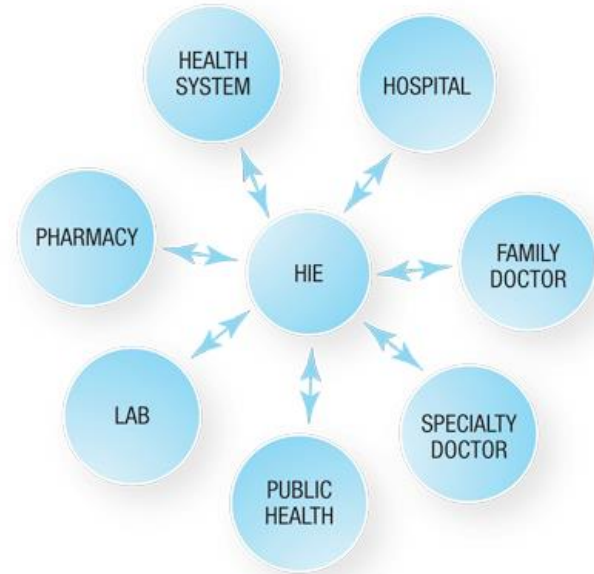# Health Information Exchange
Adoption, Usage and Patient Privacy

Presentation outline

- Introduction
- 3 papers in *ACM TMIS*, *JAMIA* and *ISR*
- Ongoing research
- Q & A

Health Information Exchange

Health Information Exchange

- **Benefits**:

    Reduces costs and increases quality of healthcare services (Fontaine et al. 2010; Hincapie et al. 2010)
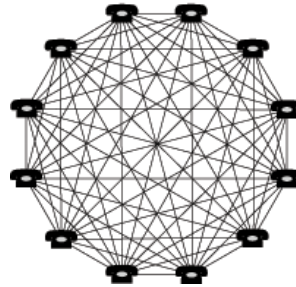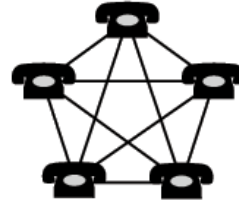
- **Challenges**:

    Its adoption rate is much lower than initial expectations (Agarwal et al. 2010)

    Interoperability (Audet et al., 2004), governance, financing and policy vision (West and Friedman, 2012), privacy (Miller and Tucker, 2009)

Multi-Sided Platform
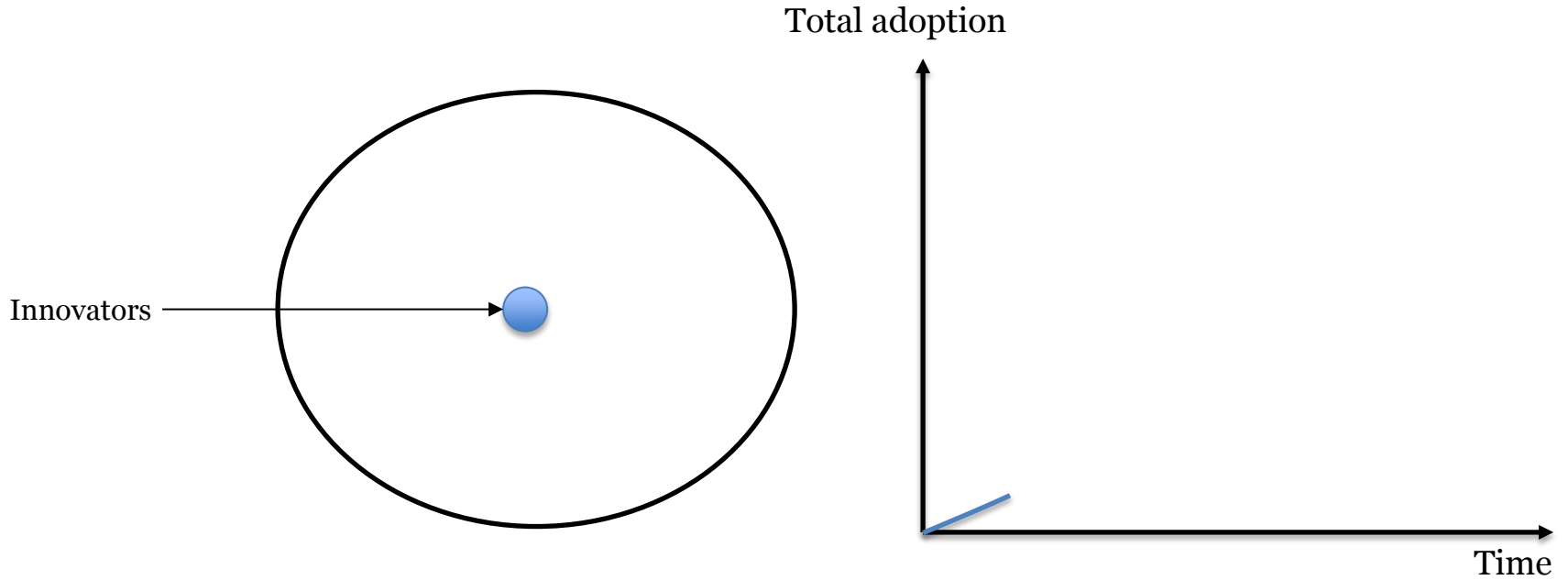
Network Externalities

