**TEMASEK POLYTECHNIC**

**SCHOOL OF INFORMATICS & IT**

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**DIPLOMA IN APPLIED ARTIFICIAL INTELLIGENCE**

**DIPLOMA IN INFORMATION TECHNOLOGY**

**AI & Ethics Report (CAI2C02)**

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**a) Background of the AI implementation (10%)**

In this section, you are first required to give the background, domain of use, and description of the real-life AI implementation.

***Background Context:***

* Development and Launch:
  + IBM Watson for Oncology (WFO) was developed under the collaboration between IBM Watson Health & Memorial Sloan Kettering Cancer Center(MSKCC). It was launched in the mid-2010s as part of IBM’s broader initiative to apply AI to healthcare to demonstrate the potential of AI in solving complex problems.
* Purpose:
  + WFO was designed to address the complexity of cancer treatment by providing oncologists help & patients with personalized, data-driven treatment recommendations. Cancer care involves understanding and interpreting multiple variables such as medical literature, clinical trial data, and patient-specific information and doing that for multiple patients can get overwhelming for healthcare providers. WFO aims to streamline this process, improve decision-making, and alleviate the stress on the shoulders of healthcare professionals.
* Technology:
  + Using Natural Language Processing (NLP) WFO reads and interprets unstructured medical data, such as clinical notes, pathology reports, and research papers. Besides that, machine learning is used to analyze papers in data and generate treatment recommendations that are based on evidence from medical literature, clinical guidelines, and real-world cases.

***Domain Use:***

IBM Watson has been applied across multiple domains, but one of its most prominent and ambitious use cases is in the healthcare industry, especially in Oncology. The primary goal of IBM Watson for oncology was to assist the healthcare professional in diagnosing cancer patients and recommending individualized treatment plans. This was possible via Watson’s ability to analyze vast amounts of medical literature, clinical trial data & patient records.

***Description of the real-life AI implementation:***

IBM Watson for Oncology (WFO) was primarily made to assist healthcare professionals in diagnosing and providing treatment to cancer patients.

**Why is Watson for Oncology (WFO) used?**

Diagnosis & treatment of cancer can be complex and require multiple possibilities that need to be considered, such as patient history, genetic data, and evolving research. It can be extremely complex and often challenging for healthcare professionals to ensure up-to-date and personalized treatment recommendations. WFO addresses these issues by:

* Enhancing Decision-Making:
  + WFO provides healthcare professionals with evidence-based treatment options that are tailored to the individual characteristics of each patient’s cancer.
* Saving Time:
  + Healthcare providers can make informed decisions more efficiently as WFO quickly analyses and synthesizes a large volume of medical data.
* Reducing Variability:
  + Treatment recommendations are standardized, reducing inconsistencies due to differing levels of expertise among clinicians providing differing appropriate treatment recommendations.

**What role does IBM Watson for Oncology play in the Healthcare industry?**

1. Clinical Insights:
   * WFO provides the providers with ranked treatment options and highlights supporting evidence using clinical trials, guidelines, and relevant publications. This aids clinicians to consider all viable options, reducing the room for human error.
2. Personalization:
   * Factoring in individual data of the patient, such as medical history, tumor type, and genetic markers, WFO can provide appropriate personalized treatment strategies.
3. Education & Awareness:
   * The system aids oncologists, especially in under-resourced areas, by making the latest medical knowledge accessible and actionable. The professionals are well-prep to provide the most advance recommendations to cancer patients.
4. Efficiency in Diagnosis
   * The time required dedicated to research and manual analysis to identify treatment recommendations is reduced, allowing physicians to spend more time with the patients.

**b) Ethical issue(s) of the AI implementation**

This is the list of Ethical Issues the IBM Watson faced:

[Misinformation and another ethical issue]

[Just talk about the current case issue for your example]

1. ***Ethical Issue: Overreliance on Limited Training Data***
   * Describe:
     1. WFO was primarily trained on data from the Memorial Sloan Kettering Cancer Centre (MSKCC). This created a knowledge base that only reflected the practices, guidelines, and patient demographics of a specific region, which was not applicable globally. This is a **Human-centric** issue where the data used disrupts the principles of **bias** and **localization** as a result humans would not be able to collaborate with the AI system, WFO is a meaningful way.
   * Evidence: (Why is Biased Dataset a big issue?)

