Interactive Visual Displays for Results Management in Complex Medical Workflows

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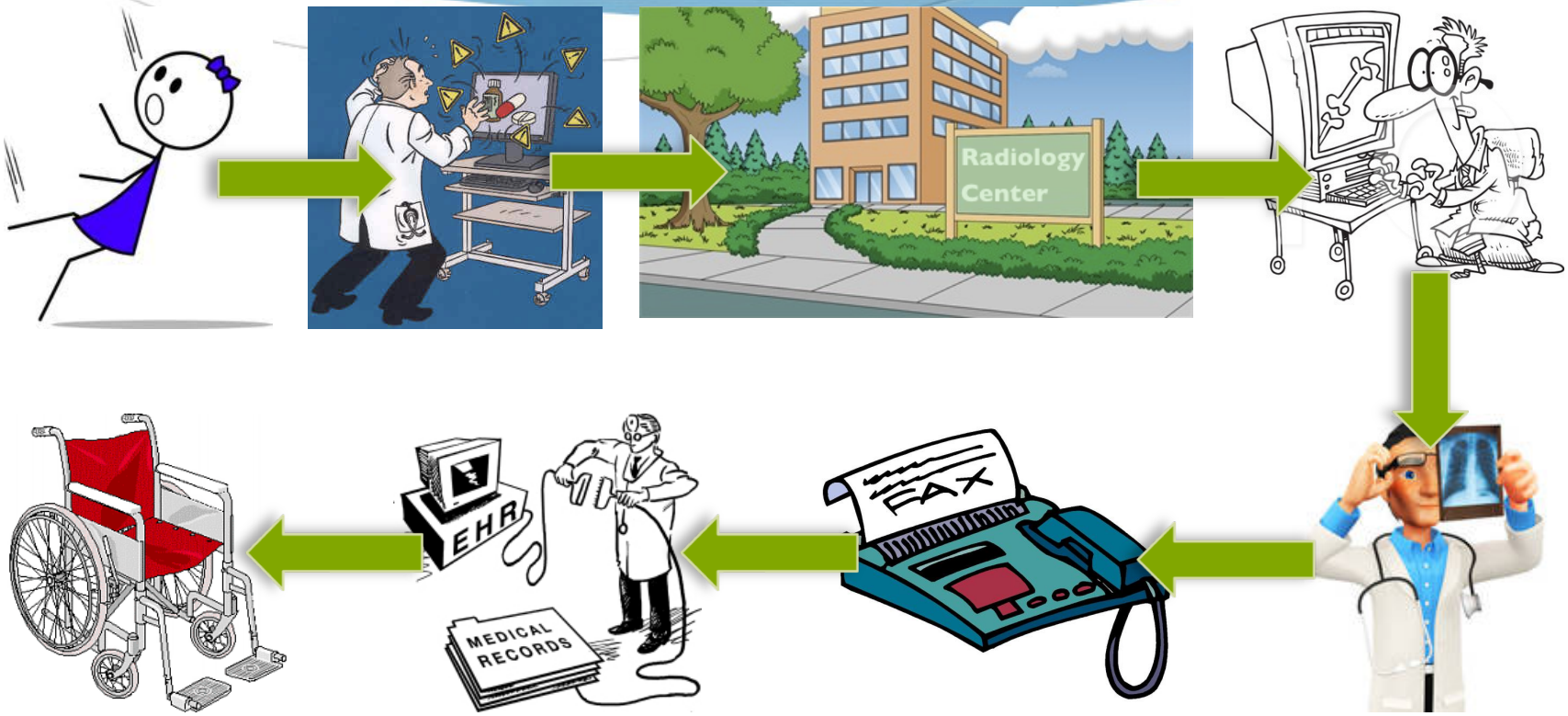
Committee: Ben Shneiderman (Chair)
Linda Aldoory (Dean's Representative)
Ben Bederson
Rance Cleaveland
Catherine Plaisant

A story…



Missed Results

Hickner, 2008; Phillips, 2004

Veterans Administration View Alert

Patient Selection

Patient List

Default: Wednesday Clinic
Providers
Clinics
Team/Personal
Wards
Specialties
All

Patients (Wednesday Clinic)

OK
Cancel

No Appointments

Patient, Test1
Patient, Test2
Patient, Test3
Patient, Test4
Patient, Test5
Patient, Test6

Save Patient List Settings

Notifications

Info	Patient	Location	Urgency	Alert Date/Time	Message	Forwarded By/When
	Patient, Test132		Moderate	01/01/2010@03:14	Scheduled Consult: ORTHOPEDICS	
	Patient, Test164		Moderate	01/01/2010@15:09	Scheduled Consult: NON-INVASIVE ECHO	
	Patient, Test243		Moderate	01/02/2010@02:06	COMPLETED EMERGENCY ROOM NOTE available for ADD'L	
	Patient, Test32		HIGH	01/02/2010@05:35	Medications Nearing expiration	
	Patient, Test17		Moderate	01/02/2010@08:09	Imaging request held: KNEE 3 VIEWS, LEFT	
	Patient, Test267	GM	Moderate	01/03/2010@07:09	Abnormal labs - [TROPONIN I]	
	Patient, Test165		Moderate	01/04/2010@03:23	Abnormal labs - [LIP D PROFILE, COMPREHENSIVE]	
	Patient, Test138		Moderate	01/04/2010@08:46	Abnormal labs - [BA IC METABOLIC PANEL]	
	Patient, Test106		Moderate	01/05/2010@02:06	Labs resulted - [MI ROALBUMIN;URINE]	
	Patient, Test286		Moderate	01/05/2010@04:33	COMPLETED PH MACY PATIENT ENCOUNTER available fc	
I	Patient, Test362	GM	HIGH	01/05/2010@08:32	Critical lab: CR 2. 5/27 05:00	
	Patient, Test151		Moderate	01/06/2010@07:09	Imaging Results, Critical: SPINE LUMBOSACRAL MIN 2 VI	
	Patient, Test209		Moderate	01/07/2010@05:00	Discontinued co DERMATOLOGY	
	Patient, Test122	GM	Mo e	01/08/2010@02:08	Comment Adde Consult PAIN MANAGEMENT	
	Patient, Test305		1	01/08/2010@08:41	Abnl Imaging R leeds Attn: CT ABDOMEN W&W/O CO	
	Patient, Test132		Moderate	01/08/2010@09:07	Completed Co URSING CASE MANAGEMENT	
	Patient, Test57		Moderate	01/08/2010@16:09	Abnl Imaging leeds Attn: MAGNETIC IMAGE LUMBAR S	
	Patient, Test160		Moderate	01/09/2010@03:09	UNSIGNED Y CARE FOLLOW-UP available for SIGNA	

Process Info | Process All | Process | Forward | Remo

Patient record has pending orders

Arrived results in chronological order

Too much text

Empty column

OpenVista Follow-up

Medsphere OpenVista® CIS [FALCON] - Connected as USER,PHYSICIAN (openvista.medsphere.org)

File Edit View Actions Options Tools Help

PATIENT,LABORATORY
MRN: TST900000104
Age/Sex: 51 (Male)
Wt: 83.915 kg
Ht: 177.8 cm
BMI/BSA: 26.5 (2.04)

MS 202-1
Provider: USER,PHYSICIAN
Admit Dx:
Admitted: 9/9/2008 3:53:13 AM
Acct #:

Postings: A
Alerts:

Care Team
Admitting MD: None
Attending MD: USER,PHYSICIAN

New Consult... New Procedure... Edit Note Delete Note

Alerted consults

Date	Title	Record
3/16/2009	ALLERGY Cons	Consult #11
3/18/2009	PHARMACY CONSULT RESULTS	

Consult: ALLERGY Cons 3/16/2009 3:00:35 PM (Completed)

```
Current Pat. Status:   Inpatient
Ward:                  MED/SURG

Order Information
To Service:            ALLERGY
Attention:             MANAGER,SYSTEM
From Service:          MED/SURG
Requesting Provider:   MANAGER,SYSTEM
Service is to be rendered on an INPATIENT basis
Place:                 Bedside
Urgency:               Routine
Orderable Item:        ALLERGY
Consult:               Consult Request
Provisional Diagnosis: Rash (782.1)
Reason For Request:
testing

Inter-facility Information
This is not an inter-facility consult request.

Status:                COMPLETE
Last Action:           COMPLETE/UPDATE

Facility
 Activity                Date/Time/Zone      Responsible Person  Entered By
-------------------------------------------------------------------------------
 CPRS RELEASED ORDER     03/16/09 15:00      MANAGER,SYSTEM      MANAGER,SYSTEM
 COMPLETE/UPDATE         03/18/09 09:36      LEES,ALLI           LEES,ALLI
     Note# 16

Note: TIME ZONE is local if not indicated

-------------------------------------------------------------------------------

       TITLE: PHARMACY CONSULT RESULTS
DATE OF NOTE: MAR 18,2009@09:35      ENTRY DATE: MAR 18,2009@09:36:05
      AUTHOR: LEES,ALLI            EXP COSIGNER:
     URGENCY:                            STATUS: COMPLETED
```

Go to Orders tab

Patient Summary | Problem List | Medications | Orders | Clinical Notes | Consults/ Procedures | Discharge Summary | Vital Signs | Lab Results | Chart Inquiries

powered by medsphere

Processing Alert: PATIENT,L (P) Completed Consult ALLERGY

Next | Renew | Forward | Remove | Stop

OpenVista Follow-up

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Admit Dx:

Admitted: 9/9/2008 3:53:13 AM
Acct #:

Postings: A
Alerts:

Care Team
Admitting MD: None
Attending MD: USER,PHYSICIAN

Active Orders (includes Pending
Current Orders (Active & Pendin
Expiring Orders
Unsigned
Recently

click Common Orders

View as Tree | Expand Tree | Collapse Tree

Service	Status	Order
Home Med	Active	HOME MEDICATIONS GINSENG CAP/TAB 1 CAP/TAB ORAL EVERY DAY Non-VA medication not recommended by VA provider.
		ONE MARROW BLOCK-TECH TISSUE WC ONCE LB #111
		B GREEN-SP PLASMA I ONCE LB #105
Lab	Active	GLUCOSE RANDOM GREEN BLOOD LC ONCE LB #104
Lab	Active	SP EOSIN STAIN TISSUE WC ONCE LB #99
Lab	Active	SP H & E STAIN TISSUE WC ONCE LB #93
Imaging - MRI	Active	MRI BRAIN W&W/O CONTRAST
Imaging - Mammography	Active	MAMMOGRAM SCREENING BILAT
Imaging - MRI	Active	MRI ABDOMEN W/O CONTRAST
Consults	Scheduled	ALLERGY Cons Bedside
Consults	Pending	CARDIOLOGY Cons Consultant's Choice

Write Orders

- Common Orders
- Cardiology Menu
- Endocrinology
- Gastroenterology
- Mental Health Menu
- Neurology
- OB/GYN
- Orthopedics
- Pediatric Menu
- Pulmonary Menu
- Surgery Menu
- **********

Write Delayed Orders

Patient Summary | Problem List | Medications | Orders | Clinical Notes | Consults/ Procedures | Discharge Summary | Vital Signs | Lab Results | Chart Inquiries

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Processing Alert: PATIENT,L (P) Completed Consult ALLERGY

Next | Renew | Forward | Remove | Stop

OpenVista Follow-up

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Alerts:
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Admitting MD: None
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Active Orders
Current Order
Expiring Order
Unsigned Orde
Recently Expir

View as Tree | Expand Tree | Collapse Tree

Write Orders
Common Orde
Cardiology Me
Endocrinology
Gastroenterol
Mental Health
Neurology
OB/GYN
Orthopedics
Pediatric Menu
Pulmonary Me
Surgery Menu
****
Write De

Patient Summary

Common Orders

CMP STAT	Metformin HCl 500mg Q...	Brain MRI WO Contrast	O2 Protocol
Hepatic Profile in AM	Triazolam 0.5mg at Bedt...	Skull Series 4 Views	Skin & Wound Care
Troponin Q8H X3	ASA EC 81mg Daily	Sinus Series	All Nursing Orders
Search All Labs	Acetaminophen 650mg ...	VQ Scan Lung	
	Search All IVs	Abdominal U/S Complete	
	Search All Meds	Lumbar Spine	
		Cervical Spine 2 views	
		Pelvic U/S Non OB	
		Carotid Duplex Ultrasound	
		Abdomen Upright	
		Abdomen Flat	
		Bone Scan Whole Body	
DIET ORDERS	**CONSULTS**		
Regular Diet	Medicine	EKG	Allergy Enter/Edit
NPO	Cardiology	Implant	
NPO NOW	Pulmonary	Holter	**TEXT ORDERS ONLY**
NPO Midnight	Gastroenterology	Echo	Text Orders
Clear Liquids	Hematology	Exercise Tolerance Test	
Enteral Formula	Allergy	PFT	

