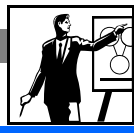
Review of Health Information System Evaluation Methodologies



Workshop Outline

TIME	TOPIC
0900	Introduction, Objectives and Expectations
0905	UVic eHealth Observatory – Models, Methods and Metrics, Part-1
0940	UVic eHealth Observatory – Models, Methods and Metrics, Part-2
1015	Nutritional Break
1030	Benefits Evaluation Experiences at Canada Health Infoway
1100	In-depth Case Study: PharmaNet-supported Medication Reconciliation
1130	Open Discussion on Experiences and Issues

1

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Introduction, Objectives, Expectations

- **Introduction**
  - Facilitator1: Francis Lau, Health Information Science, UVic
  - Facilitator2: Simon Hagens, Canada Health Infoway
  - Participant backgrounds?
- **Workshop Objectives**
  - Describe health information system (HIS) evaluation methodologies
  - Discuss HIS evaluation study findings, experiences and issues
  - Provide HIS evaluation resources and tools
  - Learn from each other
- **Participant Expectations?**
  - What (else) do you expect to get out of this workshop?

2

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UVic eHealth Observatory – Models, Methods and Metrics, Part-1

- **What is the UVic eHealth Observatory?**
- **What are the HIS Evaluation Models?**
  - Existing Infoway Benefits Evaluation (BE) framework
  - Proposed Infoway BE framework extensions?
- **What are the HIS Evaluation Methods?**
  - Study design and data collection/analysis approaches
  - Rapid response HIS evaluation methodologies
- **What are the HIS Evaluation Metrics?**
  - Infoway BE indicators for HIS quality, use and net benefits
  - Infoway BE program level indicators, others

3

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What is the UVic eHealth Observatory?

- **Overall Aim**
  - Monitor effects of HIS deployment and use in Canada
- **Specific Objectives**
  - Employ models/methods/metrics to evaluate HIS adoption/use/impact
  - Engage eHealth community in KT to synthesize/share/use knowledge
  - Build research capacity in HIS implementation/evaluation
- **Program Scope**
  - Medication management, EMR/EHR integration; care providers …
  - Secondary use in performance management
- **Contexts**
  - System related: eDrug, EMR, lab and EHR in BC and elsewhere
  - social/healthcare related: communities, organizations, domains

4

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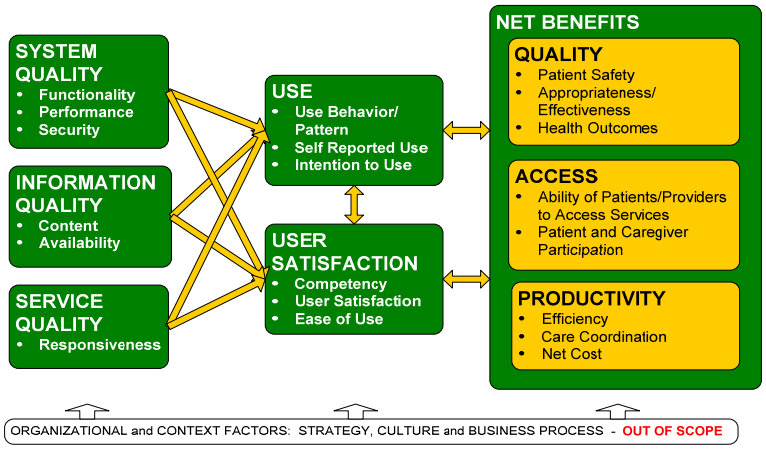
What are the HIS Evaluation Models?

Existing Infoway BE Framework



Lau et al. 2006 [1], Adapted from DeLone & McLean 2003 [2]

5

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What are the HIS Evaluation Models?

Proposed Infoway BE Framework Extensions

- **Why the Need for Extension?**
  - Original IS success model intended for stable information systems
  - Out of scope for organizational and contextual
  - Micro-view of HIS within an organization
  - Contingent factors, e.g. development, implementation, culture
  - Jurisdictions implementing HIS, with focus on adoption/use
  - Missing socio-organizational/contextual aspects

- **What Theories/Concepts/Ideas for Extensions?**
  - Information technology interaction model by Silver et al. [3]
  - Technology acceptance models by Chen, Vankatesh, others [4,5]
  - Implementation research/managing change – Kotter, Pare, others [6,7]
  - Socio-organizational and contextual issues

6

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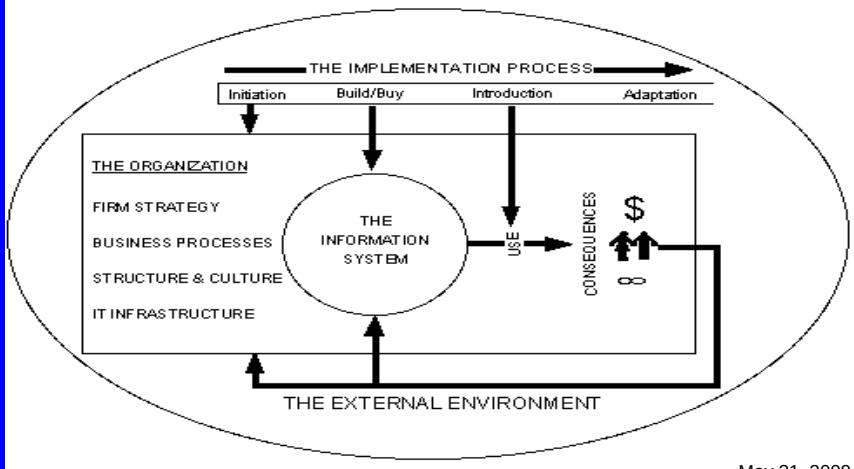
What are the HIS Evaluation Models?

IT Interaction Model by Silver et al. 1995 [3]



7

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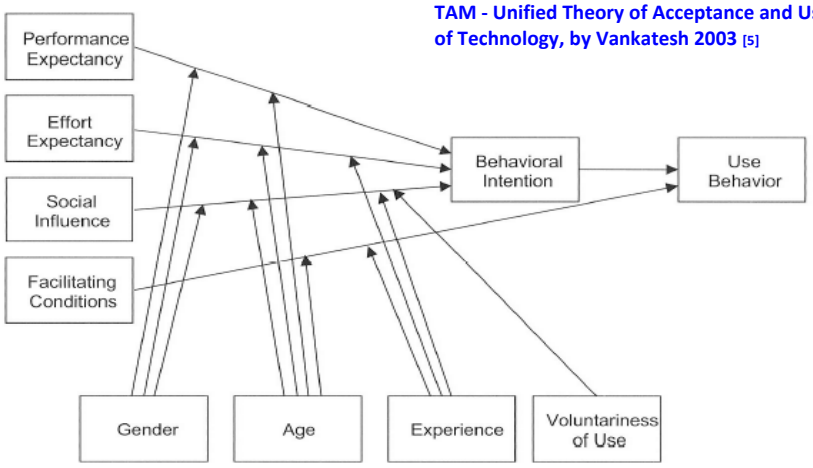
What are the HIS Evaluation Models?

Technology Acceptance Models by Lee, etc [4]

TAM - Unified Theory of Acceptance and Use of Technology, by Vankatesh 2003 [5]



8

What are the HIS Evaluation Models?

Organizational Change by Kotter 1979, 2003, 2007 [6]

1. Establishing a Sense of Urgency
2. Forming a Powerful Guiding Coalition
3. Creating a Vision
4. Communicating the Vision
5. Empowering Others to Act on the Vision
6. Planning for and Creating Short-term Vision
7. Consolidating Improvements and Producing More Changes
8. Institutionalizing New Approaches

9

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What are the HIS Evaluation Models?

HIS Project Risk Factors by Pare et al. 2008 [7]

- **Technological**
  - Introduction of new technology
  - Complex/unreliable technical infrastructure
  - Complex software solution
  - Poor software performance
- **Human/User**
  - Unrealistic expectations
  - Overall resistance to change
  - Lack of user cooperation/commitment
  - Poor computer skills
  - Prior negative experience with CIS projects
- **Usability**
  - Poor perceived system ease of use
  - Poor perceived system usefulness
  - Misalignment of system with local practice
- **Project Team**
  - Changes to membership on team
  - Poor project leadership
  - Lack of knowledge, role definitions
  - Negative attitude of team members
- **Project**
  - Large/complex project, ambiguity
  - Requirement changes, lack of resources
  - Lack of project management method
- **Organization**
  - Lack of upper management commitment
  - Organizational/environment instability
  - Lack of personnel knowledgeable in IT
- **Strategic/political**
  - Misalignment of objectives/stakes
  - Political games/conflicts
  - Unreliable partners

10

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What are the HIS Evaluation Models?
Socio-organizational/Contextual Aspects

- Policy – Governance, accountability
- Legislations – PIPEDA, FOIPPA, e-Health Act, Health Information Act
- Standards – HL7v3/CDA, vocabularies, ISO-13606/27799, etc.
- Funding/Incentives – POSP, PITO, salary vs. fee-for-service
- Professional Practices – Nurse practitioners, pharmacist prescribing, primary health care charter, shared care
- Others

