

Digital Health

Spring 2025

UNIVERSIDAD
POLITÉCNICA DE MADRID



11 - Health
Informatics
Data analytics,
Predictive
Analytics,
Clinical Decision
Support,
Business
Intelligence

Agenda

- Questions?
- Learning objectives: Discipline literacy, critical analysis skills, applied and integrative learning, global or civic engagement, soft skills
- Icebreaker: What is your favorite holiday?
- Exam results, matching game, lecture
- Group presentations
- Following week: Health accelerators, think tanks, sand boxes. Guest speaker

Digital Health Midterm Exam – 15 students

1. Definition - 10 students
2. Developing Country - 6 students – Ethiopia (2), Nepal, China, Senegal, Brazil
3. **Macrotrends – 11 students** – Climate change, urbanization, forced migration, precision medicine, authoritarianism, AI, block chain technology, smart hospitals, direct-to-consumer medicine, bioprinting, and geopolitical tension
4. EMR Scribes – 5 students
5. MLM – 5 students - Predict readmission, predict relapse, predict breast cancer
6. Blackbox – 10 students - Additive
7. Telemedicine – 9 students
8. Gamification – 6 students – BioQuest, BioLab, BioEngineer Voyager, BioEngage Quest
9. Media – 9 students
10. Speaker – 1 student

Digital Health and Chat GPT

- Do you have the free or paid subscription?
 - eg, deep research function
- How is learning or writing different when using Chat GPT?
- Would you prefer your feedback on essays from Chat GPT?
- Do you think Chat GPT grades fairly?



Grading in ChatGPT: B grade

Suggestions for Improvement

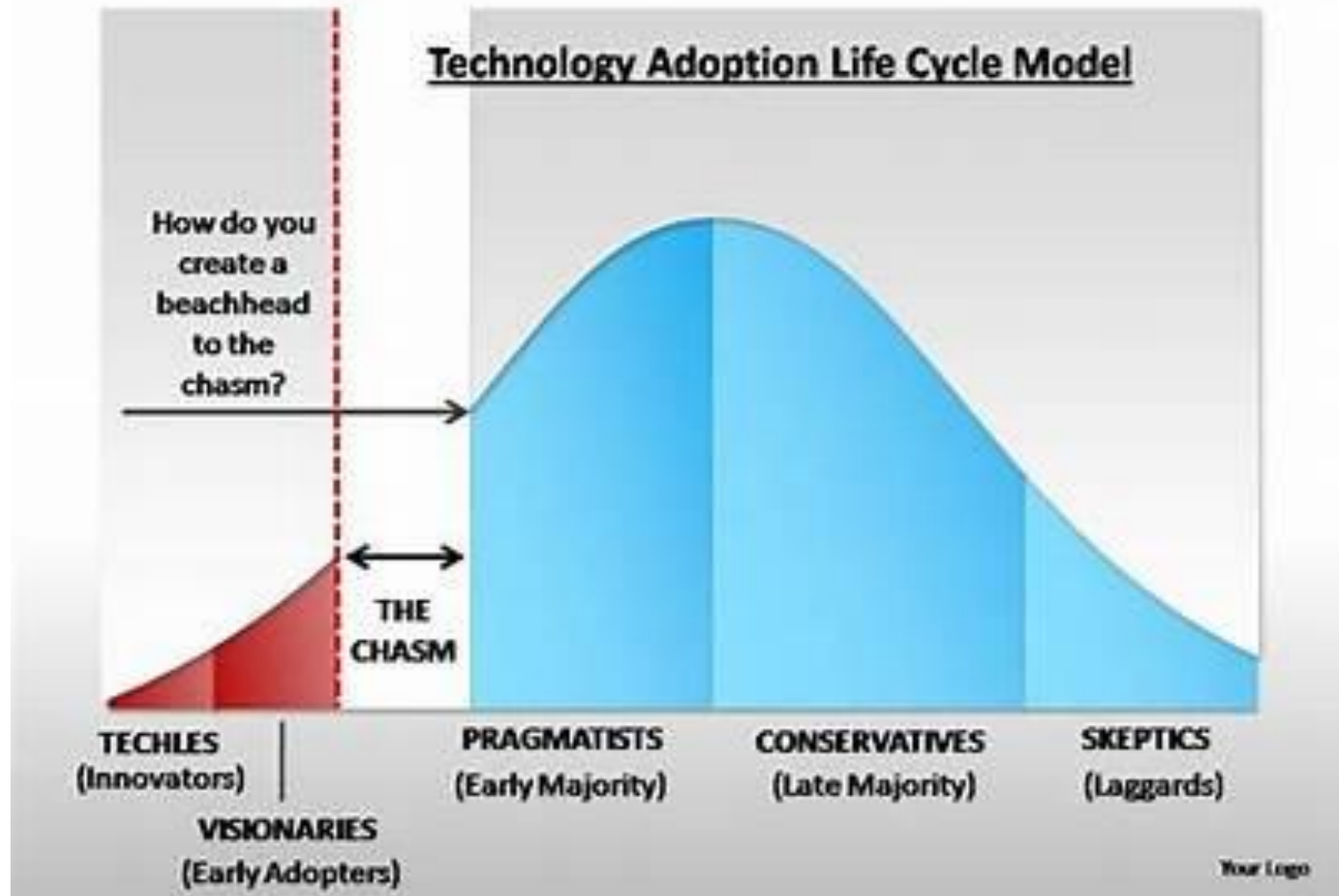
- **Polish sentence structure:** Aim for variety and clarity. Short, choppy sentences make it feel less academic.
- **Proofread carefully:** Small errors (double words, missing articles) can significantly impact readability.
- **Add a concluding sentence:** The essay ends abruptly. Consider wrapping up with a statement about why explainability is critical for adoption of AI in healthcare.

