

Patient movement and infection spreading in hospitals

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Rationale

I avoid hospitals, it is full of ill people.
Desproges

While death is not so prevalent,
a big problem are nosocomial infections
or Healthcare Associated Infections (HCAI).

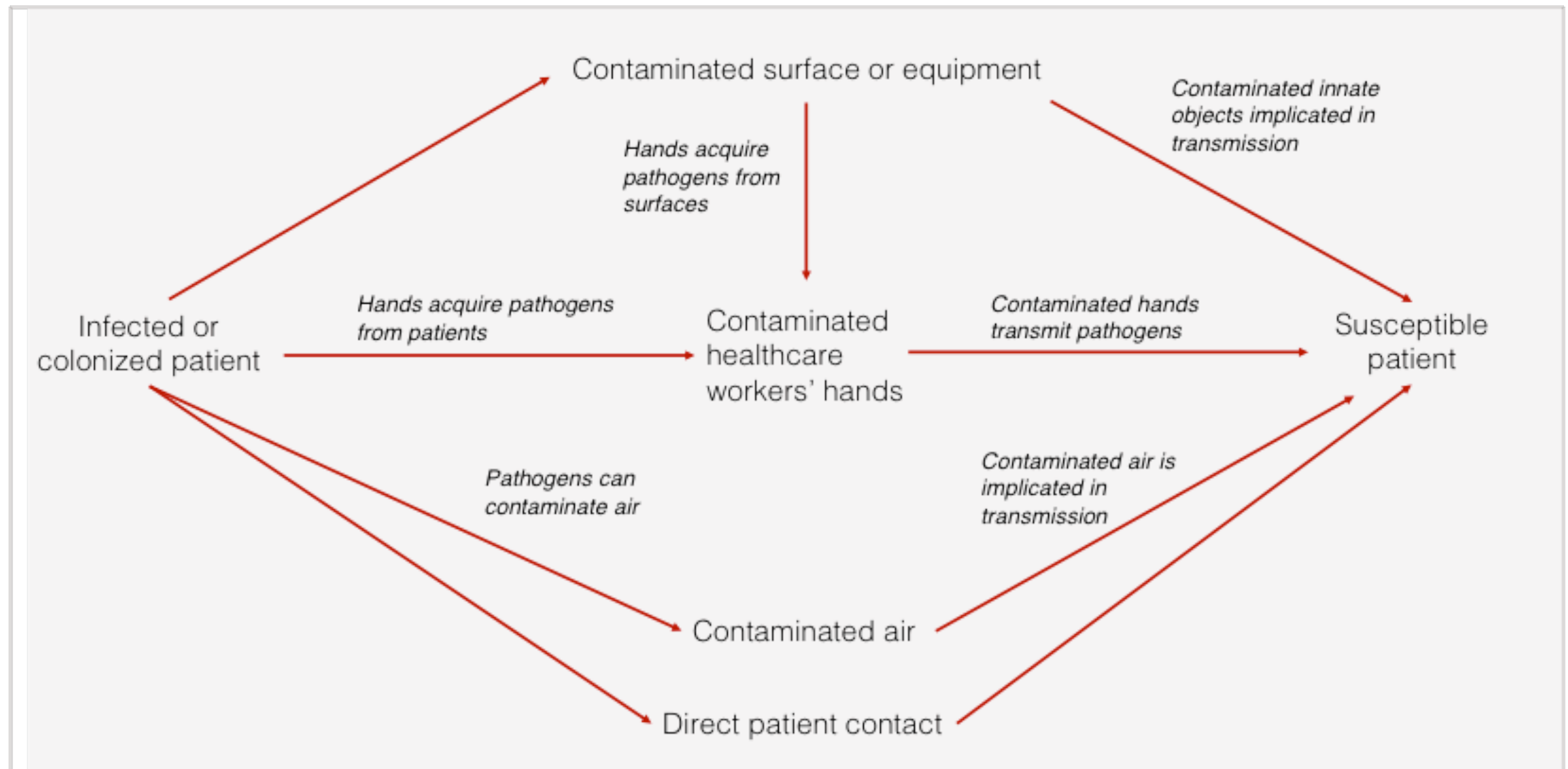


Healthcare associated infections

Antimicrobial resistance

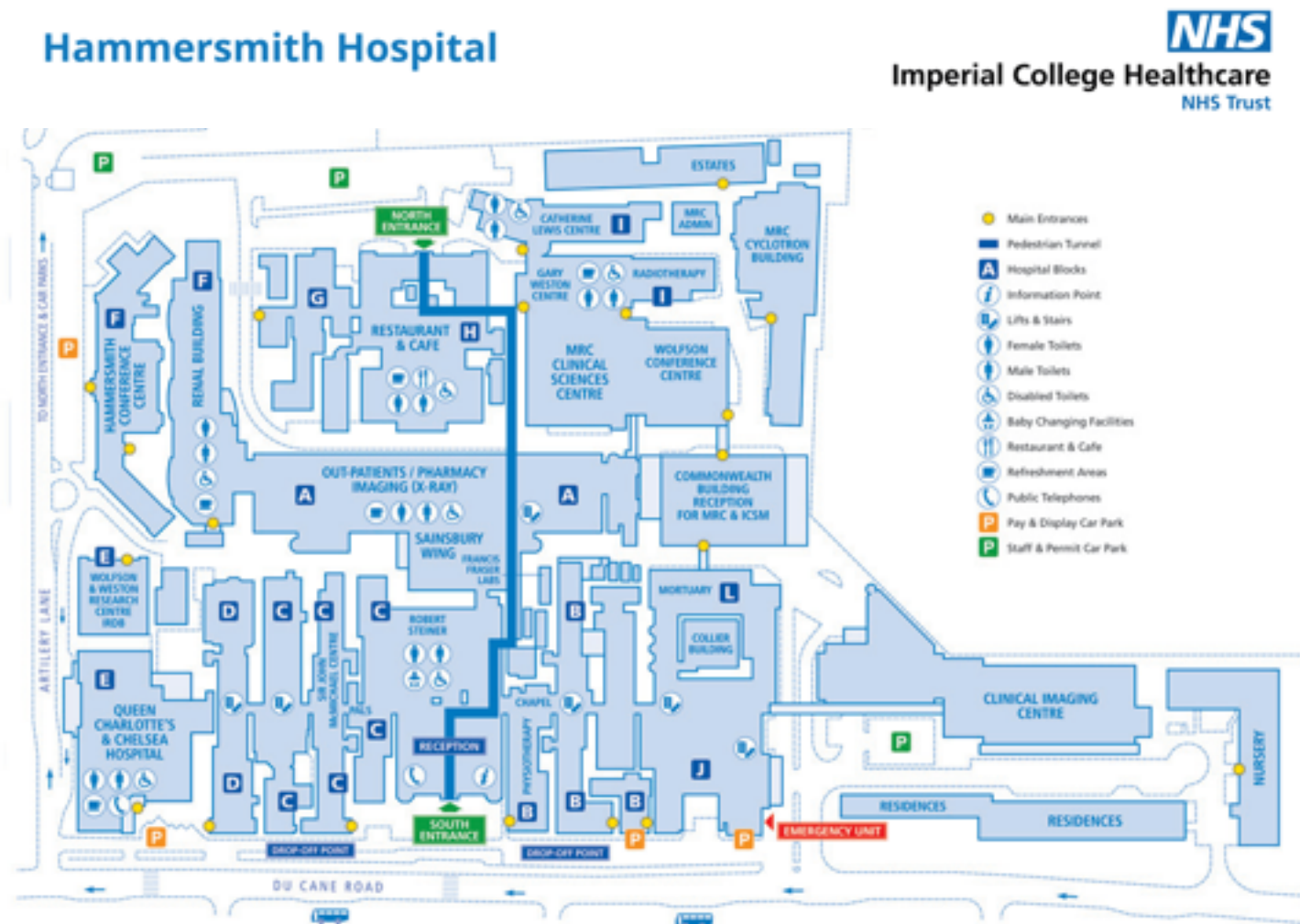
- HCAI: most prevalent adverse event in healthcare setting
- 4+ millions cases/year in Europe alone
- Prolonged hospital stay
- additional financial burden
- long term disability
- death (33k+ ~ influenza+HIV+tuberculosis)
- Increased use of antibiotics
- Drives antimicrobial resistance, overtake cancer as the main cause of death by 2050

Infection pathways



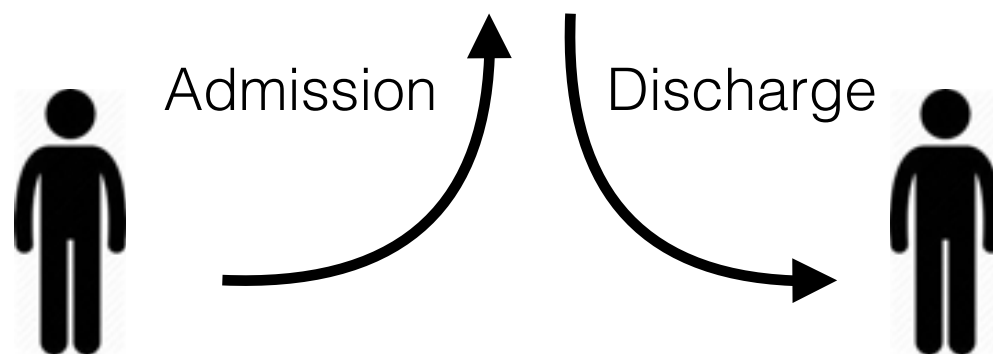
Partial quick glimpse at the complexity of a hospital.

Characterisation of a hospital spell



Electronic health records

- Age
- Gender
- Comorbidities
- Diagnosi/es
- Procedures
- Wards visited
- Length of stay
- ...



