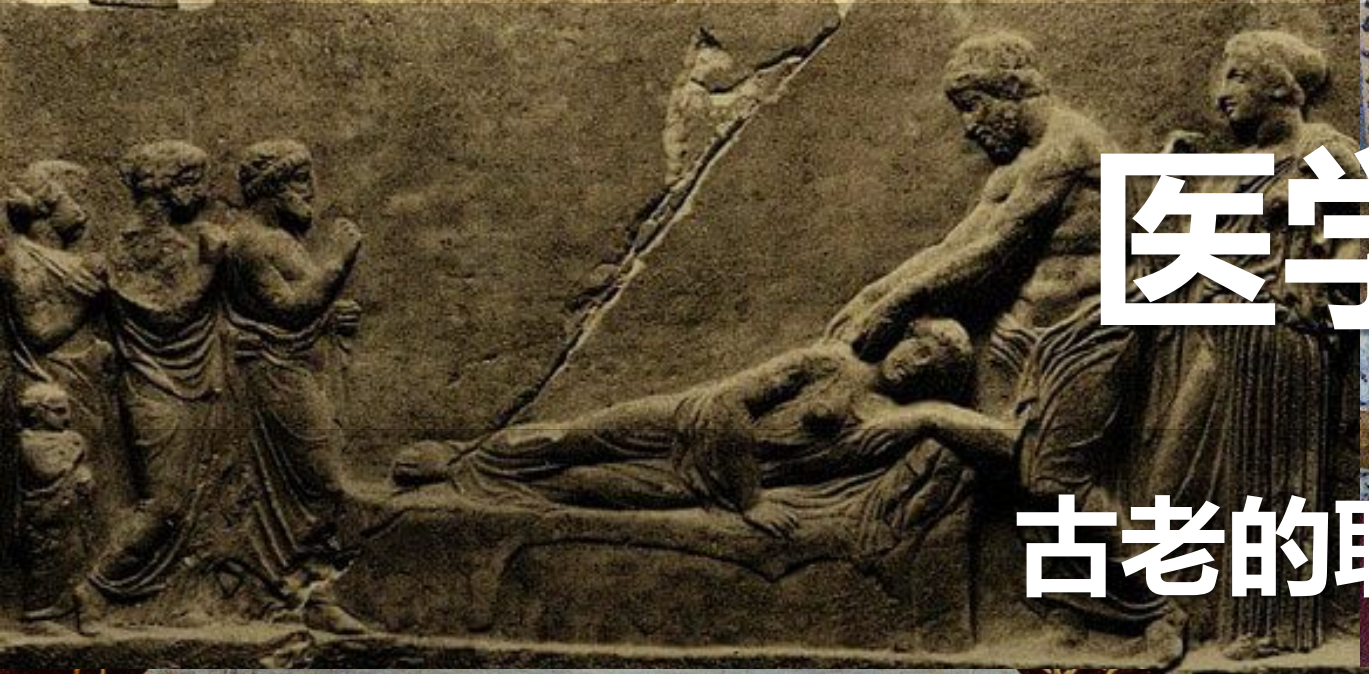
AI在心血管内科与高血压应用中的机遇和挑战

- 临床医师
- 学术导师
- 临床研究人员

George Stergiou: 医学博士、哲学博士、皇家内科医师学会院士
内科与高血压教授
国际高血压学会主席

International Society of Hypertension



医学

古老的职业

从魔法到观察

艺术与科学

持续转型

AI医学

专业医疗人员

责任重

期望高

医学+技术+试验（如何运作？）

知晓/了解“个体”的反应

必须应用最新知识

不可出现任何纰漏！

如今的要求愈加严格！

- **期望过高**
- **可靠—与时俱进—高效**
- 患者**的安全与**健康**改善**
- **责任**/敏感度（数据保护）

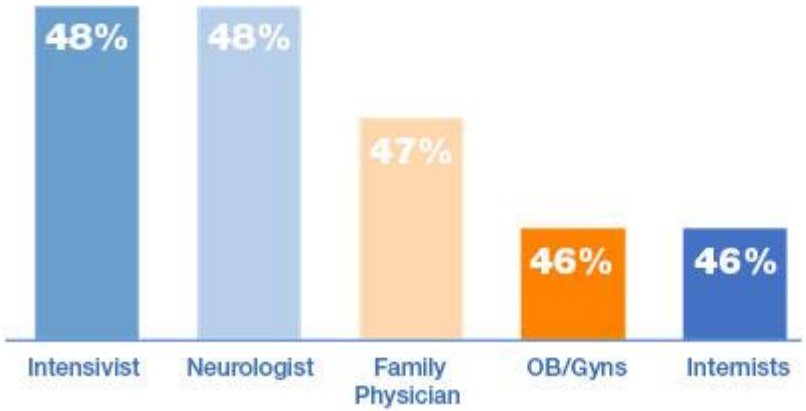
- **更多患者**（更大规模的老年人口）
- **生活方式/肥胖**引发的疾病
- 更多看似**健康**的人
- **复杂处方**（更多药物、科技、信息、电子健康记录）
- 没有哪个医疗系统配备了**足够多的医生**
- **医生的职业倦怠！**