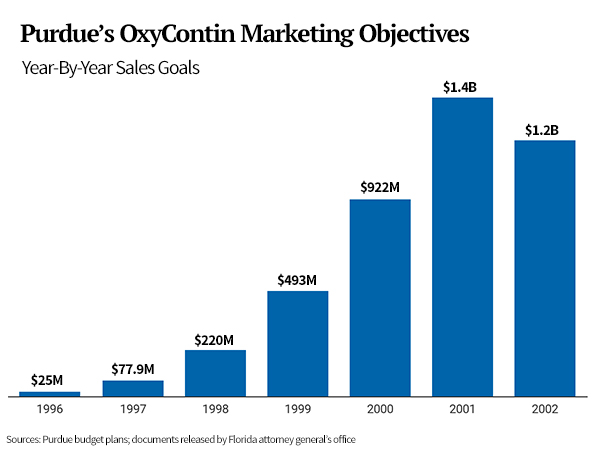
A screenshot of a graph

Description automatically generated

Source:<https://www.ml.cmu.edu/news/news-archive/2016-2020/2018/october/amazon-scraps-secret-artificial-intelligence-recruiting-engine-that-showed-biases-against-women.html>

* + 1. In 2014, the company Amazon developed a tool to review job resumes applied by applicants. However, a year later, it was found out that the AI tool that was trained was biased against women regarding technical roles. This happened due to the tool being trained on historical hiring data that the majority of the count were men.
  + Impact:
    1. Lack of Global Applicability:
       - Since WFO did not align with the different medical practices in different regions worldwide, WFO clients received inappropriate treatment recommendations for patients outside the US.
       - According to the MIT study called **The Moral Machine** found significant differences in how individuals from different regions wanted an autonomous vehicle to act.
    2. Bias in Recommendations:
       - Bias is introduced in the AI system due to Sampling Bias as it does not appropriately represent the medical standard of other regions.
       - Bias from WFO puts patients from other regions at a disadvantage in the appropriate treatment recommendations.
       - This occurred due to IBM allocating data resources from a specific group in the United States, MSKCC.
  + Link:
    1. Similar to Amazon’s biased recruiting tool that resulted in gender inequality, WFO’s overreliance on such poor-resourced data would result in biased recommendations causing healthcare inequities by failing to acknowledge the different needs of diverse populations.

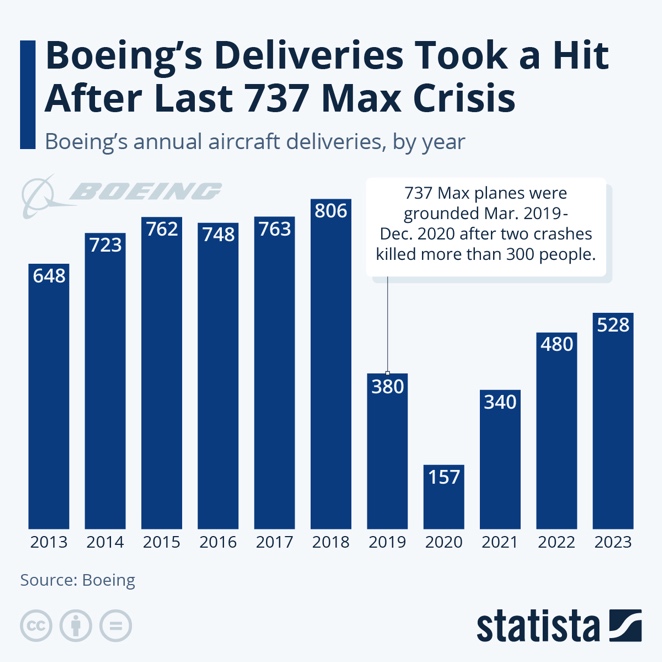
1. ***Ethical Issue: Unrealistic Marketing Claims***
   * Describe:
     1. IBM aggressively marked WFO as a revolutionary AI system that was made to transform cancer care. However, these claims made were exaggerated which created unrealistic expectations among healthcare professionals and patients. IBM lacked **Transparency,** which requires IBM’s organizational process and value to be completely open and honest in terms of what is made public about their AI and data processes.
   * Evidence: (Why are false and unrealistic marketing claims dangerous?)