Back Forward Close

select Allergy consultation

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Processing Alert: PATIENT,L (P) Completed Consult ALLERGY

Next Renew Forward Remove Stop

OpenVista Follow-up

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Common Orde
Cardiology Me
Endocrinology
Gastroenterolo
Mental Health
Neurology
OB/GYN
Orthopedics
Pediatric Menu
Pulmonary Me
Surgery Menu
****

Write De

Patient Summary

Common Orders

CMP STAT
Hepatic Profile in AM
Troponin Q8H X3
Search All Labs

Metformin HCl 500mg Q...
Triazolam 0.5mg at
ASA EC 81mg Daily
Acetaminophen 650
Search All IVs
Search All Meds

Brain MRI WO Contrast
O2 Protocol

DIET ORDERS
Regular Diet
NPO
NPO NOW
NPO Midnight
Clear Liquids
Enteral Formula

CONSULTS
Medicine
Cardiology
Pulmonary
Gastroenterology
Hematology
Allergy

Exercise Tolerance Test
PFT

Back Forward Close

Order a Consult

Consult to Service/Speciality: ALLERGY
Patient will be seen as: Inpatient / Outpatient
Attention:
Place of Consultation: CONSULTANT'S CHOICE
Urgency: ROUTINE
Provisional Diagnosis: Diagnosis
Reason for Request:

ALLERGY Cons CONSULTANT'S CHOICE

Order
Save As Quick Order
Cancel

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Processing Alert: PATIENT,L (P) Completed Consult ALLERGY

Next Renew Forward Remove Stop

Contributions

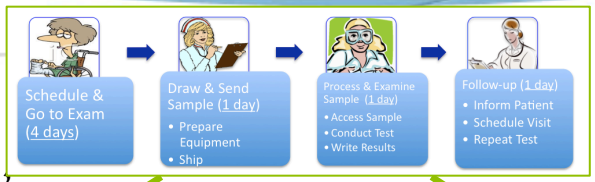
① Observations and interviews with clinicians and discussions of findings for results management

② Evaluations to quantify the benefits in time-critical applications where distractions undermine users' ability to track and react to orders

③ The development of guidelines for interactive rich tables with actions for rapid completion (ARCs)

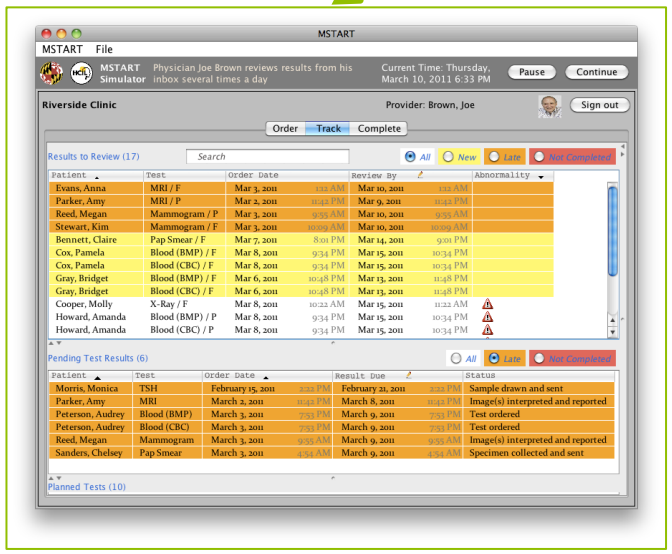
④ The design and user studies of a novel retrospective analysis visualization

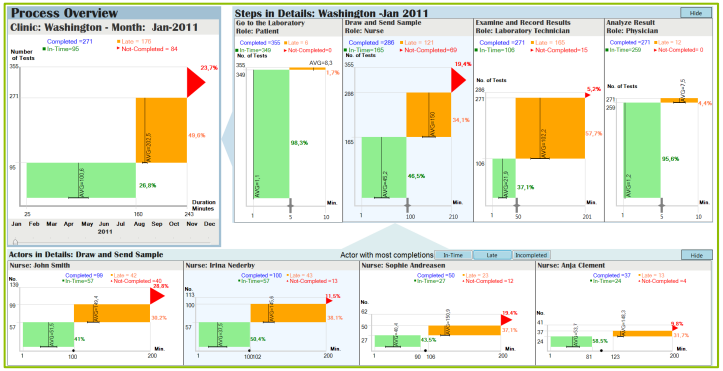
Solution



Physician,
Resident,
Assistant
…

Manager





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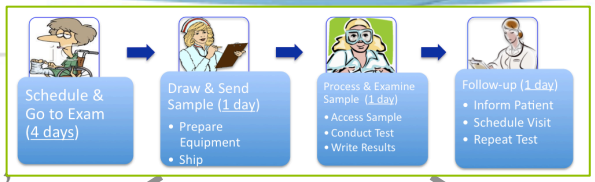
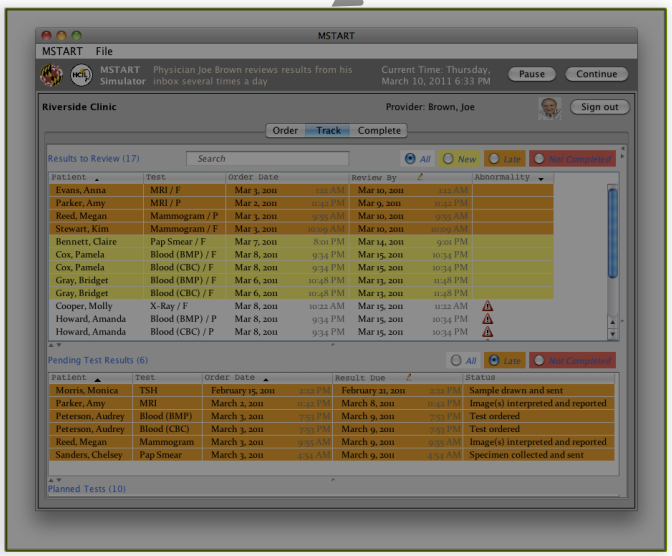
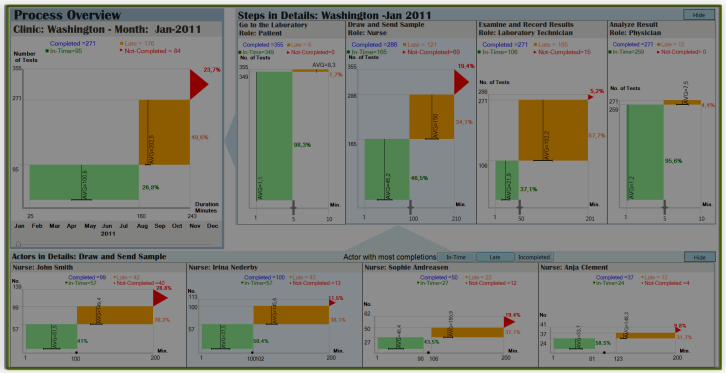


Physician, Resident, Assistant …

Manager

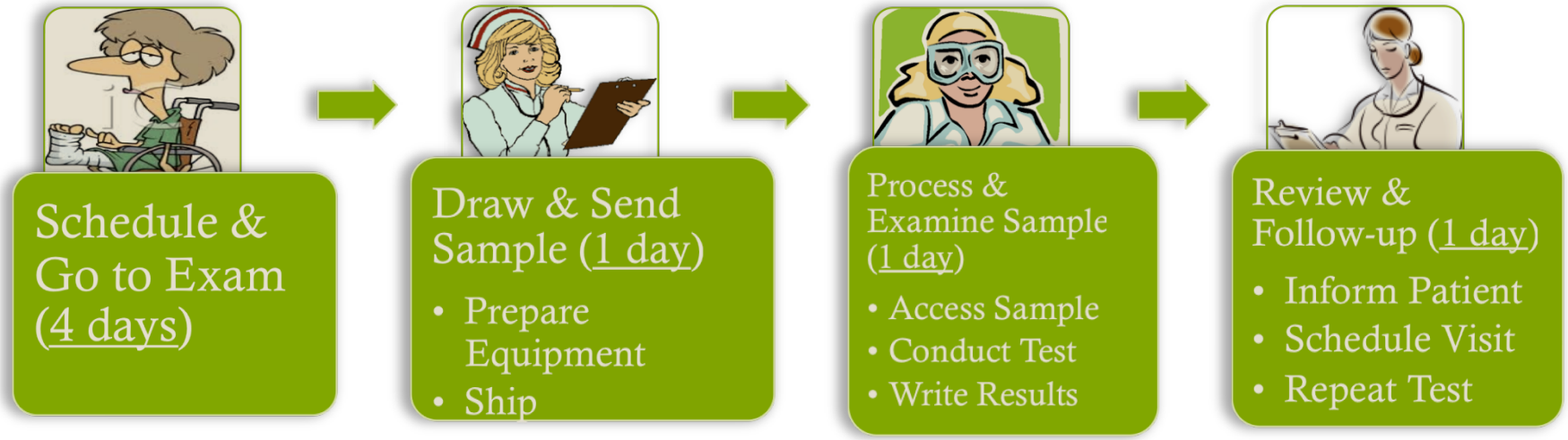




Requirements Analysis

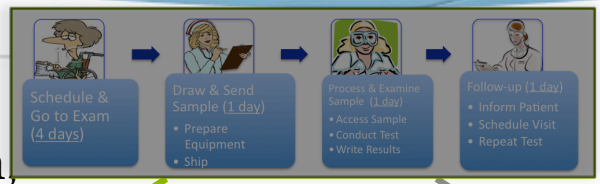
- Visits to 7 hospitals & clinics
- Observations of the medical workflow
- Electronic Health Record issues reported by clinicians
- Problems related to results management
- Design ideas about use cases, tables, delays, actions

Results Management Workflow & Actions



- [Aalst, 2005; Cass, 2000; Peterson, 1981; White, 2004]

