S76: Inferring Clinical Workflow Efficiency via Electronic Medical Record Utilization

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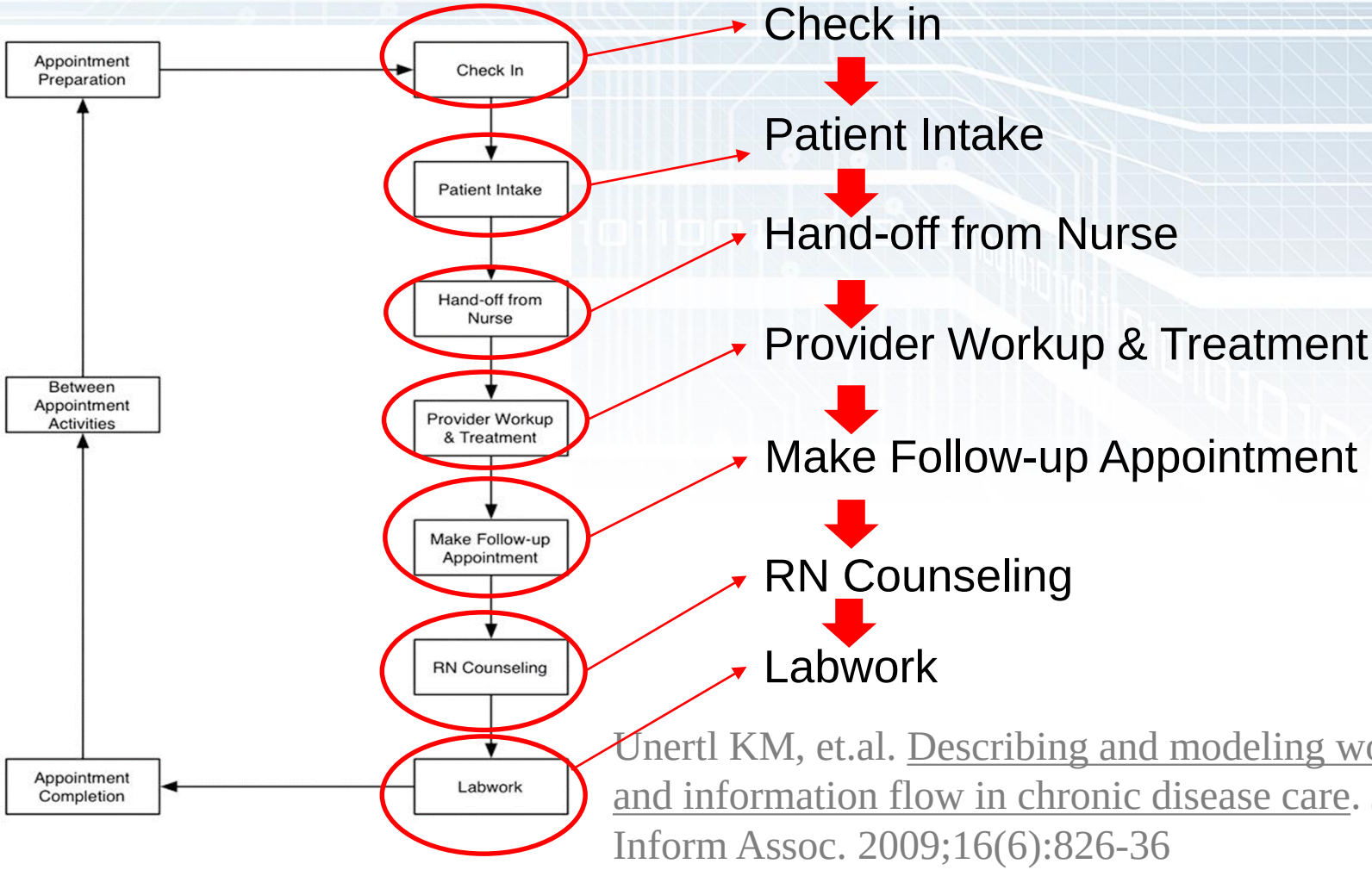
Disclosure

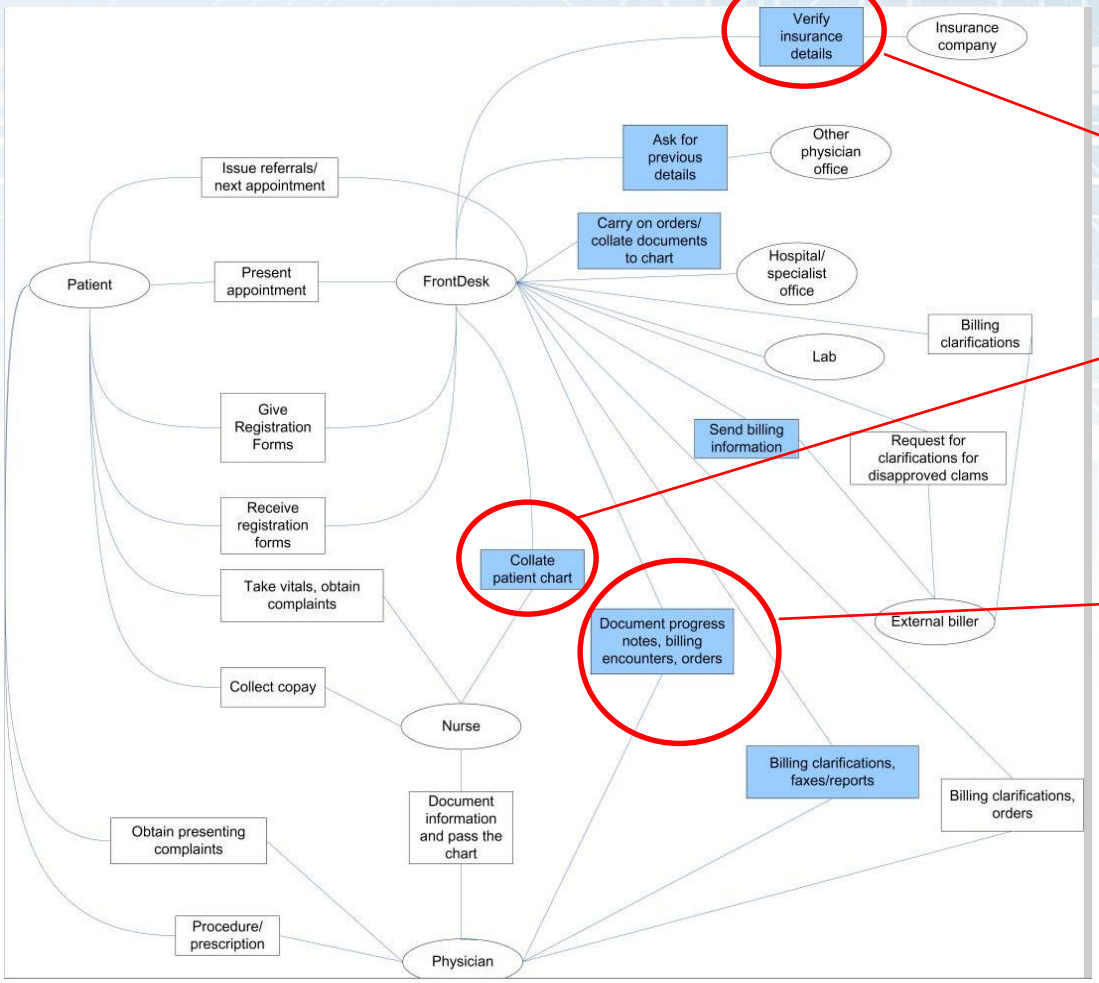
We have no competing interests to declare.