Source: <https://kffhealthnews.org/news/how-america-got-hooked-on-a-deadly-drug/>

* + 1. Around the 2000s, the company Purdue Pharma started a marketing campaign where they marketed the medicine, OxyCotin as a safer, less addictive opioid. This was exaggerated. The risks of OxyCotin were downplayed as a result, it led to widespread misuse and addiction issues. Once, the truth was exposed, healthcare professionals to patients largely lost trust in the healthcare industry and Purdue Pharma company.
  + Impact:
    1. Erosion of Trust:
       - Explanation:
         * Once healthcare providers and patients noticed that WFO did not manage to deliver the performance as stated by IBM, these providers and patients lost trust in the system, and this erosion of trust extended to general AI-driven healthcare solutions in the market.
       - Impact:
         * The loss of trust leads to negativity and reluctance to adopt future AI technologies which act as a barrier to future AI developments in the healthcare industry. The trust of clients in the product and services is essential for the successful integration of AI in healthcare, and unrealistic claims damaged this trust.
    2. Financial & Reputational Damage:
       - Explanation:
         * Names of hospitals and clinics that were clients or collaborated with IBM WFO faced reputational harm as they were viewed as supporting a system that did not perform well in such a high-risk environment.
       - Impact:
         * In the real world, financial losses heavily strain the resources of healthcare institutions which can be affecting their ability to sustain and stay afloat. Reputational damage can strongly impact a patient’s trust and the institution’s understanding generally within the medical community.
  + Link:
    1. The Purdue Pharma Scandal example emphasizes the importance of ensuring transparency between the operations & data handling, and end-users. Such issues of Unrealistic Marketing Claims take place when companies prioritize profits to show the value of the idea over transparency, openness, and honesty.

1. ***Ethical Issue: Inadequate Domain Knowledge Involvement***
   * Describe:
     1. This is a result of poor **Explainability and Interpretability** due to an inadequate involvement of domain experts who did not well consider **Future Bias and Fairness**. During the development of WFO, individuals with domain knowledge in oncology & other end-users were not actively involved. Hence, this lack of involvement led to a system that was not user-friendly and disrupted oncologists’ workflows.
   * Evidence: (What is the importance of involving Domain Experts during development?)



Source: <https://www.statista.com/chart/31542/boeings-annual-aircraft-deliveries-by-year/>

* + 1. After two fatal crashes, the plane company, Boeing, faced serious safety concerns regarding its plane model, Boeing 737 MAX. The issue turned out to be due to technical issues with the **MCAS System (**Maneuvering Characteristics Augmentation System). Many of these issues were linked to insufficient involvement with experienced pilots and aviation experts in the rigorous testing of the aircraft model by Boeing during the development and safety testing of the aircraft’s systems. Eventually, it led to costing Boeing billions in losses and severe damage to the company’s reputation.
  + Impact:
    1. Poor Usability:
       - WFO was difficult to integrate into the daily practices of the health professionals & effectiveness. Instead, found multiple improvements to be introduced making it suitable for daily use with ease.
    2. Resistance to Adoption:
       - The lack of oncologist input during the development of WFO resulted in health professionals feeling disconnected from the system’s design and their need to help patients. This disconnect led to resistance to adopting.
  + Link:
    1. The inadequate domain knowledge involvement in both IBM’s Watson for Oncology (WFO) and Boeing’s 737 MAX example highlights the critical need to collaborate with domain experts during development. Hence, ensures, that AI systems are practical, effective, and trustworthy. Otherwise, it would lead to poor usability, resistance to adoption, and significant financial and reputational damage.

**c) Possible factor(s) that may have contributed to these ethical issue(s)**

**Ethical Issue #1: Overreliance on Limited Training Data**

* Factor #1: Narrow Data Sources
  + WFO was trained mostly on data from the Memorial Sloan Kettering Cancer Center (MSKCC), a premier cancer research center in  the United States. Consequently, the knowledge base of the system was mostly a reflection on the U.S. healthcare system-specific clinical practices, treatment guidelines, and patient  demographics, constraining its applicability globally. This led to a situation in which WFO’s recommendations may not suit the diverse needs of patients in various geographic areas.
* Why it happened:
  + Partnership Constraints:

While IBM’s collaboration with MSKCC gave them access to such high-quality data, it was also  limited to practices specific to MSKCC, given the nature of the partnership. However, IBM did not engage those other institutions in the feat of cleaning the training data, nor did it do enough to make up for the lack of diversity in the training data by including contributions from other regions. Since then AI systems could not cover the whole  range of medical systems clinics and treatments for patients all over the world.