Nature of data

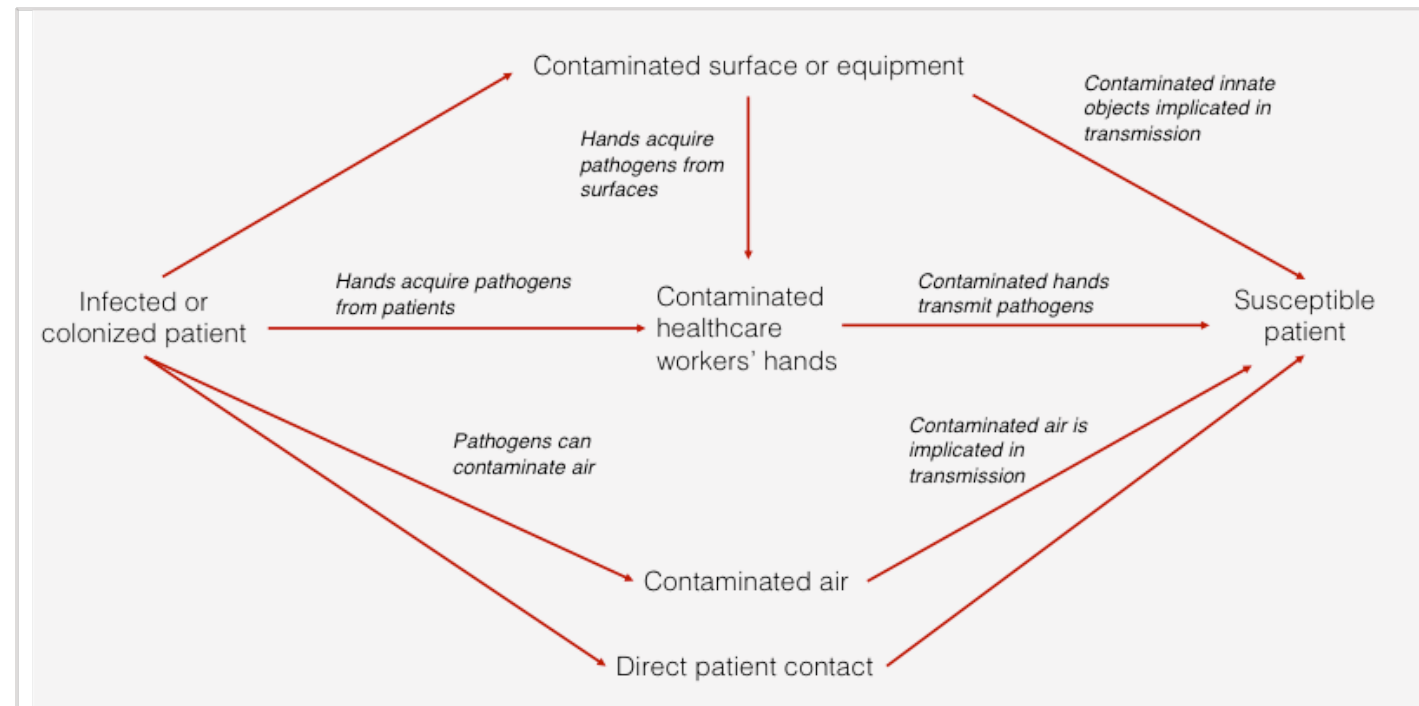
- Patient EHR
- Microbiology
- Incidents reports

Patient ID	Ward	Admission Date	Discharge Date	Ward Start	Ward End	Infection Status	Treatment...
101	A						
101	B						
101	C						
...							

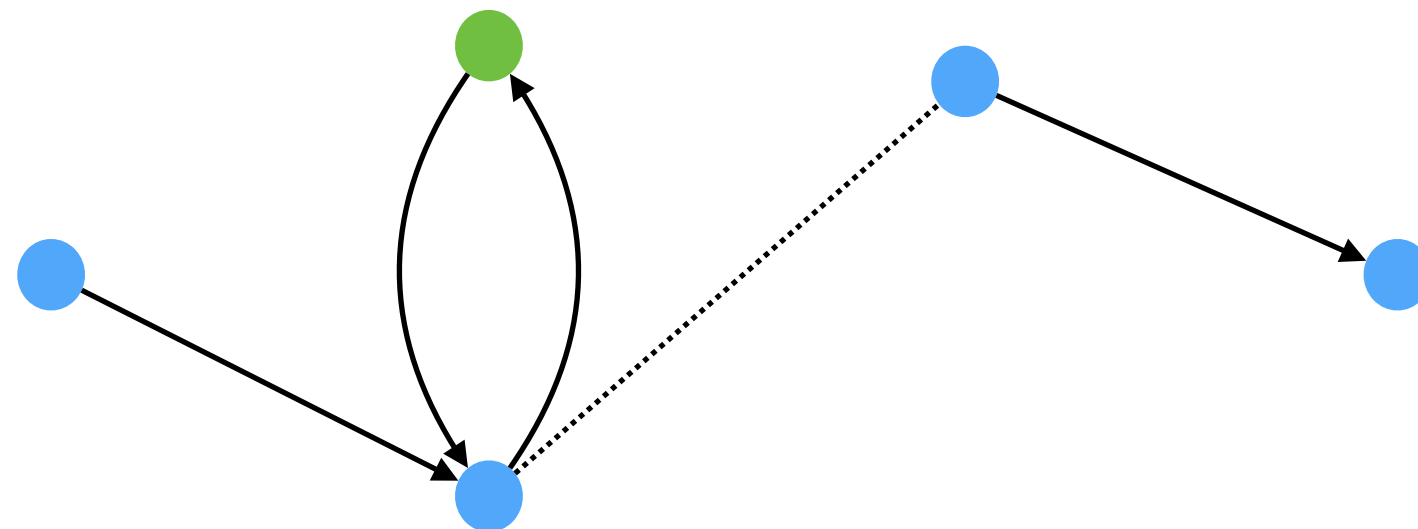


Jan 2016-Dec 2018 in Imperial College Hospital NHS Trust

Patient trajectory

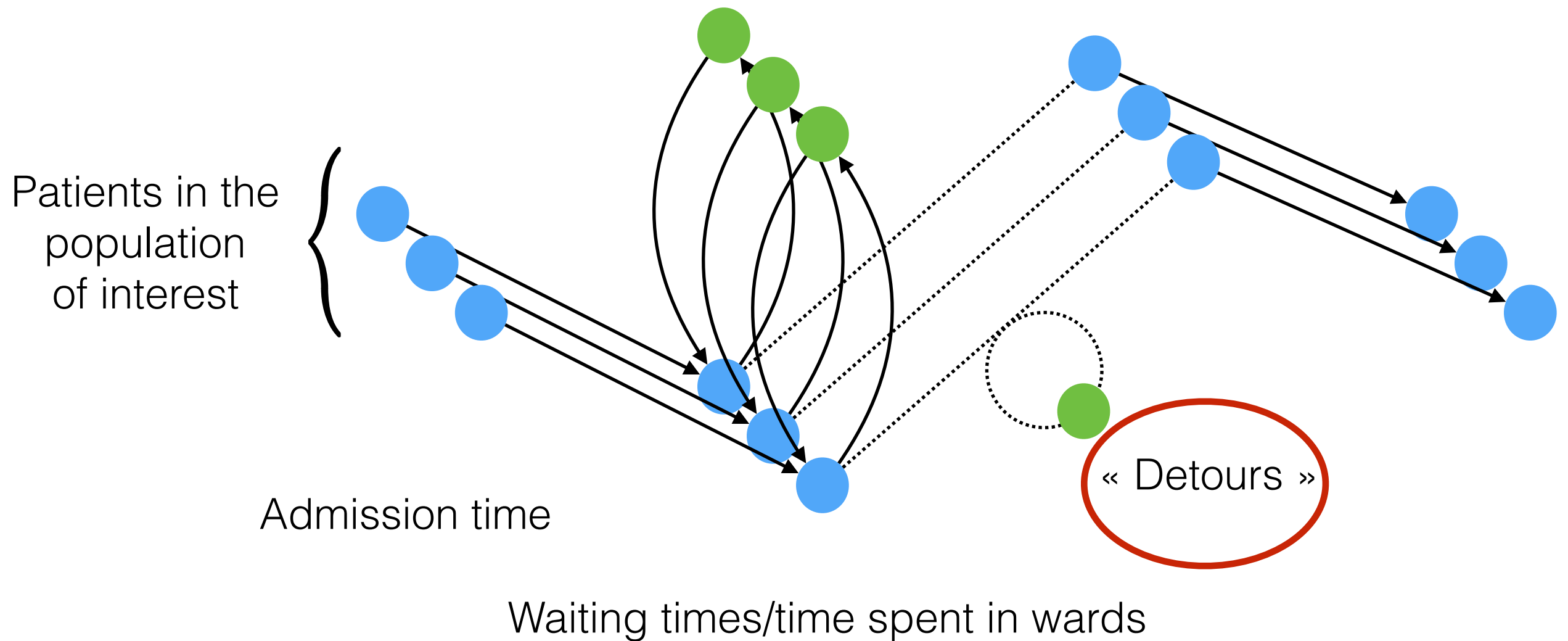


Admission

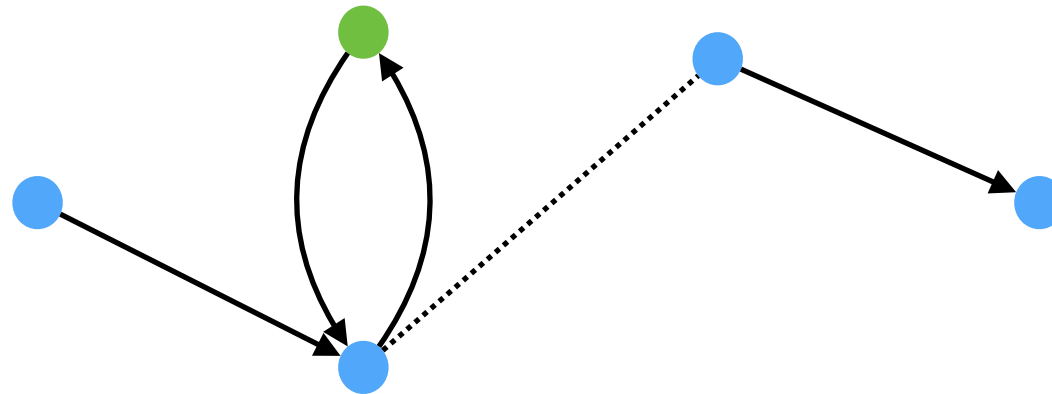
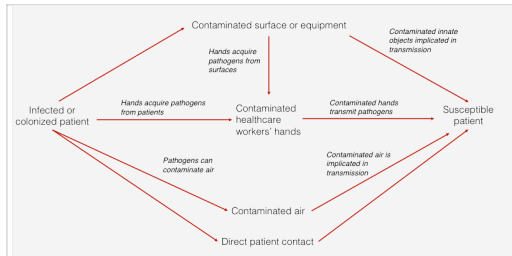


Discharge/death

Patient trajectories



First question: how bad is moving in a hospital



An Aging Population

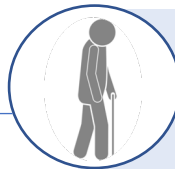


62% of hospital bed days occupied by those aged 65 or over¹

Population: 65+ y/o, stay of 3+ days (n=22,825)

Is there added pressure from the “bed crisis”?