Network Externalities

- Within group (direct) externalities
- Between group (indirect) externalities

Bass diffusion model

Bass diffusion model
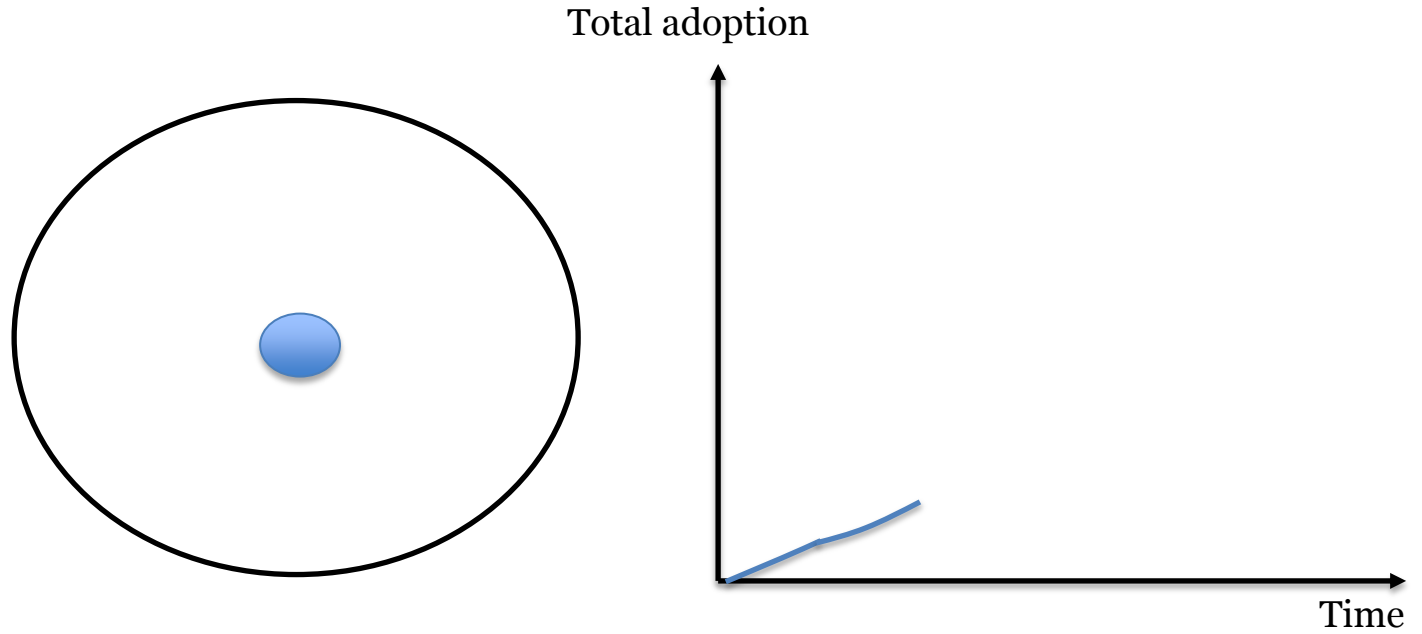
