

7.5a Evaluation of the EHR

10x10 – Introduction to Biomedical Informatics & Artificial Intelligence
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Evaluation of the EHR

Usage – adoption in ambulatory and hospital settings

Outcomes – measures of various outcomes with EHR use

Usage of the EHR

Ambulatory settings – main source is Centers for Disease Control (CDC)

[National Electronic Health Records Survey \(NEHRS\)](#)

- Formerly part of National Ambulatory Medical Care Survey (NAMCS)
- Annual survey of US usage

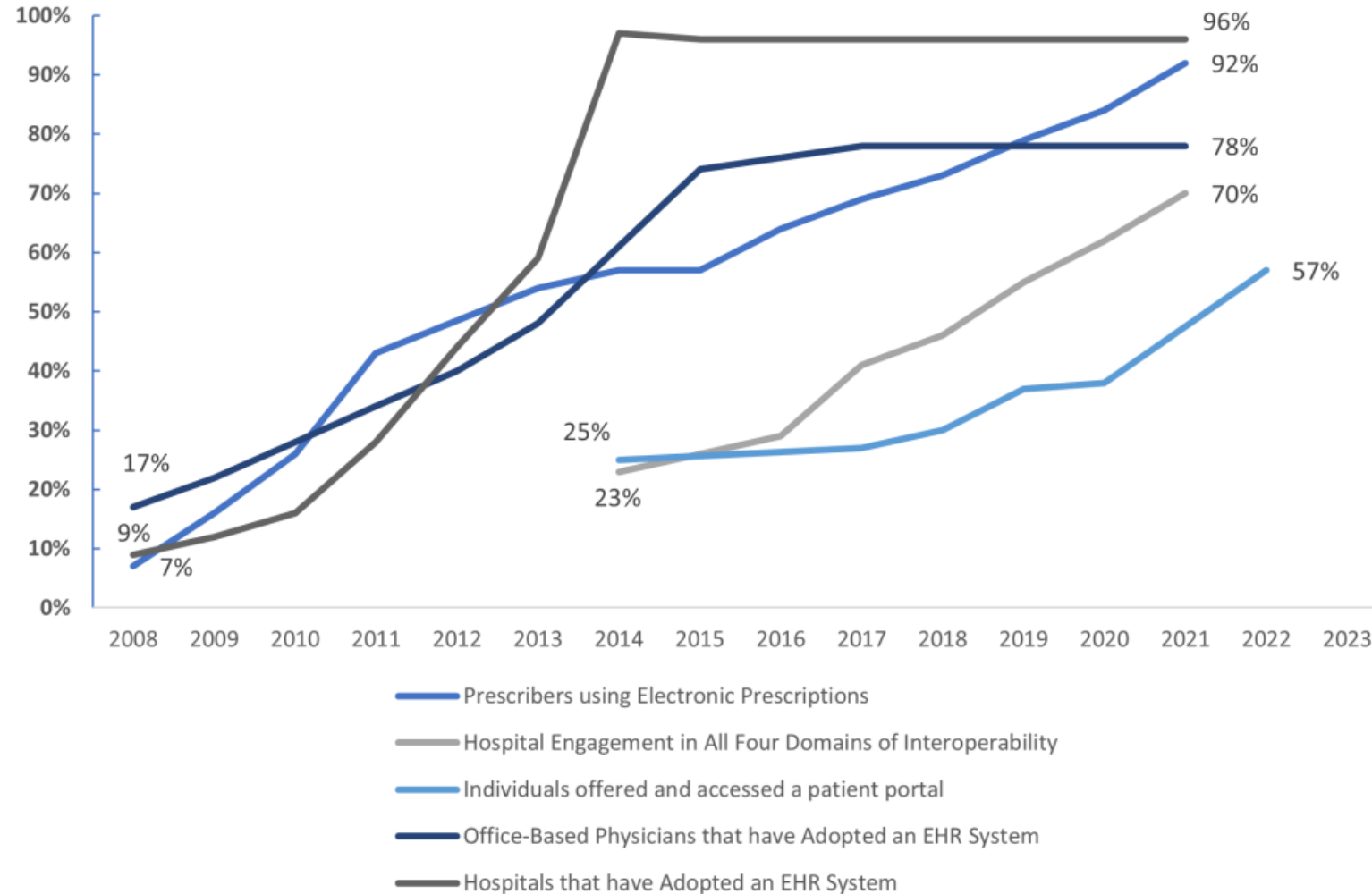
Hospital settings – main source is American Hospital Association (AHA) [IT](#)