An Aging Population



62% of hospital bed days occupied by those aged 65 or over¹

27% increase in admissions in the last decade²



Rising Admissions

Fewer Inpatient Beds



Bed stock has decreased by **56%** from 1987/88 to 2015/16²

Added layer of complexity: staff management

Is there added pressure from the “bed crisis”?

An Aging Population



62% of hospital bed days occupied by those aged 65 or over¹

27% increase in admissions in the last decade²

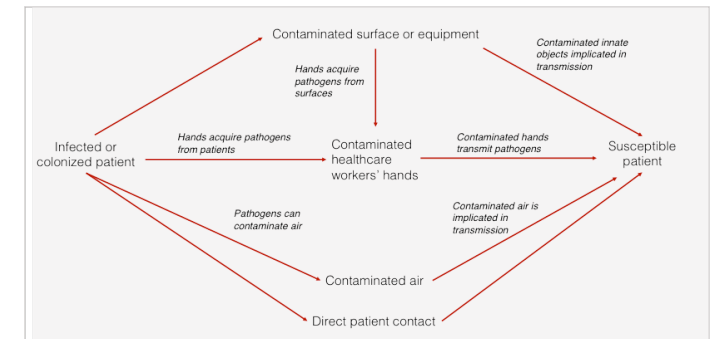


Rising Admissions

Fewer Inpatient Beds



Bed stock has decreased by 56% from 1987/88 to 2015/16²



Overflowing Emergency Department



Correct Specialist Clinical Ward



Acute Assessment Unit



Inappropriate Specialist Clinical Ward



Procedural and Diagnostic Areas

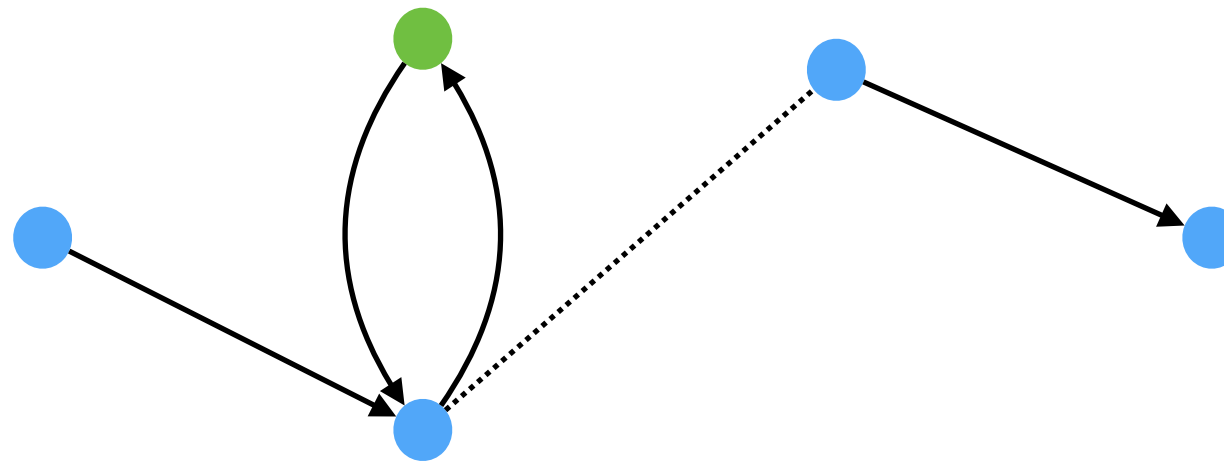
CT scanner

X-Ray

Endoscopy

Dialysis

Ward transfer vs HCAI



Exposure

Ward-transfer

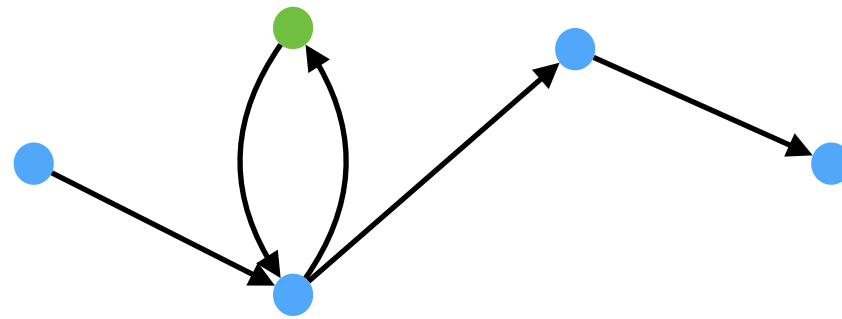
- A permanent change of ward
- A transient change to a procedural ward

Outcome

Healthcare-Associated Infection

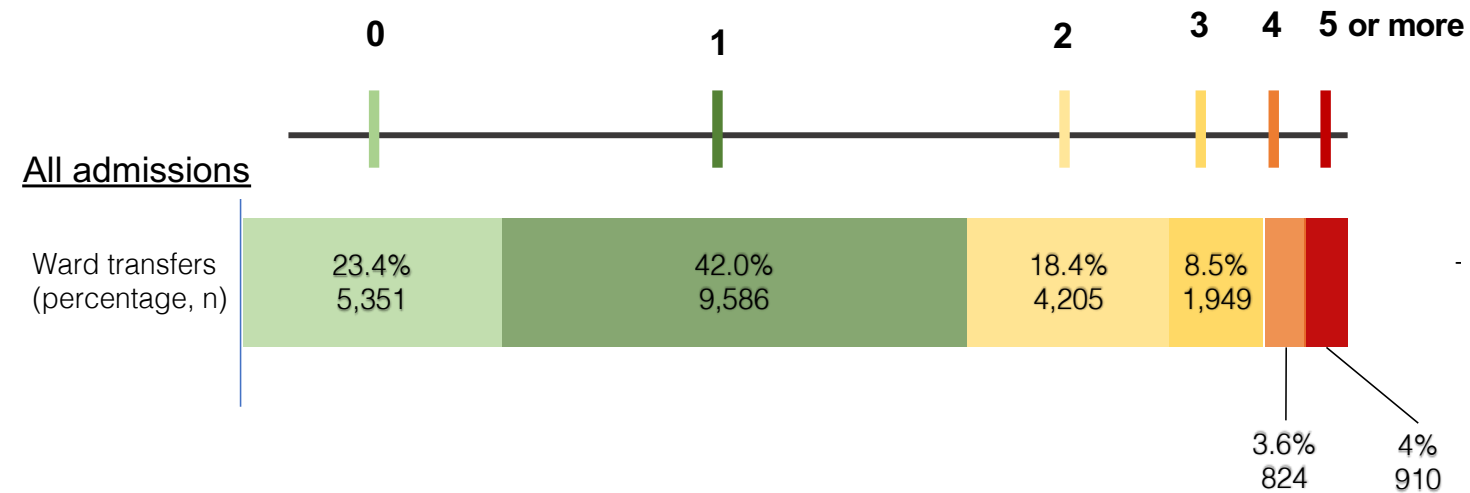
- Infection free on admission and the first 48-hours of their spell
- Acquired any infection which was culture confirmed at least 48-hours after admission into hospital

Ward transfer counts



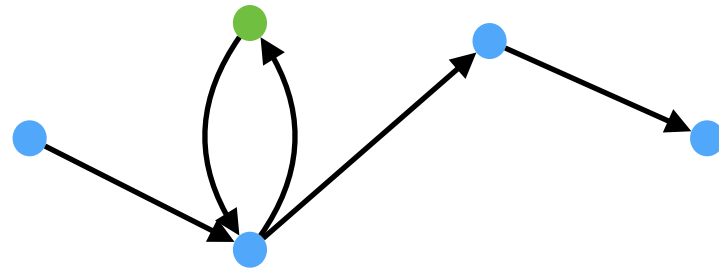
$n=5$

Ward-transfers (n)

