Institute for Healthcare Improvement

UCSD Informatics Journal Club Webinar

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Reduction in Medication Errors due to Adoption of Computerized Provider Order Entry Systems

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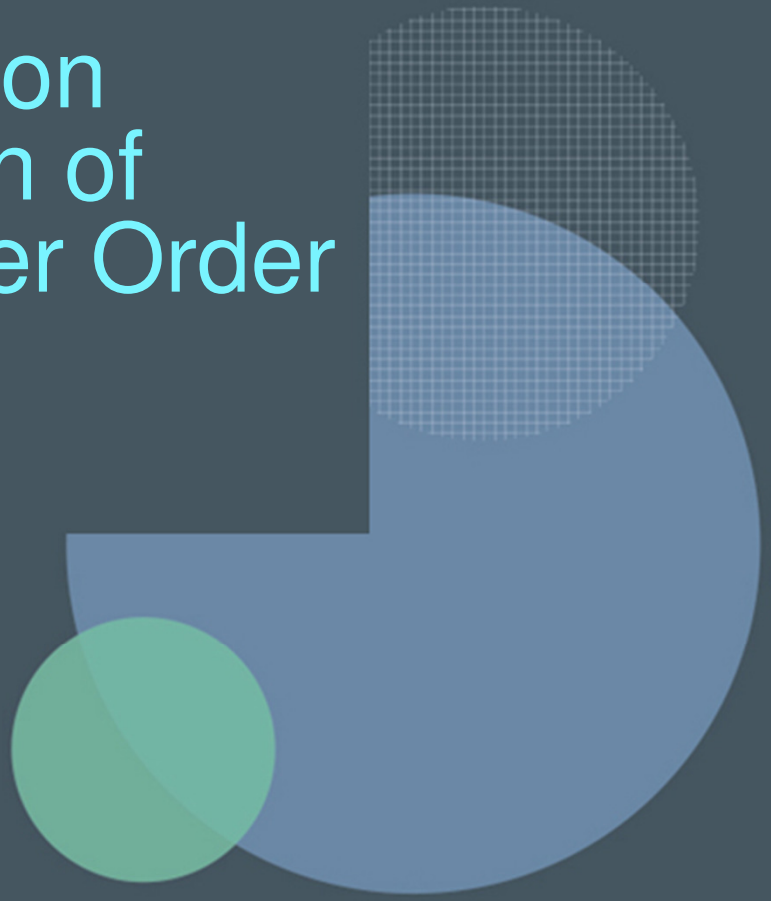

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Team Effort

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Background

- Health IT a core theme of health reform
  - Incentives for physician adoption
  - Efficiency and quality gains?
- Impact of many Health IT initiatives unknown
- Difficult to quantify Health IT's impact nationally

Evaluation Approach

Context

Settings/ Units of Analysis

Hospital Inpatient

Technology of Interest

Computerized Provider Order Entry

Adoption

Operational definition

Adoption of any CDS functionality/ in hospitals, full implementation in at least 1 unit

Data Sources

AHA EHR Supplemnt

Physician EHR Survey

Analysis Method

Sample proportions adjusted for sampling weights and non-response

Use/ Meaningful Use

Operational definition

Use of CDS at least some of the time/ by CDS type

Data Sources

Adoption data plus additional Physician EHR Survey items

No use data available from hospitals

Analysis Method

Averages adjusted for non-response plus simple arithmetic

Outcomes

Operational definition

Reduction of medication errors due to CPOE

Data Sources

CPOE Adoption and use data from AHA plus Effect estimates from the literature

Analysis Method

Meta-analysis plus simple arithmetic

Objectives

- Computerized Provider Order Entry (CPOE)
  - Medication Errors: Potentially Harmful & Costly
  - CPOE believed help avoid errors
    - Transcription, dosing, adverse interactions, etc….
  - CPOE can be a new source of errors
    - e.g. Wrong drug choice from pull-down menu
- Derive a nationally representative estimate of medication error reduction (if any) in acute hospital settings attributable to the use of CPOE

- Percent [%] reduction (***Rp*** in this presentation)
- Absolute [#] reduction (***Ra*** in this presentation)