[Supplement Survey for hospital EHR adoption](#)

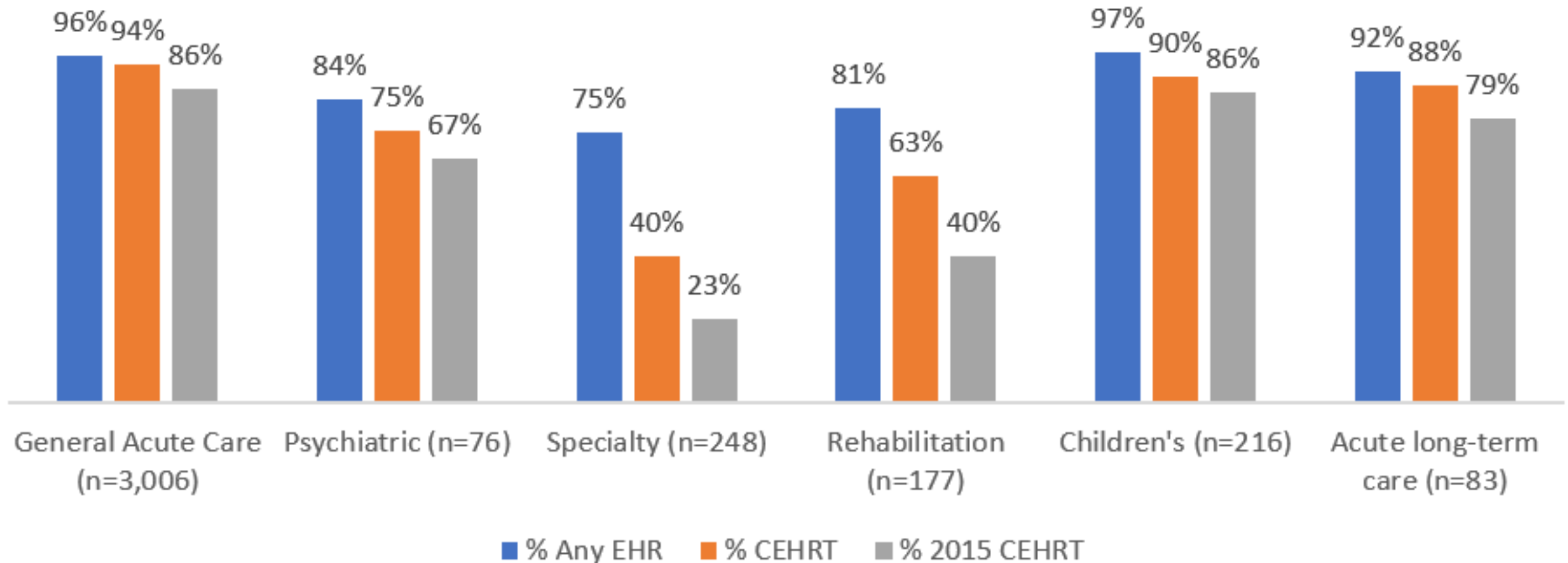
Main aggregator of data is ASTP (formerly ONC)

- [HealthIT.gov Data](#)
 - [Quickstats](#)
 - [Data Briefs](#)

US EHR usage over time (Barker, 2024)