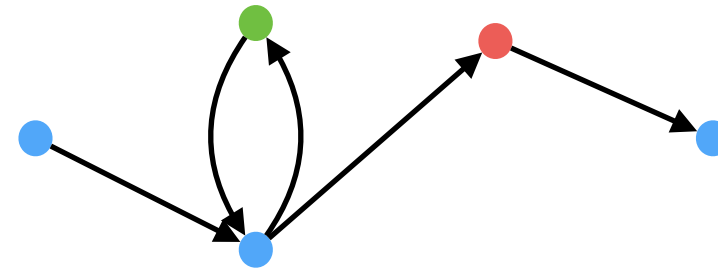


77% of spells involve at least one transfer
35% of spells involve two or more

Ward transfer counts

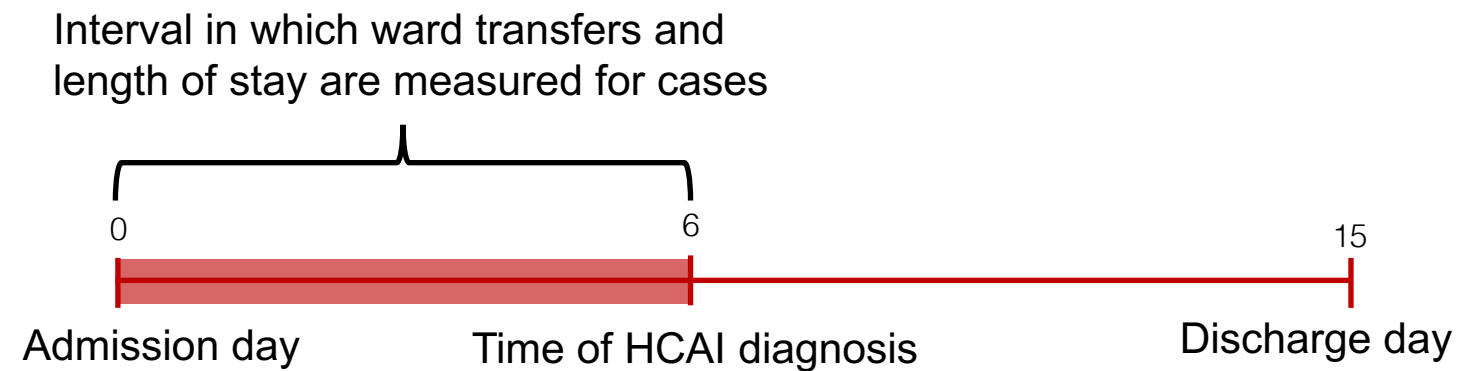


$n=5$

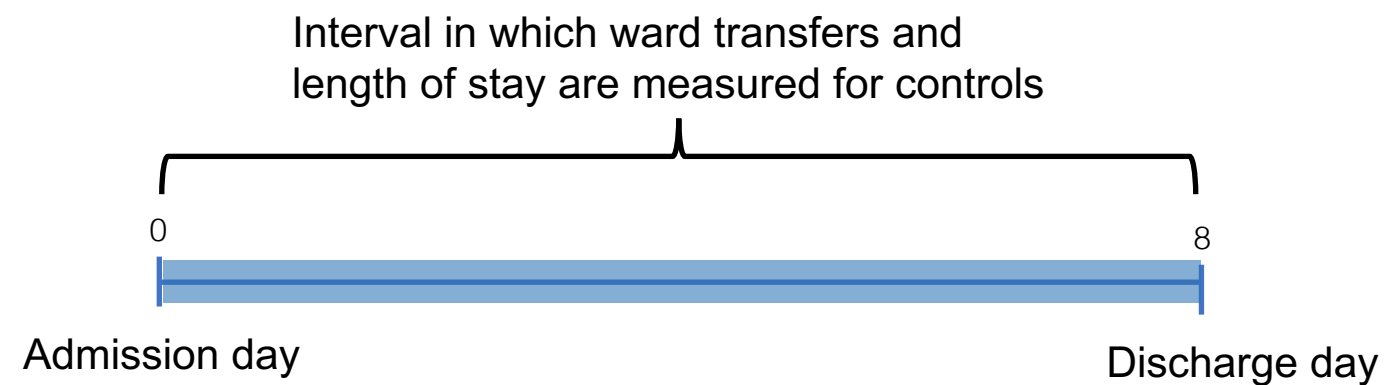


$n=4$

Cases



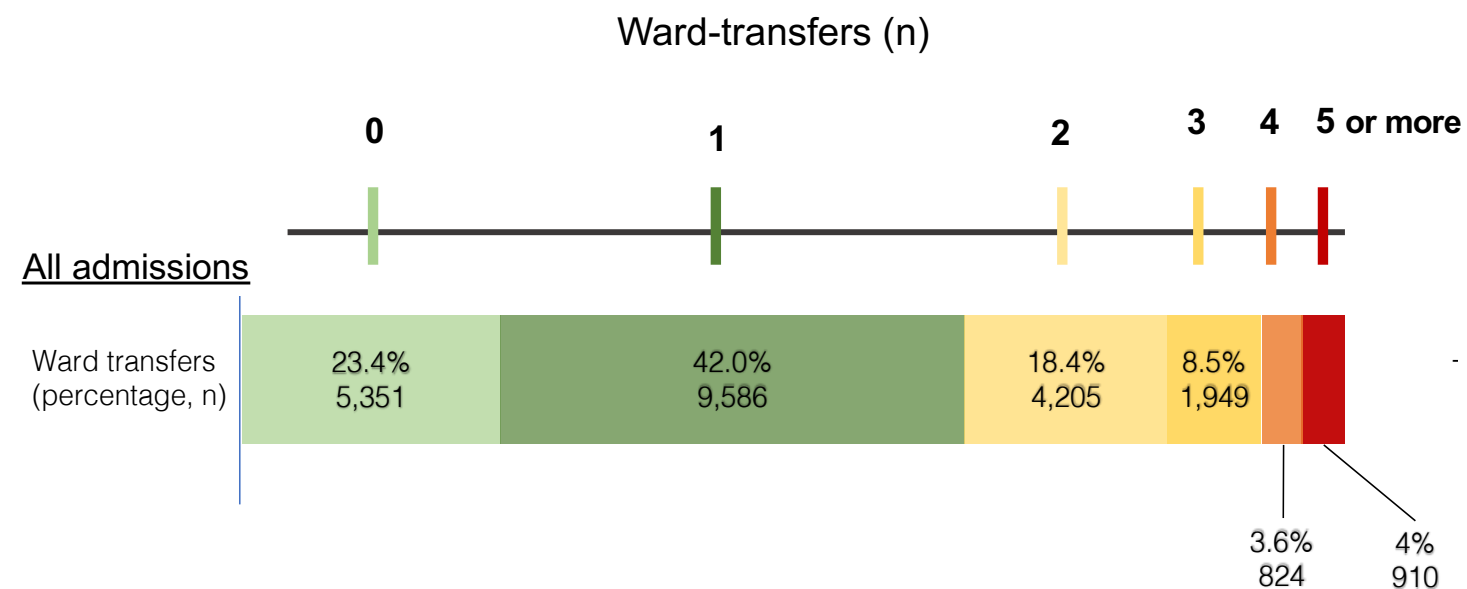
Controls



Multilevel multivariable logistic regression clustered by individual patients

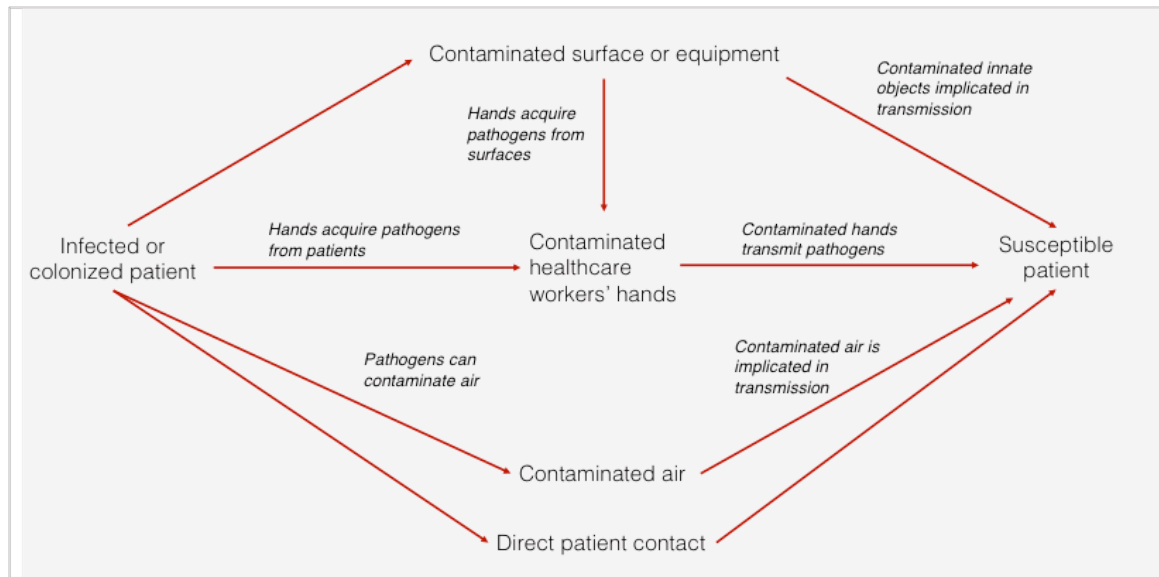
1 ward transfer -> odds of HCAI increase by 9%

(OR: 1.09; 95%CI: 1.06,1.13)



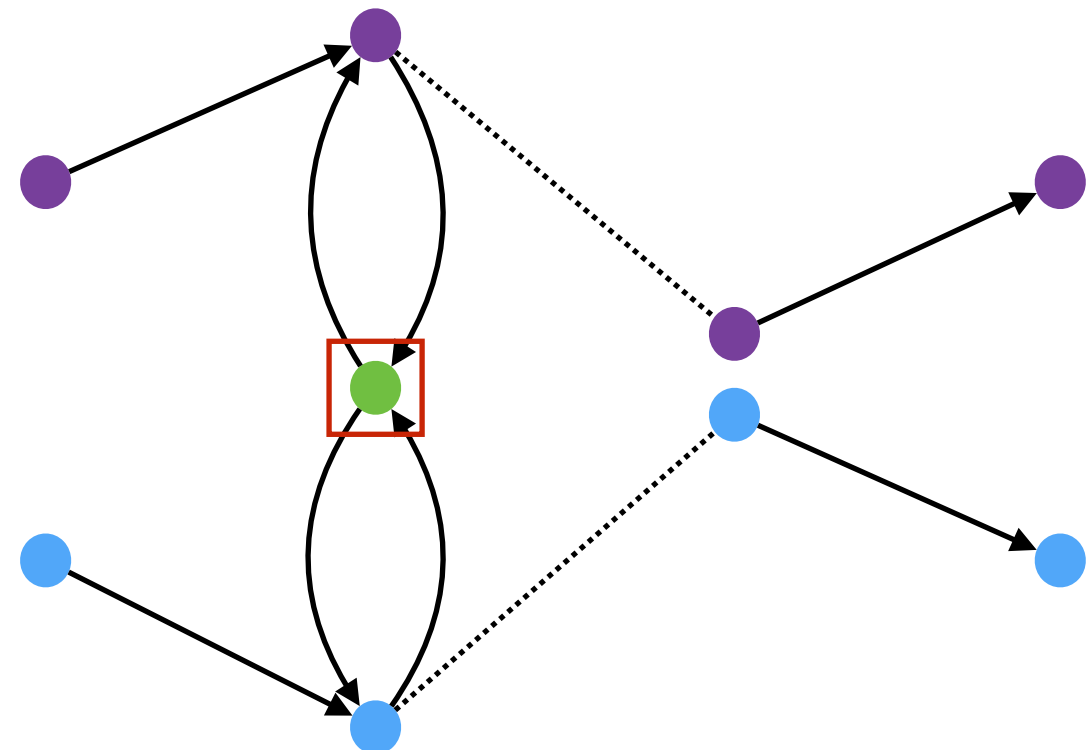
77% of spells involve at least one transfer
35% of spells involve two or more

Hospitals are complex systems



Patient i

Patient j



Trajectories interact!

