Applications of Artificial Intelligence (AI) in Pharmacy Practice

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Disclosures

- I have nothing to disclose concerning possible financial relationships with ineligible companies that may have a direct or indirect interest in the subject matter of this presentation.
- The use of names for specific products are to provide examples of products only and does not imply any endorsement of specific products.

Learning Objectives

- Describe AI terminology and methods
- Recognize the use of AI methods to address healthcare problems
- Explain the process of AI related model building
- Identify the role of Pharmacist in developing interdisciplinary AI tools

Outline

- Introduction
- What is AI?
- Some examples
- What pharmacist can do?
- Conclusion

Well! How far are we??

https://www.soundonsound.com/
https://www.reliancedigital.in/

Well! How far are we??

https://i.ytimg.com/

...niaUniversity
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Well! How far are we??

https://deepdreamgenerator.com/

...niaUniversity
...HARMACY

What!

ChatGPT is an **AI chatbot** that works by generating text responses based on human input!

Forbes

FORBES > INNOVATION

What ChatGPT And Other AI Tools Mean For The Future Of Healthcare

Sahil Gupta Forbes Councils Member
Forbes Technology Council
COUNCIL POST | Membership (Fee-Based)

Feb 6, 2023, 08:30am EST

According to a recent research experiment—which has not yet been peer-reviewed—ChatGPT, the artificial intelligence chatbot created by OpenAI, demonstrated that it was capable of passing all three parts of the USMLE without supplementary medical training. The USMLE's passing threshold is approximately 60%. ChatGPT achieved over 50% accuracy across all examinations and surpassed 60% in most.

Well! How far are we??

Fitness Tracking (Fitbit®)

Good Night's Sleep (Fitbit Inspire 3®, Apple Watch Series 8®)

To Get Rid of Stress (PIP®, MoodBit®, BioBeat®)

To Keep Blood Pressure Optimal (Withings Blood Pressure®)

To control diabetes (Insulin pump)

Wearable Technology for Social Impact (Khushi Baby®)

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Common ICU Pharmacist Scenario

63 y/o male was intubated in the ED d/t hypoxemic respiratory failure and septic shock likely due to community acquired pneumonia. He has a history of COPD, Type II DM, HFrEF (30%), and CKD (Stage II)

Vitals: BP 85/60, HR 104, RR 18, Temp 39.1° C, O_2 sat 94% on IMV
Lab values: Na = 130, K = 5.1, BUN = 22, SCr 2.7, lactate = 4.1

Current medications: norepi gtt @ 8mcg/min, fentanyl 100 mcg IVP q1h prn, alb/ipra neb q4h prn, insulin sliding scale, enoxaparin 40mg sc daily. Received 2L NS and Ceftriaxone 2g IV x 1 in the emergency department.
Home medications: fluticasone/salmeterol 250mcg/50mcg bid, glyburide 5mg daily, metformin 500mg bid, empagliflozin 10mg daily, lisinopril 10mg daily, metoprolol XL 25mg daily, furosemide 20mg daily

The team requests your consultation on which medications to initiate, continue/discontinue?

How would you currently determine the risks + benefits and potential of drug-induced disease?
(i.e., worsening of AKI, ALI/progression to ARDS, further compromise hemodynamic stability?)

Facts + Limitations

Vast amounts of data	• Ideal for ML techniques • Each patient generates > 1000 data points/day
Clinicians	• Monitors > 2.5 million data points/month • Responds to approximately 187 EHR alerts/patient/day
Human Cognitive Capacity	• Average 5 sets of facts per decision • Rank data importance based upon experience

Limitations

Complexity of acuity	**Evaluating extreme heterogeneity**	**Anticipating deterioration**

Herasevich, et al. *Biomed Inst Technol* 2012; Suppl:45–48; Stead, et al. *Acad Med.* 2011;86(4):429-434; Jalilian, et al. *Perspect Health Inf Manag*. 2022 Jan 1;19(1); Kizzier, et al. *J of Pat Saf* 15 (3): 246-250

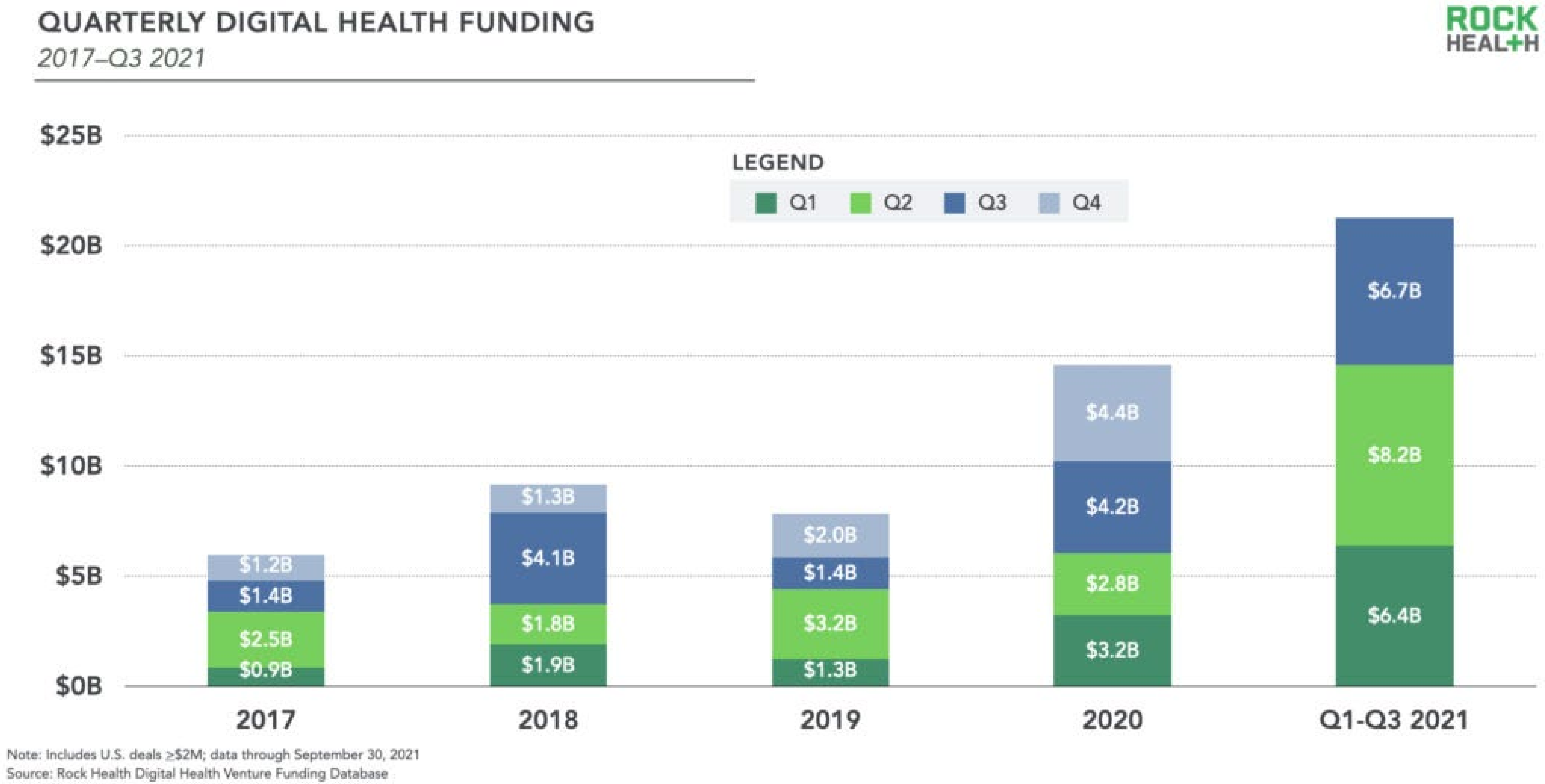
Transforming Healthcare Using Digital Health

Interdisciplinary care teams utilize new technologies with improved use and exchange of digital health paradigm to **mitigate**:

- ineffective resource utilization
- professional burnout
- unbalanced distribution of services

Goal: *Innovation to improve outcomes and ensure compassionate and equitable care*

Digital Health funding



https://rockhealth.com/reports/h1-2021-digital-health-funding-another-blockbuster-year-in-six-months/

Top 10 uses of AI in Healthcare

- Cost Reduction for New Medications
- Drug Discovery
- Accelerates Discovery and Development of Genetic Medications
- Early Prediction of AKI
- Chronic Disease Trajectory Prediction and Progression Track
- 911 Emergency Services
- Cancer Research
- Medical Imaging Analysis
- Analyzes Unstructured EHR Data
- Supports Health Equity

AI Use: Acceleration

- 2021 analysis: AI in healthcare accounted for $811 million (2015) + $6.7 billion (2021) with an annual growth rate of 40%
- AI potential: improve outcomes + reducing treatment costs by ~ 50%
- Globally: in underserved populations, AI can mitigate limited resources + improve health equity

TOP FUNDED VALUE PROPOSITIONS

2018–Q3 2021; ordered by 2021 funding

	2018	2019	2020	Q1-Q3 2021
RESEARCH & DEVELOPMENT CATALYST	$1.2B 2nd	$711M 7th	$2.1B 2nd	$4.7B 1st
ON-DEMAND HEALTHCARE	$1.6B 1st	$1.3B 1st	$2.8B 1st	$3.4B 2nd
TREATMENT OF DISEASE	$773M 8th	$903M 3rd	$1.5B 4th	$3.1B 3rd
FITNESS & WELLNESS	$1.2B 5th	$1.2B 2nd	$1.8B 3rd	$2.9B 4th
NON-CLINICAL WORKFLOW	$548M 10th	$640M 9th	$1.0B 8th	$2.1B 5th
CONSUMER HEALTH INFORMATION	$1.0B 6th	$506M 10th	$1.1B 7th	$2.0B 6th

