Web to World

Predicting Transitions from Self-Diagnosis to the Pursuit of Local Medical Assistance in Web Search

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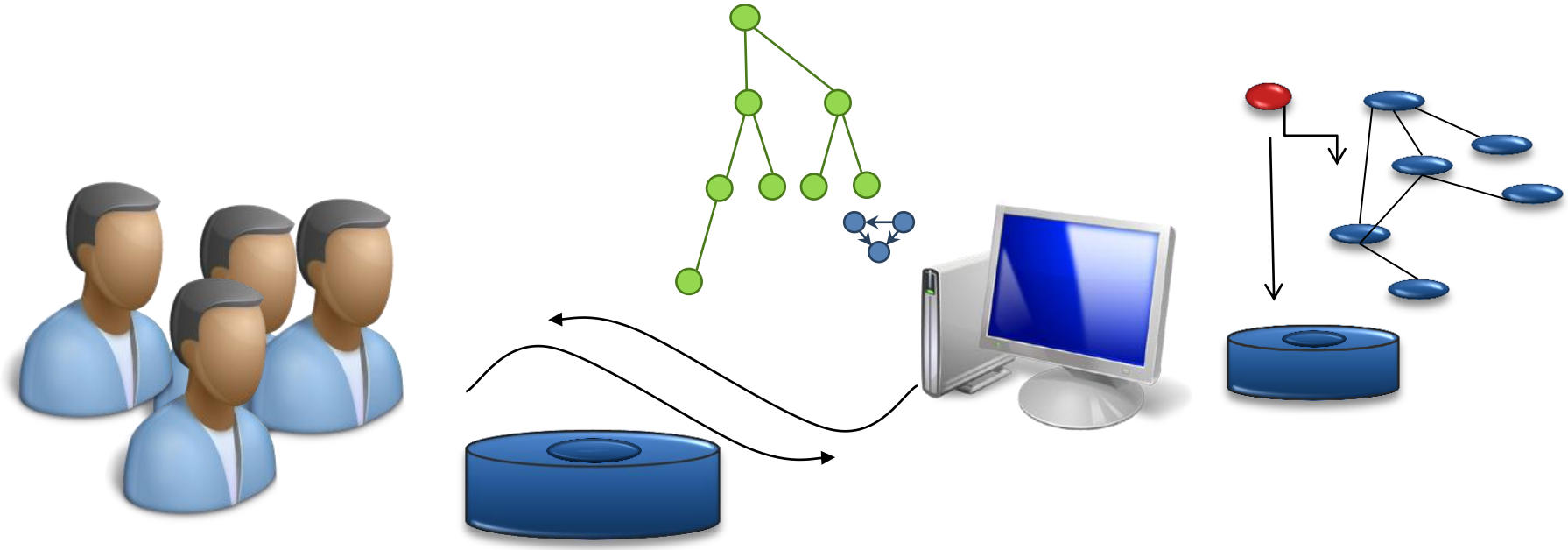
Pursuit of Insights about Consumer Experiences with Health Search

- Mining insights from large-scale logs
  - Query sequences & page accesses
  - Content distribution & dynamics
  - Insights, predictive models, services



Prior Study: Escalation of Concerns

- Large-scale crawl & log analysis, survey (TOIS 2009)
- Transition from common symptoms to rare diseases