Total adoption

Innovators

Time

Bass diffusion model

Bass diffusion model
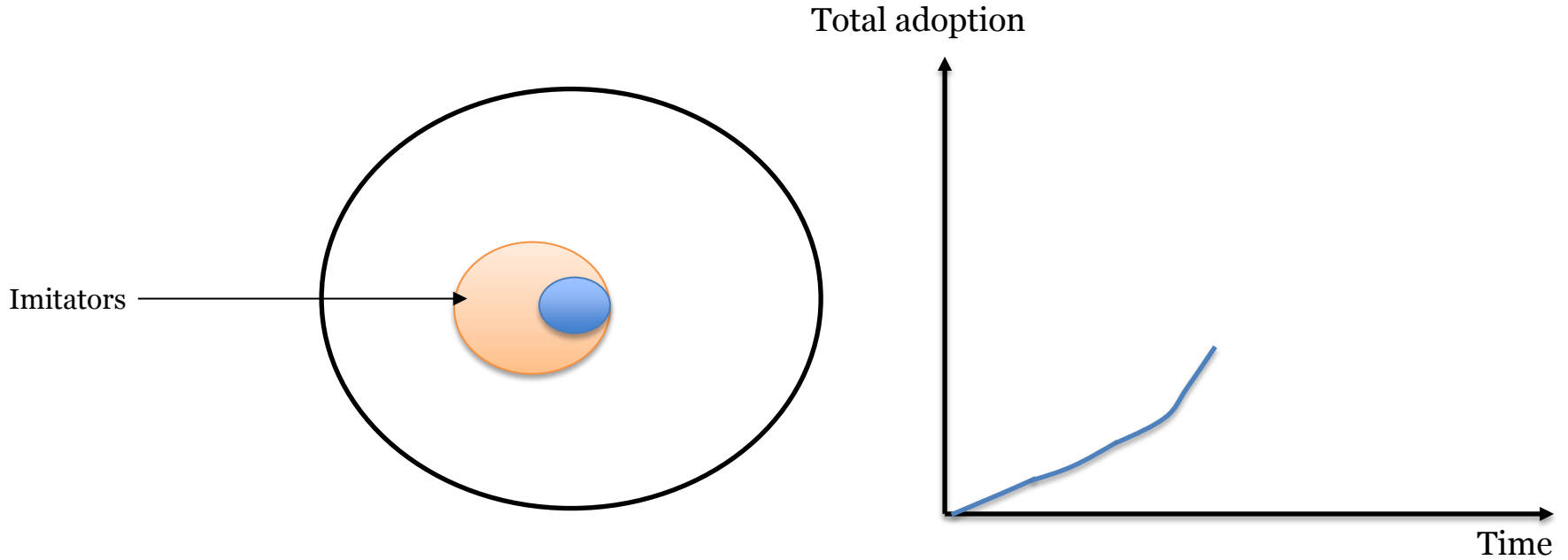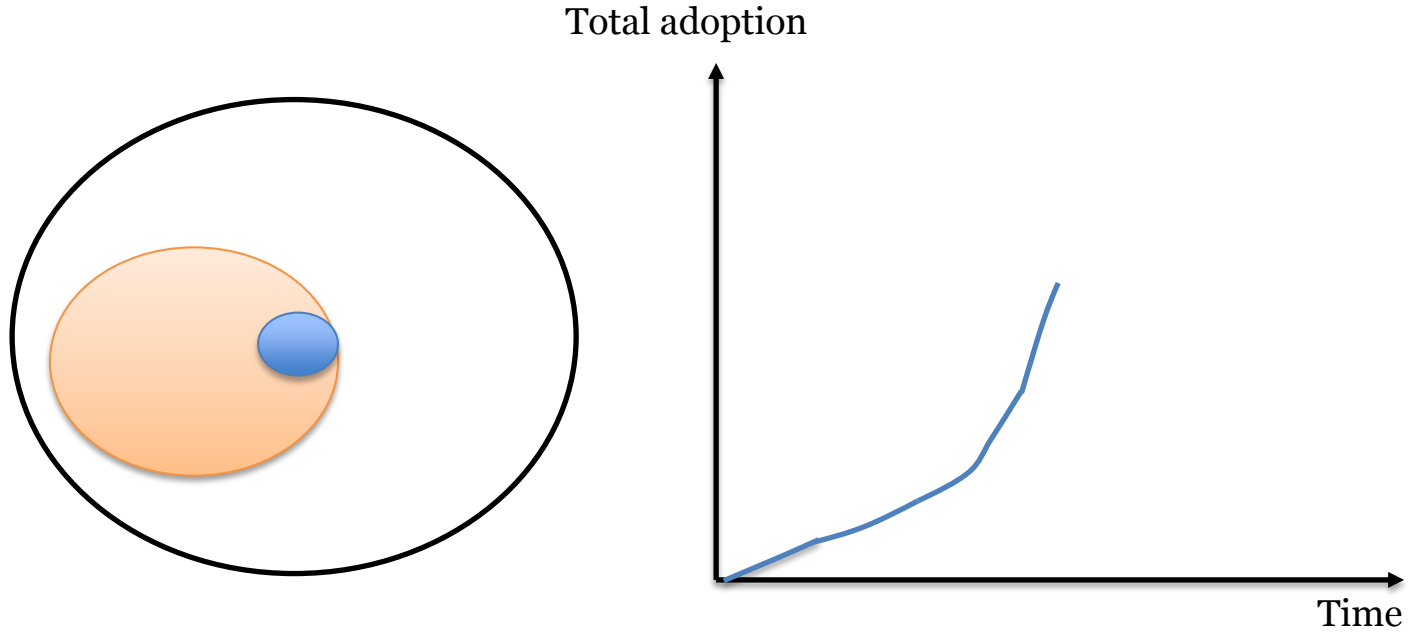
Bass diffusion model