Solution



Physician,
Resident,
Assistant
…

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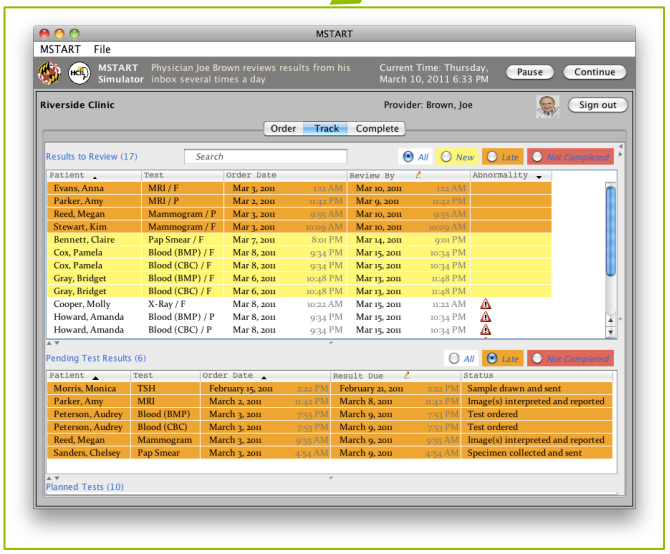
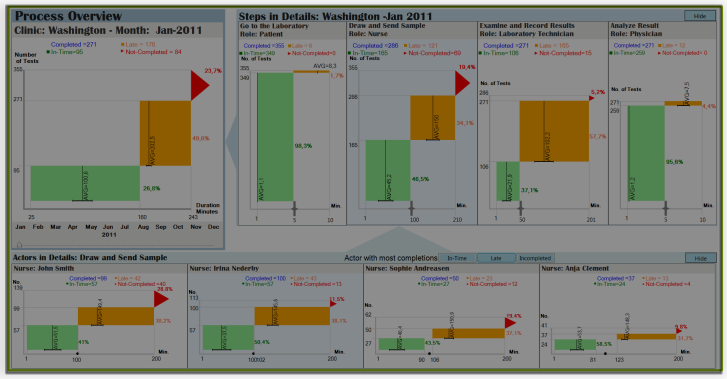
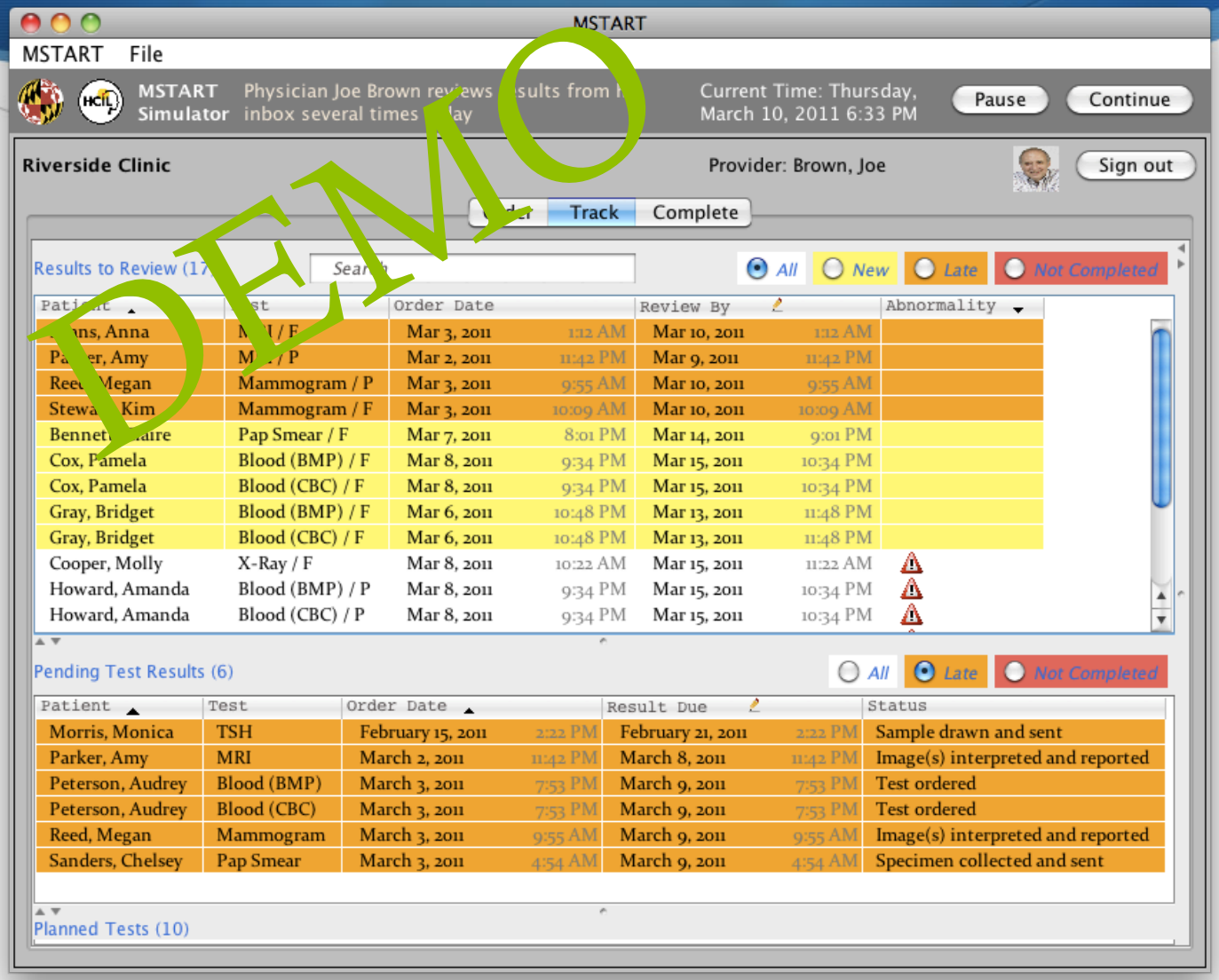




Timely Management of Medical Orders: MStart



Timely Management of Medical Results: ARC

MSTART

MSTART File

MSTART Simulator — Physician Joe Brown reviews results from his inbox several times a day

Current Time: Thursday, March 10, 2011 6:33 PM

Pause | Continue

Riverside Clinic

Provider: Brown, Joe

Sign out

Order | Track | Complete

DEMO

Results to Review (17)

Search

All | New | Late | Not Completed

Patient	Test	Order Date	Review By	Abnormality
Evans, Anna	Hx / F	Mar 3, 2011 1:12 AM	Mar 10, 2011 1:12 AM	
Parker, Amy				
Reed, Megan				
Stewart, Kim				
Cooper, Carol				
Howard, A				
Howard, Kim				
Phillips, Sara				
Phillips, Sara				
Richardson,				
Bennett, Clai				
Cox, Pamela				

No Follow-up

Ask Nurse to

Inform Patient (Evans, Anna)

Schedule Visit 1 days weeks months years

Order

Repeat Test 1 days weeks months years

Comments:

? | Review Later | Complete

Pending Test Results

Patient	Test	Order Date	Result Due	Status
Morris, Monica	TSH	Mar 2, 2011	Mar 8, 2011	Sample drawn and sent
Parker, Amy	MRI	Mar 2, 2011	Mar 8, 2011	Image(s) interpreted and reported
Peterson, Audrey	Blood (BMP)	Mar 3, 2011	Mar 9, 2011	Test ordered
Peterson, Audrey	Blood (CBC)	Mar 3, 2011	Mar 9, 2011	Test ordered
Reed, Megan	Mammogram	Mar 3, 2011	Mar 9, 2011	Image(s) interpreted and reported
Sanders, Chelsey	Pap Smear	Mar 3, 2011	Mar 9, 2011	Specimen collected and sent

Planned Tests (10)

NAME: Evans, Anna
STUDY DATE: 03/09/2011 4:28:29 PM
COMPARISON: None available
HISTORY: Pain
MRI OF THE RIGHT ANKLE (WITHOUT IV CONTRAST)
FINDINGS:

The bones demonstrate no fracture or gross marrow abnormality. Articular surfaces are within normal limits.

The spring ligament complex appears to be intact.

The tibialis posterior, flexor digitorum, and flexor hallucis longus tendons are intact. The peroneus brevis and longus tendons are intact. The Achilles tendon is intact.

The tarsal sinus is unremarkable. There are no significant fluid collections to suggest ligamentous injury.

The remaining muscles and soft tissues are unremarkable.

Evaluations

- Iterative Design Reviews with Medical Professionals
- Controlled Experiment for Awareness of Order Timeliness
- Evaluations of Actions for Rapid Completion

Iterative Design Reviews with Medical Professionals

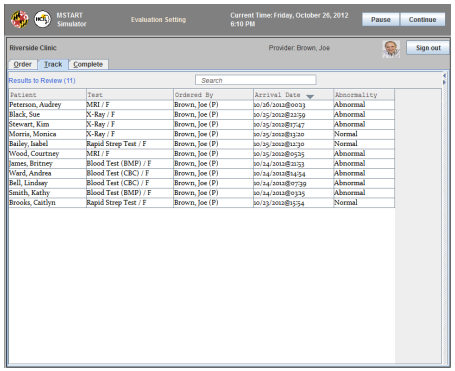
- Participatory design [Greenbaum and Kyng, 1991]
- Medicine, human-computer interaction, or software engineering
- 40 or more clinicians
- 15 presentations + 6 meetings
- 30 mins to 2 h each
- Live demonstration or with interactive executable
- Nov, 2010 – Jun, 2011 & Jan – May, 2012

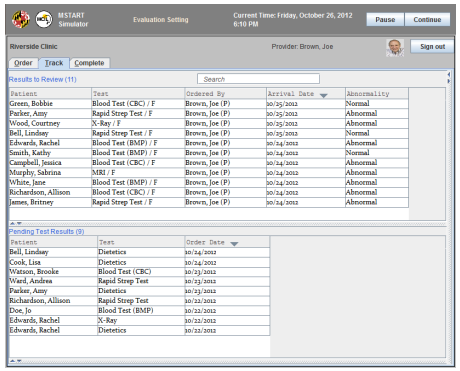
Iterative Design Reviews with Medical Professionals

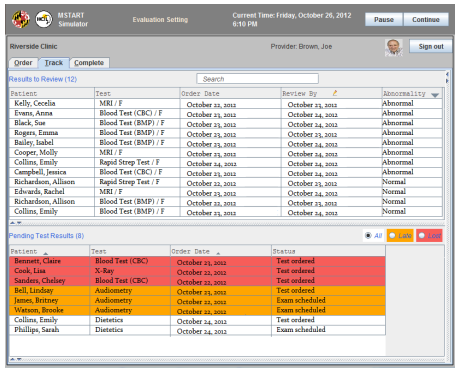
- Feedback on guidelines and evaluation
- Suggestions from a graphic designer
- Refinements to results management workflow
- Updates to prototype interface and interactions
- Design of retrospective analysis visualization

Controlled Experiment for Awareness of Order Timeliness

- Quantify the benefit of
  - showing a list of pending orders
  - prioritizing by lateness information
- Compare 3 versions
  - Time to answer question: what is late/lost?







Provide list of orders

10/22/2012

Bell, Lindsay	Blood Test (CBC)
Brooks, Caitlyn	Rapid Strep Test
Evans, Anna	Blood Test (BMP)
Smith, Kathy	Blood Test (BMP)

10/23/2012

Bailey, Isabel	Dietetics
Bailey, Isabel	Rapid Strep Test
Black, Sue	X-Ray
Brooks, Caitlyn	X-Ray
Doe, Jo	MRI
James, Britney	Blood Test (BMP)
Parker, Amy	Audiometry
Peterson, Audrey	MRI
Richardson, Allison	Dietetics
Stewart, Kim	X-Ray
Ward, Andrea	Blood Test (CBC)
Wood, Courtney	Blood Test (CBC)
Wood, Courtney	MRI

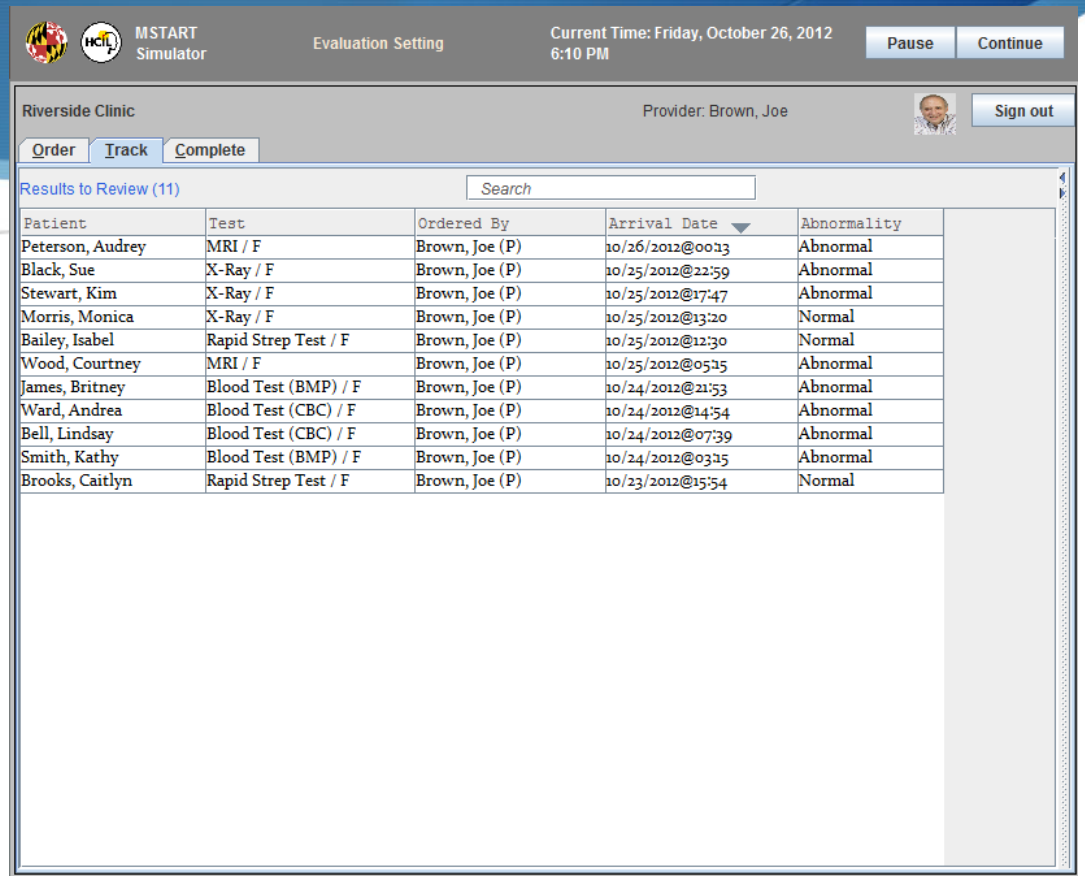
10/24/2012

Bell, Lindsay	Blood Test (BMP)
Brooks, Caitlyn	Audiometry
Morris, Monica	X-Ray

	Expected Duration (Days)	Considered Lost After (Days)
Imaging and Lab Tests	1	4
Blood Tests [BMP or CBC] Rapid Strep Test MRI X-Ray Mammogram		
Consultations	3	16
Dietetics Audiometry		