TOP FUNDED CLINICAL INDICATIONS

2018–Q3 2021; ordered by 2021 funding

ROCK HEAL+H

	2018	2019	2020	Q1-Q3 2021
MENTAL HEALTH	$1.2B 1st	$731M 1st	$2.3B 1st	$3.1B 1st
CARDIOVASCULAR DISEASE	$586M 3rd	$532M 2nd	$1.0B 4th	$1.4B 2nd
DIABETES	$408M 4th	$502M 3rd	$698M 5th	$1.4B 3rd
PRIMARY CARE	$931M 2nd	$416M 5th	$1.4B 2nd	$1.4B 4th
ONCOLOGY	$398M 5th	$468M 4th	$1.3B 3rd	$1.2B 5th
SUBSTANCE USE DISORDER	$198M 9th	$247M 9th	$554M 6th	$793M 6th

Note: Companies can be tagged to multiple value propositions and clinical indications. Rock Health tracks 20 value propositions and 23 clinical indications. For clinical indications, we include funding for companies that have a service/offering for that particular indication even if it's not the exclusive focus of the company (e.g., Amwell is included in "mental health," but is not exclusively focused there).
Funding numbers seen here are rounded to the closest decimal point, so while some numbers may appear the same, they are not equal.
Includes U.S. deals ≥$2M; data through September 30, 2021
Source: Rock Health Digital Health Venture Funding Database

AI

- Artificial Intelligence (AI) is the development of computer systems to perform tasks that normally require human intelligence
- Machine Learning (ML): A subset of AI that enables computers to discover patterns in large data sets, make predictions and improve these predictions over time with repeated exposure to the data

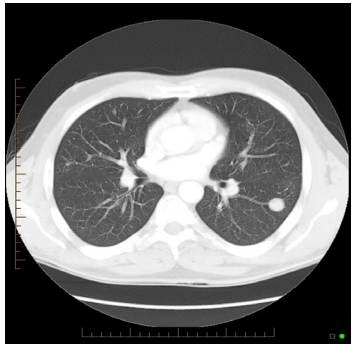
ML

Analyzes large datasets to produce unique algorithms capable of “statistical learning”. It differs from traditional statistical analysis

Goal: accurate prediction, classification or optimization

Machine Learning

- Supervised Learning (labeled data) — Inputs are pre-chosen based on defined output
- Unsupervised Learning (unlabeled/raw) — No defined output extracts data from large data set



AI: Process

Model input

Static Features

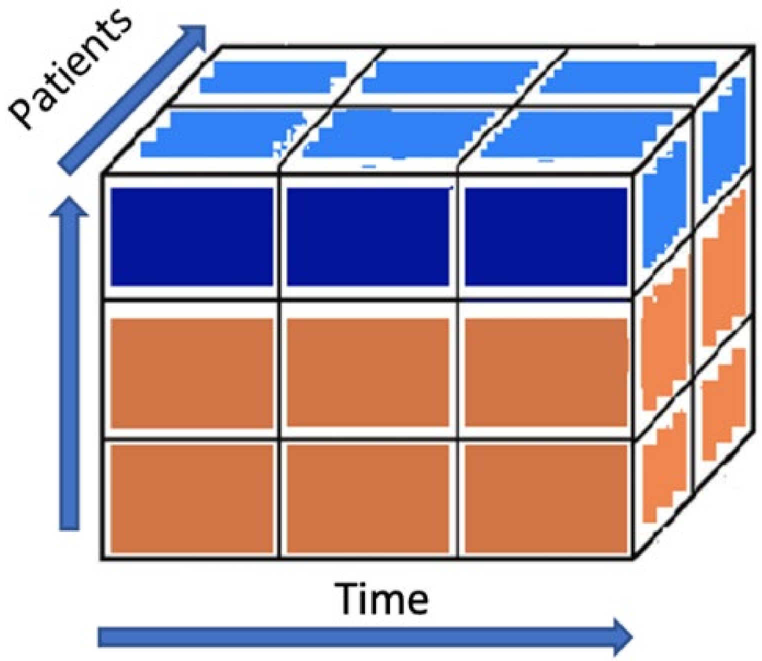
Patient	Time (days)	Age (years)	Height	Diabetes
A	0	65	5'8	Yes
A	1	65	5'8	Yes
A	2	65	5'8	Yes

Dynamic Features

Patient	Time (days)	Weight (lbs)	Medication (insulin)
A	0	145	Yes
A	1	143	Yes
A	2	144	Yes

Data Preparation

Multi-dimensional data preparation



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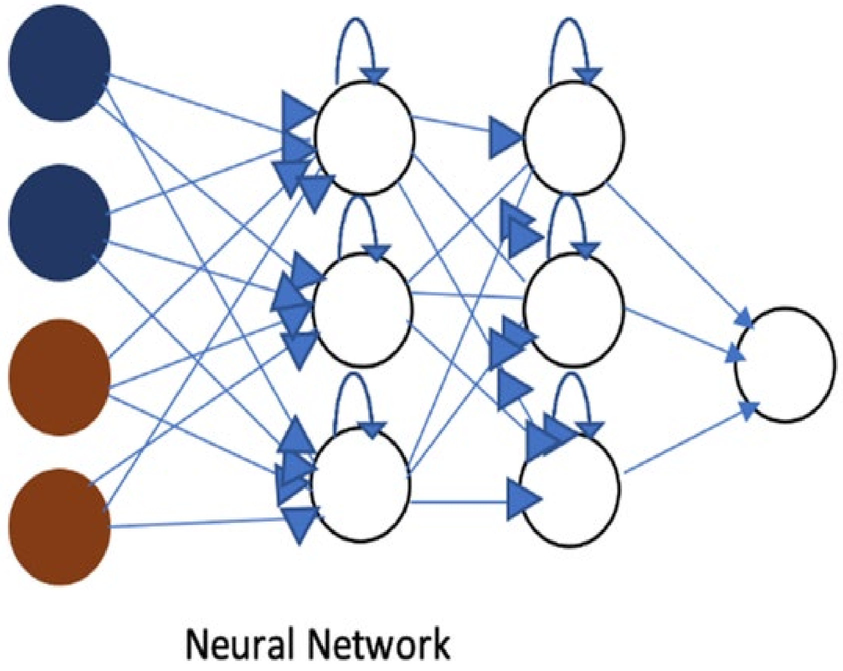
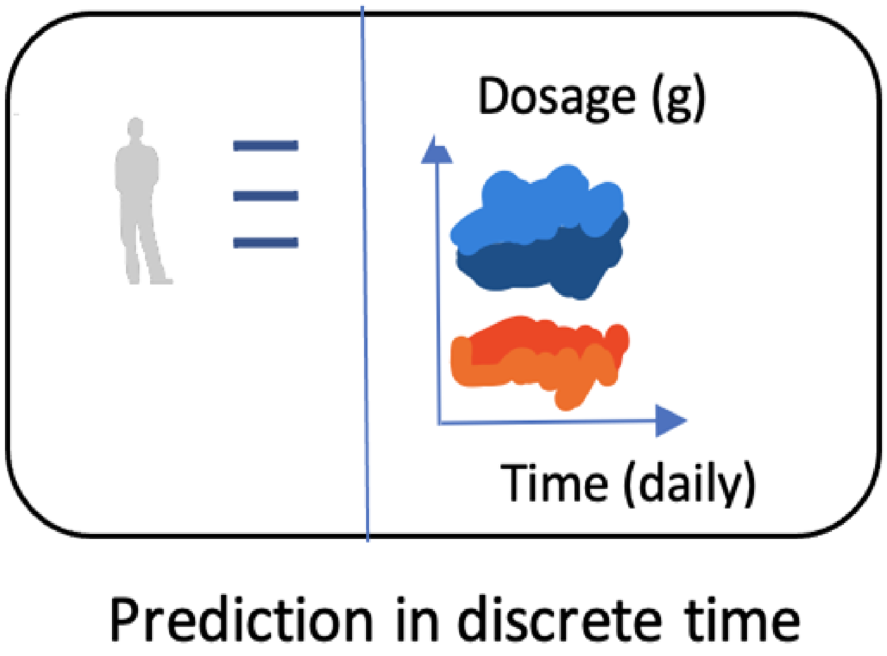
AI: Process