Bass diffusion model

Bass diffusion model
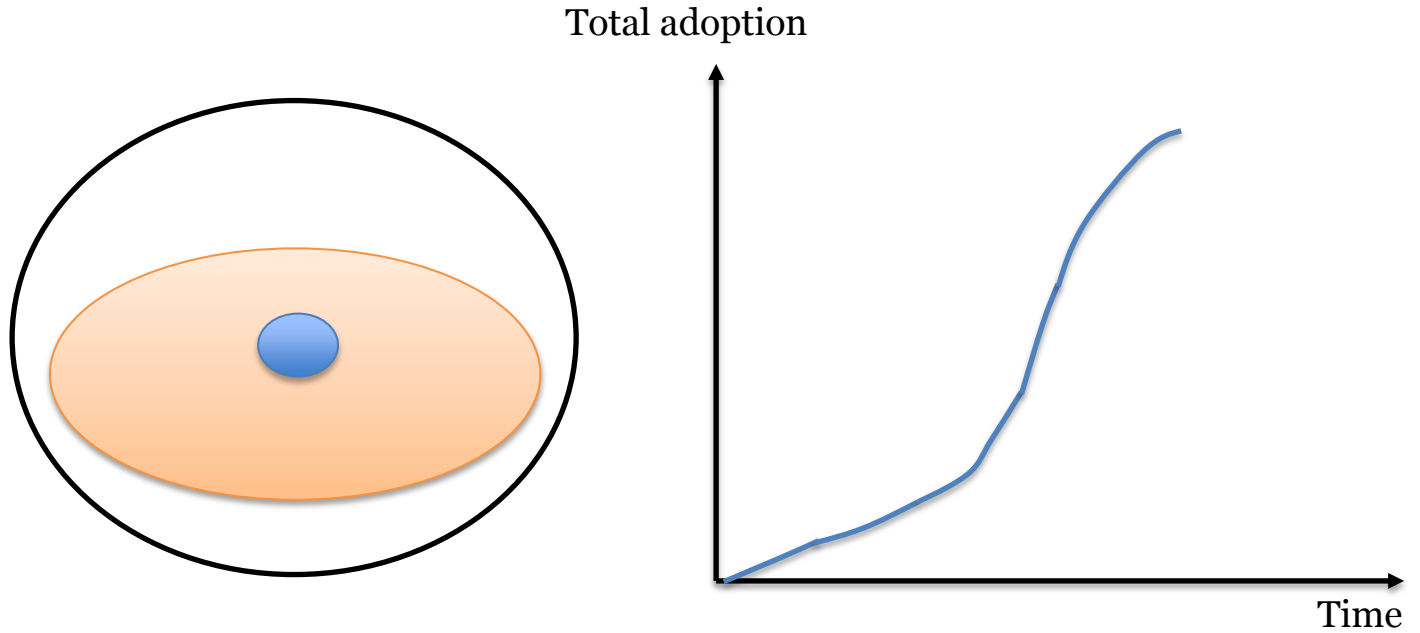
Total adoption
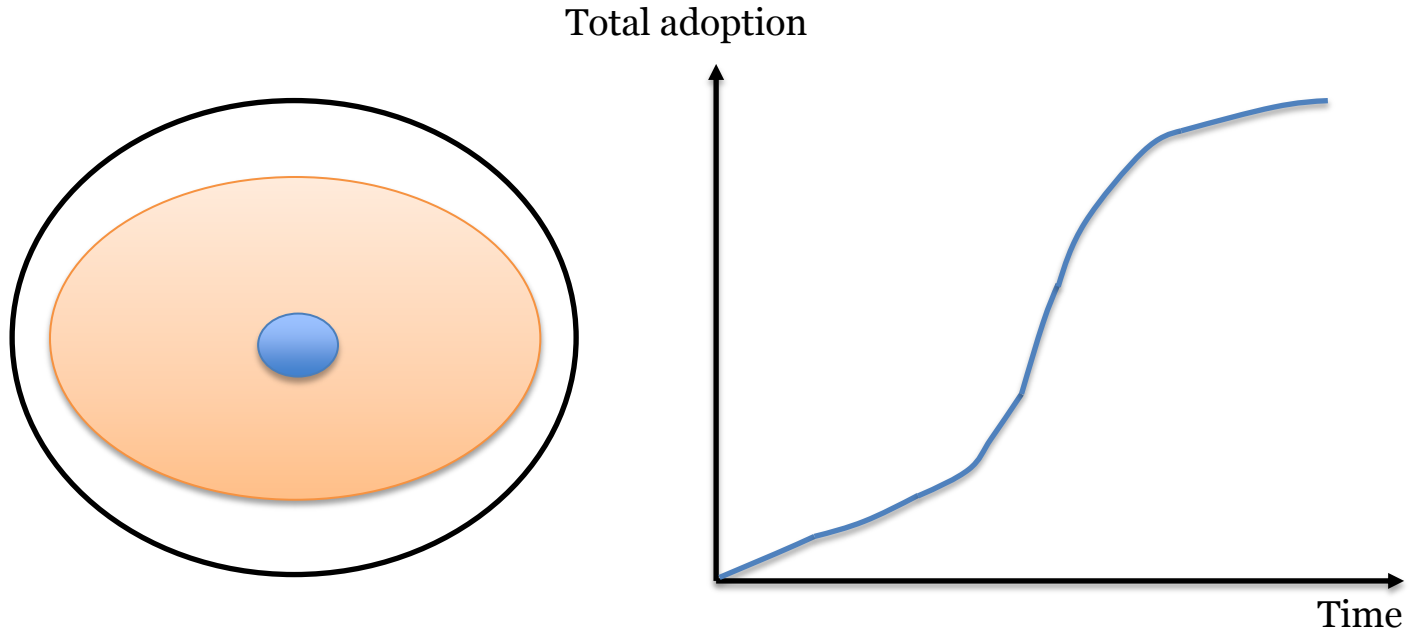
Time