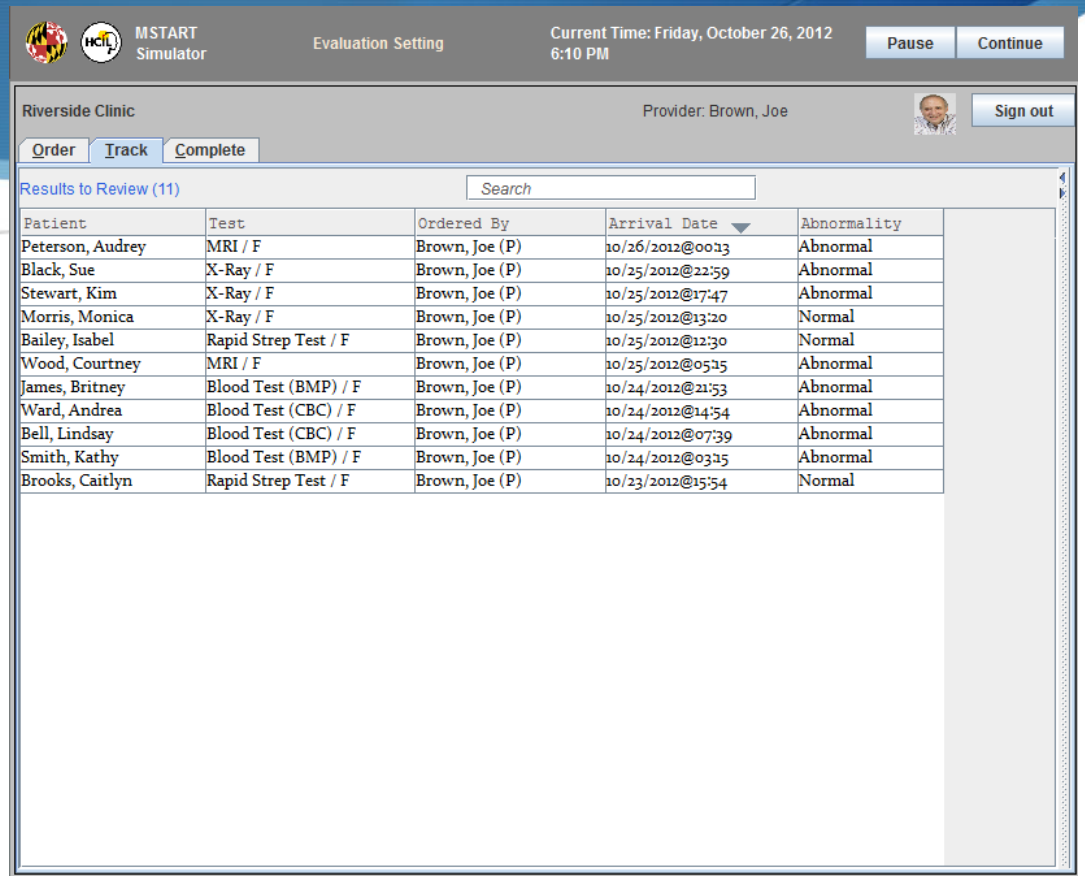
A distraction task…

Results only (sorted by time received)



Patient	Test	Ordered By	Arrival Date	Abnormality
Peterson, Audrey	MRI / F	Brown, Joe (P)	10/26/2012@00:13	Abnormal
Black, Sue	X-Ray / F	Brown, Joe (P)	10/25/2012@22:59	Abnormal
Stewart, Kim	X-Ray / F	Brown, Joe (P)	10/25/2012@17:47	Abnormal
Morris, Monica	X-Ray / F	Brown, Joe (P)	10/25/2012@13:20	Normal
Bailey, Isabel	Rapid Strep Test / F	Brown, Joe (P)	10/25/2012@12:30	Normal
Wood, Courtney	MRI / F	Brown, Joe (P)	10/25/2012@05:15	Abnormal
James, Britney	Blood Test (BMP) / F	Brown, Joe (P)	10/24/2012@21:53	Abnormal
Ward, Andrea	Blood Test (CBC) / F	Brown, Joe (P)	10/24/2012@14:54	Abnormal
Bell, Lindsay	Blood Test (CBC) / F	Brown, Joe (P)	10/24/2012@07:39	Abnormal
Smith, Kathy	Blood Test (BMP) / F	Brown, Joe (P)	10/24/2012@03:15	Abnormal
Brooks, Caitlyn	Rapid Strep Test / F	Brown, Joe (P)	10/23/2012@15:54	Normal

Results only (sorted by time received)



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Stewart, Kim	X-Ray / F	Brown, Joe (P)	10/25/2012@17:47	Abnormal
Morris, Monica	X-Ray / F	Brown, Joe (P)	10/25/2012@13:20	Normal
Bailey, Isabel	Rapid Strep Test / F	Brown, Joe (P)	10/25/2012@12:30	Normal
Wood, Courtney	MRI / F	Brown, Joe (P)	10/25/2012@05:15	Abnormal
James, Britney	Blood Test (BMP) / F	Brown, Joe (P)	10/24/2012@21:53	Abnormal
Ward, Andrea	Blood Test (CBC) / F	Brown, Joe (P)	10/24/2012@14:54	Abnormal
Bell, Lindsay	Blood Test (CBC) / F	Brown, Joe (P)	10/24/2012@07:39	Abnormal
Smith, Kathy	Blood Test (BMP) / F	Brown, Joe (P)	10/24/2012@03:15	Abnormal
Brooks, Caitlyn	Rapid Strep Test / F	Brown, Joe (P)	10/23/2012@15:54	Normal

- Which orders are **late**? **Lost**?

Results only (sorted by time received)

(Compare with orders)

10/22/2012

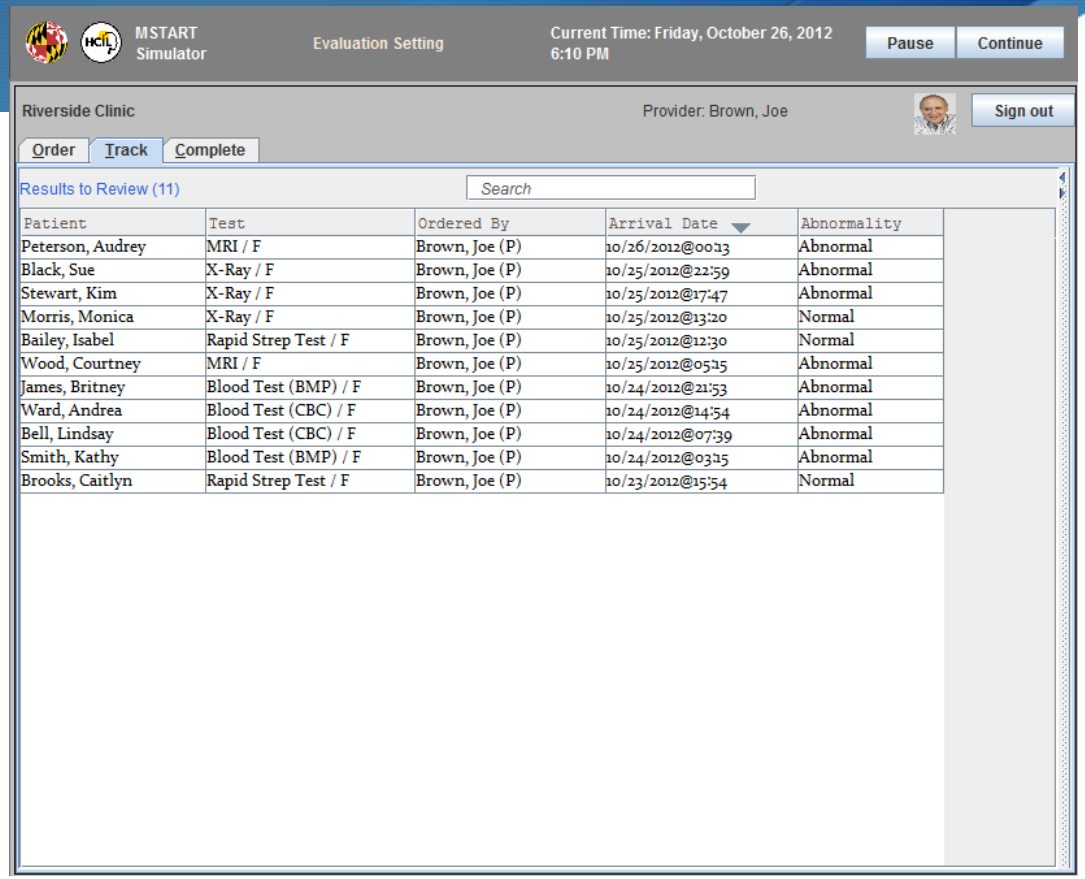
Bell, Lindsay	Blood Test (CBC)
Brooks, Caitlyn	Rapid Strep Test
Evans, Anna	Blood Test (BMP)
Smith, Kathy	Blood Test (BMP)

10/23/2012

Bailey, Isabel	Dietetics
Bailey, Isabel	Rapid Strep Test
Black, Sue	X-Ray
Brooks, Caitlyn	X-Ray
Doe, Jo	MRI
James, Britney	Blood Test (BMP)
Parker, Amy	Audiometry
Peterson, Audrey	MRI
Richardson, Allison	Dietetics
Stewart, Kim	X-Ray
Ward, Andrea	Blood Test (CBC)
Wood, Courtney	Blood Test (CBC)
Wood, Courtney	MRI

10/24/2012

Bell, Lindsay	Blood Test (BMP)
Brooks, Caitlyn	Audiometry
Morris, Monica	X-Ray



Patient	Test	Ordered By	Arrival Date	Abnormality
Peterson, Audrey	MRI / F	Brown, Joe (P)	10/26/2012@00:13	Abnormal
Black, Sue	X-Ray / F	Brown, Joe (P)	10/25/2012@22:59	Abnormal
Stewart, Kim	X-Ray / F	Brown, Joe (P)	10/25/2012@17:47	Abnormal
Morris, Monica	X-Ray / F	Brown, Joe (P)	10/25/2012@13:20	Normal
Bailey, Isabel	Rapid Strep Test / F	Brown, Joe (P)	10/25/2012@12:30	Normal
Wood, Courtney	MRI / F	Brown, Joe (P)	10/25/2012@05:15	Abnormal
James, Britney	Blood Test (BMP) / F	Brown, Joe (P)	10/24/2012@21:53	Abnormal
Ward, Andrea	Blood Test (CBC) / F	Brown, Joe (P)	10/24/2012@14:54	Abnormal
Bell, Lindsay	Blood Test (CBC) / F	Brown, Joe (P)	10/24/2012@07:39	Abnormal
Smith, Kathy	Blood Test (BMP) / F	Brown, Joe (P)	10/24/2012@03:15	Abnormal
Brooks, Caitlyn	Rapid Strep Test / F	Brown, Joe (P)	10/23/2012@15:54	Normal

- Which orders are **late**? **Lost**?

Add pending orders

(Compare with orders)

10/22/2012

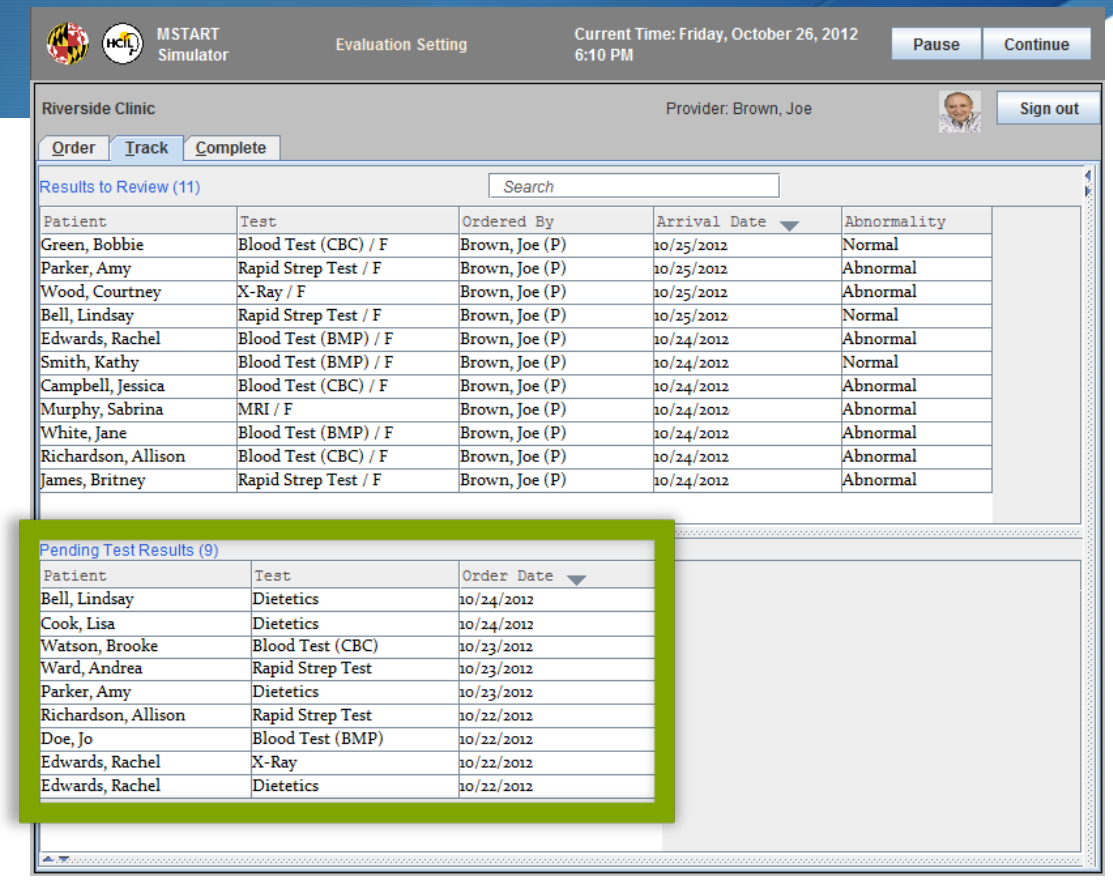
Bell, Lindsay	Blood Test (CBC)
Brooks, Caitlyn	Rapid Strep Test
Evans, Anna	Blood Test (BMP)
Smith, Kathy	Blood Test (BMP)

