Artificial Intelligence (AI) in Oncology Care

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April 19, 2024
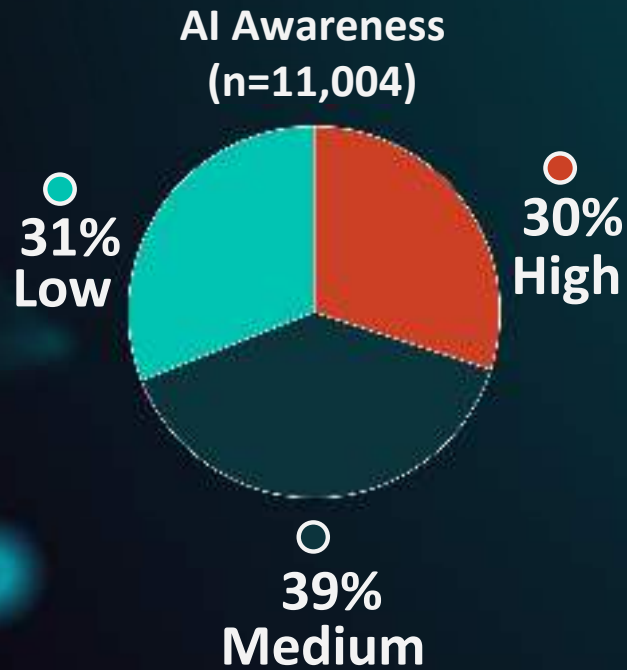
Conflict of Interest

- I have no conflict of interest to disclose

Objectives

- Discuss the transformative role of artificial intelligence (AI) in revolutionizing cancer diagnosis, treatment, and research

- Analyze the role of AI in personalized treatment planning in cancer patients

- Evaluate the role of AI in pharmacy practice

Public Awareness of AI

- How many of you are currently using AI on a daily basis or have used it in the past seven days?
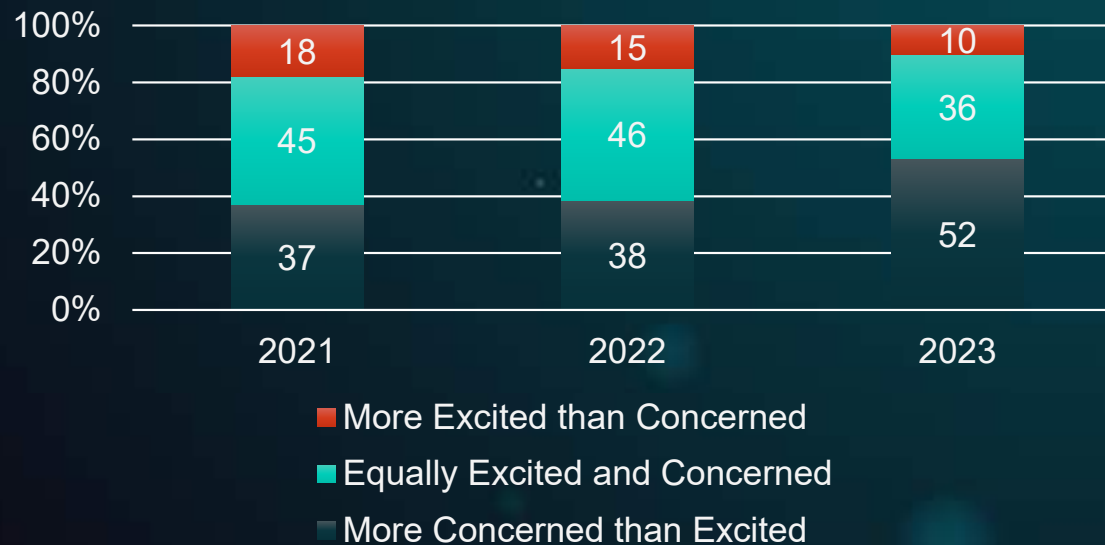
AI Awareness
(n=11,004)

31% Low

30% High

39% Medium

High (%)	
Men	28
Women	23
Asian	40
White	34
Black	14
Age 18-29	35
30-49	38
Postgrad	53
College grad	46
HS or Less	14
Upper Income	52
Middle Income	33
Lower Income	15

Public Awareness of AI

- How many of you are more concerned than excited about the increased use of AI?

    - Majority of the US are more concerned of AI
    - Fewer than half expect AI in health and medicine will improve patient outcome

Concern about AI

	2021	2022	2023
More Excited than Concerned	18	15	10
Equally Excited and Concerned	45	46	36
More Concerned than Excited	37	38	52

- More Excited than Concerned
- Equally Excited and Concerned
- More Concerned than Excited

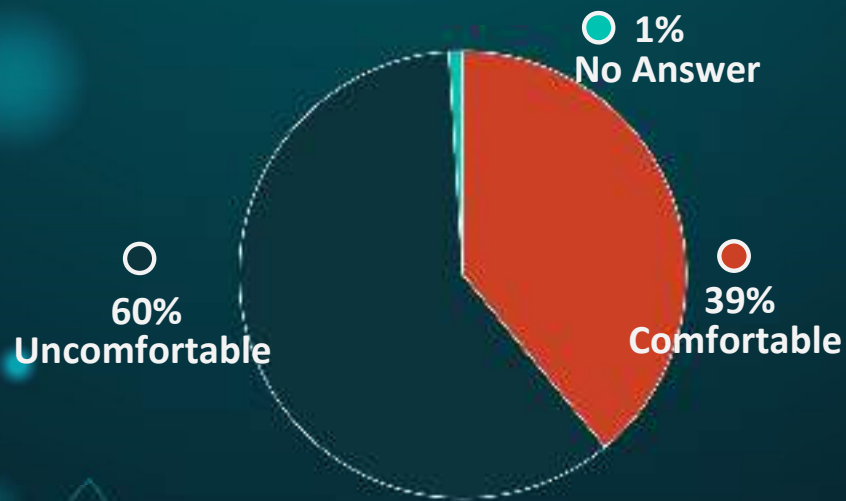Alec T. et al. Pew Research Center. Aug. 28, 2023
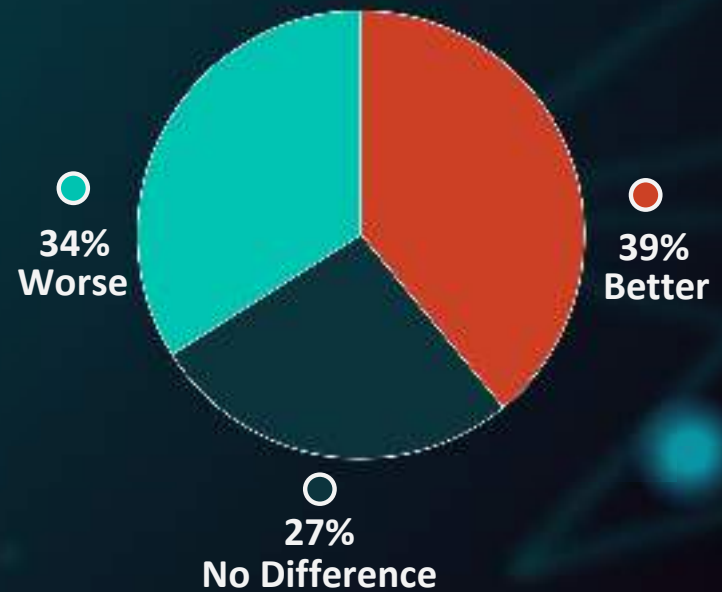
Public Awareness of AI

