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Artificial intelligence in developing countries: The impact of generative artificial intelligence (AI) technologies for development

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Abstract

This paper explores the potential impact of Generative Artificial Intelligence (Generative AI) on developing countries, considering both positive and negative effects across various domains of information, culture, and industry. Generative Artificial Intelligence refers to artificial intelligence (AI) systems that generate content, such as text, audio, or video, aiming to produce novel and creative outputs based on training data. Compared to conversational artificial intelligence, generative artificial intelligence systems have the unique capability of not only providing replies but also generating the content of those responses. Recent advancements in Artificial Intelligence during the Fourth Industrial Revolution, exemplified by tools like ChatGPT, have gained popularity and reshaped content production and creation. However, the benefits of generative artificial intelligence are not equally accessible to all, especially in developing countries, where limited access to cutting-edge technologies and inadequate infrastructure pose challenges. This paper seeks to understand the potential impact of generative AI technologies on developing countries, considering economic growth, access to technology, and the potential paradigm shift in education, healthcare, and the environment. The findings emphasize the importance of providing the necessary support and infrastructure to ensure that generative AI contributes to inclusive development rather than deepening existing inequalities. The study highlights the significance of integrating Generative AI into the context of the Fourth Industrial Revolution in developing countries, where technological change is a crucial determinant of progress and equitable growth.

Introduction

Artificial intelligence (AI) is widely recognized as a key driver of technological change in the Fourth Industrial Revolution (4IR). In recent times, there has been significant progress in AI, with Generative Artificial Intelligence (GAI) emerging as a highly discussed and popular topic. Generative AI refers to artificial intelligence tools or technologies that generate content, such as text, audio, or video, aiming to produce novel, unique, and creative content using the data it has been trained on (Aydın and Karaarslan, 2023).

It is important to highlight that Generative AI systems possess a unique capability of providing replies and generating the content of those responses, surpassing the human-like interactions seen with Conversational AI systems (Lim et al., 2023). Generative AI's ability to produce complete and comprehensive real-time responses sets it apart from Conversational AI systems, making it a powerful tool for various applications. It is worth mentioning that while some Generative AI is conversational, not all of it is, and not all conversational AI is incapable of generating content (Lim et al., 2023).

Furthermore, the recent advancements in AI have the potential to impact content production and creation profoundly. The introduction of ChatGPT and DALL-E has played a significant role in the growing popularity of generative AI in the twenty-first century. ChatGPT is a generative AI-powered conversational assistant that generates responses that closely resemble natural human language based on its training data (Lund et al., 2023a). Similarly, DALL-E is a generative AI tool that uses natural language prompts to generate realistic images (Singh et al., 2021). These developments have the potential to reshape our perspective on content production and creation.

According to PwC, the widespread adoption of AI could increase global GDP by $15.7 trillion by 2030, highlighting its importance for economic growth (PWC, 2023). However, it is crucial to recognize that AI advancements have predominantly benefited "developed countries," and the potential impact of generative AI on developing countries remains

largely unexplored. The benefits of these technologies are not equally accessible to everyone, and developing countries face unique challenges due to limited access to cutting-edge technologies and inadequate infrastructure. Therefore, the objective of this study is to explore and understand the potential impact of generative AI technologies on developing countries, focusing on both positive and negative effects across different domains.

Key terms used in this paper

The following definitions will be helpful for understanding the terminology used in this paper:

Fourth Industrial Revolution: The current era of technological advancements, characterized by the integration of digital technologies, artificial intelligence, robotics, and automation into various industries and sectors (Lund, 2021).

Artificial Intelligence: The simulation of human intelligence in machines, enabling them to perform tasks and make decisions that typically require human intelligence (Kok et al., 2009).

Generative AI: A subset of artificial intelligence that focuses on creating new content, such as text, audio, or video, using machine learning models trained on existing data (Lund and Wang, 2023).

Developing Countries: Countries that are in the process of improving their economic and social conditions, often characterized by lower income levels, limited industrialization, and infrastructure development compared to developed nations (World Trade Organization, 2023). This term may be used interchangeably with "developing nations" and "the Global South."

ChatGPT: An advanced language model developed by OpenAI that can conversationally generate text responses, resembling natural human language (Lund and Wang, 2023).

AI and employment opportunity

Although several researchers have discussed potential job replacement opportunities in the broader context of AI emergence (Acemoglu et al., 2022; Damioli et al., 2023; Genz et al., 2021; Tolan et al., 2021), this section specifically focuses on the impact of generative AI on employment in developing countries. Generative AI has the potential to revolutionize employment opportunities by addressing language barriers, improving digital literacy, automating tasks, and providing cost-effective coaching (Lund et al., 2023a). However, it is crucial to also consider the potential negative impacts,

such as job automation and reduced demand for certain skilled positions. Understanding these dynamics is essential in harnessing the benefits of generative AI while mitigating the potential challenges for employment in developing countries.

Positive impacts of AI on employment opportunity

Language proficiency and communication skills are crucial for employment opportunities in developing countries, as they impact job prospects, career advancement, and effective communication with colleagues, clients, and customers (Abbas et al., 2021; Durga, 2018; Roshid and Chowdhury, 2013; Sobaih, 2015). Generative AI, such as ChatGPT, has the potential to improve job seekers' language education, assist with translation in online platforms, and enhance grammar, language, and writing skills (Jiao et al., 2023).