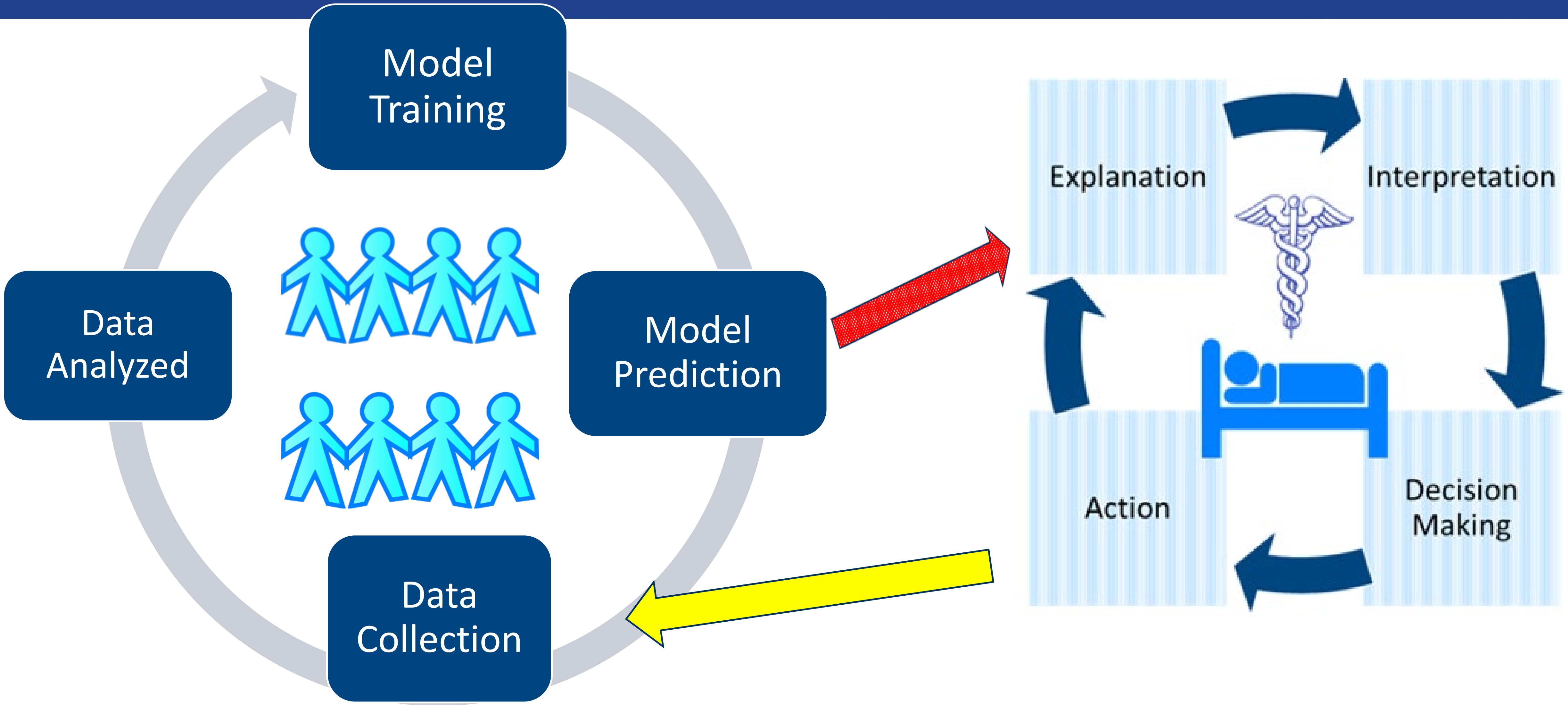
AI Model



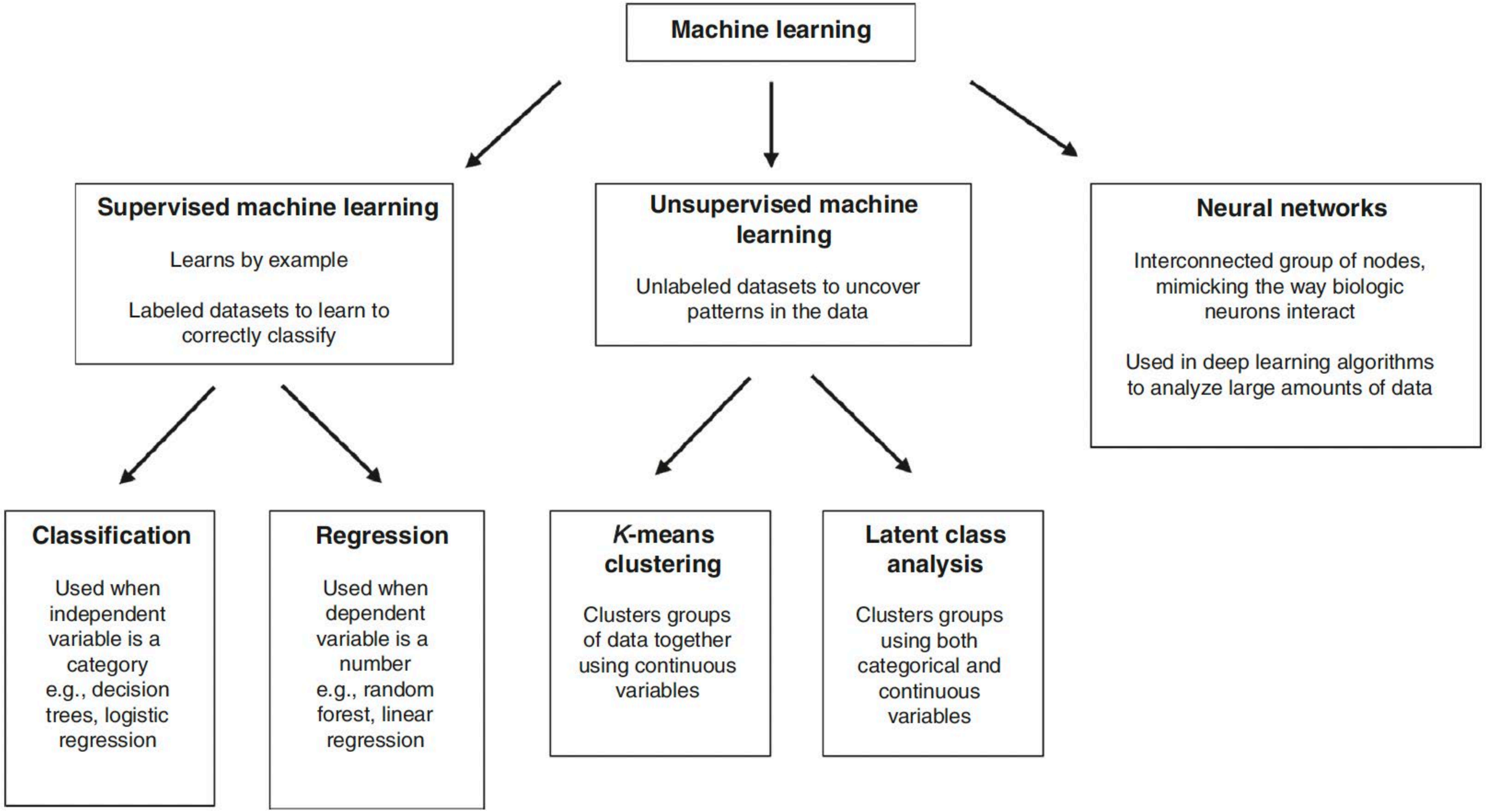
Predicting dosage



AI Process: Prediction to Decision-Making

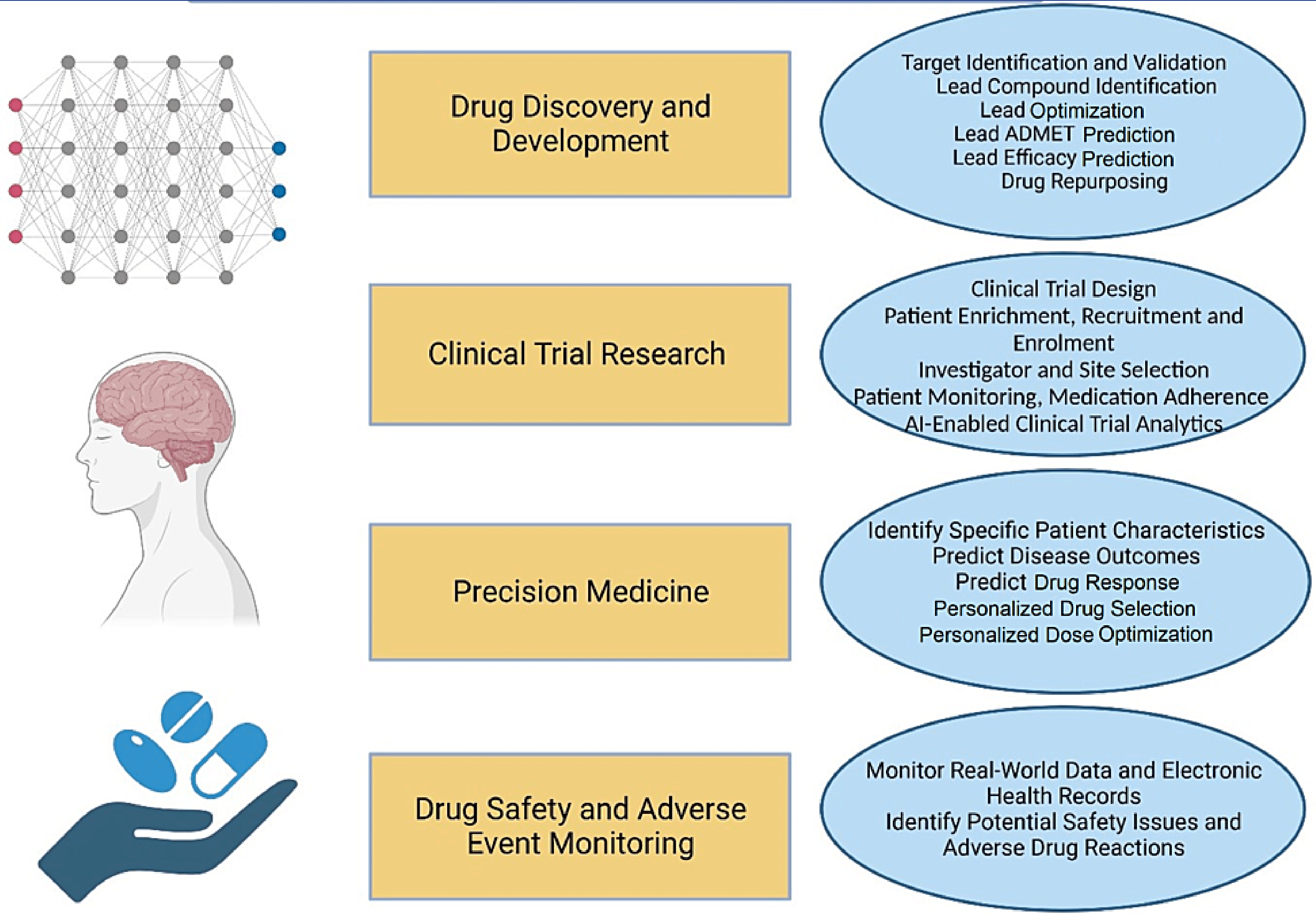


Types of ML models



Shah, N., Arshad, A., Mazer, M. B., Carroll, C. L., Shein, S. L., & Remy, K. E. (2022). The use of machine learning and artificial intelligence within pediatric critical care. *Pediatric Research*, 1-8.