10/23/2012

Bailey, Isabel	Dietetics
Bailey, Isabel	Rapid Strep Test
Black, Sue	X-Ray
Brooks, Caitlyn	X-Ray
Doe, Jo	MRI
James, Britney	Blood Test (BMP)
Parker, Amy	Audiometry
Peterson, Audrey	MRI
Richardson, Allison	Dietetics
Stewart, Kim	X-Ray
Ward, Andrea	Blood Test (CBC)
Wood, Courtney	Blood Test (CBC)
Wood, Courtney	MRI

10/24/2012

Bell, Lindsay	Blood Test (BMP)
Brooks, Caitlyn	Audiometry
Morris, Monica	X-Ray



- Which orders are **late**? **Lost**?

Add pending orders (with lateness information)

(Compare with orders)

10/22/2012

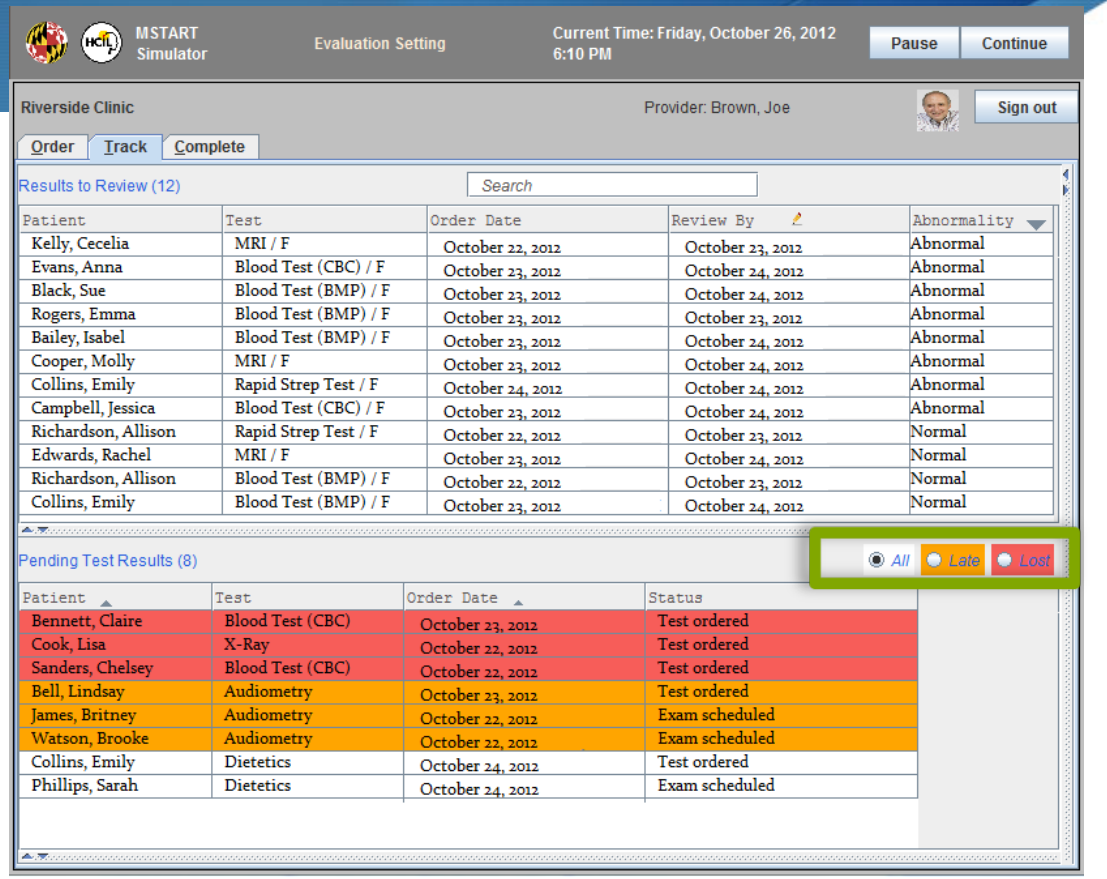
Bell, Lindsay	Blood Test (CBC)
Brooks, Caitlyn	Rapid Strep Test
Evans, Anna	Blood Test (BMP)
Smith, Kathy	Blood Test (BMP)

10/23/2012

Bailey, Isabel	Dietetics
Bailey, Isabel	Rapid Strep Test
Black, Sue	X-Ray
Brooks, Caitlyn	X-Ray
Doe, Jo	MRI
James, Britney	Blood Test (BMP)
Parker, Amy	Audiometry
Peterson, Audrey	MRI
Richardson, Allison	Dietetics
Stewart, Kim	X-Ray
Ward, Andrea	Blood Test (CBC)
Wood, Courtney	Blood Test (CBC)
Wood, Courtney	MRI

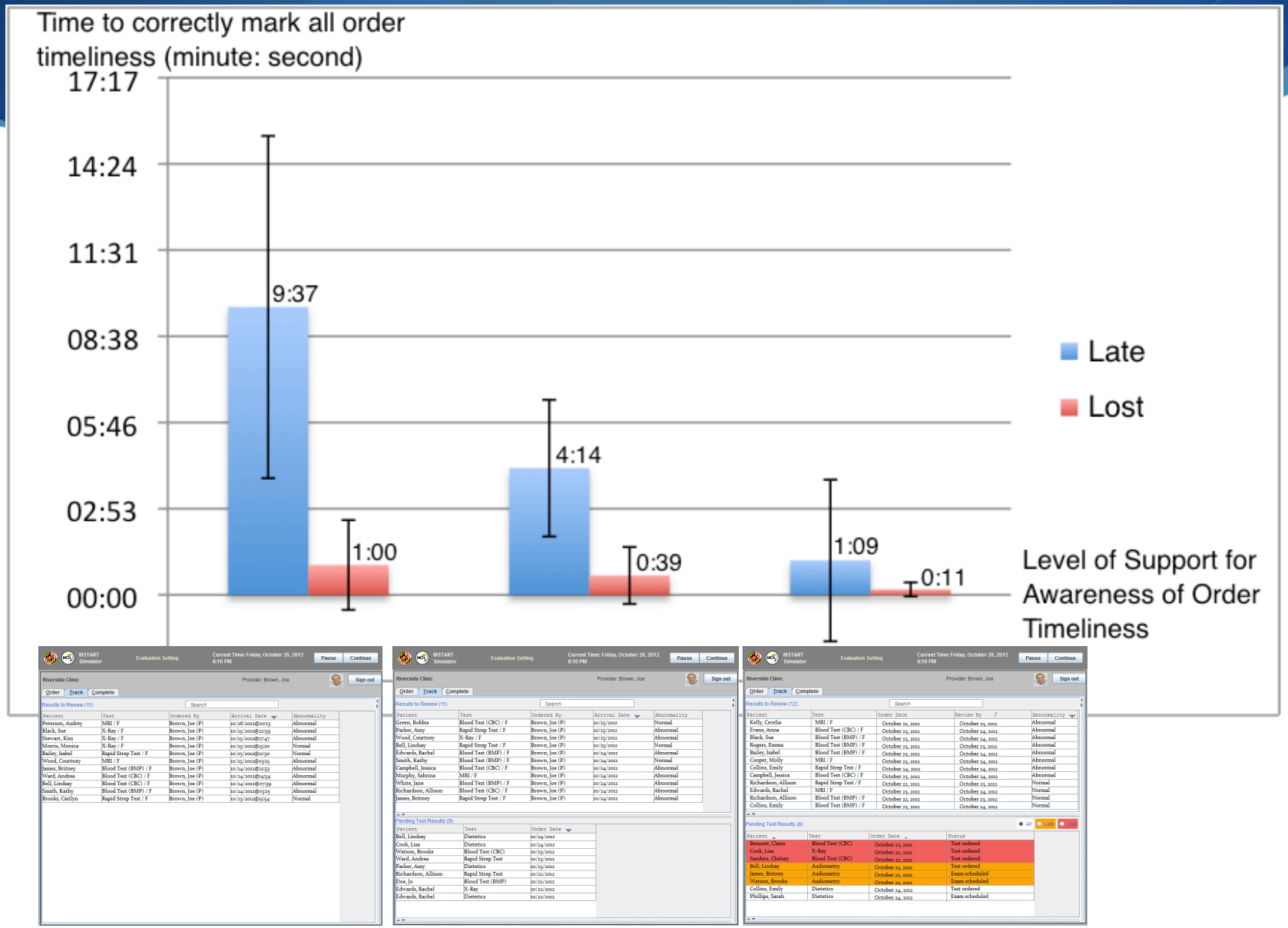
10/24/2012

Bell, Lindsay	Blood Test (BMP)
Brooks, Caitlyn	Audiometry
Morris, Monica	X-Ray

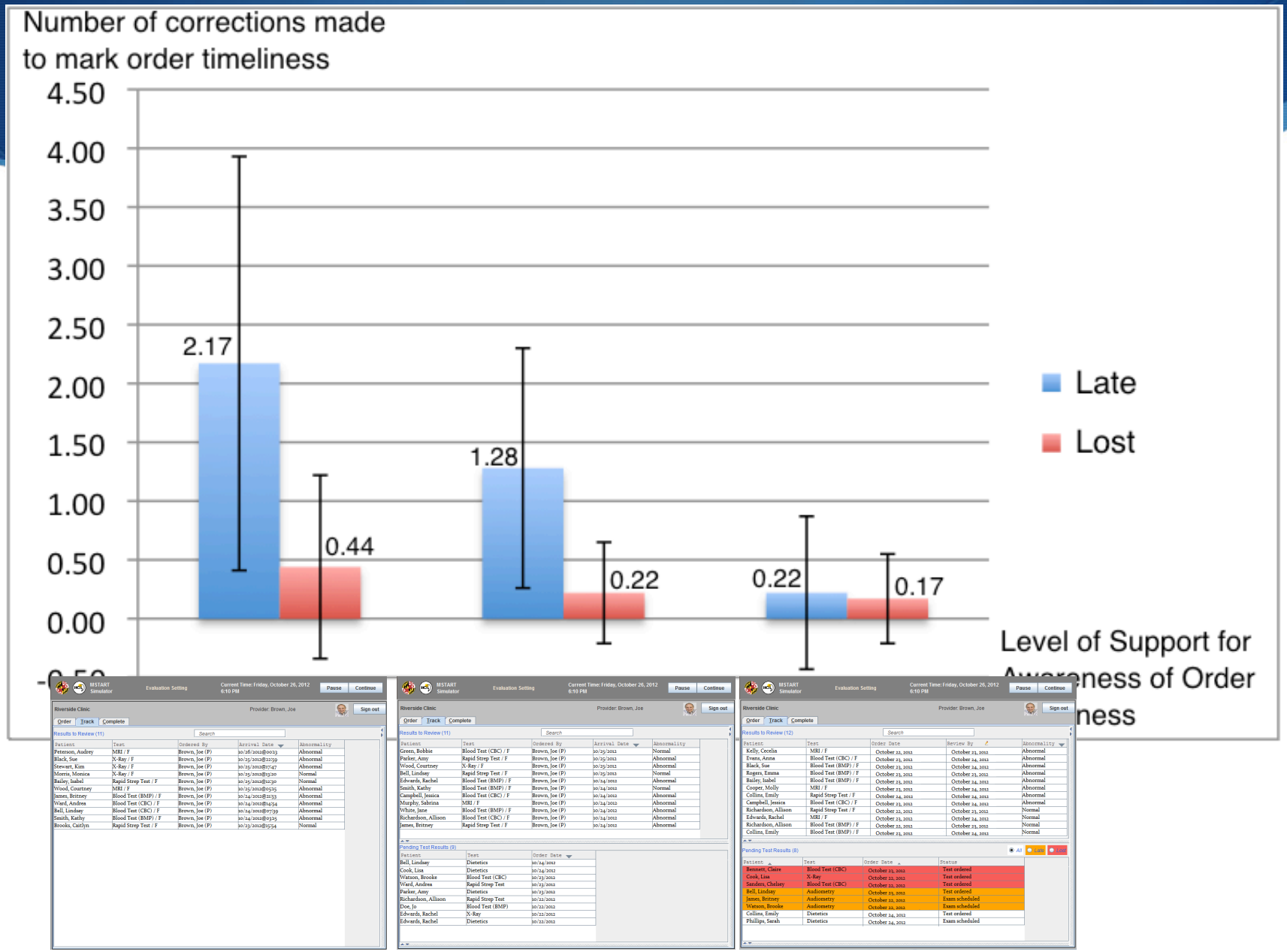


- Which orders are **late**? **Lost**?