* + Cost and Time Constraints:

Letting the model assess and analyze all data available in the global  domain would have taken an enormous amount of time, resources, and international collaboration between healthcare institutions. While IBM delivered on time, it was slow on the global diversity front as its product launch reflected its need to respond quickly to major demand with a well-timed business return, which simply meant the rest of the world wasn't its  concern yet. This economically driven decision further restricted the validity and reliability of the system outside of U.S. borders.

**Ethical Issue #2: Unrealistic Marketing Claims**

* Factor #2: Aggressive Marketing Strategy
  + IBM marketed Watson  for Oncology (WFO) aggressively as a state-of-the-art AI system that would, they claimed, transform cancer care. But while the software did perform some useful work, it also oversold its abilities, leading doctors and patients to have unrealistic expectations about what the system could do.
* Why it happened:
  + Pressure to Demonstrate ROI:
    1. IBM was under tremendous pressure to demonstrate that its massive investment in Watson Health  was paying off. To rapidly entice customers and appease investors, the company  exaggerated the capabilities of WFO. This pressure caused IBM to guarantee miraculous outcomes, even though the  AI system was not adequately prepared to be used in critical healthcare environments.
  + Competitive AI Landscape:
    1. There was a huge amount of interest around AI in the mid-2010s, especially within  healthcare. As competitors race into the AI space, IBM was forced to inflate WFO’s capabilities so it wouldn’t lose the  position of a market leader. The pressure to get ahead of the competition and cash in on the AI “hype” may have resulted in claims that exaggerated the capabilities of the technology and ultimately hurt its credibility.

**Ethical Issue #3: Inadequate Domain Knowledge Involvement**

* Factor #3: Lack of User-Centric Design
  + During the development of Watson for Oncology (WFO), key domain experts such as oncologists, and other end-users were not sufficiently involved in the development and design process, leading to a system that was not user-friendly or aligned with the healthcare professional workflows. This lack of user input led to WFO becoming a system that was not only challenging to integrate into clinical workflows but also disconnected from the practical needs of the healthcare community.
* Why it happened:
  + Focus on Technical Development:
    1. IBM prioritized the technical AI aspects of training Watson, such as the algorithm’s ability to analyze medical data and recommend treatment options instead of usability and user experience for its end users. While the focus on technical aspects was important, the focus on making the system user-friendly for oncologists and healthcare providers was neglected. Despite the technical features being advanced, they did not align with the healthcare professionals’ work from different regions, causing the system to lack effectiveness and usability.
  + Limited Feedback Loops:
    1. IBM did not establish adequate channels for healthcare professionals to easily be able to provide feedback during the design, development, and training phases of WFO. As a result, the system failed to meet the practical needs of oncologists, there were insufficient to ensure that WFO would comfortably and easily be able to fit within the daily lifestyle practices. Hence, to lack of communication, led to WFO having a disconnect between AI’s functionality and the actual needs of its users.

**d) Solution(s)**

**Factor #1 Solutions**

Solution 1: Data Diversity

* Description:
  + To overcome the problem of narrow data sources and ensure diversity in data collection, IBM would need to  partner with healthcare systems/ institutions in different parts of the world that span different cultures, education levels, and socio-economic brackets. This action would prioritize gathering, integrating, and harmonizing up-to-date medical information that originates from a broad spectrum of world healthcare platforms, thus ensuring the training set represents the full spectrum of patient demographics, clinical utilization, and treatment routines.
* Pros
  + More Universal Applicability to the Whole World:
    - In its entirety, the AI system can produce recommendations that correspond more closely with various healthcare systems and provide advantageous results for patients worldwide. For example, it would take into account local drug availability, healthcare cost, and cultural factors in its recommendations.
  + Enhanced Fairness:
    - Diversity minimizes systemic biases: treating underrepresented groups and employing their therapeutic methods ensures that the AI platform isn't biased towards a particular demographic, region, or medical approach.
  + Improved Trust and Adoption:
    - A universally accepted system would encourage local healthcare providers to implement global protocols and significantly improve treatment after diagnosis. Users begin to trust the system when they see themselves in the recommendations, i.e. recognize their contexts reflected in the behavior.
* Cons
  + Resource Intensive:
    - Global data collection, cleaning, and integration is a costly time-consuming process requiring substantial financial as well as human resources. Negotiating partnerships, working  with different legal and regulatory frameworks, and addressing logistical challenges make this a time-consuming and expensive effort.
  + Managing Complexity in Data:
    - However, aligning disparate datasets necessitates strong  governance frameworks and sophisticated tools to address inconsistencies, nulls, and variations in formats. The biggest challenge  is to make this successful and keep data integrity intact.
  + Potential for New Biases:
    - The process of data diversification could unwittingly lead to the introduction of new biases, in the  absence of careful oversight. To illustrate, if a few regions or institutions were over-represented in  the dataset, the model could be biased, creating unequal and unintended outcomes.