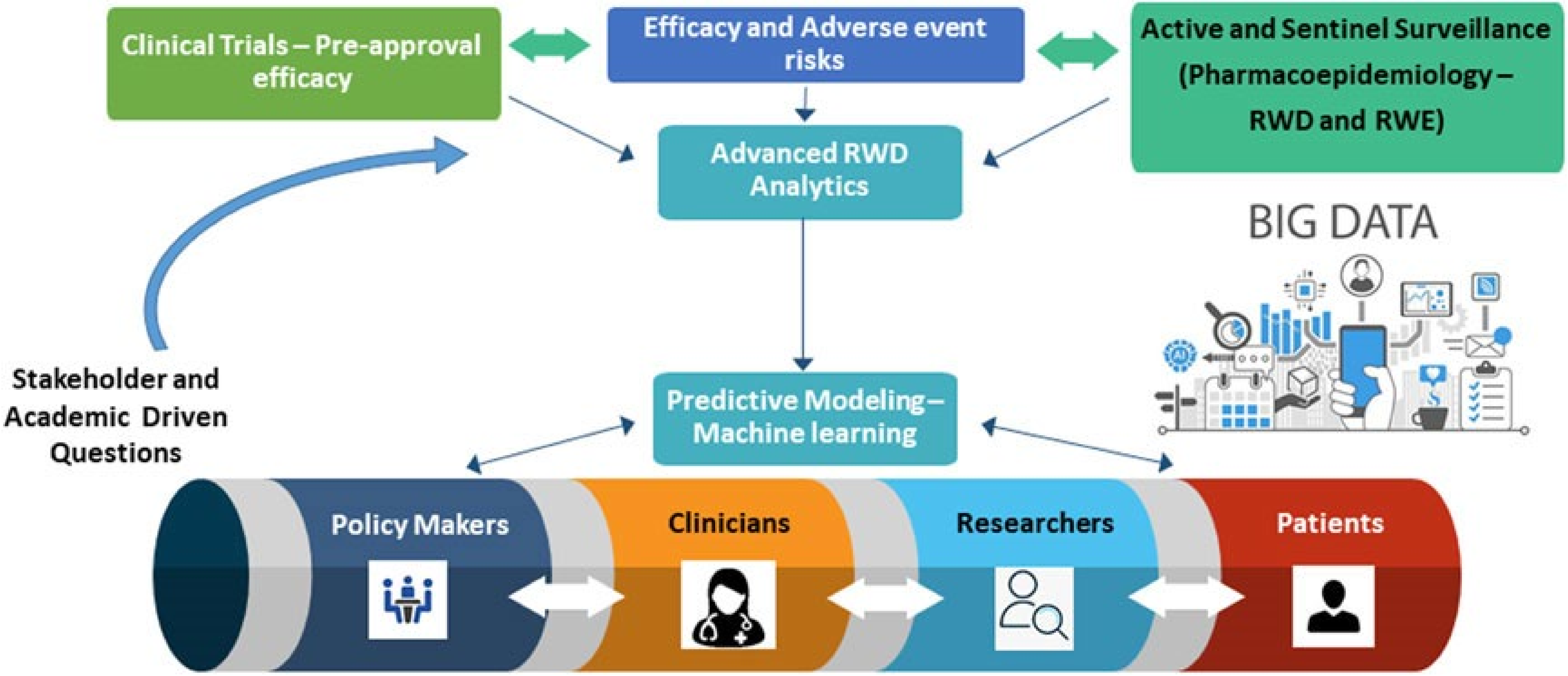
Types of AI studies



DOI: 10.7759/cureus.44359

- **Interactive AI**
  - Chatbots
  - Smart PA
- **Functional AI**
  - IoT solutions
  - Robots
- **Generative AI**
  - Content generation
- **Analytic AI**
  - Prediction
  - Supply chain
  - Drug discovery
- **Text AI**
  - NLP
- **Visual AI**

How do we blend!



https://www.frontiersin.org/articles/10.3389/fphar.2021.723427/full

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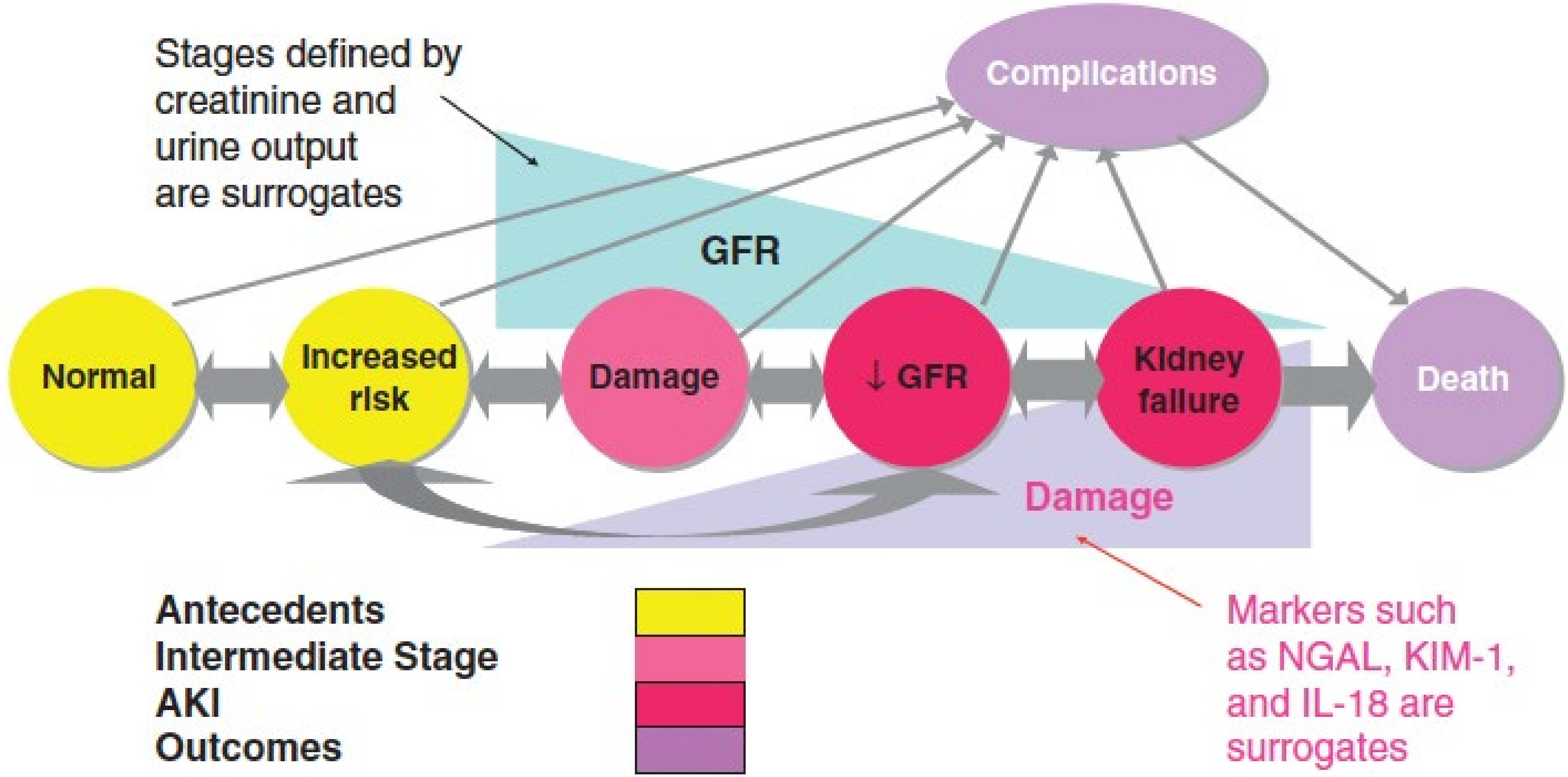
Conceptual model of AKI



http://cjasn.asnjournals.org/content/3/3/864.full

Polling Question

1. Prior to admission, which of the following technologies may have alerted the patient and their healthcare professional of their health status decline and may have prevented hospitalization?
   a. Use of an integrated wearable vital sign monitoring device
   b. Use of a life-alert alarm
   c. Use of a phone to call emergency services
   d. Use of pulse oximeter

Polling Question

2. Which components are not included in AI model building?
   a. Preparing dataset
   b. Model training
   c. Model prediction
   d. Recruiting data analysts