  e.g., {headache, nausea, dizziness} → rare illness

  - <u>Conclusions</u>

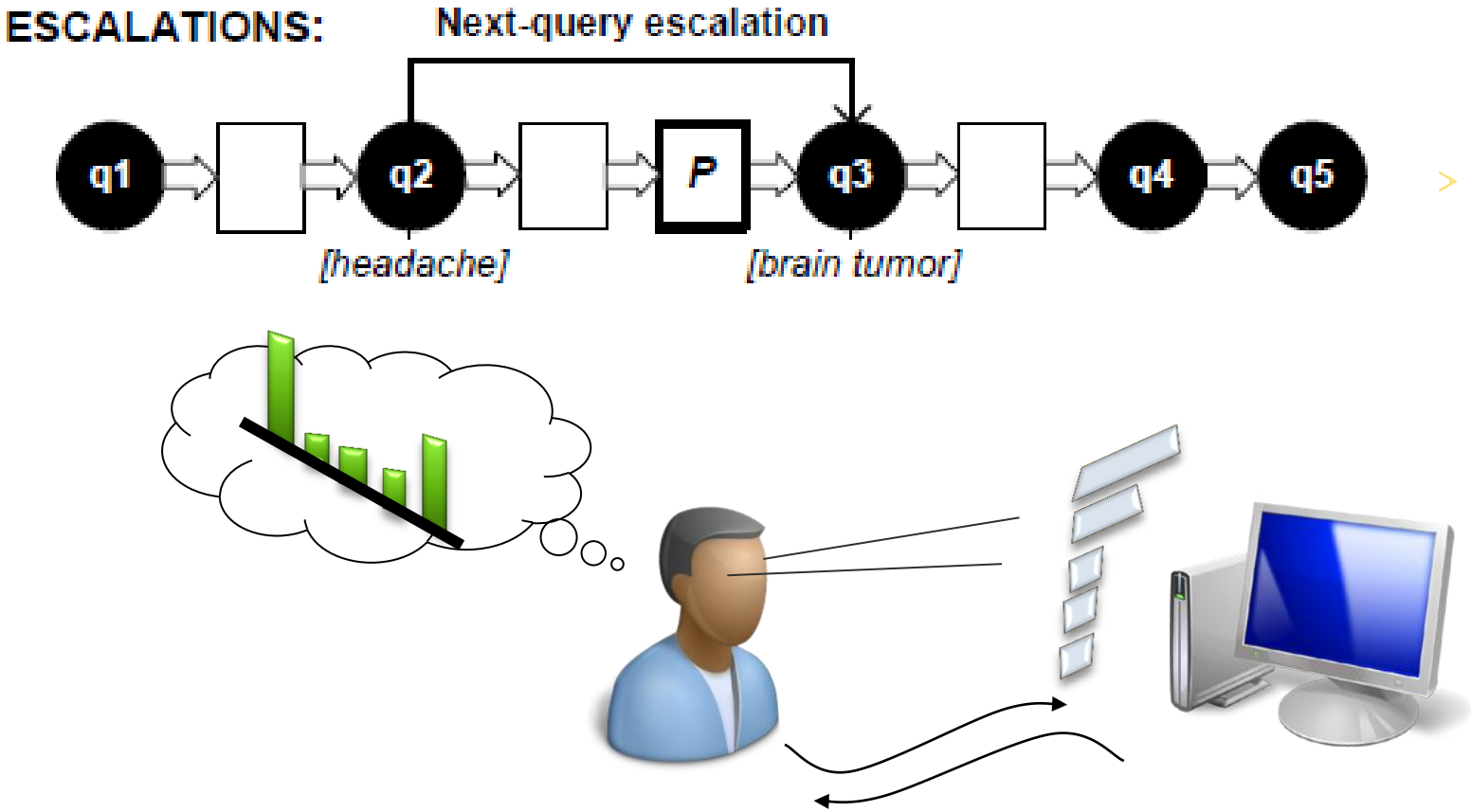
    - Escalations of concerns widespread

    - Web suffers from & amplifies biases of judgment

      - *Base-rate neglect*
      - *Availability bias*

Prior Study: Predicting Escalation

- Predict transition from common symptoms to rare illness *based on features* of pages being viewed (SIGIR 2010)



New Work: Influence of Web on Seeking Healthcare Professionals

- Web search → more engagement with healthcare system (AMIA 2009)
  - Survey of Microsoft employees (n=515):

"Web content put you over the threshold for scheduling an appointment with a health professional, when you would likely have not sought professional medical attention if you had not reviewed Web content."

→ 23.7% Yes!

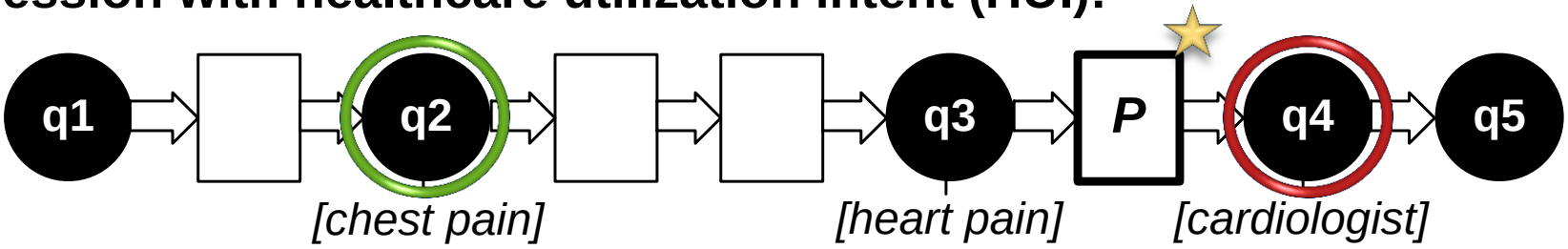
Web to World

- Predict pursuit of in-world healthcare resources: *Healthcare Utilization Intention* (HUI)
  - Querying for information on proximal physicians, specialists, healthcare centers
  - e.g., *"neurologist in seattle, wa"*, *"evergreen hospital"*, *"urgent care clinic"*
- Automated detection:
  - Appropriate medical specialty for the symptom (e.g., *neurologist* for symptom: muscle twitches);
  - medical resource (e.g., *hospital*, *physician*)
  - five-digit US zipcode, US city & state name pair (e.g., *Redmond, Washington*)