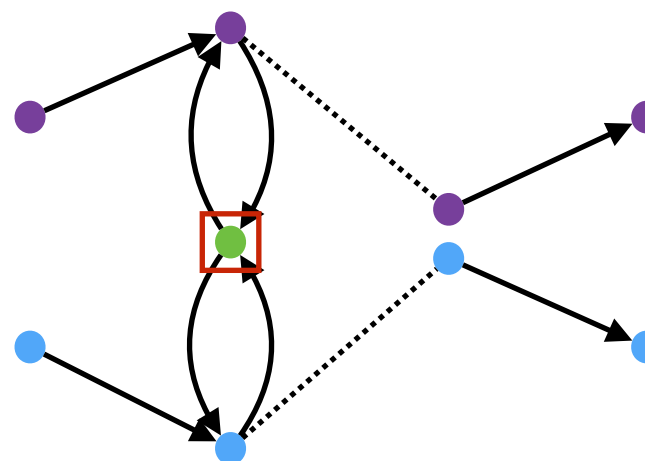
The Nightmare bacteria

Carbapenem-resistant *Enterobacteriaceae* (CRE)

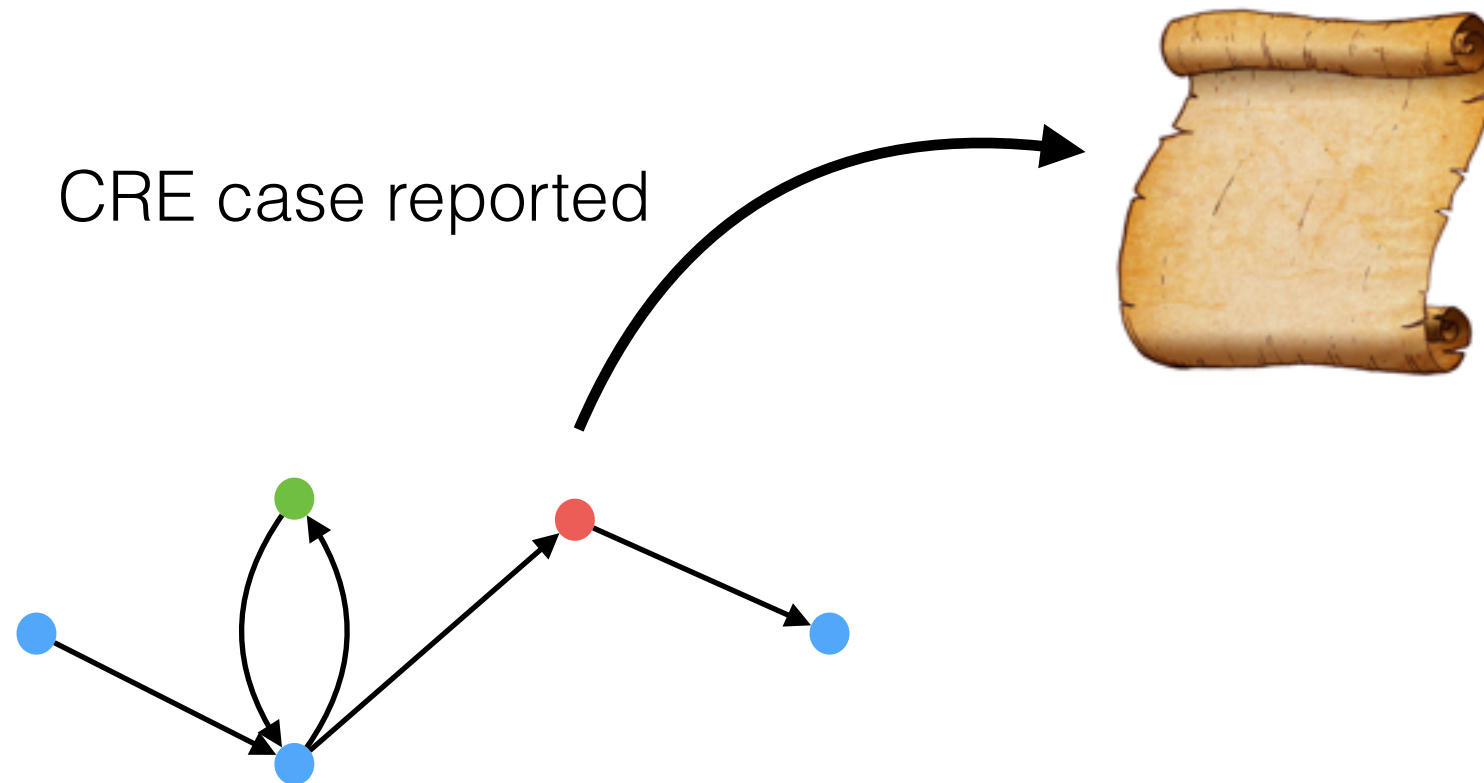
- Gram-negative bacteria, resistant to carbapenem ABX
- Emerging and growing problem
(22 *reported* cases in ICHT, lots more micro confirmed)
- Resistant to most antibiotics (AMR)



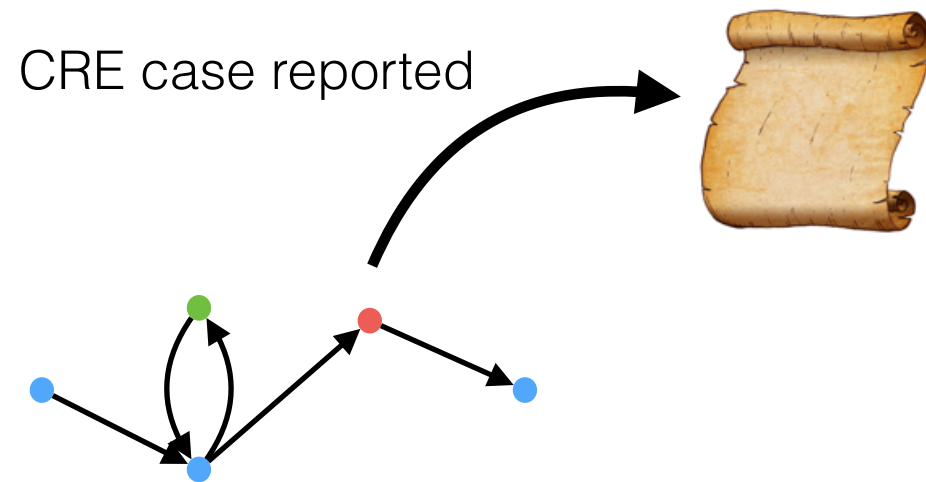
'Nightmare Bacteria'!