US EHR adoption by hospital type



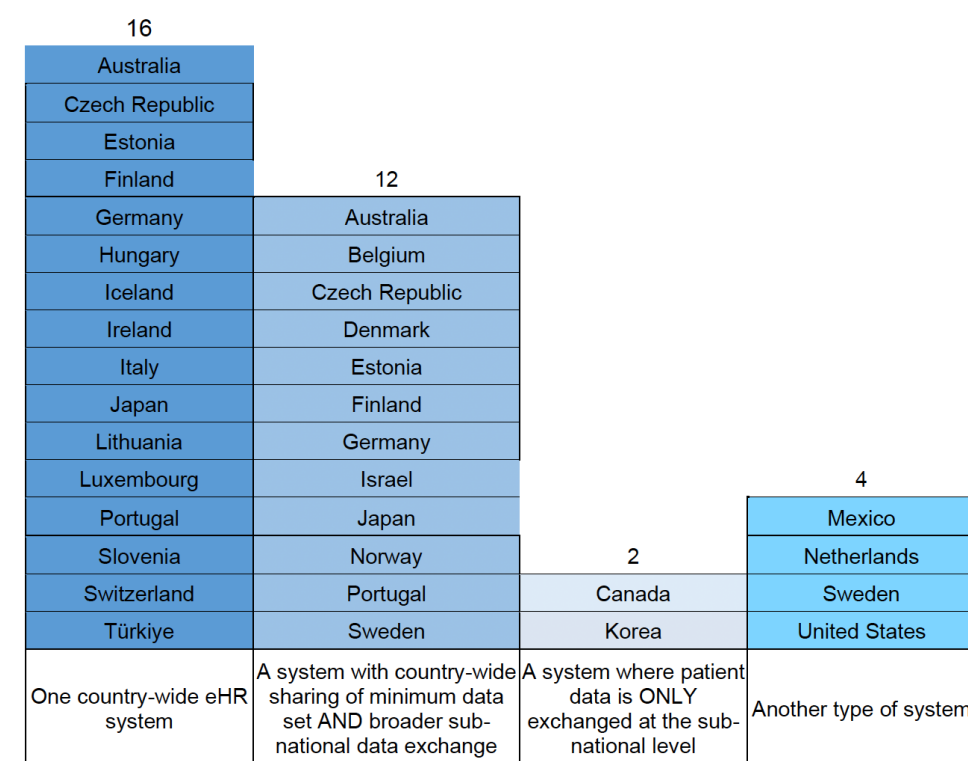