What can we learn from each other?

- Synthetic data
- Haptic Feedback
- Interpretability
- PHQ-9/GAD-7
- Explainability models
- SHAP
- LIME
- AUC Retrospective accuracy metrics
- AUC/ROC curves
- Octalysis framework
- DISNET database
- Health certification stamp
- Blockchain technology
- APACHE score
- Explainable AI
- Synthetic media
- Digital quality seal
- Multimodal monitoring
- Biometric ID technologies
- Gradient boosting machines
- Precision recall curve
- Cyberchondria
- Optimization algorithms
- Fairness aware techniques

Crossing The Chasm

How will
AI in
healthcare
cross the
chasm?



Health Data



The healthcare industry is responsible for about 30% of the world's data, and the amount of data it generates is increasing at a rate of 47% per year.

Forms, doctor's notes, medical records, observations, written text, photos, radiology images, pathology slides, video, audio, streaming device data, PDF files, faxes, PowerPoint slides, and emails.

Is there a difference among all these terms?

- Health informatics
- Health data analytics
- Health predictive analytics
- Clinical decision support
- Biomedical science
- Health data science

Digital health technology
Bioinformatics
Healthtech
Healthcare business intelligence
Biomedical engineering

Matching exercise

What is Health Informatics?

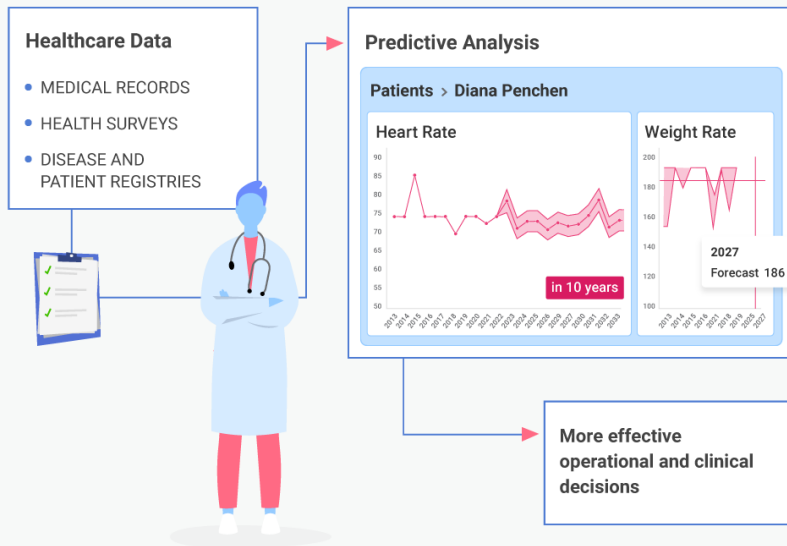
- Health informatics is the interdisciplinary study of the design, development, adoption, and application of IT-based innovations in healthcare services delivery, management, and planning.
- Health informatics is the study and implementation of computer structures and algorithms to improve communication, understanding and management of medical information.
- It can be viewed as a branch of engineering and applied science.

What is Health Data Analytics?

- Process of inspecting, cleansing, transforming and modeling data with the goal of discovering useful information, informing conclusions and supporting decision-making
- In other words, the process of analyzing raw data for understanding health trends and enabling better decision making.
- Allows the ability to data mine, risk stratify hospital patients, analyze risk factors for diseases, or avoid costly but inappropriate treatments.

What is Predictive Analytics?

Predictive Analytics in Healthcare



- Predictive analytics is the process of learning from real time or historical data to make predictions about the future.
- In medicine, predictive analytics will enable the best decisions to be made, allowing for care to be personalized for each individual.
- Typically, it uses EMR or administrative data sources.
- Leverages statistical modeling, data mining, and machine learning to deliver new insights.

What is Clinical Decision Support?

- An information system that guides medical decision-making activities.
- Analyzes data or information to help doctors improve patient care.
- Includes biomedical knowledge, person-specific data, inferences, and a knowledge set to help clinicians make decisions about patient care.

What is Healthcare Business Intelligence?

- Healthcare business intelligence is the analysis of information providing historical, current and predictive views of hospital or clinic **operations** to optimize performance.
- Goals:
- Maximize performance
- Improve decision making
- Increase revenues and lower costs
- Set strategy, key performance indicators, staffing, supply chain management
- Understand patient behavior, utilization of services, and satisfaction

What is Digital Health Technology?

General term for technology that uses computing platforms, connectivity, data, software, and sensors for health care, medicine and wellness.

What do you say in the elevator or to your grandmother?

Evolving Definitions as Technology Advances

- Whatever the definition and terms, it is all about using data and computing in health and medicine.
- Let's look at some examples, studies and stories.