Back to MSP

Bass diffusion model

Innovation coefficient

Imitation coefficient

Total adopters until time _t_

$$Y(t) = m \frac{1 - e^{-t(p+q)}}{\frac{q}{p} e^{-t(p+q)} + 1}$$

Market size

Paper #1

Network Effects in Health Information Exchange Growth

Contributions

- Develop a diffusion model that can incorporate:
  - Market heterogeneity
  - Network externalities (direct and indirect)
- Demonstrate the network externalities and the role of patient flow in HIE growth among primary care physicians and specialists

Diffusion model for Multisided platforms
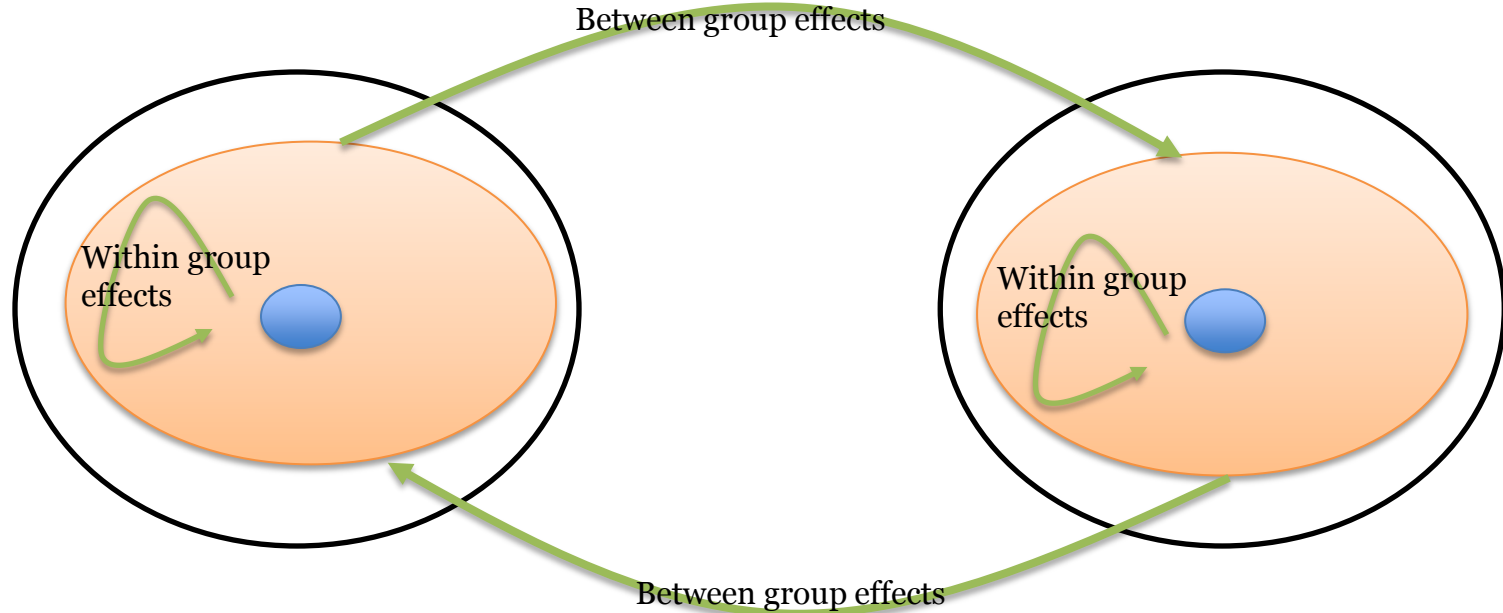
Diffusion model for Multisided platforms