In addition to language barriers, technological barriers can limit employment opportunities in developing countries, where basic technical skills and digital literacy are often required (Bejaković and Mrnjavac, 2020). Generative AI, including chatbots like ChatGPT, can help bridge the gap of digital illiteracy by providing guidance and instructions for tasks like managing a GitHub repository (Choi et al., 2020).

Generative AI can also automate tasks such as resume generation, portfolio creation, scheduling, data entry, and research, increasing job seekers' efficiency and reducing expenses (Malhotra et al., 2021). AI coaching systems can provide personalized feedback and guidance to enhance performance and achieve professional goals, offering a cost-effective alternative to traditional coaching (Graßmann and Schermuly, 2021). The emergence of generative AI models will create new job roles, such as prompt engineers, who play a crucial role in creating prompts and ensuring quality output (White et al., 2023). However, adapting to new technologies and acquiring technical proficiency will be essential for job seekers from developing countries to succeed in these roles.

In summary, generative AI has the potential to revolutionize employment opportunities in developing countries in the following ways:

- AI overcoming language barriers and helping with translation and language education.
- AI providing technological skills and improving the digital literacy of employees.
- AI increasing employer's efficiency by delegating mundane and repetitive tasks.

- AI providing a cost-effective coaching service for skill development.
- AI creating new roles for working with generative AI, such as prompt engineering.

Negative impacts of AI on employment opportunity

Generative AI offers benefits to job seekers by automating repetitive tasks, but the widespread automation of jobs can have negative implications for employment opportunities, particularly in emerging economies (Soto, 2020). Since many workers from developing nations rely on online platforms and freelance work, the impact of automation could be devastating (Beerepoot and Lambregts, 2015). Clerical tasks like data entry, tech support, and customer service, which are popular job postings in the online space, are likely to be replaced by generative AI (Kässi and Lehdonvirta, 2018). AI chatbots are already being used extensively for customer service applications across various sectors (Dwivedi et al., 2021; Mogaji et al., 2021), posing a risk of unemployment for employees in developing countries.

Moreover, generative AI has the potential to reduce the demand for certain skilled jobs as technology advances. For instance, ChatGPT has shown promise in tasks like software coding and fixing programming bugs, which traditionally required specialized training (Jalil et al., 2023; Sobania et al., 2023; Surameery and Shakor, 2023). While generative AI's creative capabilities in producing visual and literary arts are still limited, it is expected to improve over time (Shahriar, 2022). This advancement may result in the replacement of tasks like copywriting and branding, further limiting employment opportunities for artists and creative talents in developing countries.

In summary, generative AI may hinder employment opportunities in developing countries in these ways:

- AI replacing clerical tasks, such as data entry and customer service, through automation.
- AI reducing demand for some jobs requiring human expertise, such as programming.
- AI reducing employment opportunities for artists and creative workers (Rampersad, 2020).

AI and industry growth

Developing countries can achieve rapid economic growth and become global leaders through the adoption and development of generative AI technology (Houde et al., 2020). However, this growth relies on establishing infrastructure, investing in resources and education, and implementing proper policy frameworks. Research shows that investing in an AI-driven economy can reduce poverty, enhance infrastructure, and promote economic stability (Houde et al., 2020). It also facilitates international trade, knowledge exchange, and economic diversity. Generative AI offers benefits in art, architectural design, and serving underserved markets by generating realistic images, modifying audio streams, and producing high-quality speech for communication disabilities (Tacheva and Ramasubramanian, 2023). Additionally, it improves efficiency, productivity, decision-making, innovation, and customer experience by automating tasks, enabling focus on higher-level responsibilities, providing insights from complex data, and personalizing customer interactions (Bang et al., 2023; Rudolph et al., 2023). However, challenges exist, including upfront costs, limited Internet access, disparities, biases, and obstacles perpetuated by AI (Houde et al., 2020). Previous industrial revolutions highlight potential challenges, and concerns about fakes and job displacement arise. To mitigate these drawbacks, businesses and policymakers should invest in retraining programs, ensure diverse and unbiased training data, implement robust cybersecurity measures, and establish ethical standards for generative AI.

Positive impacts of AI on industry growth

Developing countries have the potential to become global leaders and experience rapid economic growth through the development and adoption of generative AI technology. However, this growth relies on the establishment of proper infrastructure, investment in resources and education, and the implementation of appropriate policy frameworks (Arun, 2020; Heng et al., 2022). Studies indicate that investing in an AI-driven economy can reduce poverty, enhance infrastructure, and create a more stable economy (Goralski and Tan, 2020; Mhlanga, 2021; Wakunuma et al., 2020). AI adoption can also elevate countries in international trade, facilitate the exchange of students and top researchers, and increase the diversity of an economy (Korinek and Stiglitz, 2021; Kakaniet al., 2020; Meltzer, 2018; Sharma et al., 2022).