Polling Question

3. Which of the following is not a heterogenous and complex dataset?

   a. Drug dispensing data from CVS

   b. Vitals data

   c. Clinician notes

   d. Home medications at the hospital admission

Polling Question

4. Which of the following is a supervised learning modeling problem?

   a. Predicting the incidence of Sepsis in ICU

   b. Triaging the patients

   c. Exploring the risk factors of CRRT

   d. Assessing/evaluating home medications at hospital admission

Break

AI, RWD, and RWE

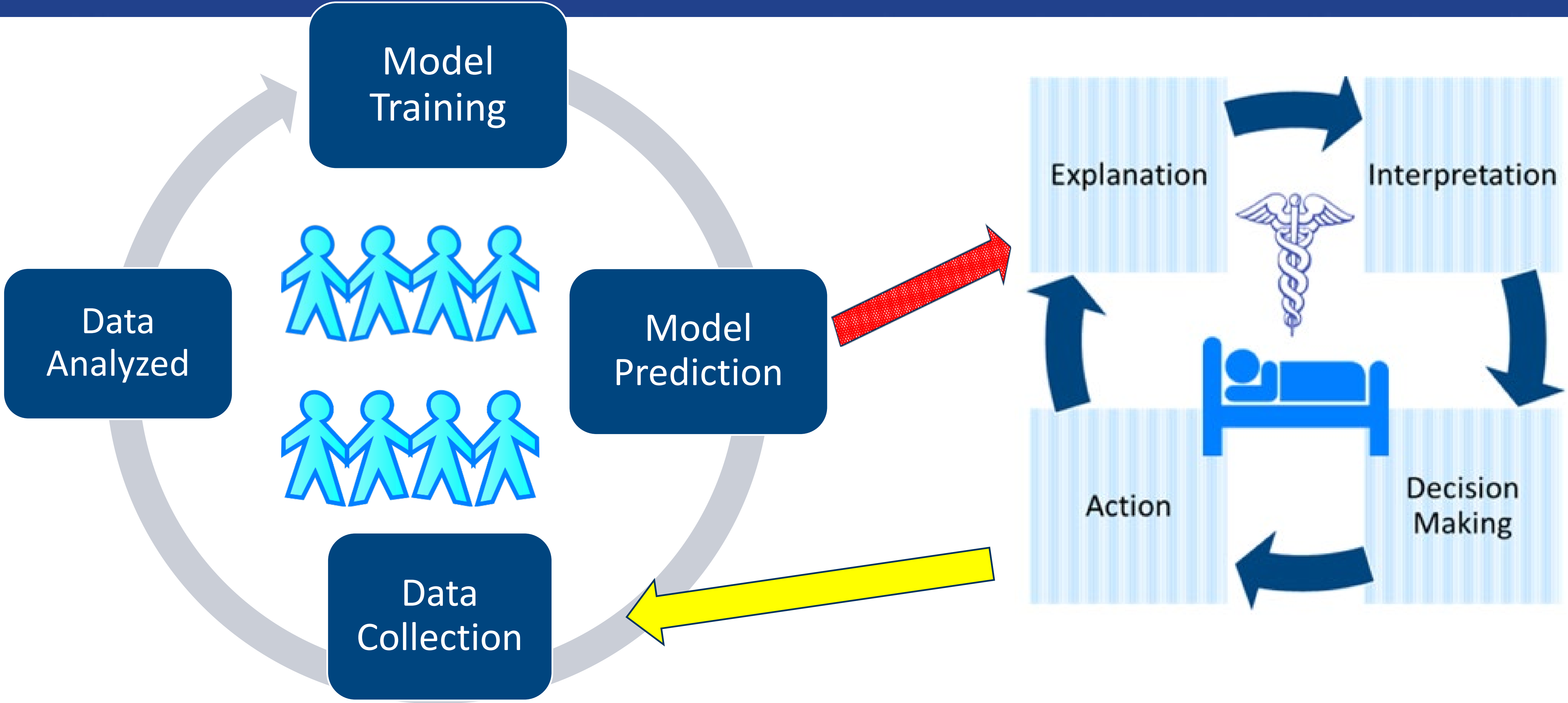
In medicine, **Real World Evidence (RWE)** is derived from **Real-World Data (RWD)** and is the evidence regarding the clinical use and potential benefits or risks of a medical product. Essentially RWD can mean any data that is collected outside of a clinical trial and can relate to the health of the patient and/or the delivery of health care. RWD can be collected in a number of different ways for example through different medical claims databases or disease registries and also directly from the patient, for example, through **Electronic Healthcare Records (EHRs)** or generated directly by the patient for example via mobile devices.

https://md.catapult.org.uk

RWD to RWE

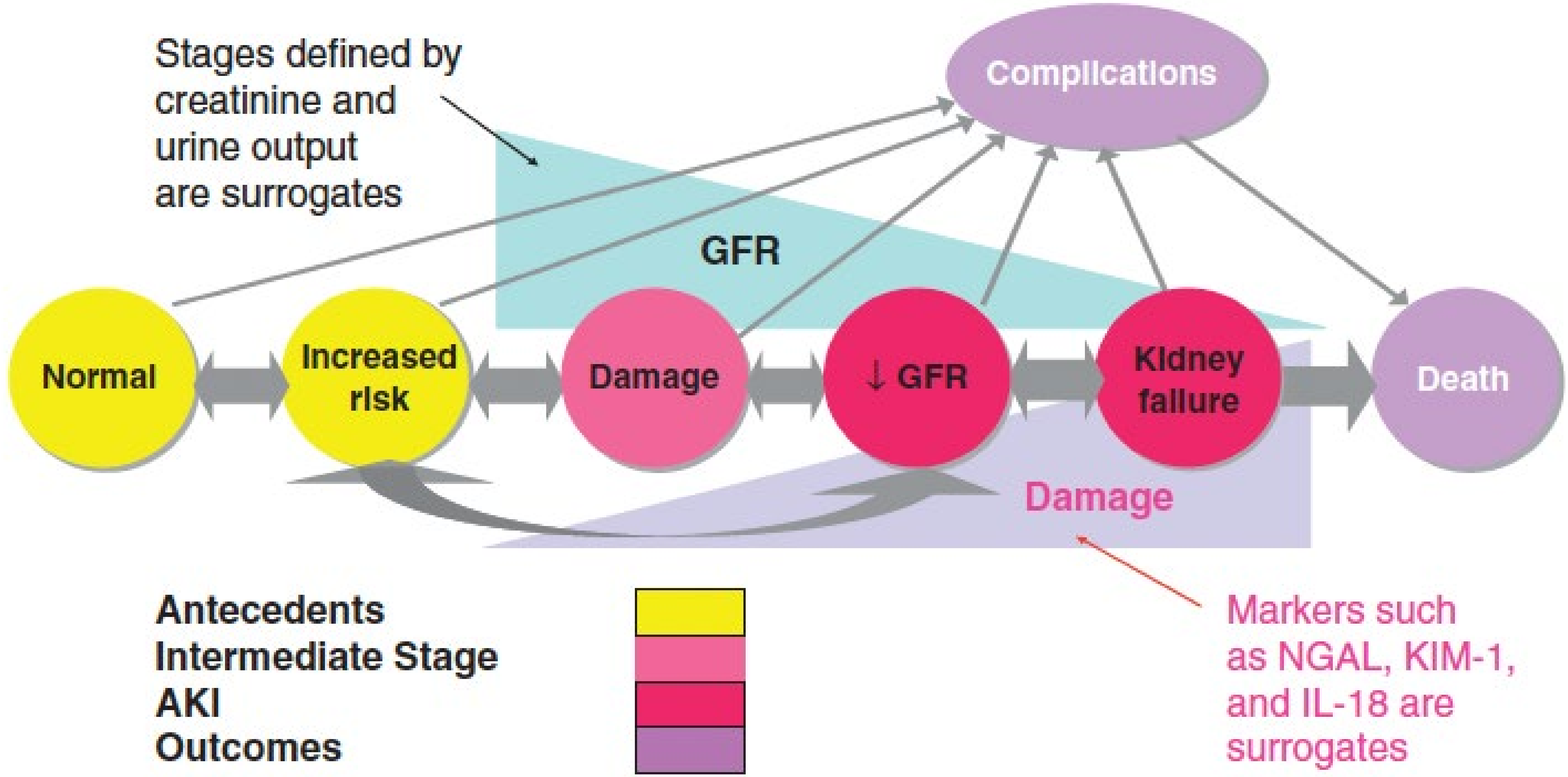
Electronic Medical Record	Patient Reported Outcomes	Social Media
Claims	Health Monitoring Device	Mobile Health
Registries	Lab Results	Medical Imaging
Surveys	Genomic data & Biomarkers	Public Health Data

AI Process: Prediction to Decision-Making



Acknowledgment: Dr. Todd Brothers (College of Pharmacy, University of Rhode Island)

Conceptual model of AKI



http://cjasn.asnjournals.org/content/3/3/864.full

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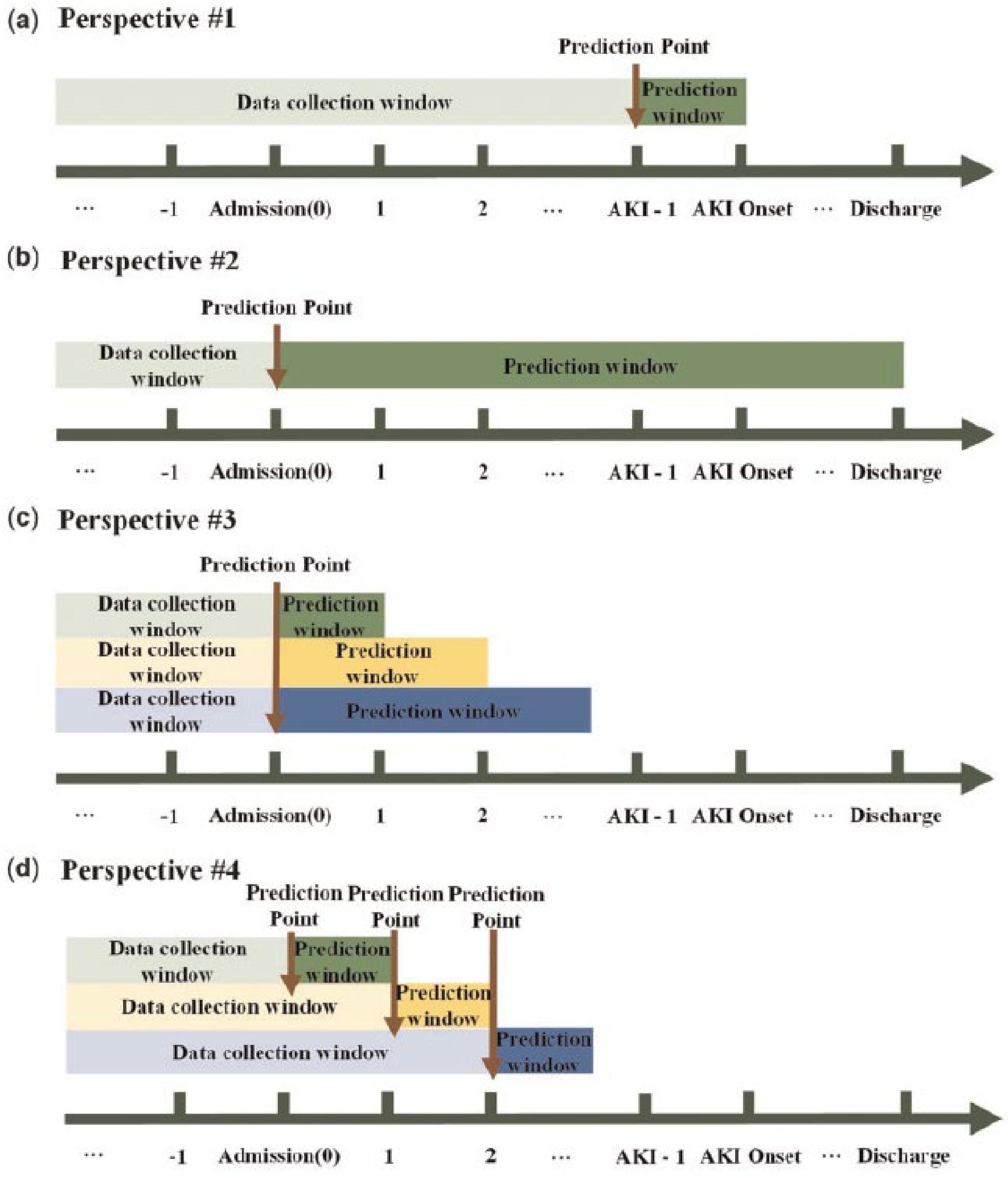
Scenarios of AKI



a) Perspective #1 - Can we predict AKI before its onset using data before the onset time?