Study: “The use of Big Data Analytics in healthcare”(2022)

- 217 medical facilities in Poland surveyed (2018) Their conclusion: “Decisions were highly data-driven”.
- Structured and unstructured data (more) was used in administrative, business and clinical areas.
- At that time, debating the definition of big data.
- Conclusion: Good review of how fast digital health is moving



- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8733917/>

Study: Review of the use of predictive analytics

Look at the size of the data sets

Conclusion: Finding data to test models is a challenge

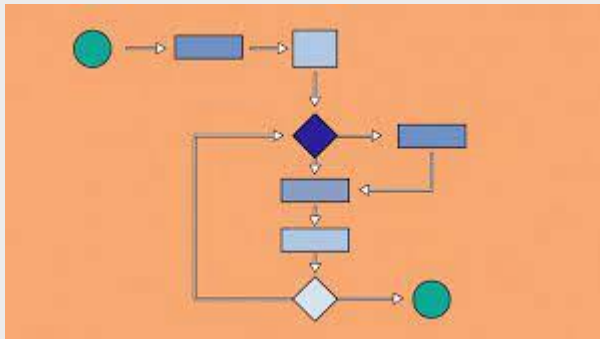
Prediction	Data Set N=	Reference
Developing diseases	704,587	Motto et al 2018, Scientific Reports
Disease onset for 133 conditions	298,000	Razavian et al 2016, ArXiv
C. difficile hospital infection from EHR	256,732	Oh et al 2018, Infection Control
Sepsis	230,936	Horng et al 2017, PLOS One
Severe sepsis from EHR	203,000	Culliton et al 2017, arXiv
3-12 month mortality for all causes	221,284	Avati et al 2017, arXiv
Chronic patients to avoid hospitalization in Valencia	500	https://www.accenture.com/_acnmedia/pdf-53/accenture-health-la-fe-credential-predictive-health-analytics-model.pdf

Predictive analytics



- Data collected between 2011 and 2015 from more than 700,000 adults (94% males) treated in 172 hospitals and 1,062 outpatient clinics run by the US Department of Veterans Affairs.
 - Alphabet, Google's artificial-intelligence unit, Deep Mind Health Laboratories
 - Developed an algorithm for machine learning that can predict who is at high risk of developing a serious kidney condition
-
- Tomasev et al (2019): A clinically applicable approach to continuous prediction of future acute kidney injury. Nature Volume 572, pages 116-199.
 - <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6722431/>
 - Topol, E. (2019): Deep learning detects impending organ injury. Nature Vol 572, pages 36-37.

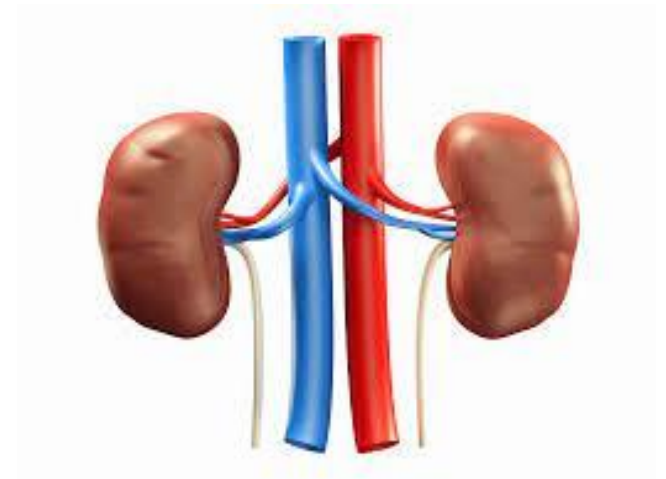
Predictive analytics



- The algorithm could predict the sudden deterioration of kidney function two days before the potential injury with 55.8% accuracy.
- For more severe kidney injuries, that later required dialysis, the accuracy was closer to 90%.
- Ongoing testing.

Study: Predictive analytics

- Chronic kidney disease (CKD), a serious illness, does not manifest until the kidney is severely damaged so early detection can save lives.
- Three predictive models (6-12 months prior): convolutional neural network (CNN), long short-term memory (LSTM) model, and deep ensemble model.
- <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10692057/>