Workflow in Diabetes Mellitus Clinics



Unertl KM, et.al. Describing and modeling workflow and information flow in chronic disease care. J Am Med Inform Assoc. 2009;16(6):826-36

Activity Diagram for Primary Care Office



Delayed activities in the workflow

Verify insurance details from insurance company

Collate patient chart by nurse

Document progress notes, billing encounters, orders by physician

Ramaiah M, et.al. Workflow and electronic health records in small medical practices. Perspect Health Inf Manag. 2012; 9: 1d

Traditional Workflow Modeling

- Methods
  - Questionnaire, interview, & observation in clinics
- Their Goals
  - Develop an in-depth understanding of workflow in disease care
  - Facilitate development of informatics tools (e.g., EHR system) to manage workflows
- Limitations
  - High cost of human effort
  - Limited to a small number of patient population

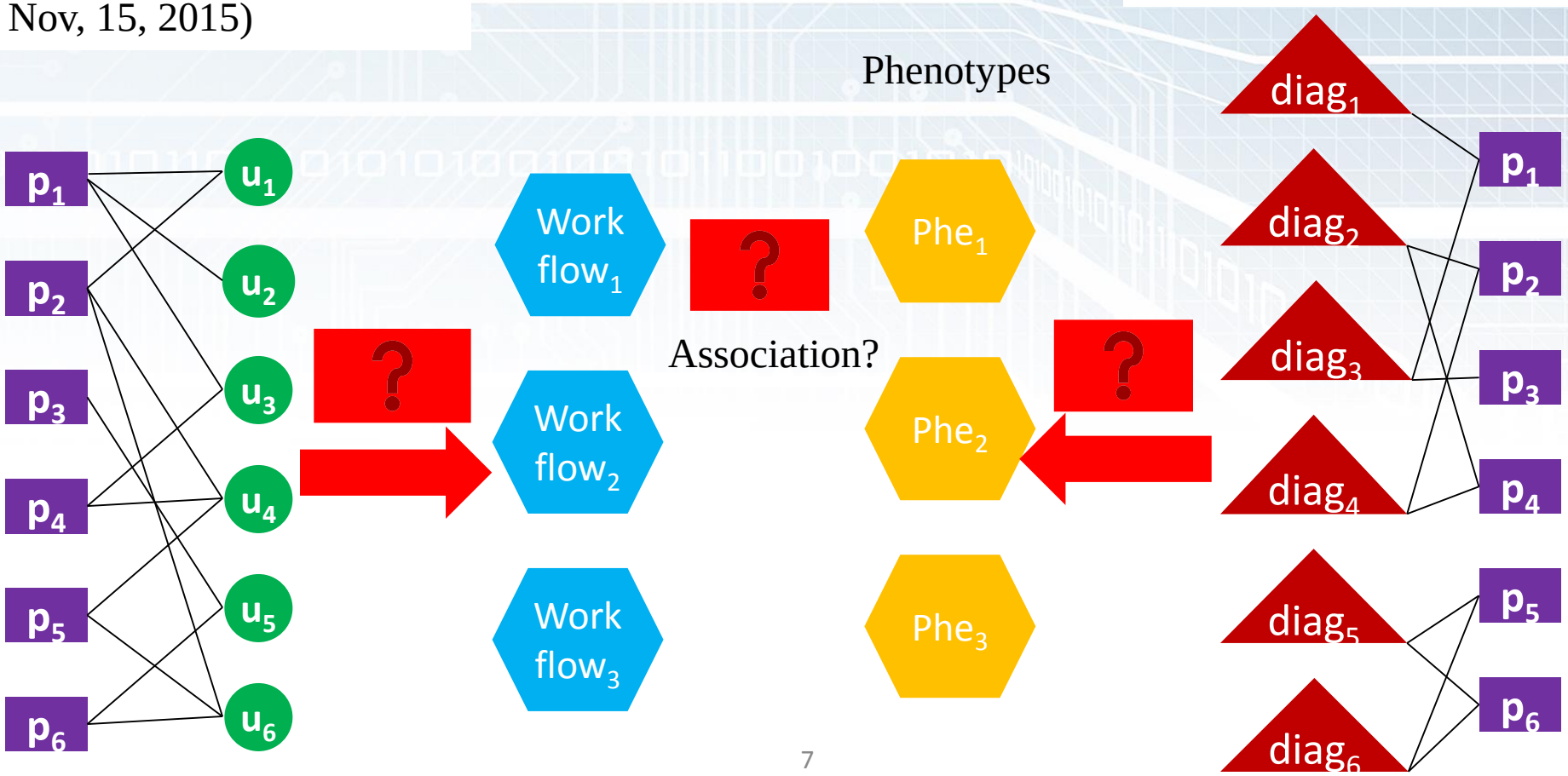
Automated Learning of Workflow

- Learn workflows from EHR systems
- "Reverse Engineering" - learn clinical workflow via EHR systems to refine process
  - Knowledge generated by healthcare workers
  - Study workflow in a wide range of patient populations

What Can We Learn From EHR Data?

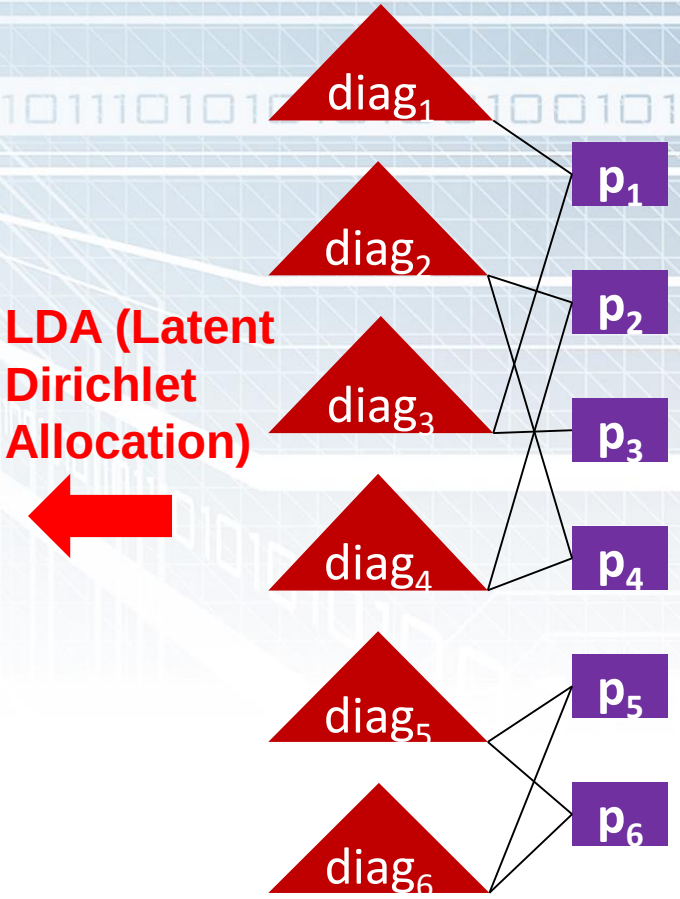
User access data (e.g., a user invoked an action at a patient's record at 9:am, Nov, 15, 2015)

