

# **National Web-Based Teleconference on Findings from Evidence-Based Practice Centers for Health IT**

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**Moderator:**

Rebecca Roper

Agency for Healthcare Research and Quality

**Presenters:**

David Lobach

Ann McKibbin

M. Chris Gibbons



# Enabling Health Care Decision-making Through Clinical Decision Support and Knowledge Management

Prepared by  
The Duke Evidence-based Practice Center

Presented by  
David F. Lobach, MD, PhD, MS

Division of Clinical Informatics  
Department of Community and Family Medicine  
Duke University Medical Center, Durham, North Carolina



# Duke Project Team

Participant	Role on Project
David Lobach, M.D., Ph.D., M.S.	Principal Investigator
Gillian D. Sanders, Ph.D	EPC Director
Tiffani J. Bright, Ph.D.	Lead Investigator
Anthony Wong, M. Tech.	Clinical Investigator
Ravi Dhurjati, Ph.D.	EPC Investigator
Erin Bristow, B.A.	Clinical Investigator
Lori Bastian, M.D., M.S.	Clinical Investigator
Remy Coeytaux, M.D., Ph.D.	EPC Investigator
Gregory Samsa, Ph.D.	Statistician/EPC Investigator
Vic Hasselblad, Ph.D.	Statistician
John W. Williams, M.D., M.H.S.	EPC Investigator
Liz Wing, M.A.	EPC Editor
Michael Musty, B.A.	EPC Project Coordinator
Amy S. Kendrick, R.N., M.S.N.	EPC Project Manager
Connie Schardt, M.S.L.S	Librarian

# Technical Expert Panel

Joan Ash, Ph.D., M.L.S., M.S., M.B.A. Oregon Health & Science University Portland, OR	Blackford Middleton, M.D., M.P.H., M.Sc. Partners Healthcare System, Inc. Wellesley, MA
David W. Bates, M.D., M.Sc. Partners Healthcare System, Inc. Harvard Medical School Boston, MA	Ida Sim, M.D., Ph.D. University of California San Francisco, CA
Eta S. Berner, Ed.D. University of Alabama Birmingham, AL	Dean F. Sittig, Ph.D. University of Texas School of Health Information Sciences Houston, TX
R. Brian Haynes, M.D., M.Sc., Ph.D. McMaster University Hamilton, Ontario, Canada	Paul C. Tang, M.D., M.S. Palo Alto Medical Foundation Los Altos, CA

# Peer Reviewers

Robert Greenes, M.D., Ph.D. Department of Biomedical Informatics Arizona State University Phoenix, AZ	Jerome A. Osheroff, M.D. Clinical Informatics Thomson Reuters
Gil Kuperman, M.D., Ph.D. Director, Interoperability Informatics New York-Presbyterian Hospital New York, NY	David M. Rind, M.D. Division of General Medicine Beth Israel Deaconess Medical Center Boston, MA



## Presentation Overview

- Background
- Methods
- Results
- Implications
- Limitations
- Future Research



# Funding, Context & Disclaimer

## Background

- AHRQ **Contract No. HHS 290-2007-10066-I**
- Duke Evidence-based Practice Center
- Third report of 3-part series focusing on the strategic goals of AHRQ's health information technology portfolio.
- The findings and conclusions in this document are those of the author(s), who are responsible for its content, and do not necessarily represent the views of AHRQ. No statement in this report should be construed as an official position of AHRQ or of the U.S. Department of Health and Human Services.

## Definition of CDSS

- “any electronic system designed to aid directly in clinical decisionmaking, in which characteristics of individual patients are used to generate patient-specific assessments or recommendations that are then presented to clinicians for consideration.” \*

\* Kawamoto K, Houlihan CA, Balas EA, Lobach DF. Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success. *BMJ* 2005;330(7494):765.

## Definition of KMS

- a tool that selectively provides information relevant to the characteristics or circumstances of a clinical situation but which requires human interpretation for direct application to a specific patient.
- Examples:
  - Information retrieval tool
  - Knowledge resource

# Continuum of Decision Support

Background

Types of decision support interventions	Classic clinical decision support	Information retrieval tool	Knowledge resource
Example	Preventive care reminder	Infobutton	Epocrates
Process: Submit patient-specific information	Automated (computer)	Automated (computer)	Manual (human)
Process: Generate patient-specific recommendation	Automated (computer)	Manual (human)	Manual (human)

# Goals & Scope

## Background

- Goals: to summarize the available evidence related to CDSSs and KMSs, highlight the limitations of the evidence, and identify areas for future research.
- **KQ 1:** What evidence-based study designs have been used to determine the clinical effectiveness of electronic knowledge management and CDSSs?
- **KQ 2:** What contextual factors/features influence the effectiveness or success of electronic knowledge management and CDSSs?



# Scope (Cont)

- **KQ 3:** What is the impact of introducing electronic knowledge management and CDSSs?
  - 3a. Changes in the organization of health care delivery
  - 3b. Changes in the workload and efficiency for the user
  - 3c. Changes in health care process measures and clinical outcomes



# Scope (cont)

- **KQ 4:** What generalizable knowledge can be integrated into electronic knowledge management and CDSSs to improve health care quality?
  - 4a. Knowledge from published evidence about electronic knowledge management and CDSSs to improve health care quality based on different types of measures (health care process, relationship-centered, clinical, economic)
  - 4b. How a clinician's expertise/proficiency/informatics competency using the electronic knowledge management and CDSS affects patient outcomes (one type of measure)



# Data Sources

- Peer-reviewed literature databases
  - Cumulative Index to Nursing and Allied Health Literature (CINAHL<sup>®</sup>)
  - Cochrane Database of Systematic Reviews
  - MEDLINE<sup>®</sup> accessed via PubMed<sup>®</sup>
  - PsycINFO<sup>®</sup>
  - Web of Science<sup>®</sup>
- Manual searching of reference lists

# Inclusion Criteria

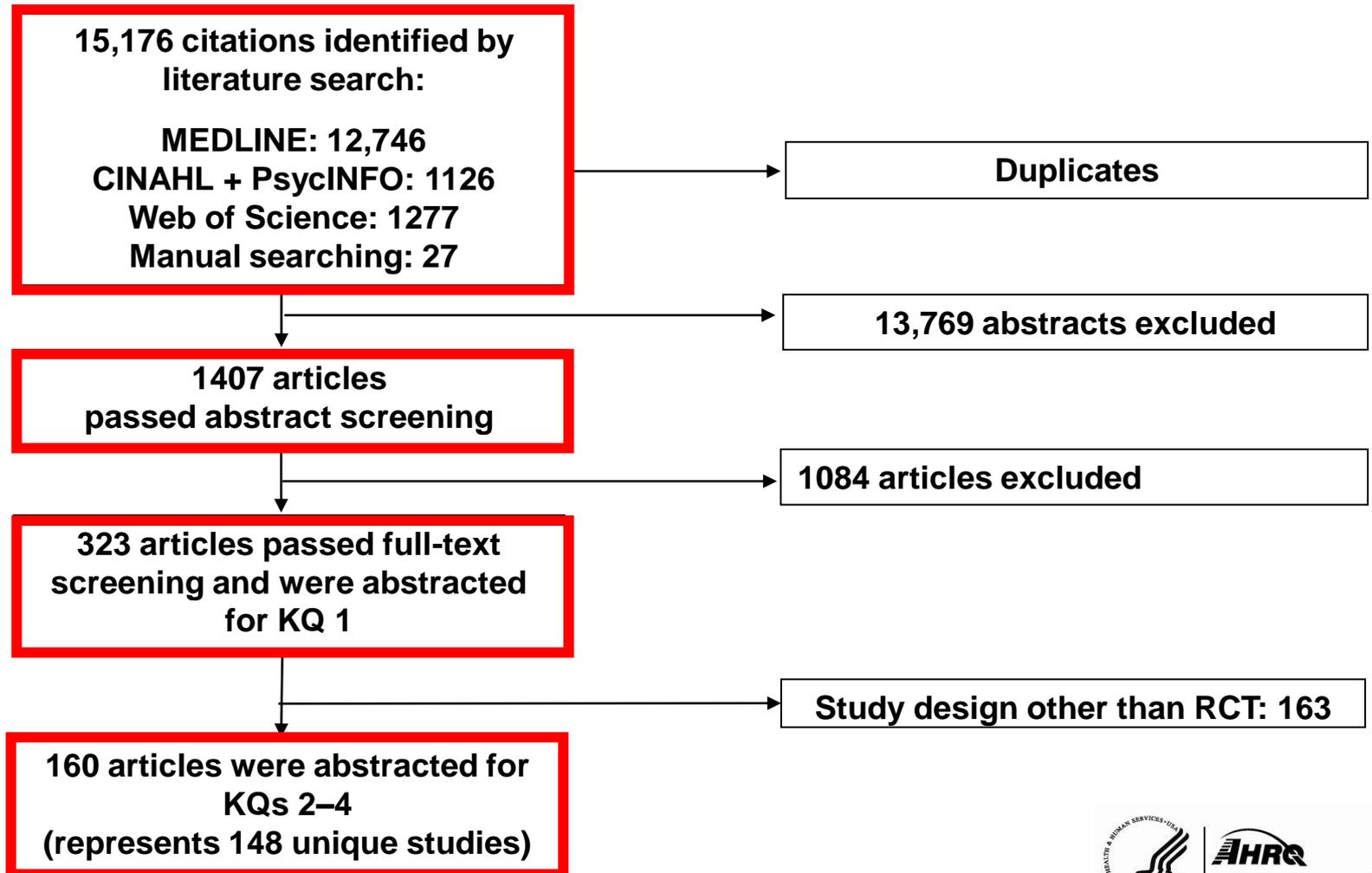
- Electronic CDSS or KMS
- Healthcare provider interaction with system
- Comparator
- Measurable outcomes of interest
- Study design: KQ1: all; KQ2-4: RCTs
- English language