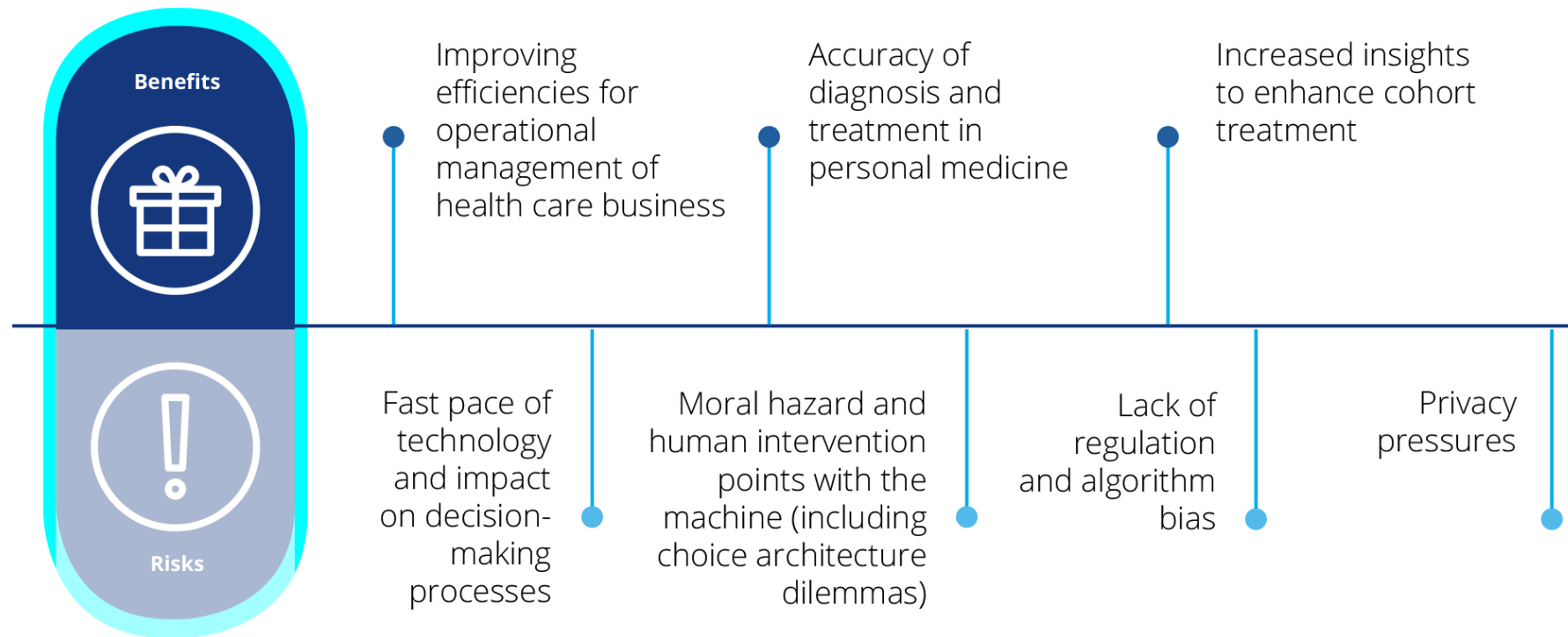


Predictive analytics Discussion Questions

- Think about all the conditions and diseases that could be analyzed.
- What other diseases, injuries, or medical situations would benefit from predictive analytics? In the future, will it be possible to predict the onset of most diseases?
- Do you want to know?
- What are the pros and cons of identifying high risk patients?
- Is 55% or 90% accuracy good enough? Will you trust a diagnosis made by an AI tool?
- Will AI be smarter than a radiologist? Or a pathologist?
- Will AI eliminate jobs for humans? Can physicians be replaced?
- Is it OK when a for-profit commercial company can determine the fate of a sick patient? What are the potential dangers?
- Are you willing to give up your private health data for the good of the world?

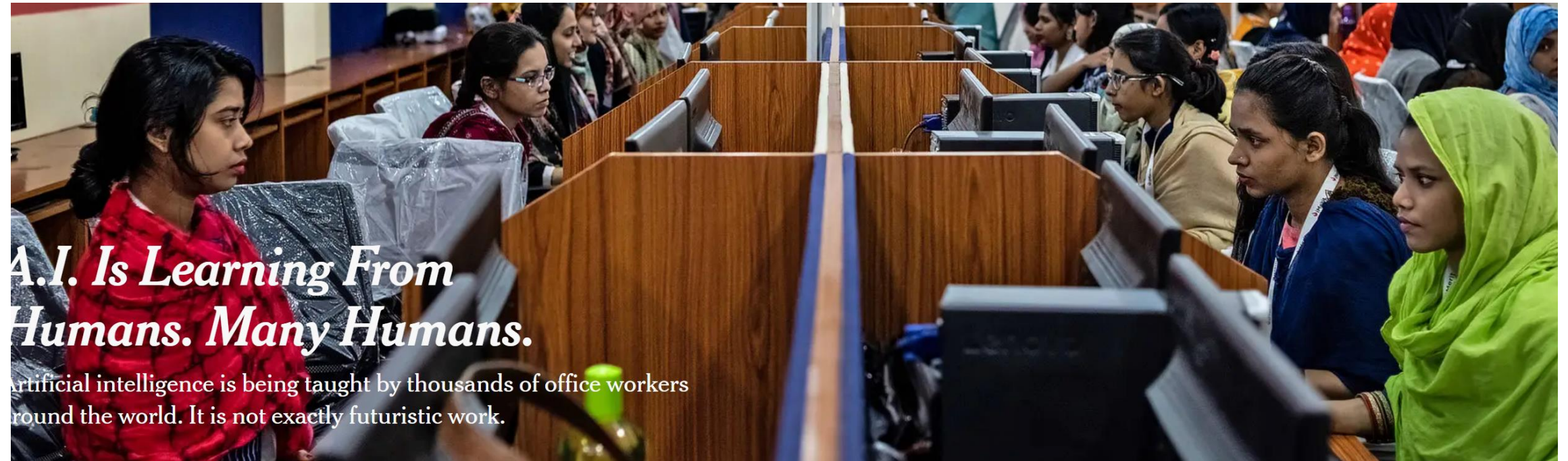
FIGURE 1

Benefits and risks associated with predictive analytics in health care



Source: Deloitte analysis.

Data, Data, Data



A.I. Is Learning From Humans. Many Humans.