Solution 2: Comprehensive Auditing and Monitoring

* Description:
  + Conducting audits and monitoring regularly to make sure that the system and its datasets are unbiased and free from vulnerabilities. This may include stress-testing the model to spot weaknesses, auditing dataset composition for fairness, and simulating real-world scenarios to measure the systems’ performance across ranges of scenarios.
* Pros
  + Improved System Robustness:
    - Stress testing brings all this to the surface early, so engineers  can improve on solutions before they go into production. This improves reliability in the entire system and validates that the system can withstand real-world variance: incomplete or noisy data.
  + Continuous Improvement:
    - Monitoring is an ongoing process that generates data, which  the developers can use to improve the AI system in an iterative process. This provides a model that continues to correspond to new standards and practices over  time.
  + Transparency and Accountability:
    - The auditing processes through a transparent procedure  help to build trust in the AI system among the stakeholders. This helps prove that fairness and ethics are  integral to development and deployment.
  + Cons
    - High Costs:
      * Site auditing requires a considerable amount of money for tools, infrastructure,  and people. It  requires specialized expertise to develop and establish effective stress-testing processes.
    - Time-Consuming:
      * Strict auditing can slow  deployment timelines down. Finding the right balance between resilience and timeliness  is key to product success.
    - Potential for Overcorrection:
      * An excessive focus on fairness during bias mitigation can then negatively impact the accuracy of algorithmic predictions or generate adverse  outcomes like under-servicing specific patient demographics.

[Don’t talk about a role; talk about a governance framework.]

**Factor #2 Solutions**

Solution 1: The Chief AI Ethics Officer (CAEO)

* Description:
  + A Chief AI Ethics Officer would ensure the ethics of the AI they develop, deploy, and market. They would ensure that all marketing is correct, reflects the actual abilities of the AI, and conforms to ethical and regulatory practices.
* Pros
  + Ethical Oversight:
    - A CAEO would serve as a gatekeeper, ensuring that marketing claims are closely scrutinized for truth and align with ethical standards. This reduces the risk of misleading stakeholders regarding the AI system’s capabilities.
  + Accountability:
    - A CAEO would create an accountability culture, integrating ethics into a company's processes to encapsulate ethical standards in a  company.
  + Trust Building:
    - Transparent and honest communication builds trust with customers, regulators, and stakeholders, which can improve the company's reputation and increase long-term loyalty.
  + Cons
    - Cost:
      * The formation of a CAEO position, and perhaps a matching ethics department, is an expensive investment, which will be a potential roadblock for smaller organizations.
    - Resistance:
      * Marketing and sales teams can oppose such scrutiny, viewing it as a hindrance to creativity or as an encumbrance of their tactics. It would take time and energy to ensure agreement across departments.

Solution 2: Developing Clear and Transparent Marketing Guidelines

* Description:
  + Establish stringent guidelines to define the ethical and factual limits of  marketing AI products. These guidelines would incorporate explicit rules for how the capabilities, limitations, and potential outcomes of AI systems can be described.
* Pros
  + Clarity:
    - Well-defined guidelines reduce uncertainty, allowing marketing departments to know their limits and preventing exaggeration.
  + Consistency:
    - Standardized messaging also leads to higher credibility in marketing materials, allowing for higher alignment between the product's real capabilities and stakeholder documentation, thus avoiding misalignment.
  + Regulatory Compliance:
    - Such transparent guidelines not only enable the firm to satisfy regulatory requirements but also reduce the chances of legal action against false claims.
* Cons
  + Rigidity:
    - The rigid guidelines could hinder creativity and adaptability in marketing strategies, potentially leading to less compelling or less localized campaigns.
  + Implementation Challenges:
    - Creating, implementing, and regularly revising recommendations for technological advancement takes time and human resources.