- How would you feel as a patient if your healthcare providers relied on AI for your care?

- Would AI lead to better outcomes for patients?

Relied on AI

- 1% No Answer
- 60% Uncomfortable
- 39% Comfortable

Health Outcome

- 34% Worse
- 39% Better
- 27% No Difference

Faverio M. et al. Pew Research Center. Nov. 21, 2023

Public Awareness of AI

- How many of you believe that healthcare workers are at risk of losing their jobs due to AI advancements?

- What are your thoughts on the job security of pharmacists and pharmacy technicians?

  - AI verifying orders in Mayo Clinic

  - Robots delivering medication in oncology infusion center at MedStar Georgetown University Hospital

  - Will there be a massive layoff? Who will protect our jobs?

Artificial Intelligence Finds Inroads to Pharmacy Environments. ASHP Midyear Daily News. Dec. 4, 2022

Public Awareness of AI

- How many of you think AI will take over humanity?
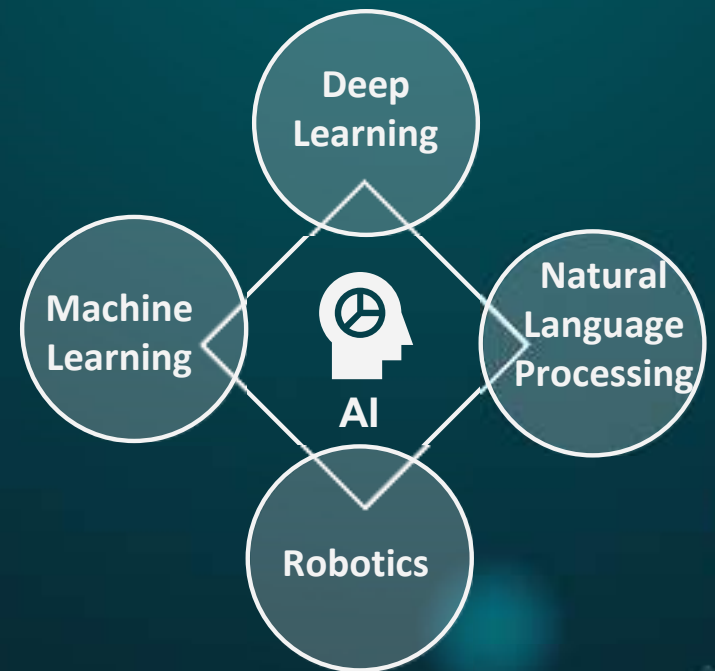

AI will not replace humans!

Humans proficient in AI technology will replace humans who don't know how to use AI!

Whamond D. Artificial intelligence: useful tool or threat to humanity? News Tribune. Dec. 20, 2023
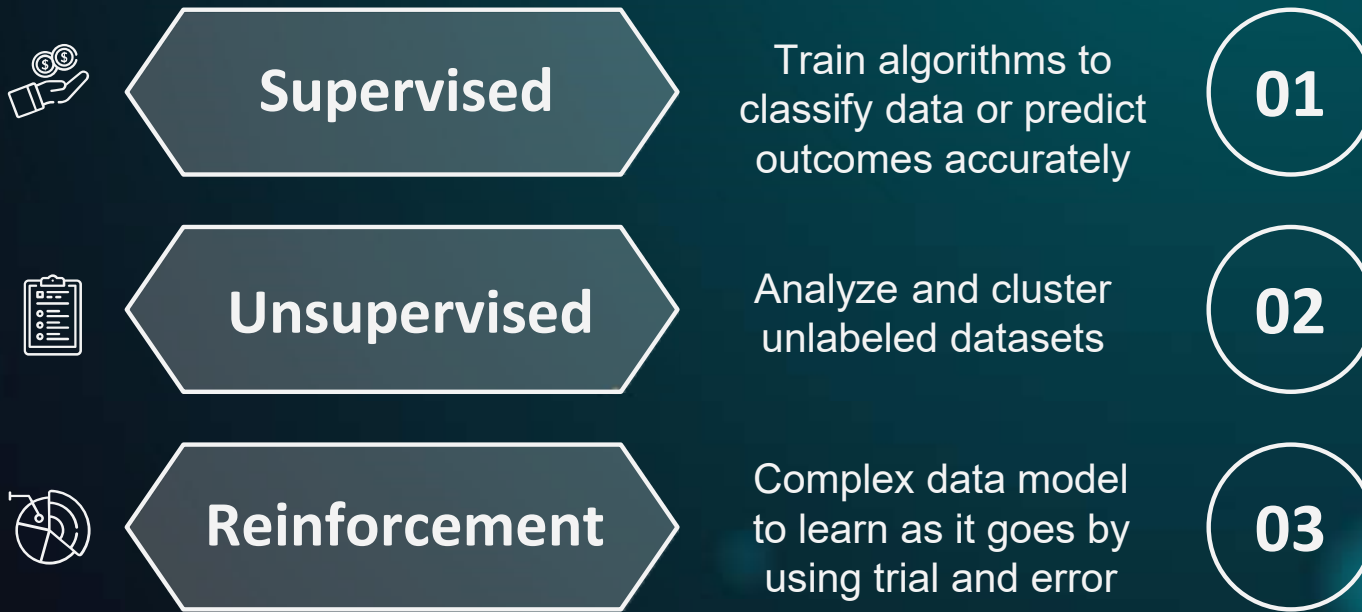
What is Artificial Intelligence (AI)?

