Exploratory Network Analysis of Clinical Interactions in the ED

Tommy Flynn*,[a]

[a] *Repository (https://github.com/tommyflynn/Flynn_N741_Project/tree/master/Flynn_Project)*

Abstract

Patient acuity in the Emergency Department is triaged at the beginning of the care process using the Emergency Severity Index (ESI) metric. The ESI is presumed to predict resource consumption in the ED, and is a validated predictor of hospital admission for the majority of ED patients. It is not sensitive to non-medical patient characteristics, such as patient race, nor is it accountable to changes in patient condition over time. ED administrators and charge nurses are left with an impression of the unit that does not reveal the reality of current paitient conditions or ED resources being utilized. The lack of real-time ED resource and patient condition information creates opportunities for unrecognized patient deterioration, medical errors, increased wait times, and decreased patient satisfaction. An objective measurement of patient resource consumption that passively observes and calulates relative patient need in real-time would allow charge nurses and administrators to make informed decisions for effective, efficient, and safe patient care. This study tests a novel approach to measuring patient acuity (ED resource consumption) using real-time location system (RTLS) contact data and network analysis. This paper presents the approach and analytic results of several ED contact networks in relation to patient acuity (ESI)

Research Question & Specific Aims

- Can network analysis of clinical interactions between patients and staff provide insight into the complex Emergency Department patient care process? (Canto et al. 2000) Aim 1: Explore the network of clinical interactions in the ED between patients and staff to determine whether predictable patterns emerge in terms of centrality, density, and change over time. Aim 2: Test the assocaition between patient acuity and network position measure of eigenvector centrality of patient composite network, compared to the centrality of teh dynamic patient network (measure TBD).

Background & Objectives

Intelligent clinical monitoring software is not a new idea, but advancements in the field of data science continue to yield powerful new tools that may make such software a reality in the near future.(Yu et al. 2015, Donoho (2017)) Real-time location systems (RTLS) are increasingly common in hospitals across the nation, especially in clinical areas where patient care and flow are both complex and time-sensitive, such as the Emergency Department (ED).(Yao, Chu, and Li 2012) A bird's-eye view of a busy urban ED might resemble a hive of frenzied bees, but as we have learned of beehives, patterns of work and interactions within EDs are necessarily purposed and complexly adaptive to the various needs of the system (or hive) as a whole.(Kridi, Carvalho, and Gomes 2016) By leveraging the technology of RTLS and analytical power of netowrk analysis, future ED monitoring systems will provide ED leadership with real-time resource allocation and patient condition information. The Emergency Severity Index (ESI) is a validated metric used to triage patients in US Emergency Departments.(Tanabe et al. 2004) That triage nurse may decide to involve the charge nurse or a physician given various concerns about the patient. These interactions, observed and measured by the Real Time Location System (RTLS), continue as more

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patients are triaged, moved into patient rooms, and so on toward a vast and complex network of interactions. This web of care is likely to correlate with the amount and quality of care delivered to individual patients. - **The purpose of this study is to explore the network of clinical interactions that take place in the Emergency Department and describe the raltionship between those network variables and patient acuity.** To study this relationship, received permission to analyse existing data that includes the following; the frequency and duration of all face-to-face interactions (patients, providers, nurses, technicians, & administrators) that occured in the ED for 81 12hr shifts, the location of those interactions, and individual patients' medical and demographic characteristics including acuity, chief complaint, gender, age, arrival mode, and disposition. The network structural characteristics will be assessed in relation to the industry standard acuity measure, the Emergency Severity Index (ESI), and potential confounding variables. Using this data will require specific knowledge of the R statistical packages, network analysis, and data science. See Tables 1-4 for my learning goals with respective action items, timeline, and outcomes.

Methods

Table 1: Patient Race

Race	Count
Black	1931
Hispanic	24
Other	35
White	353

Table 2: Patient Acuity

Acuity Level	Count
Immediate (1)	14
Emergent (2)	694
Urgent (3)	1191
Stable (4)	417
Non Urgent (5)	27