Construct Clarification

- **Medication error**: A mistake in the prescribing or dispensing process.
- **Computerized Provider Order Entry (CPOE)**: A system allowing providers to electronically write orders for diagnostic tests, therapy (e.g. medications, nursing orders) or consultations (e.g. consult to a specialist for input).
- **Adoption**: Presence of a CPOE system within an inpatient acute-care setting that has the ability to process prescription drug orders electronically
- **Implementation**: The degree to which prescription drug orders made within an inpatient acute healthcare facility are processed through a CPOE system
- **Medication Order**: A written order by a healthcare provider (with prescribing authority) for a medication to be dispensed by a pharmacy for administration to a patient

Study Approach

Step 1	Effect of CPOE on medication error frequency
Step 2	Proportion of medication orders that are ordered using a CPOE system
Step 3	Percentage reduction in medication error frequency resulting from using CPOE to process medication orders
Step 4	Absolute reduction in medication error frequency resulting from using CPOE to process medication orders

Study Approach

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Step 1: Effect of CPOE medication error frequency Methods

- Literature review
  - No randomized studies
  - Relied on high quality observational studies
- 9 pre/post studies of medication error frequency in hospitals and units that implemented a CPOE system (hospitals serve as their own control facilities)
- Comparison was CPOE vs. 'traditional' hand written Rx Orders
- Error rates standardized to number of errors per month before/after CPOE
- Data pooled using DerSimonian & Laird weights to account for within- and between-study heterogeneity

$$M = \frac{\sum (w_k \cdot \left(\frac{Mc_k - Mn_k}{Mn_k} \right))}{\sum w_k}$$

M = **Percent reduction in medication error rates associated with adoption of CPOE**