Diagnosis data (e.g., ICD-9 codes, medications, lab tests, and notes)



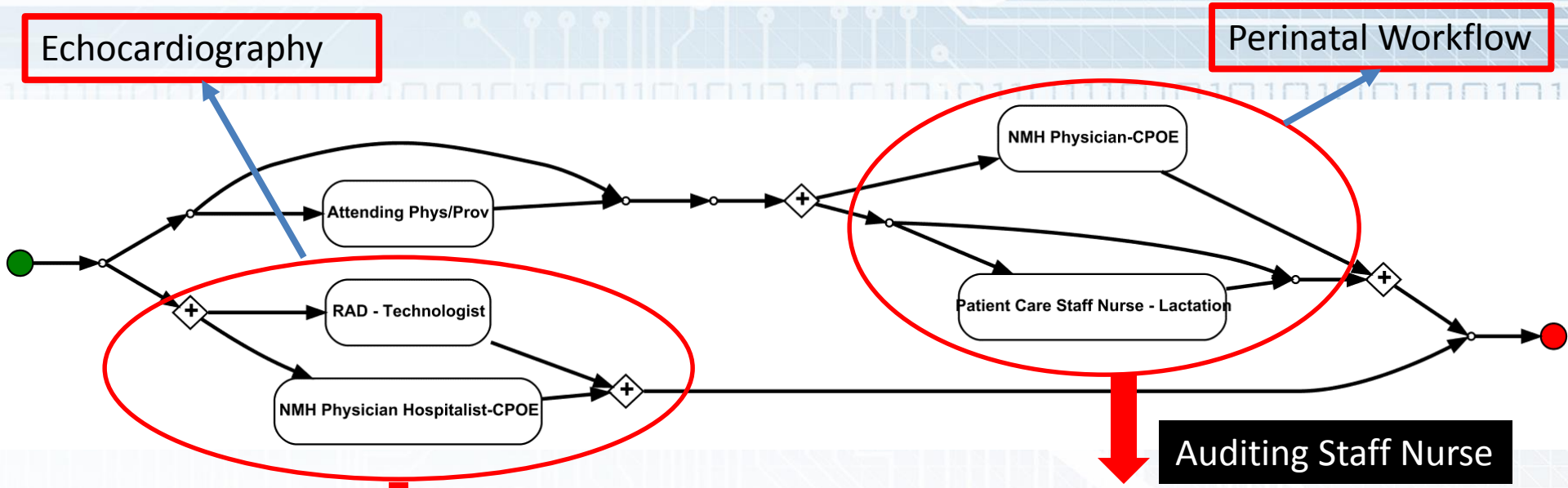
Example of a Learned Phenotype

Diagnosis	Probability
Child Birth	
Short gestation; low birth weight; and fetal growth retardation	0.25
Other perinatal conditions	0.18
Perinatal jaundice; isoimmunization	0.16
Endocrine and metabolic disturbances of fetus and newborn	0.10
Cardiac shunt; heart septal defect	0.06



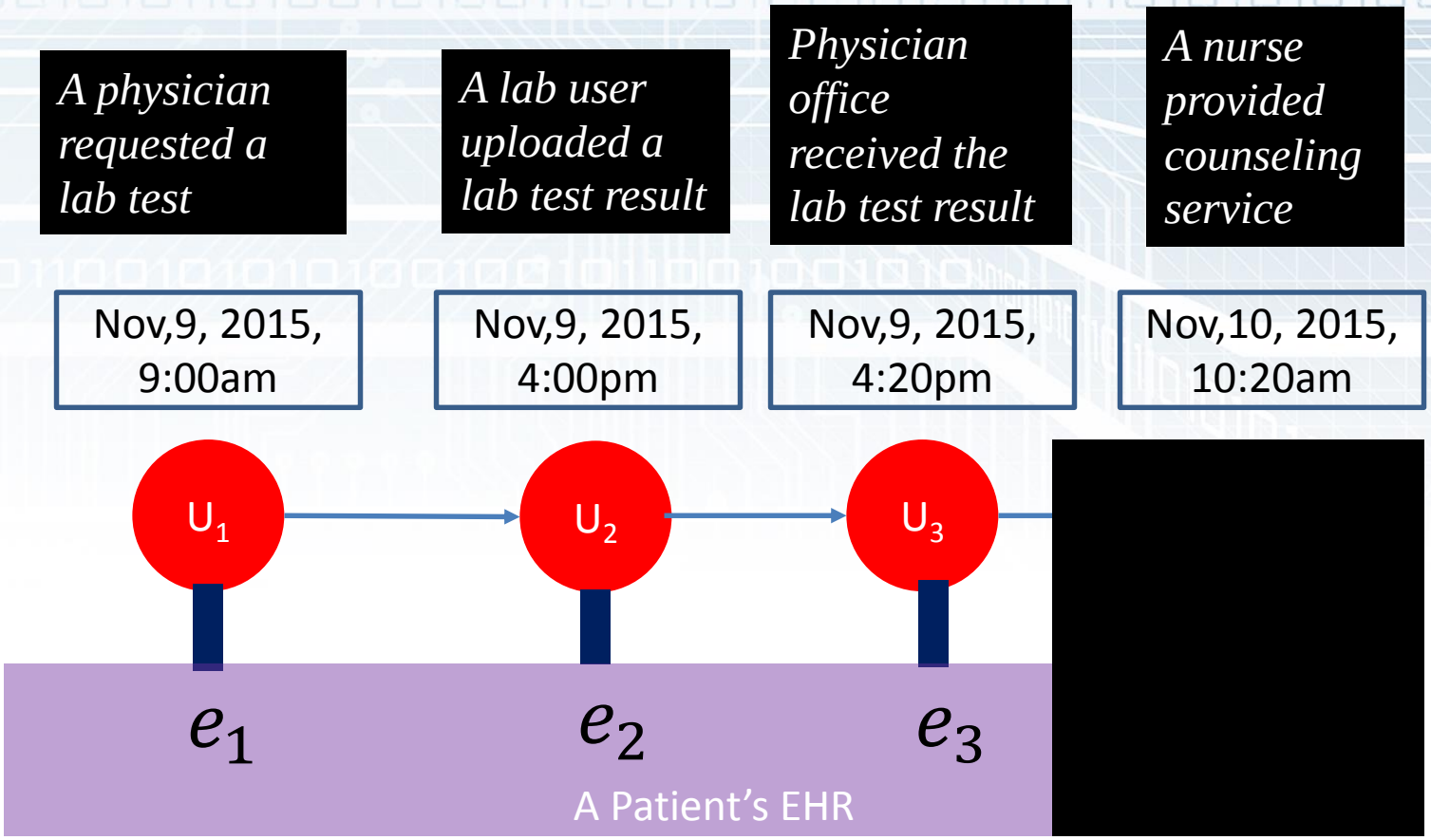
Y Chen, et.al. Building bridges across electronic health record systems through inferred phenotypic topics. Journal of Biomedical informatics. 2015; 55: 482-493.