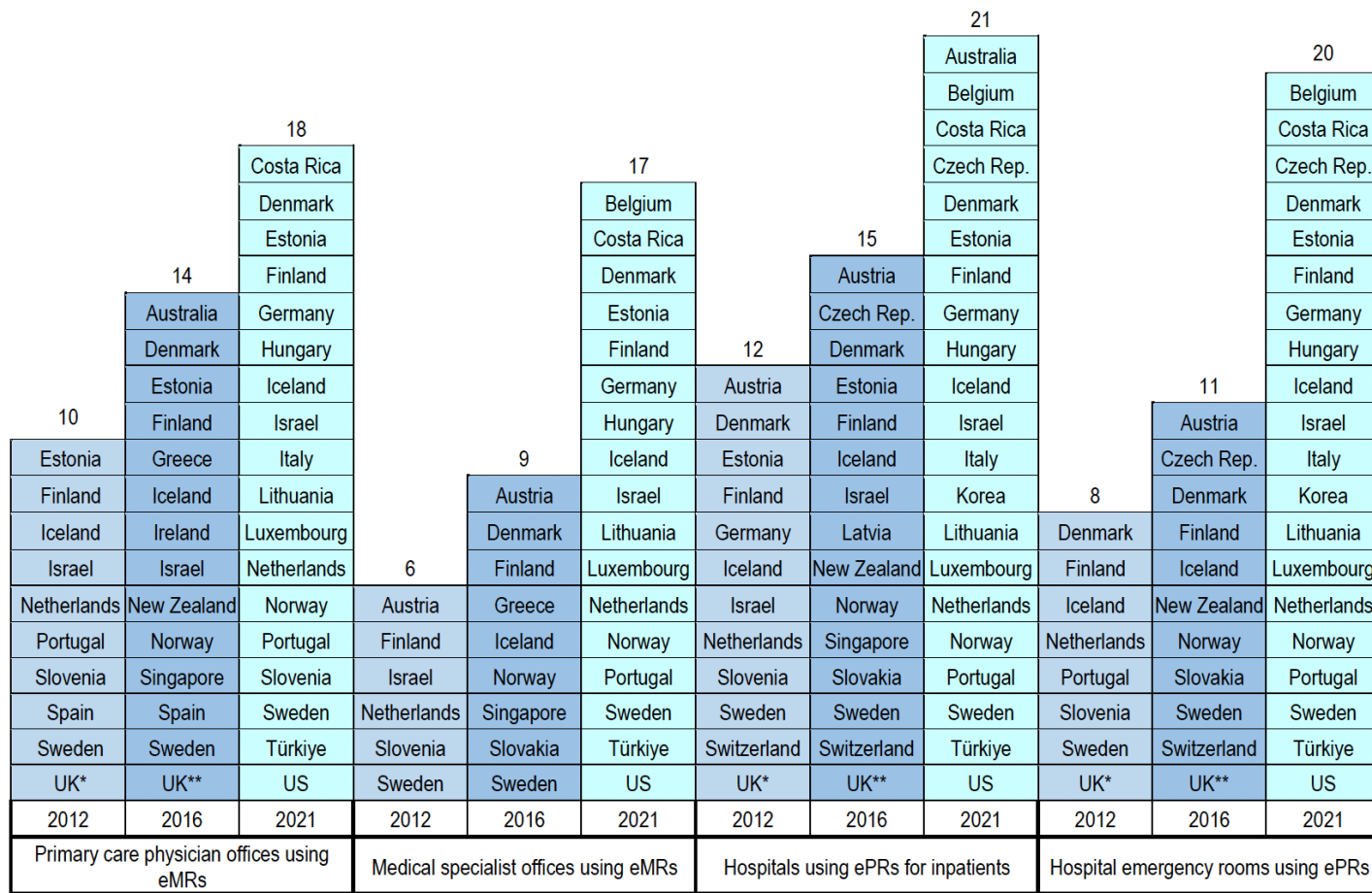
EHR adoption in US hospitals