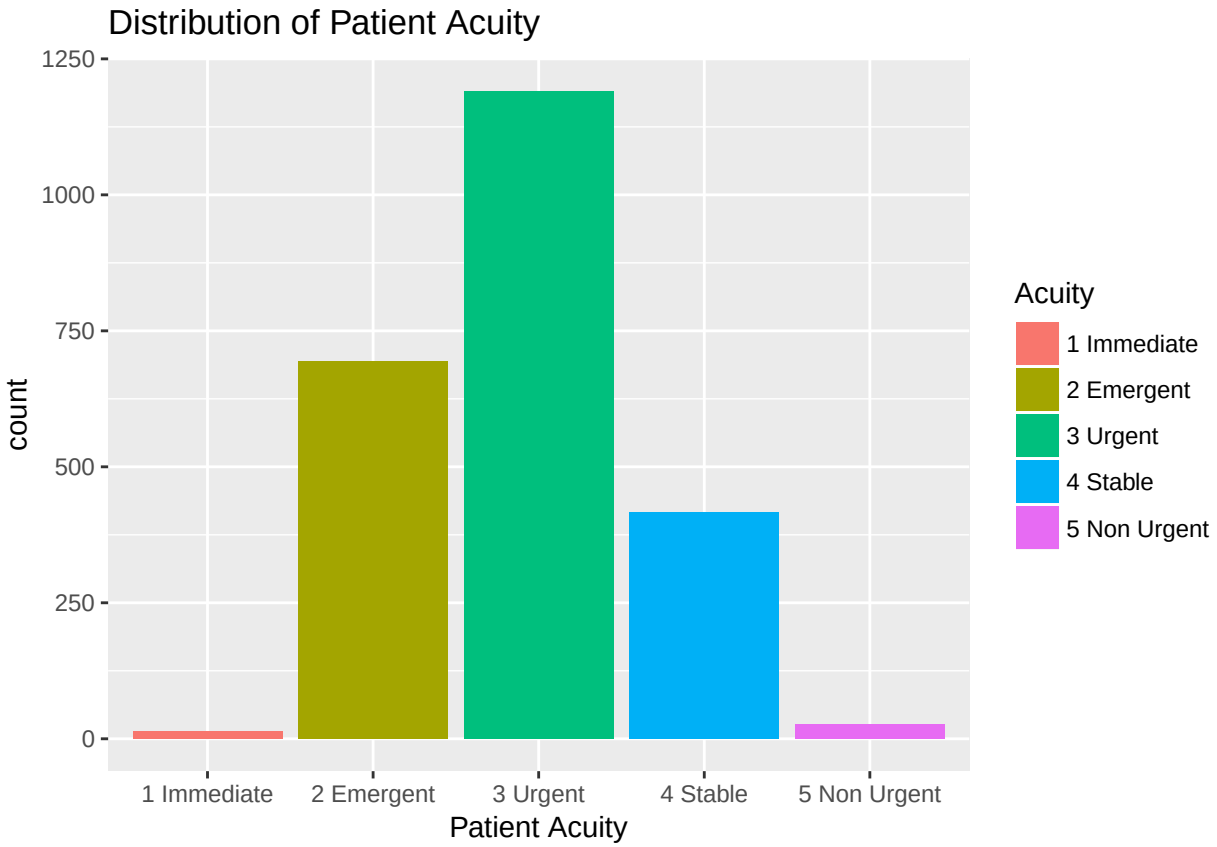

Table 3: Patient Gender

Sex	Count
Female	1334
Male	1009

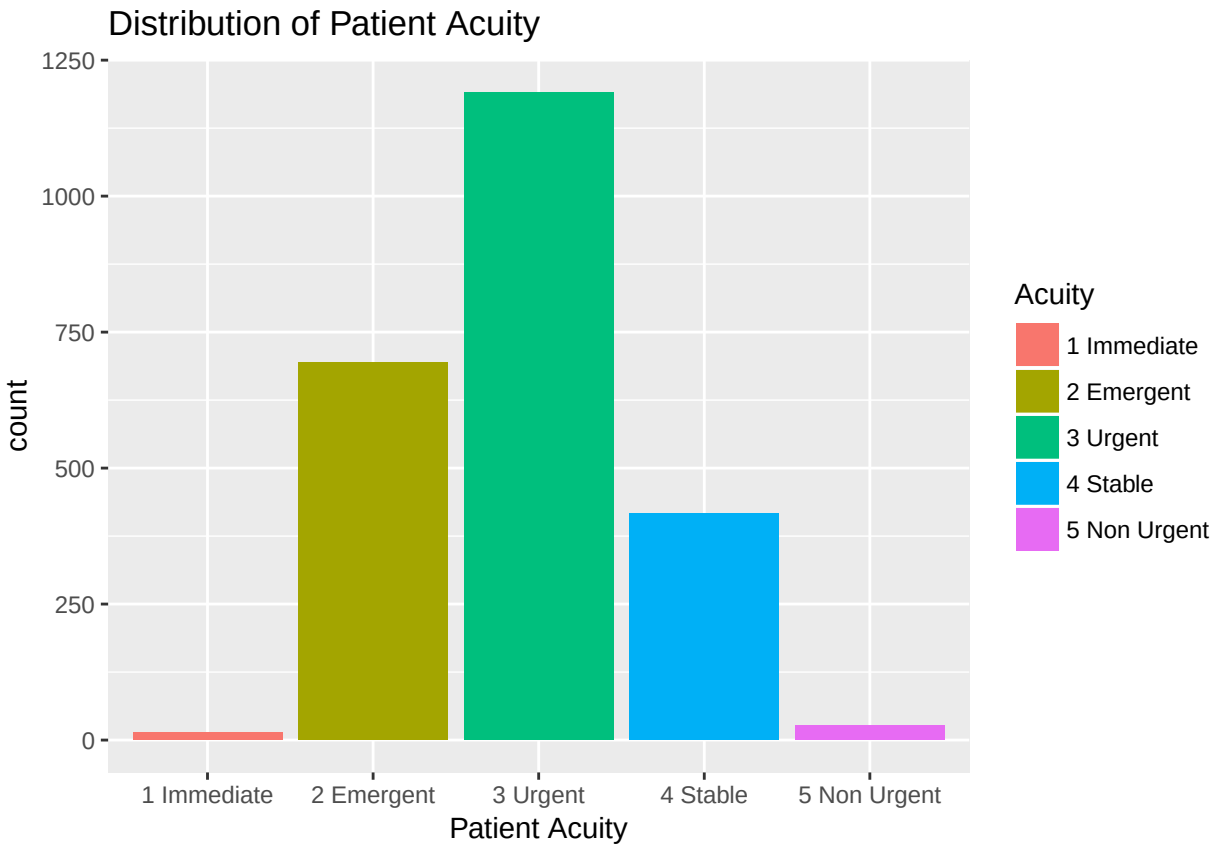

Table 4: Patient Age

Age_mean	sd
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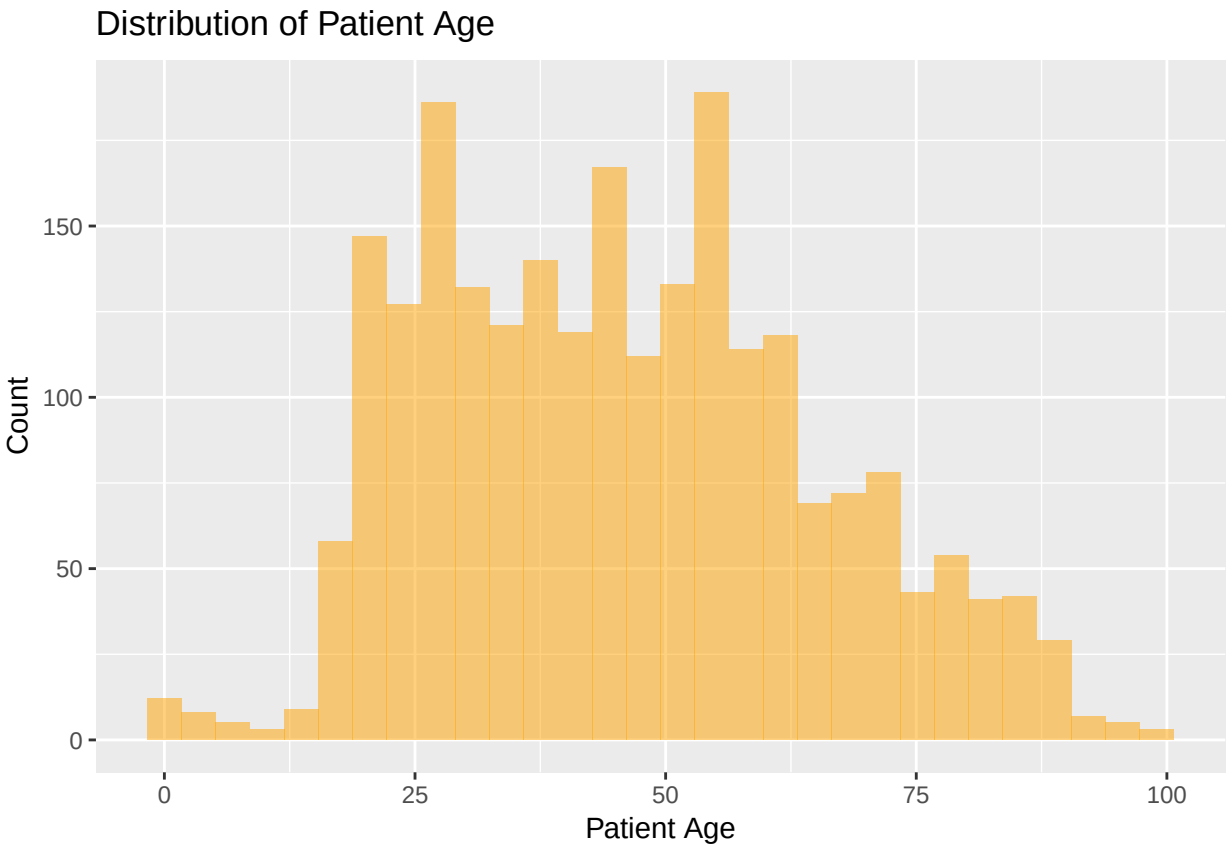
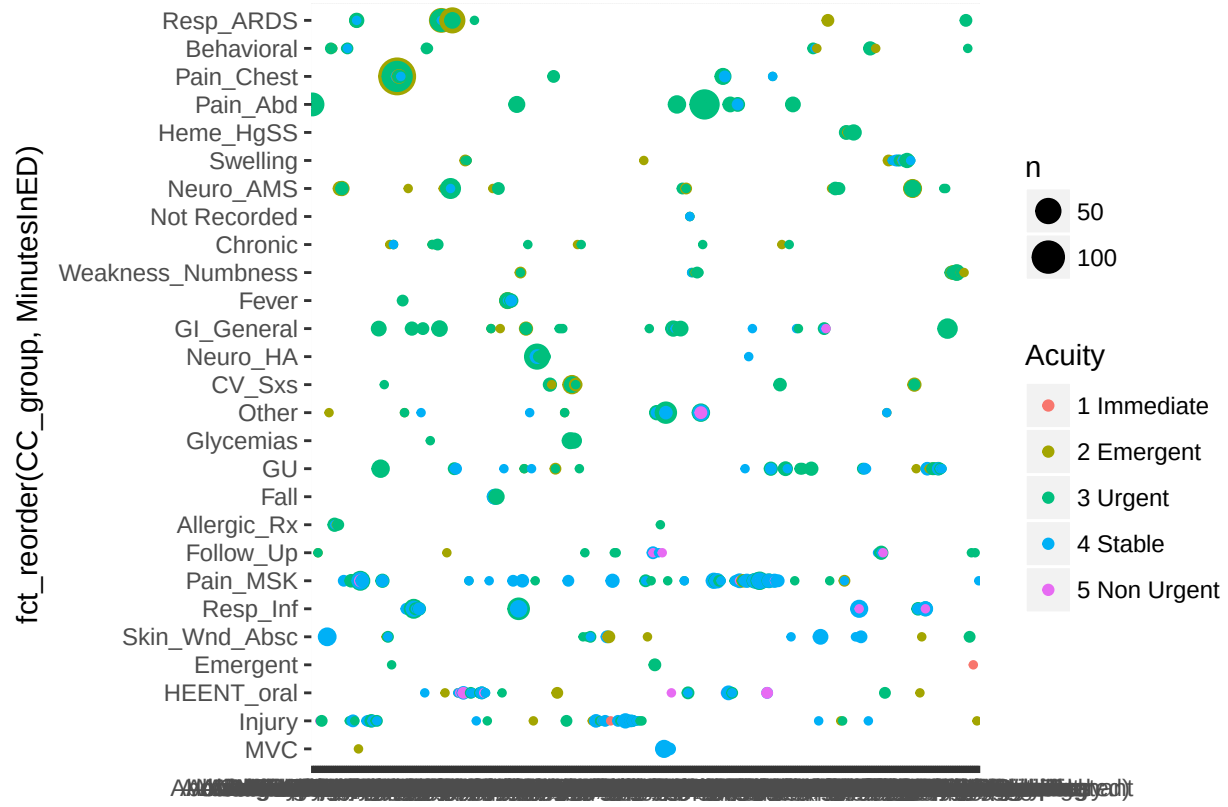