Generative AI offers numerous benefits, such as its art and design abilities, which can be utilized in the creative industry for architectural design and serving

under-served markets (Blaas, 2023; Houde et al., 2020). It can also generate time-aged images of lost loved ones, modify accents in audio streams, and produce high-quality speech for individuals with severe communication disabilities (Houde et al., 2020; Qadir, 2022). Additional benefits of generative AI include:

- AI increasing efficiency: Generative AI automates tasks that would typically require significant time from humans, leading to time and resource savings for businesses (Tacheva and Ramasubramanian, 2023).
- AI increasing productivity: By automating repetitive tasks, generative AI allows employees to focus on more creative and higher-level responsibilities, resulting in increased productivity (Tacheva and Ramasubramanian, 2023).
- AI producing better decision-making: Generative AI provides insights into complex data sets, empowering businesses to make informed decisions, particularly in areas like customer data analysis for product development and marketing strategies (Tacheva and Ramasubramanian, 2023).
- AI increasing Innovation: Generative AI enables the creation of new products and services that businesses may not have been able to develop otherwise, leading to new revenue streams (Tacheva and Ramasubramanian, 2023).
- AI enhancing customer experience: Generative AI allows for personalized customer interactions through tailored marketing campaigns and the use of technologies like facial recognition, iris scans, and fingerprints (Crawford, 2021). It can also assist public service organizations in processes like telehealth, passport issuance, and government subsidy disbursement by identifying ghost workers (Tacheva and Ramasubramanian, 2023).

Negative impacts of AI on industry growth

Risks and pitfalls for the AI economy in developing countries are as multitudinous as the potential benefits. In many countries, investing in the AI economy may be prohibitive due to upfront costs (Kumar et al., 2021; Nadeem et al., 2023; Strusani and Houngbonon, 2019). In nations where reliable Internet access is a luxury and access to necessary software costs more than a month's wages, participation in the Fourth Industrial Revolution may seem impossible (Ernst et al., 2019; Lund, 2022; Lund et al., 2021).

There are also foreseeable risks with how existing disparities in the economies of developing nations may be exacerbated by an AI-driven economy. Such disparities include gender inequities, ethnic barriers (Hagerty and Rubinov, 2019), and wealth barriers (Lutz, 2019), which is not to mention the biases and obstacles perpetuated by AI, as well documented by authors like Safiya Noble (2018).

Based on prior industrial revolutions, we can foresee the additional challenges posed by generative AI and the Fourth Industrial Revolution and their consequences. The first industrial revolution, lasting from the mid-eighteenth century to the mid-nineteenth century, produced considerable disparity as "western" countries capitalized on access to resources, trade, and labor, while once- dominant eastern nations like India and China experienced much slower growth (Mohajan, 2019; Stearns, 2020). The second industrial revolution, in the late 19th and early twentieth century, relied on skilled labor for growth in nations with existing infrastructure (Chin et al., 2006). The third industrial revolution (or "digital revolution"), in the mid-to-late twentieth century, emphasized the need for highly-trained educated workers with English language proficiency (Charlesworth, 2009). None of these industrial revolutions have destroyed economies, but they have dramatically impacted individuals and impacted people and groups in disparate ways (Makridakis, 2017).

Some opined that for generative AI to interactively present as humans might be harmful interactively, generated contents may contain fakes, and ownership and market niche for hand-crafted materials may be affected, thereby requiring more digital forensics (Houde et al., 2020).

Others anticipate a significantly increase in fake materials due to reduced costs (Houde et al., 2020). Other negative impacts include:

- Overreliance on AI: Businesses that become too reliant on generative AI may lose the ability to innovate and make decisions without the help of AI, which can be detrimental in the long run (Keding and Meissner, 2021).
- AI-produced bias and discrimination: Generative AI models are only as unbiased as the data they are trained on, and if there are biases, inequities, or discrimination in the data, the generative AI model may perpetuate those

prejudices (Costanza-Chock, 2020; D'Ignazio and Klein, 2020; Qadir, 2022; Tacheva and Ramasubramanian, 2023).

- AI-related security risks: Generative AI models may be vulnerable to security breaches, which can lead to the theft of sensitive data or intellectual property (Costanza-Chock, 2020).
- AI-caused job displacement: As generative AI becomes prevalent, some jobs may become automated, leading to job displacement for certain workers.
- Other AI-related ethical concerns: Generative AI models can create content that may be inappropriate or unethical, such as deep fakes or fake news, which can have negative impacts on society (Tacheva and Ramasubramanian, 2023).

While Generative AI offers many advantages, there are also significant drawbacks to reflect on. Therefore, businesses and policymakers must be conscious of the potential negative impacts of generative AI and work to lessen their effects. This action can include investing in retraining programs for displaced workers, ensuring that data used to train generative AI models are diverse and unbiased, implementing strong cybersecurity measures, and setting ethical standards for generative AI.

AI and higher education and academic libraries

Generative AI has the potential to bring about transformative changes in higher education among developing countries. Throughout history, higher education has been a catalyst in raising challenging questions and forming comprehensive opinions about novel concepts. In particular, higher education has played a vital role in adopting emerging technologies that have eventually been successfully incorporated into education, becoming the "norm." For instance, consider the way in which higher education revolutionized the delivery of curriculum by advocating for alternative modes of learning that catered to nontraditional students, resulting in the advent of hybrid or blended learning. This example establishes that higher education is not averse to taking a leadership role and providing guidance to others in terms of creating opportunities for emerging technologies, including Generative AI. Though "references to AI in the literature are often vague and open to debate," higher education has an opportunity to be a trailblazer in regard to pushing

the boundaries and exploring the positive and negative impacts of Generative AI (Bearman et al., 2022). "The priority should be to embrace the opportunities presented by this [Generative AI and developments that fall under its' scope like ChatGPT] development and optimally manage any associated risks" (Dergaa et al., 2023). It is, furthermore, important to consider how these positive and negative changes will specifically affect the functioning of higher education in developing countries.

