Spatio-temporal measurements of patient-healthcare worker interactions

Adi V Gundlapalli, MD, PhD, MS
Warren B P Pettey, MPH
Jose G Benuzillo, MPA, MS
Matthew H Samore, MD

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Patient-HCW interactions & respiratory viruses

- Health Care Workers (HCW)
  - Are exposed to respiratory viruses
  - May be asymptomatic after exposure
  - Experience illness and absenteeism
  - We know this from experience!

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Healthcare workers at risk

- Potentially any HCW
- High risk areas
  - Intensive care units
  - Immuno-suppressed patient care areas
- *Emergency Departments!*
  - Pediatric emergency care
    - More symptoms, more shedding
    - Less control of secretions

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Occupational exposure

- Concern for circulating viruses
  - Influenza
  - RSV
- Also for emerging infections:
  - SARS
    - 21% of worldwide cases were HCW
    - The Toronto experience
    - Duration of exposure associated with transmission
  - Avian influenza

Low JG, Wilder-Smith A. *Ann Acad Med Singapore*. 2005;34(1):105-10.
Stott DJ, Kerr G, Carman WF. *Occup Med (Lond)*.2002;52(5):249-53.
Pachucki CT, *et al*. *Arch Intern Med*.1989;149(1):77-80.
Sepkowitz KA. *Ann Intern Med*.1996;125(10):826-34.

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Patient-HCW interactions & respiratory viruses

- 2003 Hong Kong & SARS
  - "Health care workers who were at high risk of contracting SARS appear not only to have chronic stress but also higher levels of depression and anxiety."

"Immediate and sustained psychological impact of an emerging infectious disease outbreak on health care workers" (Can J Psychiatry 2007 Apr;52(4):241-7)

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Project: the hypothesis

- Transmission of respiratory virus from patient to health care worker depends on the *duration of contact* between them

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Project: the research questions

- How best can we measure contact patterns between patients and their HCW?
- Can we estimate transmission of respiratory viruses from patients to HCW?

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Project: the location & time

- Primary Children's Medical Center in Salt Lake City, Utah
- January 2007 to April 2008

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Patient-HCW interactions & respiratory viruses

- Direct transmission of respiratory viruses requires all of the following:
  - An infectious individual
  - A susceptible individual
  - A coincidence in space
  - A coincidence in time
- For analysis of HCW-patient interactions, we need all four elements

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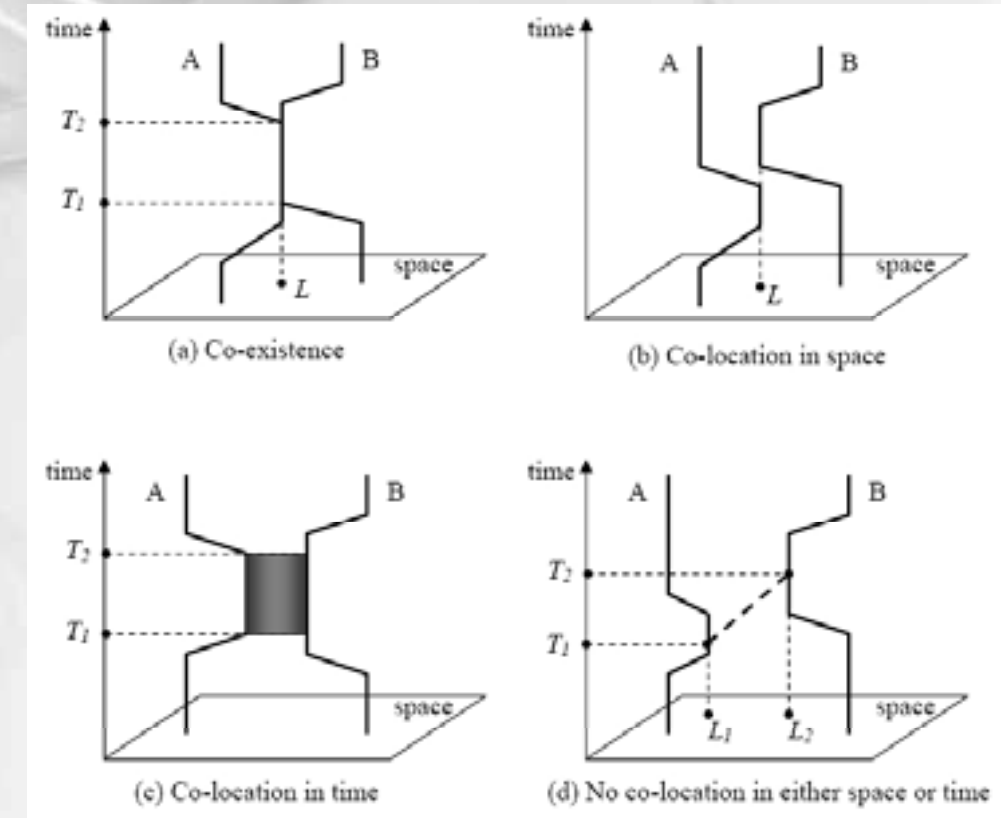
Patient-HCW interactions & respiratory viruses