Physician Burnout and Depr

42%
of physicians report burnout

15%
of physicians report depressio

38%
of male physicians experience burnout



Source: Medscape National Physician Burnout & Depression Report 2018, www.medscape.com

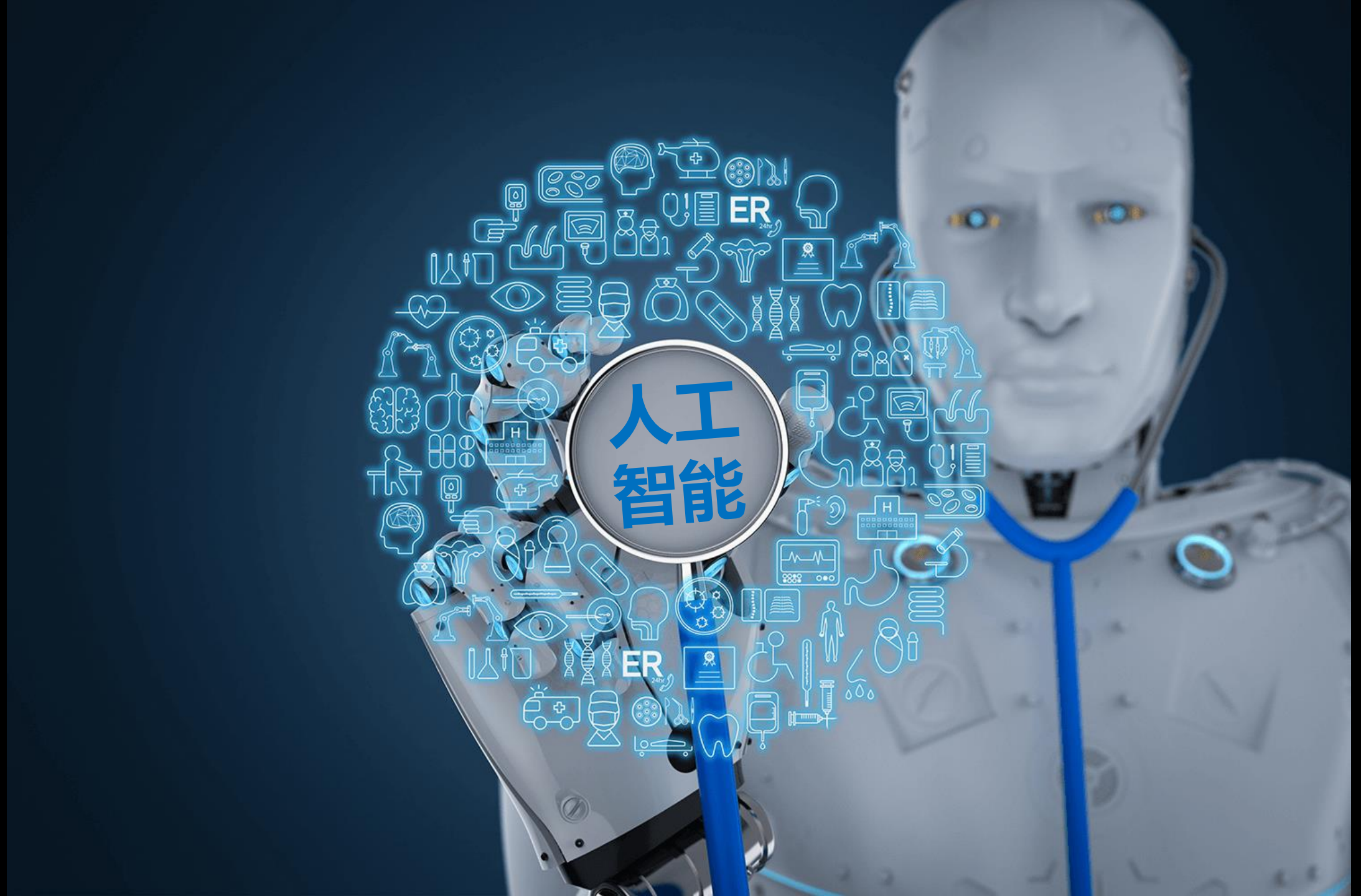
What Are the Most Common Causes of Physician Burnout?

While physician burnout often affects front-line specialties, its primary causes are present to some degree in nearly all medical practices.

- Loss of autonomy or too much micromanaging
- Excessive focus on data over patient care
- Too many government, insurance, and hospital rules
- More punishments than rewards
- Sense of powerlessness
- Complicated electronic health records