Positive impacts of AI on higher education and learning

To fully appreciate the potential of Generative AI, it is crucial to understand that it transcends Conversational AI by not only providing responses but also generating the content of those responses in a human-like manner (Lim et al., 2022). As a result, Generative AI has the capacity to bolster interpersonal communication skills, which could have a positive impact on individuals from developing countries in higher education. By retaining and utilizing information provided by users, it can assist with various tasks within higher education, such as writing, communication, curriculum, and administrative duties. Consequently, Generative AI has the potential to create significant opportunities in higher education within developing countries by improving writing performance, facilitating personalized learning experiences, advancing research capabilities, enhancing accessible learning opportunities, and optimizing grading, scheduling, and enrollment processes. For instance, an AI writing assistant application called Wordtune, helping authors writing in English improve writing skills through understanding their thoughts, is receiving increasing attention in English as Foreign Language communities (Zhao, 2022).

To begin, Generative AI has the potential to enhance writing performance by offering automated suggestions for improving word choice, sentence structure, flow, and overall coherence of the text. Since "these text-generating software [like] programs sift through massive databases to generate human-like responses to prompts or questions from users," it has the ability to further craft or hone an individual's writing skills (Garbarine, 2023, para. 2). For example, Generative AI takes large datasets of texts to identify patterns and relationships between words and phrases, enabling it to make informed suggestions for improving the quality of writing. Furthermore, it could help academics who are attempting to write in a language that is not their native tongue take advantage of these tools "for

intellectual development and higher-order reasoning" (Garbarine, 2023, para. 8). Accessibility to these improvements and suggestions could benefit students that do not, sometimes, have the support of their education systems that developed countries often do. By using Generative AI to improve their writing, these students could increase their opportunities for employment or pursue higher educational degrees.

Since Generative AI can help students become better writers it also leads to furthering their research capabilities and opportunities. This will help them thereby embark on a trajectory of enhanced academic achievement. Research, a cornerstone of higher education, stands to benefit significantly from the integration of Generative AI. Students in developing countries could have the ability of AI-powered tools to swiftly navigate vast repositories of scholarly literature, distill key insights, and streamline information. Their availability and accessibility to these tools will lead to more content being created in research. Moreover, for these students, who may encounter limited access to physical libraries or constrained resources, Generative AI presents an invaluable resource for sourcing and organizing data, thus expediting the research process.

In the context of education, the potential of Generative AI to create personalized learning experiences is of great interest in developing countries. The effective use of this technology can be a significant advantage for improving educational outcomes in this region. Pataranutaporn et al., (2021) explore how advancements in Generative AI can make an "enormous impact" on students simply because their environments matter, spending so much time in learning. Students in these regions often face a range of environmental and educational barriers and challenges, such as limited resources, overcrowded classrooms, and a lack of individual attention from teachers. By creating personalized learning experiences, Generative AI can help students overcome these challenges and improve their academic performance. This will ultimately lead to strengthening accessible learning opportunities.

In summary, Generative AI has the potential to revolutionize higher education and learning in developing countries in the following ways:

- AI enhancing writing performance through automated suggestions for improving word choice, sentence structure, and coherence of the text.
- AI supporting academics writing in a non-native language, fostering intellectual development and higher-order reasoning.

- AI improving research capabilities by swiftly navigating scholarly literature, distilling key insights, and streamlining information.
- AI expediting the research process by sourcing and organizing data, particularly valuable for students with limited access to physical libraries and resources.
- AI creating personalized learning experiences to overcome environmental and educational barriers, such as limited resources and overcrowded classrooms.
- AI improving academic performance and strengthening accessible learning opportunities, ultimately benefiting students in developing countries.

Negative impacts of AI on higher education and learning

To fully comprehend the potential effects of Generative AI, it is crucial to consider its limitations and negative implications, particularly in the context of higher education in developing countries. While Generative AI has the ability to generate content in a human-like manner, it may inadvertently hinder interpersonal communication skills rather than bolster them. The reliance on AI-generated responses can potentially discourage authentic human interaction and hinder the development of effective communication skills, which are vital in academic and professional contexts. Using AI to determine what educational and reading materials to acquire could result in biases in selection that reflect the biases of the AI algorithm. These biases may restrict the freedom of the public to access the information that they need, which has detrimental impacts on society (Teel, 2023).

Regarding writing performance, while Generative AI can offer automated suggestions for improving word choice, sentence structure, and coherence, it runs the risk of homogenizing writing styles and stifling individual expression. The AI-generated suggestions may prioritize conformity over originality, potentially inhibiting the development of unique voices and perspectives among students. This could have a negative impact on the cultural diversity and intellectual richness that students from developing countries bring to the academic landscape.