- Science of making machines that can think like human, learn by itself and do things that considered "smart"

  - Involves using computers to do things that traditionally require human intelligence

  - Can process with large amounts of data unlike human

  - Able to do things such as **recognize patterns**, make decisions, and judge

What is artificial intelligence (AI)? IBM.
https://www.ibm.com/topics/artificial-intelligence

Machine Learning (ML)

Three Primary Catagories

Supervised	Train algorithms to classify data or predict outcomes accurately	01
Unsupervised	Analyze and cluster unlabeled datasets	02
Reinforcement	Complex data model to learn as it goes by using trial and error	03

What is machine learning(ML)? IBM.
https://www.ibm.com/topics/machine-learning

Deep Learning

Unlabeled Data
Can ingest and process raw information

Large Dataset
Can process data efficiently

Greater Accuracy
Possiblities and predictions accuracy

Automation
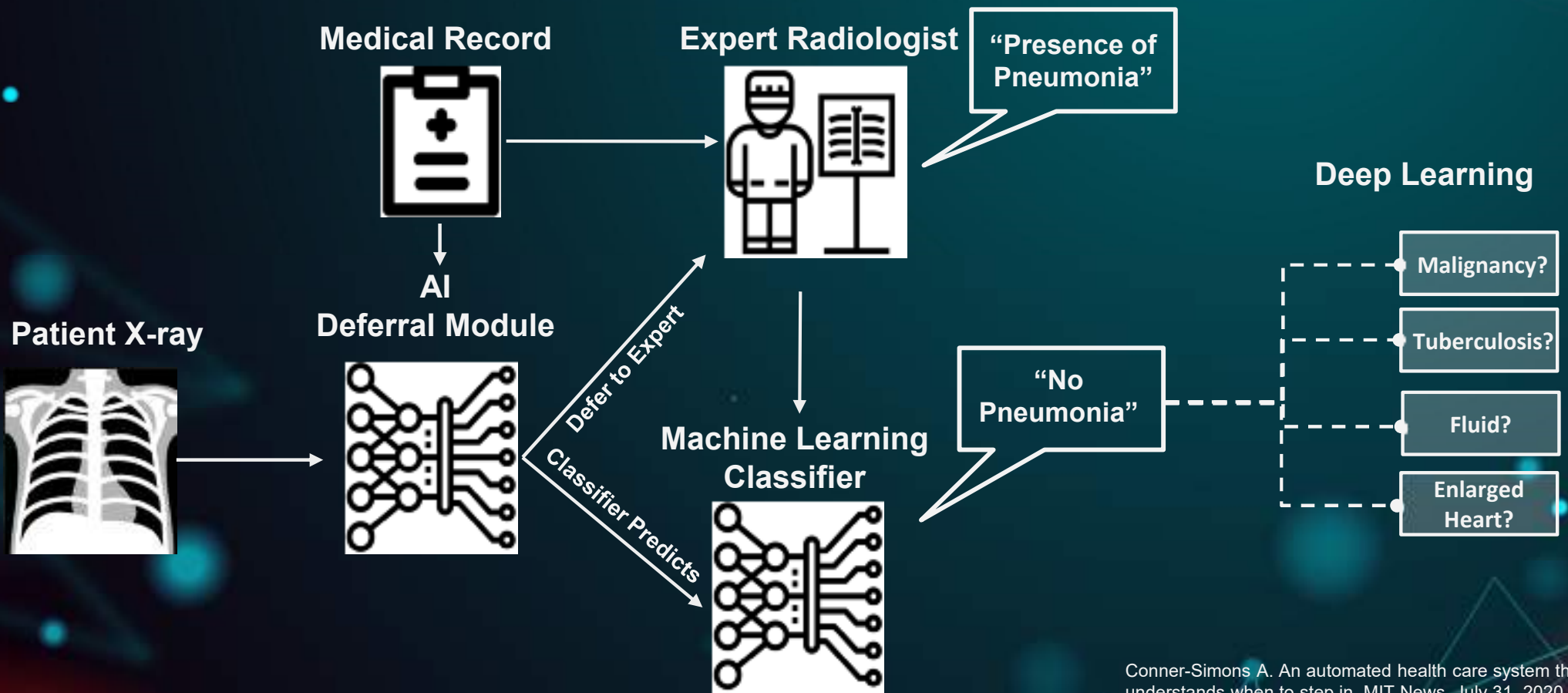Less human intervnetion and guidence

Many Layers
Extensive neural network

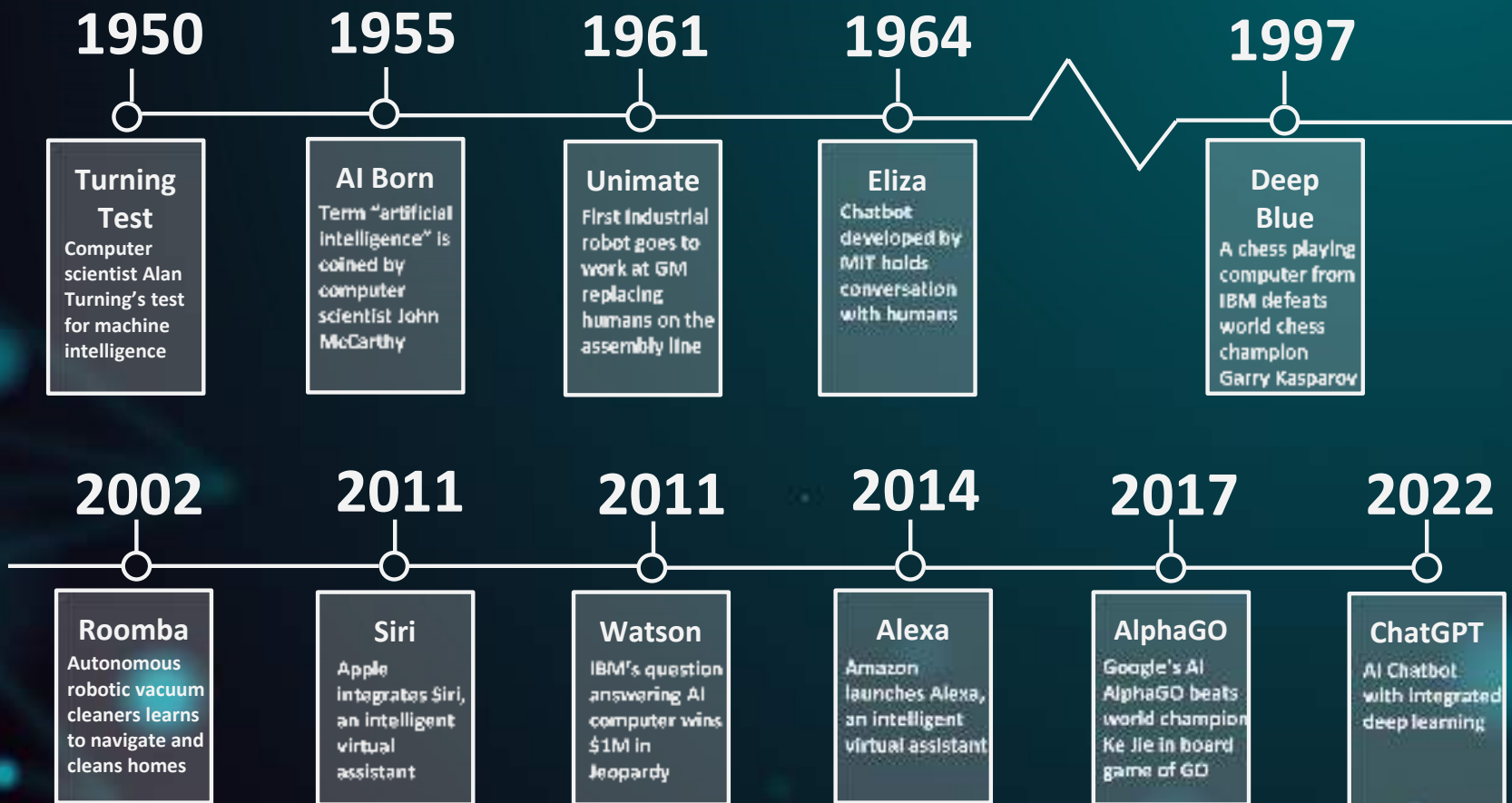**Vast Application**
Autonomous car, medical image analysis