与病人交谈的时间有限！

Source: *Texas Heart Institute Journal*


人工
智能
ER
ER

National Library of Medicine
National Center for Biotechnology Information

2025年3月1日

Log in

PubMed®

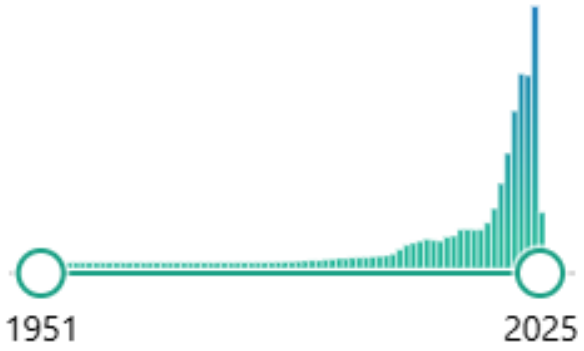
artificial intelligence

Search

Advanced Create alert Create RSS User Guide

Save Email Send to Sort by: Most recent Display options

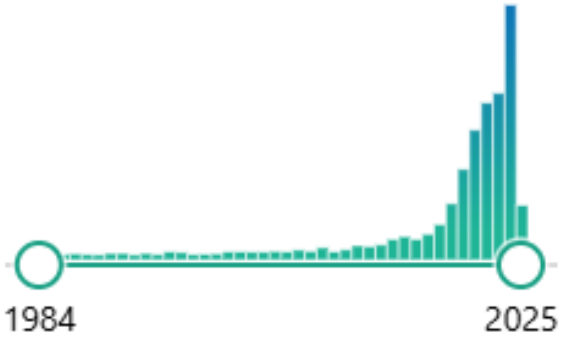
280,821 results



2025年1月至2月
11,633
190/日

2,395 results

artificial intelligence hypertension



2025年1月至2月
135
2/日

ABOUT

JAMA+ AI

The JAMA Network home for the latest advances in the application of artificial intelligence in medicine – from clinical practice to research and education.

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Roy Perlis, MD, MSc

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Clinical Review & Education

JAMA | Special Communication | AI IN MEDICINE

Will Generative Artificial Intelligence Deliver on Its Promise in Health Care?

Robert M. Wachter, MD; Erik Brynjolfsson, PhD

JAMA 2024;331(1):65-69.

办公室里的AI
临床医生是否已经准备好了？

- 无论临床医生是否准备好了，**AI都已经在医务办公室里得到了应用！**
- AI能够让治疗**更准确、更高效、更经济实惠。**
- 但也有**可能会造成伤害……**

- **黑匣子**现象
- **有偏数据**（性别、种族、历史原因、其他）
- **透明度和可解读性**（信任）
- **监督——审计**（FDA）

Ragan K. https://www.medscape.com/viewarticle/992057_print, 2023

AI在医疗中能够并且应该**起到什么作用?**

能力结合：医生+AI

→ 更准确的诊断

→ 更有效的治疗

假设!

可能证明有误

越来越多的研究表明,

AI的表现超过了医生!