-Yu, Hongbo: “Spatio-Temporal Design for Exploring Interactions of Human Activities.” pg.7 (http://www.ucgis.org/ucgisfall2004 /studentpapers/files/yu.pdf)

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Acquiring the time-geography for HCW-patient interactions

- Location and time are needed for both parties. For example, the following could work:

	(x,y)	Time
Patient	**Room Number**	**Time "Roomed"**
HCW	**Room Number**	**Time of HCW visit**

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Acquiring the time-geography for HCW-patient interactions

- What level of data granularity is sufficient to capture the moment of transmission?
  - Infectious dose:
    - Pathogenicity of infectious organism
    - Immune status of host
  - Patient-HCW proximity:
    - Usually considered 3-feet
    - “How long is my arm?”
  - Duration of contact

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Acquiring the time-geography for HCW-patient interactions

- For Patients:
  - Logicare™ System
    - Manual patient flow software
    - Records of important events such as time triaged, time escorted to room, time of various HCW visits, and disposition (admit/discharge/LWOT)
    - Importantly, all records have the following:
      - Date/Timestamp
      - Room number

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LogiCare Report

Patient **Location** **Time**

ID	Chief Complaint	Urgency	RoomNumber	ArrivalTimeStamp	Disposition	DispostionTime
1	Dehydration	3 - Urgent	13	3/1/2007 12:0[illegible] AM	Discharged ED	[illegible]7 3:55:39 AM
2	Respiratory Distress	3 - Urgent	5	3/1/2007 12:[illegible]41 AM	Discharged ED	[illegible]2007 5:20:00 AM
3	Fever	2 - Emergent	2	3/1/2007 12:26:31 AM	Discharged ED	[illegible]2007 3:25:08 AM
4	Respiratory Distress	3 - Urgent	1	3/1/2007 12:35:57 AM	Discharged ED	[illegible]2007 4:17:33 AM
5	Respiratory Distress	4 - Semi-Urgent	118	3/1/2007 1:38:54 AM	To Inpt Unit	[illegible]2007 2:00:00 PM
6	Respiratory Distress	2 - Emergent	8	3/1/2007 12:08:00 AM	Admitted	[illegible]2007 2:50:38 AM
7	Weakness	3 - Urgent	7	3/1/2007 12:38:04 AM	Discharged ED	[illegible]2007 4:09:01 AM
8	Respiratory Distress	4 - Semi-Urgent	16	3/1/2007 12:40:40 AM	Discharged ED	[illegible]2007 4:10:49 AM
9	Fever	2 - Emergent	6	3/1/2007 1:48:22 AM	Admitted	[illegible]2007 5:57:01 AM
10	Diabetic Reaction	2 - Emergent	17	3/1/2007 1:01:00 AM	Admitted	[illegible]2007 3:15:00 AM

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Acquiring the time-geography for HCW-patient interactions

- For Healthcare Workers:
  - Hill-Rom COMLinx™ Nurse Communication Module
  - Passive, infrared line-of-sight healthcare worker locating system
    - IR-emitting badges
    - Geographically known IR sensors
    - System server

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COMLinx IR-emitting badges

- Small clip-on badge that HCWs wear while on shift
  - Broadcasts unique ID via IR LED
  - Signal sent every 2-4 seconds
  - Battery powered

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COMLinx IR Sensors

- "Listen" for IR transmission of a HCW's badge identification
- Located on ceilings and walls
  - Patient rooms
  - Hallways
  - Break rooms
  - Points of entry and exit
- Senses IR badges up to 20 feet away
- Sends messages to the COMLinx server