Results (18 participants)



Results (18 participants)



Predictive Model for Results Management

- Goals, Operators, Methods, and Selection rules (GOMS) [Card, 1983]
- Time to compare names $\approx$ 0.5 sec
- $2 <$ time to look up a date ≤ 2.5
- $3 \leq$ time to compare dates ≤ 3.5

Evaluations of Actions for Rapid Completion

- Evaluating Time to Execute Actions
- Evaluating the Number of Steps

Conventional Follow-up

Act on Result of MRI

Patient: Evans, Anna

Ordered By: Brown, Joe

NAME: Evans, Anna
STUDY DATE: 03/09/2011 4:28:29 PM
COMPARISON: None available
HISTORY: Pain
MRI OF THE RIGHT ANKLE (WITHOUT IV CONTRAST)
FINDINGS:

The bones demonstrate no fracture or gross marrow abnormality. Articular surfaces are within normal limits.

The spring ligament complex appears to be intact.

The tibialis posterior, flexor digitorum, and flexor hallucis longus tendons are intact. The peroneus brevis and longus tendons are intact. The Achilles tendon is intact.

The tarsal sinus is unremarkable. There are no significant fluid collections to suggest ligamentous injury.

The remaining muscles and soft tissues are unremarkable.

- [ ] No Follow-up

Ask Nurse to

- [ ] Inform Patient (Evans, Anna)
- [ ] Schedule Visit 1 months

Order

- [ ] Repeat Test 1 months

New Test — Edit New Test

Medication — Edit Medication

Consultation — Edit Consultation

See History

Comments:

Review Later | Complete

Patient	Test	Order Date	Result Due	Status
Morris, Monica	TSH	Mar 2, 2011	Mar 8, 2011	Sample drawn and sent
Parker, Amy	MRI	Mar 2, 2011	Mar 8, 2011	Image(s) interpreted and reported
Peterson, Audrey	Blood (BMP)	Mar 3, 2011	Mar 9, 2011	Test ordered
Peterson, Audrey	Blood (CBC)	Mar 3, 2011	Mar 9, 2011	Test ordered
Reed, Megan	Mammogram	Mar 3, 2011	Mar 9, 2011	Image(s) interpreted and reported
Sanders, Chelsey	Pap Smear	Mar 3, 2011	Mar 9, 2011	Specimen collected and sent

Planned Tests (10)

Evaluating Time to Execute Actions★

Action	Conventional	ARC	ARC w/ Keyboard
Review Later	30s	28s (7%)	26s (13%)
Inform Patient + Confirm	44s	39s (11%)	29s (34%)
Inform Patient + Repeat Test (1 mo) + Confirm	51s	42s (18%)	34s (33%)
Inform Patient + Schedule Visit (1 w) + Confirm	1m 8s	51s (25%)	41s (40%)
No Follow-up (Other) + Confirm	1m 2s	53s (15%)	49s (21%)

★Measured Difference: 10 orders w/o distraction

Evaluating the Number of Steps

Action	OpenVista	Allscripts	ARC
Inform Patient	-	6	3 (50%)
Confirm	-	5	2 (60%)
No Follow-up	-	4	4 (0%)
Repeat Test	17	-	5 (71%)
Schedule Visit	12	-	5 (58%)

Design Guidelines

- Results management design guidelines (8)
- Table design guidelines (65)
- Actions for rapid completion design guidelines (17)

Results Management Design Guidelines

- Show pending orders
- Prioritize by late/lost status
- Embed actions when appropriate
- Provide retrospective analysis

Table Design Guidelines

Notifications

Info	Patient	Location	Urgency	Alert Date/Time	Message	Forwarded By/When
	Patient, Test132		Moderate	01/01/2010@03:14	Scheduled Consult: ORTHOPEDICS	
	Patient, Test164		Moderate	01/01/2010@15:09	Scheduled Consult: NON-INVASIVE ECHO	
	Patient, Test243		Moderate	01/02/2010@02:06	COMPLETED EMERGENCY ROOM NOTE available for ADD'L	
	Patient, Test32		HIGH	01/02/2010@05:35	Medications Nearing expiration	
	Patient, Test17		Moderate	01/02/2010@08:09	Imaging request held: KNEE 3 VIEWS, LEFT	
	Patient, Test267	GM	Moderate	01/03/2010@07:09	Abnormal labs - [TROPONIN I]	
	Patient, Test165		Moderate	01/04/2010@03:23	Abnormal labs - [LIPID PROFILE, COMPREHENSIVE]	
	Patient, Test138		Moderate	01/04/2010@08:46	Abnormal labs - [BASIC METABOLIC PANEL]	
	Patient, Test106		Moderate	01/05/2010@02:06	Labs resulted - [MICROALBUMIN;URINE]	
	Patient, Test286		Moderate	01/05/2010@04:33	COMPLETED PHARMACY PATIENT ENCOUNTER available fc	
	Patient, Test362	GM	HIGH	01/05/2010@08:32	Critical lab: CR 2.3 05/27 05:00	
	Patient, Test151		Moderate	01/06/2010@07:09	Imaging Results, Non Critical: SPINE LUMBOSACRAL MIN 2 VI	
	Patient, Test209		Moderate	01/07/2010@05:00	Discontinued consult DERMATOLOGY	
	Patient, Test122	GM	Moderate	01/08/2010@02:08	Comment Added to Consult PAIN MANAGEMENT	
	Patient, Test305		HIGH	01/08/2010@08:41	Abnl Imaging Reslt; Needs Attn: CT ABDOMEN W&W/O CO	
	Patient, Test132		Moderate	01/08/2010@09:07	Completed Consult NURSING CASE MANAGEMENT	
	Patient, Test57		Moderate	01/08/2010@16:09	Abnl Imaging Reslt; Needs Attn: MAGNETIC IMAGE LUMBAR S	
	Patient, Test160		Moderate	01/09/2010@03:09	UNSIGNED PRIMARY CARE FOLLOW-UP available for SIGNA	

Table Design Guidelines

- Sorting, icons, colors, columns, labels, filters, layout

All New Late

Patient	Test	Order Date		Review By		Abnormality
Evans, Anna	MRI / F	Mar 3, 2011	1:12 AM	Mar 10, 2011	1:12 AM	
Parker, Amy	MRI / P	Mar 2, 2011	11:42 PM	Mar 9, 2011	11:42 PM	
Reed, Megan	Mammogram / P	Mar 3, 2011	9:55 AM	Mar 10, 2011	9:55 AM	
Stewart, Kim	Mammogram / F	Mar 3, 2011	10:09 AM	Mar 10, 2011	10:09 AM	
Cooper, Molly	X-Ray / F	Mar 8, 2011	10:22 AM	Mar 15, 2011	11:22 AM	
Howard, Amanda	Blood (BMP) / P	Mar 8, 2011	9:34 PM	Mar 15, 2011	10:34 PM	

[Few, 2004; MSCUI, 2008; Tullis, 2004]

Actions for Rapid Completion Design Guidelines

All | New | Late

Patient	Test	Order Date		Review By		Abnormality
Evans, Anna	MRI / F	Mar 3, 2011	1:12 AM	Mar 10, 2011	1:12 AM	
Parker, Amy	MRI / P	Mar 2, 2011	11:42 PM	Mar 9, 2011	11:42 PM	
Reed, Megan	Mammogram / P	Mar 3, 2011	9:55 AM	Mar 10, 2011	9:55 AM	
Stewart, Kim	Mammogram / F	Mar 3, 2011	10:09 AM	Mar 10, 2011	10:09 AM	
Cooper, Molly						
Howard, Ama						

No Follow-up

Ask Nurse to

Inform Patient (Stewart, Kim)

Schedule Visit 1 days weeks months years

Order

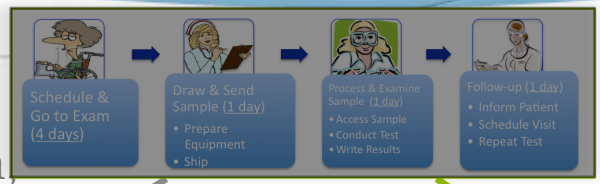
Repeat Test 1 days weeks months years

Comments:

? Review Later Complete

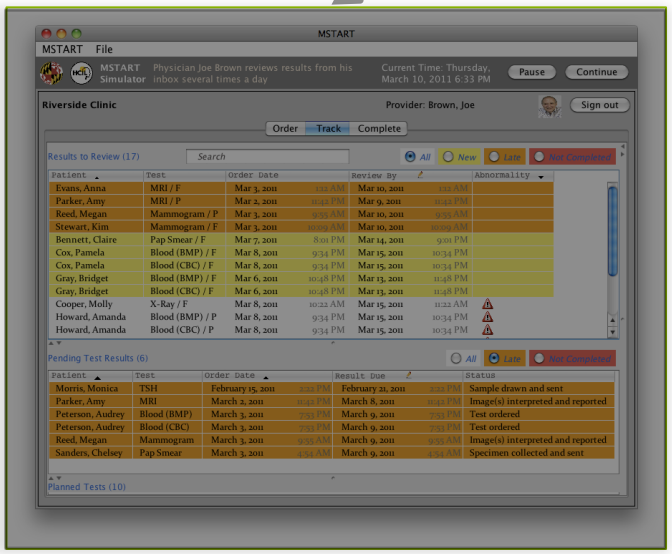
Procedure reported
Film screen mammography, both breasts.
Reason for procedure
Screening
Findings
Comparison was made to exam from 11/14/2001. The breasts are heterogeneously dense. This may lower the sensitivity of mammography. No significant masses, calcifications, or other abnormalities are present. There is no significant change from the prior exam.
Impressions
BI-RADS® Category 1: Negative. Recommend normal interval follow-up in 12 months