Example of a Learned Workflow



Inferring Workflow Through Utilization of an EHR

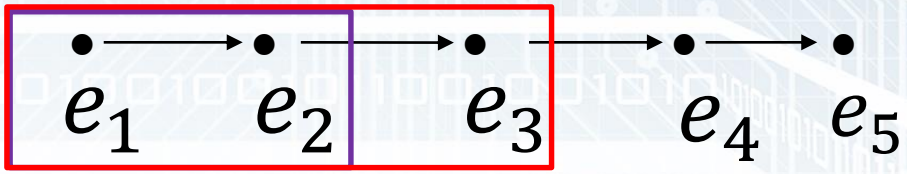
How Can We Learn Workflow From EHR?



Using stable strong relation to construct workflow

Learning the Ordered Relations of Events

Window size matters



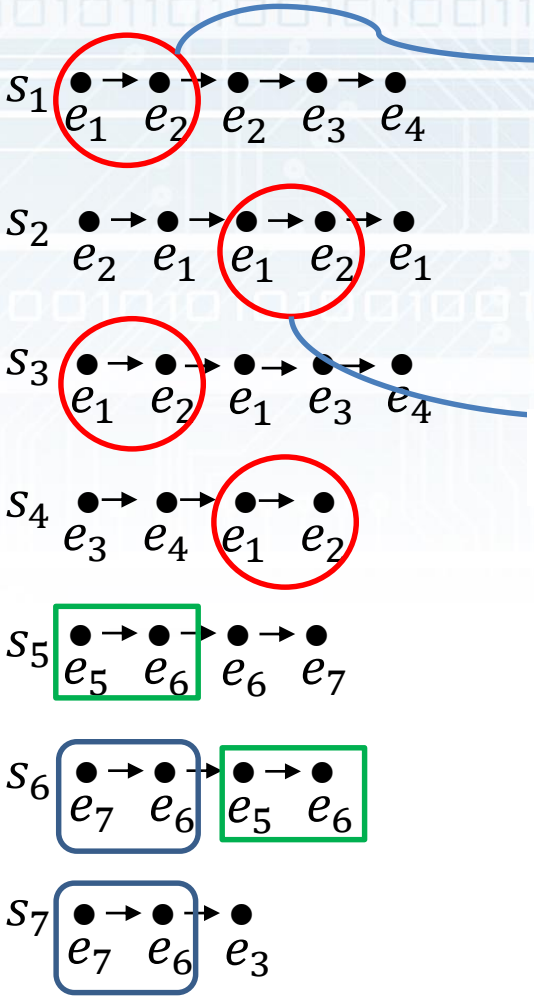
e_1 has an order relation with e_2 and e_3, but not with e_4 or e_5

Distance matters

e_1 has a stronger relation with e_2 than e_3

Learning the Ordered Relation of Events

Window size set as 1



$\mathbf{position(e_1)=1}$

$\boldsymbol{position(e_2)=2}$

$$r_1(e_1, e_2) = \frac{1}{(2-1)^2}$$

$\mathbf{position(e_1)=3}$

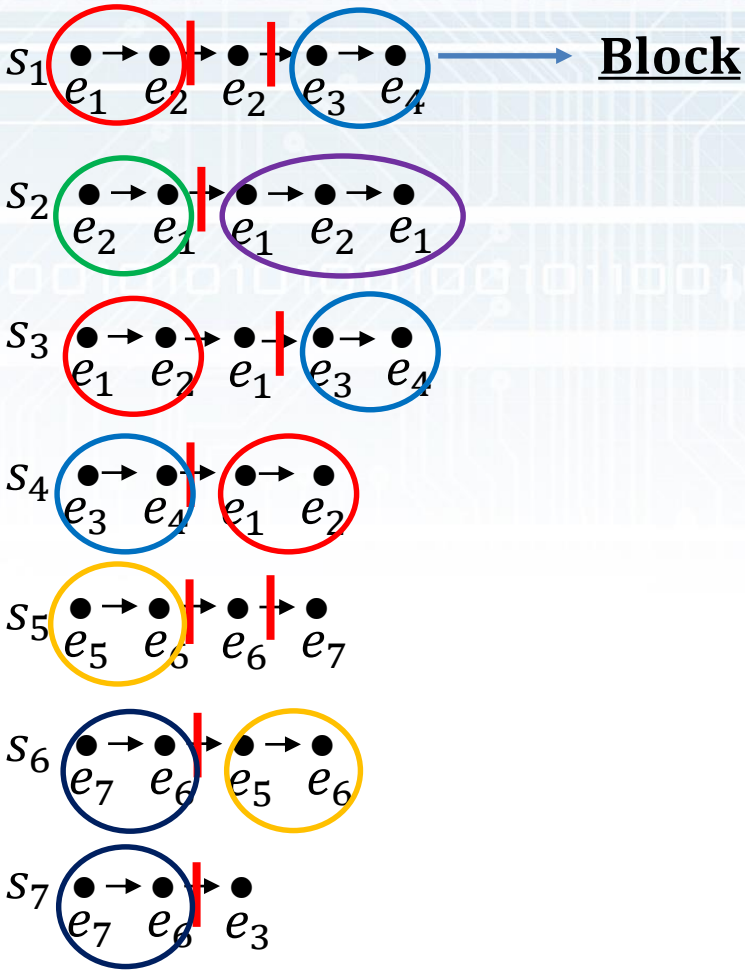
$\boldsymbol{position(e_2)=4}$

$$r_2(e_1, e_2) = \frac{1}{(4-3)^2}$$

$$R(e_1, e_2) = r_1(e_1, e_2) + r_2(e_1, e_2) + r_3(e_1, e_2) + r_4(e_1, e_2) = 4$$

Keep Strong Relations

Sequences



Block

Event Relation ≥ 2

$e_1 \rightarrow e_2$ (4)

$e_2 \rightarrow e_1$ (3)

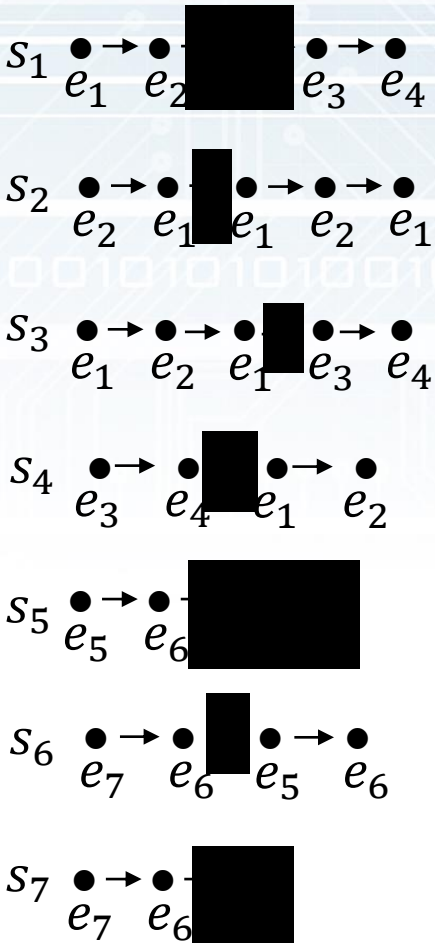
$e_3 \rightarrow e_4$ (3)