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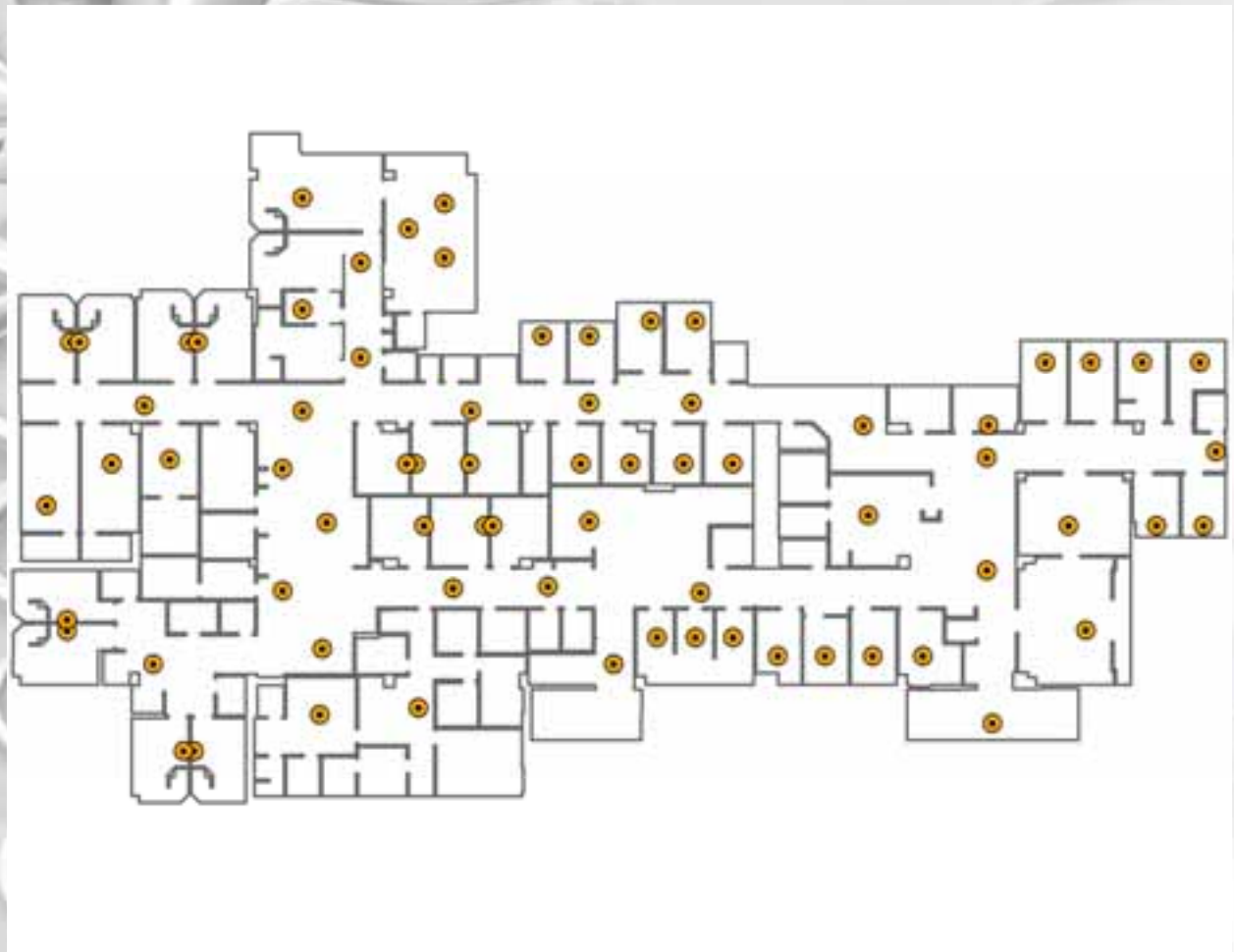
COMLinx IR Sensor Locations



The floorplan of Primary Children's Medical Center's ED/RTU has changed significantly.

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Sensor coverage with doors open

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Sensor coverage with doors closed

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COMLinx Server

- Records all sensor messages
  - Records IR-emitting badge unique ID
  - Creates Date/Timestamp
  - Records duration
- Adjustable system parameters
  - Location exit timer: 14 seconds
  - Active staff timer: 10 minutes
- Always on