Usage high in all but slightly lower in smaller, critical access, and/or rural hospitals (Parasrampuria, 2019) – have used EHR to

- Support quality improvement – 82%
- Monitor patient safety – 81%
- Measure organization performance – 77%

Critical access hospitals have also achieved near-complete adoption but lag in advanced use for patient engagement and clinical data analytics (Apathy, 2021)

EHR usage in OECD (Slawomirski, 2024) and Europe (Tornero Costa, 2025)

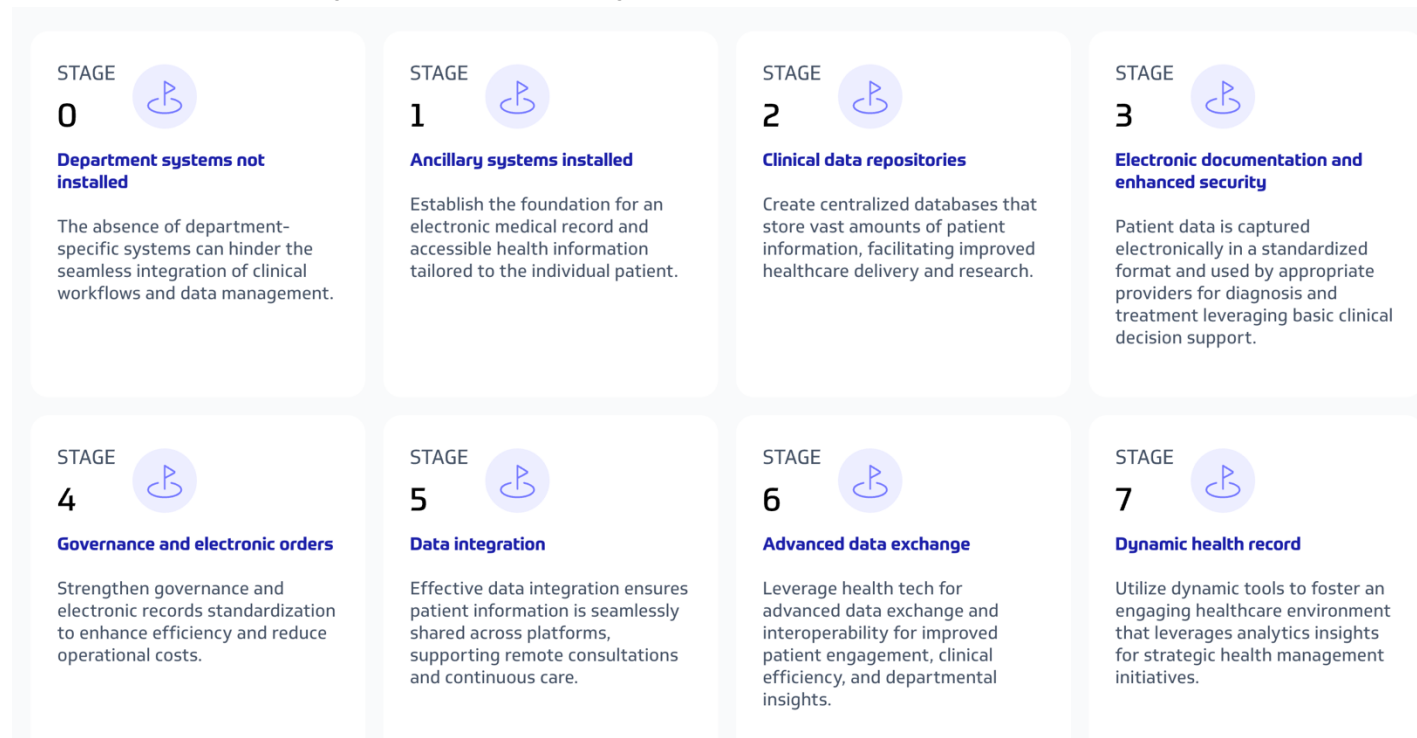


HIMSS Analytics EMRAM

HIMSS Analytics Electronic Medical Record Adoption Model (EMRAM) is most widely cited model for level of adoption

Started with US hospital adoption but has expanded internationally

Only a model; not necessarily a pathway for adoption



Beyond EMRAM

HIMSS Analytics has evolved EMRAM to more “outcomes-focused” approach (Lynn, 2022) and developed “maturity models” for IT functions in organizations

- Analytics Maturity Assessment Model (AMAM)
- Infrastructure Adoption Model (INFRAM)
- Community Care Outcomes Maturity Model (C-COMM)
- Digital Imaging Adoption Model (DIAM)
- Continuity of Care Maturity Model (CCMM)

Digital Health Indicator measures progress toward “digital health ecosystem”

Previous US hospital EMRAM levels

HIMSS [™] EMRAM	EMR Adoption Model Capabilities	U.S. Hospital Count as of March 2020
7	Complete EMR; External HIE; Data Analytics, Governance, Disaster Recovery, Privacy and Security	401
6	Technology Enabled Medication, Blood Products, and Human Milk Administration; Risk Reporting; Full CDS	2,027
5	Physician documentation using structured templates; Intrusion/Device Protection	Stage 0-5: 3,052
4	CPOE with CDS; Nursing and Allied Health Documentation; Basic Business Continuity	
3	Nursing and Allied Health Documentation; eMAR; Role-Based Security	
2	CDR; Internal Interoperability; Basic Security	
1	Ancillaries - Laboratory, Pharmacy, and Radiology/Cardiology information systems; PACS; Digital non-DICOM image management	
0	All three ancillaries not installed	