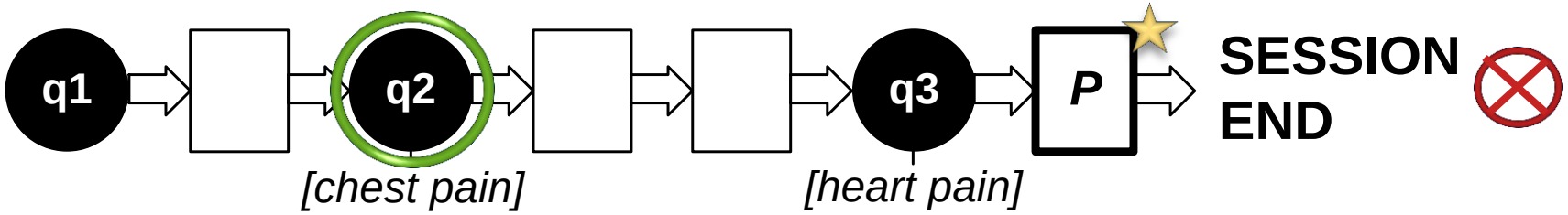
Study of Web to World!

- Prediction of transition to HUI

Session with healthcare utilization intent (HUI):



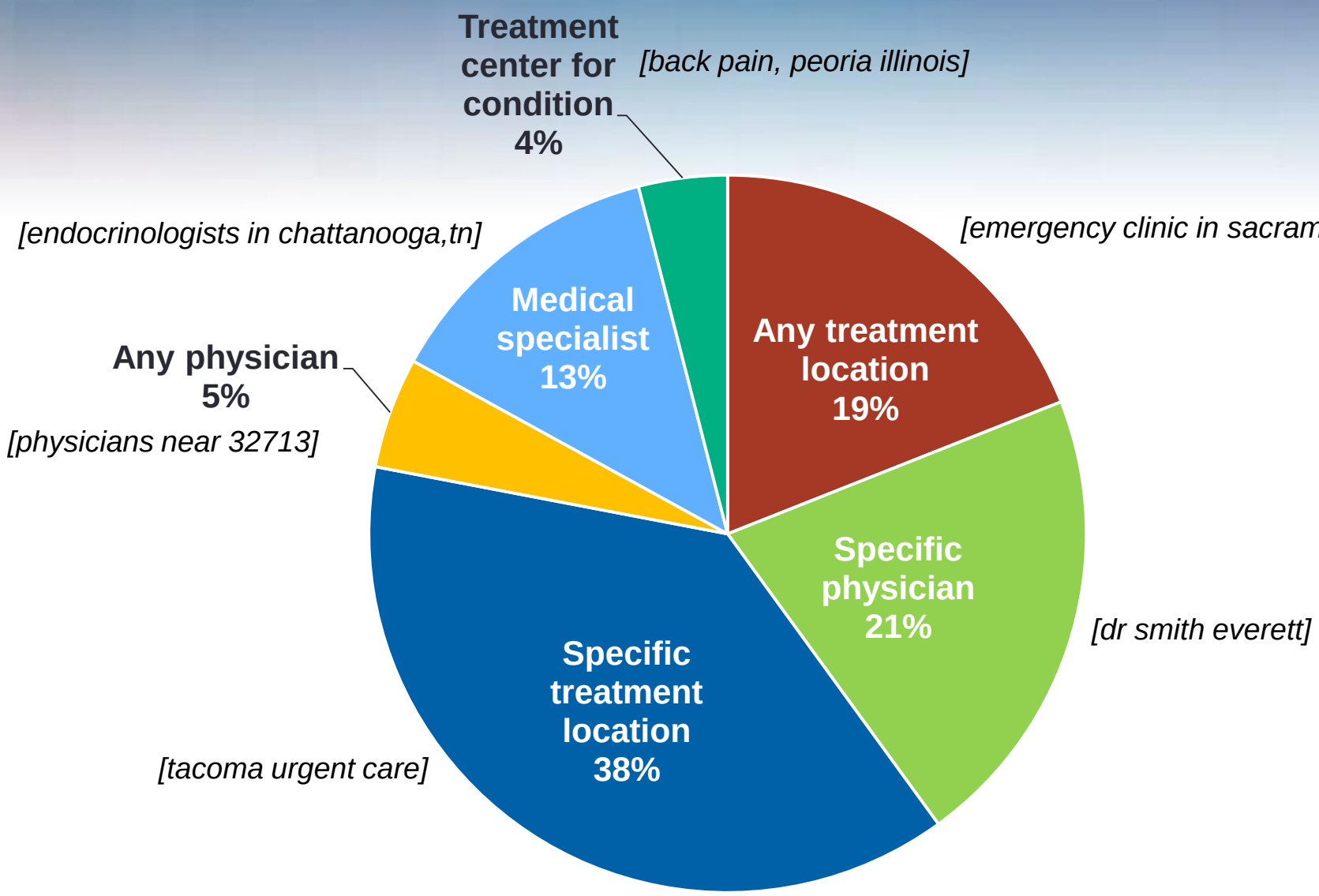
Session without healthcare utilization intent (No HUI):