Table 5: Overall Participation

Participants (n)	Shifts	Participants/Shift	Participation Rate (mean%)	Total Ties	Ties/Shift
3635	35	103.8571	63.09335	21600	617.1429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Pain_Chest
Pain_Abd
Heme_HgSS
Swelling
Neuro_AMS
Not Recorded
Chronic
Weakness_Numbness
Fever
GI_General
Neuro_HA
CV_Sxs
Other
Glycemias
GU
Fall
Allergic_Rx
Follow_Up
Pain_MSK
Resp_Inf
Skin_Wnd_Absc
Emergent
HEENT_oral
Injury
MVC
n
50
100
Acuity
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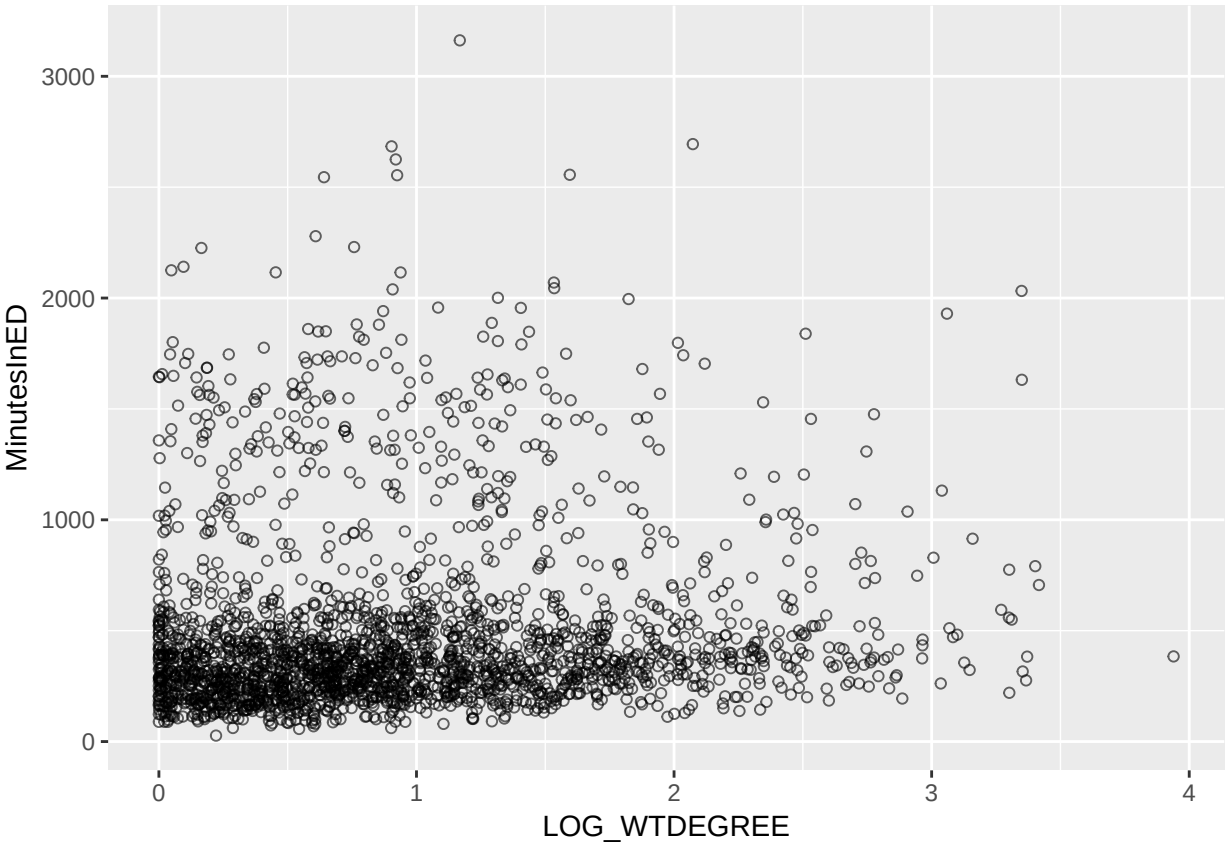
2 Emergent
3 Urgent
4 Stable
5 Non Urgent
Chief_Complaint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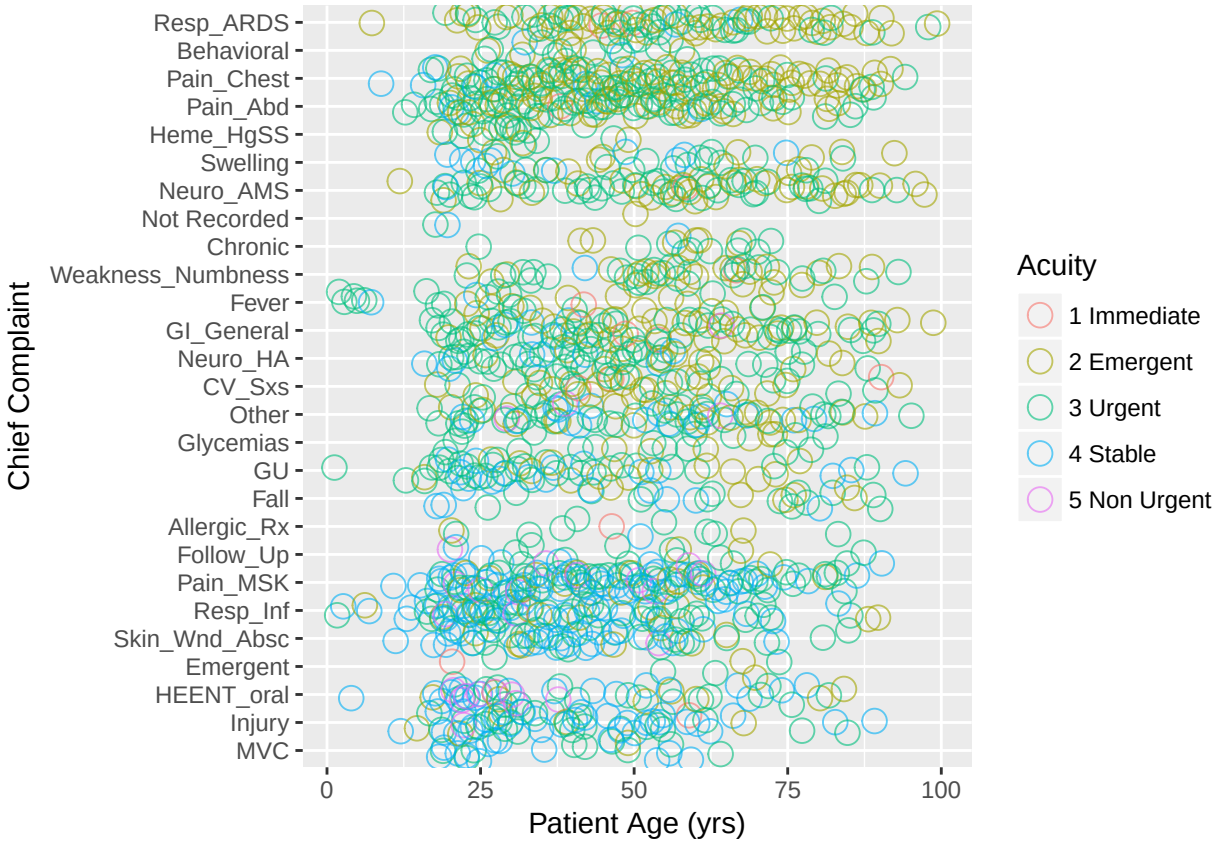
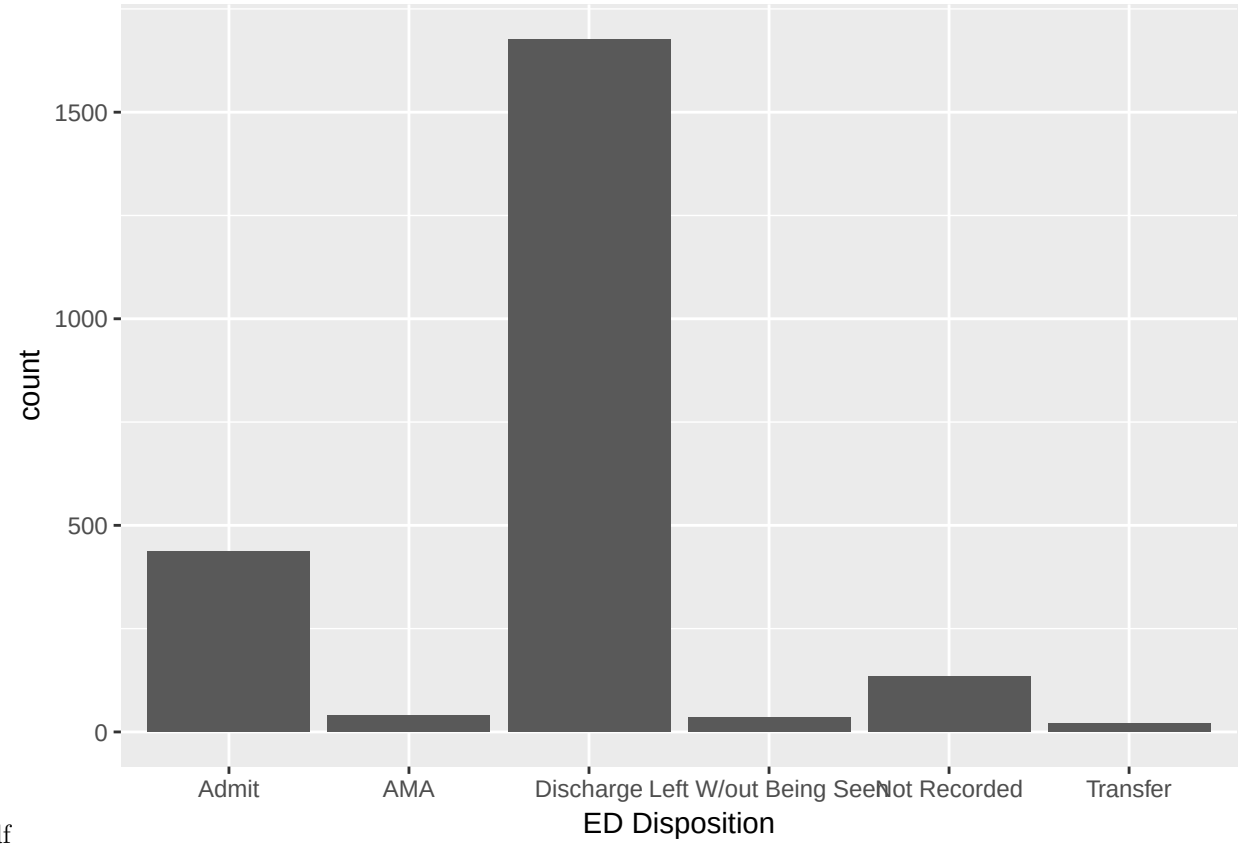