$e_5 \rightarrow e_6$ (2)

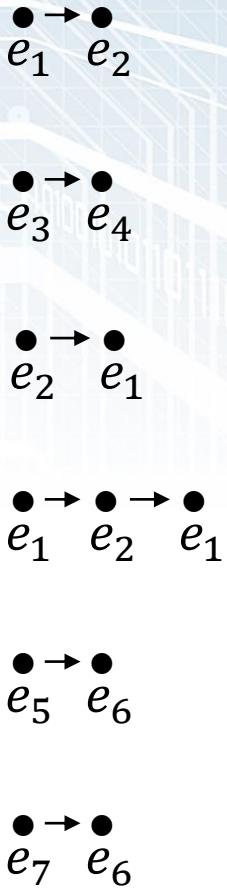
$e_7 \rightarrow e_6$ (2)

Using Blocks to Represent Sequences

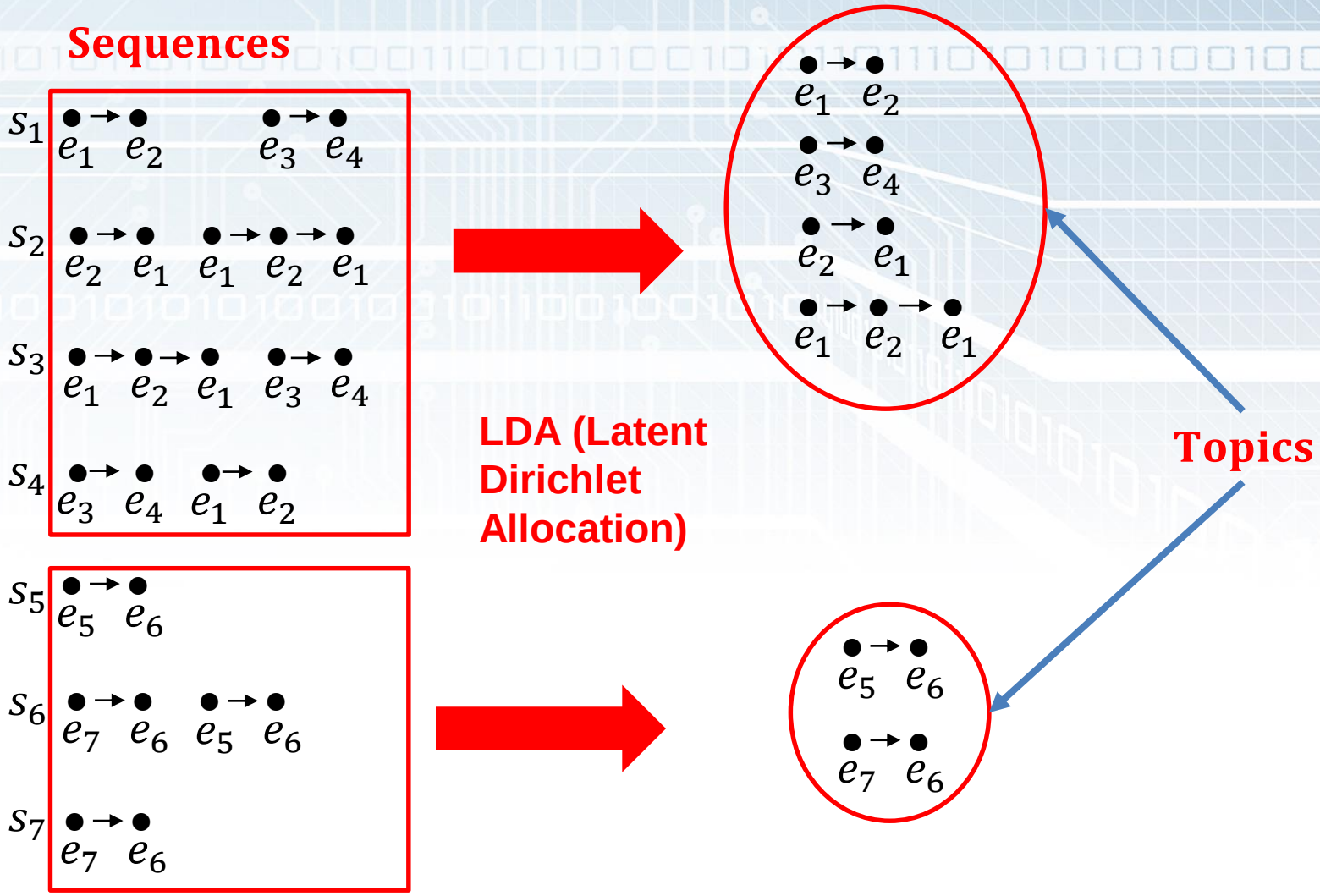
Sequences



Blocks



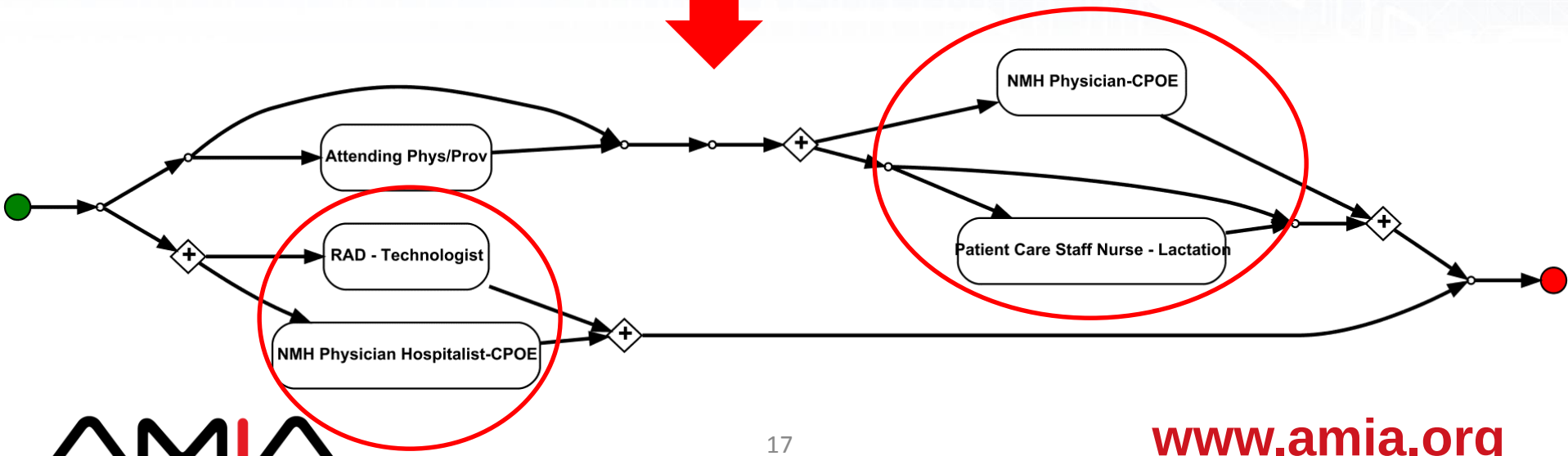
Grouping Co-Common Blocks



Transform Topic into Workflow

Block	
Attending Phys/Prov -> Physician-CPOE	0.04076
Physician-CPOE -> Patient Care Staff Nurse - Lactation	0.01873
RAD - Technologist -> Physician Hospitalist-CPOE	0.01765
Physician Hospitalist-CPOE -> RAD - Technologist	0.01726
Patient Care Staff Nurse - Lactation -> Physician-CPOE	0.01711