Methods

- Analysis of Log Data
  - Six mos. anonymized logs from MSN Toolbar (opt in)
  - Extract search sessions using automated tools
  - Sessions: start query and all queries and URLs
  - Symptoms: *chest pain*, *muscle twitches*, *abdominal pain*
  - Automatic extraction of sessions w/ symptom → HUI
  - 700 HUI, 700 no-HUI sessions

Characteristics of Resource Pursuits



Characteristics of Resource Usage

- HUI queries toward end of sessions
  - 36% of sessions, HUI query was last query in session
  - Mean: HUI queries occur 75% of the way through session
- When additional queries follow, search activity is:
  - **Refine** query in pursuit of resource (46%)
  - **Explore** a medical condition (22%)
  - **Compare** different resources (e.g., two specialists) (14%)
  - **Other**
    - Request next search results page (10%)
    - Shift topics (8%)

Predicting Escalations to HUIs

- Prediction task

  Probability that user will next issue an initial HUI query given currently viewing page p.

- Three classes of features
  - **Page:** Structure & content of current page.
  - **Session:** Attributes of search interaction in current session.
  - **User:** Aspects of users' historic medical search interactions from the beginning of our log data to start of current session.

Page Features

FracPageFirstSerious: **Fraction page to first serious illness**

FracPageFirstBenign: **Fraction page to first benign explanation**

NumSeriousInFirstPara: **Number serious illness in first para.**

NumBenignInFirstPara: **Number benign explanations in first para.**

NumNegMod: **Number negative modifiers (e.g., don't have)**

NumPosMod: **Number positive modifiers (e.g., do have)**

NumTestimonials: **Number testimonials (e.g., I was scared)**

UrlTrusted: **Page from trusted source (e.g., medlineplus)?**

TrustedDomain: **Page from trusted domain (e.g., .edu)?**

IsWebForum: **Page from a Web forum?**

HasURACVerification: **Verified by www.urac.org?**

HasHONVerification: **Verified by www.healthonnet.org?**

HasSeekMedicalAdvice: **Recommends medical consult.?**

ForHealthProfessionals: **Content meant for health prof.?**

LengthInWords: **Number of words**

SizeInKB: **Size in kilobytes (text only)**

HasResources: **Mentions external resources (e.g., doctor)?**

Page Features

AdsPresent: **Advertisements present on page?**

NumAdBlocks: **Number of advertising blocks**

SeriousThenBenign: **Serious illness for concern appears on the page before a benign explanation for that symptom?**

NumWordsToSerious: **Number words to first serious illness**

NumWordsToBenign: **Number words to first benign explanation**

NumWordsBetweenSeriousAndBenign: **Number words between first serious illness and first benign explanation**