Complaint-1.pdf



Complaint-2.pdf

RTLS Data

This study applies a secondary data analysis design due to the exploritory nature of the research aims. Data was made available with permissions from the originating research team. The purpose of the original study was to describe contact characteristics between patients and staff in the ED of a busy urban hospital to inform cross-infection control measures. Data were collected using a radio-frequency identification system that triangulated patient and staff (nurses, providers, and ancillary staff) locations within the ED at Emory University Hospital Midtwon. Data for this secondary analysis were collected using a prospective, longitudinal, observational design with a random sampling of one day shift and one night shift per week for one year, July 1, 2009 to June 30, 2010. This strategy was chosen to minimize sampling bias related to seasonal or weekly fluctuations in census, acuity, and ED staffing changes. Although a total of 104 shifts were observed, the original research team retained only 81 shifts for reasons related to issues with the RFID system and study staff sick leave.(Lowery-North et al. 2013)

Results

Analysis Plan

Data Exploration & Cleaning

Data will be maintained in private repositories in the GitHub version control platform. Patient characteristic data will be evaluated for missing or implausible data with discriptive analyses, and RFID generated networks will be included for statistical analysis if variables of network density, centrality, and a network diversity scale are distributed normally across networks.

Why do I find 1102 unique nodes in the vertices data, 1023 unique nodes in the edges dataset, and 1017 unique patients in the patient characteristics dataset?