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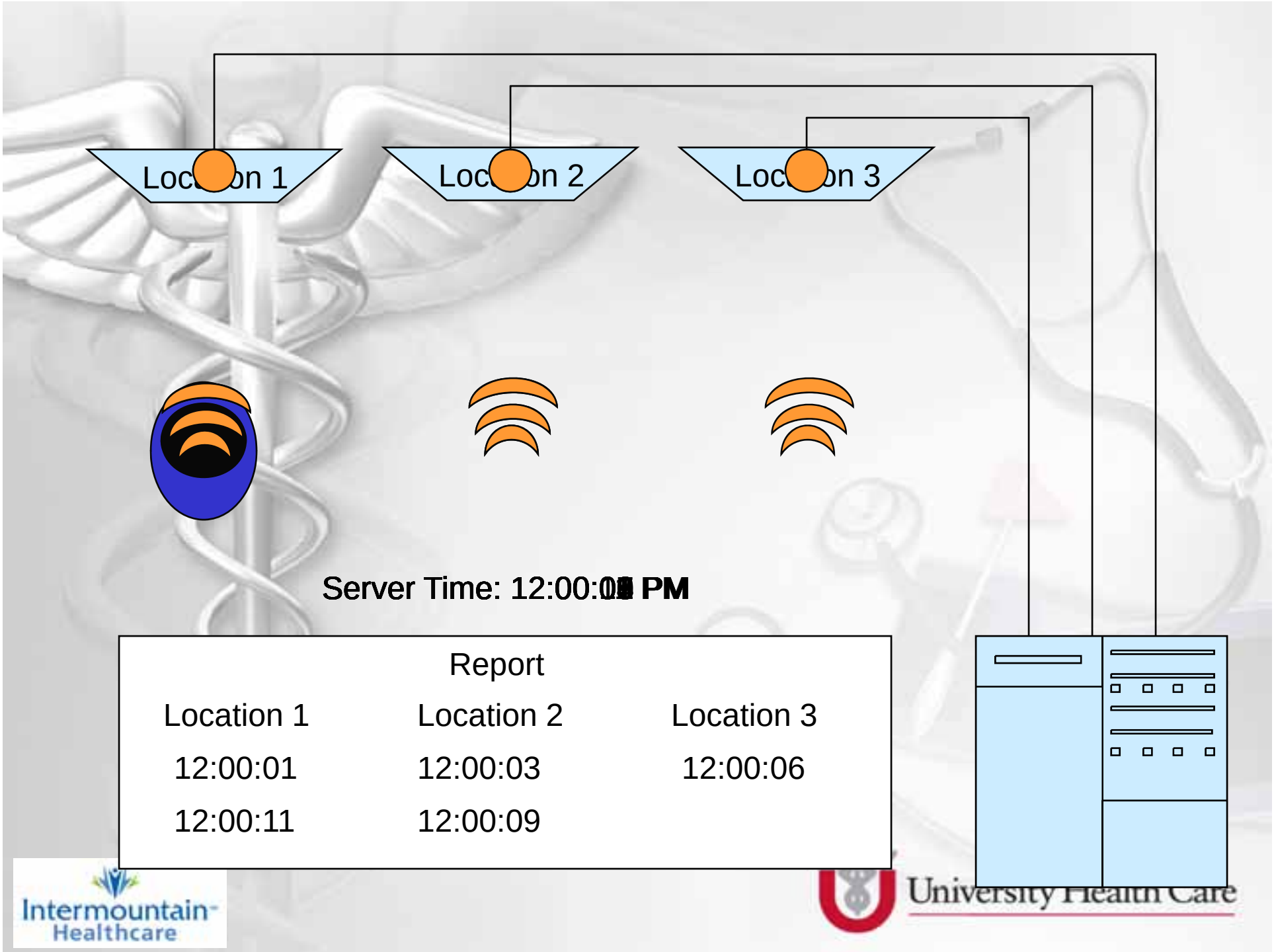
Location 1
Location 2
Location 3
Server Time: 12:00:0 PM
Report
Location 1
Location 2
Location 3
12:00:01
12:00:03
12:00:06
12:00:11
12:00:09
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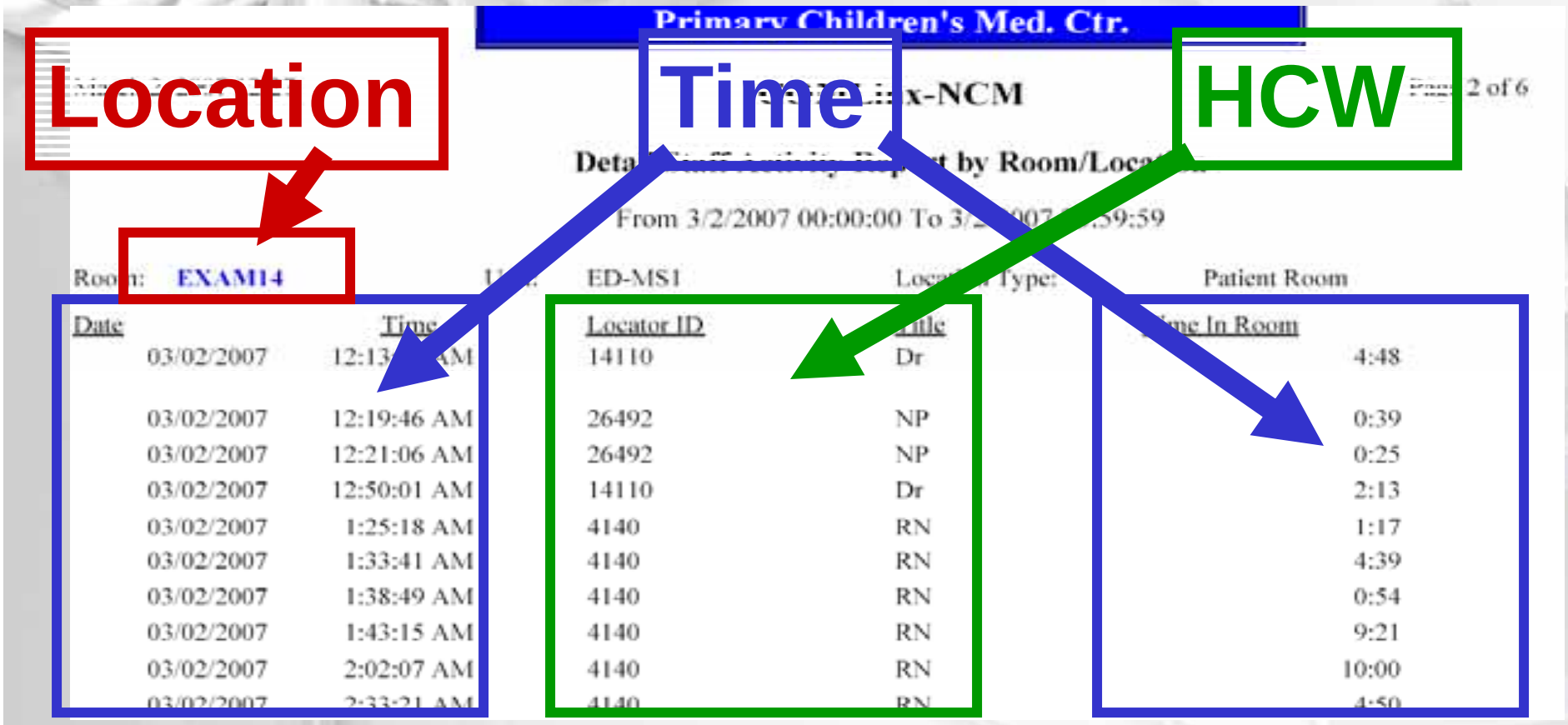
COMLinx Server Report