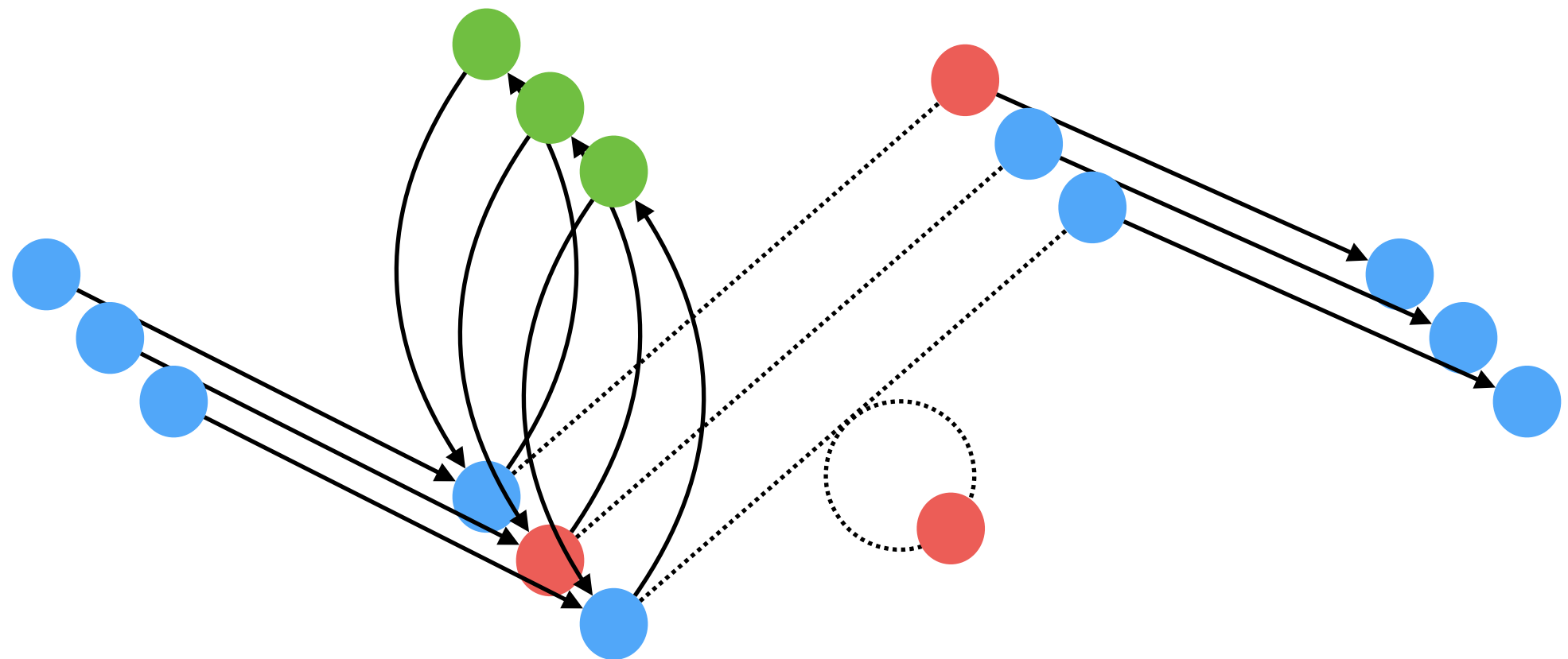
Incidents wards



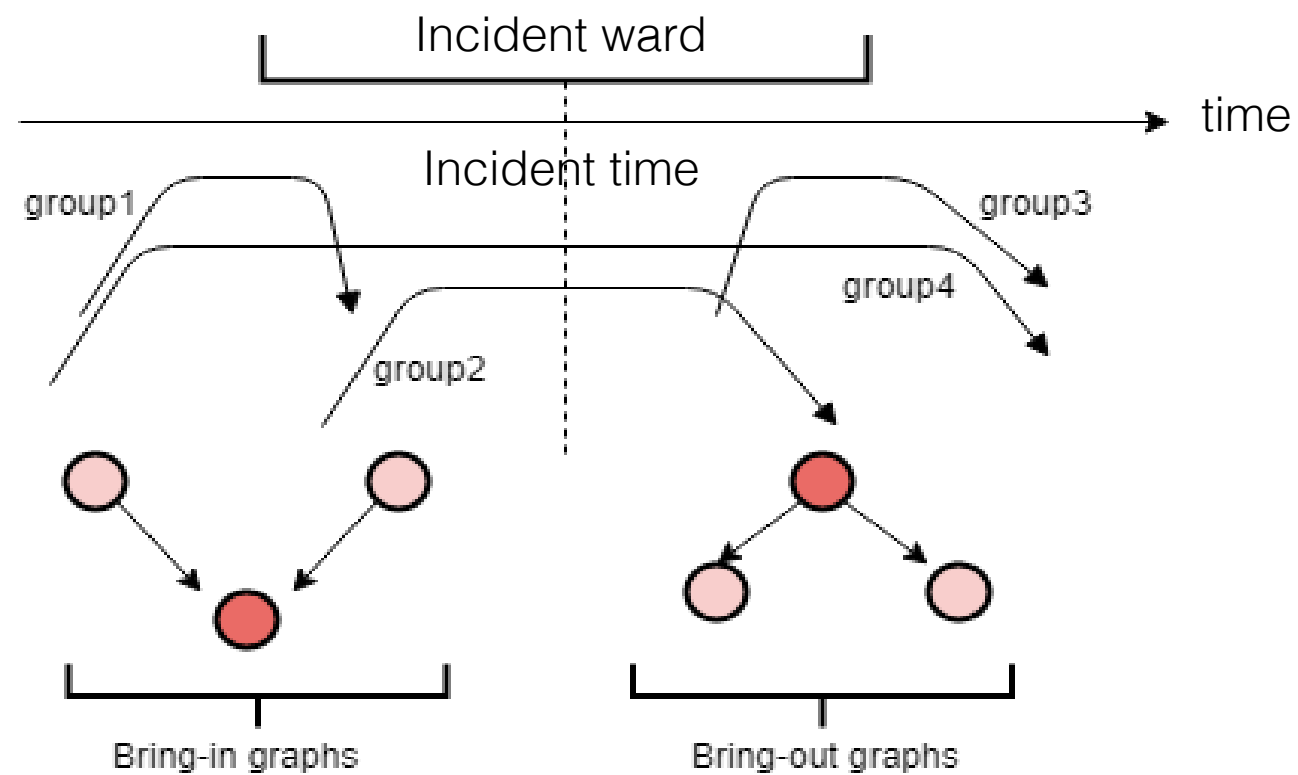
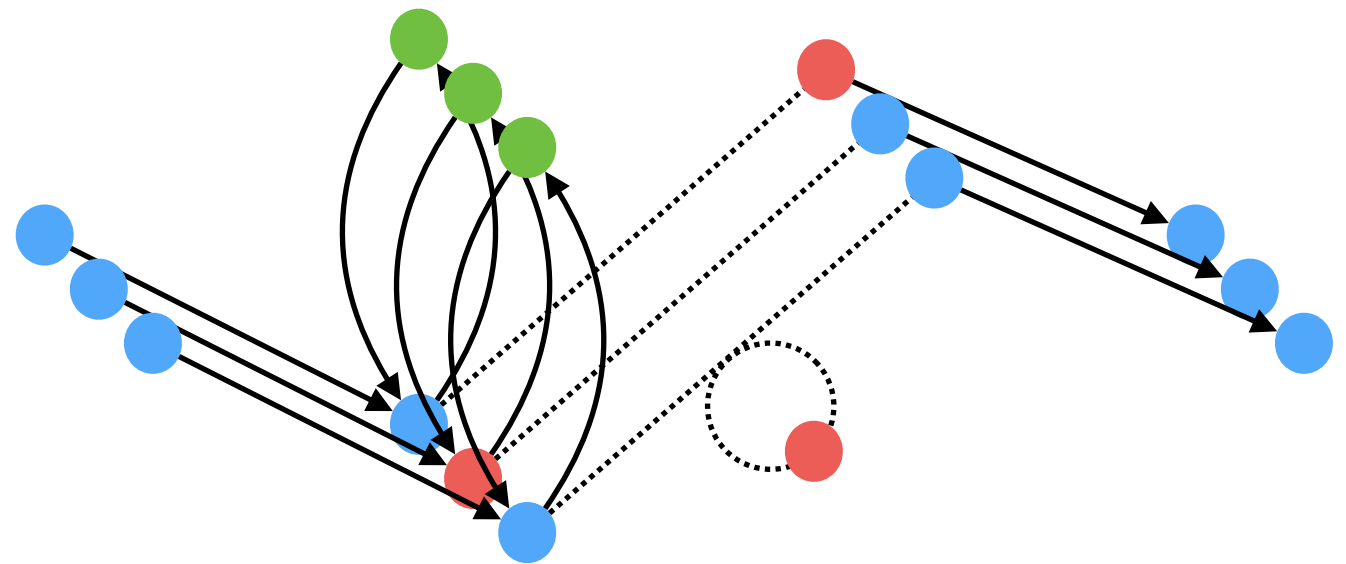
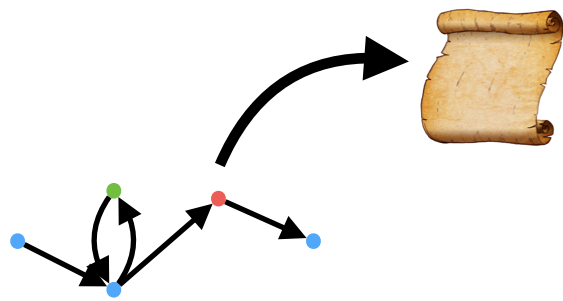
Incident ward population



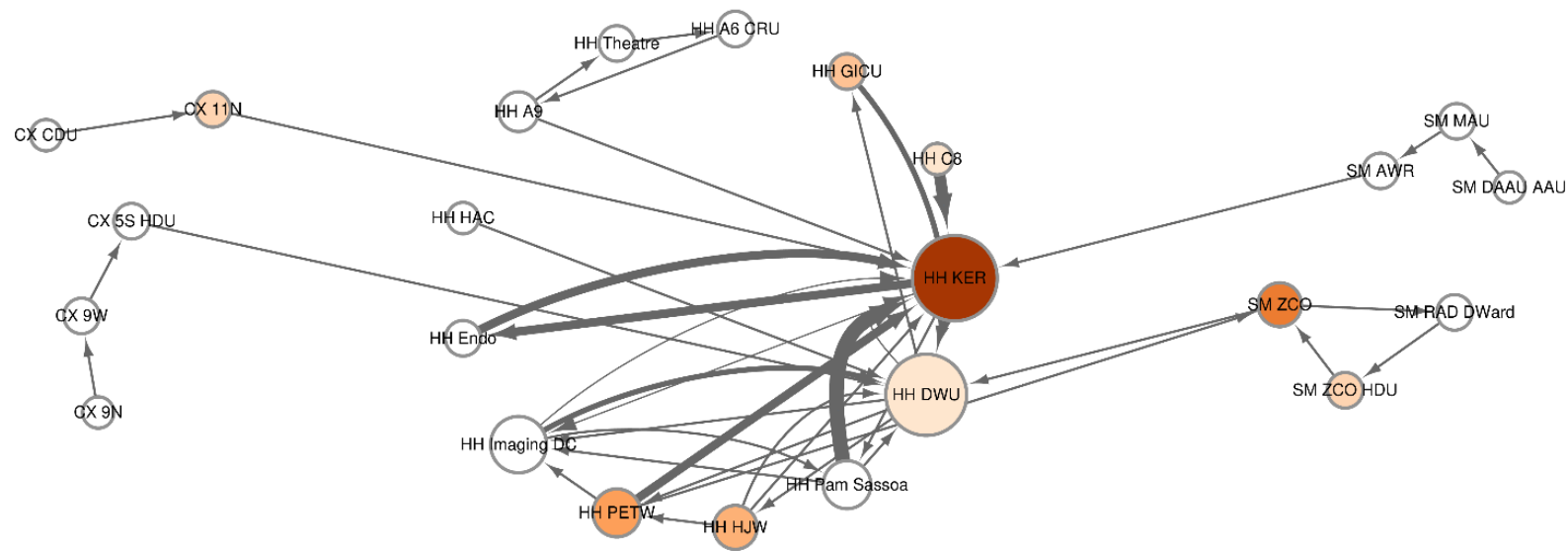
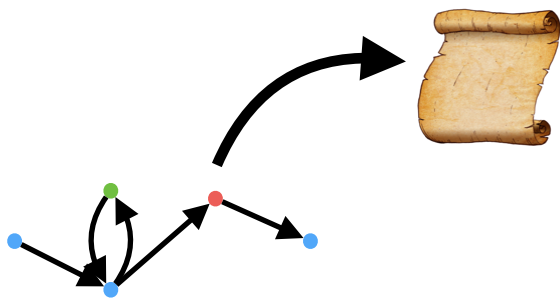
Patients that visited
the incident ward