11

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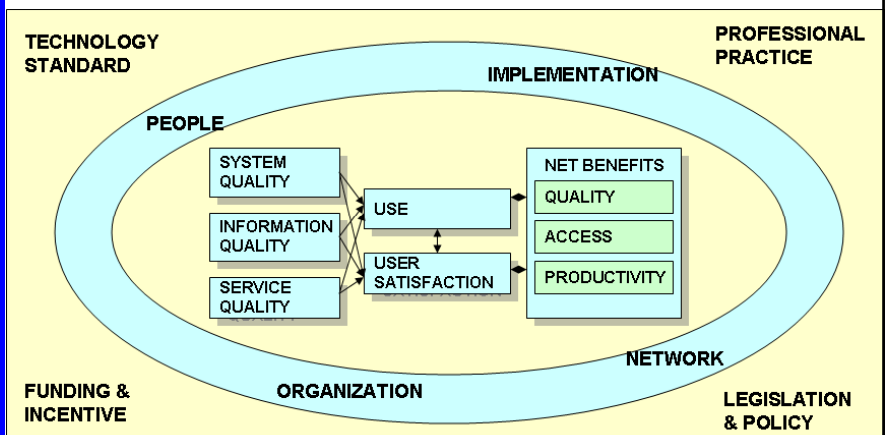
What are the Evaluation Models?
Proposed Infoway BE Framework Extensions

Extended **Infoway BE Framework for HIS *in Contexts*** [8]



12

What are the Evaluation Models?

Proposed Infoway BE Framework Extensions

Integrated Micro, Meso and Macro Views of HIS Deployment/Use

- **Micro View**
  - *HIS quality:* system, information and service quality
  - *Use/satisfaction*: use and user satisfaction
  - *Net benefits:* care quality, access and productivity
- **Meso View**
  - *People:* characteristics, performance/effort, social influence and facilitating conditions
  - *Organization*: type/fit of structure, culture, strategy, process and infrastructure
  - *Network:* range/depth of alliances, partners, affiliate and governance
  - *Implementation:* type/intensity of process, changes and risks
- **Macro View**
  - *Technology standard:* range of data, messaging and terminology standards
  - *Funding/incentive:* type of remuneration and investment available
  - *Legislation/policy:* legislative acts, regulations and policies on HIS design and use
  - *Professional practice:* roles/responsibilities and practice standards for HIS use

13

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What are the HIS Evaluation Methods?

- **Study Design Approaches**
  - Interventional: randomized vs. non-randomized trials
  - Observational: cross-sectional survey, case control, cohort studies
  - Others: descriptive, case studies/series, exploratory
- **Data Collection/Analysis Approaches**
  - Subjective vs. objective: satisfaction vs. lab results (e.g. hemoglobin)
  - Prospective vs. retrospective: using new vs. historical data
  - Quantitative vs. qualitative: e.g. 1, 2, 3.5 vs. "feeling depressed"
  - Data collection: survey (e.g. questionnaire, one-on-one or group interview), observation, focus group, parametric data (e.g. lab results, measurements)
  - Descriptive vs. inferential statistics: frequency counts vs. hypothesis testing
  - Qualitative analysis: thematic analysis, grounded theory
  - Others: simulation, economic evaluation, meta-analysis ….

14

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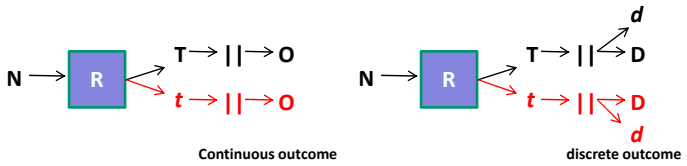
What are the HIS Evaluation Methods?

Interventional Trials – RCT Design

- **Randomized controlled studies** [9-11]
  - Individual vs. cluster randomization, by patient, family, provider, clinic …
  - Allocation concealment: done by others at time of randomization
  - Blinding of subjects: early vs. delayed, or partial blinding
  - Follow-up/missing data: including dropouts, imputation for missing data
  - Sample size/power: based on events, clusters, dropouts, effect size
  - Statistical analysis: intention-to-treat principle



15

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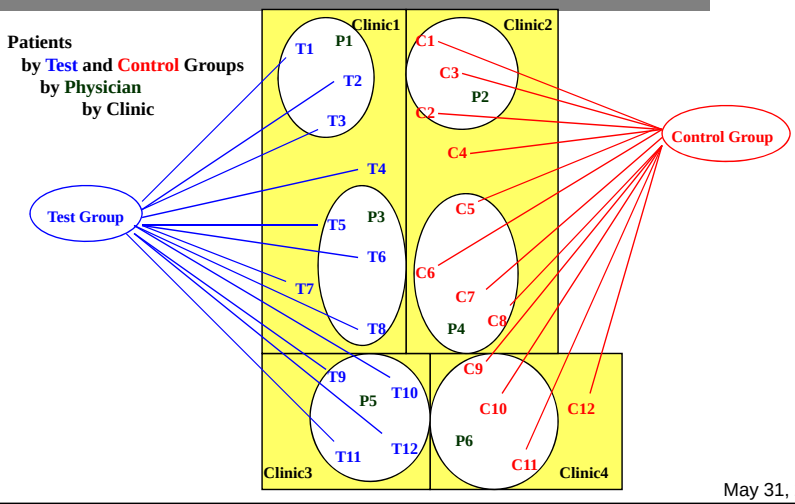
What are the HIS Evaluation Methods?

Interventional Trials – Cluster RCT Design [10]



16

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	Quasi-experimental Study Designs [10]	Design Notation
A	**Quasi-experimental without control groups**	
	1. One-group posttest-only	X O1
	2. One-group pretest-posttest	O1 X O2
	3. One-group pretest-posttest with double pretest	O1 O2 X O3
	4. One-group pre-post, nonequivalent dependent variable	(O1a,O1b) X (O2a,O2b)
	5. Removed-treatment	O1 X O2 O3 removeX O4
	6. Repeated-treatment	O1 X O2 removeX O3 X O4
B	**Quasi-experimental with control group but no pretest**	
	1. Posttest-only with nonequivalent groups	Intervention group: X O1 Control group: O2
C	**Quasi-experimental with control groups and pretests**	
	1. Untreated control group, dependent pre-post samples	Intervention: O1a X O2a Control: O1b O2b
	2. Untreated control, dependent pre-post, double pretest	Intervention: O1a O2a X O3a Control: O1b O2b O3b
	3. Untreated control, dependent pre-post, with switching	Intervention: O1a X O2b O3b Control: O1b O2b X O3b
D	**Interrupted time-series**	
	1. Multiple pre-post observations at equal time intervals	O1 O2 O3 O4 O5 X O6 O7 …

17

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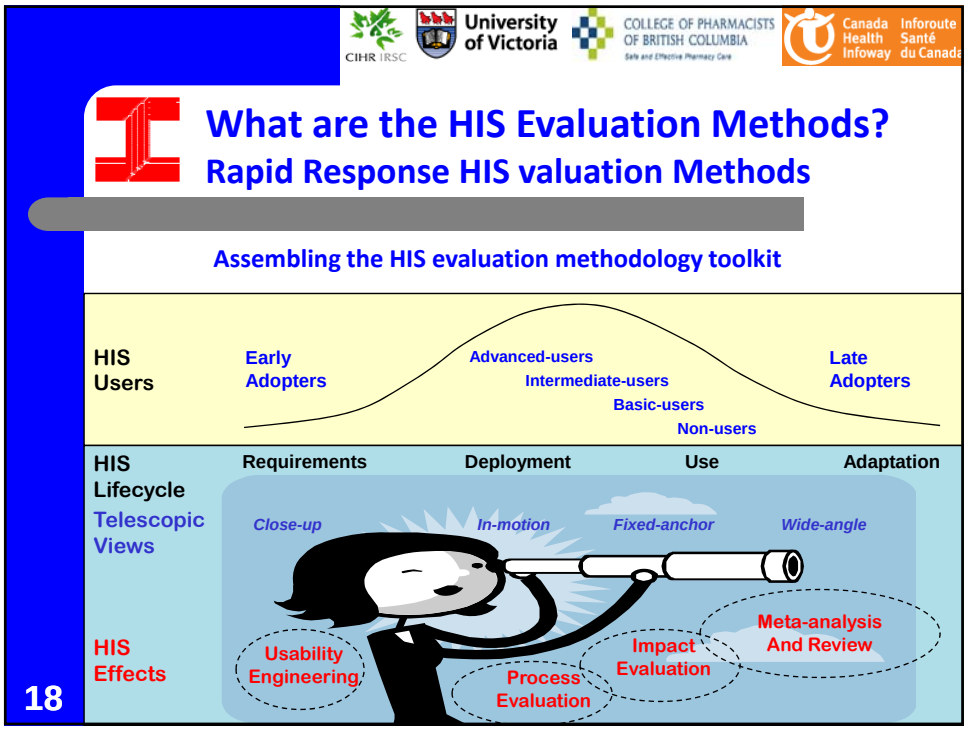

What are the HIS Evaluation Metrics?

