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Term Paper

**COR-MGMT2207 Innovations for Asia's Smart Cities (G1)
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Use of Artificial Intelligence (AI) in the Healthcare Industry

- History of AI in the healthcare industry

Recently, there has been much excitement surrounding AI. However, the concept of AI has existed for decades. Through the lens of smart cities, this term paper aims to discuss the usage of AI in healthcare by reviewing the history of AI, exploring the various use cases and ending with the future of AI in healthcare.

- Key Milestones

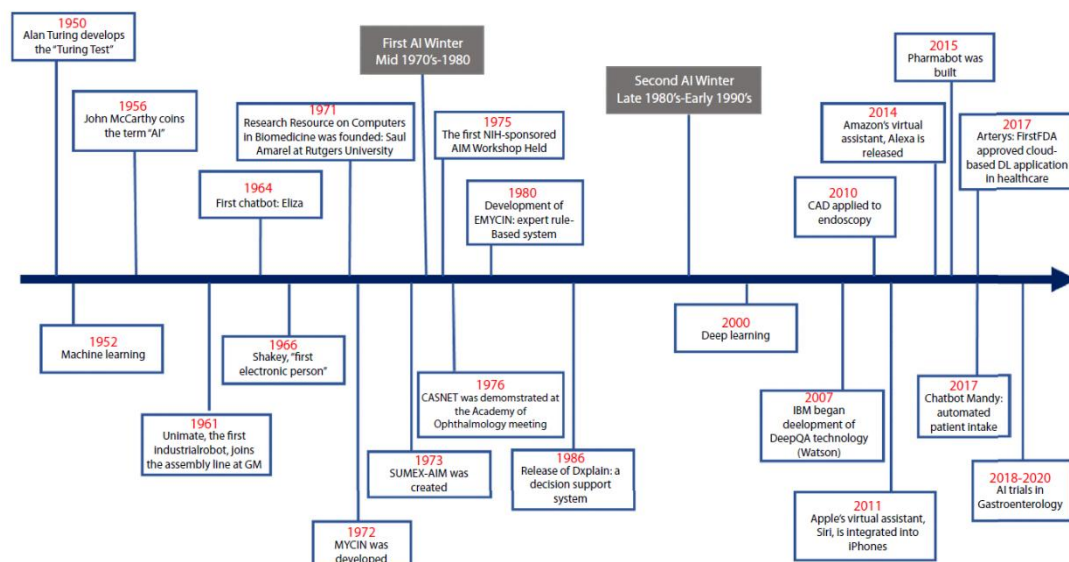
Alan Turing introduced the Turing test in 1950. It describes a computer as intelligent if humans are unable to distinguish between human responses and machine responses to a series of questions (Blakemore, 2024).

In 1956 at Dartmouth College, a group of scientists namely John McCarthy, Nathaniel Rochester, Claude Shannon and Marvin Minsky used the term “Artificial Intelligence” for the first time, describing it as “the science and engineering of making intelligent machines” (Joshi & Mishra, 2010).

Another notable development was Eliza, the first chatbot created by Joseph Weizenbaum in 1964 (Kaul et al., 2020). Then came the AI Winter, which saw a decrease in funding and development. Moving into the 2000s, there were more healthcare chatbots like Pharmabot and Chatbot Mandy being developed (Figure 1).

Figure 1

Historical Timeline of AI Development and Usage in Healthcare



Note. From *History of artificial intelligence in medicine* [Image], by Kaul, V., Enslin, S. & Gross, S.A., 2020, *Gastrointestinal Endoscopy*, 92(4), p. 808 (<https://doi.org/10.1016/j.gie.2020.06.040>). Copyright 2020 by the GIE Journal.

- How the Use of Technology in Healthcare Went Wrong

Using technology comes with risks and AI is no exception. In 2019, an algorithm that distinguish patients who should potentially join the “high-risk care management” programs, was more likely to flag White patients than Black patients in US (Olavsrud, 2024). There is bias present with the accessibility of healthcare treatments.