Artificial intelligence is being taught by thousands of office workers around the world. It is not exactly futuristic work.

Labeling data for AI

- Thousands of individuals in India are labeling colonoscopy videos for polyps, blood clots, inflammation and other signs of disease.
 - Thousands of other workers (mainly from home) annotate data through crowdsourcing services like Amazon Mechanical Turk (distributing digital tasks globally). Few pennies for each label.
 - iMerit also labels data for many huge tech companies.
 - Labeling accounts for **80%** of the time spent building AI systems.
 - Is the work exploitative?
-
- Metz, C. (2019, August 18). Oh, the monotony of shifting the tedium to A.I. The New York Times. AI is Learning from Humans.
 - <https://www.nytimes.com/2019/08/16/technology/ai-humans.html>

Clinical Decision Support



Example: Clinical decision support

- Check out this brief demo of a tool to help physicians make decisions.
- Up-to-Date - Diagnosis and treatment information – commercial product. Watch a demo (5 min) .
 - <https://www.wolterskluwer.com/en/solutions/uptodate/resources/user-academy/training-videos#cat-demo>
 - [Resources - Training Videos | UpToDate | Wolters Kluwer](#)
- Evidence-based point of care information, includes 25 specialties, used by 2 million worldwide

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The trusted evidence-based resource to answer clinical questions

Each patient is unique, and every decision counts. With medicine growing more complex and evidence changing rapidly, it is critical that you have a clinical decision support resource you know you can trust and that is proven to improve patient outcomes.

Providing clarity when you need it most

As a clinician, you find yourself at the intersection of complexity and uncertainty – when the next steps are unclear, and you must make decisions based on the best evidence available to you. This is where UpToDate excels as a clinical decision support resource. We deliver the evidence powered by clinical expertise from the world's leading physicians



Previously, all large data sets needed to be tagged with searchable terms from a vocabulary, now free text searching.

Example: Clinical decision support

- Scenario: A mother calls a poison center in the U.S.
 - 64 poison centers in the U.S. with a national free phone line.
 - She says that her 2-year-old child drank Windex, a cleaning solution for windows. What should she do?
- First poison center started in 1949 in the Netherlands, now 47% of WHO member countries have one. (2023)
- Poison centers provide expertise on the diagnosis and treatment of poisoning to medical professionals. They provide emergency advice to the general public.



Example: Clinical decision support

- Poison centers use **Poisindex** emergency management poison system. Owned by Merative/Micromedex.
- A database of more than 483,000 chemical and household products.
- Each product is assigned a unique code to identify the exact substance involved in the exposure, including the brand name and manufacturer.



Toxicology

Under **Related Documents** are all of the active ingredients in the product that have entries in **Poisindex**. They are in order of severity. Clicking on the hyperlinked ingredient name will take you to the full **Poisindex** monograph for that ingredient.

MICROMEDEX® 2.0 | MOBILE

MY SUBSCRIPTION | MICROMEDEX GATEWAY | LOG OUT | HELP

Tools: Drug Interactions | Trisess's™2 IV Compatibility | Drug Identification | Tox & Drug Product Lookup | Drug Comparison | RED BOOK Online® | Calculators | CareNotes® | NeoFax®

SEARCH Example Searches

Tox & Drug Product Results [Modify Search](#) [Print](#)

Displaying results found for "Windex Original Glass Cleaner (Blue)"

Results from: **United States** | Other Countries | Display: **Product/Substance Names (3)** | Synonyms (2) | Manufacturer Contact Info (0) | Results begin with | Results contain

Jump To: **ALL** | 0-9 | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z

Results 1 - 3 Page 1 of 1 Go | Previous | Next

Name	Strength/Form	Manufacturer	Country	Product ID	AAPCC Code	Related Document(s)
1. Windex Original Streak Free Shine Glass Cleaner With Ammonia D - Blue	Liquid	SC Johnson	Canada United States	5418409	173281	IRRITANTS - POISINDEX® ISOPROPYL ALCOHOL - POISINDEX® ETHYLENE GLYCOL BUTYL ETHER - POISINDEX® GLASS CLEANERS - POISINDEX®
2. Windex Original Streak-Free Shine Glass Cleaner with Ammonia D - Blue	Liquid	SC Johnson	United States Canada	6784874	173281	ISOPROPYL ALCOHOL - POISINDEX® AMMONIA - POISINDEX® GLASS CLEANERS - POISINDEX®
3. Windex Powered Original Glass Cleaner with Ammonia D - Commercial Line - Blue	Liquid	SC Johnson	United States	6687036	173281	IRRITANTS - POISINDEX® ISOPROPYL ALCOHOL - POISINDEX® ETHYLENE GLYCOL BUTYL ETHER - POISINDEX® GLASS CLEANERS - POISINDEX®

Toxicology

Here is the **Poinsindex** monograph for **Barbituates**.

Windows Internet Explorer window titled "Toxicology details - MICROMEDEX® 2.0". The address bar shows the URL: http://www.thomsonhc.com/micromedex2/librarian/ND_T/evidenceexpert/ND_PR/evidenceexpert/CS/F50F7.

The page displays the MICROMEDEX® 2.0 interface. The top navigation bar includes links for MY SUBSCRIPTION, MICROMEDEX GATEWAY, LOG OUT, and HELP. Below this is a search bar with a "SEARCH" button and "Example Searches" link.