SeriousInTitle: **Serious illness in page title?**

BenignInTitle: **Benign explanation in page title?**

SeriousInFirstPara: **Serious illness in first paragraph?**

BenignInFirstPara: **Benign explanation in first paragraph?**

SeriousAndBenignInFirstPara: **Serious/benign first para.?**

NoSeriousBenignInFirstPara: **No serious/benign first para.?**

NumSerious: **Number serious illnesses**

NumBenign: **Number benign explanations**

NumGraveConcerns: **Number grave concerns (e.g., fatal)**

Session and User Features

NumQueries: **Number queries**

AvgQueryLength: **Average query length (in tokens)**

NumEscQueries: **Number queries with escalations for concern**

NumNonEscQueries: **Number queries with benign explanation**

NumURLs: **Number (non- search engine result) pages**

AvgDwellTime: **Average dwell time on pages**

TotalDwellTime: **Total dwell time on pages**

AvgConcernSearchesPerDay: **Number concern queries per day**

AvgMedicalSessionsPerDay: **Number medical sessions per day**

NumUniqueSymptoms: **Number unique Merck symptoms**

NumEscalations: **Number previous queries for serious illnesses**

Exploration of Key Features

- Explore page, session, user features

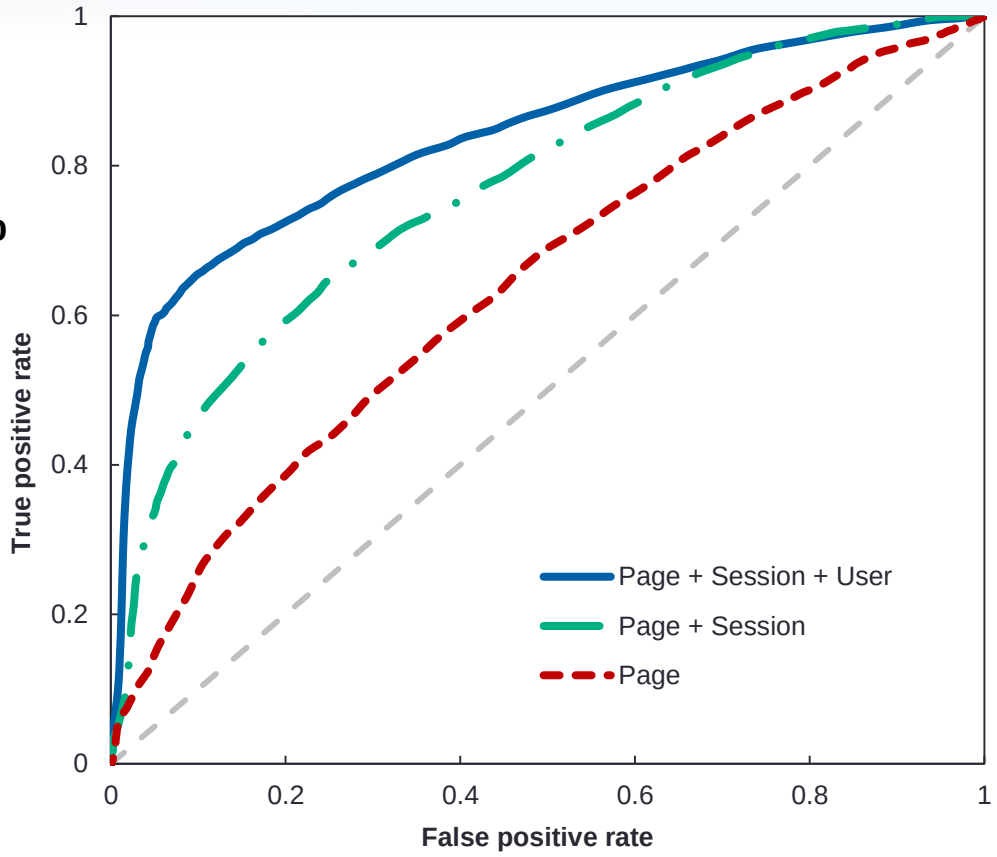
Features	HUI	No HUI
SeriousBeforeBenign (Page)	59%	48%
IsWebForum (Page)	14%	9%
NumQueries (Session)	4.9	2.9
AvgQueryLength (Session)	4.5	4.1
NumUniqueSymptoms (User)	3.6	2.2
NumResourceQueries (User)	5.5	2.0

- *All differences are significant*

Study of Predictive Model

Logistic regression with five-fold cross-validation

- Accuracy:
  - Page features = 59.3%
  - Page + session = 68.9%
  - **Page + session + user = 77.7%**



Prediction Findings

- Inspected feature weights
- Top features by evidential weight, relative to most predictive feature, *AvgDwellTime*:

Feature	Class	Importance
AvgDwellTime	Session	1.00
NumEscalations	User	0.71
HasResources	Page	0.60
NumResourceQueries	User	0.56
NumURLs	Session	0.47

Value of multiple classes of features in building predictive models

Summary

- Web to world: Predicting *Health Utilization Intention* (HUI)
- Predictive models of escalation to HUI given features of a page, session, user
- Characterized resource seeking:
  - Most HUIs are searches for specific locations or physicians
  - Post-initial HUI query, users refine, explore, or compare