		2006 Final	2007 Final
Stage 7	Medical record fully electronic; CDO able to contribute to EHR as byproduct of EMR	0.0%	0.0%
Stage 6	Physician documentation (structured templates), full CDSS (variance & compliance), full R-PACS	0.1%	0.8%
Stage 5	Closed loop medication administration	0.5%	1.4%
Stage 4	CPOE, CDSS (clinical protocols)	3.0%	2.2%
Stage 3	Clinical documentation (flow sheets), CDSS (error checking), PACS available outside Radiology	18.0%	25.1%
Stage 2	CDR, CMV, CDSS inference engine, may have Document Imaging	38.8%	37.2%
Stage 1	Ancillaries – Lab, Rad, Pharmacy – All Installed	18.9%	14.0%
Stage 0	All Three Ancillaries Not Installed	20.7%	19.3%

Outcomes of the EHR

Early studies

- Pre-HITECH giving incentive for increased adoption
- Post-HITECH mostly comparing EHR and paper records

Widespread EHR era outcomes

Drilling down

- Usability
- Organizational issues
- Clinician time and efficiency
- Clinician burnout

Using results in reducing EHR burden

Clinical outcomes – early

Successive systematic reviews summarized outcomes of studies of health information technology (HIT) using similar methodology

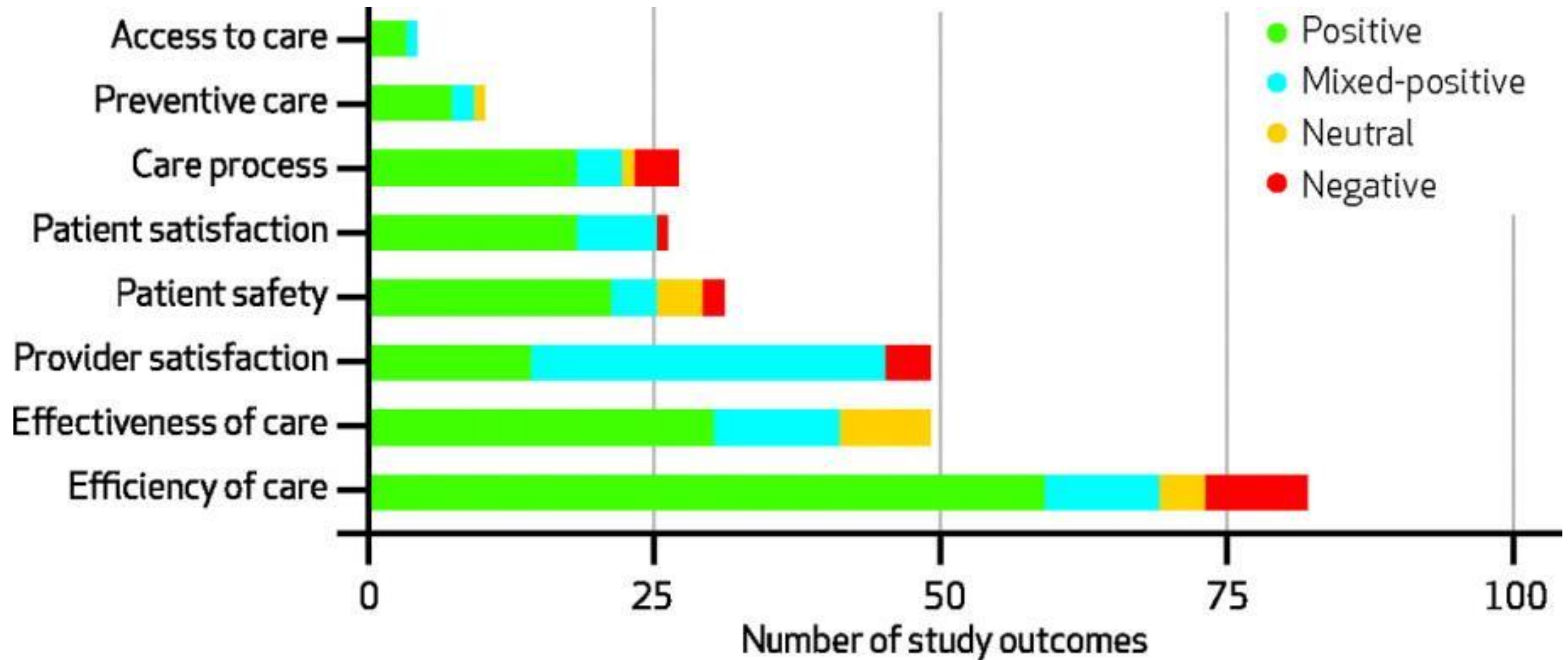
- Chaudhry, 2006 – studies from 1995-2004
- Goldzweig, 2009 – studies from 2004-2007
- Buntin, 2011 – studies from 2007-2010
- Jones, 2014 – studies from 2007-2013 categorized by meaningful use (MU) criteria

