https://doi.org/10.1016/j.patter.2022.100744

University of Toronto. (2023). *Artificial intelligence and health equity course.* https://ihpme.utoronto.ca/ai-health-equity/

Veinot, T. C., Mitchell, H., & Ancker, J. S. (2018). Good intentions are not enough: How informatics interventions can worsen inequality. *Journal of the American Medical Informatics Association, 25*(8), 1080–1088. https://doi.org/10.1093/jamia/ocy052

Vayena, E., Blasimme, A., & Cohen, I. G. (2018). Machine learning in medicine: Addressing ethical challenges. *PLOS Medicine, 15*(11), e1002689. https://doi.org/10.1371/journal.pmed.1002689

What's so secret about data giant's NHS deal with Palantir? (2024, February 19). *Tortoise Media.* https://www.tortoisemedia.com/2024/02/19/whats-so-secret-about-data-giants-nhs-deal-with-palantir/

World Health Organization. (2021). *Ethics and governance of artificial intelligence for health: WHO guidance.* https://www.who.int/publications/i/item/9789240029200

Zimmer, M. (2020). Addressing conceptual gaps in data ethics: A review of recent frameworks. *Journal of Information Ethics, 29*(1), 22–35. https://doi.org/10.3172/JIE.29.1.22