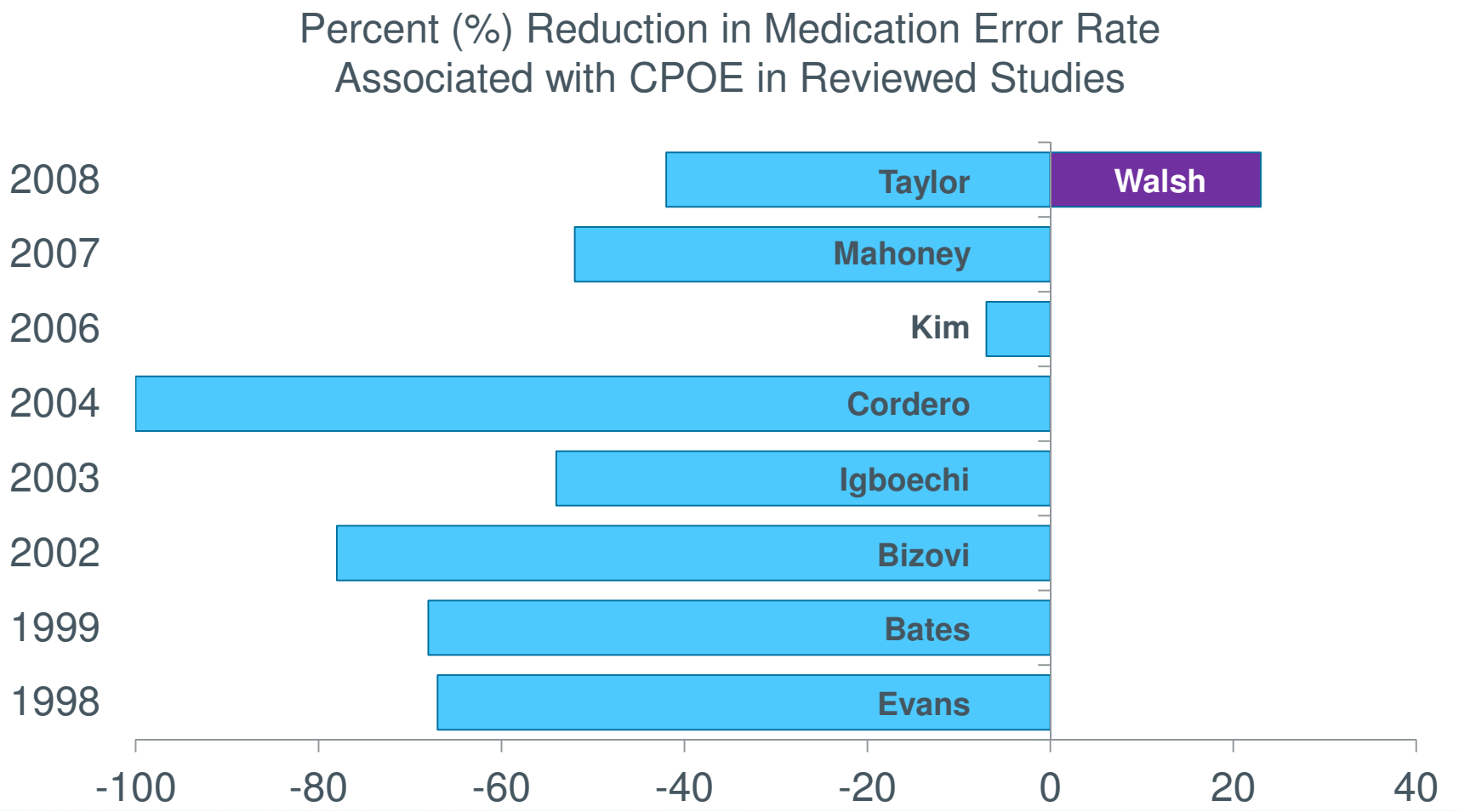
k = Denotes the study

Mc = Medication error rate in settings with CPOE

Mn = Medication error rate in settings without CPOE

w = Meta analytic study weight, defined using the DerSimonian method

Step 1: Effect of CPOE medication error frequency Findings (literature review)



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Step 2: Proportion of Rx Orders Processed by CPOE Methods

- Nationally representative
- Accounts for CPOE adoption and implementation
- Data from hospital surveys:
  - AHA Annual Survey (2007): hospital size, bed days & other characteristics
  - EHR Adoption Supplement (2007): CPOE adoption & implementation
  - ASHP Annual Survey: Medication Order Volume
- Non-Response mediated using a regression imputation

$$Pc = \frac{\sum_{j=1}^{4} \sum_{i=1}^{N_j} B_j A_i C_i D_i}{\sum_{j=1}^{4} \sum_{i=1}^{N_j} B_j A_i}$$