Machine learning vs deep learning vs neural network.
IBM. https://www.ibm.com/topics/deep-learning

AI is Not New!

1950

Turning Test
Computer scientist Alan Turning's test for machine intelligence

1955

AI Born
Term "artificial intelligence" is coined by computer scientist John McCarthy

1961

Unimate
First industrial robot goes to work at GM replacing humans on the assembly line

1964

Eliza
Chatbot developed by MIT holds conversation with humans

1997

Deep Blue
A chess playing computer from IBM defeats world chess champion Garry Kasparov

2002

Roomba
Autonomous robotic vacuum cleaners learns to navigate and cleans homes

2011

Siri
Apple integrates Siri, an intelligent virtual assistant

2011

Watson
IBM's question answering AI computer wins $1M in Jeopardy

2014

Alexa
Amazon launches Alexa, an intelligent virtual assistant

2017

AlphaGO
Google's AI AlphaGO beats world champion Ke Jie in board game of GO

2022

ChatGPT
AI Chatbot with integrated deep learning

Madjour T et al. Artificial Intelligence-Part 1. Atthis-technologies. Oct. 2018

The Era of ChatGPT
2022 & Beyond!

ChatGPT Sprints to One Million Users

Time it took for selected online services to reach one million users

Service	Launched	Time
Netflix	1999	3.5 years
Kickstarter*	2009	2.5 years
Airbnb**	2008	2.5 years
Twitter	2006	2 years
Foursquare***	2009	13 months
Facebook	2004	10 months
Dropbox	2008	7 months
Spotify	2008	5 months
Instagram***	2010	2.5 months
ChatGPT	2022	5 days

* one million backers   ** one million nights booked   *** one million downloads
Source: Company announcements via Business Insider/Linkedin

statista

Bard can draft a packing your weekend

Google AI·

GPT

Meta AI LLaMA

Hawley M. What is ChatGPT? Everything you need to know. Cmswire. Sept. 8, 2023

AI in Health Care

Drug Discoveries

Improving Speed & Accuracy of Diagnosis

Smart Electronic Record

Clinical Trials

Cancer Care

Tadam I. he future of AI part 3. LinkedIn. Aug. 30, 2019

Living With Cancer

Increase in Estimated New Cancer Cases Between 2020 & 2040

2022 — 18+ MILLION SURVIVORS (5.4% OF THE POPULATION)

1971 — 3 MILLION SURVIVORS (1.4% OF THE POPULATION)
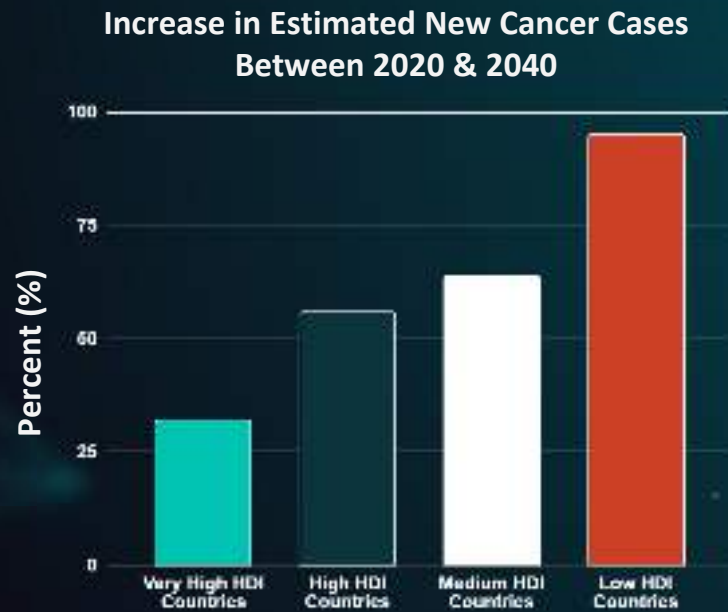
It is expected that 30.2 million new cancer cases will be diagnosed in 2040

Rapidly Evolving Cancer Treatment

2023 Review

13 Novel Cancer Drugs

67 Expanded Use or Patient Population of Previously Approved Drugs

118 Oncology Devices

A **first-in-class antibody drug conjugate** patients with **ovarian cancer**

A **new gene therapy-based immunotherapy** for **bladder cancer**

First approval of **a combination of two HER2 targeted therapeutics** to treat patients with metastatic **colon cancer**

The first approval of **an immune checkpoint inhibitor** for patients with a **rare form of sarcoma**

A **new KRAS-targeted therapeutic** for advanced **lung caner**

Four new T-cell Engaging bispecific antibodies for patients with **hematological malignancies**

FDA approvals in two key classes of immunotherapetuic (As of January 2024)