In the realm of research, the integration of Generative AI may inadvertently lead to a devaluation of traditional research methodologies. While AI-powered tools can assist in navigating scholarly literature and extracting key insights, there is a danger of

overlooking the nuanced and context-specific aspects of research. Relying solely on AI-generated information may neglect the critical evaluation and interpretation of data, potentially compromising the quality and validity of research conducted by students in developing countries. Moreover, the adoption of Generative AI in personalized learning experiences can raise concerns about equity and access. The reliance on AI algorithms may exacerbate existing disparities in educational resources and opportunities. Students in developing countries, who already face limited resources and educational barriers, may encounter further marginalization if they lack access to the necessary technology, infrastructure, or training required to leverage Generative AI effectively, which could deepen the digital divide and perpetuate existing inequalities in education.

While Generative AI presents potential benefits for students in higher education, particularly in developing countries, it is essential to critically examine its negative implications. The potential hindrance of interpersonal communication skills, overdependence on AI systems, homogenization of writing styles, devaluation of traditional research methodologies, and exacerbation of equity issues are all factors that should be carefully considered and addressed to ensure the responsible and inclusive integration of Generative AI in higher education settings.

In short, it is important to contemplate the negative implications of generative AI in higher education and learning, including the following ways:

- AI hindering interpersonal communication skills by discouraging authentic human interaction and reliance on AI-generated responses.
- Biases in AI algorithms for determining educational materials, potentially restricting access to information and undermining freedom.
- AI homogenizing writing styles and stifling individual expression by prioritizing conformity over originality.
- Devaluing traditional research methodologies by relying solely on AI-generated information, potentially compromising research quality.
- Raising equity and access concerns, as students lacking necessary technology, infrastructure, or training may face further marginalization.
- AI deepening the digital divide and perpetuating existing inequalities in education.

To maximize the benefits and mitigate the drawbacks, it is crucial for higher education institutions in developing nations to take a proactive approach. They should lead in exploring the potential of Generative AI, while also critically examining its limitations and negative implications. Responsible integration of Generative AI should prioritize the development of effective communication skills, the preservation of individual expression and diversity, and the equitable distribution of resources and opportunities.

By carefully considering the positive and negative aspects of Generative AI in higher education, institutions in developing countries can harness its potential for transformative change while ensuring that it aligns with their specific needs and values. The responsible and inclusive integration of Generative AI can contribute to advancing education and empowering students in developing countries, while also addressing the challenges and risks associated with the technology.

Furthermore, the issue for higher education related colleges and universities is intellectual integrity policies. It is the principle that the students should do their own work rather than use generative AI. An automatic academic fraud detection machine may lag behind new technology and innovation (Anctil, 2023).

AI and environmental issues

This section of the paper explores the positive and negative impacts of General Artificial Intelligence on the environment. AI has the potential to play a significant role in mitigating global warming and reducing greenhouse gas emissions through its ability to automate data processing, expedite knowledge acquisition, and enhance decision-making processes (Barteková and Börkey, 2022). By enabling computers to understand natural language, AI facilitates climate analysis and forecasting, aiding in the understanding of human activities' interactions with natural phenomena (Rosenbaum, 2023). Additionally, AI contributes to energy conservation by automating energy audits, identifying energy-saving opportunities in buildings, and optimizing renewable energy systems' design (Murphy, 2023; Maharaj, 2023). It also assists in improving the efficiency of carbon capture and storage by automating the design process (Maharaj, 2023). However, there are negative environmental impacts associated with AI, primarily related to its energy consumption, water usage, and greenhouse gas emissions during model development and training (Barteková and Börkey, 2022). These negative consequences must be carefully managed to minimize their impact.

Positive impacts of AI on the environment

AI has the potential to significantly contribute to mitigating the consequences of global warming and lowering greenhouse gas emissions by automating data processing, providing new knowledge more quickly, and helping us make better decisions (Huntingford et al., 2019). It plays a crucial role in advancing human communication by enabling computers to understand and converse in natural language (Barteková and Börkey, 2022). Understanding the interactions between human activities and natural phenomena is key to combating climate change and the biodiversity crisis, and developing a digital twin of the Earth will enable dynamic Earth simulations, improve prediction capabilities, and inform environmental policy-making (Rosenbaum, 2023).

The ability of AI to automate most of the analysis and computations reduces the time and effort necessary to complete an energy audit. It examines a building's design, construction materials, and environment to identify possible energy savings and sustainability improvements, fast-tracking the energy audit and certification procedures while lowering costs and improving accuracy (Murphy, 2023).

AI can also help improve the effectiveness of renewable energy systems by automating the design process and evaluating data on energy output and consumption using machine learning algorithms. It may provide new designs that are more efficient, economical, and scalable, while also improving the accuracy of energy forecasts by evaluating data from weather satellites and other sources (Maharaj, 2023; Murphy, 2023). However, the ethical use of AI in this context is crucial to avoid incorrect resource allocation and forecasts that can lead to waste and inefficiency.

Furthermore, AI can assist in improving the efficiency of carbon capture and storage by automating the design process. By evaluating data on carbon collection and storage, AI can provide new solutions that are more effective, economical, and scalable, helping to enhance carbon storage and greenhouse gas absorption (Maharaj, 2023).