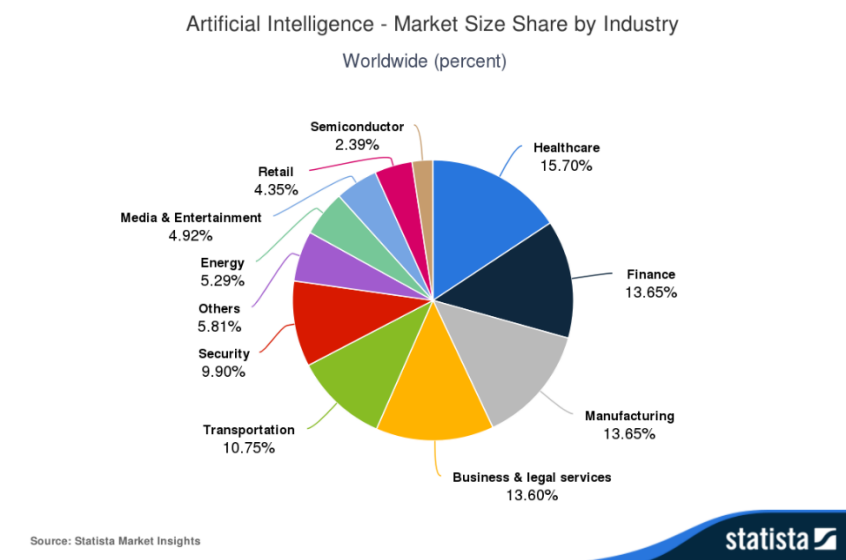
IBM’s Watson system won the Jeopardy game against humans in 2011 and drove IBM to implement it for healthcare (Kaul et al., 2020). Having had a strong partnership with Memorial Sloan Kettering and even hired 7,000 employees, Watson Health still fell short after being in the market for years and it was eventually sold off with a huge loss (Govette, n.d.).

- Market Size and Importance to Smart Cities

According to Statista Market Insights (2024), the AI market size is around US\$184 billion. Key sectors contributing to this growth include healthcare, finance and manufacturing (Figure 2). There is currently 71% of healthcare leaders in Singapore investing heavily into AI and it is set to increase to 80% in three years. In 2023, healthcare analytics and diagnostics are the top 2 domains adopting AI (Figure 3).

AI supports the concept of smart cities which is an “urban setting that applies technology to enhance the benefits and diminish the shortcomings of urbanization for its citizens.” (International Institute for Management Development, 2021). AI improves the quality of life and the interconnectedness of citizens and helps businesses provide efficient products and services. This ensures that the smart city is thriving economically and socially.

Figure 2
Artificial Intelligence Market Size Share by Industry



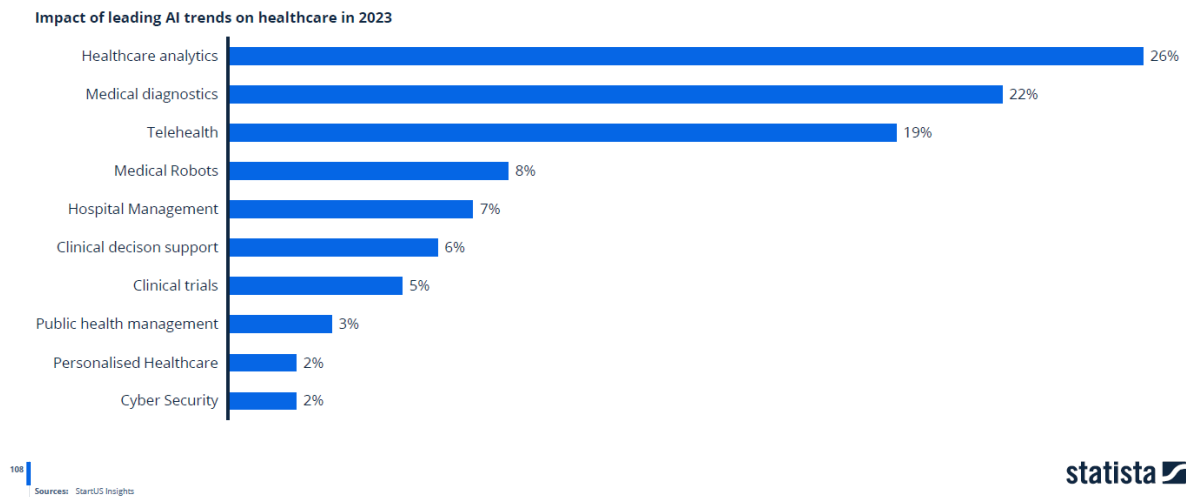
Note. Market Size Share by Industry. From *Artificial Intelligence – Worldwide Market Insights* [Image], by Statista, 2024, (<https://www-statista-com.libproxy.smu.edu.sg/outlook/tmo/artificial-intelligence/worldwide>). Copyright 2024 by Statista Market Insights.