Pc* = *Proportion of total medication orders processed through a CPOE system

i = denotes the study

j = denotes the study

B = *Estimated medication orders per bed-day from ASHP survey*

A = *Reported bed days in hospitals from AHA survey*

C = *Probability that a hospital has adopted CPOE*

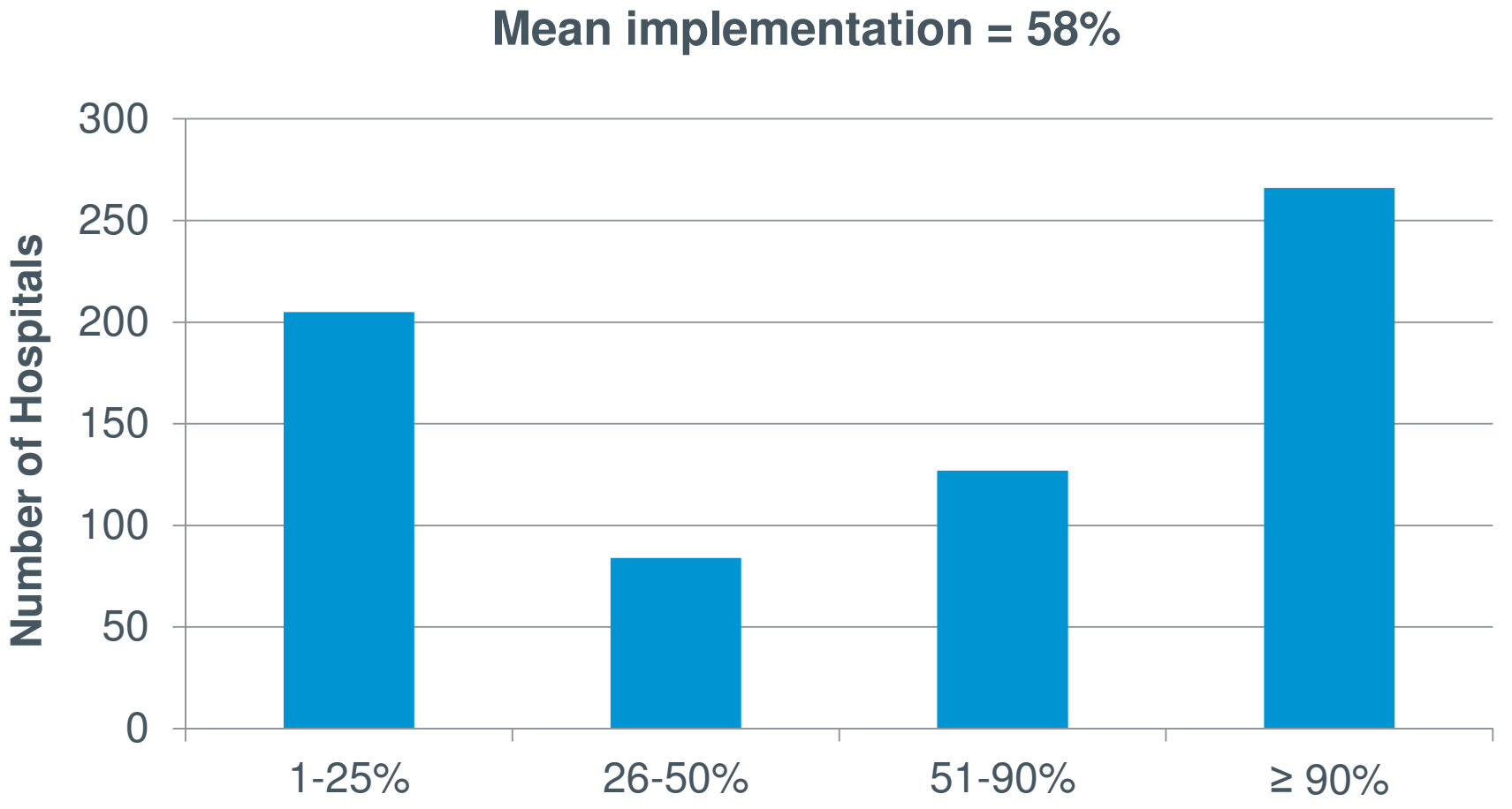
D = *CPOE implementation - the percent of medication orders in facilities with CPOE that are processed through the CPOE system*

Step 2: Proportion of Rx Orders Processed by CPOE Findings – CPOE Adoption

Hospitals with CPOE ≈34% (1,589 of 4,701)

CPOE Adoption by select Hospital Characteristics		
Characteristic		**CPOE % With / Without**
Children's Hospital		100 / 0
Bed Size:	Small (<100)	30 / 70
	Medium (100-399)	35 / 65
	Large (>=400)	56 / 44
Location:	Rural	28 / 72
	Urban	41 / 59
Teaching:	≤ 20 residents	32 / 68
	> 20 residents	53 / 47
Other factors: Region of the Country (NE is highest), Ownership Type (not for profit is highest), Part of a System (not significant)		

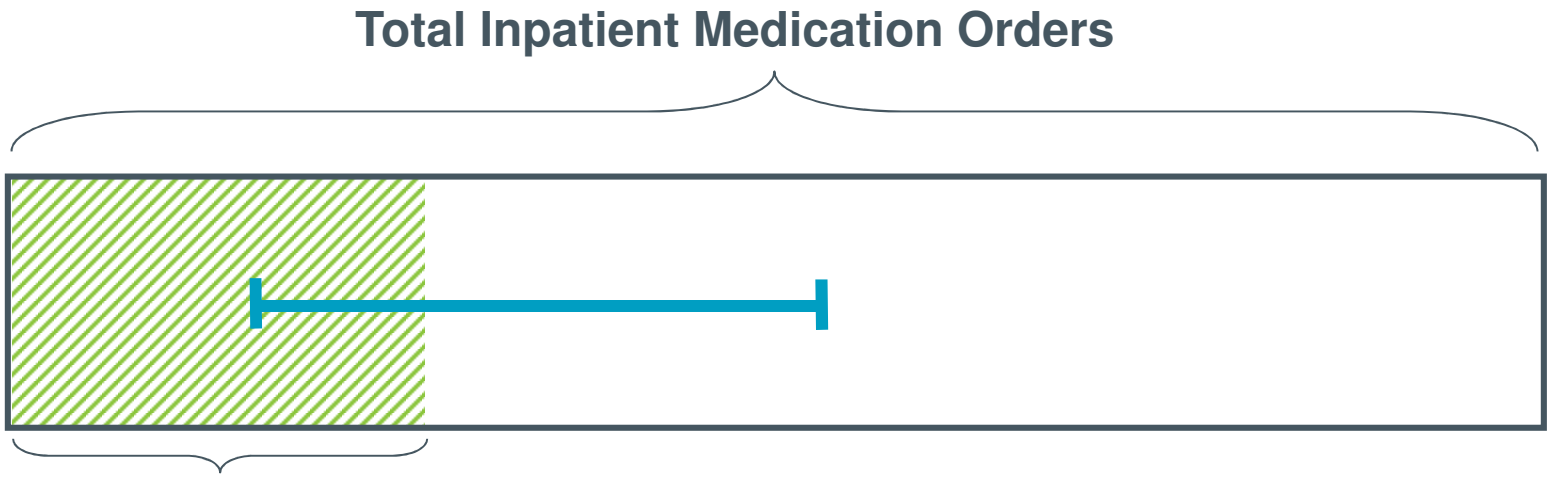
Step 2: Proportion of Rx Orders Processed by CPOE Findings – CPOE Implementation