In summary, the positive impacts of Generative AI on the environment include:

- AI facilitating climate analysis and forecasting
- AI promoting energy and biodiversity conservation
- AI enhancing carbon storage and GHG absorption while also decarbonizing carbon-intensive industries, including transportation and agriculture.
- AI enhancing design optimization and retrofitting modifications
- AI aiding calculation of energy performance ratings
- AI supporting digital twin simulations of Earth's environmental characteristics

Negative impacts of AI on the environment

The direct environmental impacts of AI computing, particularly in the development and training of AI models, are primarily negative in terms of greenhouse gas (GHG) emissions and resource consumption (Barteková and Börkey, 2022). The energy consumption associated with large-scale AI models and the widespread use of AI in various applications, including basic searches, can be substantial, surpassing conventional conceptions (Chang and Kidman, 2023). The magnitude of energy usage is projected to increase significantly, with each AI query demanding four to five times more computer power (Kumar, 2023). OpenAI's power consumption in January 2023 has been estimated to be equivalent to the yearly consumption of 175,000 Danish families, and the potential spread of AI usage could result in millions of people's electrical use (Auslender and Ashkenazi, 2023; Pascual, 2023).

The rising demand for data centers, driven by the growth of Generative AI and other AI applications, is straining local energy networks and affecting new housing developments (Financial Times, 2022; The Times, 2022). Moreover, the demand for power systems and data centers is expected to increase due to climate change and more frequent heat waves, potentially causing disruptions (Google Cloud, 2022). Water consumption is another concern associated with AI systems, with water used for cooling and energy generation in the hardware and infrastructure (OECD, 2022). Data centers, including those supporting Generative AI, are among the top water-consuming businesses in the United States, relying on limited water sources and impacting watersheds (Mytton, 2021; Siddik et al., 2021).

GHG emissions from Generative AI model training and development contribute to the environmental cost of AI computing (Barteková and Börkey, 2022). Even when renewable energy sources are available, the high energy demands of these models remain a concern, and the emissions disproportionately affect marginalized

communities residing in polluted areas (Chang and Kidman, 2023; Michelle, 2023).

In summary, the negative impacts of AI on the environment include:

- AI creating high energy consumption
- AI increasing water consumption
- AI increasing greenhouse gas (GHG) emission and pollution

Generally, the environmental impacts of AI will be determined by how it is built, implemented, and managed. Like with any technology innovation, it is critical to carefully consider the potential environmental effects and work to minimize the negative consequences while taking full advantage of its positive benefits.

AI and health and well-being

Since the mid-twentieth century, medicine has been considered one of the most promising application areas of AI based on the development of clinical decision support systems, interpreting ECGs, diagnosing, and choosing treatments (de Dombal et al., 1972; S Kundu et al., 2000; Miller, 1994; Yu et al., 2018). In recent years, with the proliferation of AI and related technologies, algorithms have been shown to outperform radiologists in finding malignant tumors and can guide researchers in building fleets for expensive clinical trials (Davenport and Kalakota, 2019). In addition, AI can help medical professionals provide up-to-date medical information from journals, textbooks, and clinical practices, and extract useful information from large patient populations to help infer health risk alerts and health outcome predictions in real time (Jiang et al., 2017; Neill, 2013). However, the medical community has also widely discussed the ethical and legal challenges associated with the application of AI in healthcare.

Positive impacts of AI on health and well-being

The application of AI in the medical field is vast, such as cardiology, neurology, and genetics (Bouton et al., 2016; Dilsizian and Siegel, 2014; Somashekhar et al., 2017). It has positively impacted the development of medicine, such as accelerating drug discovery, assisting clinical trials, patient caring (Shaheen, 2021), estimating health status via wearable health devices, and automatic robotic surgery (Yu et al., 2018). Automated medical image diagnosis is the most prosperous area of medical AI, especially in image-based diagnosis

disciplines, such as ophthalmology, dermatology, and radiology (Yu et al., 2018). In radiology, for instance, radiologists use a collection of images for disease screening and diagnosis to determine the disease's cause and monitor the disease's signs of progress (Reed, 2010). With the help of modern machine learning methods, AI has formed deep neural networks by training them with millions of natural, non-medical images and fine-tuning neural network connections with thousands of biomedical images. AI has reached expert diagnosis accuracy in radiology (Yu et al., 2018).

Rare diseases are a significant challenge for healthcare providers due to factors such as delayed diagnosis and misdiagnosis, lack of response to treatment, and inadequate practical surveillance tools, caused by the small number of individuals with a single rare disease, the lack of relevant information, and the overlap of symptoms in multiple rare diseases (Hurvitz et al., 2021; Wang et al., 2023). AI has not only been proven to provide early detection and diagnosis, treatments, prognostic prediction, and evaluation for patients suffering from common diseases such as stroke (Jiang et al., 2017) but also find new disease mechanisms and therapeutic targets through mutation detection, prediction, and classification of AI algorithms to provide and accelerate diagnosis, and correct misdiagnosis for individuals with rare diseases, and bosts relevant drug development (Brasil et al., 2019). For instance, the Hugh Kaul Precision Medicine Institute has developed mediKanren, an AI tool that identifies treatment options by linking all relevant literature and identifying mechanically-based insights into rare diseases (Foksinska et al., 2022). In addition, Kiely et al. (2019) used AI algorithm modeling to screen idiopathic pulmonary hypertension to promote early diagnosis rate and patient prognosis of the disease. With the continuous development of AI, it has been able to monitor health status and interpret changes in patient status, disease progression, treatment response, and environmental factors through a dynamic feedback loop, to improve treatment and care outcomes and reduce cost (Hurvitz et al., 2021).