Most studies positive, but some concerns, especially for earlier studies – mostly

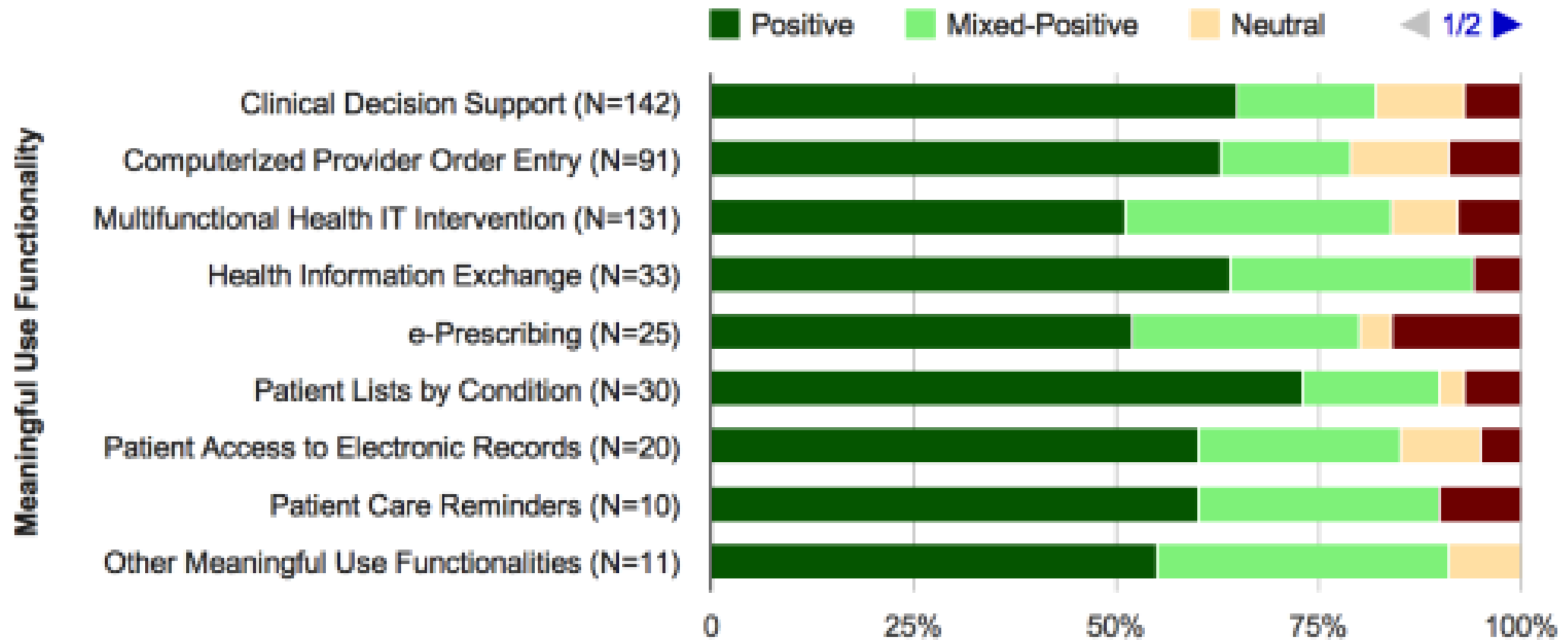
- Home-grown, i.e., non-commercial, systems
- From “health IT leader” institutions
- Evaluation by same team as developers