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Patient-HCW time-geography

- Patient:
  - Geographic component: LogiCare record of patient room
  - Temporal component: LogiCare Date/Timestamp
- Healthcare Worker:
  - Geographic component: IR sensors & IR-emitting HCW badges
  - Temporal component: COMLinx Date/Timestamp

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Creating the patient-HCW time-geography dataset

- Data prepartion:
  - Deidentification of LogiCare data as per IRB protocol
  - Manipulation of COMLinx data
  - Adjust for COMLinx system parameters
- Merging the datasets
  - Link on time stamp
  - Link on room number

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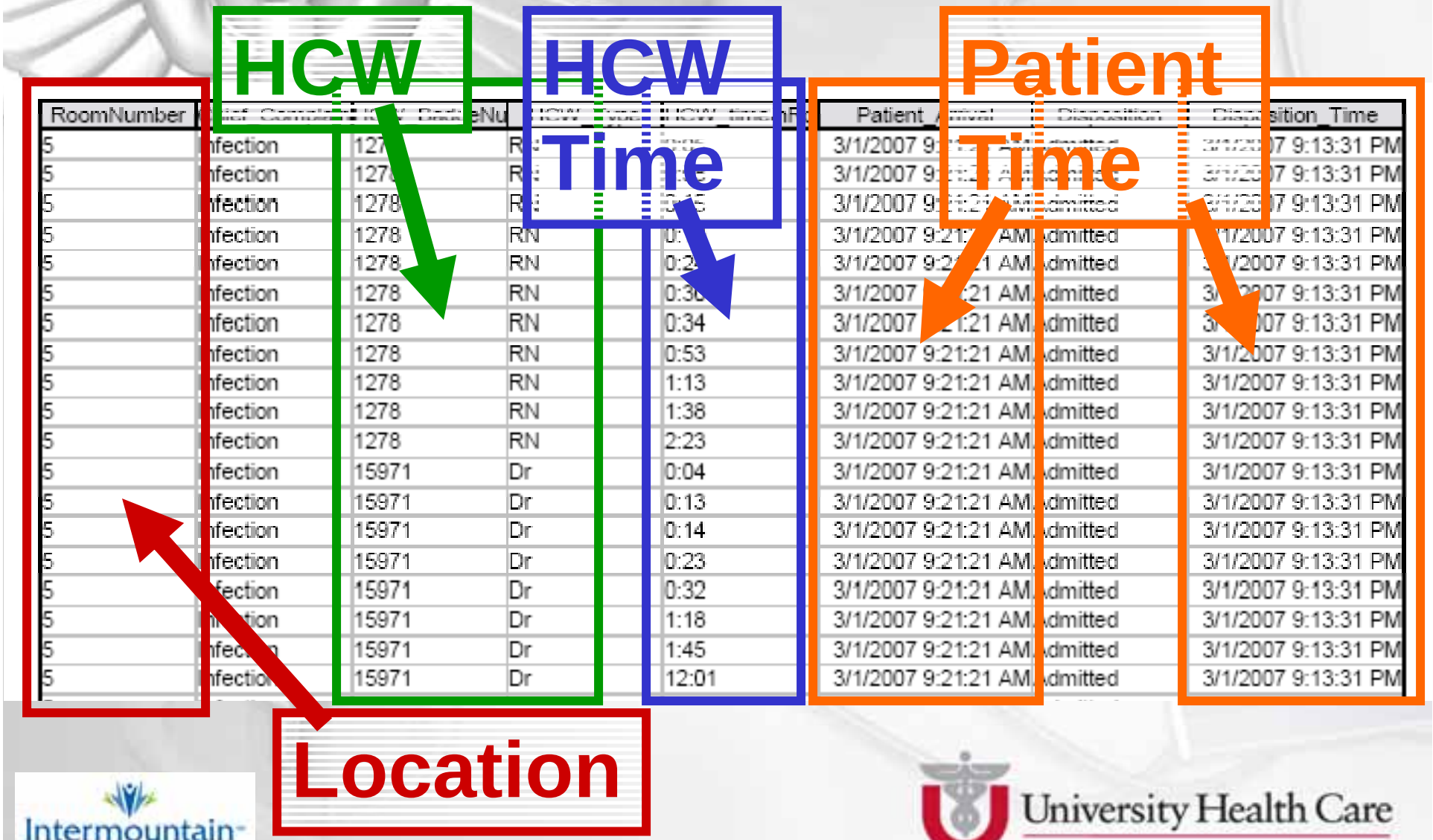
Data merge for unique