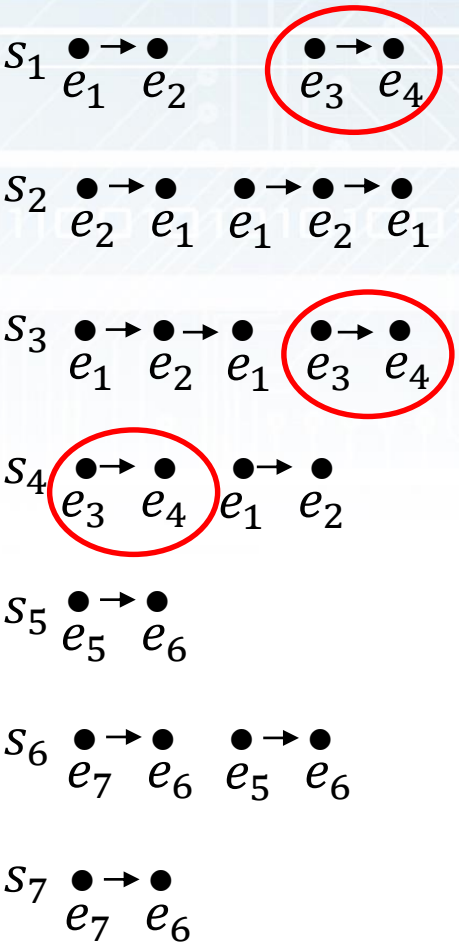
ProM Tool



Measuring the Efficiency of Inferred Workflows

A Block can Exist in Different **Sequences** for Different **Reasons** with Different **Durations**

Sequences



Radiology Manager and Resource Coordinator (*includes scheduling and patient experience issues*)

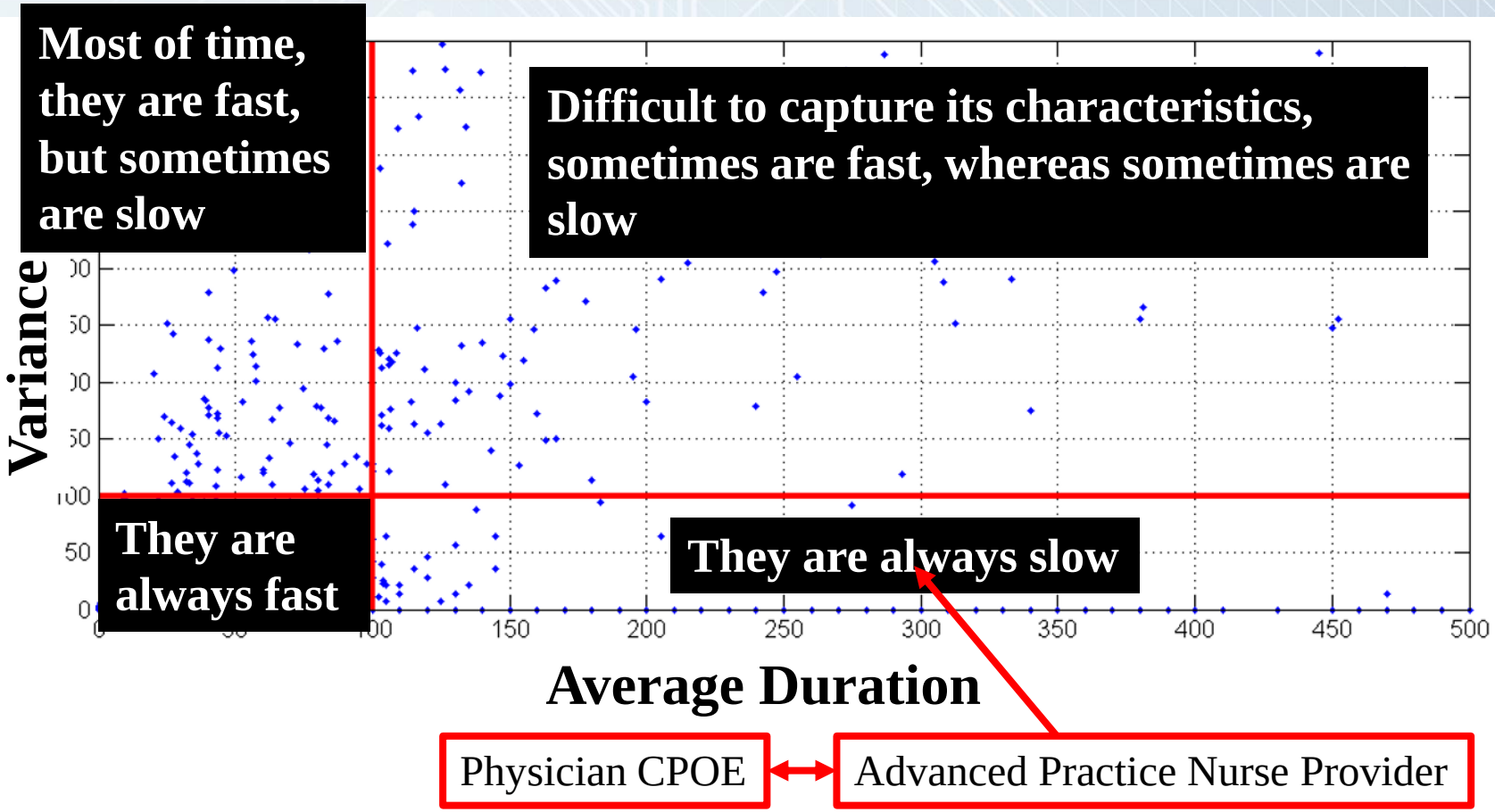
→ Physician-CPOE

Radiology Mgr/RC → Resident- Inpatient Consulting Service (Half hour)