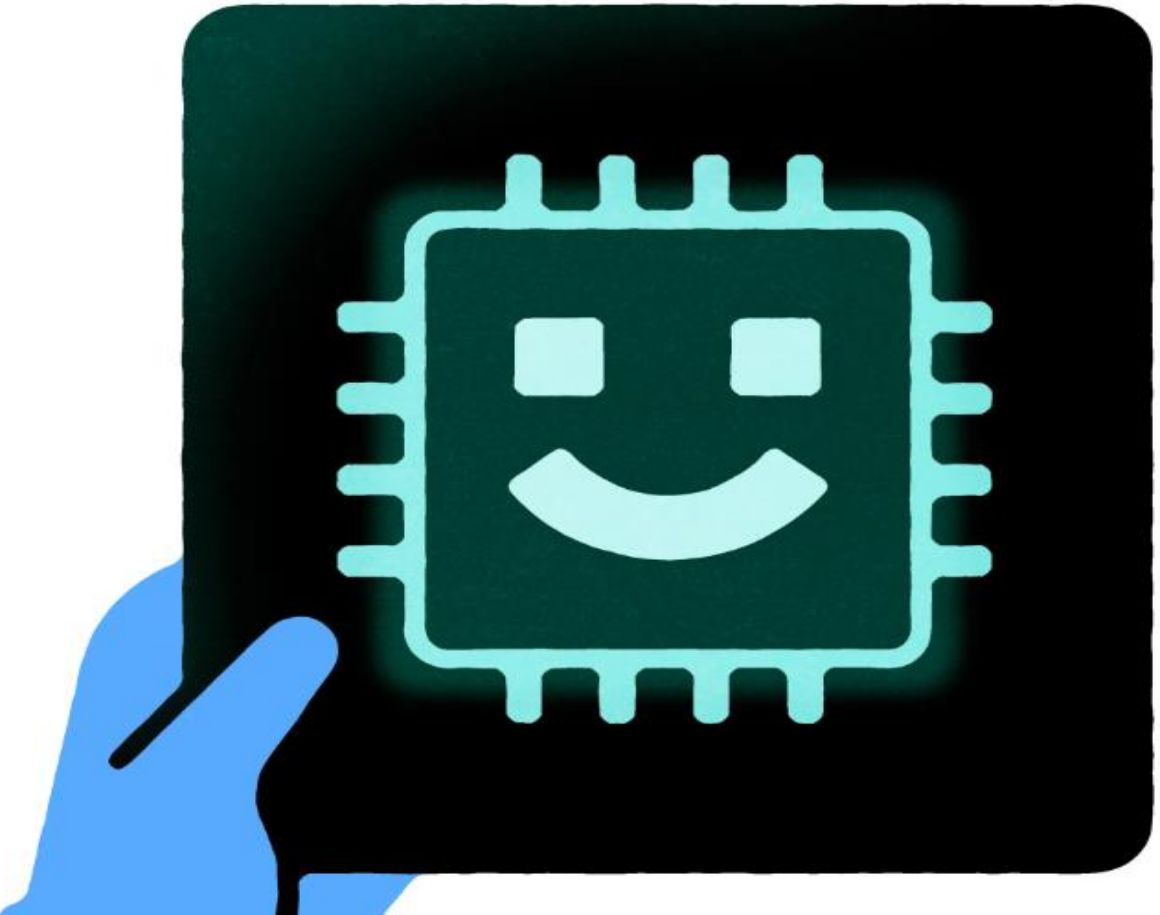
E Topol, P Rajpurkar. 2025年2月4日

The New York Times

OPINION
GUEST ESSAY

The Robot Doctor Will See You Now

Feb. 2, 2025



医学的未来！

最佳合作模式

了解优势和局限性

- *AI该做什么？*
- *人类该做什么？*
- *能从合作中得到什么？*

以*真正*有利于患者治疗的方式

协调协作

E Topol, P Rajpurkar. 2025年2月4日

AI的医学应用：为临床医生解读AI

A Incorporation of artificial intelligence (AI) into clinical practice

CLINICAL INDICATIONS	EXAMPLES OF AI
Interaction with patient	Ambient voice dictation, scheduling, electronic health record inbox tools
Risk stratification (precision medicine)	Patient risk assessment tools
Diagnosis	Analysis of clinical data or imaging (eg, echocardiography)
Interpretation of laboratory results	Analysis and description of test results
Eliciting patient preferences or behavioral changes	Conversational chatbot
Procedures	Surgical assistance
Prescribing medication	Drug interaction assessment
Patient or population monitoring	Glucose monitoring, population-at-risk monitoring
Research and learning	Research participant identification and engagement
Continuing education and training	Virtual reality case simulation

B Development of clinical AI analogous to pharmacotherapies

	DRUG DEVELOPMENT	AI DEVELOPMENT
Phase 1	Pharmacokinetics and pharmacodynamics studies	Model development: Testing on large retrospective dataset
Phase 2	Collection of safety data and efficacy signals	Silent mode evaluation: Prospective performance evaluation in the clinical environment without notification to clinical teams
Phase 3	Clinical trial with outcomes assessment	Clinical deployment: AI prospectively implemented with measurement of downstream care and outcomes (consider randomized clinical trial [RCT] design for high-risk clinical indication)
Phase 4	Real-world use (postmarket registry of use in practice)	Monitoring and assurance network: Deployment in multiple environments with local monitoring of performance and outcomes

Patel MR等人，JAMA，2024年10月


Software
as a Medical Device

为临床医生解读AI

Patel MR等人，JAMA，2024年10月

SIZE OF TREATMENT EFFECT

Class I	Class IIa	Class IIb	Class III
Benefit >>> risk	Benefit >> risk	Benefit ≥ risk	No benefit or harm
Should be performed	*Reasonable to perform*	*May be considered*	*Should not be performed*

LEVEL OF EVIDENCE

Level A	Level B	Level C
Multiple populations	Limited populations	Very limited data
Data derived from multiple RCTs or meta-analyses	*Data derived from a single RCT or nonrandomized studies*	*Expert consensus of opinion, case studies, or standard of care*