# Exclusion Criteria

- System not used in real clinical setting
- Closed loop systems (no provider)
- Mandatory compliance with recommendations
- Sample size <50

# Literature Search Flow

Methods



# Outcome Categories

Methods

Outcome Category	Examples
Clinical	Length of stay, morbidity, mortality, health-related quality of life, adverse events
Health care process	Adoption/implementation of CDSS/KMS-recommended preventive care/clinical study/treatment, patient adherence to CDSS/KMS recommendation, impact on user knowledge
Health care provider workload, efficiency, and organization	Number of patients seen/unit time, clinician workload, efficiency
Relationship-centered	Patient satisfaction
Economic	Cost, cost-effectiveness
Health care provider use and implementation	User acceptance, satisfaction, and use and implementation of CDSS/KMS

# System Features

Methods

Feature
<b>General System Features</b>
Integration with charting or order entry system to support workflow integration
<b>Clinician-System Interaction Features</b>
Automatic provision of decision support as part of clinician workflow
No need for additional clinician data entry
Request documentation of the reason for not following CDSS recommendations
Provision of decision support at time and location of decisionmaking
Recommendations executed by noting agreement



# System Features (cont)

Feature
<b>Communication Content Features</b>
Provision of a recommendation, not just an assessment
Promotion of action rather than inaction
Justification of decision support via provision of reasoning
Justification of decision support via provision of research evidence*
<b>Auxiliary Features</b>
Local user involvement in development process
Provision of decision support results to patients as well as providers
CDSS accompanied by periodic performance feedback
CDSS accompanied by conventional education

# KQ1: Study Designs for CDSS

- 311 studies were reviewed
  - 148 RCTs (47.5%),
  - 121 quasi-experimental (38.9%)
  - 42 observational studies (13.5%)
- Clinical outcomes: 19.6% of RCTs, 35.5% of quasi-experimental, 40.5% of observational studies
- Health care process measures : 86.5% of RCTs, 75.2% of quasi-experimental, 69% of observational studies



## KQ2: System Features

- Previously identified factors/features\*
  - Automatic provision of decision support as part of clinician workflow
  - Provision of decision support at time and location of decisionmaking
  - Provision of a recommendation, not just an assessment

\* Kawamoto K, Houlihan CA, Balas EA, Lobach DF. Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success. *BMJ* 2005;330(7494):765.



## KQ2: System Features (cont)

- Newly identified factors/features
  - Integration with charting/order entry system
  - No need for additional data entry
  - Promotion of action rather than inaction
  - Justification of decision support via provision of research evidence
  - Local user involvement in the development process
  - Provision of decision support results to patients as well as providers



## KQ3: Impact of CDSS/KMS

- Changes in the organization of health care delivery (3a)
  - Insufficient evidence
- Changes in the workload and efficiency for the user (3b)
  - Insufficient evidence



## KQ3: Impact of CDSS/KMS

- Changes in healthcare process measures (3c)
  - Recommended preventive care service ordered/completed (n=43, 20 good quality)
    - Odds ratio: 1.42 (95% CI 1.27 to 1.58), n= 25
  - Recommended clinical study ordered/ completed (n=29, 16 good quality)
    - Odds ratio:1.72 (95% CI 1.47 to 2.00), n=20
  - Recommended treatment ordered/ prescribed (n=67, 35 good quality)
    - Odds ratio: 1.57 (95% CI 1.35 to 1.82), n=46



## KQ3: Impact of CDSS/KMS

- Changes in clinical outcomes (3c)
  - Length of stay (n=6, 6 good quality)
    - Relative risk: 0.96 (95% CI 0.88 to 1.05), n= 5,
  - Morbidity (n=22, 13 good quality)
    - Relative risk: 0.88 (95% CI 0.80 to 0.96), n=16
  - Mortality (n=7, 6 good quality)
    - Odds ratio: 0.79 (95% CI 0.54 to 1.15), n=6

## KQ3: Impact of CDSS/KMS

- Changes in economic outcomes (3c)
  - Cost (n=22, 10 good quality)
    - Trend toward lower costs and greater cost savings
  - Cost-effectiveness (n=6, 1 good quality)
    - Insufficient



## KQ4: Generalizable Knowledge

- Structured care protocols (61 studies, 41.2%)
- Clinical practice guidelines that focused on a single or limited set of medical conditions (42 studies, 28.4%)

# CDSS Features/Factors

## Implications

- Nine CDSS features/factors associated with effective impact
- General system features, clinician-system interaction features, communication content features, and auxiliary features
- Factors/features were present across the breadth of CDSS implementations in diverse venues using both locally and commercially developed systems



# CDSS/KMS Outcomes

## Implications

- Strong evidence that CDSSs/KMSs favorably impacted health care processes, including facilitating preventive care services, ordering clinical studies, and prescribing treatments
- Effect spanned diverse venues and systems
- Effect now been observed at community sites and with use of commercially developed systems



# Gaps in the Evidence

## Implications

- Effects of clinical decision support on clinical and economic outcomes remains limited
- Limited evidence showing an impact of clinical decision support on clinical workload and efficiency
- Most of the published RCTs on CDSSs focused on a single or limited set of conditions
- Most studies concentrated on decision support delivered to physicians
- Only 3 RCTs on KMSs



## Limitations

- Publication bias
  - No consistent bias for most endpoints
  - Strong bias detected around CDSS promoting adherence to ordering a clinical study
- Heterogeneous literature: systems, populations, settings, outcomes
- Unable to isolate impact of individual features/factors
- Variable level of system detail in manuscripts
- Focused on RCTs

## Future Directions

- CDSSs that simultaneously address a breadth of comorbid conditions
- Approaches to delivering CDSS/KMS content
- Methods for integrating CDSS/KMS into workflow
- CDSS/KMS for non-physician users