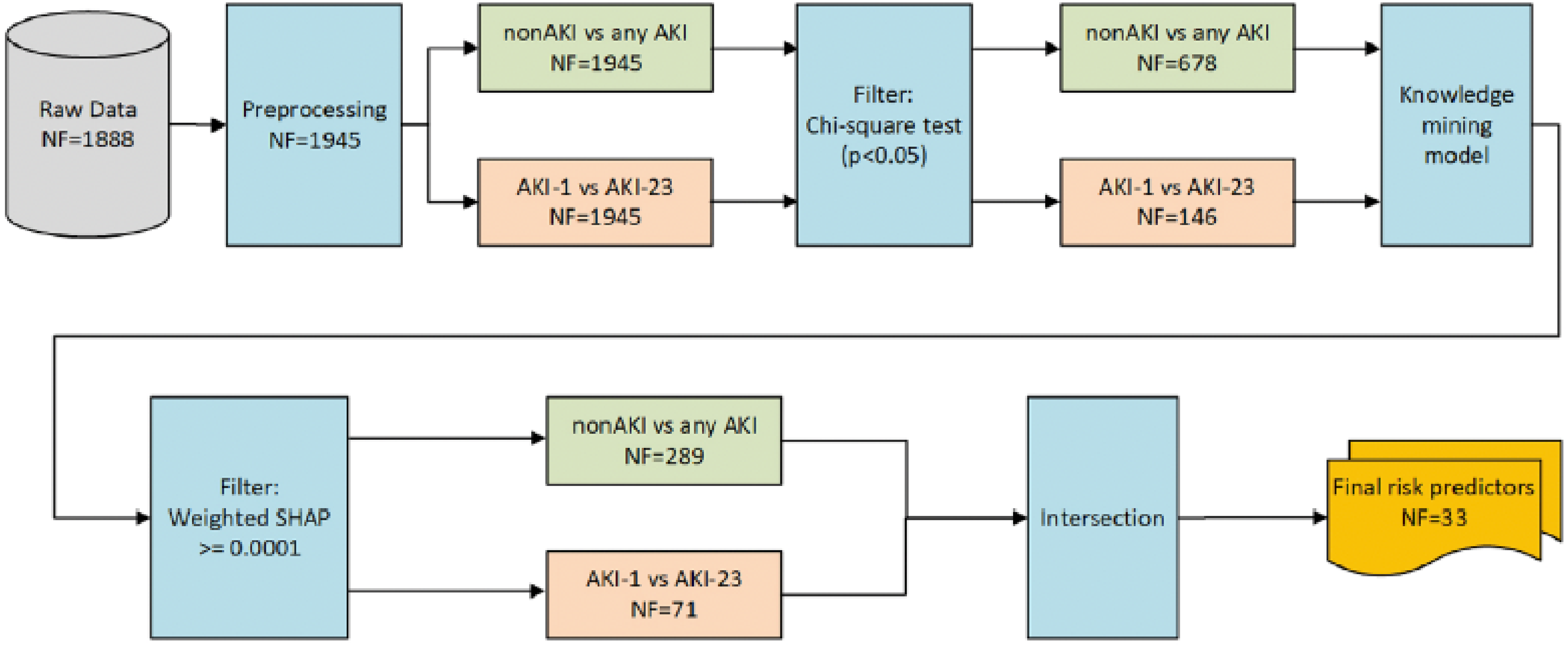
b) Perspective #2 - Can we predict at admission if AKI will occur for patients during their stay?

c) Perspective #3 - Can we predict at admission if AKI will occur within various numbers of days afterwards?

d) Perspective #4 - Can we predict if a patient will develop AKI within the next day in a clinical scenario?

He, J., Hu, Y., Zhang, X., Wu, L., Waitman, L. R., & Liu, M. (2019). Multi-perspective predictive modeling for acute kidney injury in general hospital populations using electronic medical records. *JAMIA open*, *2*(1), 115-122.

Knowledge base and Prediction model

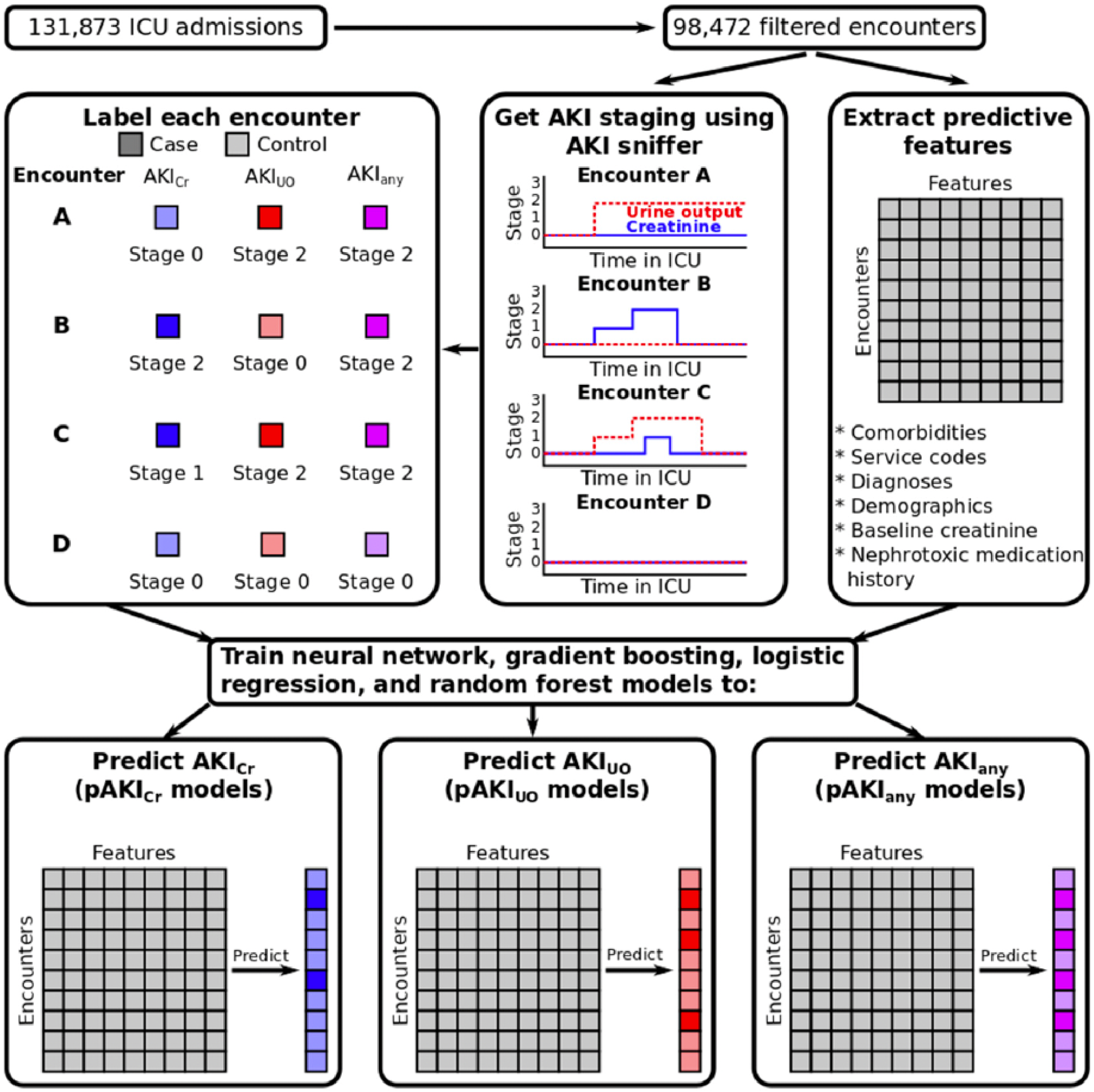


Wu, L., Hu, Y., Yuan, B., Zhang, X., Chen, W., Liu, K., & Liu, M. (2020). Which risk predictors are more likely to indicate severe AKI in hospitalized patients?. *International journal of medical informatics*, *143*, 104270.

Prediction model

Data preparation and feature selection

Three separate models (pAKICr, pAKIUO, and pAKIany) using each of four architectures



Schwager, E., Lanius, S., Ghosh, E., Eshelman, L., Pasupathy, K. S., Barreto, F., & Kashani, K. (2021). Including urinary output to define AKI enhances the performance of machine learning models to predict AKI at admission. *Journal critical care*, *62*, 283-288.