11 immune checkpoint inhibitors to treat 20 types of cancer and with certain molecular features
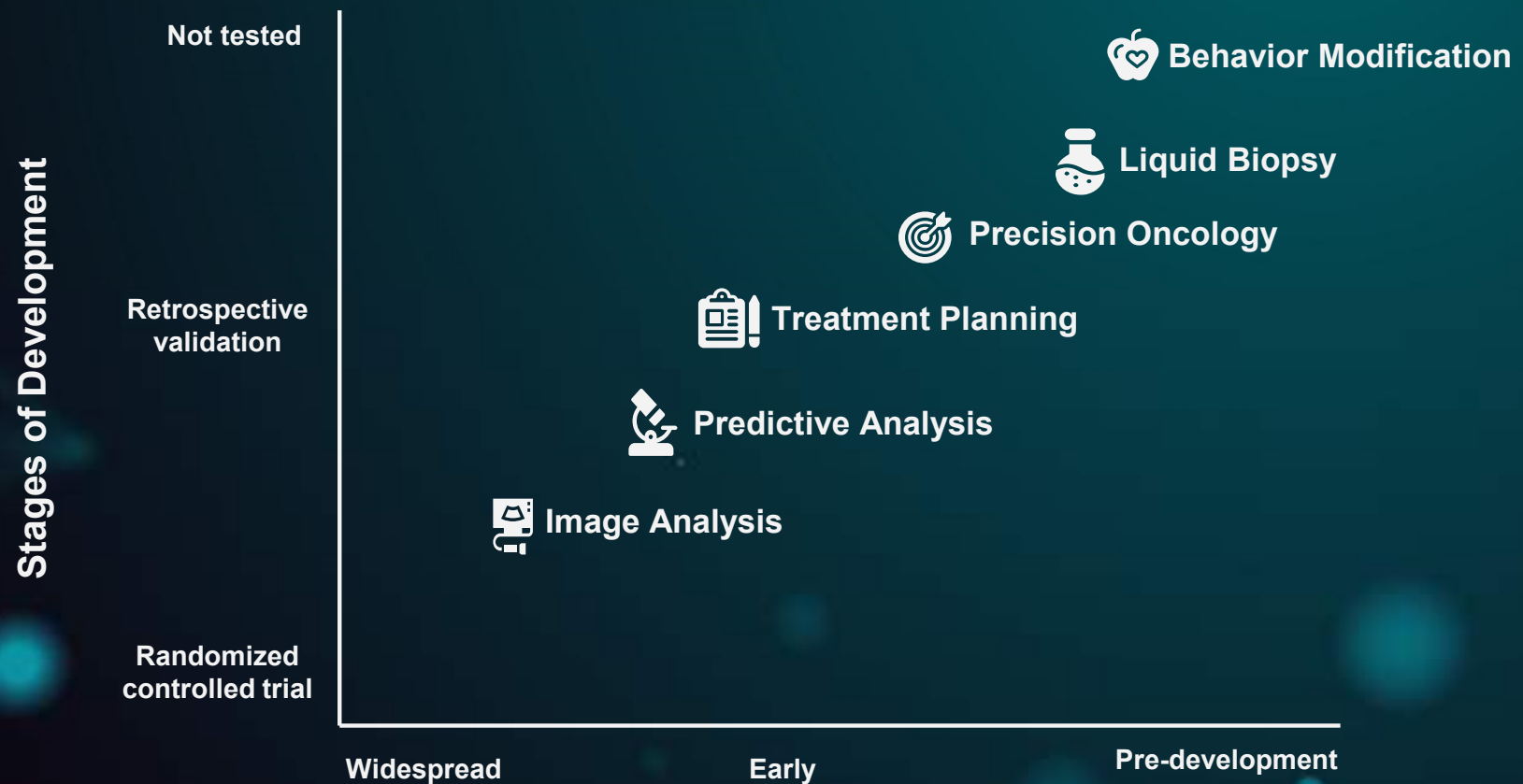
6 CAR T-cell therapies to treat a range of blood cancer

Complexity & Lack of Uniformity

1 — Sophisticated, complex diagnosis and treatment

2 — Widely different practice model and care

3 — Comorbidities and advanced age

4 — Extensive side effects and monitoring

5 — Complex clinical trials

6 — Complex and diverse data to analyze

Complexity & Lack of Uniformity

- Where should cancer patients get their cancer care from?

  - The role of large academic medical center with specialized oncologists and support team

  - Highly sophisticated and complex diagnosis and treatment regimen

  - **Pattern recognition** and appropriate treatment are crucial

- AI is better in recognizing pattern than humans

  - Data feeding and deep learning

  - Can revolutionize cancer care by facilitating access and appropriate care

  - Revamp **early detection** and **preventative care**

Chua I et al. Artificial intelligence in oncology. *Cancer Med.* 2021;10(12):4138-4149

Chua I et al. Artificial intelligence in oncology. *Cancer Med*. 2021;10(12):4138-4149

AI in Cancer Detection

- FDA approved more than 171 AI and machine learning enabled medical devices in 2022-23

  - >80% are in the field of radiology
  - +30% growth over year to year

- Sybli: Lung cancer detection AI tool developed by MIT and Mass General Cancer Center

  - Accurately detecting lung cancer from CT scan that could be missed by human

Sybli predicted sign of lung cancer
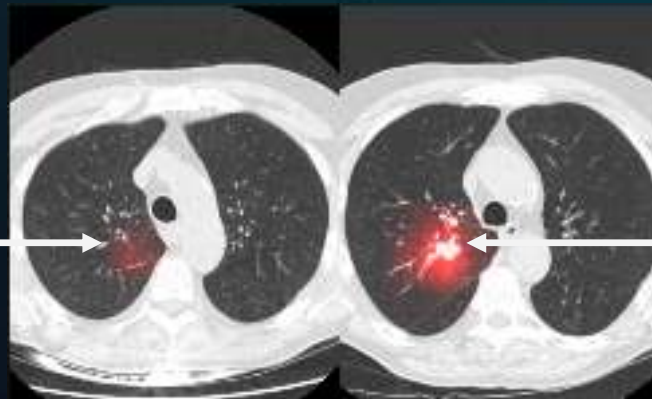
Same patient 2 years later diagnosed with lung cancer

MIT researchers develop an AI model that can detect future lung cancer risk MIT News. January 2023

AI in Cancer Detection

- DermaSensor: First FDA-approved AI-powered medical device that can detect all major skin cancers

  - Uses FDA-cleared algorithm trained on data related to >4000 malignant and benign lesions to provide real-time results

  - Intended to use in primary care setting

  - 96% sensitivity of detecting skin cancer

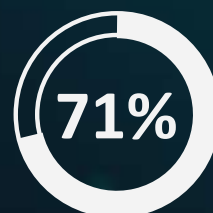 - Found to decrease the number of missed skin cancers by half