The main content area is titled "BARBITURATES-LONG ACTING". It features a left sidebar with a table of contents and a main content area with expandable sections.

Table of Contents (Left Sidebar):

OVERVIEW
LIFE SUPPORT
CLINICAL EFFECTS
LABORATORY/MONITORING
TREATMENT OVERVIEW
RANGE OF TOXICITY
SUBSTANCES INCLUDED/SYNONYMS
THERAPEUTIC/TOXIC CLASS
SPECIFIC SUBSTANCES
AVAILABLE FORMS/SOURCES
CLINICAL EFFECTS
SUMMARY OF EXPOSURE
VITAL SIGNS
HEENT
CARDIOVASCULAR
RESPIRATORY
NEUROLOGIC
GASTROINTESTINAL
HEPATIC
GENITOURINARY
ACID-BASE
HEMATOLOGIC
DERMATOLOGIC
PSYCHIATRIC
IMMUNOLOGIC
REPRODUCTIVE

Main Content Area:

BARBITURATES-LONG ACTING

POINSINDEX® Managements  [OTHER SOURCES >](#)

OVERVIEW [Expand All](#) [Collapse All](#) [Top of Page](#)

- ▶ **LIFE SUPPORT**
- ▶ **CLINICAL EFFECTS**
- ▶ **LABORATORY/MONITORING**
- ▶ **TREATMENT OVERVIEW**
- ▶ **RANGE OF TOXICITY**

Additional links: [Display Entire Document](#) | [Print](#)



Clinical decision support

- Benefits include:
- Increased quality of care and enhanced health outcomes
- Avoidance of errors and adverse events
- Improved efficiency, cost-benefit, and provider and patient satisfaction
- Less ambiguity and time saved to treatment

Clinical decision support using AI



CareBot – AI company based in Czech Republic

Carebot AI CXR is a deep learning-based software that assists radiologists in the interpretation of regular chest xrays.

Automatically detects abnormalities for: atelectasis, consolidation, cardiomegaly, mediastinal widening, pneumoperitoneum, pneumothorax, pulmonary edema, pulmonary lesion, bone fracture, hilar enlargement, subcutaneous emphysema, and pleural effusion.

According to the company with published studies, the AI tool alerts doctors to possible findings on a chest xray with up to **99%** sensitivity. It speeds up image evaluation time by up to 33%.

Kvak, D., Chromcová, A., Biroš, M., Hrubý, R., Kvaková, K., Pajdaković, M., & Ovesná, P. (2023). Chest x-ray abnormality detection by using artificial intelligence: A single-site retrospective study of deep learning model performance. *BioMedInformatics*, 3(1), 82-101.

Example: Healthcare business intelligence

- Management Information for hospitals and clinics, eg, Oracle Health Data Warehouse
- Goals: Cut costs, increase revenues, manage workforce and supplies



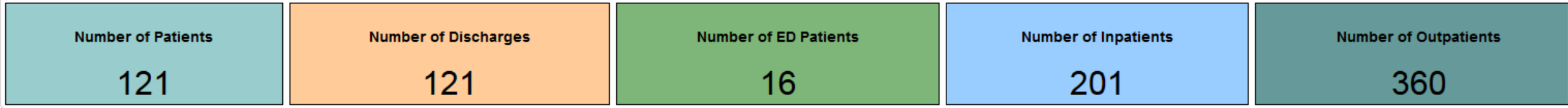
OHF Self Service Analytics - Clinical (Sample)

Summary Encounters with Stroke Diagnosis LOS Analysis

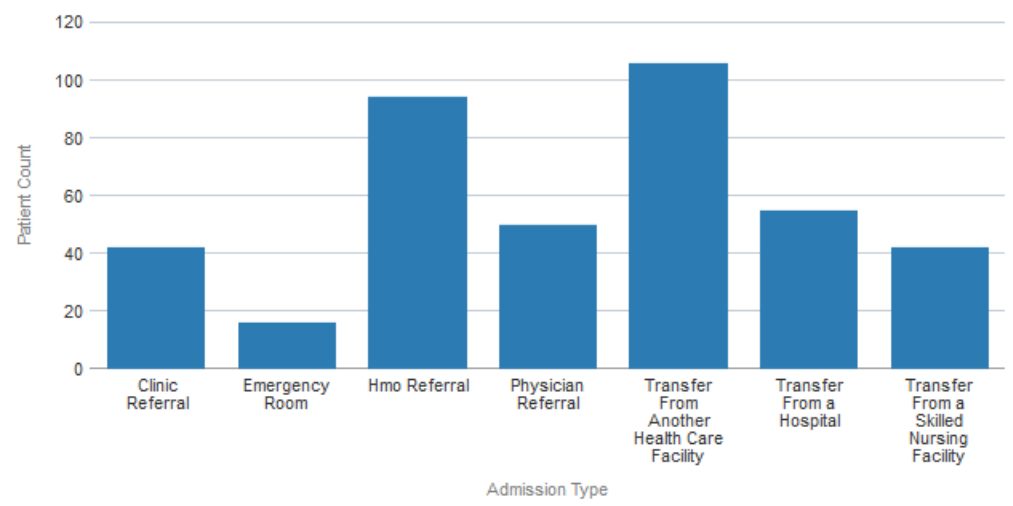


Organization Provider (All Column Values) Physician (All Column Values) Calendar Year (All Column Value) Apply Reset