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001021b5	29	2009-08-24	824200929	RN	NA				
00102235	30	2009-08-24	824200930	RN	NA				
0010223e	31	2009-08-24	824200931	MD	NA				
0010224d	32	2009-08-24	824200932	RN	NA				
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00215eb5	38	2009-08-24	824200938	_PAT	69	Black	Male	4 Stable	Private Ve
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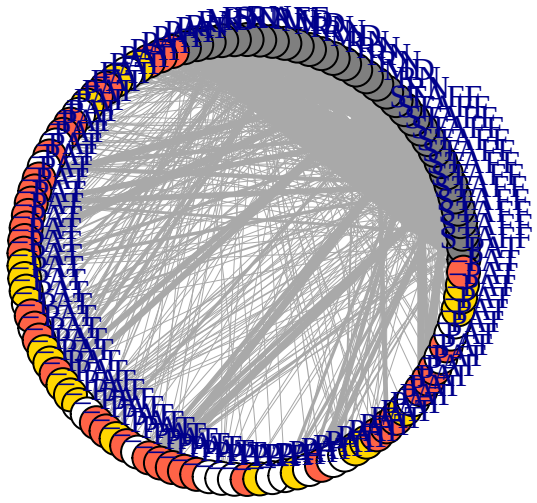
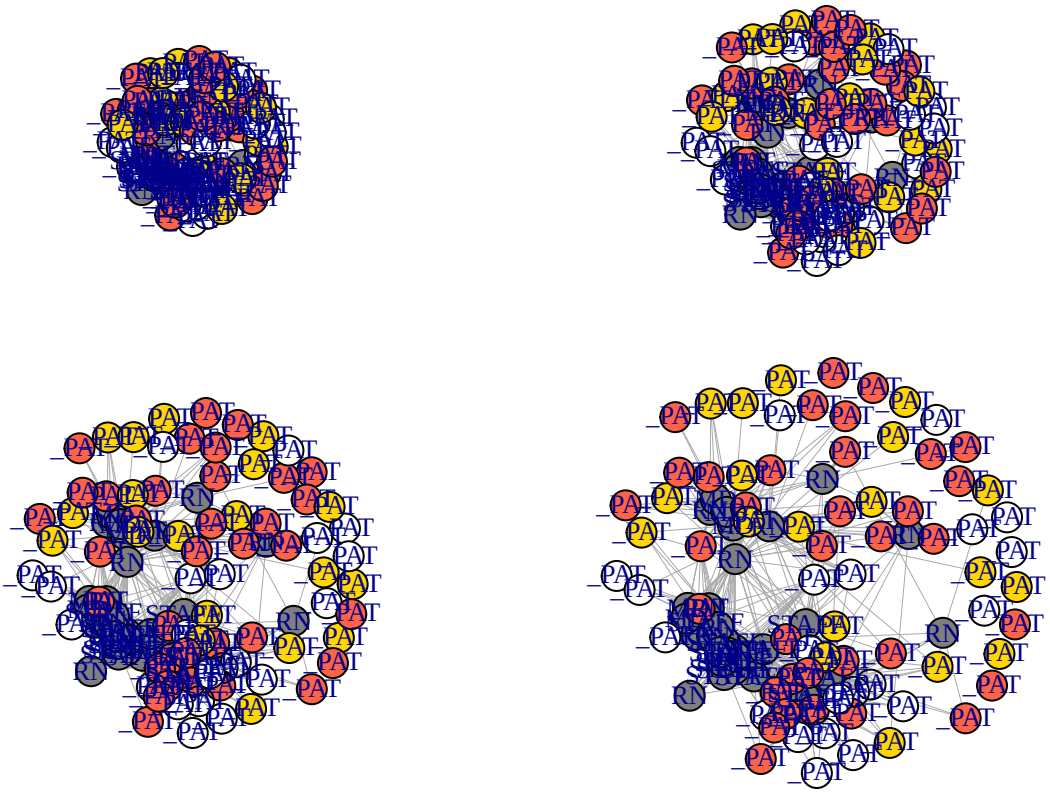


circle-1.pdf

Descriptive statistics of the network data as well as patient demographic data will be evaluated for asssumptions of normality. The data will be skewed in certain predictable ways due to the observed patient populations. The distribution of study subject demographics will be described in tabular format, noting irregularities and potential sources



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00216391	51	2009-10-20	1020200951	_PAT	57	Black	Male	2 Emergent	Walk	
00216490	52	2009-10-20	1020200952	_PAT	37	Black	Female	3 Urgent	Private Vehicle	
0021651e	53	2009-10-20	1020200953	_PAT	19	White	Female	3 Urgent	EMS Ground	
002165d1	54	2009-10-20	1020200954	_PAT	90	White	Female	2 Emergent	EMS Ground	
002165f0	55	2009-10-20	1020200955	_PAT	84	Black	Male	3 Urgent	Not Recorded	
002166a9	56	2009-10-20	1020200956	_PAT	54	Black	Female	4 Stable	Private Vehicle	
002166af	57	2009-10-20	1020200957	_PAT	43	Black	Female	2 Emergent	EMS Ground	
002166e1	58	2009-10-20	1020200958	_PAT	85	White	Female	2 Emergent	Private Vehicle	
002166f1	59	2009-10-20	1020200959	_PAT	94	Black	Female	3 Urgent	EMS Ground	
00216700	60	2009-10-20	1020200960	_PAT	51	Black	Male	2 Emergent	Private Vehicle	
0021670c	61	2009-10-20	1020200961	_PAT	16	White	Female	2 Emergent	Private Vehicle	
00216715	62	2009-10-20	1020200962	_PAT	36	Black	Male	2 Emergent	Private Vehicle	
00216725	63	2009-10-20	1020200963	_PAT	40	Black	Male	3 Urgent	Private Vehicle	
0021673b	64	2009-10-20	1020200964	_PAT	45	Black	Female	4 Stable	Private Vehicle	
0021673d	65	2009-10-20	1020200965	_PAT	70	Black	Female	3 Urgent	EMS Ground	
00216743	66	2009-10-20	1020200966	_PAT	53	Black	Female	2 Emergent	Private Vehicle	
00216746	67	2009-10-20	1020200967	_PAT	39	Black	Female	2 Emergent	EMS Ground	
0021674b	68	2009-10-20	1020200968	_PAT	54	Black	Female	3 Urgent	Public Trans	
0021674f	69	2009-10-20	1020200969	_PAT	76	Black	Male	4 Stable	EMS Ground	
002167ef	70	2009-10-20	1020200970	_PAT	55	Black	Male	3 Urgent	Private Vehicle	
00216857	71	2009-10-20	1020200971	_PAT	25	Black	Male	3 Urgent	Private Vehicle	
0021685a	72	2009-10-20	1020200972	_PAT	21	White	Female	2 Emergent	Private Vehicle	
0021687d	73	2009-10-20	1020200973	_PAT	68	Black	Female	2 Emergent	Private Vehicle	
002169b3	74	2009-10-20	1020200974	_PAT	19	Black	Female	3 Urgent	Walk	
002169bc	75	2009-10-20	1020200975	_PAT	25	White	Male	3 Urgent	Private Vehicle	
002169c5	76	2009-10-20	1020200976	_PAT	52	Black	Male	4 Stable	Walk	

sid	i	d8	ID	participant_type	AGE	Race	Sex	Acuity	Arr_Mode	shif
002169ca	77	2009-10-20	1020200977	_PAT	17	Black	Female	4 Stable	Private Vehicle	

```
## [1] "layout_as_star"

## [1] "layout_components"

## [1] "layout_in_circle"

## [1] "layout_nicely"

## [1] "layout_on_grid"

## [1] "layout_on_sphere"

## [1] "layout_randomly"

## [1] "layout_with_dh"

## [1] "layout_with_drl"
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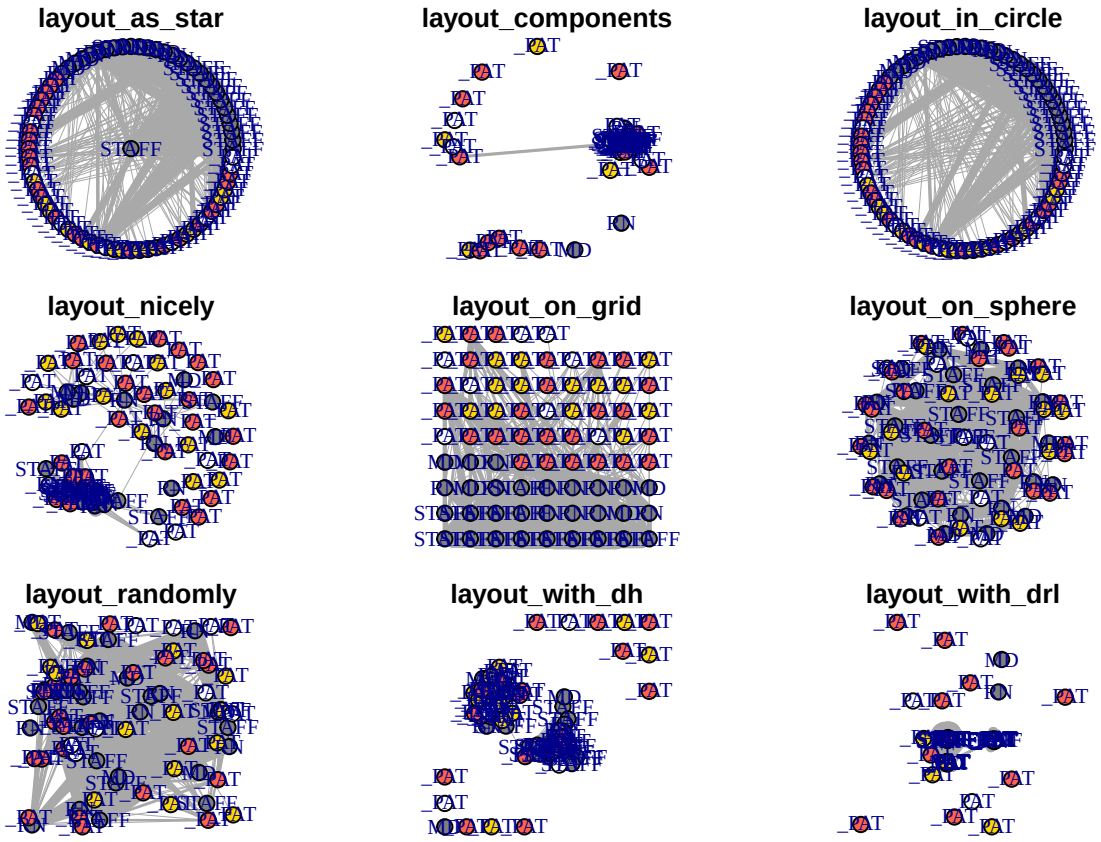


layouts-1.pdf