Innocent mole or skin cancer? FDA clears device with BU-Developed technology that makes detection easier. Boston University. Feb 2024
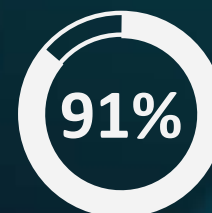
AI in Cancer Detection

- AI software developed by National Cancer Institute (NCI) to detect cervical pre-cancer by analyzing >60,000 cervical images to test the accuracy
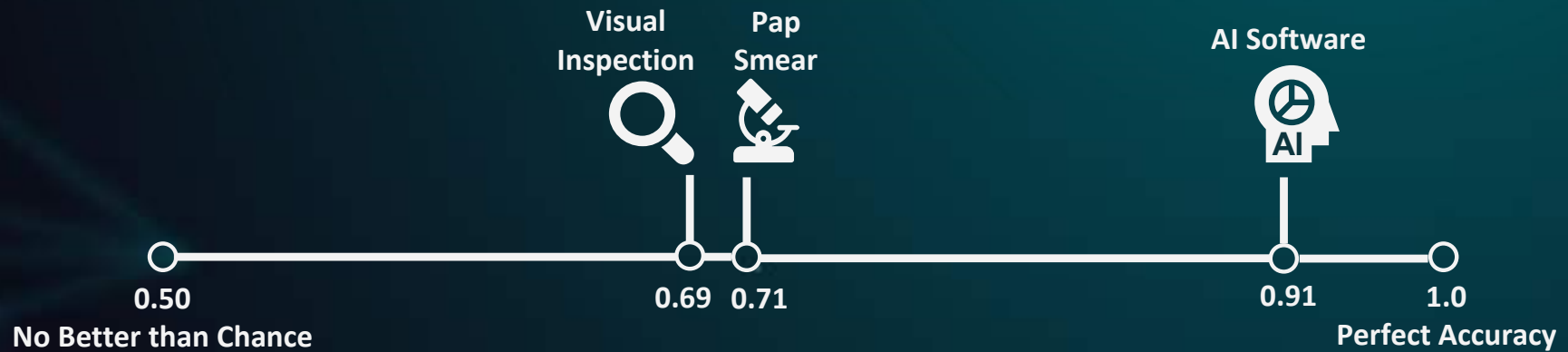
Visual Inspection

Pap Smear

AI Software

0.50
No Better than Chance

0.69   0.71

0.91   1.0
Perfect Accuracy

69%
Visual Inspection

71%
Pap Smear

91%
AI Software

Hu L, et al. *J Natl Cancer Inst.* 2019 0(0):djy225

AI in Cancer Treatment

Study	Objectives	Results
Gerdes H, Casado P, Dokal A, et al. Drug ranking using machine learning (DRUML) systematically predicts the efficacy of anti-cancer drugs. *Nat Commun*. 2021;12(1):1850	• AI and machine-based learning (MBL) to predict best cancer treatment for acute myeloid leukemia (AML) • Used data from 48 cell lines and validated it with 53 cancer cell models and 36 primary cases of acute myeloid leukemia	• DRUML predicts drug responses in independent verification datasets with low error (mean squared error < 0.1 and mean Spearman's rank 0.7) • DRUML predictions of cytarabine sensitivity in clinical leukemia samples are prognostic of patient survival (Log rank $p < 0.005$) • DRUML accurately ranks anti-cancer drugs by their efficacy across a wide range of pathologies
Holborow A, Coupe B, Davies M, Zhou S. Machine learning methods in predicting chemotherapy-induced neutropenia in oncology patients using clinical data. Clin Med (Lond). 2019;19(suppl 3):89-90. doi:10.7861/clinmedicine.19-3s-s89	• Use MBL to predict individual with risk for neutropenia from cancer treatment • Analyzed 15,119 patients aged 18 years or older with a diagnosis of cancer	• Compared MBL to logistic regression and created a web app for associated risk prediction • Validation 77.22% with sensitivity 68.99% and specificity 72.25%

Gerdes H et al. *Nat Commun*. 2021;12(1):1850
Holborow A et al. *Clin Med (Lond)*. 2019;19(suppl 3):89-90

AI in Cancer Treatment

Study	Objectives	Results
Li J, Zhou Z, Dong J, et al. Predicting breast cancer 5-year survival using machine learning: a systematic review. *PLoS One*. 2021;16(4):e0250370 doi:10.1371/journal.pone.0250370	• Using MBL techniques to identify most effective and safe drug pairs in breast cancer patients	• MBL technique did not show significant benefit but provided valuable insights to guide efforts in developing drug combination treatment • Could be a promising solution to improve treatment outcomes and overcome drug resistance
Manz CR, Zhang Y, Chen K, et al. Long-term effect of machine learning-triggered behavioral nudges on serious illness conversations and end-of-life outcomes among patients with cancer: a randomized clinical trial. *JAMA Oncol*.2023;9(3):414-418. doi:10.1001/jamaoncol.2022.6303	• Analyzed 20,506 patients with cancer to identify if MBL could improve patient care delivery	• Significant increase in serious illness conversations for high-risk patients (3.4% to 13.5%) • Decrease (10.4% to 7.5%) in end-of-life systemic therapy for outpatients with cancer

Li J et al. PLoS One. 2021;16(4):e0250370
Mary CR et al. *JAMA Oncol*. 2023;9(3):414-418
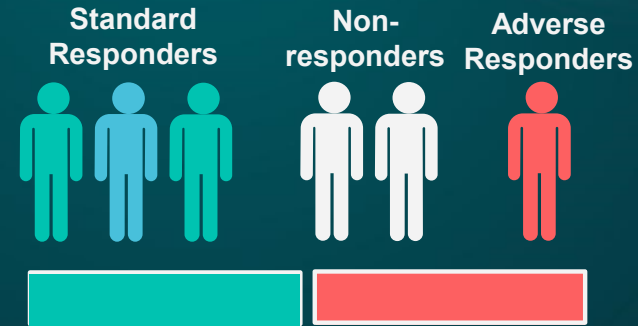
Precision Medicine