AI in Pediatrics population

The Federal Food, Drug, and Cosmetic Act (FD&C Act) defines pediatric patients as **persons aged 21 or younger at the time of their diagnosis or treatment.**

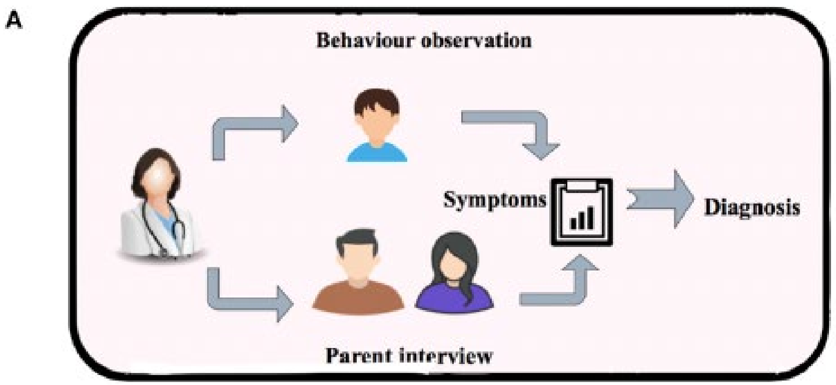
- Neonates - from birth through the first 28 days of life.
- Infants - 29 days to less than 2 years
- Children - 2 years to less than 12 years
- Adolescents - aged 12 through 21

Characteristics and Challenges

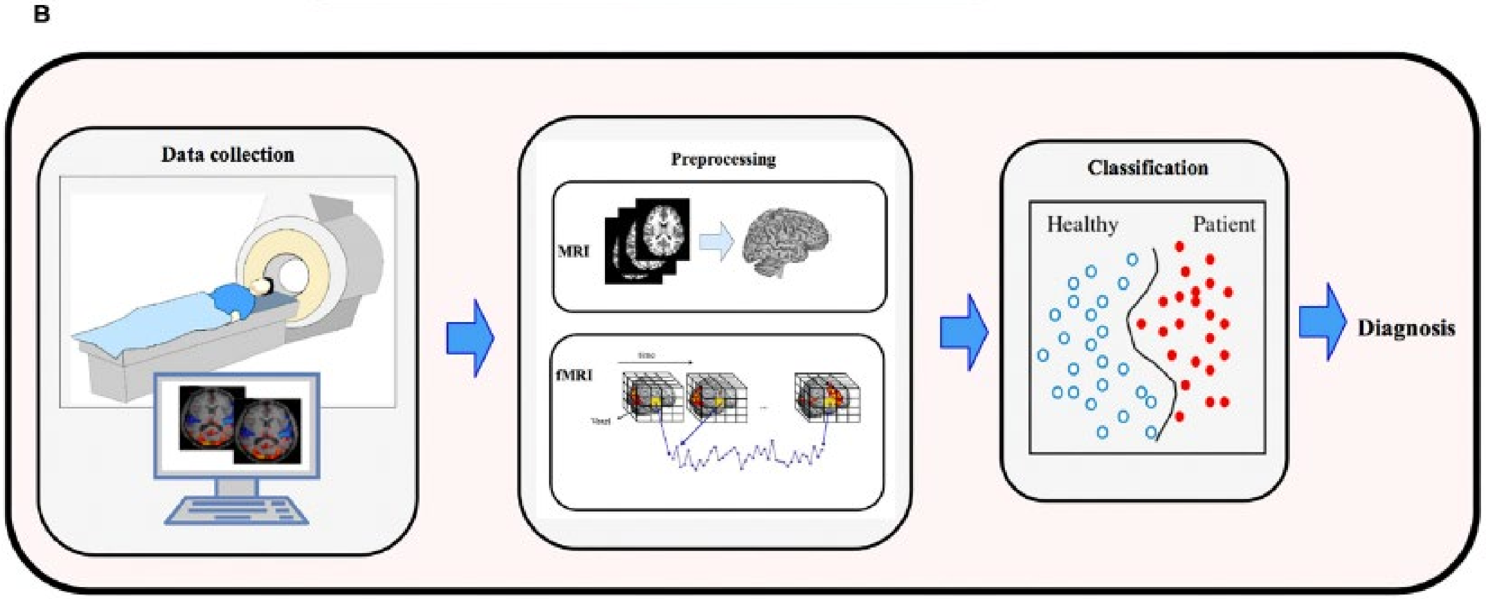
- Age-corrected reference values (lab test, vital sings and developmental assessment)
- Specification of adverse drug
- Comorbidities
- Comedications
- Outcomes
- Limited availability of bio samples
- Limitations of invasive study procedures

Example 1

Eslami, T., Almuqhim, F., Raiker, J. S., & Saeed, F. (2021). Machine learning methods for diagnosing autism spectrum disorder and attention-deficit/hyperactivity disorder using functional and structural MRI: a survey. *Frontiers in neuroinformatics*, 62.



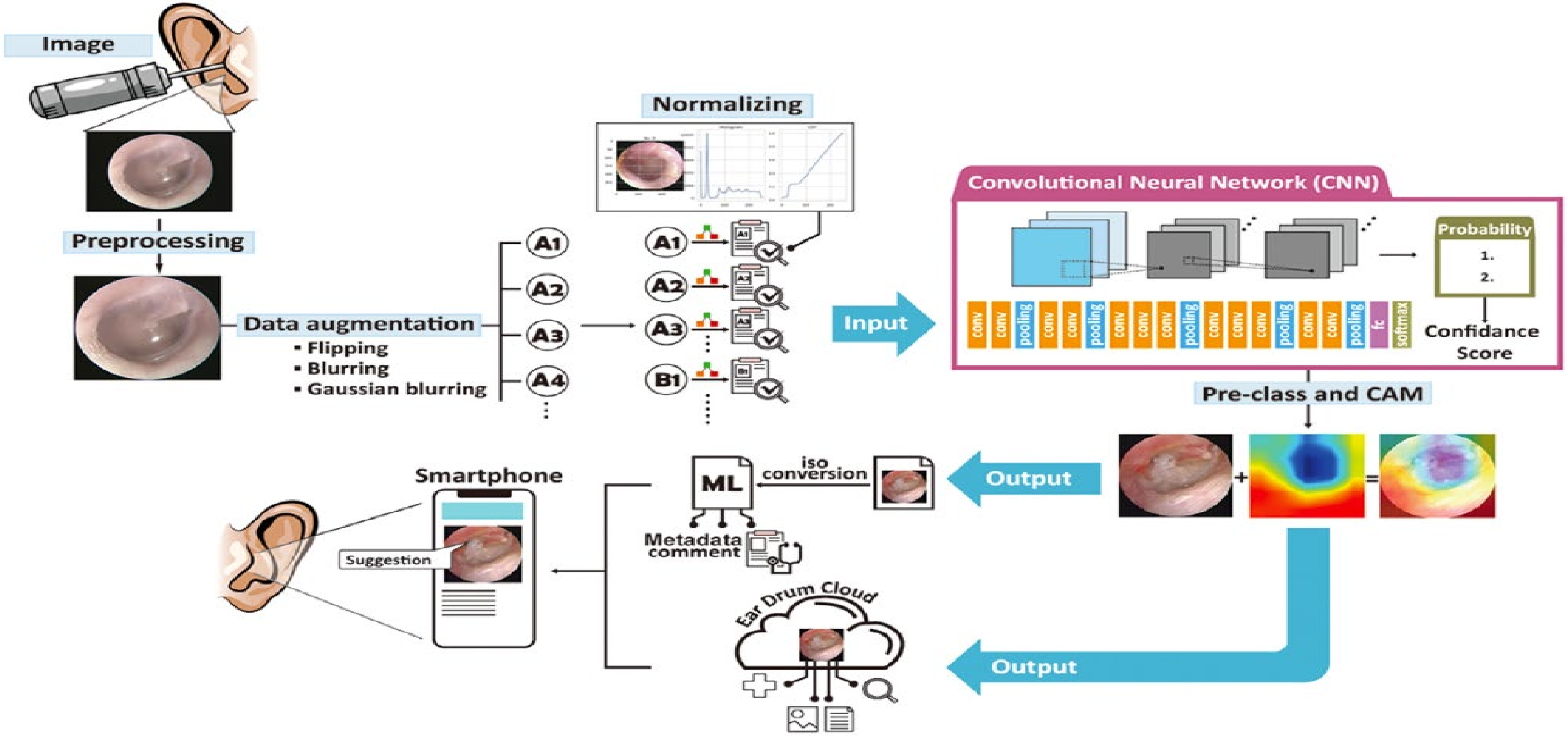
(A) Traditional methods for diagnosing brain disorders



(B) Classification based on brain imaging and machine learning

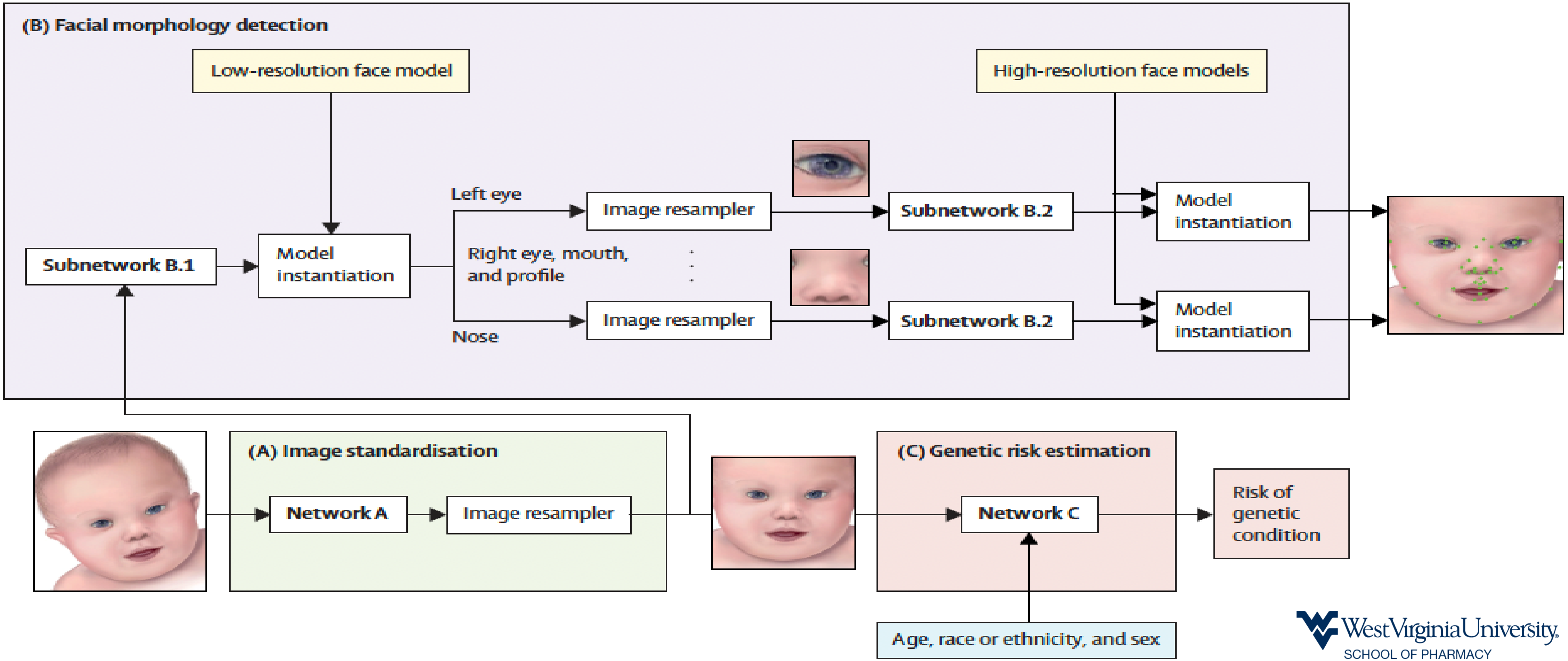
Example 2

Chen, Y. C., Chu, Y. C., Huang, C. Y., Lee, Y. T., Lee, W. Y., Hsu, C. Y., ... & Cheng, Y. F. (2022). Smartphone-based artificial intelligence using a transfer learning algorithm for the detection and diagnosis of middle ear diseases: A retrospective deep learning study. *EClinicalMedicine*, 51, 101543.