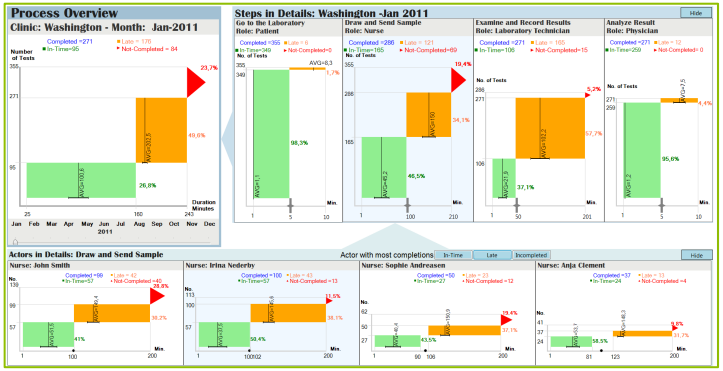
Solution



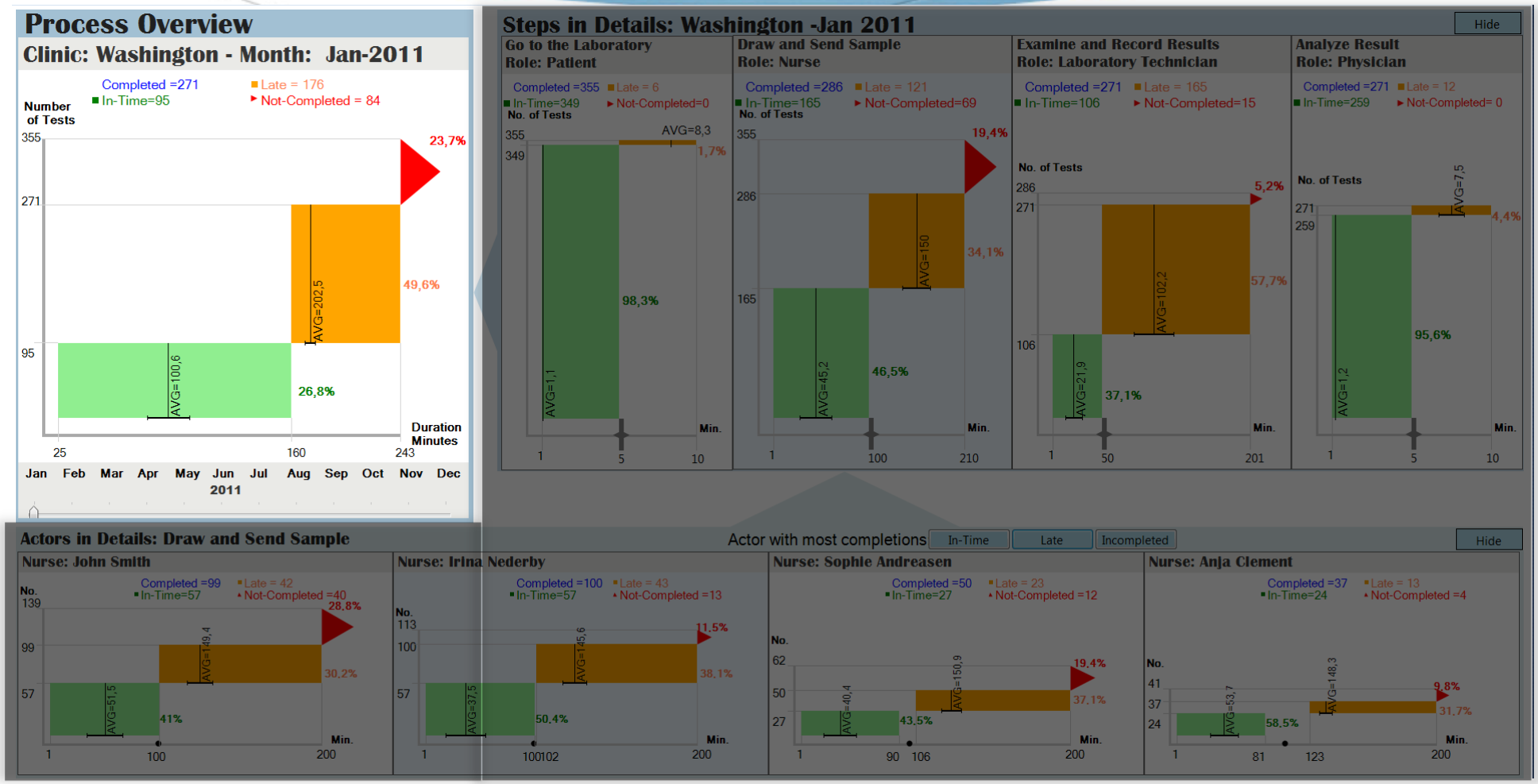
Physician, Resident, Assistant …

Manager

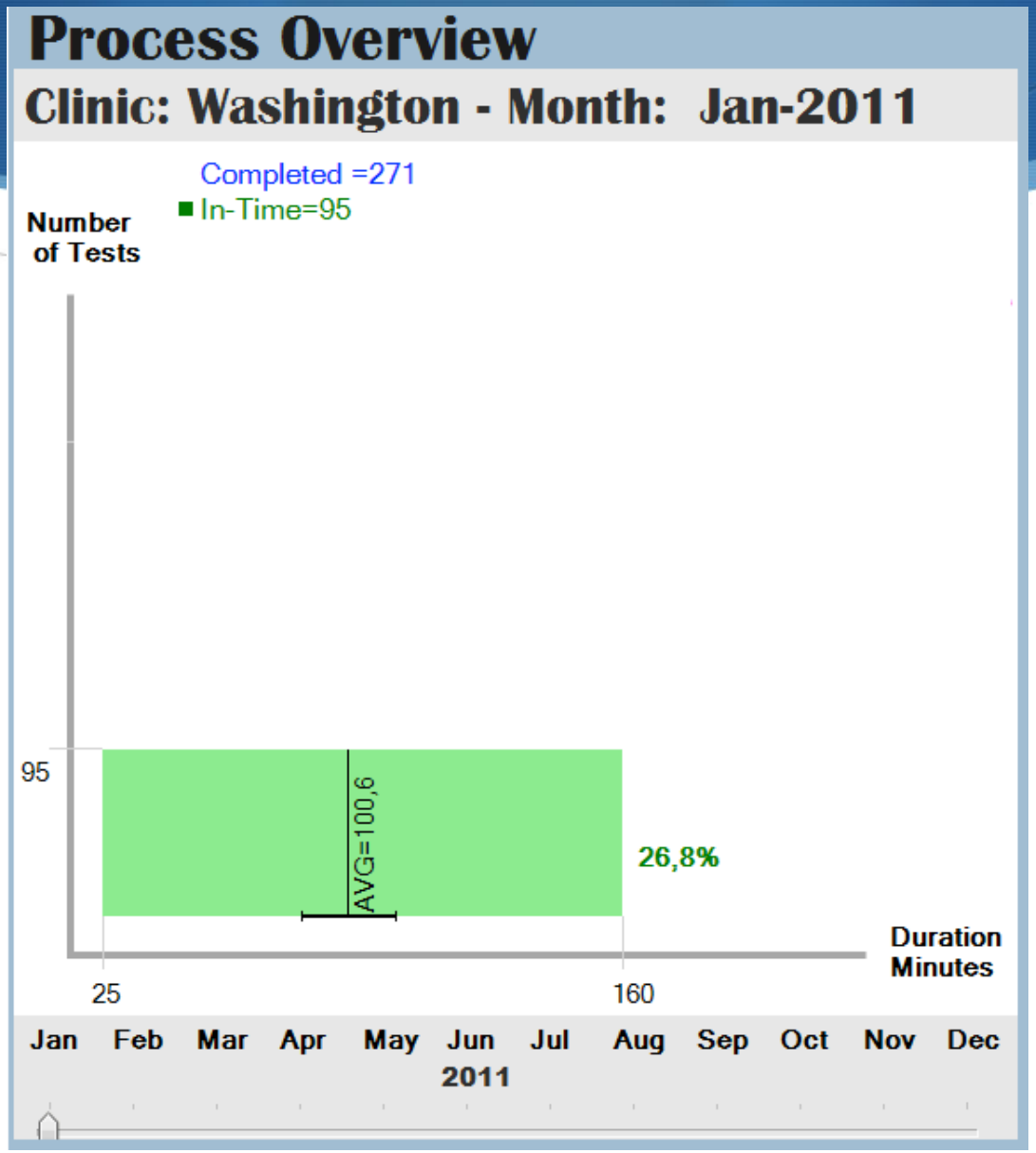




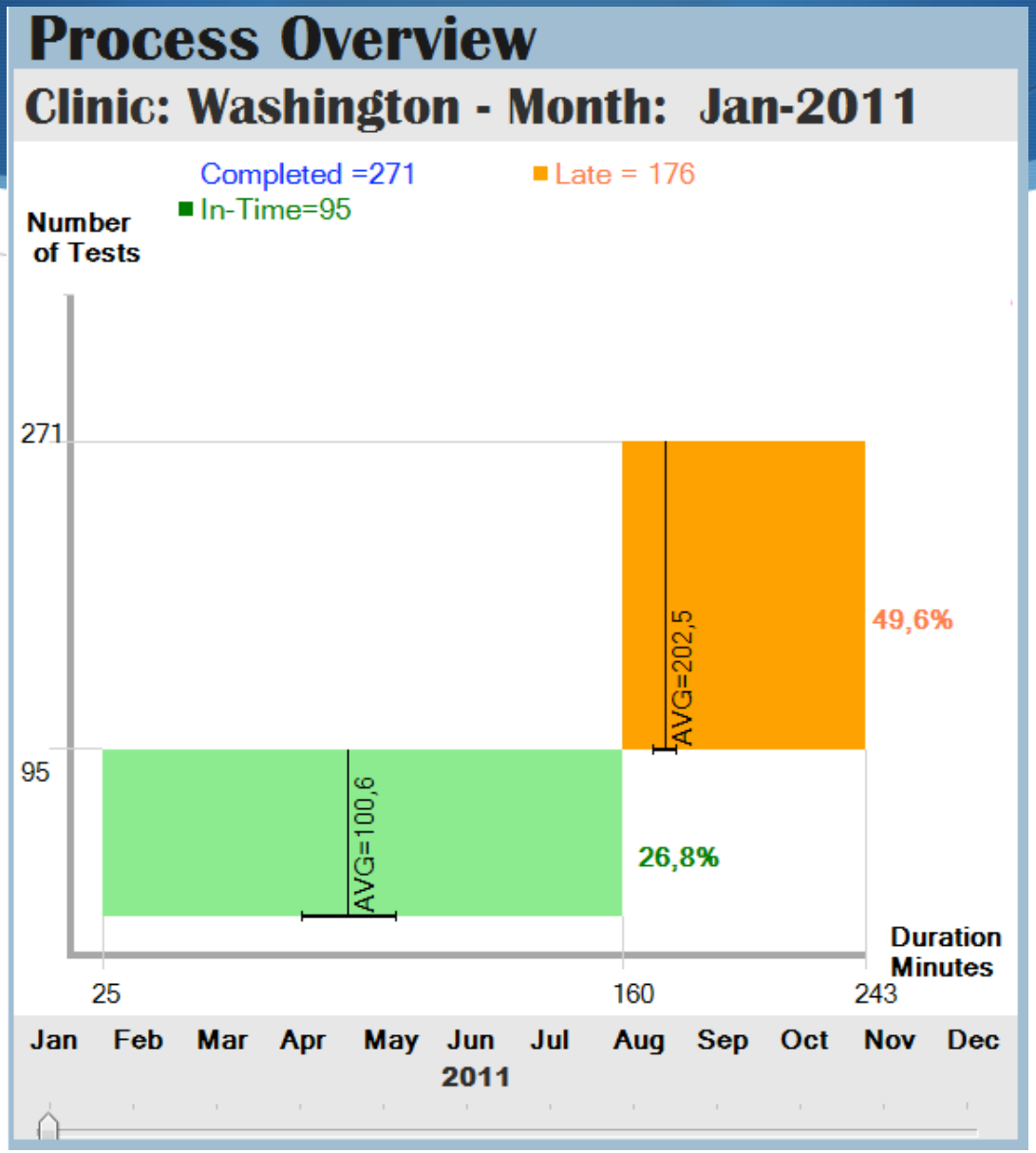
Retrospective Analysis of Medical Orders: MSProVis



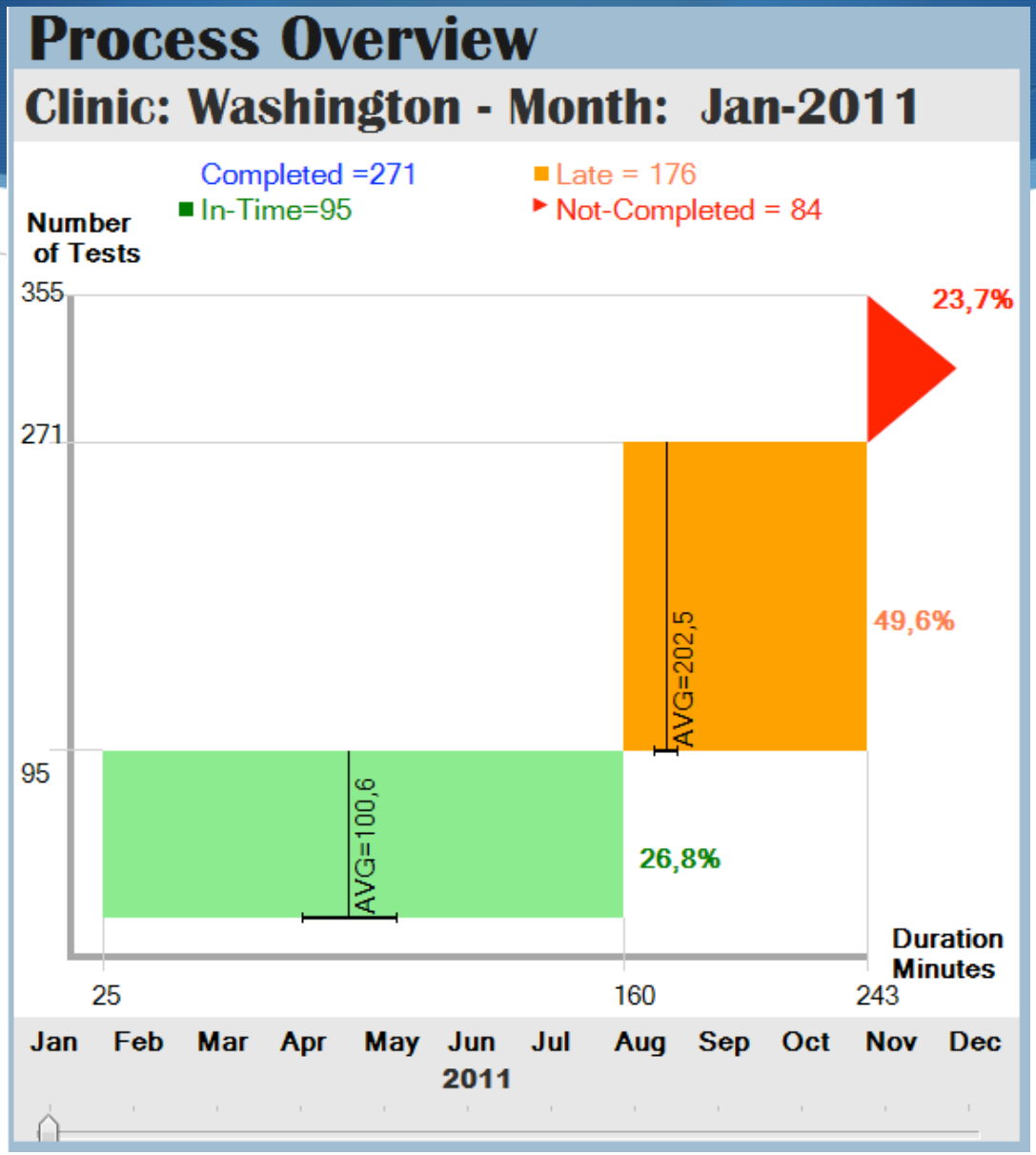
Process Completion Diagram (PCD)