```
## [1] "layout_with_fr"

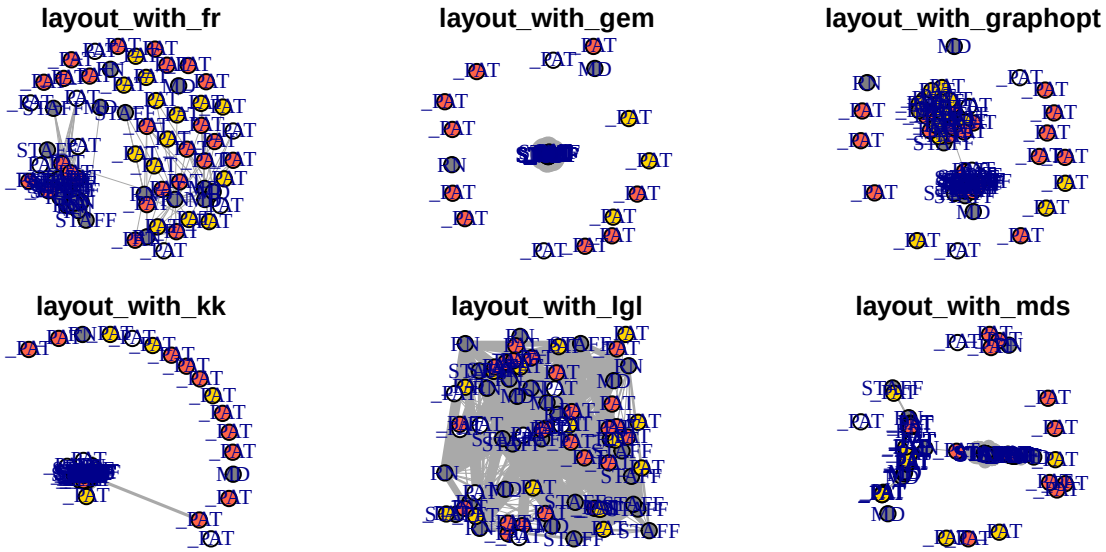
## [1] "layout_with_gem"