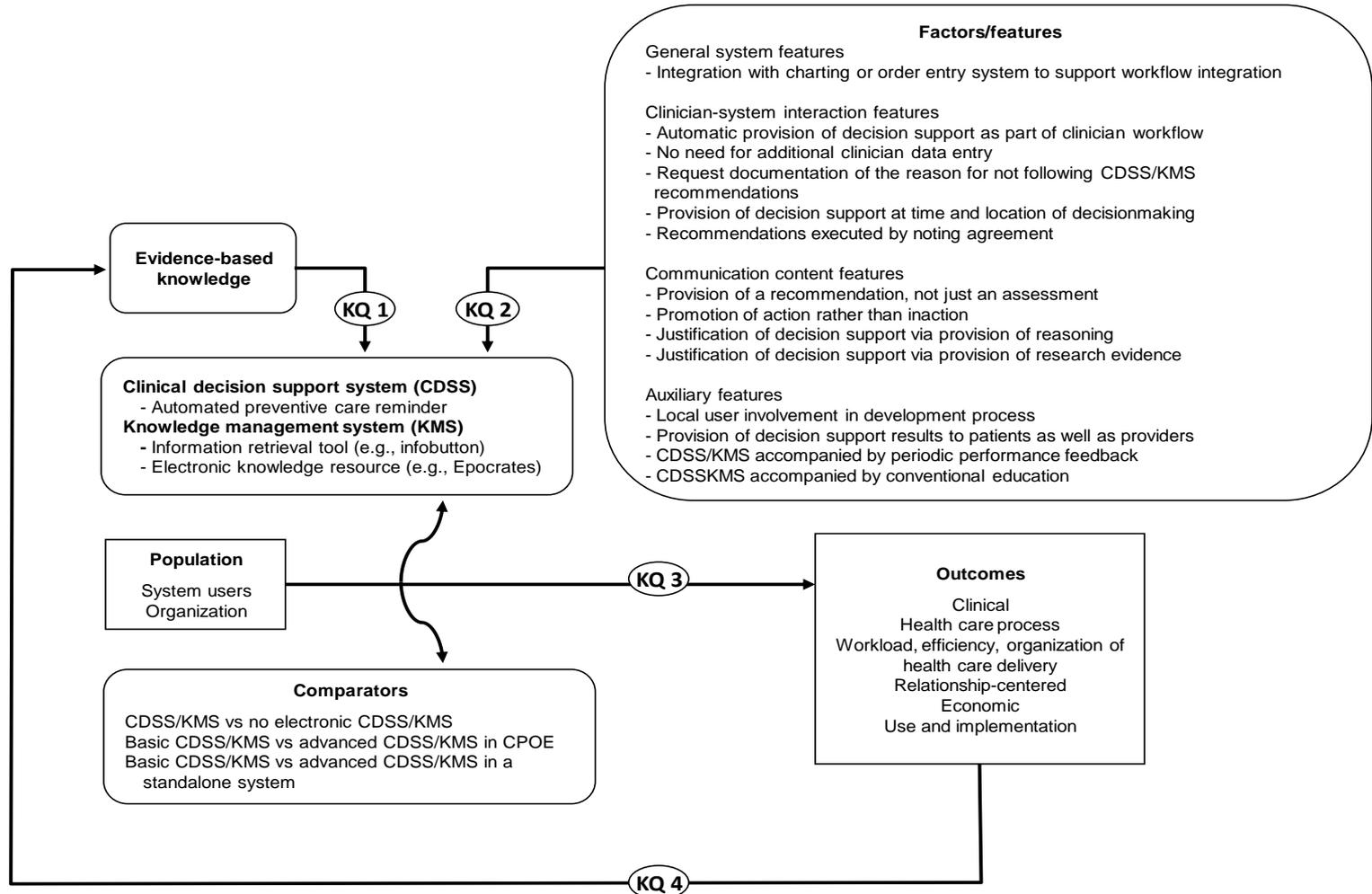


# Future Studies

- Studies on clinical outcomes
- Studies on economic endpoints
- Studies on KMSs

# Analytic Framework

Methods



# KQ2: System Features-Odds Ratios

## Results

- Previously identified factors/features
  - Automatic provision of decision support as part of clinician workflow
    - Odds ratio (OR): 1.45, 95% CI of 1.28 to 1.64 for adherence to preventive care (PC), n = 19
    - OR: 1.85, 95% CI of 1.52 to 2.25 for ordering of clinical studies (OS), n = 15
    - OR: 1.59 95% CI of 1.33 to 1.90 for prescribing or ordering of therapy (OT), n = 38
  - Provision of decision support at time and location of decisionmaking
    - OR: 1.35, 95% CI of 1.20 to 1.52 for PC, n = 22
    - OR: 1.78, 95% CI of 1.46 to 2.17 for OS, n = 15
    - OR: 1.75, 95% CI of 1.47 to 2.08 for PT, n = 37
  - Provision of a recommendation, not just an assessment
    - OR: 1.50, 95% CI of 1.30 to 1.74 for PC, n = 18
    - OR: 2.01, 95% CI of 1.63 to 2.48 for OS, n = 15
    - OR: 1.61, 95% CI of 1.34 to 1.93 for PT, n = 36



# KQ2: System Features-OR (cont)

## Results

- Newly identified factors/features
  - Integration with charting/order entry system
    - OR: 1.47, 95% CI of 1.21 to 1.77 for PC, n = 13
    - OR: 1.56, 95% CI of 1.29 to 1.87 for OS, n = 9
    - OR: 1.67, 95% CI of 1.39 to 2.00 for PT, n = 36
  - No need for additional data entry
    - OR: 1.43, 95% CI of 1.22 to 1.69 for PC, n = 16
    - OR: 1.58, 95% CI of 1.31 to 1.89 for OS, n = 11
    - OR: 1.78, 95% CI of 1.44 to 2.19 for PT, n = 30
  - Promotion of action rather than inaction
    - OR: 1.28, 95% CI of 1.09 to 1.50 for PC, n = 15
    - OR: 1.52, 95% CI of 1.23 to 1.87 for OS, n = 9
    - OR: 1.71, 95% CI of 1.35 to 2.16 for PT, n = 22



# KQ2: System Features-OR (cont)

## Results

- Newly identified factors/features
  - Justification of decision support via provision of research evidence
    - OR: 1.60, 95% CI of 1.04 to 2.46 for PC, n = 5
    - OR: 2.93, 95% CI of 1.40 to 6.12 for OS, n = 5
    - OR: 1.59, 95% CI of 1.13 to 2.24 for PT, n = 15
  - Local user involvement in the development process
    - OR: 1.45, 95% CI of 1.23 to 1.73 for PC, n = 11
    - OR: 1.41, 95% CI of 1.18 to 1.70 for OS, n = 10
    - OR: 1.90, 95% CI of 1.38 to 2.61 for PT, n = 20
  - Provision of decision support results to patients as well as providers
    - OR: 1.18, 95% CI of 1.02 to 1.37 for PC, n = 5
    - OR: 1.41, 95% CI of 1.26 to 1.58 for OS, n = 5
    - OR: 1.97, 95% CI of 1.20 to 3.21 for PT, n = 5



# Enabling Medication Management through Health Information Technology

## **Prepared by:**

McMaster Evidence-based Practice Center, Hamilton,  
Ontario, Canada

## **Presented by:**

Ann McKibbin, Ph.D.

*Principal Investigator*

I do not have any relevant financial relationships with any commercial interests to disclose.



Inspiring Innovation and Discovery



# Note

These slides are based on research conducted by the Johns Hopkins EPC under contract to the Agency for Healthcare Research and Quality (AHRQ), Rockville, MD. The findings and conclusions in this document are those of the author(s) who are responsible for its contents; the findings and conclusions do not represent the views of AHRQ. Therefore, no statement in this document should be construed as an official position of AHRQ or of the U.S. Department of Health and Human Services

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For more information about the Evidence-base Practice Centers Program and to view the final report from which these slides are based, please visit

<http://www.ahrq.gov/clinic/epcsums/medmgmtsum.htm>.