Figure 3

Healthcare analytics and diagnostics stand out as the primary domains witnessing significant AI adoption

Healthcare analytics and diagnostics stand out as the primary domains witnessing significant AI adoption

Healthcare: AI adoptions



Note. Impact of leading AI trends on healthcare in 2023. From *Artificial Intelligence: in-depth market analysis* [Image], by Hoffman, J. & Mehta, D., 2024, Market Insights Report. (<https://www.statista.com/study/50485/in-depth-report-artificial-intelligence/>). Copyright 2024 by Statista.

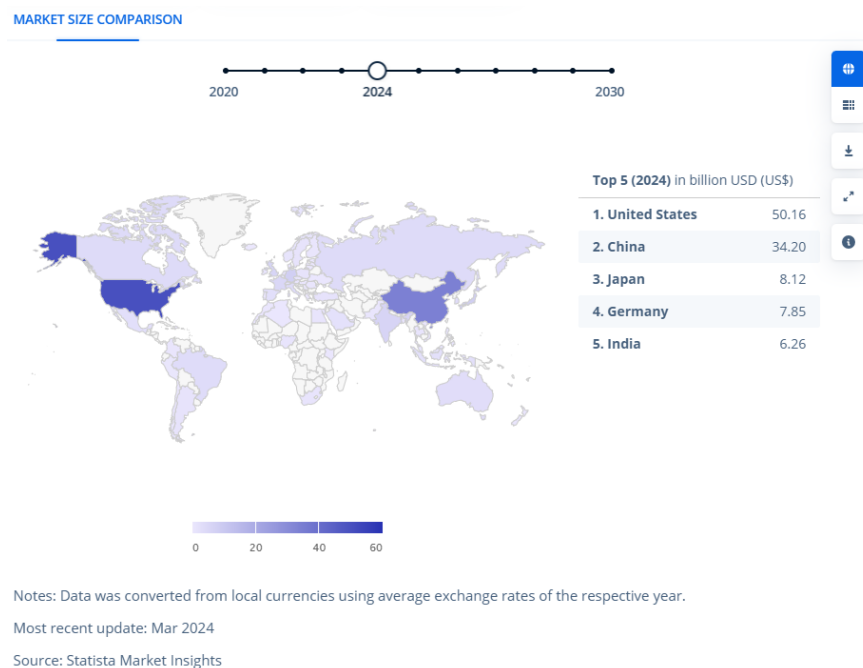
- Leading market players (countries and companies)

The top 5 countries with the highest AI market size are US, China, Japan, Germany and India (Figure 4). Furthermore, most of the top companies are from US which include Google (Figure 5) and OpenAI.

Google has a rich history in AI research, particularly DeepMind. It has a few healthcare initiatives such as a research partnership with University College London Hospitals NHS Foundation Trust's radiotherapy department that uses ML to decrease the time needed for treating head and neck cancers with radiotherapy and to come up with an algorithm that segments different body parts for radiotherapy (Hoffman & Mehta, 2024).

Founded in 2015, OpenAI is a big player in the AI sector (Kay & Jackson, 2024). The company became well-known with the launch of ChatGPT in November 2022 when people shared examples of using the chatbot via social media. Since 2022, OpenAI has released multiple versions of ChatGPT with the latest one being GPT-4o.