Source: EHR Adoption Supplement Survey. Only includes EHR supplement responders

Step 2: Proportion of Rx Orders Processed by CPOE Findings – Total CPOE Exposure

Total Inpatient Medication Orders (*Ot*)	1,757 Million
Inpatient Medication Orders made using CPOE (*Oc*)	459 Million



CPOE Exposure: 26% (estimate bounds: 16-53%)

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Steps 3 & 4: National Estimates of Medication Error Reduction Methods

- *Step 3:* Percentage reduction in medication error frequency resulting from using CPOE to process medication orders

$$Rp = M \cdot Pc$$

Rp = Percent reduction in medication errors due to CPOE

M = Percent reduction in medication error rates associated with adoption of CPOE ***(step 1)***

Pc = Proportion of *total medication orders processed through a CPOE system* ***(step 2)***

- *Step 4:* Absolute reduction in medication error frequency resulting from using CPOE to process medication orders

$$Ra = Ot \cdot Mn \cdot Rp$$

Ra = Absolute reduction in medication errors due to CPOE

Ot = Total number of medication orders processed annually in U.S. hospitals ***(step 2)***

Rp = Percent reduction in medication errors due to CPOE ***(step 3)***

Mn = Medication error rate in settings without CPOE ***(step 1)***

Steps 3 & 4: National Estimates of Medication Error Reduction Methods – Estimate Bounds

- Probability-based bounds not realistic
- Based on logical assumptions about variability in underlying statistics
- Bounds set as follows:
  - Rx orders: reported sampling variance from ASHP survey
  - CPOE Adoption
    - Lower: set to 0 for all non-reporting hospitals
    - Upper: set to 1 for all non-reporting hospitals
- CPOE Implementation
    - Lower: set to 0 for non-responders and lower value of reported range for responders
    - Upper: set to mean for non-responders and upper value of reported range for responders
- Summary statistics re-calculated using upper and lower estimates

Steps 3 & 4: National Estimates of Medication Error Reduction Findings

Step 3

Percentage reduction in medication error frequency resulting from using CPOE to process medication orders