## [1] "layout_with_graphopt"

## [1] "layout_with_kk"

## [1] "layout_with_lgl"

## [1] "layout_with_mds"
```



layouts-2.pdf

sid	i	d8	ID	participant_type	AGE	Race	Sex	Acuity	Arr_Mode
0002f35c	1	2009-09-09	9920091	STAFF	NA				
0002f445	2	2009-09-09	9920092	STAFF	NA				
0002f468	3	2009-09-09	9920093	STAFF	NA				
0002f469	4	2009-09-09	9920094	STAFF	NA				
0002f46c	5	2009-09-09	9920095	STAFF	NA				
0002f472	6	2009-09-09	9920096	STAFF	NA				
0002f495	7	2009-09-09	9920097	STAFF	NA				
0002f4a3	8	2009-09-09	9920098	STAFF	NA				
0002f4e2	9	2009-09-09	9920099	STAFF	NA				
0002f4e8	10	2009-09-09	99200910	STAFF	NA				
0002f4f9	11	2009-09-09	99200911	STAFF	NA				
0002f503	12	2009-09-09	99200912	STAFF	NA				
0002f507	13	2009-09-09	99200913	STAFF	NA				
0002f508	14	2009-09-09	99200914	STAFF	NA				
0002f515	15	2009-09-09	99200915	STAFF	NA				
00101d8f	16	2009-09-09	99200916	RN	NA				
00101f37	17	2009-09-09	99200917	RN	NA				
00101f73	18	2009-09-09	99200918	RN	NA				
00101f7e	19	2009-09-09	99200919	RN	NA				
00101f80	20	2009-09-09	99200920	RN	NA				
00101f9f	21	2009-09-09	99200921	MD	NA				
00101faf	22	2009-09-09	99200922	RN	NA				
00101fd6	23	2009-09-09	99200923	RN	NA				
00101fdd	24	2009-09-09	99200924	MD	NA				
00102156	25	2009-09-09	99200925	MD	NA				
00102159	26	2009-09-09	99200926	RN	NA				
00102164	27	2009-09-09	99200927	STAFF	NA				
001021b0	28	2009-09-09	99200928	RN	NA				
001021b5	29	2009-09-09	99200929	RN	NA				
00102288	30	2009-09-09	99200930	RN	NA				
001022a1	31	2009-09-09	99200931	RN	NA				
0012476b	32	2009-09-09	99200932	MD	NA				
00124775	33	2009-09-09	99200933	MD	NA				
001248f7	34	2009-09-09	99200934	RN	NA				

sid	i	d8	ID	participant_type	AGE	Race	Sex	Acuity	Arr_Mode
00215d96	35	2009-09-09	99200935	_PAT	44	Black	Female	3 Urgent	Private Veh
00215da1	36	2009-09-09	99200936	_PAT	50	Black	Female	1 Immediate	Private Veh
00215de8	37	2009-09-09	99200937	_PAT	52	Black	Male	3 Urgent	Private Veh
002161de	38	2009-09-09	99200938	_PAT	53	Black	Male	2 Emergent	Private Veh
002161f8	39	2009-09-09	99200939	_PAT	29	White	Female	3 Urgent	Private Veh
00216206	40	2009-09-09	99200940	_PAT	79	Black	Female	2 Emergent	Private Veh
00216210	41	2009-09-09	99200941	_PAT	77	White	Female	3 Urgent	EMS Groun
00216229	42	2009-09-09	99200942	_PAT	50	Black	Female	2 Emergent	EMS Groun
00216230	43	2009-09-09	99200943	_PAT	22	Black	Female	Not Recorded	Not Record
00216239	44	2009-09-09	99200944	_PAT	39	Black	Female	3 Urgent	EMS Groun
0021624d	45	2009-09-09	99200945	_PAT	56	Black	Male	3 Urgent	EMS Groun
00216266	46	2009-09-09	99200946	_PAT	18	Black	Male	4 Stable	Public Tran
002162ac	47	2009-09-09	99200947	_PAT	29	Black	Male	3 Urgent	Private Veh
002162da	48	2009-09-09	99200948	_PAT	56	Black	Male	4 Stable	Private Veh
002162f0	49	2009-09-09	99200949	_PAT	26	Black	Female	3 Urgent	Private Veh
00216300	50	2009-09-09	99200950	_PAT	20	Black	Male	4 Stable	Private Veh
00216301	51	2009-09-09	99200951	_PAT	21	Black	Female	Not Recorded	Not Record
0021630c	52	2009-09-09	99200952	_PAT	90	White	Male	1 Immediate	EMS Groun
0021635d	53	2009-09-09	99200953	_PAT	22	Black	Female	4 Stable	Private Veh
00216372	54	2009-09-09	99200954	_PAT	74	Black	Female	3 Urgent	EMS Groun
00216395	55	2009-09-09	99200955	_PAT	10	Not Recorded	Female	Not Recorded	Not Record
002163a5	56	2009-09-09	99200956	_PAT	53	Black	Female	3 Urgent	Not Record
00216410	57	2009-09-09	99200957	_PAT	3	Black	Female	3 Urgent	Private Veh
0021642e	58	2009-09-09	99200958	_PAT	76	Black	Female	3 Urgent	Private Veh
00216439	59	2009-09-09	99200959	_PAT	66	Black	Female	2 Emergent	EMS Groun
00216447	60	2009-09-09	99200960	_PAT	27	Black	Female	3 Urgent	Private Veh
0021645b	61	2009-09-09	99200961	_PAT	82	Black	Female	3 Urgent	Private Veh
00216466	62	2009-09-09	99200962	_PAT	46	Black	Female	3 Urgent	EMS Groun
00216479	63	2009-09-09	99200963	_PAT	33	Black	Female	3 Urgent	Private Veh
00216503	64	2009-09-09	99200964	_PAT	45	Black	Male	3 Urgent	Private Veh
0021654b	65	2009-09-09	99200965	_PAT	50	Black	Male	3 Urgent	Private Veh
00216550	66	2009-09-09	99200966	_PAT	29	White	Male	2 Emergent	Private Veh
00216552	67	2009-09-09	99200967	_PAT	25	Black	Female	4 Stable	Private Veh
002165b3	68	2009-09-09	99200968	_PAT	21	White	Male	3 Urgent	Private Veh
002165b4	69	2009-09-09	99200969	_PAT	40	Other	Female	3 Urgent	Private Veh
002165b8	70	2009-09-09	99200970	_PAT	39	White	Male	3 Urgent	Walk
002165ba	71	2009-09-09	99200971	_PAT	65	Black	Male	2 Emergent	EMS Groun
002165c3	72	2009-09-09	99200972	_PAT	9	Black	Female	4 Stable	Public Tran
002165fe	73	2009-09-09	99200973	_PAT	25	Black	Female	3 Urgent	EMS Groun
00216615	74	2009-09-09	99200974	_PAT	24	Black	Female	4 Stable	Private Veh
0021666a	75	2009-09-09	99200975	_PAT	20	Black	Male	2 Emergent	Private Veh
00216670	76	2009-09-09	99200976	_PAT	21	Black	Male	3 Urgent	Private Veh
0021668f	77	2009-09-09	99200977	_PAT	24	Black	Female	4 Stable	Walk
002166c6	78	2009-09-09	99200978	_PAT	57	Black	Female	2 Emergent	EMS Groun
002166c7	79	2009-09-09	99200979	_PAT	52	White	Female	3 Urgent	Private Veh
002166cb	80	2009-09-09	99200980	_PAT	19	Black	Female	4 Stable	Private Veh
002166cd	81	2009-09-09	99200981	_PAT	46	Black	Female	1 Immediate	EMS Groun
002166ce	82	2009-09-09	99200982	_PAT	25	Black	Female	2 Emergent	Private Veh
002166d1	83	2009-09-09	99200983	_PAT	70	Black	Female	2 Emergent	EMS Groun
002166d3	84	2009-09-09	99200984	_PAT	31	Black	Male	2 Emergent	EMS Groun
002166d5	85	2009-09-09	99200985	_PAT	85	Black	Female	3 Urgent	EMS Groun
002166d7	86	2009-09-09	99200986	_PAT	49	White	Male	4 Stable	Private Veh

sid	i	d8	ID	participant_type	AGE	Race	Sex	Acuity	Arr_Mode
002166df	87	2009-09-09	99200987	_PAT	16	Black	Female	3 Urgent	Private Veh
002166e0	88	2009-09-09	99200988	_PAT	27	Black	Female	3 Urgent	Private Veh
002166fa	89	2009-09-09	99200989	_PAT	46	Black	Male	1 Immediate	EMS Groun
00216728	90	2009-09-09	99200990	_PAT	68	Black	Female	3 Urgent	EMS Groun
0021672a	91	2009-09-09	99200991	_PAT	62	White	Male	2 Emergent	Private Veh
00216732	92	2009-09-09	99200992	_PAT	30	Black	Female	4 Stable	Private Veh
00216733	93	2009-09-09	99200993	_PAT	23	Black	Female	3 Urgent	Private Veh
00216735	94	2009-09-09	99200994	_PAT	89	Black	Male	3 Urgent	EMS Groun
00216736	95	2009-09-09	99200995	_PAT	41	White	Female	2 Emergent	Private Veh
00216758	96	2009-09-09	99200996	_PAT	45	White	Male	2 Emergent	Walk
0021675b	97	2009-09-09	99200997	_PAT	30	Black	Male	4 Stable	Walk
0021675e	98	2009-09-09	99200998	_PAT	41	Black	Male	1 Immediate	Private Veh
00216762	99	2009-09-09	99200999	_PAT	46	Black	Male	3 Urgent	Private Veh
0021689b	100	2009-09-09	992009100	_PAT	18	Black	Female	3 Urgent	Private Veh
00216965	101	2009-09-09	992009101	_PAT	41	Black	Female	3 Urgent	Private Veh
0021699e	102	2009-09-09	992009102	_PAT	43	Black	Female	3 Urgent	EMS Groun
002183fc	103	2009-09-09	992009103	_PAT	18	Black	Female	3 Urgent	EMS Groun
00218405	104	2009-09-09	992009104	_PAT	52	Black	Male	2 Emergent	EMS Groun
00218408	105	2009-09-09	992009105	_PAT	31	Black	Female	3 Urgent	Private Veh
00218409	106	2009-09-09	992009106	_PAT	51	Black	Female	Not Recorded	Not Record
0021840f	107	2009-09-09	992009107	_PAT	82	Black	Male	4 Stable	Private Veh
00218413	108	2009-09-09	992009108	_PAT	52	Other	Male	3 Urgent	EMS Groun
0021843a	109	2009-09-09	992009109	_PAT	35	Black	Female	3 Urgent	Private Veh
00218440	110	2009-09-09	992009110	_PAT	15	Black	Male	2 Emergent	Private Veh
00218443	111	2009-09-09	992009111	_PAT	57	Black	Male	3 Urgent	Private Veh
0021844e	112	2009-09-09	992009112	_PAT	69	Black	Female	3 Urgent	Private Veh
0021844f	113	2009-09-09	992009113	_PAT	51	Black	Male	4 Stable	EMS Groun
00218455	114	2009-09-09	992009114	_PAT	62	White	Male	3 Urgent	Private Veh
00218456	115	2009-09-09	992009115	_PAT	62	Black	Female	2 Emergent	Private Veh
00218459	116	2009-09-09	992009116	_PAT	58	Black	Female	3 Urgent	Private Veh
0021845e	117	2009-09-09	992009117	_PAT	45	Black	Female	1 Immediate	EMS Groun
00218460	118	2009-09-09	992009118	_PAT	42	Black	Male	3 Urgent	EMS Groun
00218461	119	2009-09-09	992009119	_PAT	50	White	Male	2 Emergent	Private Veh
00218462	120	2009-09-09	992009120	_PAT	66	Black	Female	3 Urgent	Private Veh
00218464	121	2009-09-09	992009121	_PAT	69	Black	Male	3 Urgent	EMS Groun
0021846b	122	2009-09-09	992009122	_PAT	31	Black	Male	3 Urgent	Walk
00218470	123	2009-09-09	992009123	_PAT	71	White	Male	2 Emergent	Private Veh
00218473	124	2009-09-09	992009124	_PAT	21	Black	Female	3 Urgent	Public Tran
00218483	125	2009-09-09	992009125	_PAT	43	Black	Female	4 Stable	Private Veh
00218484	126	2009-09-09	992009126	_PAT	13	Black	Male	3 Urgent	Private Veh

sid	i	d8	ID	participant_type	AGE	Race	Sex	Acuity	Arr_Mode
00218487	127	2009-09-09	992009127	_PAT	90	Black	Female	3 Urgent	EMS Grou