Figure 4
Top 5 Countries with the Largest AI Market Size in 2024



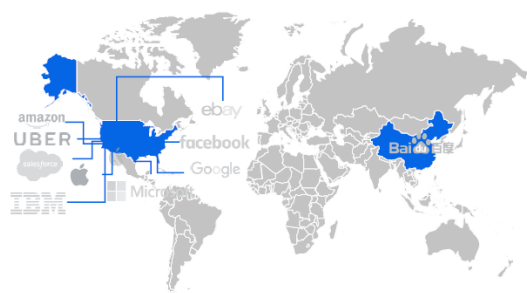
Note. Market Size Comparison. From Artificial Intelligence – Worldwide Market Insights, by Statista [Image], 2024, (<https://www-statista-com.libproxy.smu.edu.sg/outlook/tmo/artificial-intelligence/worldwide>). Copyright 2024 by Statista Market Insights.

Figure 5
Most of the leading AI companies are from the US

Most of the leading AI companies are from the U.S.

Company comparison

Location of selected leading AI companies



Comparison of selected leading AI companies

Company	Headquarter	Revenue in bnUS\$ ⁽¹⁾	Key AI areas
Amazon	Washington, U.S.	574.8	Text-to-speech, computer vision, deep learning, NLP
Apple	California, U.S.	383.3 ⁽²⁾	Machine learning
Baidu	Beijing, China	19.0	Machine learning, robotics
eBay	California, U.S.	10.1	Predictive analytics, cloud-based AI, big data
Facebook	California, U.S.	134.9	Language technology, machine learning, computer vision
Google	California, U.S.	307.4	Machine learning, deep learning, automotive industry
IBM	New York, U.S.	61.9	Machine learning, cognitive architectures
Microsoft	Washington, U.S.	211.9 ⁽³⁾	Machine vision, machine learning, healthcare
Salesforce	California, U.S.	34.9 ⁽⁴⁾	Machine learning, analytics
Uber	California, U.S.	37.3	Voice and image recognition, machine learning, automotive industry

175 Notes: (1) As of Dec 2022 (2) As of Sep 2022 (3) As of Jun 2022 (4) As of Jan 2023
Sources: Annual reports; Corporate newsletters

statista

Note. Company Comparison. From Artificial Intelligence: in-depth market analysis, by Hoffman, J. & Mehta, D. [Image], 2024, Market Insights Report. (<https://www.statista.com/study/50485/in-depth-report-artificial-intelligence/>). Copyright 2024 by Statista.

- How AI in Healthcare Work
 - AI's Role in Predictive and Preventive Healthcare

There is a transformative shift from focusing on the treatment of pre-existing medical conditions to the prevention of such conditions (Hoffman & Mehta, 2024) and keeping patients away from hospitals.

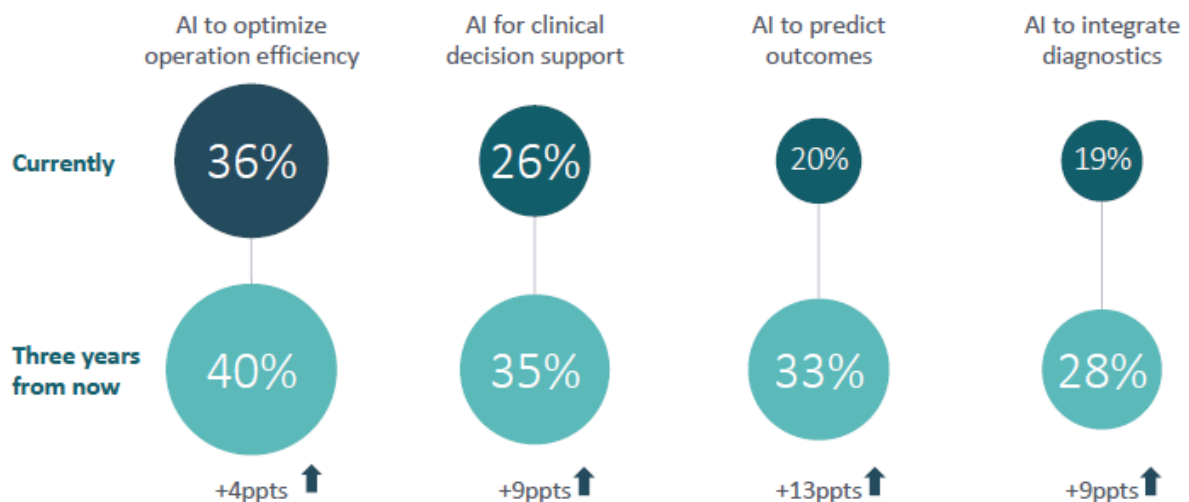
In Singapore, there are a few initiatives such as Healthier SG and Age Well SG that emphasise preventive healthcare (NTUC LearningHub, 2024). Healthcare leaders are heavily investing in AI capabilities to optimise operation efficiency, clinical decision support, predict outcomes and integrate diagnostics. (Figure 6).