Infoway BE HIS Quality/Use Indicators [1]

System Quality
- Performance - response time for standard tasks, Reliability
- Integration with workflow
- User friendliness
- Security

Information Quality
- Completeness / accuracy of information – medication profile, DI & lab results
- Timeliness and relevance of information

Service Quality
- Training and support

Use
- Frequency of use
- Frequency of use by patient
- Intention to increase use

User Satisfaction
- Perceived usefulness and value
- Perceived impact on productivity and integration with workflow
- Perceived impact on quality of care

19

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What are the HIS Evaluation Metrics?

Infoway BE HIS Net Benefits Indicators [1]

Change in patient safety
- Medication errors and Adverse Drug Events

Change in health system outcomes
- Readmission rates
- Efficiency of recovery
- Patient transfers

Change in provider effectiveness / appropriateness of care
- Access to information
- Timeliness of service delivery, pharmacists, public health, referring physicians, radiologists
- Vaccination rates, Outbreak detection and intervention

Change in access to services
- Volume of service provision
- Access to previously unavailable services
- Timeliness of DI services

Change in patient and caregiver participation
- Patient awareness and adherence

Change in provider efficiency
- Radiology Technologist and Radiologist efficiency
- Pharmacists and Lab technician callbacks
- Time to take medication history or assess patient
- Clinician workflow

Change in coordination of care
- Information sharing among different providers
- Management of outbreaks

Change in net costs
- Unnecessary events: radiology, lab tests, vaccinations

20

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What are the HIS Evaluation Metrics?

Infoway BE Program Level Indicators , Others

- **Diagnostic Imaging**
  - Efficiency improvements for staff
  - Improved turnaround time of test results
  - Reduced test duplications
- **Drug**
  - Improved medication patient assessment and history taking
  - Pharmacist call-back to prescribing physicians
  - Reduced medication errors and adverse drug events
- **Lab**
  - Improved turnaround time of test results
  - Reduced test duplications
  - Completeness of lab profiles
- **Other Indicators?**
  - Infoway BE Indicators Technical Report version 1.0, Sep 2006 [12]
  - Cusack et al. AHRQ Evaluation Toolkit Data Exchange Projects, n.d. [13]

21

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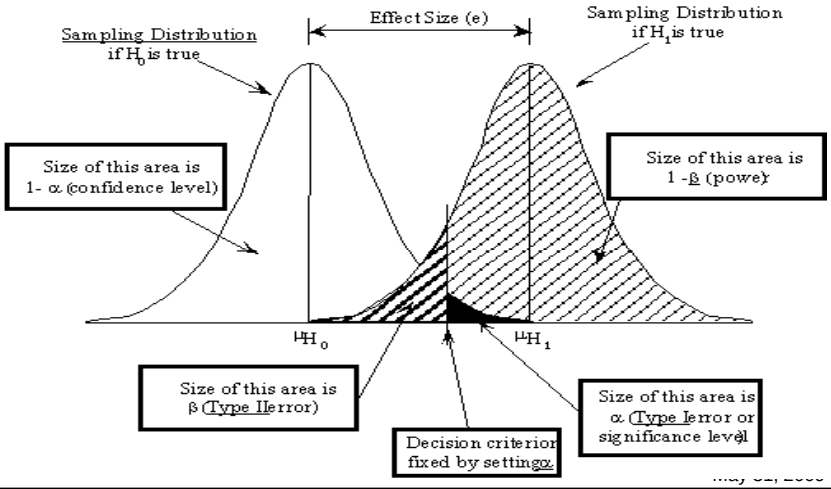
What are the HIS Evaluation Metrics?

Statistical Significance, Power, Effect Size [14]



22

What are the HIS Evaluation Metrics?

Odds Ratio, Relative Risk, Risk Difference [15]

Trial Result	Event	No event	Total
Intervention	A	B	N1 = A+B
Control	C	D	N2 = C+D

OR, RR			
Odds ratio =	Odds of event in intervention group = Odds of event in control group	A/B C/D	AD BC
Relative risk =	Risk of event in intervention group = Risk of event in control group	A/(A+B) C/(C+D)	

RD		
Risk difference =	Risk of event in intervention group – risk of event in control group =	A/(A+B) – C/(C+D)

23

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What are the HIS Evaluation Metrics?

Sensitivity, Specificity, LR +/-ve, PPV, NPV [16]

Test results	With disease	Without disease	Participants
Positive test	True positives	False positives	Total positive
Negative test	False negatives	True negatives	Total negative
	Total with disease	Total without disease	

Diagnostic accuracy	Equation
Sensitivity	No. of true positives / total with disease
Specificity	No. of true negatives / total without disease
Likelihood ratio +ve	Sensitivity / (1 - specificity)
Likelihood ratio -ve	(1 - sensitivity) / specificity
Positive predictive value	No. of true positives / total positive
Negative predictive value	No. of true negatives / total negative

24

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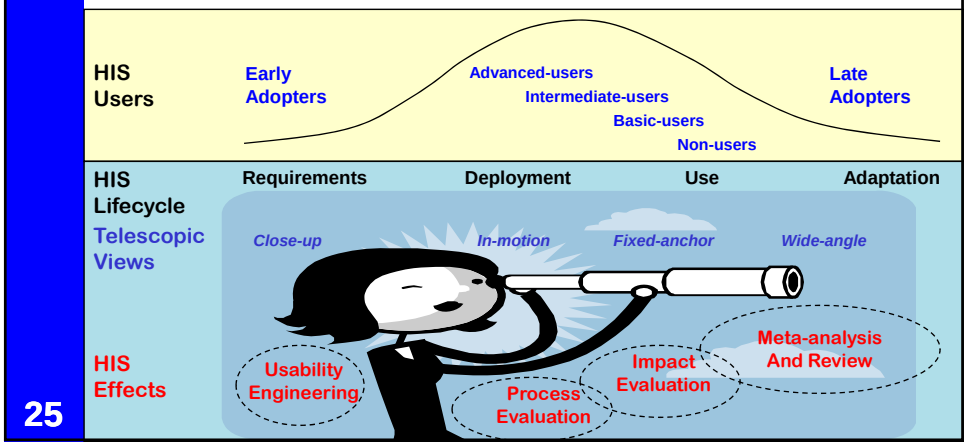
UVic eHealth Observatory – Models, Methods and Metrics, Part-2

Assembling the HIS evaluation methodology toolkit



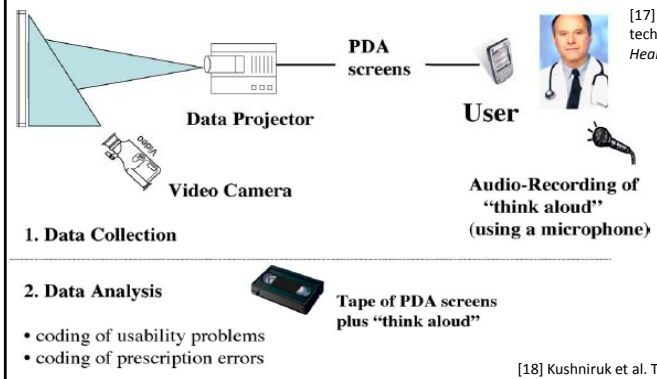
25

Usability Engineering

Usability Testing/Inspection

Figure 1. Steps in the Usability-Based Assessment of Technology-Induced Error in Healthcare.

	Activities
Step One	Select representative users
Step Two	Select representative tasks
Step Three	Develop scenarios
Step Four	Select equipment and recording methods
Step Five	Collect video, computer screens and audio data
Step Six	Qualitatively code transcripts and quantify qualitative data



[17] Borycki et al. Identifying and preventing technology induced error using simulation. *Healthcare Q* 2005;8:99-106.

[18] Kushniruk et al. Technology induced error and usability. *IJMI* 2005;74:519-26.

Fig. 1 Portable handheld usability laboratory.

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Rapid Response Evaluation Methods

Process Evaluation – *Workflow Analysis*

[19] Bell et al. Conceptual framework for electronic prescribing systems. *JAMIA* 2004;11(1):63-74.

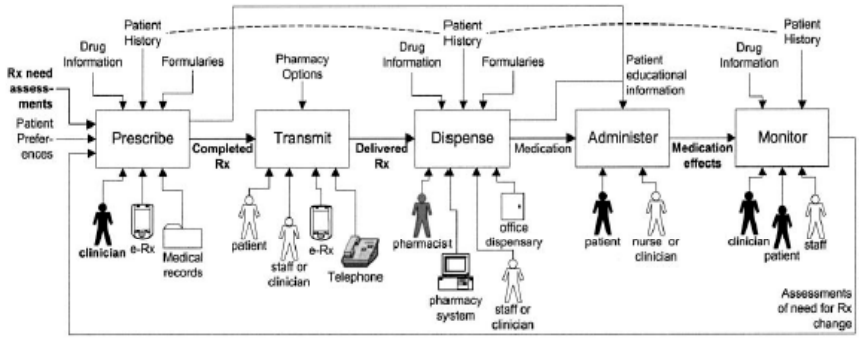

Figure 1. A function model of medication management. The major activities involved in medication management are shown as boxes. For each box, arrows on the left show the activity's inputs, those on the right show its outputs, those above show information that may influence the activity's performance, and those below show resources that the activity may occupy. This notation is based informally on the Integrated Definition for Functional Modeling (IDEF0).[79] In addition, the dashed lines indicate the potential unifying effects of system integration, making the same patient data available across activities. Black shading or bold lettering indicates an element that is mandatory for the particular activity. Gray shading indicates an element that is usually involved in the activity but is not mandatory. "e-Rx" is an abbreviation for electronic prescribing.