```
## [1] "layout_as_star"

## [1] "layout_components"

## [1] "layout_in_circle"

## [1] "layout_nicely"

## [1] "layout_on_grid"

## [1] "layout_on_sphere"

## [1] "layout_randomly"

## [1] "layout_with_dh"

## [1] "layout_with_drl"
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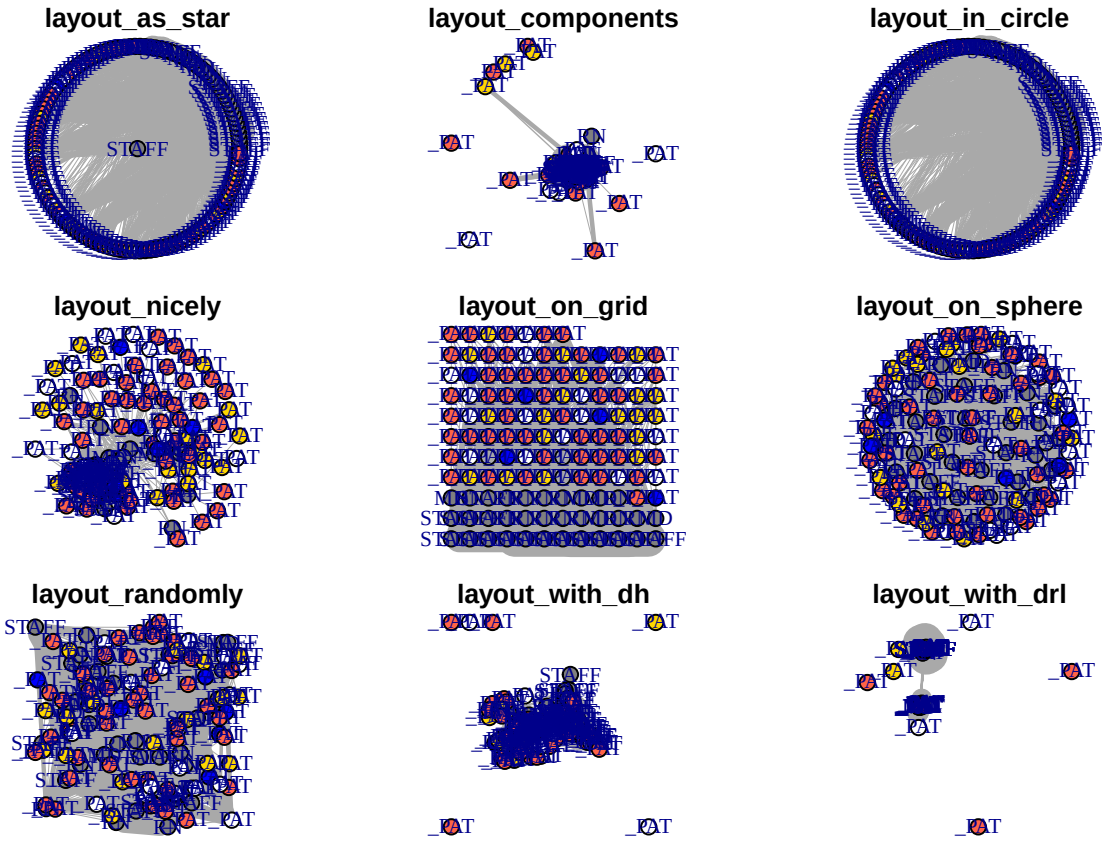
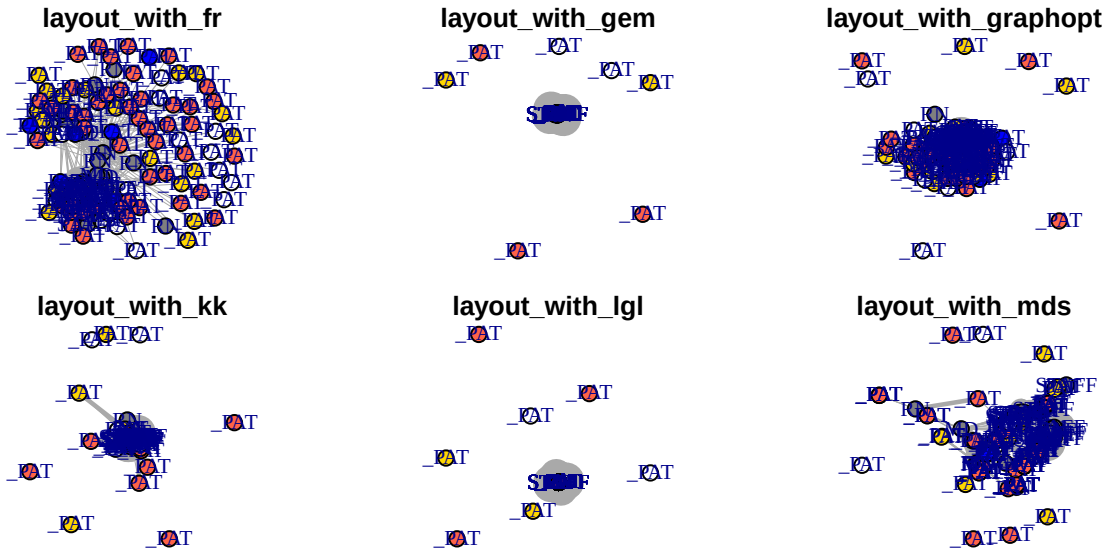



```
## [1] "layout_with_fr"

## [1] "layout_with_gem"

## [1] "layout_with_graphopt"

## [1] "layout_with_kk"

## [1] "layout_with_lgl"

## [1] "layout_with_mds"
```



Variables available for final analysis:

Network Variables > - Network Centrality (based on the eigenvector up to, but not including, any other patient-staff interactions) > - Network density > - Network clustering coefficient

Staff title > - Title (RN, MD, Other Staff)

Patient variables > - *Acuity* (ESI, independant variable of interest) > - Gender > - Age > - Race > - Arrival mode (ambulance v. walk-in) > - Disposition (admission v. discharge) > - Length of stay (common measure of quality in the literature used for comparison)

Analysis

The open-source R statistical language and R-Studio user interface from the developers at CRAN were used for all data exploration, wrangling, cleaning, description, and analysis.(R Core Team 2017) Pandoc's Markdown allows for seemless integration of code, results, visualizations, and author interpretation of the research into a single document.(Allaire et al. 2017) Running all code and calculating all results within the menuscript itself, Markdown eliminates risk for errors in transferring statistical software output into foreign documents. The data were explored, cleaned, and assessed for statistical assumptions using the Tidyverse group of R packages.(Wickham 2017, Wickham (2016)) Data were prepared for network analysis with the iGraph package.(Csardi and Nepusz 2006) Muliple linear regression will be used for the final analysis to assess the correlation between patient acuity and patient centrality. Relationships will be evaluated visually (see below) as well as statistically to an alpha of 0.05.

Results

Results will be discussed with the visual supplementation of network graphs. This allows the reader to understand concepts that may be difficult to grasp through text alone.

Discussion

Allocating staff resources in an Emergency Department is an ongoing challenge. How can these results begin to offer solutions to ED staff and patient management?

What were my primary limitation (both expected and unexpected)?

Conclusion

Did I meet my learning objectives? How would I design a better study next time?

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