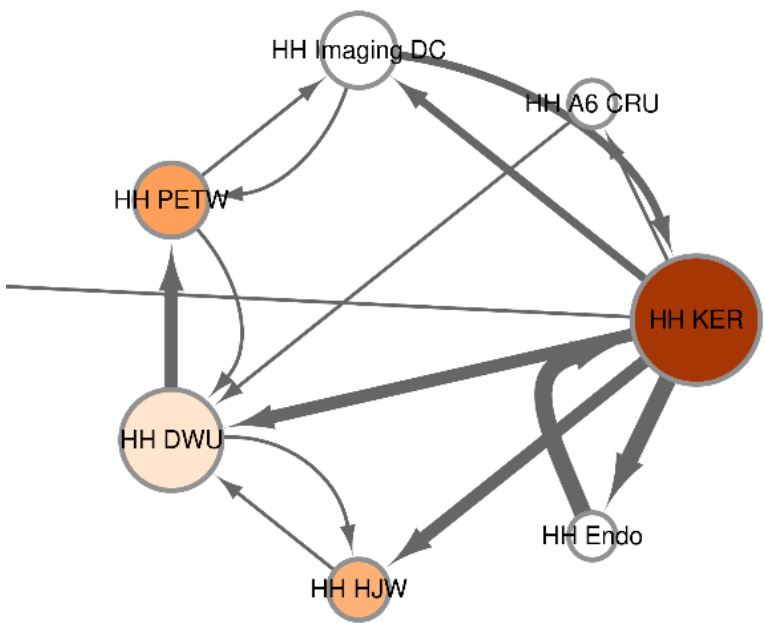
Incident ward population



Incidents networks

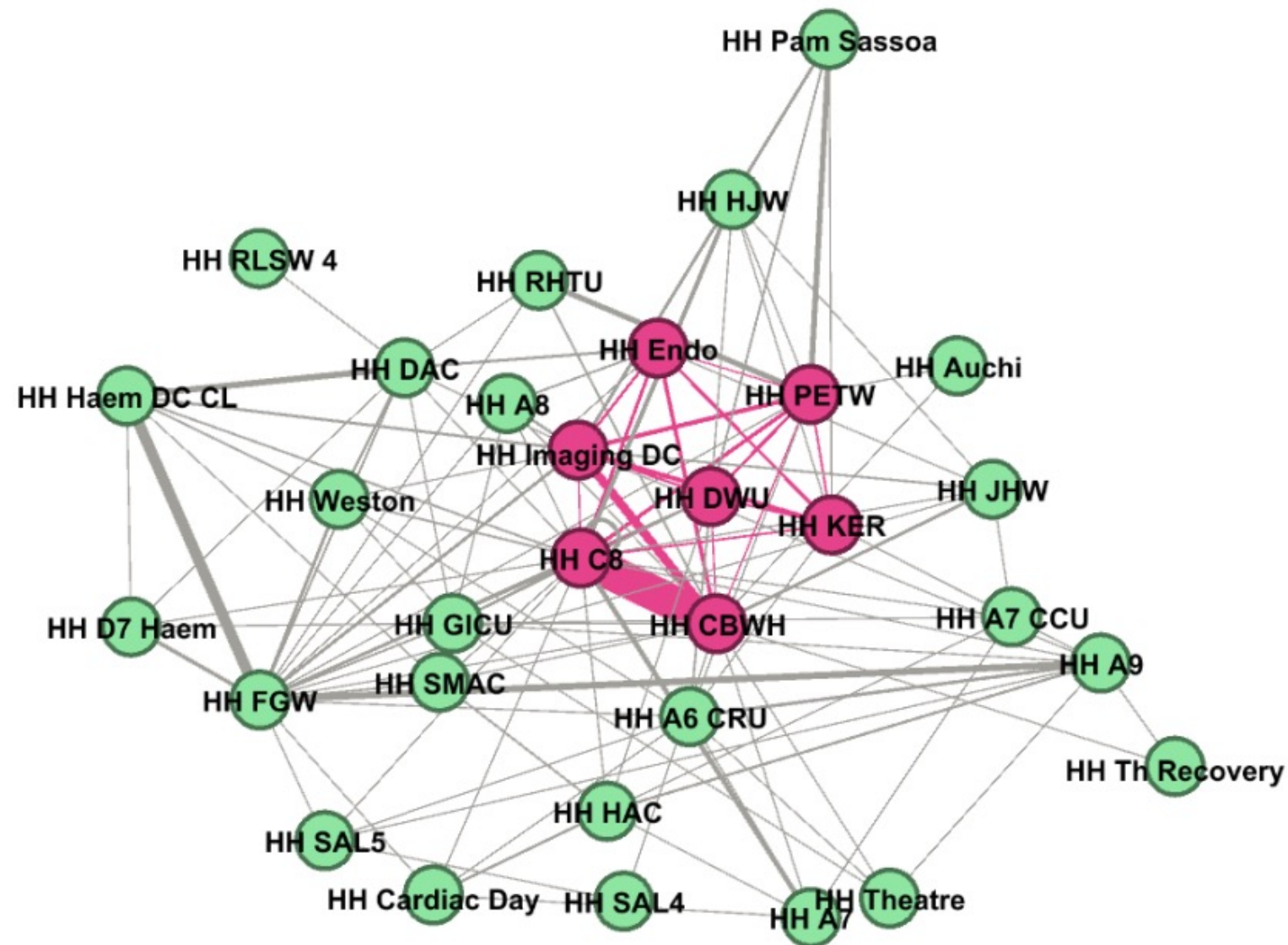


In-network



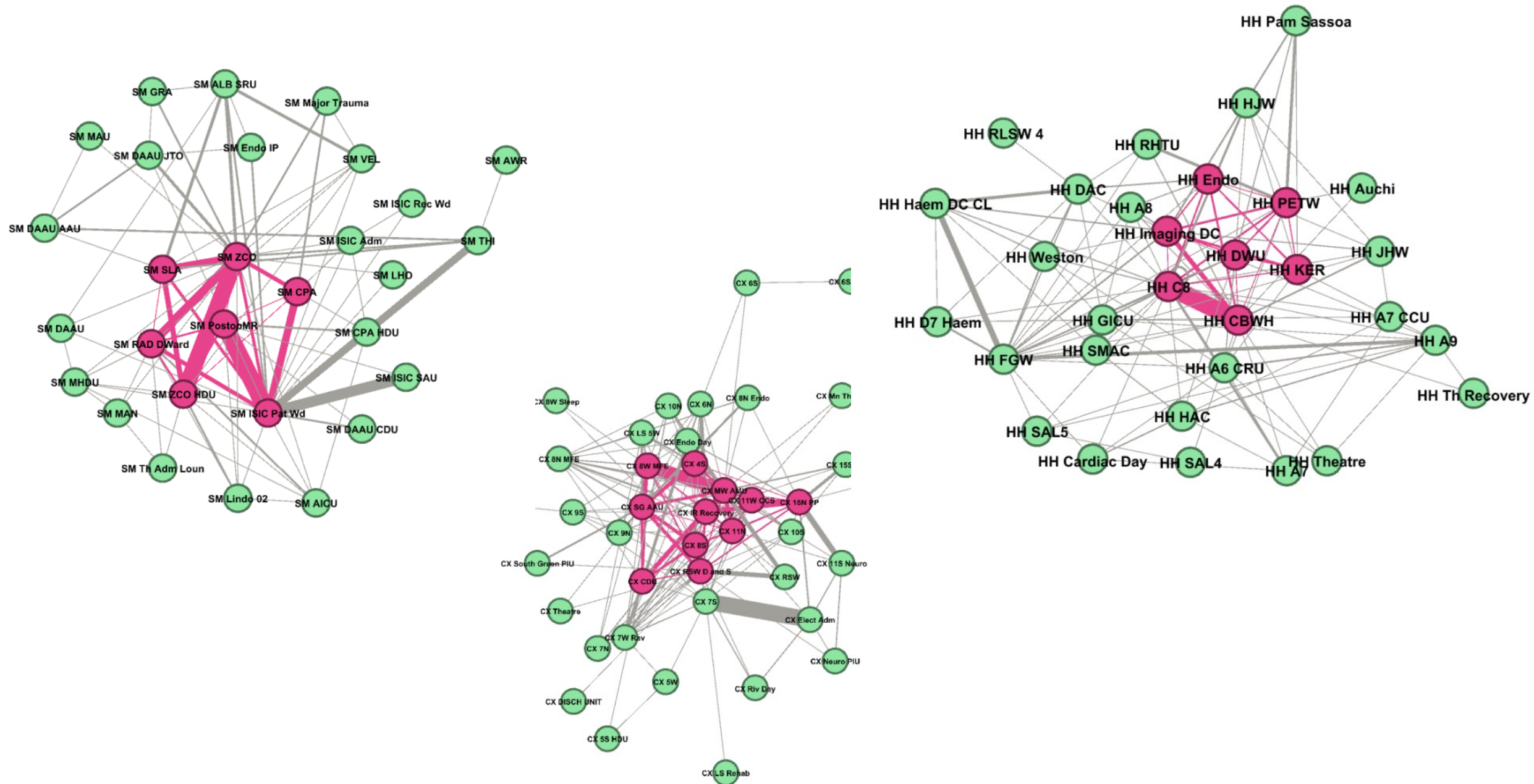
Out-network

Hospital aggregated incidents



Core wards account for the majority of patient movements in hospital incident networks.