27

Rapid Response Evaluation Methods

Process Evaluation – *Time-Motion Study*

[20] Hollingworth. Impact of e-Prescribing on prescriber/Staff time. *JAMIA* 2007;14(6):722-30

- **Question/Scope**
  - What is the impact of e-prescribing on workflow?
  - Comparison of time-efficiency of paper vs. e-prescribing for physician/staff in clinics
- **Evaluation Design**
  - Cross-sectional comparison of 3 sites at different stages of implementation
  - Time-motion techniques to compare prescribing times at 3 ambulatory care sites
  - Comparison between paper-based prescribing, desktop or laptop e-prescribing
  - Observer timed prescriber (n=27) and staff (n=42) tasks over 4-hours
  - For optional e-prescribing, >75% events were electronic
- **Summary of Findings**
  - e-prescribers spent less time writing; time-savings offset by increased computer tasks
  - e-prescribing tasks marginally longer than hand-written prescriptions
  - e-prescribing site nursing staff spent longer in computer tasks
  - e-prescribing not associated with increase in computer and writing time for prescribers
  - ***Careful implementation of e-prescribing will NOT disrupt workflow***

28

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Table 1 ■ Characteristics of Prescribers, RNs/MAs, and Staff

	SL—Paper	HP—Desktop	SN—Laptop	Total
		Prescribers		
Consented (%)	8/10 (80%)	11/15 (73%)	8/8 (100%)	27/33 (82%)
Specialty				
Family Practice	3	4	4	11
Pediatrics	1	2	1	4
WIC	2	2	1	5
Internal Med	2	3	2	7
Females (%)	3 (38%)	3 (27%)	5 (63%)	11/27 (41%)
Mean Age in Years	44	46	46	45
Mean Hours Observed	3.54	3.61	3.81	3.65
Mean Time Unable to Observe	19.8 mins	12.7 mins	7.7 mins	13.3 mins
		Staff		
	RNs: 7 MAs: 4	RNs: 12 MAs: 9	RNs: 3 MAs: 7	RNs: 22 MAs: 20
Number Observed/Number of Potential Subjects (%)	11/21 (52%)	21/25 (84%)	10/13 (77%)	42/59 (71%)
% Female	11/11 (100%)	20/21 (95%)	10/10 (100%)	41/42 (98%)
Mean Age	44	37	49	43
Mean Hours Observed	3.52	3.61	3.77	3.62
Mean Time Unable to Observe	1.0 mins	1.9 mins	0.5 mins	1.3 mins

MA = medical assistant; mins = minutes; RN = Registered nurse; WIC = Walk-in clinic; SL = Silver Lake; HP = Harbour Pointe; SN = Snohomish.

Table 3 ■ Prescription-related Events (Prescribers)

	Hand Written Prescription Event Seconds per Event (n)	e-prescription Event Seconds per Event (n)	Adjusted Mean Difference*
SL—Paper	47.6 (68)	N/A (0)	—
HP—Desktop	38.1 (26)	43.6 (79)	9.5 (−9.8, 28.8)
SN—Laptop	63.1 (10)	72.5 (59)	9.8 (−23.4, 43.1)
All Sites	46.7 (104)	56.0 (138)	12.0 (−1.6, 25.6)
New Prescriptions	45.6 (88)	61.2 (80)	15.4 (−10.4, 41.2)
Renew Prescriptions	52.9 (16)	48.7 (58)	4.0 (−17.9, 26.0)

SL = Silver Lake; HP = Harbour Pointe; SN = Snohomish.
*Mean additional time spent for an e-prescription compared to a handwritten prescription calculated from the linear mixed effects model adjusting for prescriber and type of prescription (new/renew).

Table 2 ■ Prescribers' Time Spent on Specific Task Categories*

Task Category	SL—Paper Mins. per Hr (n = 8)	HP—Desktop Mins. per Hr (n = 11)	SN—Laptop Mins. per Hr (n = 8)	Weighted Mean Difference (95% CI) Between e-prescribing and Paper-based Sites Mins. per Hr
Computer Tasks	3.8	7.4	8.1	3.9 (0.3, 7.5)†
Writing Tasks	8.7	5.5	5.9	−3.0 (−5.6, −0.2)†
Computer and Writing Tasks, combined†	12.4	12.9	14.0	1.0 (−3.4, 5.3)
Talking to Patient or Family	19.0	17.8	20.3	−0.1 (−5.5, 5.2)
Talking Colleague/Other	6.6	11.6	8.2	3.6 (−0.2, 7.3)
Examining Patient	8.9	4.9	5.3	−3.8 (−5.8, −1.9)†
Examine Chart/Other	6.1	5.7	5.3	−0.6 (−2.7, 1.5)
Other Tasks—Total				0.2 (−3.2, 3.6)
Procedure	2.1	1.5	1.9	
Phone Colleague/Other	0.5	1.0	1.0	
Walking	1.3	1.0	1.5	
Looking For	0.5	0.9	0.7	
Phone Patient	0.3	1.2	1.0	
Other	1.3	1.6	0.8	

SL = Silver Lake; HP = Harbour Pointe; SN = Snohomish.
*We provide detail on task categories that took up ≥7.5% of time at one or more site. Other tasks are grouped as 'other'.
†$p < 0.05$.

Table 4 ▪ Staff Time Spent on Specific Task Categories*

Task Category	Registered Nurses SL—Paper Mins. per Hr (n = 7)	Registered Nurses HP—Desktop Mins. per Hr (n = 12)	Registered Nurses SN—Laptop Mins. per Hr (n = 3)	Weighted Mean Difference (95% CI) Mins. per Hr	Medical Assistants SL—Paper Mins. per Hr (n = 4)	Medical Assistants HP—Desktop Mins. per Hr (n = 9)	Medical Assistants SN—Laptop Mins. per Hr (n = 7)	Weighted Mean Difference (95% CI) Mins. per Hr
Computer Tasks	12.1	17.8	16.1	5.4 (0.0, 10.7)†	5.9	9.7	8.9	3.4 (−0.1, 7.0)
Writing Tasks	4.7	3.9	3.3	−0.9 (−2.5, 0.7)	4.5	5.3	2.4	−0.4 (−6.2, 5.4)
Computer and Writing Tasks, combined*	16.9	21.7	19.4	4.4 (−2.2, 11.0)	10.4	15.0	11.3	3.0 (−1.9, 7.9)
Talking Colleague/Other	8.4	7.9	7.2	−0.7 (−5.0, 3.5)	12.9	15.7	7.4	−0.8 (−7.8, 6.2)
Examine Chart/Other	4.6	6.2	2.0	0.8 (−2.1, 3.6)	3.9	10.3	7.8	5.3 (0.6, 9.9)‡
Phone Colleague/Other	5.4	8.0	7.2	2.4 (−1.7, 6.5)	3.0	4.3	3.8	1.1 (−2.1, 4.3)
Walking	4.4	3.9	2.3	−0.9 (−2.5, 0.7)	5.7	6.1	5.6	0.2 (−3.1, 3.5)
Talking to Patient or Family	3.5	0.8	3.3	−2.2 (−5.1, 0.7)	3.5	0.7	10.3	1.4 (−2.2, 5.0)
Phone Patient	7.1	6.5	7.5	−0.4 (−4.7, 3.8)	0.9	0.1	2.1	0.1 (−1.9, 2.1)
Procedure	2.5	3.1	6.9	1.3 (1.5, 4.2)	3.1	1.9	5.9	0.6 (3.5, 4.7)
Other, miscellaneous	7.2	2.1	4.2	−3.4 (−5.1, −1.7)‡	16.7	5.9	5.9	−10.8 (−27.0, 5.5)
Prescription or formulary related fax or phone call	1.2	1.0	1.3	−0.2 (−1.3, 1.0)	0.3	1.0	0.8	0.6 (−0.4, 1.5)

SL = Silver Lake; HP = Harbour Pointe; SN = Snohomish.
*We provide detail on task categories that took up ≥7.5% of time at one or more site. Other tasks are grouped as 'other'.
‡P ≤ 0.05.