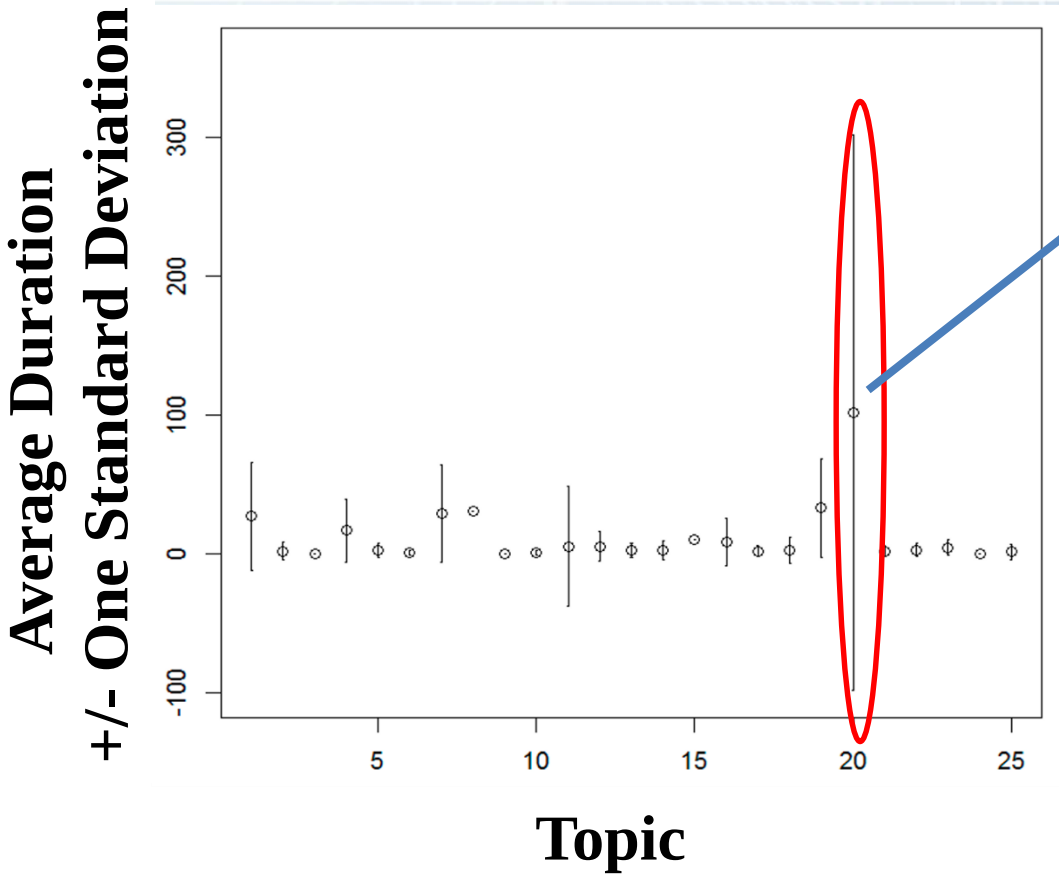
Radiology Mgr/RC → Approved Quality or Peer Review Process (Half hour)

Radiology Mgr/RC → Patient Care (associated with nursing roles) (5 Hours)

Can We Manage Effectiveness of Blocks through Their Duration (and Variances)?



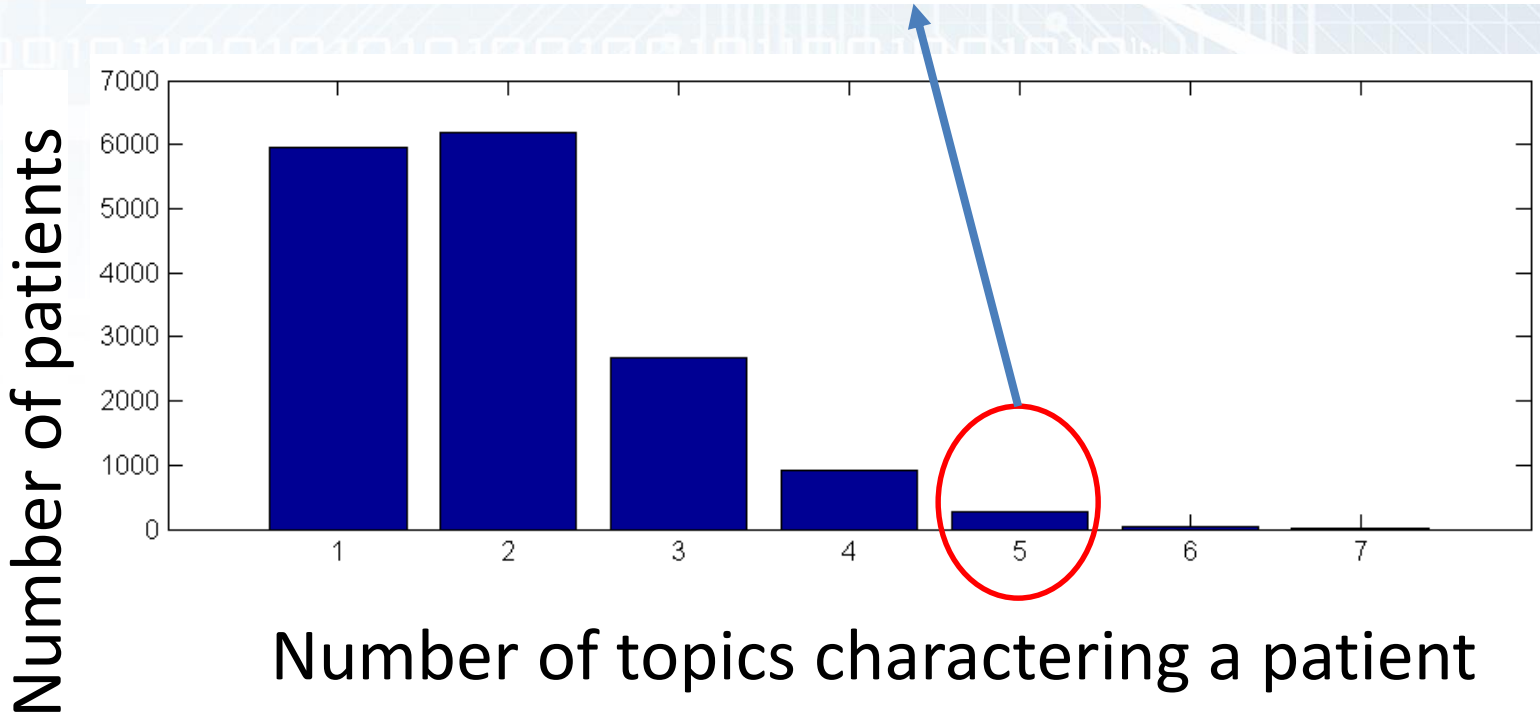
Effectiveness of Topic Workflow Can Be Utilized to Manage Complex Patients



Several blocks with long durations, whereas others with short durations, which indicates a patient condition is associated with a combination of long processes and short processes

An Example of Complex Patients Associated with Multiple Workflow Topics

Oncology and Diabetes: multiple myeloma, diabetes mellitus, esophageal reflux, urinary tract infection, and personal history of malignant neoplasm of breast



Summary & Next Steps

- A pilot study of workflow modeling through EHR data
- Future steps
  - Inferred workflows need further investigations
  - Gap measurement between inferred workflow and workflow utilized in clinical practice

Acknowledgements

Vanderbilt

- Bradley Malin, Ph.D
- Wei Xie, M.S.

UIUC

- Carl Gunter, Ph.D.

Northwestern

- David Liebovitz, M.D.
- Sanjay Mehotra, Ph.D.
- He Zhang, Ph.D.

Funding

- National Institutes of Health
  - K99LM011933
  - R01LM010207
- NSF
  - 09-64392
- CNS
  - 13-30491

Questions?

Thank you!