Example 3

Porras, A. R., Rosenbaum, K., Tor-Diez, C., Summar, M., & Linguraru, M. G. (2021). Development and evaluation of a machine learning-based point-of-care screening tool for genetic syndromes in children: a multinational retrospective study. *The Lancet Digital Health*, 3(10), e635-e643.



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Some of my research

Annals of Pharmacotherapy
Volume 55, Issue 4, April 2021, Pages 421-429

https://doi.org/10.1177/1060028020959042

SAGE journals

Research Reports

Development of Machine Learning Models to Validate a Medication Regimen Complexity Scoring Tool for Critically Ill Patients

Mohammad A. Al-Mamun, PhD[1], Todd Brothers, PharmD, BCPS, BCCCP [1,2], and Andrea Sikora Newsome, PharmD, BCPS, BCCCP [3]

International Journal of *Environmental Research and Public Health*

MDPI

Article

Medication Regimen Complexity Index Score at Admission as a Predictor of Inpatient Outcomes: A Machine Learning Approach

Yves Paul Vincent Mbous [1,*], Todd Brothers [2,3] and Mohammad A. Al-Mamun [1]

Some of my research

frontiers in Microbiology

ORIGINAL RESEARCH
published: 12 April 2019
doi: 10.3389/fmicb.2019.00687

Shared Multidrug Resistance Patterns in Chicken-Associated *Escherichia coli* Identified by Association Rule Mining

Casey L. Cazer[1], Mohammad A. Al-Mamun[2†], Karun Kaniyamattam[1†], William J. Love[3], James G. Booth[4], Cristina Lanzas[3] and Yrjö T. Gröhn[1]*

Expert Systems With Applications 64 (2016) 305–316

Contents lists available at ScienceDirect

Expert Systems With Applications

journal homepage: www.elsevier.com/locate/eswa

ELSEVIER

An adaptive rule-based classifier for mining big biological data

Dewan Md. Farid[a,*], Mohammad Abdullah Al-Mamun[b], Bernard Manderick[a], Ann Nowe[a]

[a] *Computational Modeling Lab, Department of Computer Science, Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussels, Belgium*
[b] *Department of Population Medicine & Diagnostic Sciences, College of Veterinary Medicine, Cornell University, Ithaca, NY 14850, USA*

rsity.

How a pharmacist should participate

- Identification of **use cases** and project prioritization
  - In what extent the use cases can be optimized
- Pharmacists **understand the workflows**
  - **Where to chime in!** saving time, increasing patient safety, reducing ADEs, improving patient care
- Mapping **value sets** (medications)
- Identification of where the **data lives in the EHR**
  - Familiarity with the data systems **values and caveats**
- Understanding where there are inconsistencies
  - **Multi-way handshaking**
- Testing and validation of models
  - **Always ask questions** to the AI analyst about the input and output of the models

How a pharmacist should approach AI

- Is this something that can be done by a human given available data and enough time?
  - Do we have a lot of data for specific disease?
  - Do we have an example already?

- What is the outcome?
  - Estimating the probability of a yes/no label (classification)
  - Estimating a continuous target value (regression)
  - Finding patterns in the data (unsupervised learning, data mining)

- How accurate would the predictions or patterns need to be clinically useful?

- What do we already know about the relationship between inputs and outputs?

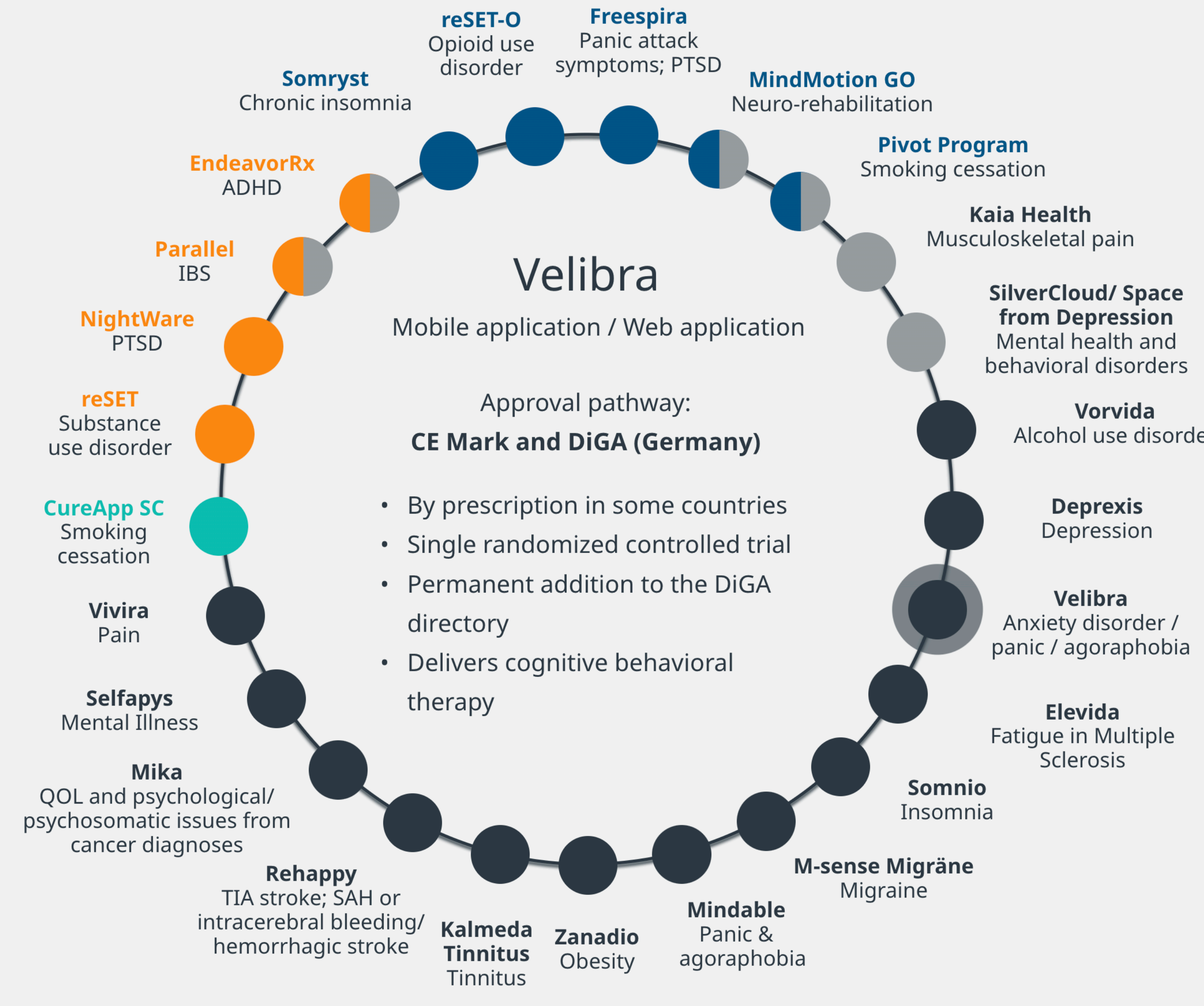
- Are we saving something? (lives, time, and money!)

Reshaping Health Care

AI methods (i.e., machine learning, natural language processing, and deep learning) use data patterns to:

- Identify needs
- Find faster, more accurate solutions
- Enables improved real time decision-making

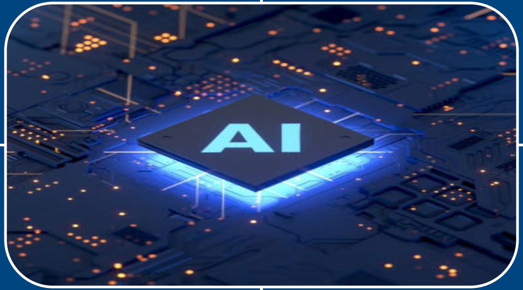
https://www.iqvia.com/insights/the-iqvia-institute/reports/digital-health-trends-2021



Key Points

Clinicians + researchers need to understand the benefits + limitations of ML in research

ML-based platforms require relevant, high-quality data to be trained, tested, and trusted



Ethical + legal issues regarding database privacy, security, and opensource access are continued areas in need of development

AI can reduce healthcare costs + improve decision-making, lending to better clinical outcomes

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Polling Question

1. A pharmacist should not get involved in an AI project if the project team is

   a. Developing a model to evaluate drug efficacy
   b. Reporting adverse drug events to the U.S. Food and Drug Administration
   c. Preparing an adaptive treatment schedule for chemotherapy
   d. Building a post marketing model

Polling Question

2. A pharmacist can develop

   a. A chart review for a diabetic patient
   b. Deep learning neural network
   c. List of nephrotoxic drugs
   d. A model to include patient feedback in an AI model

Polling Question

3. As a part of an interdisciplinary AI team, you developed an alert system for septic shock. The model was created using data from 1,000 patients and the accuracy of predicting septic shock is 92%. Are you ready to implement in your hospital systems?

a. Need to validate the AI model first using more data from the same hospital that you work
b. Need to develop a multicenter randomized trial to validate the prediction accuracy of the tool prior implementation
c. We should use it on a test basis
d. No, we should not use it

Questions?

Thanks!

CE Evaluation Access Code

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Capital Letters, No spaces, complete by __________

Note: CE credit will be reported to NABP CPE Monitor within 4-6 weeks

Applications of Artificial Intelligence (AI) in Pharmacy Practice

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