RoomNumber	Infection	1278	RN	0:34	3/1/2007 9:21:21 AM	admitted	3/1/2007 9:13:31 PM
5	Infection	1278	RN	0:53	3/1/2007 9:21:21 AM	admitted	3/1/2007 9:13:31 PM
5	Infection	1278	RN	1:13	3/1/2007 9:21:21 AM	admitted	3/1/2007 9:13:31 PM
5	Infection	1278	RN	1:38	3/1/2007 9:21:21 AM	admitted	3/1/2007 9:13:31 PM
5	Infection	1278	RN	2:23	3/1/2007 9:21:21 AM	admitted	3/1/2007 9:13:31 PM
5	Infection	15971	Dr	0:04	3/1/2007 9:21:21 AM	admitted	3/1/2007 9:13:31 PM
5	Infection	15971	Dr	0:13	3/1/2007 9:21:21 AM	admitted	3/1/2007 9:13:31 PM
5	Infection	15971	Dr	0:14	3/1/2007 9:21:21 AM	admitted	3/1/2007 9:13:31 PM
5	Infection	15971	Dr	0:23	3/1/2007 9:21:21 AM	admitted	3/1/2007 9:13:31 PM
5	Infection	15971	Dr	0:32	3/1/2007 9:21:21 AM	admitted	3/1/2007 9:13:31 PM
5	Infection	15971	Dr	1:18	3/1/2007 9:21:21 AM	admitted	3/1/2007 9:13:31 PM
5	Infection	15971	Dr	1:45	3/1/2007 9:21:21 AM	admitted	3/1/2007 9:13:31 PM
5	Infection	15971	Dr	12:01	3/1/2007 9:21:21 AM	admitted	3/1/2007 9:13:31 PM

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COMLinx & LogiCare Merge

- COMLinx records:
  - Data from Feb 2007 – April 2008
  - 5,521,804 unique records
- LogiCare records:
  - Data from Jan 2007 – April 2008
  - 50,248 records
  - 48,268 unique records

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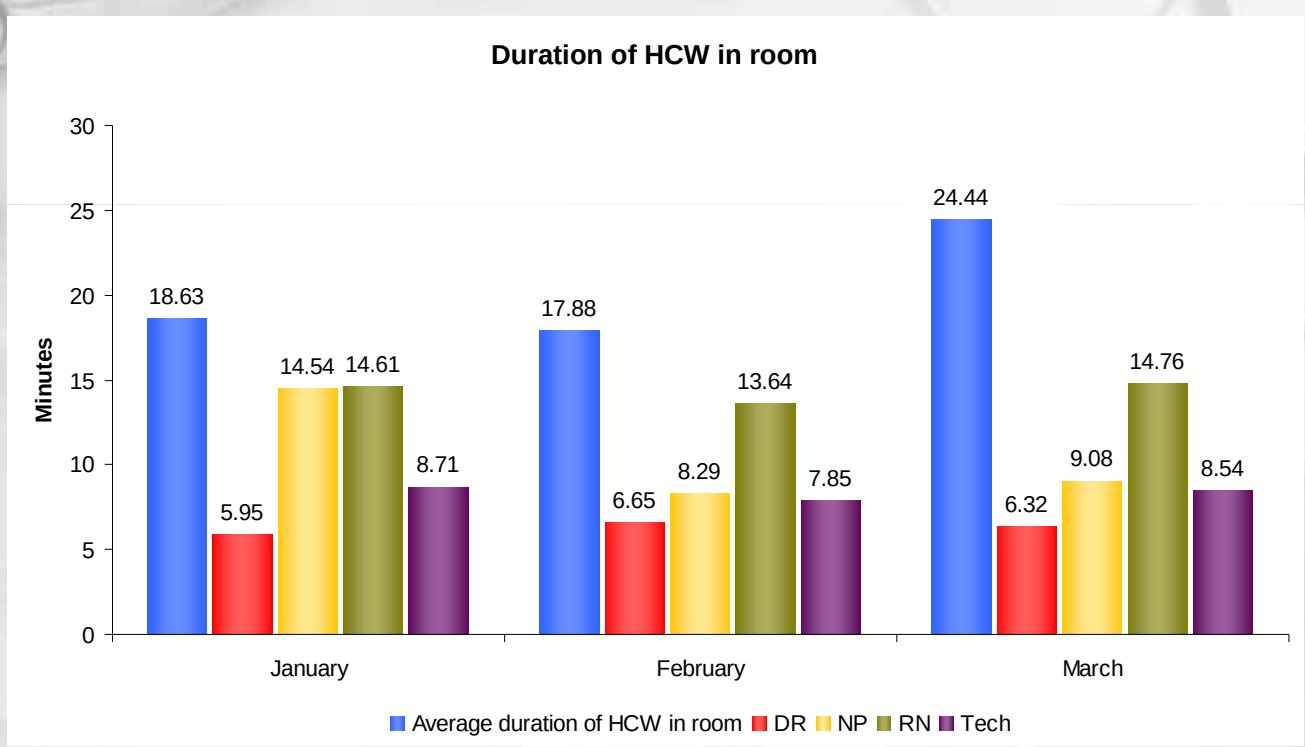
Some preliminary numbers