31

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Rapid Response Evaluation Methods

Impact Evaluation – *Randomized Trial*

[21] Sequist. Randomized trial of clinical reminders to improve care. *JAMIA* 2005;12(4):431-7

- **Question/Scope**
  - What is the impact of clinical reminders on diabetes+CAD care and physician attitudes?
  - Integrated patient-specific electronic clinical reminder system
- **Evaluation Design**
  - Randomized primary care clinics with EMR+reminders or usual care
  - 194 physicians, 4549 diabetic patients, 2199 CAD patients, 20 ambulatory clinics
  - Primary outcome: receipt of recommended care for diabetes and CAD
  - Summary outcome: odds of increased compliance, diabetes x5 and CAD x4 measures
  - Physician survey on attitudes towards reminder system
- **Summary of Findings**
  - Baseline adherence rates to quality measure were low
  - Reminders increased odds of recommended care, but individual impact variable
  - 3 of 9 reminders increased rates of recommended care
  - 76% physicians thought reminders improved quality of care
  - ***Integrated electronic reminders led to variable improvement in diabetes+CAD care***

32

May 31, 2009

Table 1 ■ Baseline Patient and Physician Characteristics among Enrolled Patients with Overdue Recommendations

	Intervention	Control	p-Value
Patient characteristics	(n = 2924)	(n = 3319)	
Mean age, yr (± SD)	62.4 (±14)	65.3 (±14)	<0.001
Male (%)	1201 (41)	1529 (46)	<0.001
Race (%)			
White	1588 (54)	2114 (64)	<0.001
Black	464 (16)	414 (12)	
Hispanic	631 (22)	304 (9)	
Asian	35 (1)	87 (3)	
Other	49 (2)	58 (2)	
Unknown	157 (5)	342 (10)	
Insurance (%)			
Medicare	1425 (49)	1760 (53)	<0.001
Medicaid	501 (17)	345 (10)	
Commercial	936 (32)	1157 (35)	
Other	61 (2)	55 (2)	
Physician characteristics	(n = 92)	(n = 102)	
Mean age, yr (± SD)	39.2 (± 10)	41.4 (± 11)	0.15
Male (%)	32 (35)	49 (48)	0.06

SD = standard deviation.

Table 3 ■ Primary Care Physician Attitudes Regarding Guideline Adherence and Electronic Clinical Decision Support

	No. of Physicians Agreeing (%)
Barriers to guideline adherence*	
Lack of time during patient visit	81 (51)
Patient noncompliance or refusal of treatment	66 (42)
Lack of knowledge of specific guideline recommendation	64 (40)
Lack of awareness of guideline existence	61 (38)
Disagree with guideline recommendation	54 (34)
Agree with guideline, but forgot to apply during office visit	42 (26)
Lack of reimbursement for services	8 (5)
Electronic clinical decision support†	
Notice electronic reminders during a patient encounter	60 (38)
Electronic reminders prompt physician to take specific action	55 (35)
Electronic reminders useful for diabetes disease management‡	53 (68)
Electronic reminders useful for coronary artery disease management‡	41 (53)
Electronic reminders improve quality of patient care	121 (76)

*Defined as either moderately (3) or extremely (4) significant on a 4-point Likert scale.
†Defined as at least 5 on a 7-point Likert scale.
‡Among physician respondents in the intervention group (n = 78).

Table 2 ■ Baseline Adherence Rates in the Entire Population and Impact of Electronic Reminders in the Enrolled Population for Diabetes and Coronary Artery Disease Care

	Baseline Adherence, No. (% of total population)*	Enrolled Patient Population, No. (% of total population)†	Hazard Ratio for Intervention (95% CI)	p-Value
Diabetes				
Annual cholesterol exam	4957 (58)	1185 (14)	1.41 (1.15–1.72)	<0.001
Biennial hemoglobin A1c exam	4868 (57)	2245 (26)	1.14 (0.89–1.46)	0.29
Annual dilated eye exam	1464 (17)	4049 (47)	1.38 (0.81–2.32)	0.23
Hypertension/ACE inhibitor use	2761 (62)	711 (16)	1.42 (0.94–2.14)	0.10
Statin use for LDL cholesterol ≥130 mg/dL	476 (31)	595 (38)	1.10 (0.65–1.85)	0.73
Coronary artery disease				
Annual cholesterol exam	5039 (53)	1151 (12)	0.99 (0.75–1.29)	0.92
Aspirin use	2883 (41)	669 (9)	2.36 (1.37–4.07)	0.002
Beta-blocker use	2701 (38)	808 (11)	1.09 (0.72–1.63)	0.69
Statin use for LDL cholesterol ≥130 mg/dL	495 (28)	385 (21)	1.51 (1.05–2.17)	0.03

CI = confidence interval (adjusted for baseline patient and physician characteristics, as well as for clustering within clinics and the presence of a paper reminder system); ACE = angiotensin-converting enzyme; LDL = low-density lipoprotein.
*This column includes baseline adherence data for the entire population of patients with diabetes or coronary artery disease. To be enrolled, patients had to meet the criteria of (1) nonadherence to at least one quality measure during the study period and (2) primary care physician receiving a reminder during the study period.
†This column includes combined (intervention and control arm) sample sizes for patients enrolled in the study, as well as the proportion of the total population represented by each sample size. Enrolled patients met the criteria of (1) nonadherence to at least one quality measure during the study period and (2) primary care physician receiving a reminder during the study period.

Rapid Response Evaluation Methods

Impact Evaluation – *Observational Cohorts*

[22] Staes. Computerized alerts improve outpatient lab monitoring. *JAMIA* 2008;15(3):324-32

- **Question/Scope**
  - Impact of computerized alerts on quality of lab monitoring of transplant patients?
  - Outpatient laboratory, liver transplant patients
- **Evaluation Design**
  - Observational study, traditional lab result reporting vs. computerized alerts
  - 356 outpatient liver transplant patients; alerts within EHR for clinicians
  - Alerts of new results, overdue orders for creatinine and immunosupression drug levels
- **Summary of Findings**
  - Completeness of reporting increased from 66 to >99%
  - Positive predictive value of report including new info increased from 46 to >99%
  - Timeliness of reporting and clinician responses improved significantly (p<0.001)
  - Median times to receive/complete actions dropped from 33 to 9 hours
  - ***Computerized alerts led to more efficient, complete and timely management of lab information***

35

May 31, 2009

Table 2 ▪ Timeliness of Traditional Process and Computerized Alerts for Reporting Outpatient Intermountain Healthcare Laboratory Results

	Intermountain facility	Traditional reporting with faxes, printouts and mailed reports			Computerized alerts			
		N	median # hrs	range*	n	median # hrs	range*	p value
		Specimen collected → nurse started reviewing results			*Specimen collected → nurse completed actions*			
	Total Time	145	33.4	(25.8 – 58)	2106	9.2	(4.3 – 28)	
Reporting Time		*Specimen collected → Report arrived†*			*Specimen collected → Alert arrived§*			
Creatinine	LDS Hospital	48	1.5	(0.9 – 7.6)	567	0.8	(0.6 – 1.1)	<.001
	Other	29	7.2	(3.9 – 24.2)	475	1.3	(0.9 – 1.8)	<.001
Tacrolimus	LDS Hospital	38	7	(3.6 – 24)	572	3.5	(2.4 – 4.9)	<.001
	Other	25	25.6	(22.7 – 47.3)	452	17.4	(12 – 24)	<.001
Cyclosporin A	LDS Hospital	2	14.8	(12.0 – 17.5)	21	3.4	(2.0 – 4.8)	0.07
	Other	3	28	(21.4 – 42.8)	19	26.1	(23.8 – 28)	0.39
Response Time		*Report arrived→ nurse reviewed result‡*			*Alert arrived → nurse completed actions§*			
Creatinine	LDS Hospital	48	22.4	(5.0 – 31.9)	567	3.5	(1.4 – 7.7)	<.001
	Other	29	19.9	(6.7 – 34.7)	475	5.6	(1.7 – 24)	.004
Tacrolimus	LDS Hospital	38	24.9	(12.2 – 34.1)	572	4.1	(1.9 – 22)	<.001
	Other	25	11.6	(6.7 – 44.8)	452	13.5	(5.1 – 35)	0.72
Cyclosporin A	LDS Hospital	2	31.1	(16.3 – 45.9)	21	4.5	(1.9 – 22)	0.3
	Other	3	32.7	(3.8 – 80)	19	4.4	(0.8 – 51)	0.6

*Reported ranges are interquartile ranges.

†For creatinine and tacrolimus tests, there was a significant difference in the paper-based reporting time from LDS Hospital vs. other Intermountain hospitals ($p < 0.002$).

‡There was no significant difference in the response time during paper-based reporting, by source of the report or type of lab test.

§Using computerized alerts, there was a significant difference in the reporting time from LDS Hospital vs. other Intermountain hospitals for each lab test ($p < 0.001$) and there was a significant difference in the response time for creatinine and tacrolimus results ($p<0.001$).