# McMaster Project Team

Participant	Role on Project
Ann McKibbin, MLS PhD	Principal Investigator
Cynthia Lokker, PhD	EPC Investigator
Parminder Raina, PhD	EPC Director
Steve Handler, MD PhD	Clinical Investigator, University Pittsburgh
Lisa Dolovich, PharmD, MSc	Clinical Investigator
Anne Holbrook, PharmD, MD	Clinical Investigator
Daria O'Reilly, PhD	Economics Investigator
Robyn Tamblyn, PhD	Clinical Investigator, McGill University
Brian Hemens, BScPhm, MSc	Clinical Investigator
Runki Basu, MA	EPC Investigator
Sue Troyan, BA, RT	EPC Investigator
Pavel Roshanov, BSc	EPC Investigator
Norm Archer, PhD	Business Investigator
Mary Gauld, BA	EPC Coordinator

# Technical Expert Panel

<b>David Bates, MD, MSc</b> Partners Healthcare System, Inc. and Harvard Boston, MA	<b>Chris Gibbons, MD, MPH</b> Johns Hopkins Bloomberg School of Public Health Baltimore, MD
<b>Joseph Hanlon, PharmD, MS</b> University of Pittsburgh Pittsburgh, PA	<b>Kevin Johnson, MD, MS</b> Vanderbilt University Medical Center Nashville, TN
<b>Bimla Schwarz, MD, MS</b> University of Pittsburgh Pittsburgh, PA	<b>Doug Bell, PhD, MD</b> RAND Corporation and University of California Los Angeles CA
<b>Gordon Schiff, MD</b> Harvard Medical School/Brigham and Women's Boston, MA	<b>Jerry Gurwitz, MD</b> University of Massachusetts Boston, MA
<b>Joy Grossman, PhD</b> Center for Studying Health System Change Washington, DC	<b>Dennis Tribble, Pharm D</b> ForHealth Technologies, Inc. Daytona Beach, FL
<b>John Poikonen, Pharm D</b> UMass Memorial Medical Center Worcester, MA	<b>Kenneth Boockvar, MD, MS</b> Mount Sinai School of Medicine New York, NY

# Peer Reviewers

<b>Anne Bobb, BSPHarm</b> Northwestern Memorial Hospital Chicago, IL	<b>Elizabeth Chrischilles, MS PhD</b> University of Iowa Iowa City, IA
<b>Allen J. Flynn, PharmD</b> University of Michigan Hospitals Ann Arbor, MI	<b>Joy Grossman, PhD</b> Center for Studying Health System Change Washington, DC
<b>Joseph Hanlon, PharmD, MS</b> University of Pittsburgh Pittsburgh, PA	<b>Kevin Johnson, MD, MS</b> Vanderbilt University Medical Center Nashville, TN
<b>Kevin Marvin, RPh, MS</b> Medication Systems Informatics Burlington, VT	<b>John Poikonen, Pharm D</b> UMass Memorial Medical Center Worcester, MA
<b>Bimla Schwarz, MD, MS</b> University of Pittsburgh Pittsburgh, PA	<b>Dennis Tribble, Pharm D</b> ForHealth Technologies, Inc. Daytona Beach, FL



# Objectives

- Evidence Report
  - Review the literature of MMIT
  - Synthesize evidence
  - Identify gaps
  - Make recommendations
- Webinar
  - Introduce the report
  - “shape” of the literature base



# Content

- Medication management
- Health information technology
- No restrictions on
  - Settings
  - People involved
  - Conditions
  - Geography
  - Time
  - Study design

# Medication Management Phases—Bell Model\*

- Prescribing
- Order communication
- Dispensing
- Administering
- Monitoring
- Plus
  - Reconciliation
  - Education

\*Bell DS, Cretin S, Marken RS, Landman AB. A conceptual framework for evaluating outpatient electronic prescribing systems based on their functional capabilities. J Am Med Inform Assoc 2004; 11(1):60-70.



# MMIT Inclusion Criteria

## The information technology

- Processed patient-specific information
- Sent clinical data to a decision maker
- Integrated with another IT system



# Key Questions for MMIT

1. Effectiveness
2. Gaps in knowledge and evidence
3. Value proposition
4. System characteristics
5. Sustainability
6. 2-way electronic data interchange (EDI) for order communication
7. RCTs for CDSS



# Literature Searches

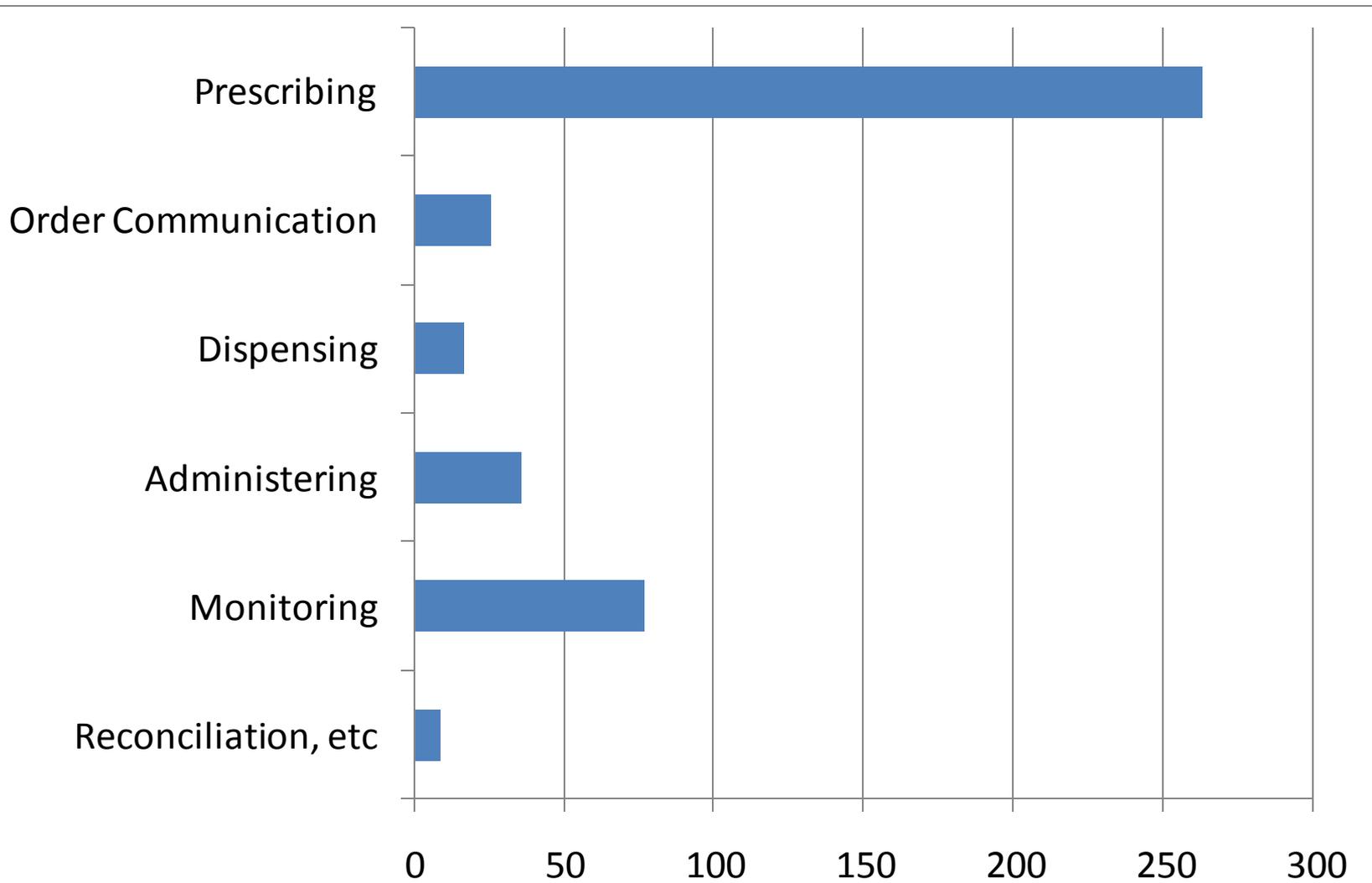
Databases (n = 11)