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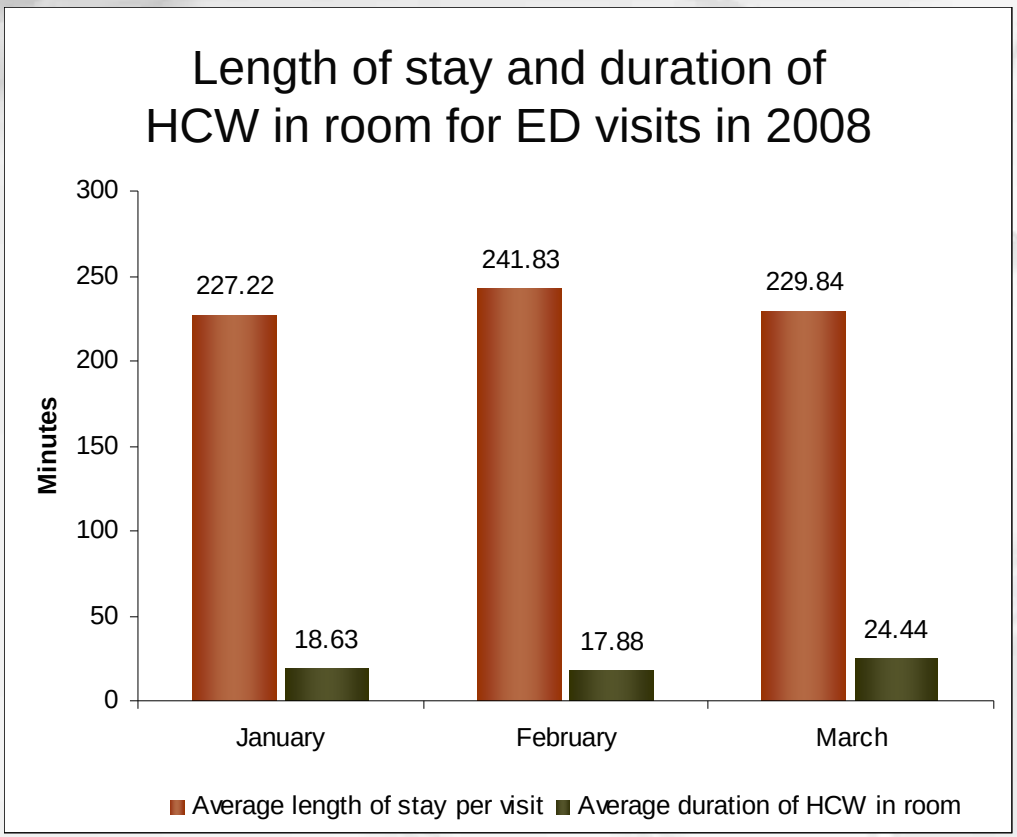

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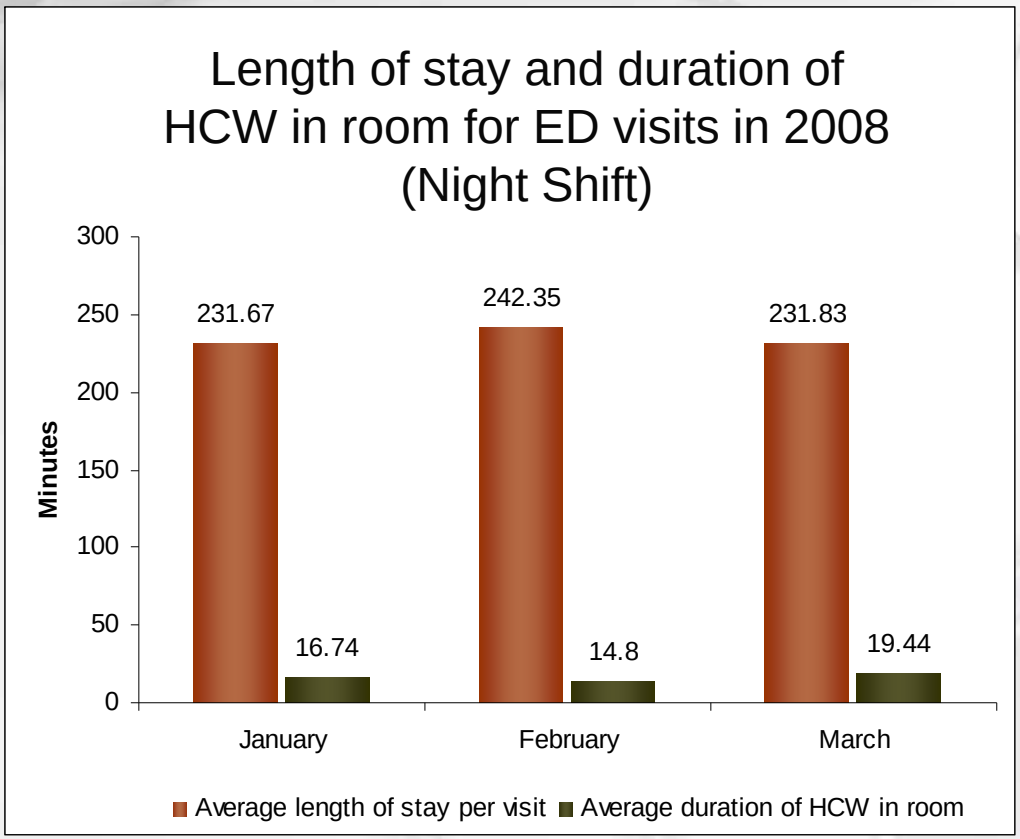
Some preliminary numbers