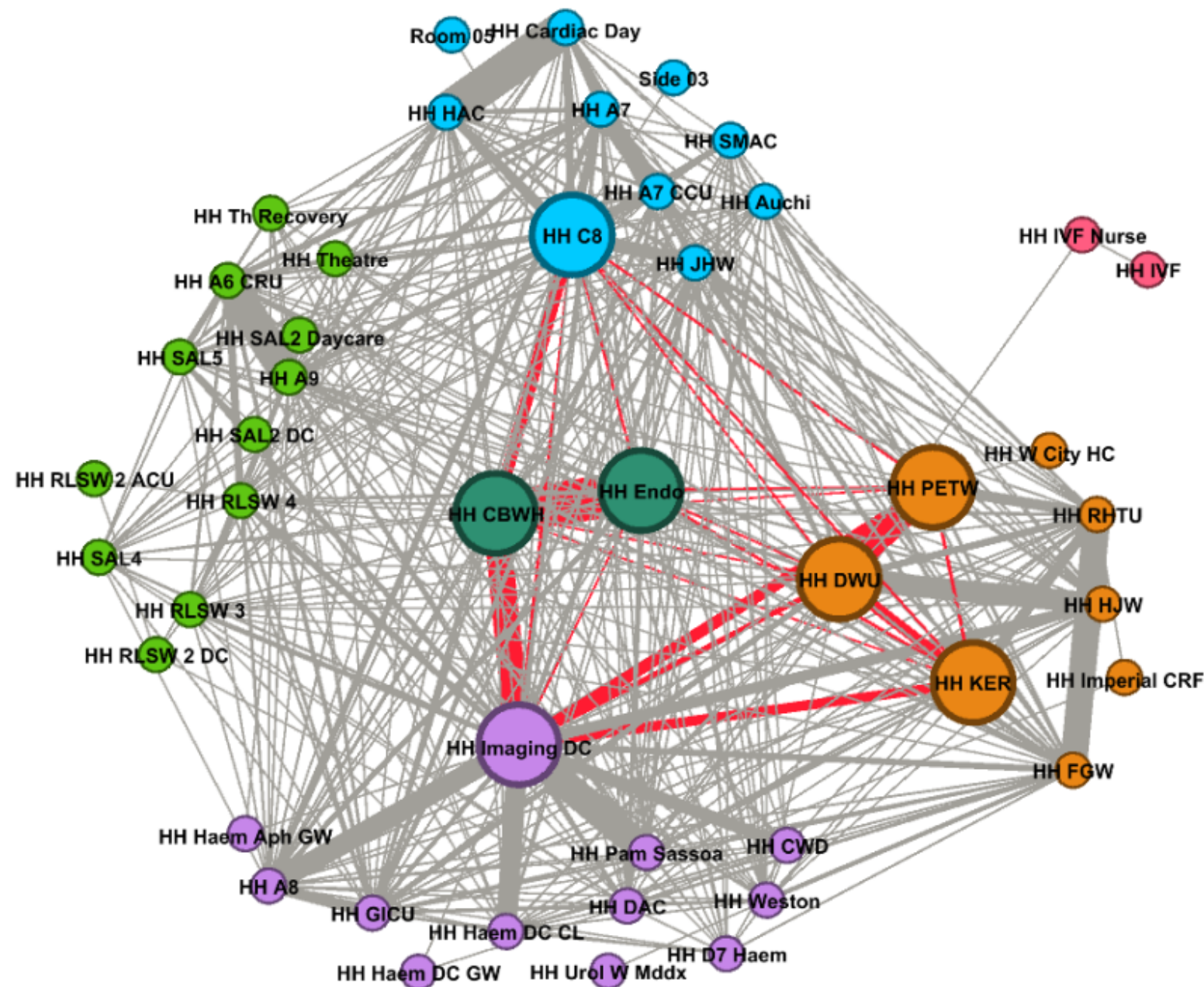
Hospital aggregated incidents



Different core wards, similar patterns across hospitals

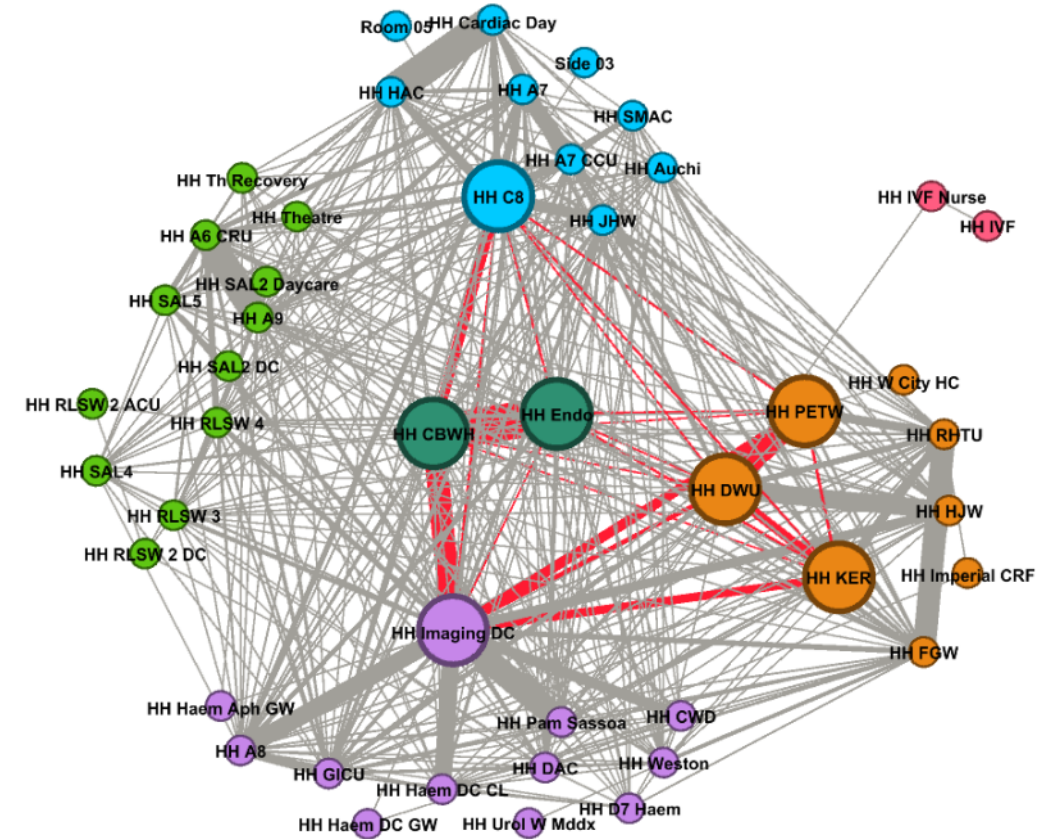
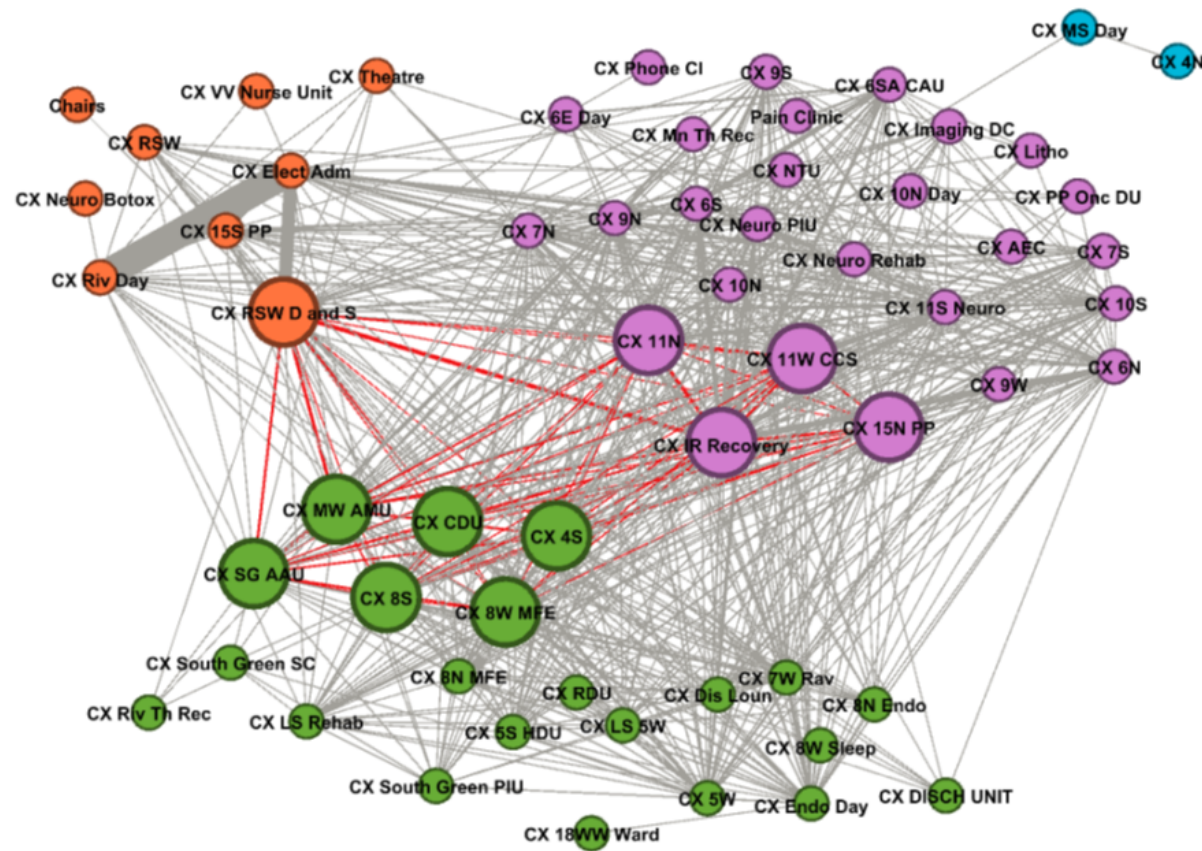
Pathways for CRE spreading

Core infection wards are gateways for CRE into functional clusters of wards.

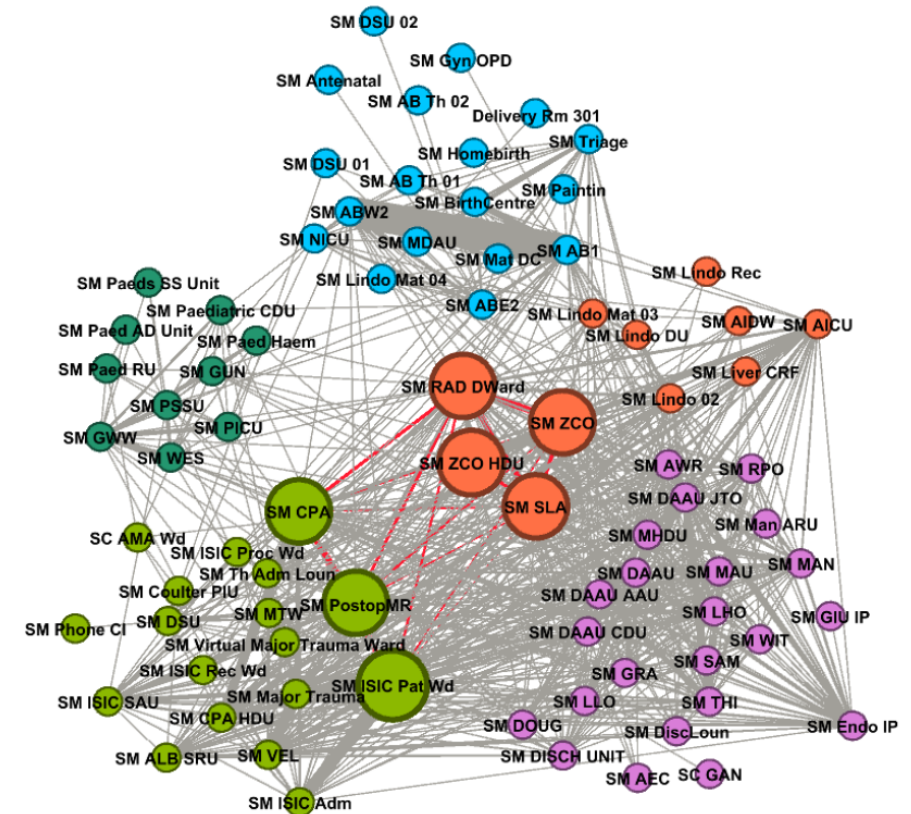


Projection of the incident network onto the general population movement network.

Pathways for CRE spreading



Different core wards, different clusters,
similar patterns!



Summary

- Avoid moving in (overstretched) hospitals if possible.
- EHR can be naturally turned into networks and analysed.
- Sheds light on infection pathways and opens route to devising mitigation strategies.
- Only a glimpse at what can be done with EHR:
 - Interaction between infectious disease
 - Overall infectious disease assessment
 - Bed and patient flow management
 - etc ...



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We are looking for international collaborators
to learn and compare from practice outside UK.
Come talk to me!

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