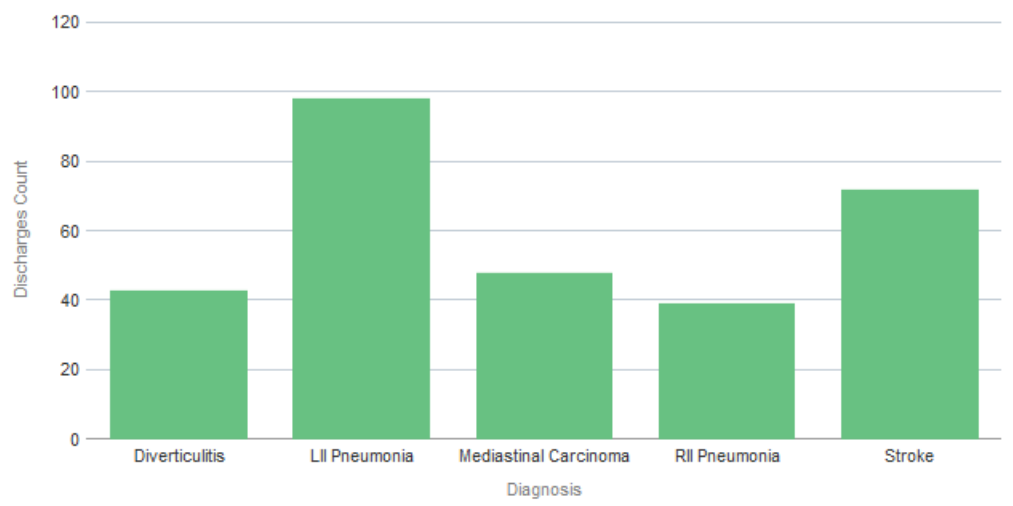
Overview



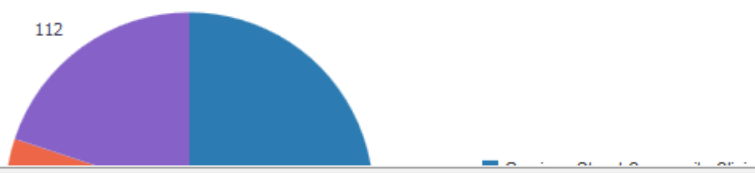
Number of Patients by Admission Type



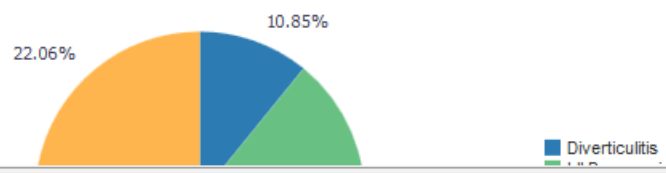
Number of Discharges by Diagnosis



Number of Encounters by Organization



Percentage of Encounters by Diagnosis



Proposed Federal RN-to-Patient Safe Staffing Ratios

Based on patient acuity, with the most critical receiving 1-to-1 care.

Operating Room
Trauma Patient in ER



Intensive/Critical Care • Neonatal Intensive Care
Post-anesthesia • Labor & Delivery • ICU in ER
Coronary Care • Acute Respiratory Care • Burn Unit



Antepartum • Combined L&D and Postpartum
Postpartum Couplets • Pediatrics • ER
Step Down • Telemetry



Intermediate Care Nursery • Med/Surg
Psychiatric • Other Specialty Care Units



Rehabilitation
Skilled Nursing Facility



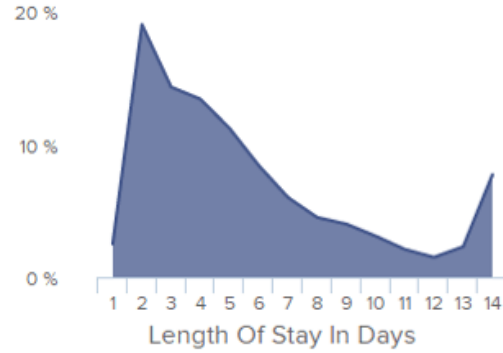
Well Baby Nursery



National
Nurses
United @nationalnursesunited

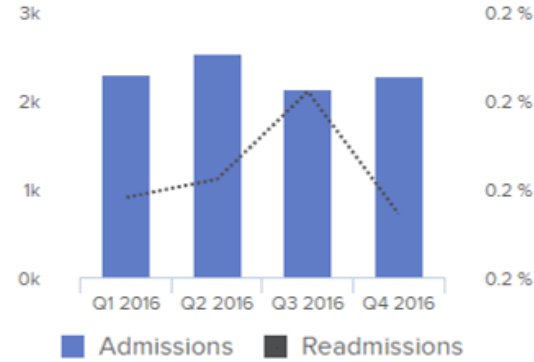
Safe Ratios Save Lives.