A concern: publication bias (Vawdrey, 2013)

Outcomes by category (Buntin, 2011)



Studies from 2007-2013 categorized by MU criteria (Jones, 2014)



Early post-HITECH studies comparing EHR and paper records – hospital

National sample of patients treated in hospitals with advanced EHRs cost about 10% less than patients admitted to hospitals without advanced EHRs, after controlling for patient and hospital characteristics (Kazley, 2014)

Lower mortality in hospitals with EHRs, although only after time to mature (Lin, 2018)

Reduced length of stay and readmissions for any use of EHR, not meaningful use (MU) (Wani, 2018)

Hospitals with EHR use showed better outcomes in process measures but not readmission rate or mortality (Yuan, 2019)

No association between EHR use and improved

- Quality measures or clinical outcomes for patients with stroke (Joynt, 2015)
- Quality measures, 30-day mortality, or readmission for patients with congestive heart failure (Selvaraj, 2018)

Early post-HITECH studies – outpatient

EHR use in safety-net clinics associated with lower patient satisfaction (Ratanawongsa, 2015)

Ambulatory EHR use associated with reduced hospital admission for ambulatory care-sensitive conditions but not readmissions (Lammers, 2016)

EHR use associated with reduced Medicare expenditure per beneficiary (Lammers, 2017)

Patients less likely to engage physicians in presence of using EHR (Street, 2018)

Patients perceived physicians as more compassionate and professional and as having better communication skills when computer not used in exam room (Haider, 2018)

More recent studies – outpatient

Increased time spent using EHR associated with improved quality of care – improved control of diabetes and hypertension, higher rate of cancer screening (Rotenstein, 2022)

In academic primary care practices, physicians reported less eye contact, listening, and focusing while patients reported sufficient eye contact, listening, and focusing and overall high satisfaction (Metzler, 2022)

Pediatric academic faculty reported neutral or negative satisfaction with EHR use, but was higher for those with higher EHR skills (Kissel, 2022)

Volume of EHR messages increased with COVID-19 pandemic and remained elevated afterwards; not due to substituting other communication (Holmgren, 2025)



Outcomes from CDS

Systematic review of CDS found reduced medication errors and adverse drug events with moderate- and low-certainty evidence but also unintended consequences of implementation and CDS-related errors (Syrowatka, 2024)

EHR nudges associated with improvements in some areas of healthcare quality, e.g., descriptive and patient-centeredness measures but not other quality areas or in clinical outcomes (Nguyen, 2024)

CDS studies in specific clinical areas

Displaying cost information in alerts led to 1 in 8 medication orders changed after clinicians reviewed price estimates; 1 in 6 changed when potential costs savings were >\$20 (Sinaiko, 2023)

EHR-based alert system for acute heart failure did not lead to higher number of overall guideline-directed medical therapy prescriptions at discharge (Ghazi, 2023)

CDS did not reduce number of inappropriate imaging requests ordered by physicians in 3 German academic hospitals (Dijk, 2025)

Systematic review of CDS in prescribing of empirical antibiotics found reduced use of broad-spectrum antibiotics without harm from untreated organisms (Hatton, 2025)