A key application of AI in healthcare is transcription. Medical Social Workers (MSWs) in Singapore use Scribe to record conversations with patients and this is transcribed into organised documents (Hack for Public Good, n.d.). Concerns with patient data being exposed outside of the system arise. However, the data is protected as the models used are open-source and there are no external API connections. MSWs benefit when using Scribe as it saves time to take down notes, allowing them to focus on building genuine connections with patients.

Figure 6

Areas of Healthcare that AI Help with Identified by Singaporean Healthcare Leaders

Digital health technologies Singaporean healthcare leaders are most heavily investing in now and in the future: AI technologies



Note. From *A resilient future – Singapore* [Image] by Philips, 2021, *Future Health Index 2021*. (www.philips.com/futurehealthindex-2021). Copyright 2021 by Philips.

- Medical Diagnosis

AI contributes greatly to medical diagnosis specifically telemedicine, also known as telehealth which allows for remote delivery of healthcare. Due to the COVID-19 pandemic, telemedicine has become a popular choice for patients seeking medical assistance. Healthcare leaders are aware of this demand for telemedicine and show a rising interest in investing for the next few years (Figure 7).

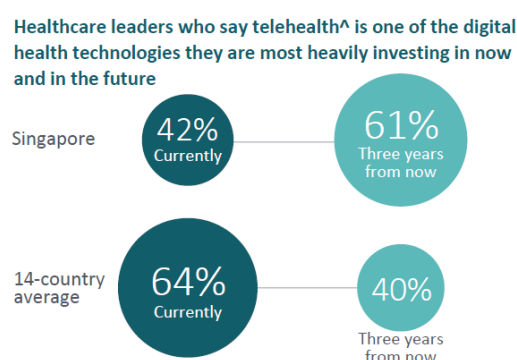
Telemedicine is essentially consultations with medical professionals for patients done outside of medical facilities. It allows for convenient access to healthcare and professional treatment advice. Medical professionals and patients save time as they do not need to travel. For pandemic management, telemedicine prevents unnecessary spread of the virus by reducing the medical professionals' exposure to the virus (Hirani et al., 2024).

There is a type of telemedicine service called “forward-triage” that helped to manage the COVID-19 cases (Hirani et al., 2024). Video consultations were held between clinicians and patients with suspected or confirmed COVID-19. The clinicians would evaluate the patient's condition and provide medical advice either to proceed with remote treatment or to seek medical care from the emergency department (ED). Telemedicine allowed for better and more efficient allocation of ED resources and mitigated the unnecessary spread of COVID-19.

Although telemedicine has advantages such as increased accessibility of healthcare and saving time and cost, there are sustainability and ethical concerns to consider. Firstly, it exacerbates healthcare inequalities due to the existing digital divide. People living in rural areas have limited access to the internet and this leads to them not being able to use telemedicine services. Telemedicine is not a one-size-fits-all service. Patients still must visit the medical facilities physically for certain procedures such as imaging tests and blood work. Lastly, securing sensitive patient health data can be difficult when it is transferred online frequently as there is a risk of data breach (Watson, 2020).

Figure 7

Healthcare Leaders heavily investing in telehealth now and in the future



Note. From *A resilient future – Singapore*, by Philips, 2021 [Image], *Future Health Index 2021*. (www.philips.com/futurehealthindex-2021). Copyright 2021 by Philips.

- Healthcare Data Analysis and Management

Healthcare collects massive amounts of data daily on the patient's personal information. However, valuable insights are not being derived as medical professionals are not equipped with analytical skills. According to NTUC LearningHub, data analytics is the third top training area that healthcare leaders want their employees to enrol in (Figure 8).