Rapid Response Evaluation Methods
Meta-analysis / Systematic Review

Topics	Reviews	HIS Features	Key Findings	Evidence
Performance Outcomes	17	Reminders, CPOE, CDS, EPR, EHR, guidelines, nursing, eHealth	Improved compliance, safety, documentation, utilization, behavior	√√√
Drugs	13	CPOE, CDS, drug dose, prescribing, safety, alert, event monitoring	Improved adherence, drug use and dosing; reduced errors, ADE, events, LOS	√√√√
Health Conditions	7	Diabetes, chronic illness, hypertension, acute chest pain/abdomen	Improved diagnosis, LOS, adherence, referral/follow-up, monitoring	√√
Data/Service Quality	5	Administrative registers, EPR, EMR, laboratory	Variable data quality, lacking gold standard; improved lab service	√
Preventive Care	4	Reminders	Improved screening and vaccination	√√√√

Total = 46 reviews

Rapid Response Evaluation Methods
Meta-analysis / Systematic Review

[23] Ammenwerth. Effect of e-prescribing on med errors/ADE: review. *JAMIA* 2008;15(5):585-600

- **Objective/Scope**
  - Relative risk reduction on medication error and adverse drug events (ADE)
  - All computerized physician order entry (CPOE) systems, drugs and clinical settings
- **Review Method**
  - Included only controlled and pretest-posttest studies
  - Calculated risk ratio with 95% confidence interval, i.e. relative risk reduction (RRR)
  - Subgroup categories by care level, patient group, drug type, system type/functionality, comparison group type, study design, method for detecting errors
- **Summary of Findings**
  - 23 of 25 studies showed significant RRR 13-99% of medication error rate
  - 6 of 9 studies showed significant RRR 35-98% of potential ADEs
  - 4 of 7 studies showed significant RRR 30-84% of ADEs
  - Higher RRR in home-grown systems, e-prescribing vs. handwriting, manual chart review
  - ***e-Prescribing can reduce risk for medication errors and ADE***

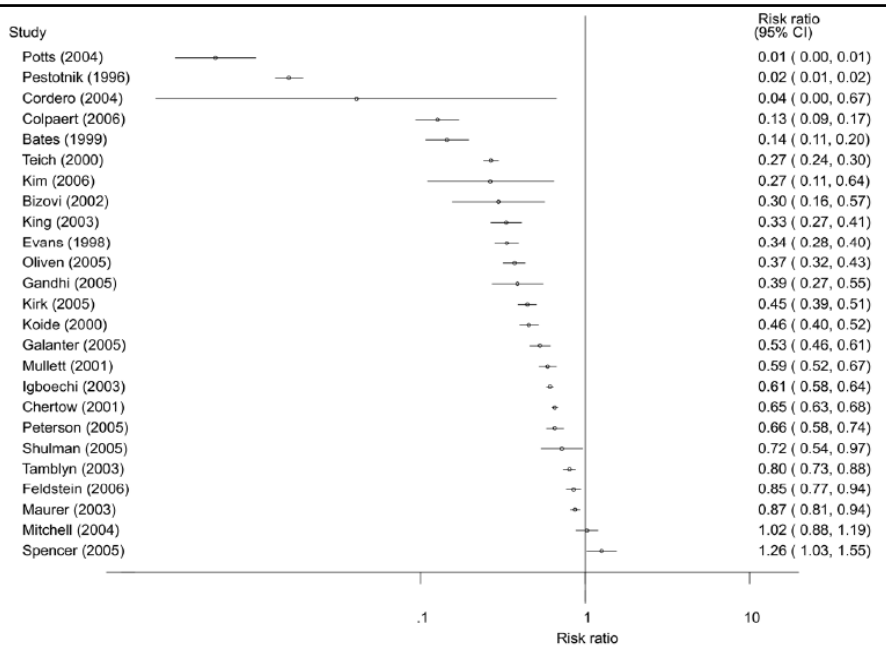

Figure 2. Risk ratios of 25 studies analyzing the effect of electronic prescribing on medication errors.

39

May 31, 2009

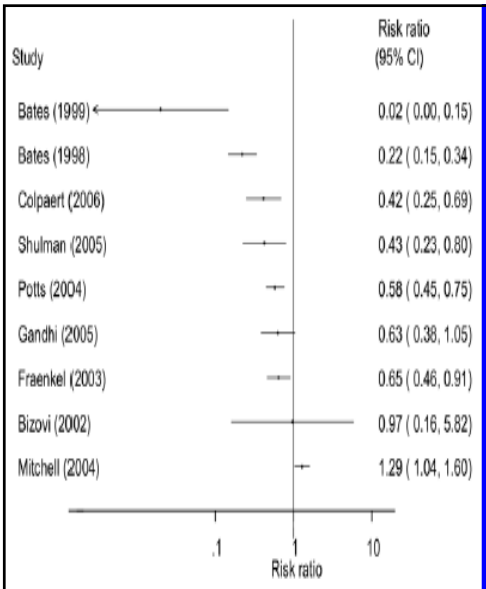

Figure 3. Risk ratios of nine studies analyzing the effect of electronic prescribing on potential ADEs.

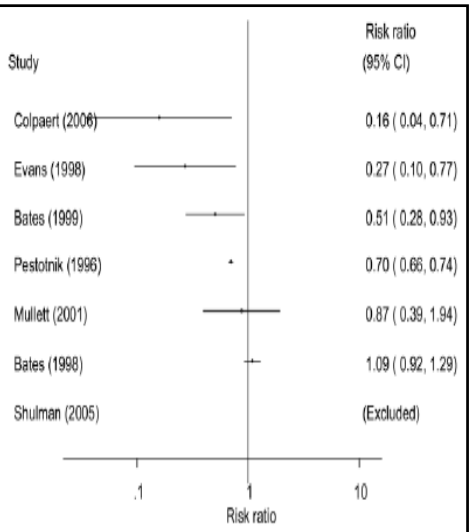

Figure 4. Risk ratios of seven studies analyzing the effect of electronic prescribing on ADEs. Shulman was excluded, because there was no event in either the intervention group or the comparision group.

40

May 31, 2009

Rapid Response Evaluation Methods

Meta-analysis / Systematic Review

[24] Garth. Effect of CDSS on performance and outcome: review. *JAMA* 2005;293(10):1223-38

- **Objective/Scope**
  - Effects of CDSS on practitioner performance and patient outcomes
  - Identifying study characteristics that predict benefit
- **Review Method**
  - Included only randomized/nonrandomized trials compared with care without CDSS
  - 10 pt quality scale 5 bias: allocation method, allocation unit, baseline differences, blinded outcomes, follow-up
  - CDSS success defined as improvement in ≥50% of all outcomes, with 2-sided p<0.5
- **Summary of Findings**
  - 100 studies met inclusion criteria; study quality improved over time
  - 62 of 97 (64%) studies had improved practitioner performance
  - 4/10 diagnostic, 16/21 reminder, 23/37 disease management, 19/29 drug dosing
  - 7 of 52 (13%) studies had improved patient outcomes
  - Improved performance with auto-prompts and authors as CDSS developers
  - ***CDSS improve practitioner performance, but effects on patient outcomes inconsistent***

41

May 31, 2009

Table 5. Trials of Computer-Assisted Management for Other Active Health Conditions*

Source	Methods Score	No. of Sites	Indication	Performance Outcomes	Patient Outcomes	Improvement in Practitioner Performance†	Improvement in Patient Outcomes†
Petrucci et al,[66] 1991	7	2	Recommendations for nurse management of urinary incontinence in nursing homes	Nurse knowledge of incontinence	Rate of urinary incontinence	Yes	Yes
Rubenstein et al,[67] 1995	8	1	Detection and management of functional status impairments in outpatients; patient self-reported information was collected for computer-assisted system	Physician recognition of functional status problems, recommended interventions undertaken to improve patient functioning	Functional status (physical, psychological, and social) at 6 mo as measured by questionnaire	Yes	No
Safran et al,[68] 1995	6	1	Screening, treatment, and management recommendations for outpatients with human immunodeficiency virus infection	Vaccination, ophthalmologic referral, CD4 cell count and blood cell count, *Pneumocystis jiroveci* prophylaxis	Need for physician visits; emergency and hospital admission; mortality	Yes	No
Dexter et al,[69] 1998	10	1	Reminders to discuss and complete advanced directives in outpatients	Rates of discussions and documentation	. . .	Yes	. . .
East et al,[70] 1999	8	10	Mechanical ventilation management (respiratory evaluation, oxygenation, ventilation, weaning, and extubation) in critically ill patients with acute respiratory distress syndrome	. . .	Survival to hospital discharge, intensive care unit length of stay, barotrauma score (improved), multiorgan dysfunction score (improved)	. . .	Yes
Kuperman et al,[71] 1999	6	1	Automated physician alerts via pager for critical laboratory results for hospital inpatients	Time to ordering of treatment for critical laboratory value, time to resolution of alerting condition	Adverse events (death, cardiac arrest, transfer to intensive care unit, stroke, renal impairment) within 48 h of alerting event	Yes	No