- Health
- Technology
- Business
- Grey literature

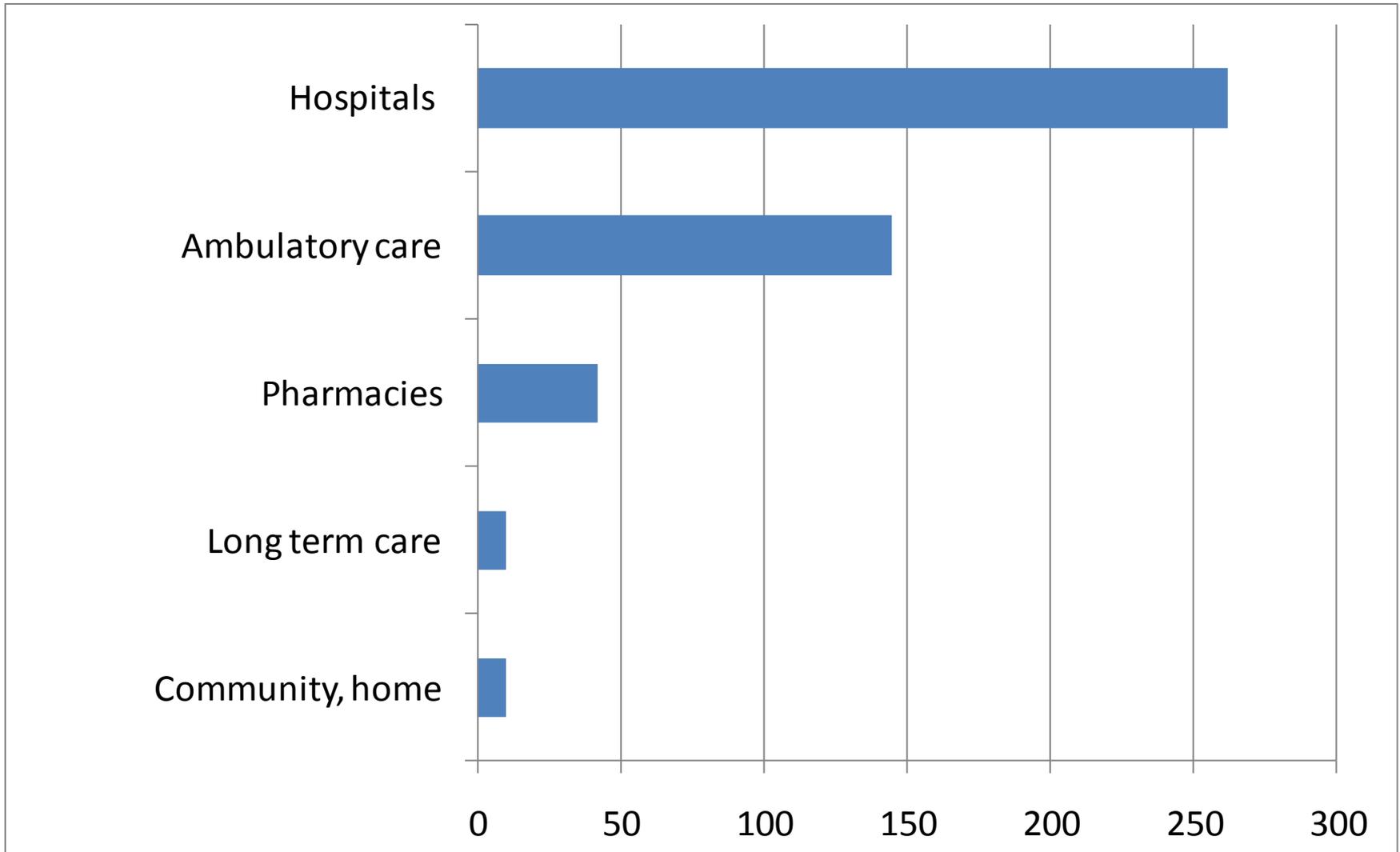
40,582 → 428 articles

Growth in 2000s

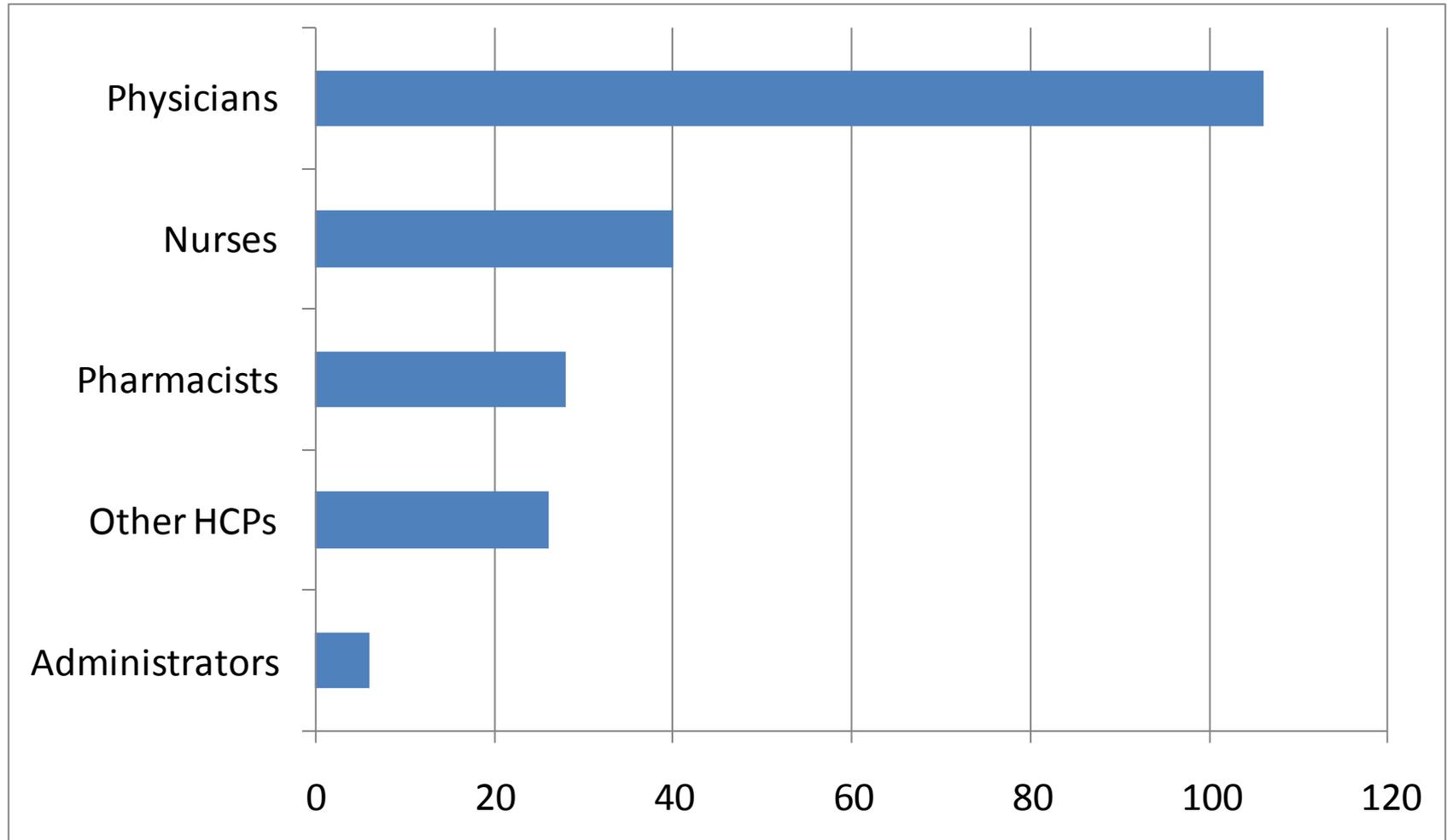
# Phases-Number of Studies



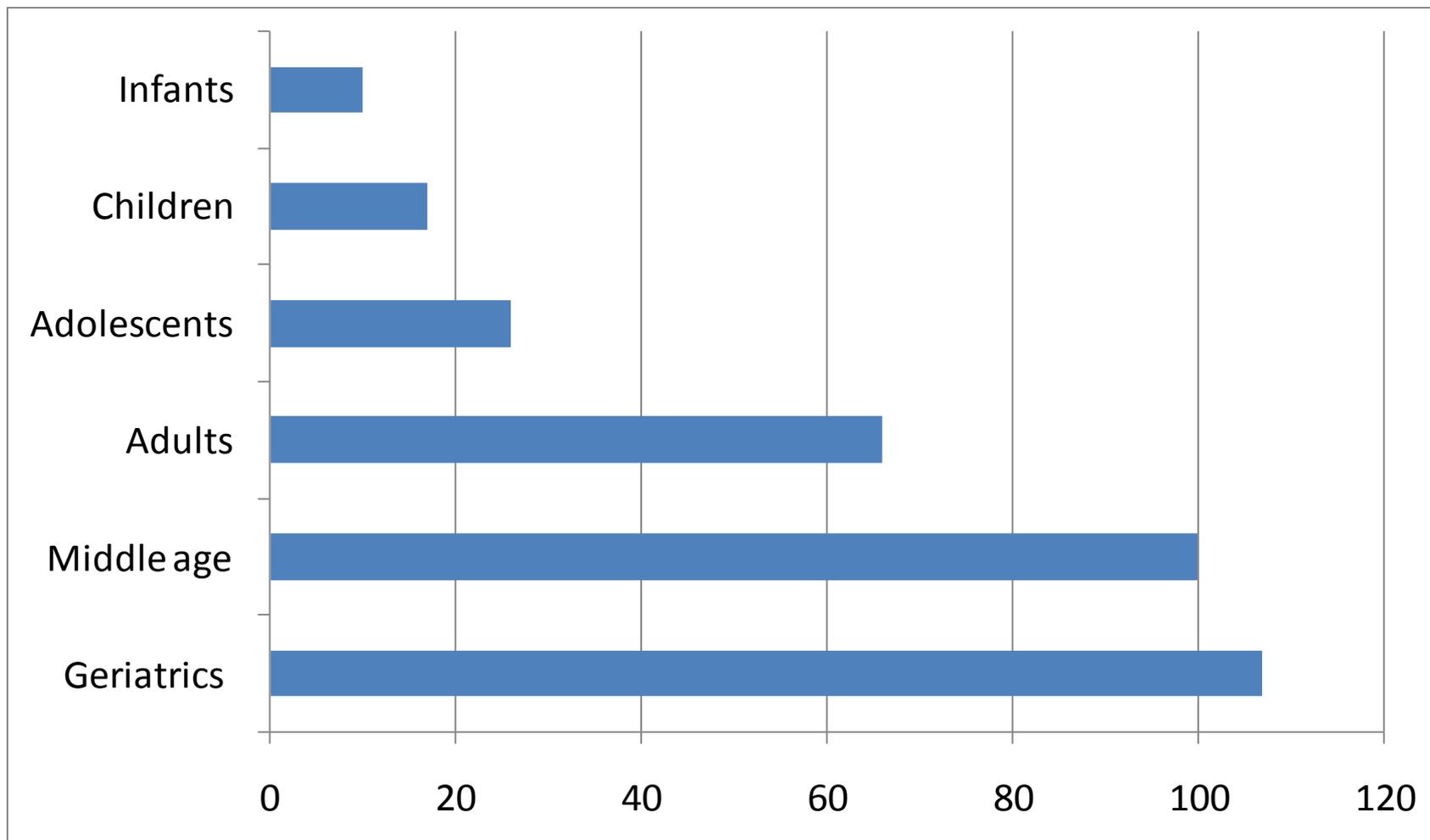