In summary, the application of AI may have tremendous impacts on healthcare in developing countries, including:

- AI accelerating drug discovery and assisting clinical trials.
- AI assisting in patient care and estimating health status through wearable health devices.

- AI enhancing automated medical image diagnosis in disciplines such as ophthalmology, dermatology, and radiology.
- AI improving early detection, diagnosis, and treatment of rare diseases.
- AI providing prognostic predictions and evaluations for patients with common diseases.
- AI identifying new disease mechanisms and therapeutic targets.
- AI facilitating mutation detection, prediction, and classification for individuals with rare diseases.
- AI monitoring health status, disease progression, treatment response, and environmental factors for improved treatment outcomes and reduced costs.

Negative impacts of AI on health and well-being

The successful implementation of AI in healthcare services faces three primary challenges: ethical challenges, social and regulatory concerns, and technical barriers. Ethical challenges encompass potential biases in AI models, safeguarding patient privacy, and establishing trust among clinicians and the public when utilizing AI in healthcare (Whittlestone et al., 2019). Biases arise when the training data used for AI models lack representation of the target population or are inadequate and incomplete, exacerbating health disparities (Reddy et al., 2020). Protecting patient privacy is crucial as the deep learning model employed by AI may inadvertently collect and transmit data without the patient's knowledge, leading to privacy breaches (Vayena et al., 2018). Breaches in privacy can result in psychological and reputational harm to patients, necessitating robust privacy safeguards (Dawson et al., 2019). The researchers also noted the relevant concerns. Wu et al. (2022) proposed a medical service data privacy protection scheme based on blockchain and AI—users can securely transmit healthcare data to doctors by managing session keys.

Integrating AI applications into a decentralized healthcare system encounters challenges due to complex political and economic dynamics influenced by medical practice norms and commercial interests (Panch et al., 2019). Ambiguity in current medical and legal guidelines regarding AI's role can create confusion about responsibilities, potentially impacting treatment strategies in routine clinical practice and increasing regulatory complexity (Reddy et al., 2019). The absence of standardized regulatory standards for assessing the safety and impact of AI algorithms further complicates the implementation of AI in healthcare (Aronson and Rehm, 2015). Clinician trust in AI-recommended treatment strategies is crucial, as lacking trust may lead to the rejection of appropriate recommendations (Luxton, 2019). Additionally, the introduction of AI in healthcare, while aiming to improve care quality by reducing human error and physician fatigue, may increase physician workload as AI clinical guidelines recommend more frequent examinations of high-risk patients (Yu et al., 2018).

While AI has demonstrated success in tasks such as image classification, translation, and speech recognition, clinical diagnostic and therapeutic tasks require a deeper understanding of context, including patient preferences, values, social support, and medical history (Boulanger-Lewandowski et al., 2012; LeCun et al., 2015). The current algorithms for AI multi-modal clinical data analysis often lack consideration of social context, posing a challenge in comprehensive healthcare analysis (Yu et al., 2018). Although AI models may outperform humans in analyzing medical data and images, they may struggle to provide intuitive explanations for their conclusions or identify their own weaknesses, which humans can often accomplish (Yu et al., 2018).

In developing nations, the use of AI technology in the medical field raises concerns about over-reliance due to the cost disparity between AI and human labor (Mahomed, 2018; Panesar et al., 2020). Collaborative partnerships between AI and human healthcare professionals can yield productive outcomes (Kolbjornsrud et al., 2017; Liaw and Kakadiaris, 2020). However, relying solely on AI without human intervention poses risks. While AI may perform exceptionally well in most cases, human intervention becomes critical in the rare instances where AI misprescribes medications or makes obvious surgical errors, potentially saving lives (Chen and Decary, 2020; Wiljer and Hakim, 2019). Patient reluctance or hesitancy toward AI-driven treatment is another challenge, particularly in developing countries, where technology innovations may be slower to gain acceptance (Cadario et al., 2021; Ghosh, 2022; Longoni et al., 2019; Shandlen, 2012).

In short, the potential negative impacts of generative AI in developing nations are multitudinous, including the following:

- Ethical challenges: Biases in AI models and patient privacy concerns.

- Regulatory complexity for AI: Ambiguity in medical and legal guidelines, lack of standardized regulatory standards.
- Physician workload: Potential increase due to AI-recommended guidelines.
- Contextual limitations: AI algorithms often overlook social context in healthcare analysis.
- AI acceptance and adoption challenges: Patient reluctance toward AI-driven treatment, especially in developing countries.

AI has revolutionized the medical field with its applications ranging from drug discovery and clinical trials to automated medical image diagnosis and patient care, especially to detect and diagnose rare diseases, find new disease mechanisms and therapeutic targets, and improve treatment and care outcomes. However, the ethical, social, regulatory, and technical issues of the implementation of AI exist, which should be addressed to ensure it is appropriately used to improve healthcare outcomes.