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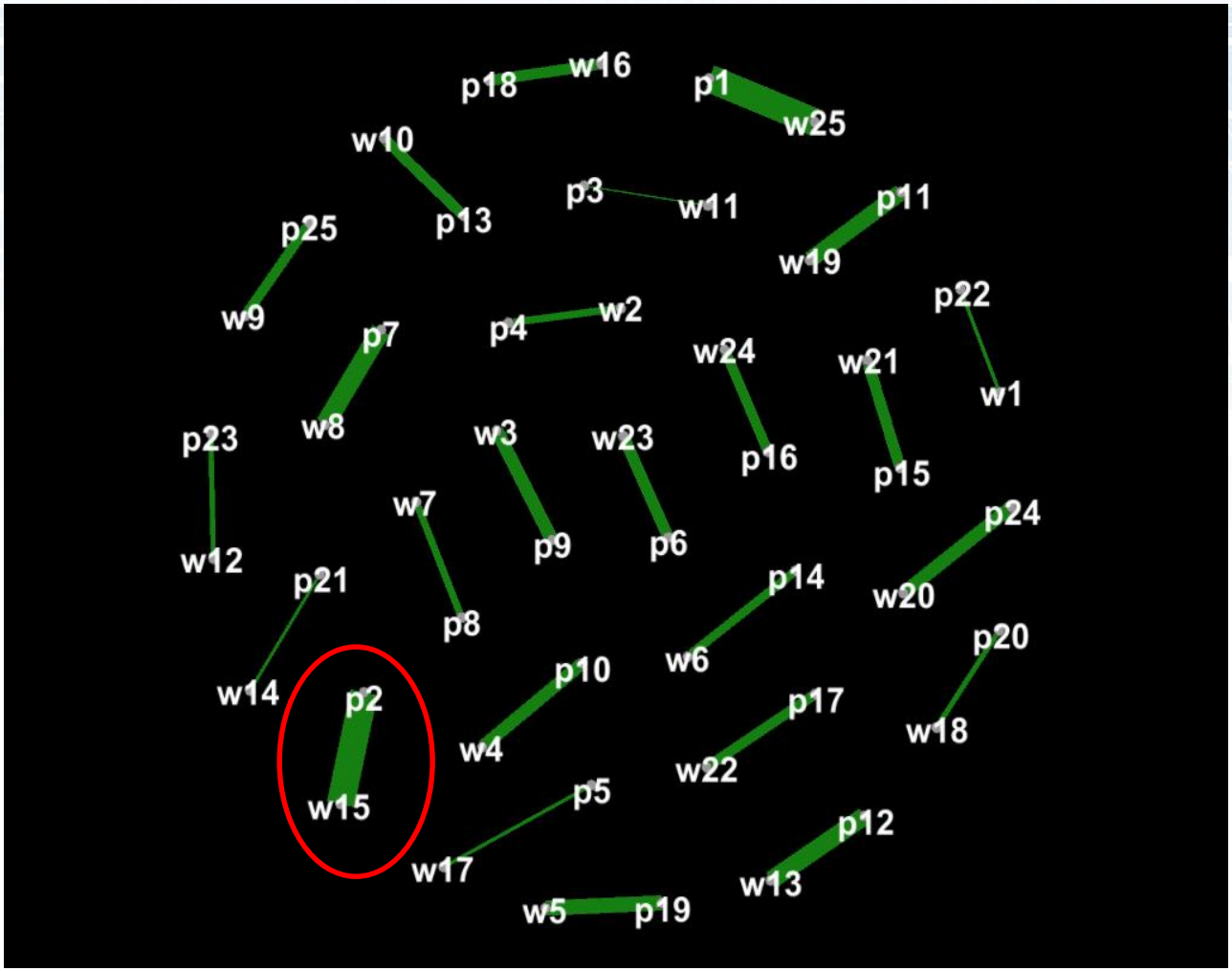
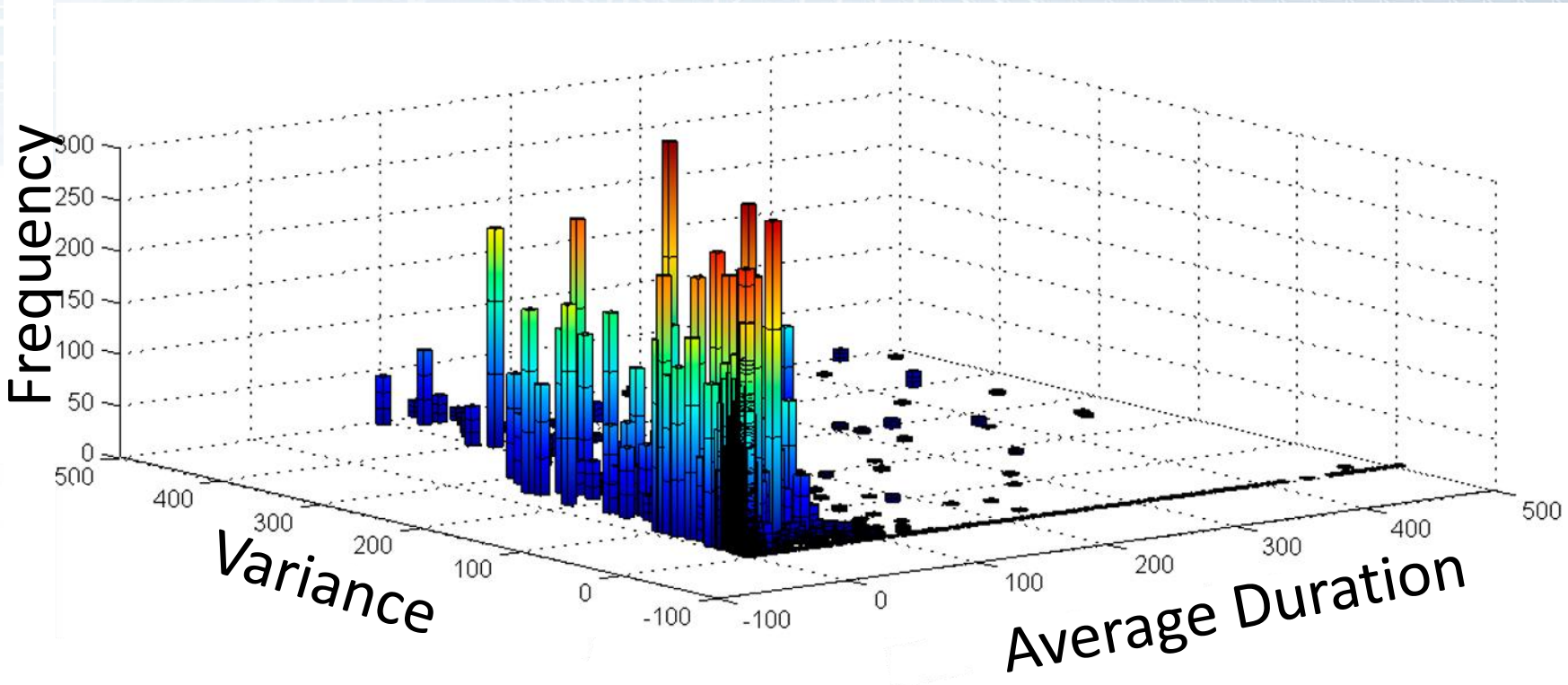
Association between Workflow and Phenotype



w: workflow

p: phenotype


Frequency
300
250
200
150
100
50
0
500
400
300
200
100
0
-100
Variance
-100
0
100
200
300
400
500
Average Duration