# Settings-Number of Studies



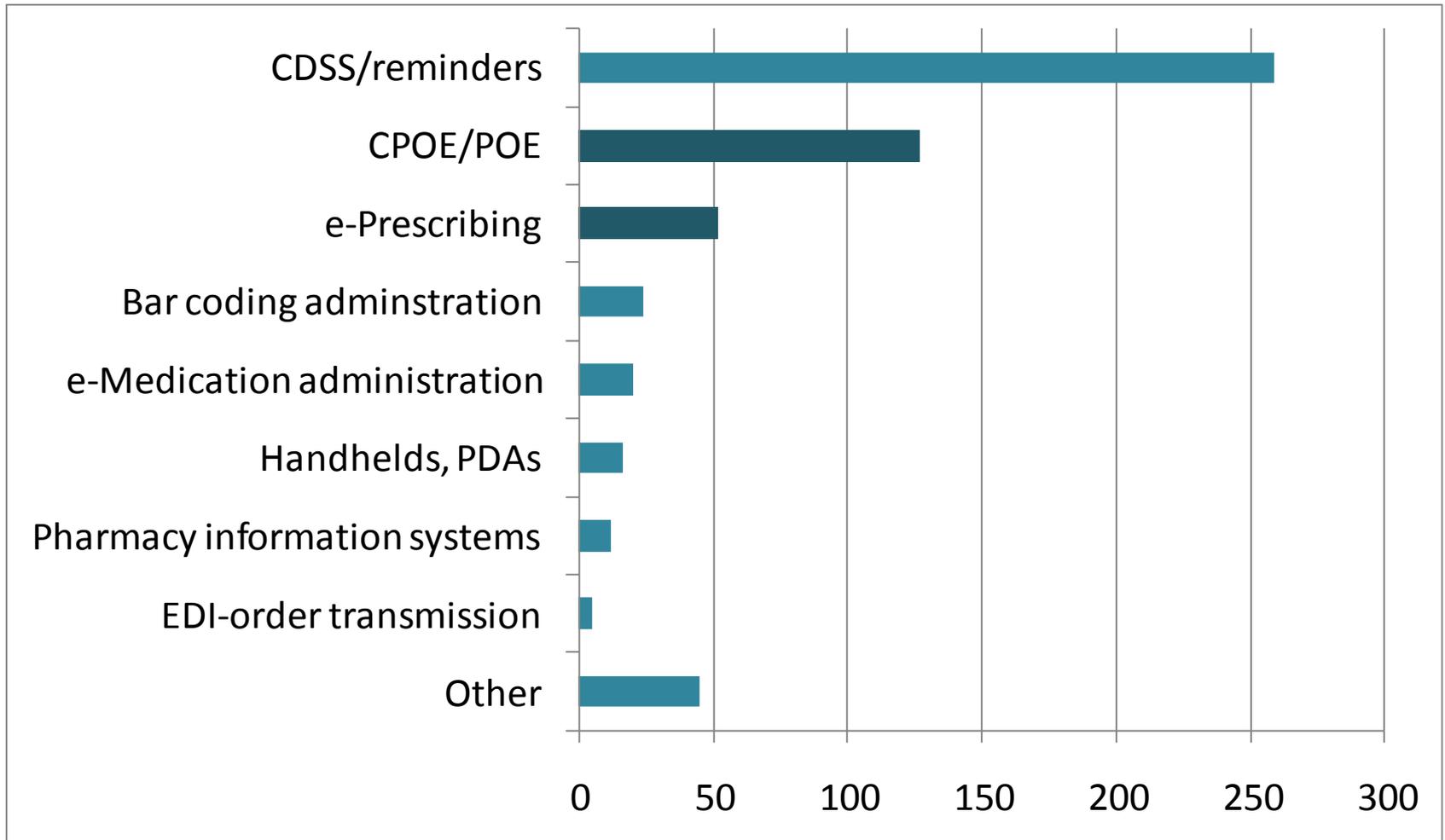
# Clinicians-Number of Studies



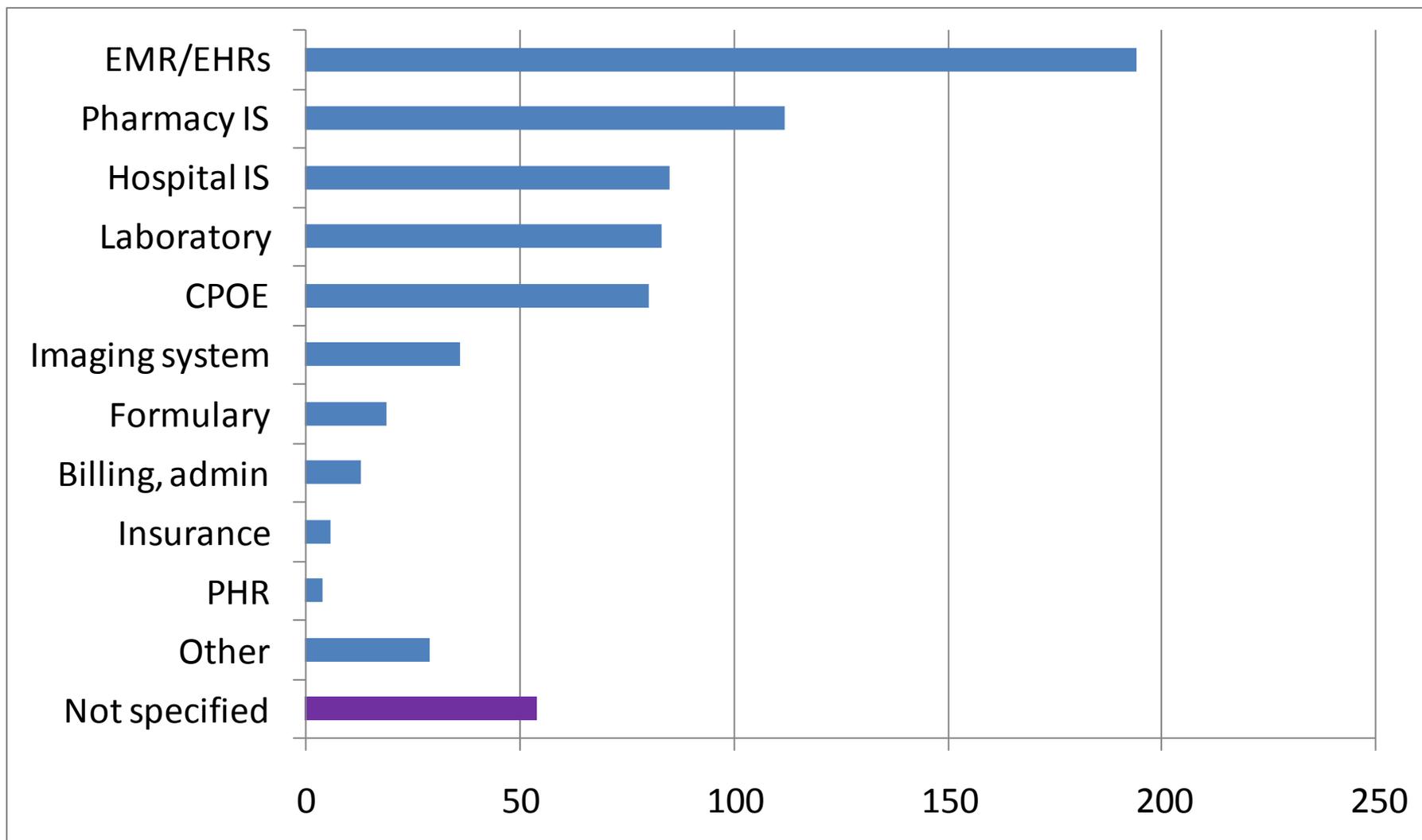
# Patients and Caregivers- Number of Studies