重新聚焦AI技术发展

更贴近临床医生/患者理解的**健康目标**

否则，AI技术的使用将**难以获得足够的信任**

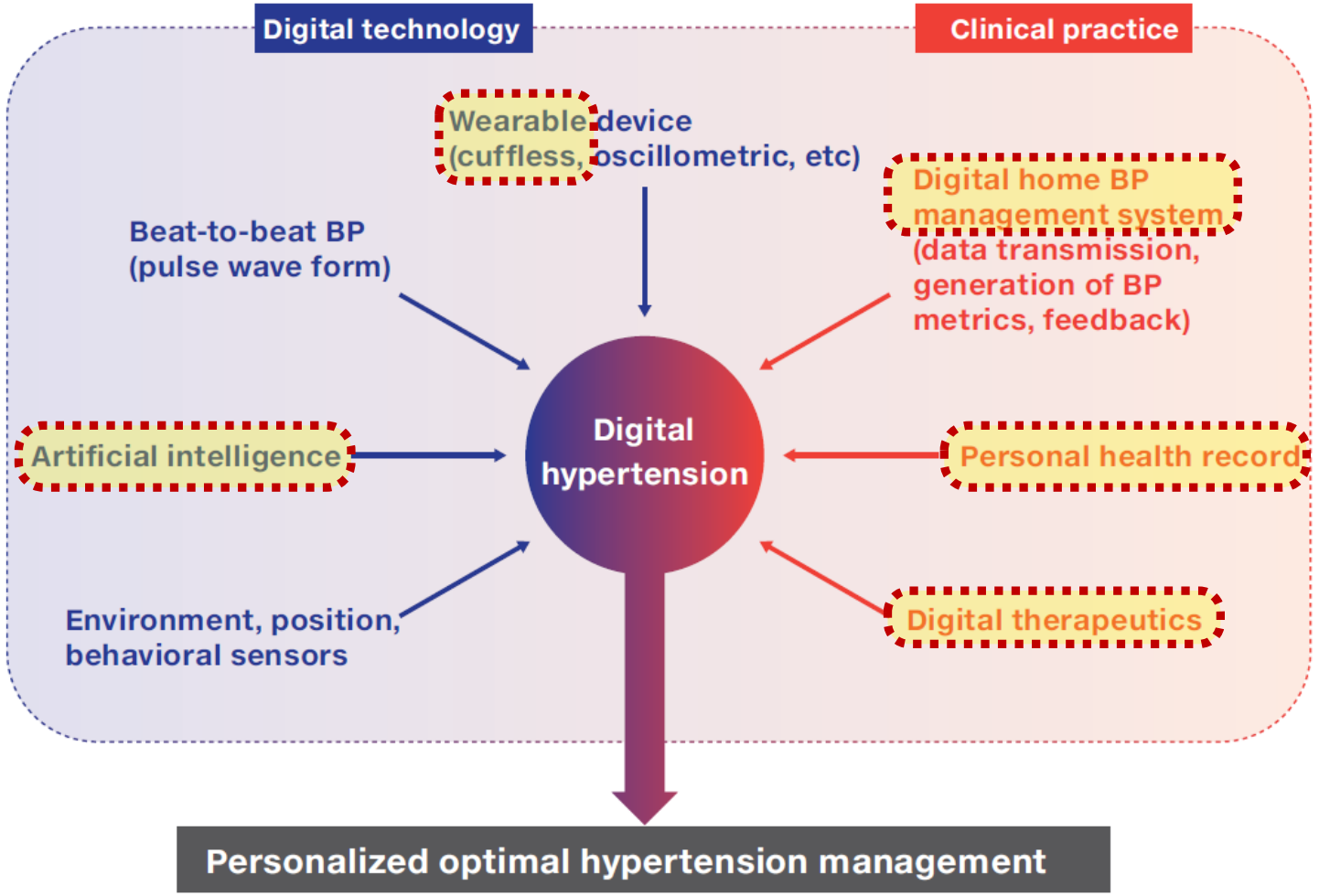
AI在高血压管理中的应用：
王牌在手

	Applications	Benefits
Measuring BP	Estimate BP by analyzing PPG signal with ML and DL algorithms.	Self-monitoring BP for hypertension
Predicting AH development	Predict the risk of developing AH by using genetics, medical data, and behavioral, environmental, and socioeconomic factors.	Timely intervention
Diagnosing AH	Accurately diagnosing AH by using CV risk factors, anthropometric data, vital signs, and laboratory data.	Precision diagnosis
Predicting AH treatment success	Identify factors contributing to treatment success.	Personalized treatment plan
Predicting AH prognosis	Stratify patients and predict CV outcomes.	Treatment plan adjustment

Visco V等人，*J Cardiovasc Dev Dis.* 2023年，10,74.