**Factor #3: Lack of User-Centric Design**

Solution 1: Ensuring Domain Experts are integrated across the Development Process

* Description:
  + By directly involving domain experts, including oncologists, clinical researchers, and healthcare professionals, at each step of AI development, the system developed will be crafted towards the specific requirements of those who will use it. Their expertise can direct decisions regarding data choice, model training, and data output interpretation.
* Pros
  + Improved Usability:
    - Collaboration with domain experts can facilitate early identification of workflows and usability challenges, preventing a disconnect between the AI system and clinical practice, and aligning with the practical demands of healthcare professionals.
  + Enhanced Relevance:
    - Persistent engagement also guarantees the AI system is focused on same-type real-world issues, including complex clinical decisions, patient demands, and regional healthcare routines.
  + Increased Adoption:
    - This would help build trust and facilitate adoption among healthcare professionals as they will work with these AI systems crafted with user-centered inputs.
* Cons
  + Resource Intensive:
    - Engaging with domain experts throughout the process takes considerable time, money, and coordination, especially because experts may come from diverse geographic and institutional backgrounds.
  + Potential Conflicts:
    - Misalignment in priorities and expectations between the technical developers and domain experts can cause misconfigurations, leading to delays in development and resulting in either a state of affairs that ‘compromises’ features the system is meant to deliver or to break backward compatibility.

Solution 2: Research into a healthy Feedback Loop

* Description:
  + Adopting measures for real-time user feedback helps the AI system adapt over time to emerging needs, usability issues, and shortcomings. This feedback loop includes surveys, interviews, or digital platforms with the means to log concerns and suggestions.
* Pros
  + Continuous Improvement:
    - This also allows for iterative refinements of the AI system, making sure it is relevant and it continues to respond to healthcare  professional’s needs.
  + User Satisfaction:
    - Users are more likely to feel a sense of ownership over the system and trust its outcomes if they can provide their input, which can lead to greater satisfaction and long-term adoption.
  + Early Issue Detection:
    - Collecting user feedback during development and production allows the application to identify and resolve issues before they become problems, increasing the application’s reliability.
* Cons
  + Implementation Complexity:
    - Now, the actual process of building these feedback loops and keeping them going requires some infrastructure — this can be a technical setup, but a guidance system to understand how to move things on is also needed, and this requires people and money.
  + Feedback Overload:
    - Receiving and processing large quantities of feedback — particularly when that feedback is inconsistent or contradicts another piece of feedback — can present bottlenecks, thereby pushing the development timeline backward.

Solution 3: User-Centric Design Workshops

* Description:
  + This is possible through workshops where developers work directly with healthcare professionals. These workshops might involve discussions, simulations, and prototype testing to extract practical insights.
* Pros
  + Focused Development:
    - By providing such workshops, developers can better understand the unique requirements, challenges, and workflows relevant to end-users, leading to the design and implementation of more appropriate  and effective AI solutions.
  + Collaborative Environment:
    - Ability to bridge technical possibilities and practical ​needs. The collaboration between developers and healthcare professionals leads to mutual understanding and communication, which, if not done, leaves a gap.
  + Prototype Testing:
    - User Testing prototypes during workshops means rapid feedback and iteration so that the developers can adjust from the outset rather than having to go back during full-scale development to a poorly defined system.
* Cons
  + Scheduling Challenges:
    - Scheduling workshops with healthcare professionals, particularly specialists such as oncologists, can be time-consuming and introduce delays.
  + Resource Allocation:
    - This approach requires funds, people, and time to run workshops, which may exhaust the capacity of a small organization or project.

**Conclusion**

Key lessons from the roll-out of IBM Watson for Oncology (WFO) reflect the challenges but also the opportunities related to AI adoption in healthcare. Even though WFO was designed to transform cancer care through personalized, data-driven treatment recommendations, it struggled with ethical and practical concerns that hindered its efficacy and dissemination. This dependence on geographically biased training data, inflated marketing claims, and the insufficient involvement of domain experts have resulted in issues with generalizability and skepticism among healthcare professionals.

Dealing with these challenges necessitates a multi-pronged strategy. Global healthcare partnerships can significantly increase training data, enabling more inclusivity and decreasing bias. Transparency, robustness, and vulnerability issues can  be addressed with comprehensive audits and monitoring processes. The CAEO can help build ethical  principles around marketing, thus setting realistic expectations. Importantly, better embedding of domain experts across the development process and effective feedback loops can better orient AI  systems within real-world clinical workflows.

These measures require investments of effort and cross-organizational coordination for buy-in, but are essential to building trust, ensuring fairness, and realizing the potential of AI in healthcare. The WFO experience reinforces the importance of ethical foresight, user-centric design, and transparent communication in AI development. This way, AI systems of the future can indeed revolutionize health care and other essential industries responsibly and effectively.

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