# MMIT-Number of Studies



# Integration-Number of studies



# KQ1a Effectiveness Process Changes

- Many studies
- Lots of RCTs
- Set in hospitals
- Many positive findings

.....*examples*

# KQ1a Effectiveness Process—Prescribing

174 studies

- Changes: 85 of 104 studies +
  - Better matches for antibiotics or doses
- Errors: 17 of 24 studies +
  - Potential drug interactions, wrong doses
- Compliance: 28 of 36 studies +
  - Reminders, guidelines, best practices
- Workflow: 1 of 2 studies +



# KQ1a Effectiveness Process—Administration

16 studies

- Errors: 8 of 13 studies +, 1 -
  - Timing of administration
- Compliance: 2 of 3 studies +
  - Guidelines
- Time for administration tasks: 3 of 4 +
  - Mostly time spend on recording
- Workflow: 1 of 1 study +



# KQ1 Effectiveness Clinical Endpoints

76 studies—all methods

- 54% show improvements

23 RCTs with primary clinical outcomes

- 43% show improvements

26 RCTs with secondary clinical outcomes

- 12% show improvements



# KQ1 Effectiveness Clinical Endpoints

76 studies—all methods

- Length of stay: 7 of 14 studies +, 1 -
- Quality of life: 1 of 5 studies +
- Adverse drug events: 8 of 12 studies +
- Disease events: 6 of 16 studies +
  - Blood clots, infections, depression
- Physiological measurements: 18 of 32 +
  - Blood pressure, glucose levels



# KQ1 Effectiveness

## Clinical Endpoints—Mortality

CPOE in US pediatric hospitals

3 cohort studies with historical controls

Han	2005	increase	OR 3.3 (CI 1.9 to 5.6)
Keene	2007	no difference	OR 0.7 (CI 0.3 to 1.6)
Longhurst	2010	decrease	1.01 vs 0.71 deaths/100 discharges per month

PubMed IDs: Han 16322178 Keene 17417119

Longhurst 20439590



# KQ1 Effectiveness

## Economic/Cost Endpoints

5 full economic evaluations

26 cost analyses studies

- Lack cost data related to
  - Capital investment
  - Implementation
- *Cost savings possible over time*



# KQ1 Effectiveness Qualitative Studies

56 qualitative and mixed methods studies

- Similar themes across settings and users
- Expectations were unrealistic
- Strong emotions involved
- Important changes to process occurred
- New errors were introduced
- Technology affected working relationships



# KQ1 Effectiveness

## Unintended consequences

18 studies: Qualitative and Quantitative  
Both positive and negative

- Errors
  - Flexibility
  - Power of displays
  - Dependence
  - Workarounds
- Alert fatigue
- Changing roles
- Communication
- Workflow



# KQ7 RCTs of CDSS

- Well studied
- Focused on only RCTs (n = 77)
- Prescribing and monitoring phases
- Outcomes for the MMIT RCTs
  - 36 process changes: 67% positive
  - 16 clinical endpoints: 31% positive



# KQ3 Value Proposition

- Financial
  - Cost reduction
  - Revenue enhancement
  - Productivity gain
- Clinical
  - Care process improvements
  - Improved patient outcomes
- Organizational
  - Stakeholder satisfaction improvements
  - Risk mitigation

*...evidence leans towards a positive VP*



# KQ5 Sustainability

- What is sustainability?
  - Discussed in health IT literature
  - Poorly defined
  - No studies assessing sustainability
- Most relevant definition:
  - “the ability of a health service to provide ongoing access to appropriate quality care in a cost-effective and health-effective manner”*  
(Humphreys et al.)



# KQ6 2-way EDI (order communication)

- Facilitators for EDI:
  - Incentives
  - Supportive regulatory environment
  - Messaging standards for EDI
- Barriers to EDI:
  - Effects on pharmacists and pharmacies
  - Regulatory and legal uncertainties
  - Low preexisting adoption rates of EMRs and EHRs



# Call to Action—Research Focus

- Phases
  - Order communication, dispensing, and administering
- People
  - Pharmacists, nurses, and mental health
  - Patients and families
- Information technologies
  - that are used by and for these people



# Call to Action—Research Expansion

- Studies with control groups
- Move beyond process measures
- Balance qualitative/quantitative studies
- Teams with broad input
  - Methodologists
  - Clinicians
  - Statisticians
  - Technology experts
- Complete work on the value proposition
- Sort out sustainability



# Call to Action: Researchers

- Develop new research methods using our own data collection capabilities
- Better adherence to reporting standards (longer articles)
- Better use of terminologies and standard definitions
- Be serious about knowledge translation/translational research efforts