Length Of Stay



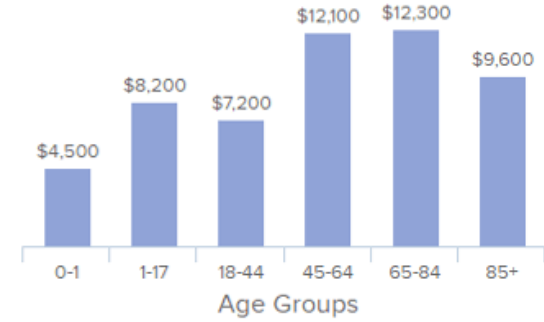
3.5 days
Avg Length Of Stay

Admissions & 30-Day Readmission Rate



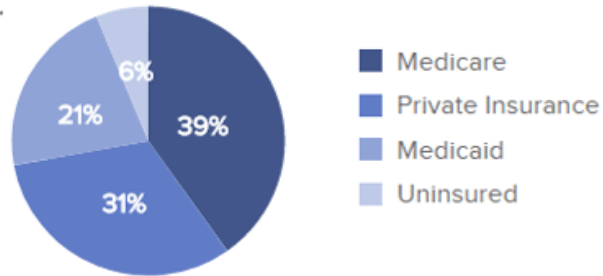
20.4%
Avg 30-Day Readmission Rate

Avg Treatment Costs



\$ 9,700
Avg Treatment Costs All Ages

Stays By Payer



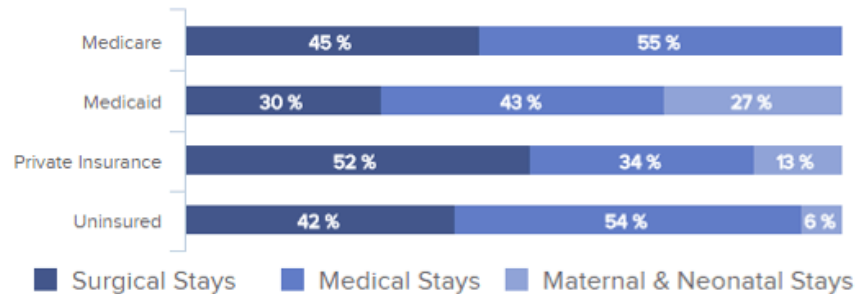
Avg Nurse Patient Ratio



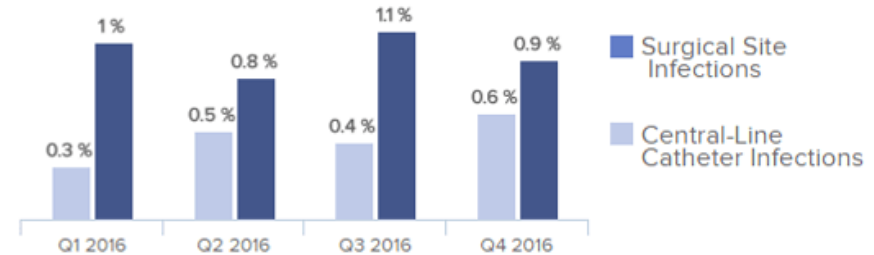
Day Shift: 1:4 Night Shift: 1:8

- * Trauma Units: 1:1
- * Emergency Rooms: 1:3
- * Surgical Rooms: 1:5
- * Rehabilitation Units: 1:6
- * Nursery Units: 1:8

Costs By Payer & Type Of Stays



Hospital-Acquired Infections (Percent Of Cases)



Case Analysis –
Epic Health
Systems –
Predictive
analytics, clinical
decision support,
AI



Case Analysis



- **Epic** Systems Corporation is a privately held healthcare software company in the U.S., producing an electronic medical record
 - Market share in the U.S. 39% hospitals
 - 64% of patients in the U.S. and 2.5% of patients worldwide.
- Epic has offices worldwide
 - Bristol, UK, the Netherlands; Dubai, United Arab Emirates; Helsinki, Finland; Melbourne, Australia; Dhahran, Saudi Arabia; Singapore; Trondheim, Norway and Søborg, Denmark.
- Within their EMR, they have developed predictive analytics for sepsis, atrial fibrillation and stroke
- Incorporated GPT-4 for note writing.

Case Analysis



- Check out Epic's web site and some of the stories on the Internet about Epic's predictive analytics and use of AI.
- <https://www.epic.com/epic/post/cool-stuff-now-epic-and-generative-ai/>
- <https://www.healthcareitnews.com/video/ehr-giant-epics-success-ai-detailed-its-evp-rd>
- <https://www.epic.com/software>
- <https://www.epic.com/epic/post/atrial-fibrillation-screening-epic-saves-lives>
- <https://www.beckershospitalreview.com/ehrs/accuracy-of-epics-sepsis-model-faces-scrutiny.html#:~:text=Epic's%20model%20is%20used%20to,timely%20than%20other%20sepsis%20tools.>

Case Analysis



- Imagine that you work now or will work for Epic Systems and need to make management decisions.
- What are the skills needed for a new job at Epic?
<https://careers.epic.com/Jobs>
- If you were a product manager for Epic Systems, how would you determine which medical conditions for which to develop predictive analytics?
- How do you make sure that the alerts do not become noise? In other words, how do the alerts have a high degree of predictability so that physicians and nurses act on the information?
- How does the product manager ensure quality for the tools? How does the product manager improve the product?
- Where else in their EMR would you explore using AI?

Next session

- Following week:
 - Guest speaker
 - Health accelerators, think tanks, sand boxes in digital health