Table 7. Trials of Computer-Assisted Anticoagulant Dosing*

Source	Methods Score	No. of Sites	Indication	Practitioner Performance Outcomes	Patient Outcomes	Improvement in Practitioner Performance†	Improvement in Patient Outcomes†
Warfarin							
Abbrecht et al,[85] 1982	6	1	Warfarin initiation in postoperative cardiac surgery inpatients	Proportion of days in therapeutic range, average number of days to achieve therapeutic INR	. . .	Yes	. . .
Carter et al,[86] 1987	6	1	Warfarin initiation for hospital inpatients	Time to achieve therapeutic stable INR	Time to hospital discharge after first dose	No	No
White et al,[87] 1987	8	2	Warfarin initiation for hospital inpatients	Time to achieve therapeutic INR, time to reach stable warfarin dose, time above therapeutic INR	Bleeding complications, hospital length of stay (improved)	Yes	Yes
White and Mungall,[88] 1991	8	1	Warfarin maintenance for outpatients	Proportion of time with therapeutic INR, need for follow-up appointments for anticoagulation adjustment	. . .	No	. . .
Poller et al,[89] 1993	8	1	Warfarin maintenance for outpatients	Proportion achieving target INR, average follow-up time for appointments needed for anticoagulation	Bleeding complications, mortality	No	No
Fitzmaurice et al,[90] 1996	6	2	Warfarin maintenance for outpatients	Proportion of time with therapeutic INR, number of follow-up appointments needed to adjust anticoagulation	Mortality, bleeding, and thrombotic complications	Yes	No
Vadher et al,[91] 1997	6	1	Warfarin initiation and maintenance for inpatients	Time to achieve therapeutic INR, time with therapeutic INR, number of supratherapeutic and subtherapeutic INR levels	Bleeding and thrombotic complications	No	No
Vadher et al,[92] 1997	6	1	Warfarin maintenance for outpatients; system used by nurse practitioner compared with training physicians in routine care	Proportion of time with therapeutic INR, number of days between INR testing, number of test measurements	Thrombotic episodes, bleeding complications	Yes	No

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Benefits Evaluation Experiences at Canada Health Infoway

Simon Hagens, Director
Benefits Realization & Quality Improvement

44

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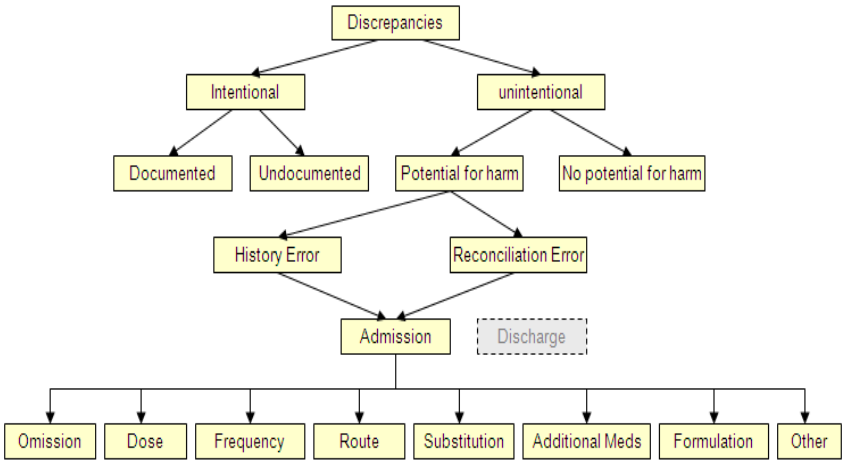
Case Study: PharmaNet-supported Medication Reconciliation - *Background*

- **Medication History Errors**
  - Tam's review on medication history errors during hospital admission [25]
  - 22 studies on 3755 patients had med history errors in 67% cases
  - 5 studies had ≥1 med history error in 27-54% of cases, 19-75% unintentional
  - 6 studies had 11-59% med history errors were clinically significant
- **Need for Medication Reconciliation**
  - Process to arrive at an accurate and complete medication list for patient
  - Done during handoff or transition: admission/transfer/discharge
  - 2005 Safer Healthcare Now! Campaign: improve patient safety by preventing adverse drug events (ADEs) at care interfaces [26]
- **PharmaNet-supported MedRec, or PharmaNet-MedRec**
  - PharmaNet1: a province-wide drug dispensing info system in BC
  - Used in hospitals during admission to reconcile patient's medications
  - New PharmaNet2 being developed with enhanced e-prescribing features

45

May 31, 2009

Case Study: PharmaNet-supported Medication Reconciliation – *Error Types* [27,28]



46

May 31, 2009

Date: 7-Apr-2006
DOB: 07-Nov-1978
Visit number: 251001042

Fork, Knife
MRN: 7002604
Letter status: In progress.

Referring physician: Generic,Physician-EM
Family physician: Generic,Physician
Attending physician: Generic,Physician

Medication Reconciliation status for [pt last name, first (MRN: 123456)]

BPMH – Best Possible Medication History
COMPLETED on [month day, year] by [Last name, first name] [Job Title]

Admission Medication Reconciliation
COMPLETED on [month day, year] by [Last name, first name] [Job Title]

Transfer Medication Reconciliation
COMPLETED on [month day, year] by [Last name, first name] [Job Title]

If any of the above not signed off, do not display status

Best Possible Medication History (BPMH)

[Pt last, first name] MRN: [MRN] was seen by a pharmacist on [Date Seen] to review and document pre-admission medications. A Best Possible Medication History (BPMH) was completed on [date BPMH completed].

MEDICATION ALLERGIES: (From the Electronic Patient Record (EPR)
[No medication Allergies]

SOURCE(S) of MEDICATION HISTORY:
[Source 1]
[Source 2]

PRE-ADMISSION MEDICATIONS:

Prescription Medications:
- [Medication 1 dose route frequency]
- [Medication 2 dose route frequency]
- [Medication 3 dose route frequency]
- [Medication 4 dose route frequency]

Clarifications/Other Issues:
[Issues]
[Issues]
[Issues]
[Issues]

Other Medications:
- [Other Med 5 dose route frequency]
- [Other Med 6 dose route frequency]

Clarifications/Other Issues:
[Issues]
[Issues]

Should only appear if selected

Community Pharmacy Information: [Community Pharmacy Info]

Additional Clarifications /Issues:
[Additional Issues]

Should only appear if Information entered in text box

[29] Fernandes. Electronic Medication Info Transfer Tool 2009.

47

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Case Study: PharmaNet-supported Medication Reconciliation – *Evaluation Study*

- **Study Questions**
  - Overall: Impact of PharmaNet-MedRec on quality of care?
  - Can it improve detection of discrepancies and reduce likelihood of ADEs?
  - What effect on provider productivity in efficiency and coordination?
- **Evaluation Design**
  - *Time series:* to compare discrepancies in 2 groups w/o PharmaNet-MedRec
  - *Usability engineering:* to examine workflow and usability issues
  - *Expert consensus:* to identify potential ADEs
- **Data Collection/Analysis**
  - Electronic MedRec tool for pharmacists/technicians
  - Record meds, reconcile meds, print lists, record discrepancies
  - Expert consensus to identify potential ADEs

48

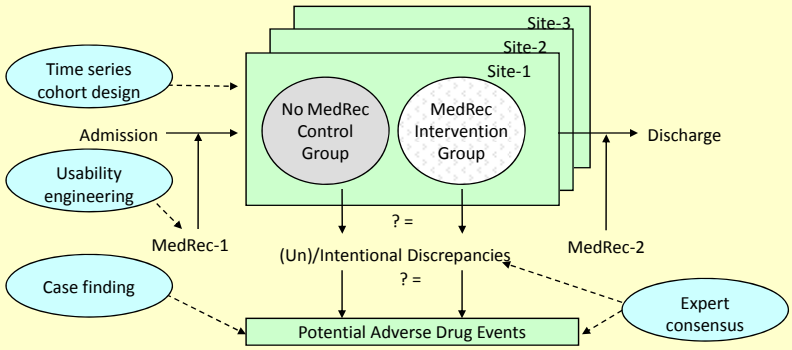
May 31, 2009

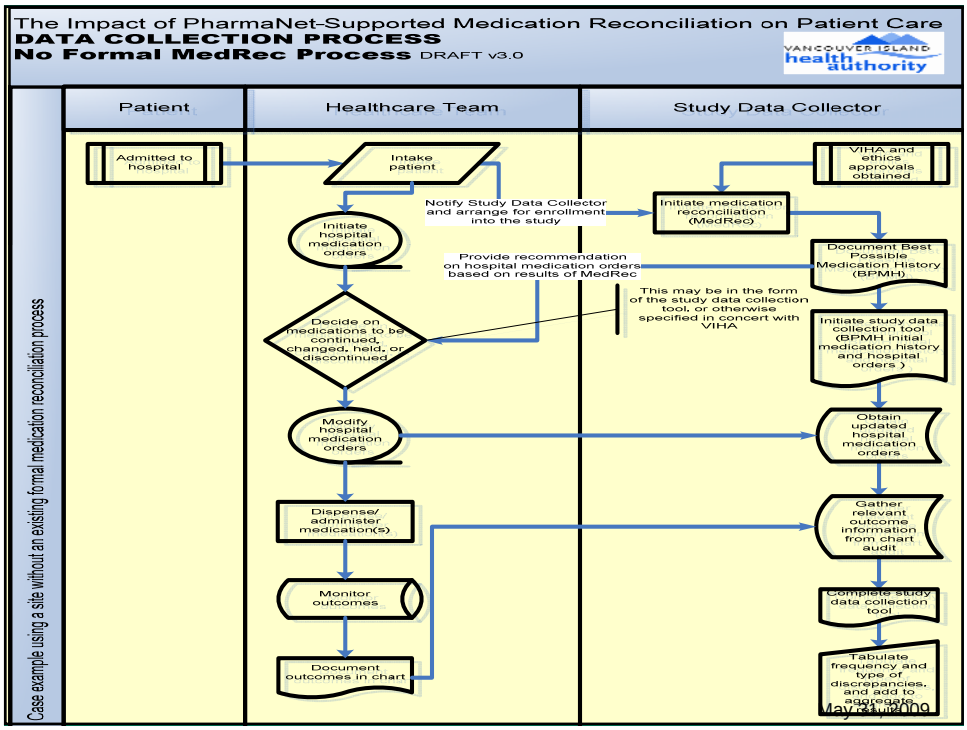
Case Study: PharmaNet-supported Medication Reconciliation - *Design*