- Emerging approach for cancer treatment and prevention

  - Consider individual variability in genes, environment and lifestyle
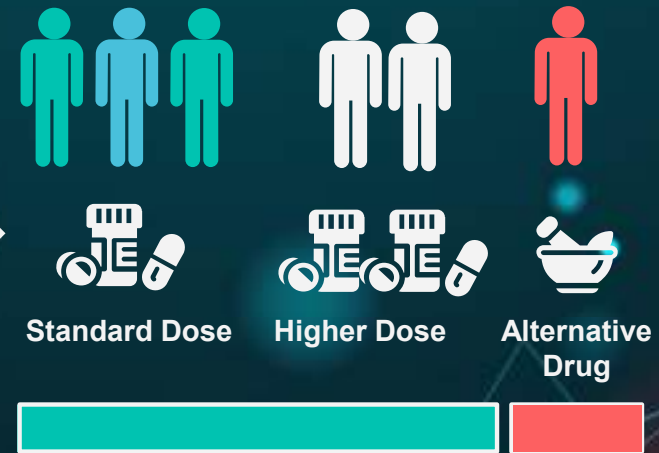 - Transition from *one-fits-all* treatment option to individualized care

Chemo therapy

Surgery

Radiation

Genetics

Targeted Therapy

Immuno Therapy

What is precision medicine? NYP Medicine.
https://healthmatters.nyp.org/precision-medicine/

Precision Medicine Framework

American Association of Cancer Research (AARC) Cancer Progress Report 2023

Leveraging AI in Precision Medicine

Genome

Individual Traits

Treatment Outcome

Adapting Therapies

Human Genome Project

Unraveling genetic variants & implications

AI selecting best cancer treatment

Identify trends

Bates A. Leveraging AI for precision medicine: unlocking the future of healthcare. Jul 26, 2023
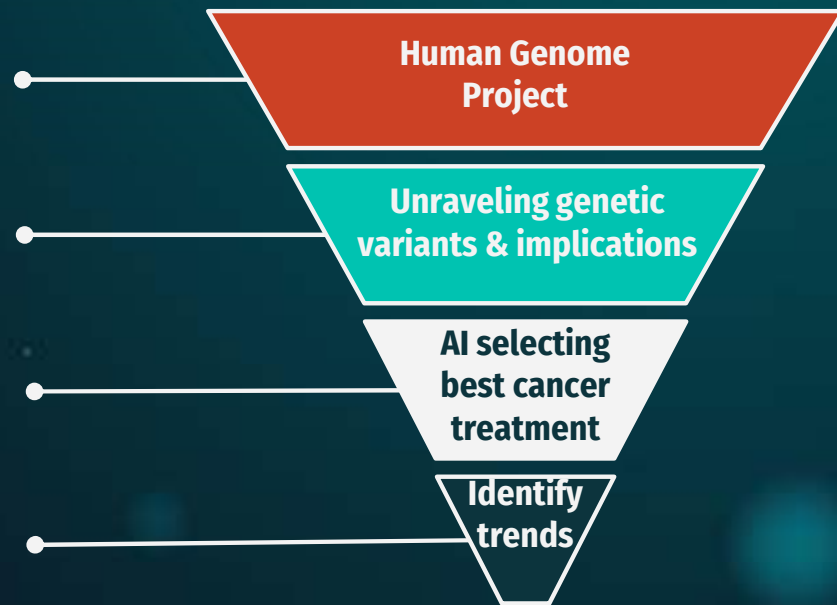
The Challenges & Limitations of Artificial Intelligence (AI)

Precision Medicine, AI & Data!

Data is the New Fuel!

"Data is the new currency"
"Data is the new oil"
"Data is the new economy"

Sing H. Data is the new fuel, AI is the accelerator. May 14, 2021

Quality Data is Essential

- Complex, diverse and unorganized data

  - Providers' typed or dictated notes, laboratory findings, histopathological and imaging data and patient-generated health data

  - Limited relevance of crude medical data

- Disconnected major electronic health record software e.g., EPIC, Allscripts, PrimeRx

- HIPPA and regulatory requirements

- Adequate data extraction, processing, analysis, interpretation and integration

G I G O

Garbage In Garbage Out

AI Implementation:
Smart Electronic Health Record

- Electronic health records are messy and hard to analyze

- Smart electronic health records powered by AI will improve data accuracy and accessibility

Predictive Analysis

Data Visualization

Natural Language Processing

Privacy & Security
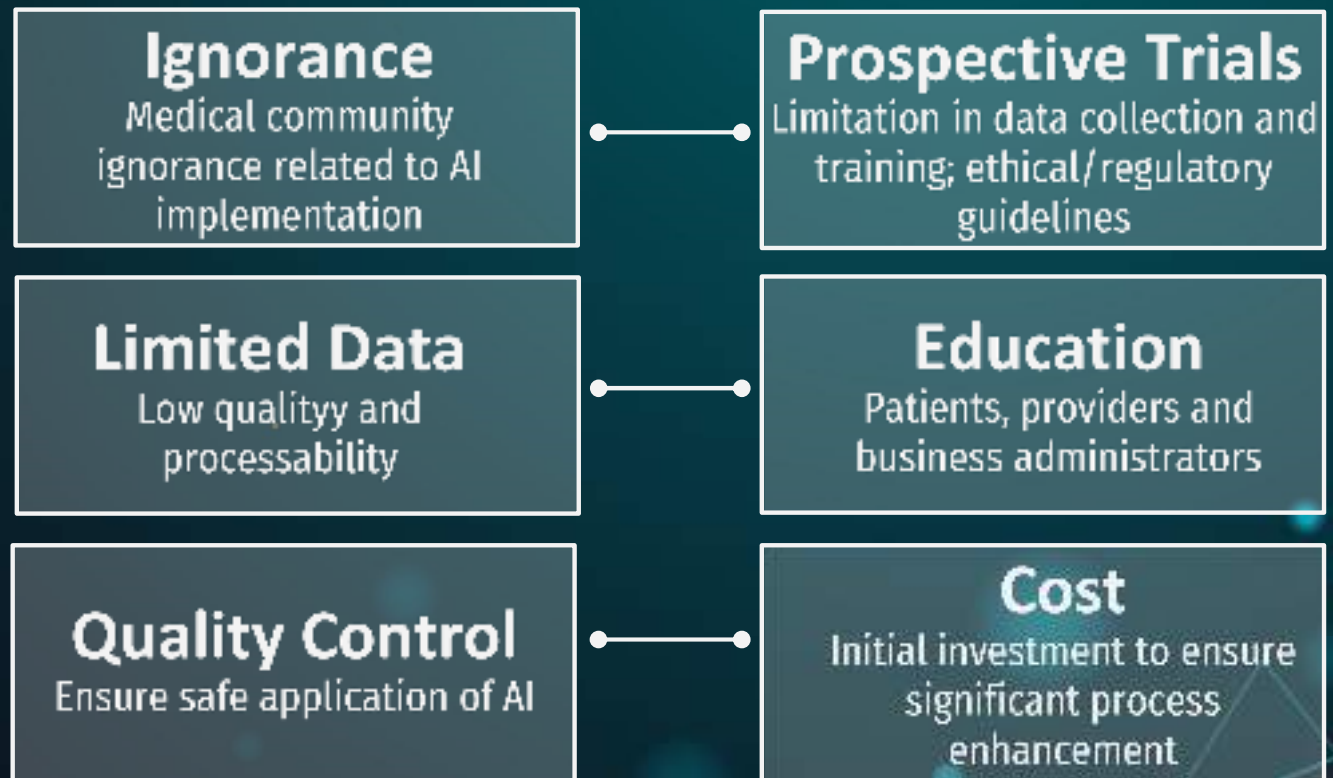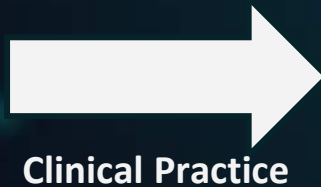
Pre-existing Condition Monitoring