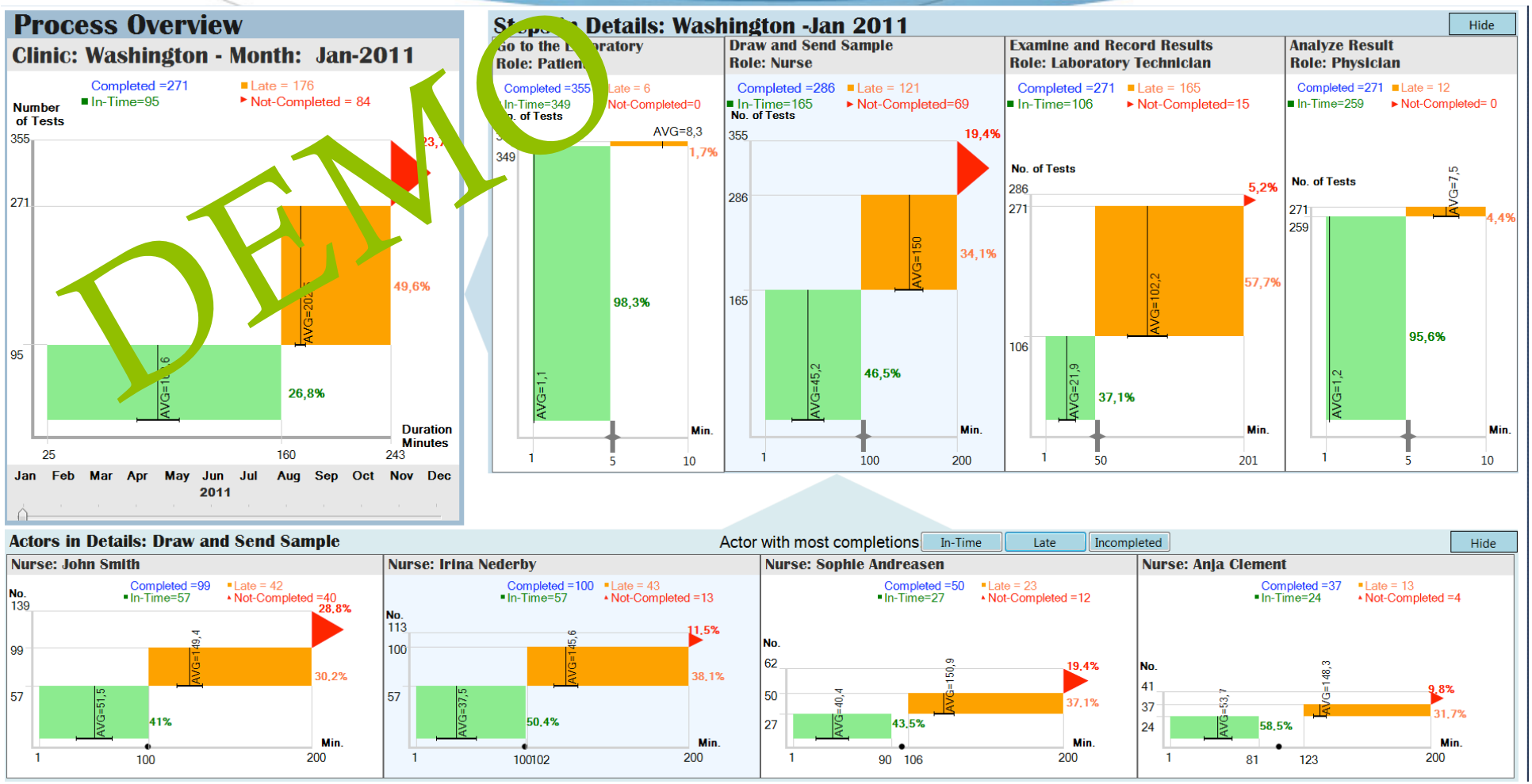
Process Completion Diagram (PCD)



Process Completion Diagram (PCD)



Multi-Step Process Visualization

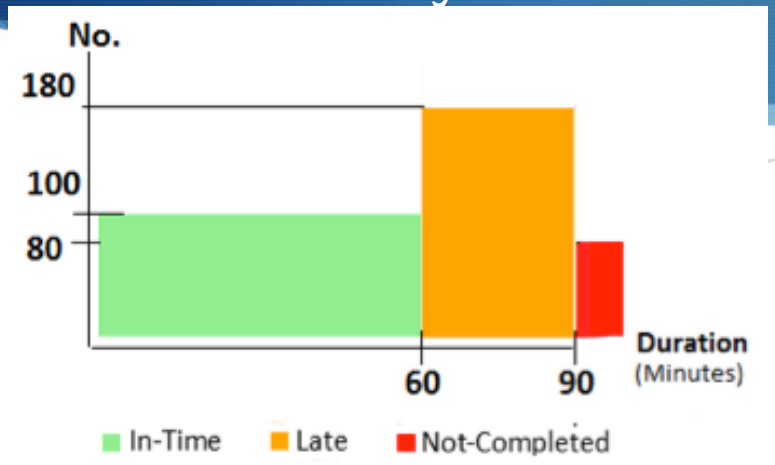


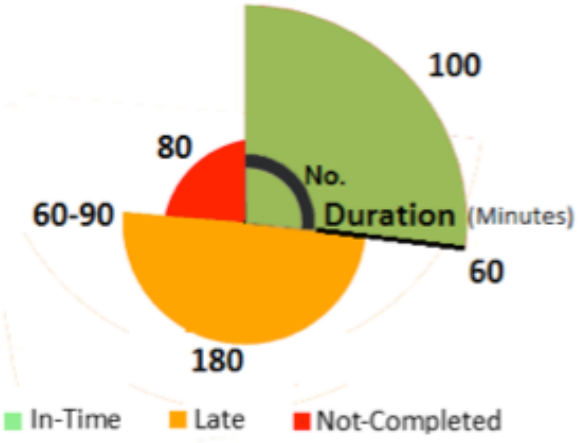
Evaluation

- Usability studies
  - Studies with 5 novices
  - Studies with 2 physicians
- Surveys

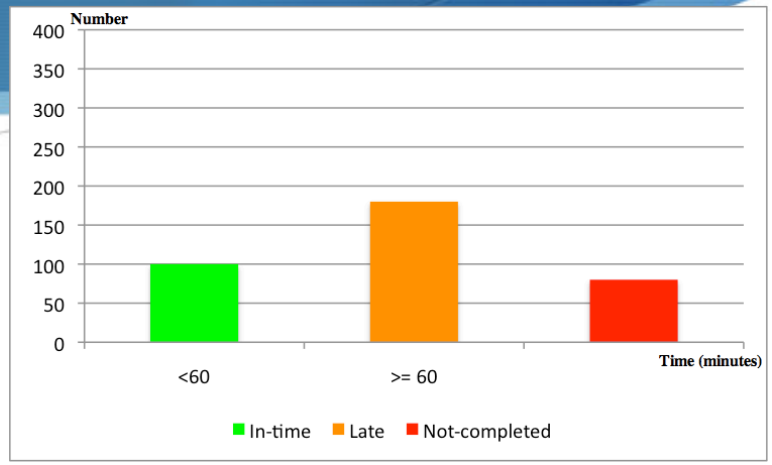
Surveys

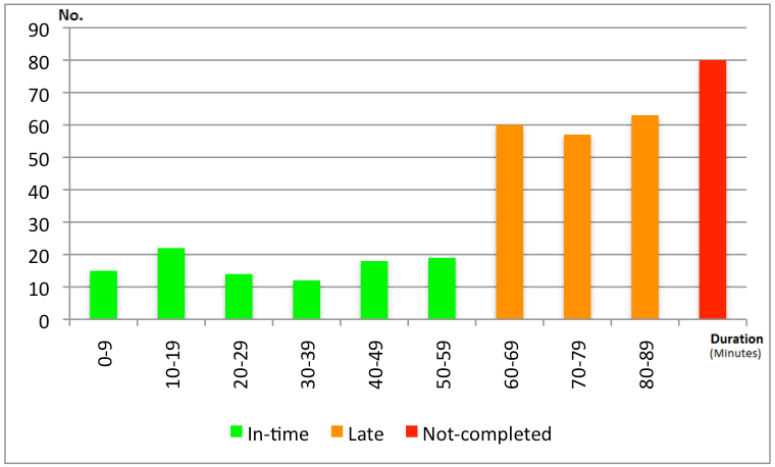
Survey 1





Survey 2





Conclusion

① Observations and interviews with clinicians and discussions of findings for results management

② Evaluations to quantify the benefits in time-critical applications where distractions undermine users' ability to track and react to orders

③ The development of guidelines for interactive rich tables with actions for rapid completion

④ The design and user studies of a novel retrospective analysis visualization

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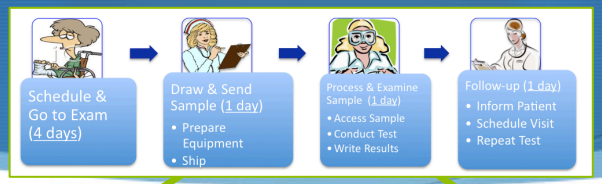
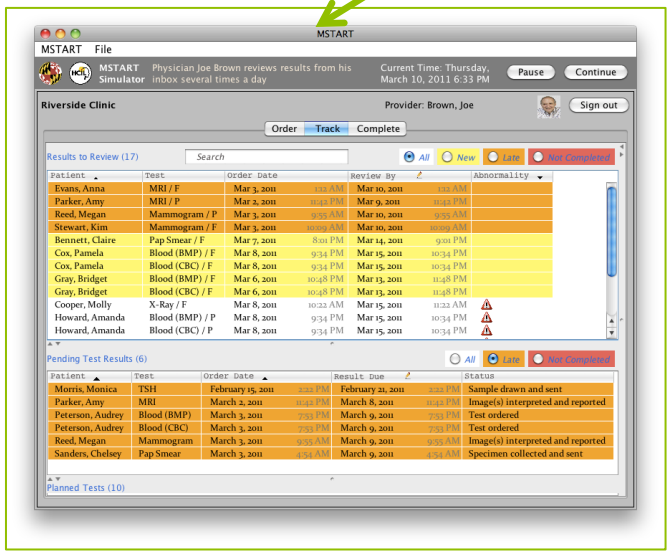
NCCD

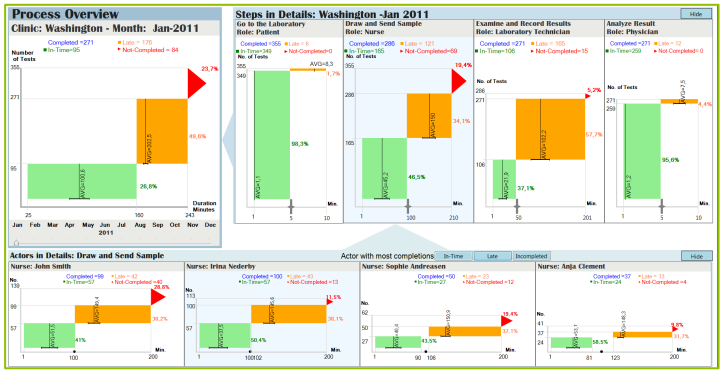
Conclusion



Provider, Resident, Assistant …

Manager





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