Adoption by primary care doctors

Coefficient of imitation from other primary care doctors

Innovation coefficient in primary care doctors

Coefficient of imitation from specialists

Adoption by specialists

$$Y_1(t) = m_1 \frac{1 - e^{-(q_1+p_1)t + \frac{q_{21}}{m_2}Y_2(t)(\frac{1}{q_1+p_1}\ln\frac{q_1}{p_1}-t)} - \frac{q_{21}}{p_1 m_2}Y_2(t)e^{-(q_1+p_1)t + \frac{q_{21}}{m_2}Y_2(t)(\frac{1}{q_1+p_1}\ln\frac{q_1}{p_1}-t)}}{\frac{q_1}{p_1}e^{-(q_1+p_1)t + \frac{q_{21}}{m_2}Y_2(t)(\frac{1}{q_1+p_1}\ln\frac{q_1}{p_1}-t)} + 1}$$

$$Y_2(t) = m_2 \frac{1 - e^{-(p_2+q_2)t + \frac{q_{12}}{m_1}Y_1(t)(\frac{1}{p_2+q_2}\ln\frac{q_2}{p_2}-t)} - \frac{q_{12}}{p_2 m_1}Y_1(t)e^{-(p_2+q_2)t + \frac{q_{12}}{m_1}Y_1(\frac{1}{p_2+q_2}\ln\frac{q_2}{p_2}-t)}}{\frac{q_2}{p_2}e^{-(p_2+q_2)t + \frac{q_{12}}{m_1}m_1 Y_1(t)(\frac{1}{p_2+q_2}\ln\frac{q_2}{p_2}-t)} + 1}$$

Jump to SSP formula

Data

Longitudinal adoption data over the period of 07-2008 to 07-2011

Participating Practice▲	Physician	Specialty	Participation Date	Print 🖨	EMR to EMR Exchange	Results Delivery Enabled
Balanced Living Chiropractic	Niemiec, Steven	CHIROPRACTOR	April, 2013	🖨		
Balanced Living Chiropractic	NiemiecKlimek, Katelyn	CHIROPRACTOR	April, 2013	🖨		
Balanced Living Chiropractic	Phalen, Kevin	CHIROPRACTOR	April, 2013	🖨		
Batavia Pediatrics	DeRosa, Daniela	STUDENT IN AN ORGANIZED HEALTH CARE EDUCATION/TRAINING PROGRAM	February, 2011	🖨		
Batavia Pediatrics	Haitz, Nancy	LEGAL MEDICINE	February, 2011	🖨		
Batavia Pediatrics	Jain, Lalit	LEGAL MEDICINE	February, 2011	🖨		
Batavia Pediatrics	Tenney, Emily	PEDIATRICS	February, 2011	🖨		

Results

Parameter	Estimate	Approx Std. Err.	t Value	Approx $p_r > |t|$
p_1	0.006915	0.00136	5.09	<0.0001
q_1	0.001888	0.000582	3.23	0.0032
p_2	0.00872	0.00205	4.25	0.0002
q_2	0.003579	0.00121	2.95	0.0065
q_{21}	0.015158	0.00387	3.91	0.0003
q_{12}	0.03048	0.00742	4.10	0.0006

Conclusions

- Primary care physicians and specialists are affected by media differently.
- Direct network effects within each group is different form other groups.
- Indirect network effect between groups exist and is stronger than within group effects.
- The primary care doctors create a very powerful network effect and drive the adoption of specialist.