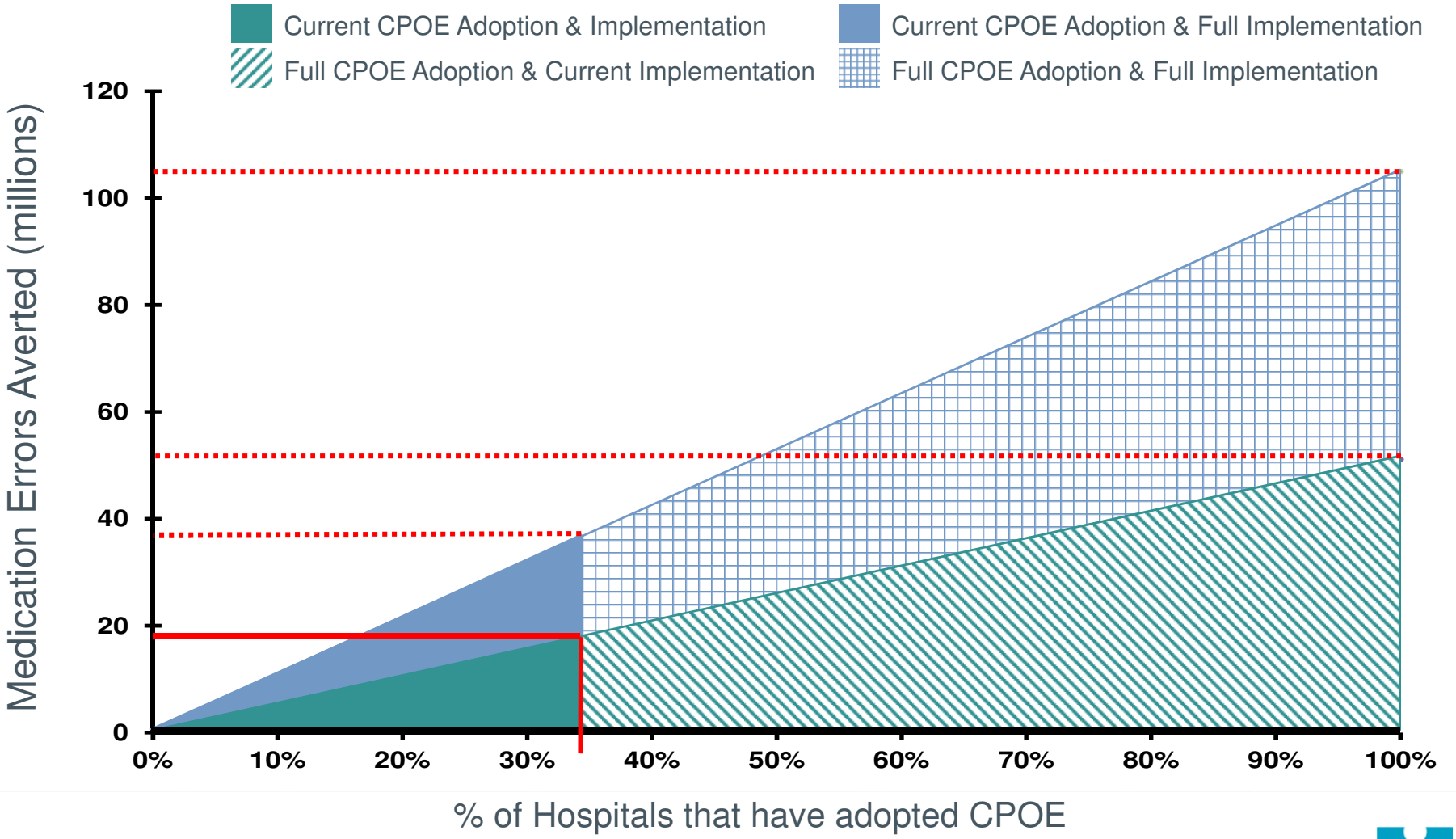
Step 4

Absolute reduction in medication error frequency resulting from using CPOE to process medication orders

Summary

		Point Estimate	Estimate Bound
Step 1	Average percent (%) reduction in medication error rates conditional on using CPOE to prescribe the order	-48%	(-55% *to* -41%)
Step 2	Proportion of medication orders that are ordered using a CPOE system	26.1%	(16.0% *to* 53.6%)
Step 3	*Percentage* reduction in medication error frequency	-12.5%	(-14.6% *to* -10.6%)
Step 4	*Absolute* reduction in medication error frequency	17,390,443	(88,058 *to* 27,094,038)

Findings: What if…?



Limitations

- Authors' definition of medication error varies between studies
- No risk-adjustment
- Unobservable factors could explain study-specific effect
- Estimate bounds are wide
  - Conservative estimation approach
  - Weights on pooled data from literature review
  - Extreme bounds for CPOE adoption and implementation

Conclusions

- CPOE appears to be an effective strategy for reducing medication errors in hospitals
- The use of CPOE in hospitals for ordering prescription drugs is modest
- Opportunities exist to increase CPOE use that may result in fewer medication errors
- Medication errors is an important, but intermediate outcome. Additional attention should be given to assessing costs and patient health outcomes
- Effective strategy for measuring outcomes associated w/ Health IT in the absence of comprehensive data