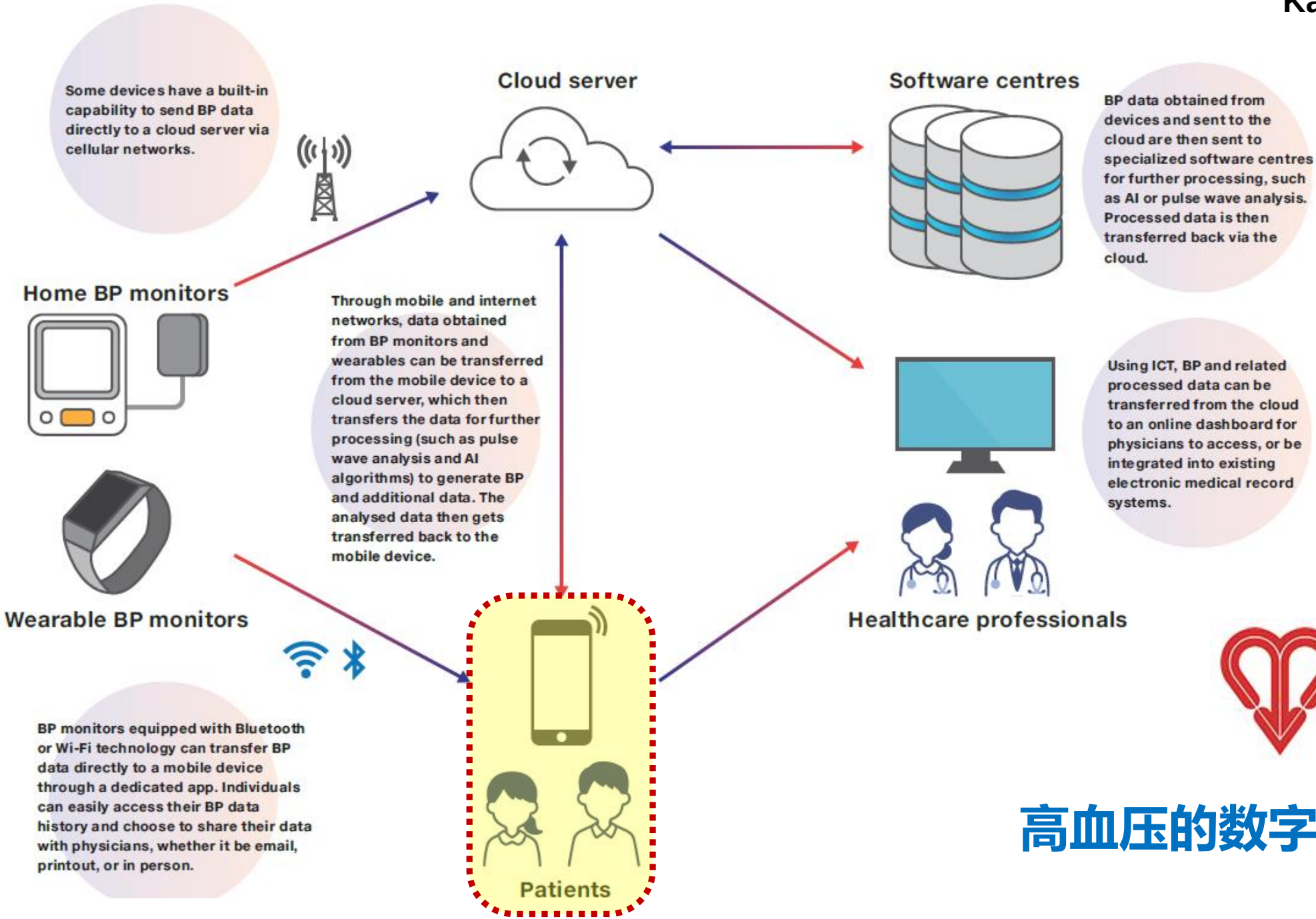
International Society of Hypertension

血压测量与报告技术的创新



Kario K, …. , Stergiou G. *J Hypertens.* 2024年11月, 42:1874-88.

Kario K,…., Stergiou G
J Hypertens
2024年11月



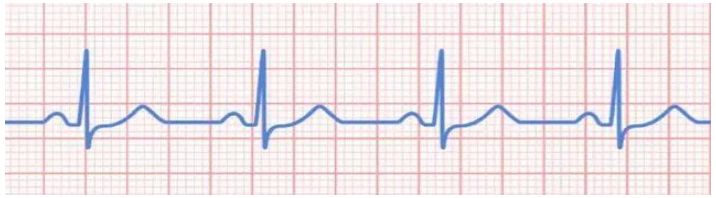
International Society of Hypertension

高血压的数字化干预与技术

JAMA Cardiology | Original Investigation

Sau A等人. *JAMA Cardiol.* 2025年1月

Artificial Intelligence–Enhanced Electrocardiography for Prediction of Incident Hypertension

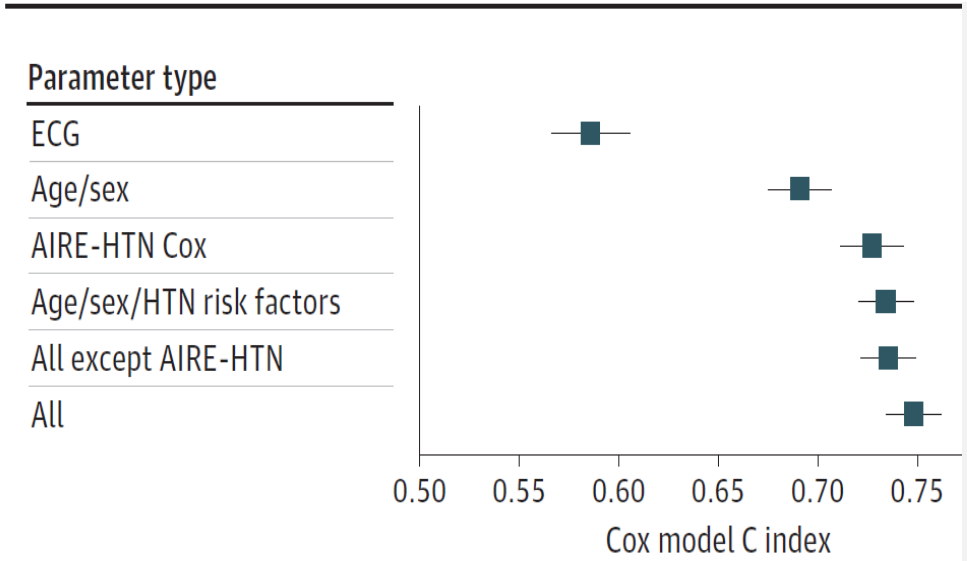


AI-心电图风险评估器 **预测新发高血压**对根据结果划分**风险**

AI-心电图模型的训练：
超过100万次心电图
(19万名患者)

- ✓ **可预测**新发高血压
- ✓ **可识别**存在风险的患者

Figure 2. Cox Models for Prediction of Incident Hypertension



- ✓ **超越传统的**临床风险因素
- ✓ 在无**左室肥厚（LVH）**的情况下，表现良好且**心电图为“正常”**

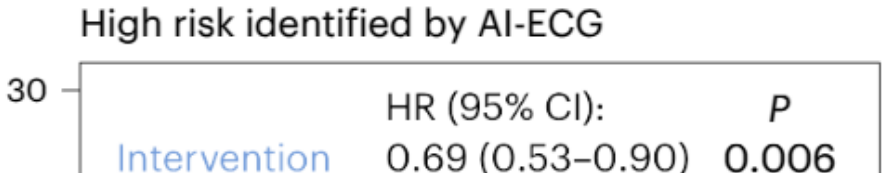
AI直通医生：24小时心电图报告

针对危及生命的心律失常：假阴性大大减少，假阳性略有增加

AI分析报告直发医生：可以降低**成本**，进而改善**信息获取和治疗结果**

Johnson LS等人. *Nat Med*，2025年2月10日

基于AI的心电图预警与全因死亡率



检测人类可能忽视的东西……

病情恶化的早期症状往往难以识别

Lin CH等人. *Nat Med*，2024年;30:1461-70.