Policy implications

- Financial incentives should be targeted toward increasing the participation of primary care physicians.
- Marketing campaigns should be designed to entice word of mouth among physicians.
- HIE advertisements should focus on the value of HIE for specialists.
- Type of members should be considered in evaluating the benefits of HIE.

Paper #2

Professional and Geographical Network Effects on Health Information Exchange Growth: Does Proximity Really Matter?

2014, Journal of the American Medical Informatics Association 21 (4), 671-678

Contributions

- Demonstrate the network externalities and the role of patient flow in HIE growth within two segmentation schemes:
    - Professional proximity
    - Geographical proximity

Data

- HIE system logs by 20over the period of 07-2008 to 07-2011:
  - 500,000 observations
  - 2100 physicians

	HeL_Patient_ID	Opened_Date	Practice	Result_Type	Ordering_Name
2351	20671	14MAR11:08:58:...	Sadashiv S Shen...	Lab	Dombrowski, Jacqu...
2352	41668	16MAR11:12:56:...	Sadashiv S Shen...	Lab	SCHULTZ, RAYM...
2353	41668	16MAR11:12:57:...	Sadashiv S Shen...	Lab	SCHULTZ, RAYM...
2354	57880	08MAR11:09:41:...	Sadashiv S Shen...	Radiology	COOLEY, CRAIG
2355	167864	10MAR11:14:54:...	Sadashiv S Shen...	Lab	ADDAGATLA, SUJ...
2356	167864	10MAR11:14:54:...	Sadashiv S Shen...	Lab	ADDAGATLA, SUJ...

Professional Proximity

- The ratio of common patients between each pair of medical specialty is identified
- The medical specialties with highest ratio of common patients are clustered together

Results

Parameter	Description	Estimate	Std. Err.	t-value	$P_r > |t|$
q_{11}	emulation effect within group 1	0.1201	0.0397	3.02	0.0050
q_{22}	emulation effect within group 2	0.0938	0.0291	3.23	0.0030
q_{33}	emulation effect within group 3	0.1400	0.0596	2.35	0.0254
p_1	innovation effect in group 1	0.0138	0.0072	1.91	0.0655
p_2	innovation effect in group 2	0.0190	0.0058	3.23	0.0027
p_3	innovation effect in group 3	0.0186	0.0105	1.77	0.0864
q_{12}	emulation effect from group 1 on group 2	0.0409	0.0201	1.95	0.0602
q_{13}	emulation effect from group 1 on group 3	0.3716	0.1262	2.94	0.0061
q_{21}	emulation effect from group 2 on group 1	-0.0304	0.0673	-0.45	0.6540
q_{23}	emulation effect from group 2 on group 3	-0.2205	0.1509	-1.46	0.1540
q_{31}	emulation effect from group 3 on group 1	0.0564	0.0355	1.59	0.1221
q_{32}	emulation effect from group 3 on group 2	0.0195	0.0150	1.31	0.2002

Conclusions

- The flow of shared patients among the specialties within a cluster creates significant network externalities within each cluster.

- The clusters which do not considerably share patients between each other do not create network externalities between clusters.

  - HIE adoption is driven by the perceived value of the system for each specialty as a function of shared patients with others.

Policy implications

- To design effective HIE promotion policies, the flow of patients between different medical providers should be taken into account.