In Singapore, National University Hospital (NUH) has taken great strides in implementing data-driven applications. One initiative is the Russell-GPT which analyses historical data of

patients to predict their healthcare journey with the help of AI (National University Health System, 2024). The benefits include decreasing the workload of doctors and nurses to do administrative tasks such that they can free up time to focus on caring for the patients. It also reduces the risk of human errors.

Providing immediate insights on ED waiting times and bed occupancy rates, Pathfinder is another AI tool that allows medical professionals to make informed and data-driven decisions (National University Health System, 2024). Pathfinder tracks statistics like waiting time and forecasts daily patient turnout. The benefit of using Pathfinder is minimising bottlenecks and ED staff can better deliver care to patients by changing the manpower allocation when needed and optimising the admission of patients based on expected demand.

Similar to telemedicine, there are issues when using AI in healthcare data analysis and management. It consumes a lot of energy as the vast amount of data collected requires significant storage capacity. This accelerates data centers and technology infrastructure usage which increases carbon footprints, thereby impacting the environment. Data management is not just about collecting data but also ensuring that the data collected is of high quality, accurate and timely. It is essential that medical facilities uphold data quality and integrity policies so that the data insights remain accurate and reliable to be used for medical research and patients can receive effective medical care. Lastly, medical facilities must comply with constantly evolving data governance regulations such as Health Insurance Portability and Accountability Act (HIPAA) for data protection.

Figure 8

Top Five Training Areas That Healthcare Leaders Are Keen To Enrol Employees For

TOP FIVE TRAINING AREAS THAT HEALTHCARE LEADERS ARE KEEN TO ENROL EMPLOYEES FOR



Note. From *Industry Insights Report 2024 – Healthcare* [Image], by NTUC LearningHub, 2024 (<https://www.ntuclearninghub.com/media/research-reports/2024/Healthcare>). Copyright 2024 by NTUC LearningHub.

- The Future of AI in Healthcare in Smart Cities
 - Biases in AI

Like humans, AI can be biased. If there is bias present in the input data, the system may intensify it in the results (Mauro & Valigi, 2020). Bias can arise from labels. Labels reduce ambiguity, change outcomes, shape what we see and also events that have not occurred yet (Alter, 2013). It is assumed that AI algorithms are more impartial than humans when in reality, it “simply learns to reproduce the same biases that appeared in their training datasets” (Mauro & Valigi, 2020).

- Replacing human doctor with an AI Avatar in telemedicine

Given the major bias issue with AI and linking back to telemedicine, it is difficult to replace a human doctor with an AI Avatar during online consultations as it is relatively unsafe for the avatar to safely handle 80% of the cases that the human doctor currently handles. On Doctor Anywhere's website, doctors who give consultations virtually must be registered with the Singapore Medical Council and are licensed to practice in Singapore (Doctor Anywhere, 2023). Inherently, patients still trust human doctors more than machines. It will take time for patients to accept an AI Avatar to provide them with medical advice and for the technology to mature and be reliable.

- Regulating AI

There is an urgent need to establish regulations for AI concerning algorithms and organisations to mitigate biases in the machines (Haenlein & Kaplan, 2019). It is important to develop regulations for the training and testing of AI algorithms with warranty. Despite technical changes to AI over time, this approach enables stable regulation to protect healthcare organisations and patients.

- Potential future application of AI

A future AI application is Siemens Healthineers' HoloLens augmented reality prototype that visualises 3D detailed CT scans of the heart. This helps with the preparation of complex heart surgeries. Pediatric cardiologist, Dr Muhannad Alkassar who has used this prototype said, "It definitely makes sense to use this technology in the future to provide support in the operating room, but the technology still needs to be developed further, for example in the area of artificial intelligence." (Engelhardt, 2020). Many AI experimentation initiatives are currently being developed but time is needed for them to be reliably used when treating patients.

- Conclusion

AI integration in healthcare is transforming patient care from a reactive to a preventive approach, improving accessibility and efficiency in areas like telemedicine and data management. However, challenges such as algorithm bias, data privacy, and sustainability persist, highlighting the need for robust regulations. While AI holds promise for enhancing healthcare and quality of life in smart cities, human oversight remains essential. With proper regulation and addressing key concerns, AI is a valuable tool for the future of healthcare innovation.

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