NHLBI研讨会
2023年3月29日至30日

National Heart, Lung, and Blood Institute

目的 ➔ 评估AI技术在改善高血压诊断/管理方面的潜力

最终目标 ➔ 识别重要的研究问题、障碍和机会

Transforming Hypertension Diagnosis and Management in The Era of Artificial Intelligence: A 2023 National Heart, Lung, and Blood Institute (NHLBI) Workshop Report

Daichi Shimbo, Rashmee U. Shah, Marwah Abdalla, Ritu Agarwal, Faraz S. Ahmad, Gabriel Anaya, Zachi I. Attia, Sheana Bull, Alexander R. Chang, Yvonne Commodore-Mensah, Keith Ferdinand, Kensaku Kawamoto, Rohan Khera, Jane Leopold, James Luo, Sonya Makhni, Bobak J. Mortazavi, Young S. Oh, Lucia C. Savage, Erica S. Spatz, George Stergiou, Mintu P. Turakhia, Paul K. Whelton, Clyde W. Yancy, Erin Iturriaga

Hypertension；2025年1月；82：36-45

Transforming Hypertension Diagnosis and Management in The Era of Artificial Intelligence: A 2023 National Heart, Lung, and Blood Institute (NHLBI) Workshop Report

- ✓ **隐私和安全原则**
- ✓ **高优先级和交叉研究问题**
- ✓ **AI使用的研究障碍**
- ✓ **高优先级机会点**

National Heart, Lung, and Blood Institute

Hypertension；2025年1月；82：36-45

Medical News & Perspectives | AI IN MEDICINE

Study Finds People Prefer AI Over Clinician Responses to Questions in the Electronic Medical Record

JAMA Network Open™

Research Letter | Health Informatics

Perspectives on Artificial Intelligence–Generated Responses to Patient Messages

Jiyeong Kim, PhD, MPH; Michael L. Chen, BA; Shawheen J. Rezaei, MPhil; April S. Liang, MD; Susan M. Seav, MD; Sonia Onyeka, MD; Julie J. Lee, MD, MPH; Shivam C. Vedak, MD, MBA; David Mui, MD, MBA; Rayhan A. Lal, MD; Michael A. Pfeffer, MD; Christopher Sharp, MD; Natalie M. Pageler, MD, MEd; Steven M. Asch, MD, MPH; Eleni Linos, MD, DrPH

***JAMA Network Open* 2024年；7(10):e2438535**

Study Finds People Prefer AI Over Clinician Responses to Questions in the Electronic Medical Record

Division	AI[a]					Clinicians				
	Assessments, No.	Satisfaction estimate (SE)[b]	No. of characters, mean (SD)	Satisfaction and the length of response		Assessments, No.	Satisfaction estimate (SE)[b]	No. of characters, mean (SD)	Satisfaction and the length of response	
				Standardized β[c]	*P* value				Standardized β[c]	*P* value
Overall	213	3.96 (0.09)	1470.77 (391.83)	0.10	.16	195	3.05 (0.09)	254.37 (198.85)	0.23	.002
Cardiovascular	78	4.09 (0.14)	1559.04 (424.83)	0.068	.58	75	3.25 (0.14)	306.36 (221.09)	0.29	.02
Internal medicine	87	3.82 (0.13)	1314.72 (347.11)	0.037	.72	78	2.94 (0.14)	146.31 (109.43)	0.0056	.96
Endocrinology	48	4.00 (0.19)	1610.19 (330.87)	0.25	.08	42	2.90 (0.20)	362.21 (200.79)	0.31	.09

JAMA Network Open 2024年；7(10):e2438535

Medical News & Perspectives | AI IN MEDICINE

Study Finds People Prefer AI Over Clinician Responses to Questions in the Electronic Medical Record

- 可以提高临床团队的效率——减轻医生的职业倦怠
- 实现患者和医生的双赢 → 效率
- AI提供更详细/更长的回答
- AI的回答在同理心方面得到了高度评价！

Eleni Linos
斯坦福数字健康中心

✓ 不断提升（每年）
✓ 医疗保健快速转型

- 任何医疗失误都能让研究停滞！
- 是否有副作用？是否有并发症？是否有负面影响？

Watch: AI robot attacks' participant at Chinese festival

At a Chinese festival, AI robot moved toward the crowd, causing panic. Security intervened amid malfunction concerns

Terrifying scenes unfolded at a festival in **China** when a **robot lost control and began attacking attendees**. It was powered by artificial intelligence, something the organisers have described as **"a simple robot failure"**.