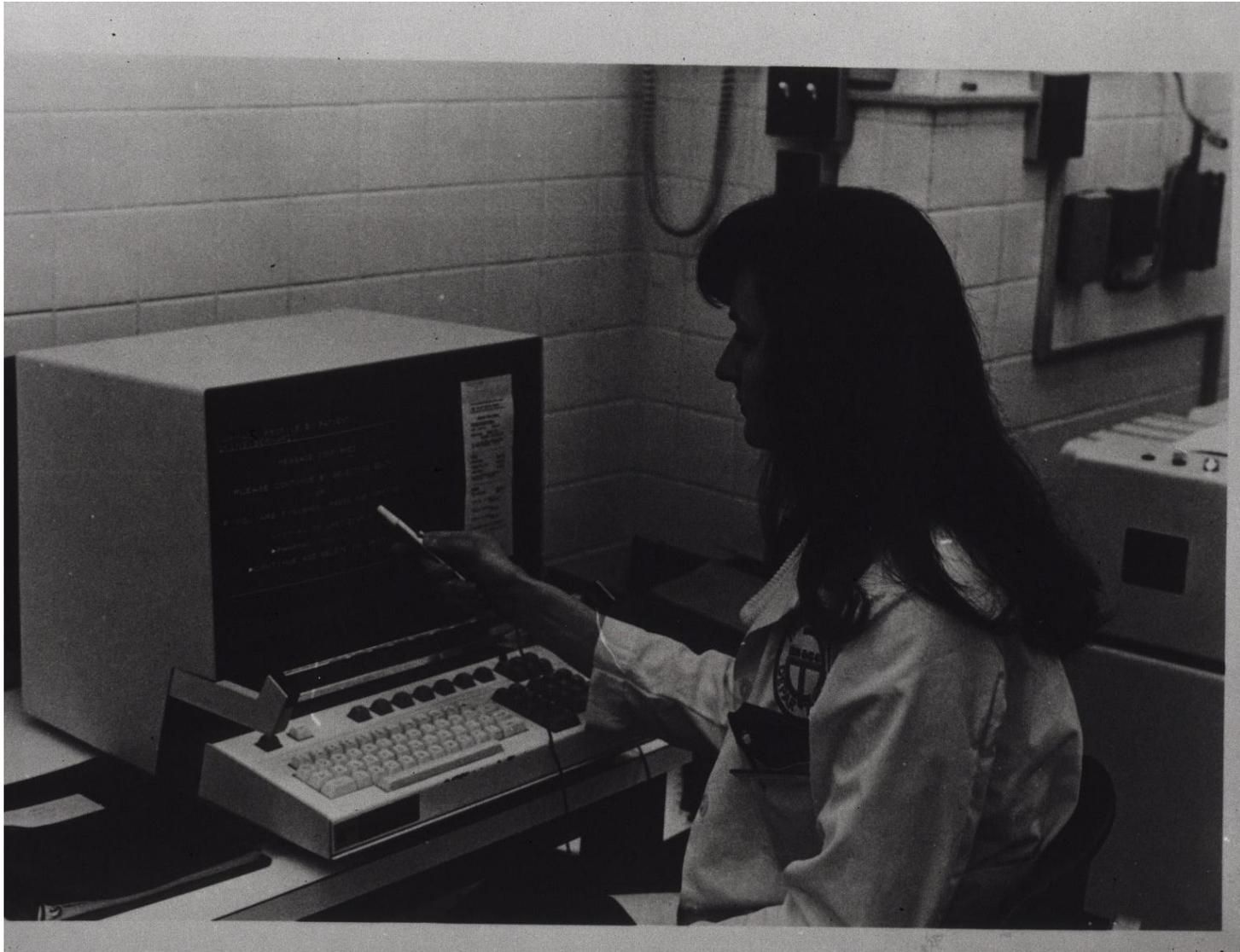


# Call to Action: Implementers

- Manage expectations
- Look for and value unintended consequences
- Recognize systems change relations and communication patterns
- Updating needs are not addressed
  - systems themselves
  - knowledge base of our systems

# US History of Medicine Collection NLM

<http://ihm.nlm.nih.gov/luna/servlet/view/search?q=A018201>



# Impact of Consumer Health Informatics Applications

The Johns Hopkins Evidence Based Practice Center

M. Christopher Gibbons, MD, MPH (PI)

Renee F. Wilson, MS, Lipika Samal, MD, Christoph U. Lehmann, MD, Kay Dickersin, MA, PhD, Harold P. Lehmann, MD, PhD, Hanan Aboumatar, MD, Joe Finkelstein, MD, PhD, Erica Shelton, MD, Ritu Sharma, BS, Eric B. Bass, MD, MPH

**July 20, 2011**

I do not have any relevant financial relationships with any commercial interests to disclose.



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Financial disclosure: None of the authors have a financial interest in any of the products discussed in these slides.

For more information about the Evidence-base Practice Centers Program and to view the final report from which these slides are based, please visit <http://www.ahrq.gov/clinic/epcix.htm>.

# Background

- Health Information technologies may enable future transformations in Healthcare delivery quality, outcomes and costs. There is growing interest in electronic tools that are owned and operated primarily by patients and healthcare consumers.
- Consumer Health Informatics (CHI) is defined as any electronic tool, technology or electronic application that is designed to interact directly with consumers, with or without the presence of a healthcare professional, that provides or uses individualized (personal) information and provides the consumer with individualized assistance, to help the patient better manage their health or healthcare.
- The objectives of this report were to review the literature on the evidence of the health impact of currently developed CHI applications, to identify the gaps in the CHI literature, and to make recommendations for future CHI research.



# Key Questions

## 1) What evidence exists that CHI applications impact:

- Health care process outcomes (e.g., receiving appropriate treatment) among users?
- Intermediate health outcomes (e.g. self management, health knowledge, and health behaviors) among users?
- Relationship-centered outcomes (e.g. shared decision making or clinician-patient communication) among users?
- Clinical outcomes (including quality of life) among users?
- Economic outcomes (e.g., cost and access to care) among users?

2) What are the barriers that clinicians, developers, consumers and their families or caregivers encounter that limit utilization or implementation of CHI applications?

3) What knowledge or evidence exists to support estimates of cost, benefit, and net value with regard to CHI applications?

4) What critical information regarding the impact of CHI applications is needed to give consumers, their families, clinicians, and developers a clear understanding of the value proposition particular to them?



# Methodology

- Search strategy
  - RCT's Only (Key Question #1)
  - All study designs (Key Questions #2, #3, #4)
- Databases
  - MEDLINE®, EMBASE®, The Cochrane Library, Scopus, and CINAHL
  - Published reviews, Grey literature
  - Query of technical experts , advisors, and project investigators
- Exclusion Criteria
  - No health informatics application, Application does not apply to the consumer, General health information application (general Web site) and is not tailored to individual consumers, “Point of care” device (defined as requiring a clinician to use or obtain and is part of the regular provision of care), or No original data provided.



# Methodology

- Quality assessment
  - Jadad Criteria
  - GRADE Working Group Criteria Criteria
- Double data review and Quality assessment
- Iterative feedback and review by TEP & External Advisors

# Results for Process & Intermediate outcomes

- **Significant (+) impact of CHI in at least one outcome**
  - Process outcomes
    - 4 of 5 asthma studies
  - Intermediate outcomes
    - 100% of 3 breast cancer studies,
    - 89% of # diet/exercise/physical activity studies
    - 100% of XXX alcohol abuse studies,
    - #% of # smoking cessation studies,
    - 40% of # obesity studies,
    - 100% of # Diabetes studies,
    - 88% of # mental health studies,
    - 25% of # asthma/COPD studies
    - 50% of two menopause/HRT utilization studies.
    - 13 miscellaneous single studies



# Results for Clinical outcomes

- **Significant (+) impact of CHI in at least one outcome**
  - Doctor-Patient relationship
    - 5 of 8 studies
  - Clinical outcomes
    - 1 of 3 breast cancer studies
    - 80% of 5 diet/exercise/physical activity studies
    - 100% of 7 mental health studies
    - 100% of 3 Diabetes studies
    - xx% of # miscellaneous single studies
- **No evidence of consumer harm attributable to CHI**
- **Insufficient evidence to determine economic impact of CHI**
- **Several individual & system level utilization barriers found**



# Discussion

- Current literature is broad (studies on many topic areas) but at times thin (limited number of studies in each topic area)
- Emerging themes
  - CHI applications can significantly impact health outcomes
  - CHI applications may also be effective adjuvants to traditional healthcare
  - Effective CHI applications include 1) individual tailoring, 2) personalization and 3) behavioral feedback.



# Discussion

- **Knowledge Gaps regarding CHI**

- The role of CHI applications targeting children, adolescents, the elderly and caregivers.
- The role of Web 2.0, social networking, “On Demand”, Television and health gaming technology in CHI applications
- Consumer knowledge, attitudes, beliefs, perceptions and practices regarding technology utilization, particularly among priority populations
- The effect of CHI applications on health outcomes among racial and ethnic minority populations, low literacy populations and the potential effect of these applications on healthcare disparities.
- The impact of CHI content design (software) vs platform design (hardware) on consumer utilization and outcomes

- **Research needs and opportunities**

- Standardized interdisciplinary CHI nomenclature
- A CHI Design & evaluation registry



# Question and Answer Session

## National Web-Based Teleconference on Using Health IT for Chronic Disease Management

July 20, 2011

## Outcome Categories

Outcome Category	Examples
Clinical	Length of stay, morbidity, mortality, health-related quality of life, adverse events
Health care process	Adoption/implementation of CDSS/KMS-recommended preventative care/clinical study/treatment, patient adherence to CDSS/KMS recommendation, impact on user knowledge
Health care provider workload, efficiency, and organization	Number of patients seen/unit time, clinician workload, efficiency
Relationship-centered	Patient Satisfaction
Economic	Cost, cost-effectiveness
Health care provider use and implementation	User acceptance, satisfaction, and use and implementation of CDSS/KMS