Discussion

Generative Artificial Intelligence (AI) holds both promises and threats for nations with developing economies. Without the necessary support, the AI revolution may serve as another barrier that exacerbates the economic divide among countries (Yu, 2020). It is plausible that some countries may seize the opportunity for growth, while others will struggle to launch an AI economy. Similarly, some countries in developed countries may lose their prominence as they struggle to transition their economies (Aly, 2022). With rapid transformation in the information and technology sectors, it is necessary for nations to invest in the following areas for sustainable development: AI policy, AI education and training, AI infrastructure, and public-private partnerships (Lund et al., 2023b).

AI policy

At the macro-level, it is essential for developing countries to establish comprehensive policy frameworks to guide AI adoption and development. These policies should outline a clear vision, objectives, and strategies for integrating AI across sectors (Schiff, 2022). Such policies will create an environment that attracts investments, fosters innovation, and supports AI-driven economic activities. Investing in AI research and development is crucial for developing indigenous

capabilities and driving economic growth. Therefore, governments must allocate resources to support AI-focused research institutions, universities, and innovation centers to strengthen the AI ecosystem and harness its benefits for economic advancement (OECD, 2022). Simultaneously, fostering a skilled AI workforce is essential for economic development and improved employability in developing countries (Executive Office of the President, 2016).Making explainable artificial intelligence a requirement, where AI creators must explain how the technology works, can enhance safety and security for the public (Guo, 2020).

At a micro and mezzo-scale, organizations should adopt AI policies that govern how employees, members, and/or users utilize AI technologies. For example, employers may implement a policy that restricts employees to use AI only with non-confidential information due to the risks related to data collection by AI companies. Having these policies in place allows employers to take appropriate actions if issues arise concerning employee use of AI technologies (Schiff et al., 2021). Similarly, schools may impose significant limits on the use of AI, such as large language models, not only to mitigate plagiarism and cheating risks but also to prevent the disclosure of confidential information, such as class materials.

AI education and training

Governments should prioritize AI-related skills through educational initiatives, training programs, and industry collaborations. By equipping individuals with AI skills, countries can drive innovation, enhance employability, and foster entrepreneurship in AI sectors, promoting economic growth. This entails integrating AI into curricula, forging partnerships with industry stakeholders, and providing support for AI startups, empowering the next generation to thrive in an AI-driven economy. Dynamic higher education programs that emphasize the integration of artificial intelligence into industry should be prioritized by grant funding agencies.

An example of a successful implementation of AI training is detailed in Leoste et al. (2021). In this study, the authors detail a series of workshops designed to introduce future workers to emerging technologies such as AI through direct interaction with the technology. Other practical implementations of AI training include AI microcredential programs (Ralston, 2021) and learning games (Alam, 2022).

AI infrastructure

Access to AI infrastructure and resources is vital for developing countries to participate in the AI revolution (Makridakis, 2017). Governments should invest in robust digital infrastructure, including high-speed internet connectivity, cloud computing facilities, and data centers (Mhlanga, 2021). By reducing barriers to entry, developing countries can empower entrepreneurs, startups, and small and medium-sized enterprises to leverage AI technologies for economic development.

For example, China has invested considerably in the infrastructure to support emerging AI technology (Ding, 2018). The aim of China's investment is to become a leader in AI development rather than become dependent on international technologies, which is accomplished by providing access to necessary hardware, data sources, and training while instilling Chinese national values (Allen, 2019). Investment in AI at a national level ensures coherence and consistent sources of funding and support (Roberts et al., 2021).

Public-Private partnerships for AI development

Public-private partnerships and collaborations hold immense potential in driving AI adoption, economic development, and innovation across various sectors (Baldoni et al., 2020). Governments should nurture an environment conducive to collaboration between AI startups, established businesses, research institutions, and healthcare providers. By fostering entrepreneurship and collaboration, developing countries can leverage AI as a catalyst for economic growth, job creation, and advancements in healthcare delivery. Such partnerships can lead to the development of AI-driven solutions that improve patient care, enhance diagnostics, enable early disease detection, and optimize treatment outcomes. Embracing collaboration and innovation enables developing countries to harness the transformative power of AI, addressing healthcare challenges, driving economic growth, and enhancing the well-being of their populations.

Conclusion

Generative AI has emerged as a highly discussed and influential technology in the era of the Fourth Industrial Revolution. The advancements in generative AI, exemplified by tools like ChatGPT, hold immense potential to reshape content production and creation. However, the impacts of generative AI are not evenly distributed, with the Global South facing unique challenges in accessing and benefiting from these transformative technologies. The potential for job replacement, industry growth, higher education transformation, environmental consequences, and impacts on health and well-being are significant considerations in the context of generative AI's integration. While generative AI presents opportunities for economic growth and transformative changes, it also raises ethical, legal, and environmental concerns that require careful attention and resolution.

To ensure equitable access and maximize the positive impacts of generative AI, it is crucial to provide comprehensive support, infrastructure, and policy frameworks for developing nations to harness its potential. Additionally, responsible adoption and integration of generative AI call for careful consideration of its implications in various domains. The transformative potential of generative AI can only be realized through collaborative efforts that prioritize ethical considerations, inclusivity, and sustainable development across global contexts. By embracing the advancements in AI, including generative AI, and addressing its challenges responsibly, we can pave the way for a more equitable and prosperous Fourth Industrial Revolution.

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