Prognosis & Diagnosis

Data Fetching from Wearables

How AI in healthcare can improve the efficiency of EHR systems? iTech. January 2, 2023

AI Implementation: Laboratory to Clinical Practice

AI In Laboratories

Clinical Practice

Ignorance Medical community ignorance related to AI implementation

Prospective Trials Limitation in data collection and training; ethical/regulatory guidelines

Limited Data Low qualityy and processability

Education Patients, providers and business administrators

Quality Control Ensure safe application of AI

Cost Initial investment to ensure significant process enhancement

Farina E et al. *Future Sci OA.* 2022 Feb 10;8(4):FSO787

Artificial Intelligence (AI) in Pharmacy Practice

Milenkovich N. The rise of AI in pharmacy practice presents benefit and challenges. Pharmacy Times. July 2023

AI in Pharmacy Practice

- **Streamlining Pharmacy Operations**

  - 80-90% time spent in verifying and processing prescriptions

  - AI can streamline these steps by correctly typing prescriptions, checking interactions, identifying due date, processing insurance claim, responding patients' call/text for refill, manage inventory etc.

- **Patient Centered Care**

  - Save time, reduce errors, operate more efficiently, and provide better service to the patients

  - Prioritize workload and focus on patients who may have more immediate needs

Milenkovich N. The rise of AI in pharmacy practice presents benefit and challenges. Pharmacy Times. July 2023

AI in Pharmacy Practice

- **Medication Management**

  - Manage medication inventory, predict medication demand, and identify potential drug interactions and adverse reactions

  - Assist pharmacists in identifying patients who may be at risk of nonadherence

- **Patient Outcomes**

  - Monitor patients' health outcomes by analyzing patient data, including medical history and medication usage

  - Identify patients who may be at risk of complications and intervene before serious health problems occur

Milenkovich N. The rise of AI in pharmacy practice presents benefit and challenges. Pharmacy Times. July 2023

AI in Telemedicine: A Paradigm Shift

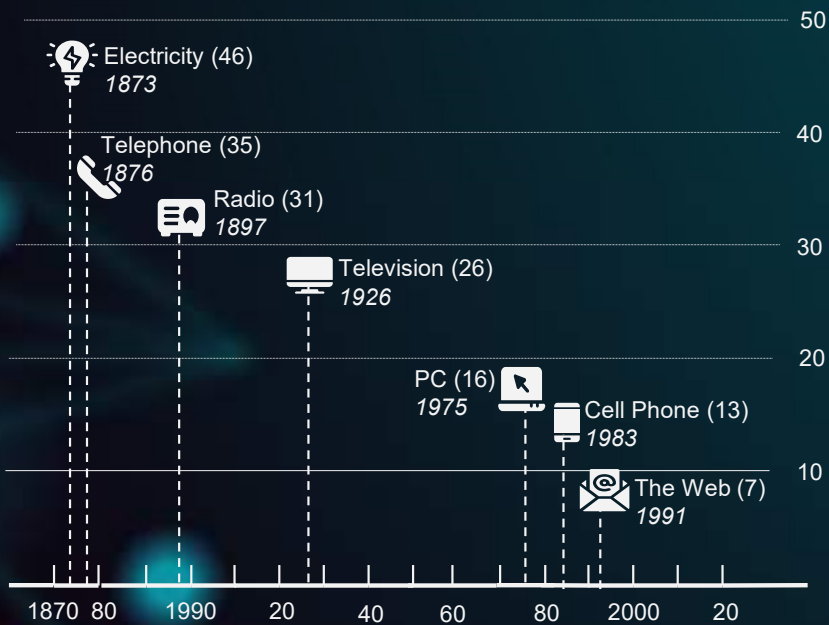Barrett M et al. *EPMA Journal.* 2019;(10)445-464

AI in Drug Discoveries

- Only 13.8% of drugs successfully pass clinical trials and receive FDA approval

  - Cost $161 million to $2 billion

- AI algorithms can analyze vast datasets to identify potential drug candidates

Identification
Lead compound discovery and synthesis

Optimization
AI in silico assays

Accumulation
In vivo/vitro data accumulation

Discovery
Target discovery

Measuring the risks and rewards of drug development.
MIT Sloan Office of Communication Jan 31, 2018

Why AI is So Important

Technology Adoption

Years until used by one-quarter of American population

Electricity (46)
1873

Telephone (35)
1876

Radio (31)
1897

Television (26)
1926

PC (16)
1975

Cell Phone (13)
1983

The Web (7)
1991

50
40
30
20
10

1870 80 1990 20 40 60 80 2000 20

Past
- Changes were inter generational
- Enough time to adapt

Present
- Changes are intra generational
- Need to adapt within few years

Future
- AI is dramatically shrinking adoption time
- Adapt quickly or you will be replaced!

K.N.C et al. Happy birthday world wide web: society is adopting technology at an increasingly fast pace. The Economist. March 12, 2014

Will AI Take My Job?

- AI will revolutionize many aspects of healthcare including pharmacy but can never take away human factors

  - Compassion, human interactions, judgement

  - Imperative for pharmacies to adapt AI

  - Major shift in roles and responsibilities for pharmacists

  - Pharmacy technicians and support staff may get replaced by AI

- State board of pharmacy and other regulatory bodies will have to step in to create guidance

Summary

- AI excels in recognizing complex patterns and large data analysis, particularly in the realms of oncology care and precision medicine

- AI is making healthcare more accessible and affordable

- AI is being implemented in every aspect of healthcare, including pharmacy

- It is imperative for us to adapt AI and use it as a valuable tool in pharmacy practice

Artificial Intelligence (AI) in Oncology Care

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