Software
as a Medical Device

FROM THE HEART

AI IN CARDIOLOGY

Echoes of Concern—AI and Moral Agency in Medicine

医学变革正在我们眼前发生
快速增加的诊断/治疗技术力量

医生将从技术中获益，但仍应秉持同样**深切的个人责任来为患者服务**

当我们自己生病时，我们希望有人关心，就像我们关心托付给我们照顾的人一样

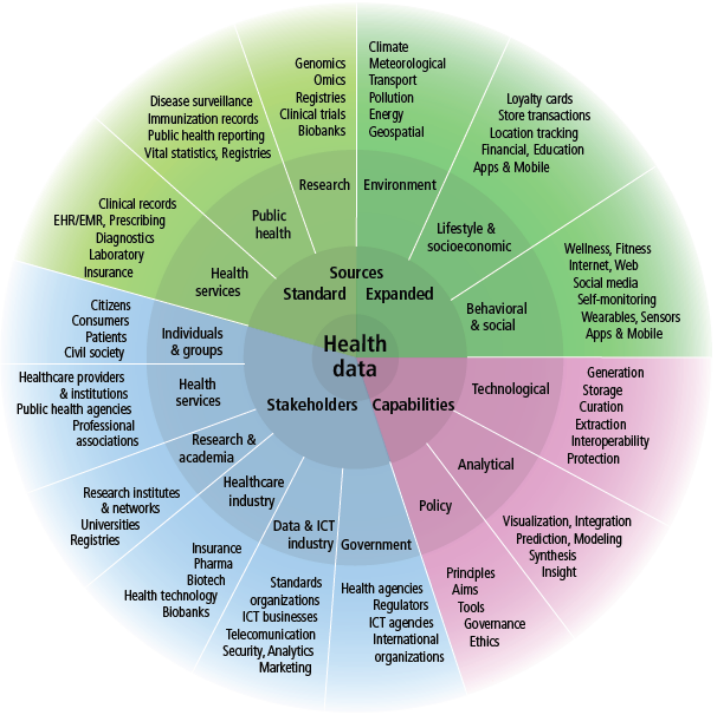
Hull SC, Fins JJ. JAMA Cardiol，2024年11月

“It is much more important to know what sort of a patient has a disease than what sort of a disease a patient has.”

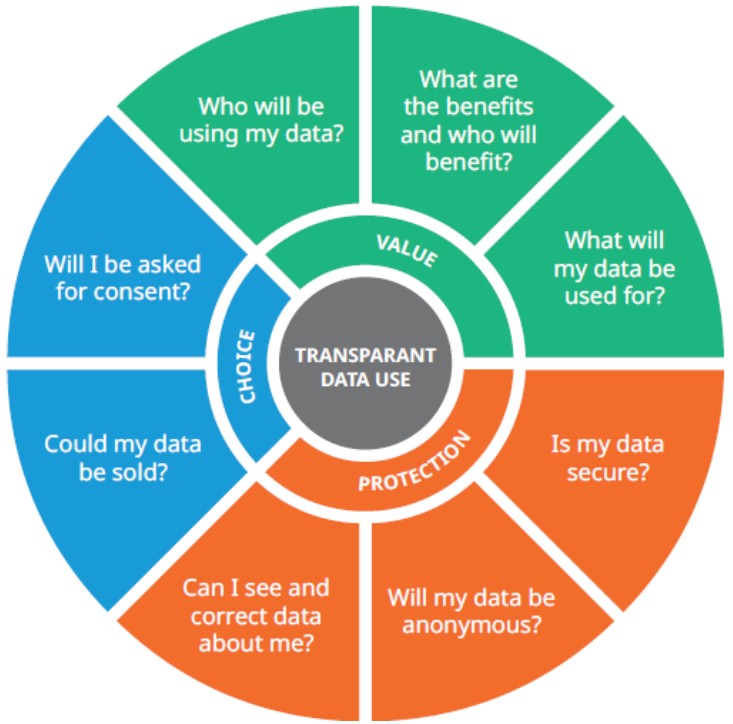
– William Osler

1849–1919

健康数据生态



透明数据使用的要素



World Health Organization

16 May 2023

WHO calls for safe and ethical AI for health

世界卫生组织对AI的潜力非常感兴趣，
但呼吁人们将AI应用于医疗保健时保持谨慎

- **目前的担忧包括如何使用AI**以更好地获取健康信息，如何将其作为决策支持工具以改善诊断

- **用于训练AI的数据可能存在偏差**
  生成不准确/误导性信息
  模型可能被滥用以生成虚假信息

Robert Harrington敦促要小心那些利用AI”干坏事的人“

Cornell University

这一切都取决于

- ***可靠数据***
- ***可靠信息***

（有意义信息）

Robert Harrington
威尔康奈尔医学院院长
和医疗事务的教务长
康奈尔大学

2025年2月

JAMA | Special Communication | AI IN MEDICINE

FDA Perspective on the Regulation of Artificial Intelligence in Health Care and Biomedicine

Haider J. Warraich, MD; Troy Tazbaz, BS; Robert M. Califf, MD

- **FDA将继续在**确保安全、有效、可信赖的AI工具方面**发挥核心作用，**以改善患者和临床医生的生活
- FDA强有力的监督**有助于行业的长期成功；**专注于评估，以提升可帮助改善健康的受监管技术
- 相关实体需要**以严谨的态度对待AI**这一变革性技术的优点

未来取决于现在！

AI医学

“感谢各位朋友的帮助！”

医学工程师

George Stergiou，2025

AI在心血管内科与高血压应用中的机遇和挑战

George Stergiou: 医学博士、哲学博士、皇家内科医师学会院士
内科与高血压教授
国际高血压学会主席

International Society of Hypertension