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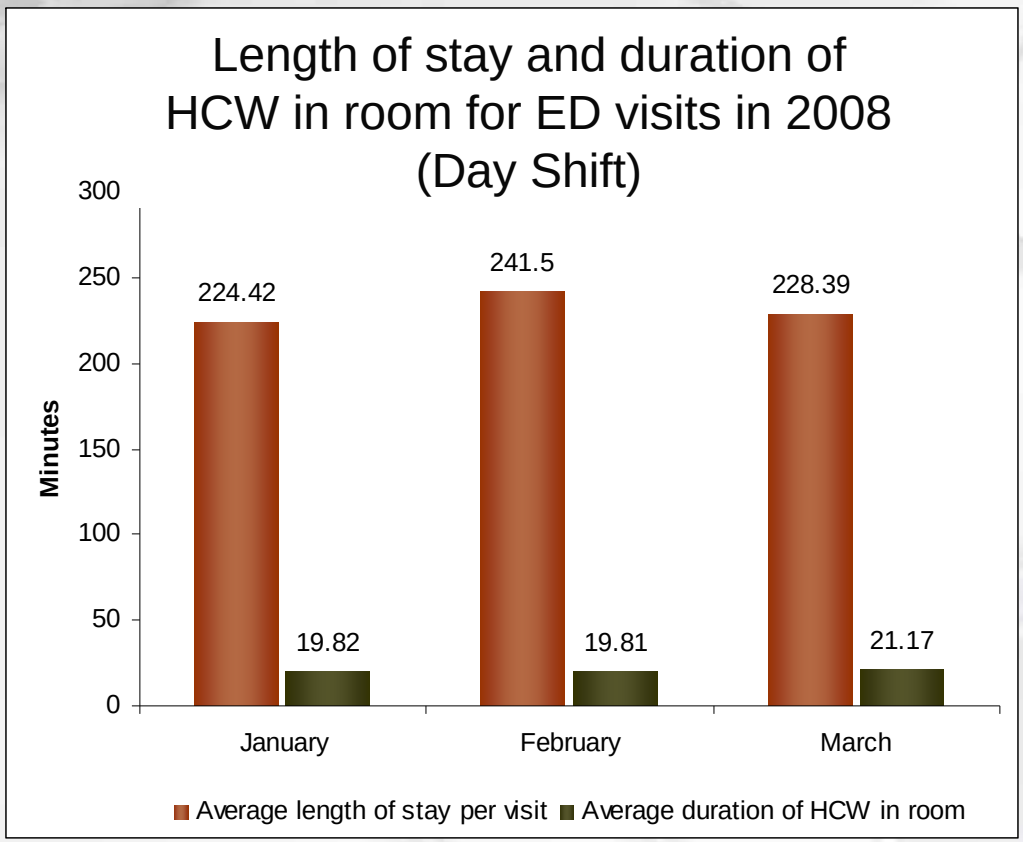
Some preliminary numbers



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Challenges and problems

- Badges
  - Habit:
    - HCW not wearing badges
    - HCWs exchanging badges
  - Technical:
    - IR LED covered
    - Battery weak
- IR Sensors
  - Multiple coveage areas
- COMLinx Server
  - Subject to system parameters such as the 14-second exit timer
- LogiCare
  - Requires active HCW participation
  - Subject to usual data entry errors

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Sensor multiple coverage areas with doors open

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Sensor multiple coverage areas with doors closed

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Ongoing and future efforts to answer the research quesion

- Network modeling and analysis
- Agent-based simulation of disease spread and “What if?” scenarios
- Merging with and analysis of other data that complement our effort to understand how respiratory viruses may spread during the patient-HCW interaction

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Questions?

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