PharmaNet-MedRec Study Phases – 6 months each →

Baseline	Implementation-1	Implementation-2	Followup-1	Followup-2

No PharmaNet → PharmaNet1 → PharmaNet2 → PharmaNet1/2 →





VANCOUVER ISLAND health authority

The Impact of PharmaNet-Supported Medication Reconciliation on Patient Care

Data Collection Tool DRAFT v3.0

Medication Reconciliation Scenario:
❒ Existing formal process ❒ No formal process ❒ Retrospective

Medication Reconciliation Done By: _____
Date: _____ Time: _____

Study Data Collected By: _____
Date: _____ Time: _____

Source of Medication Information: *(Check ALL that apply)*
❒ Review of PharmaNet *Date accessed:*
❒ Patient interview ❒ Family/caregiver interview
❒ Review of patient medication list ❒ Review of medication vials
❒ Review of physician list ❒ Phone call with physician
❒ Review previous hospital records ❒ MAR from another facility
❒ Community pharmacy list *pharmacy name:*_____
❒ Other:_____

Patient Information:
Age: _____ Gender *(circle one)*: Male/Female/Unknown
Allergies and Intolerances: _____

Diagnosis: *(Check ALL that apply)*
❒ IHD ❒ PVD ❒ CRF ❒ R. Arthritis ❒ Epilepsy
❒ Atrial fibrillation ❒ CVA ❒ ARF ❒ O. Arthritis ❒ Anxiety
❒ CHF ❒ HTN ❒ COPD ❒ Type 1 DM ❒ Depression
❒ Dyslipidemia ❒ MS ❒ Type 2 DM
❒ Other: _____

Primary Reason for Hospital Admission: _____
Date of hospital admission: _____

Resolution/Outcome Upon Hospital Discharge:_____
Date of hospital discharge: _____

INSTRUCTIONS:
- Compare the Initial Medication History to Hospital Medication Orders. These lists should encompass all medications (including prescription medications, regularly-taken non-prescription medications). This tool can be used at admission (initial = home) and at discharge (initial = inpatient).
- To complete the Best Possible Medication History (BPMH) Discrepancy columns for each medication, check the appropriate box. Type 0= NO discrepancy; Type 1= Intentional discrepancy; Type 2= Undocumented Intentional Discrepancy; Type 3= Unintentional Discrepancy and comment as applicable. Indicate for all Type 2 and Type 3 discrepancies whether they were resolved by placing a ✓ in the "Resolved" column.
- For all additional medications found during the BPMH process, and not captured on medication orders while in hospital, note '**ADDITIONAL' at the end of the list, record medications and score discrepancies appropriately.

BPMH* Initial Medication History *Medication name, dose, route & frequency* (*Best Possible Medication History of all prescription medications and regularly-taken non-prescription medications at home)	**Hospital Medication Orders** *Medication name, dose, route & frequency* (if new orders reconcile with BPMH of initial medications simply check the "Same" column; if not write out the order as written)		NO discrepancy	Intentional Discrepancy	Undocumented Intentional Discrepancy	Unintentional Discrepancy	Resolved ✓	**Discrepancy Comments** *Indicate reasons for change, hold, or discontinuation of medication **AND** resulting outcome for discrepancy (including date of outcome)if known*
Name, Dose, Route, Frequency	**Same**	**Name, Dose, Route, Frequency**	**0**	**1**	**2**	**3**		*Documented reasons for differences and resulting outcomes and dates if known*
		BPMH Discrepancy Total						
		BPMH Discrepancy Type	**0**	**1**	**2**	**3**		

Type 1= Intentional discrepancy - physician has made an intentional choice to add, change or discontinue a medication and is clearly documented.
Type 2= Undocumented Intentional Discrepancy - physician has made an intentional choice to add, change or discontinue a medication but this choice is not clearly documented.
Type 3= Unintentional Discrepancy - physician unintentionally changed, added or omitted a medication the patient was taking prior to admission or discharge.

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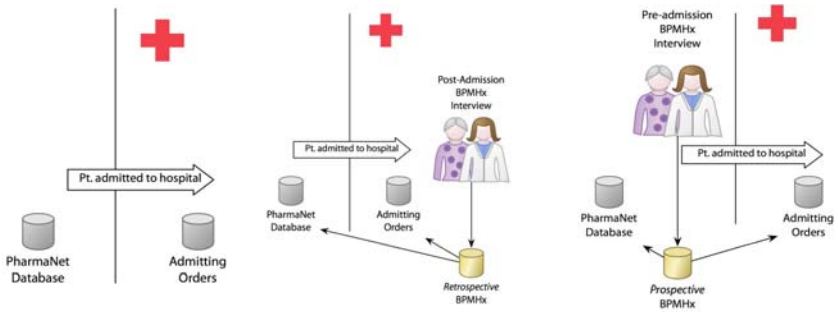
Case Study: PharmaNet-supported Medication Reconciliation - *Scenarios*



Retrospective, no MedRec, only able to extract historical med orders from PharmaNet and Hospital Pharmacy Info System for comparison. No gold standard available.

Retrospective, formal MedRec done post-admission (prior to discharge) as gold standard med history. Extract med orders from MedRec tool, PharmaNet and Hospital Pharmacy Info System for comparison to gold standard. Expect to see discrepancies and potential ADEs.

Prospective, PharmaNet-MedRec done as part of admission. Gold Standard Med History on admission MedRec extracts med orders from MedRec tool, PharmaNet and Hospital Pharmacy Info System for comparisons. Expected reduction in discrepancies and potential ADEs

52

May 31, 2009

Case Study: PharmaNet-supported Medication Reconciliation - *Metrics*

Patient Safety Outcomes	Provider Productivity Outcomes
Quantitative metrics No. Of documented ADEs %patient reconciled at admission/discharge Med discrepancies – freq/type un/intentional Mean no. Discrepancies resolved per patient %patient with ≥1 unintentional discrepancies % acceptable med orders (success index)	**Quantitative metrics** System use log – freq/type/duration of use Usability errors – freq/type/severity of errors Workflow change – %time change in process
Qualitative metrics Agreement by users with ADEs found Perception of MedRec impact by users	**Qualitative metrics** Perception of change in coordination by users Perception of change in workflow efficiency Perception of system usage/support

53

Case Study: PharmaNet-supported Medication Reconciliation – *Data Sources*

- **Data Collection and Analysis**
  - *Best Possible Medication History* (BPMHx) data, electronic medication orders
  - Tabulation/comparison of discrepancies, expert consensus on potential ADEs
  - Thematic analysis on usability/workflow related data
- **Estimated Sample Size**
  - *Published discrepancy rates:* ~25% potential harmful discrepancies (PHD) [25,27]
  - *PHD cases:* 25% of 100 patients, with 90% detection rate, we expect (100x25%/90%) = 28 of 100 pts with PHD
  - *Admission/yr at 3 sites:* (a) PAC MedRec 615 pts/6mths = 18% non-ER adm, or ~1200 pts/yr; (b) CSPAC ~800 pts/yr; (c) ~3000 ER adm/wkdays = ~17% ER visits/yr … total adm ~5000 pts/yr [30]
  - *Expert meetings on PHD cases:* 2hrs/2x/mth or 4hrs/mth for 10mths/yr, with ~40hrs/yr available, at 10min review/case = 6 cases/hr x 40hrs/yr = 240 cases/yr. For 240 cases/yr at 25% discrepancy and 90% detection rates, need (240x4)/90%=~1000 cases/yr, or 1000 pts/yr needed to detect 25% PHD
  - *Sample:* ~40% of 5000 adms/yr or ~2000 pts/yr, 50% with expert review

54

May 31, 2009

Case Study: PharmaNet-supported Medication Reconciliation – *Next Steps*

- Ministry approval of MedRec evaluation plan
- Implementing e-MedRec data collection tool in VIHA
- Starting phase 1 of the evaluation study
- Considering replication with other Health Authorities
- Hosting a KT workshop to share experience, ideas, lessons
- Feedback and questions?

55

May 31, 2009

Open Discussion on Experiences and Issues

- Are you involved with HIS evaluation? *What? How? Where?*
- How would you plan/conduct HIS evaluation studies? *Why?*
- What are your experiences, issues and needs?
- What further suggestions/insights do you have?

And finally …..
Would you like to be part of our eHealth evaluation forum?

56

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May 31, 2009

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57

May 31, 2009

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58

May 31, 2009