Geographical proximity
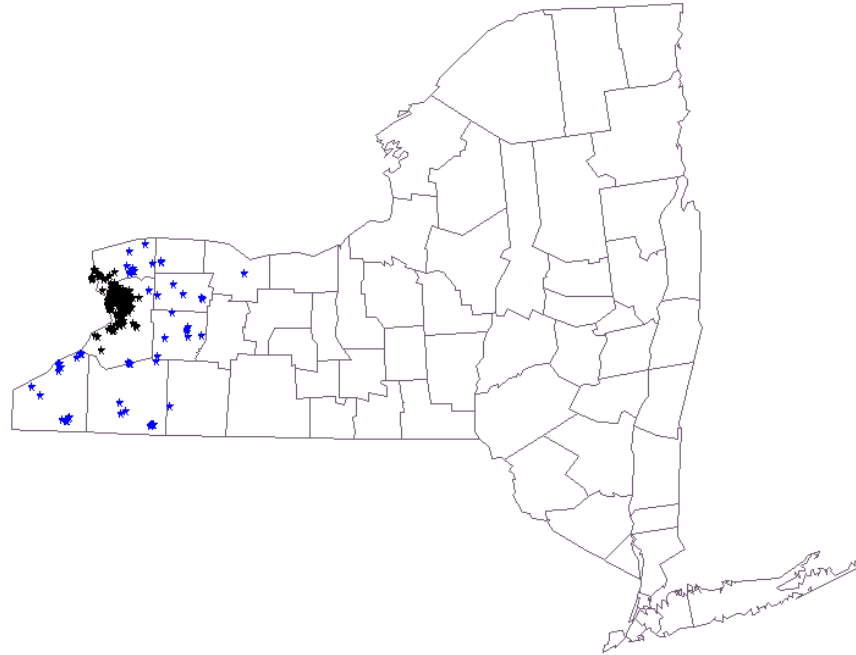
Results

Parameter	Description	Estimate	Std. Err.	t-value	$P_r > |t|$
p_1	innovation effect in urban group	0.010086	0.00190	5.31	<.0001
q_{11}	emulation effect within urban group	0.003148	0.00160	1.96	0.0574
q_{21}	emulation effect from rural group on urban group	0.078106	0.0393	1.99	0.0546
p_2	innovation effect in rural group	0.015343	0.000250	61.43	<.0001
q_{22}	emulation effect within rural group	0.016824	0.000682	24.66	<.0001
q_{12}	emulation effect from urban group on rural group	0.057861	0.00290	19.97	<.0001

Conclusions

- Urban physicians are highly affected by marketing campaigns and media
- Urban physicians are not affected by network externalities
- Word of Mouth is a strong driver of HIE adoption in rural areas
- Rural physicians follow the lead of urban physicians

Policy implications

- Along with the previous results, chicken and egg problem in HIE is solved:
    - Get primary physicians in the urban areas on board
    - Approach specialties who share more patients with primary care doctors
    - Create cluster seeds and then grow them according to patient flow

Paper #3

Health Information Exchange as a Multi-sided Platform: Adoption, Usage and Practice Involvement in Service Co-Production

(forthcoming at Information Systems Research)

Contributions

- Social network theory is applied to study the drivers of HIE adoption and *use* at a much more granular level.

- Big brother effect (institutional isomorphism) and the value of different services of HIE for each provider is taken into account

▶

Jump to data

Network of patients

- Nodes are practices
- Links are shared patients
- Size represents degree centrality
- The more patients received from others, the more valuable HIE is
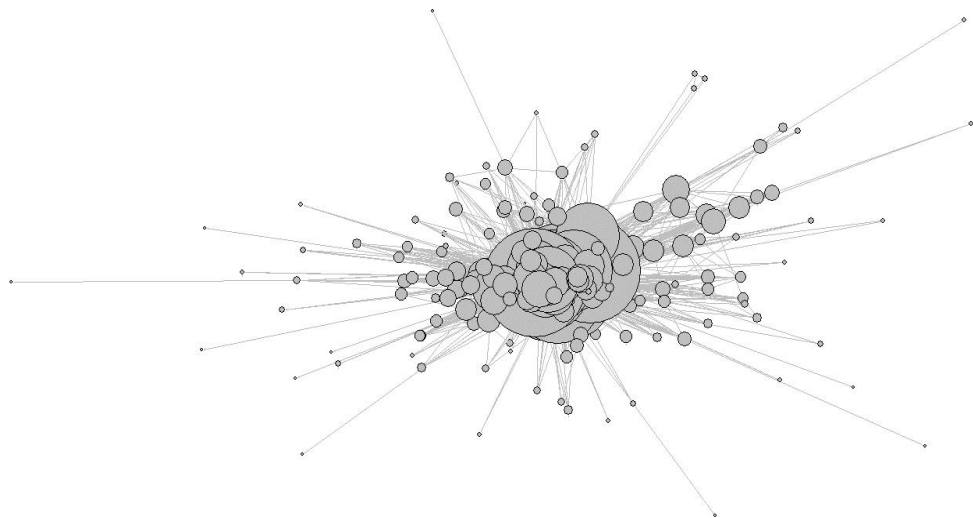
Network of physicians

- Nodes are practices
- Links are shared physicians
- Size represents Betweenness centrality
- Higher degree of betweenness centrality leads to higher knowledge about HIE

Results

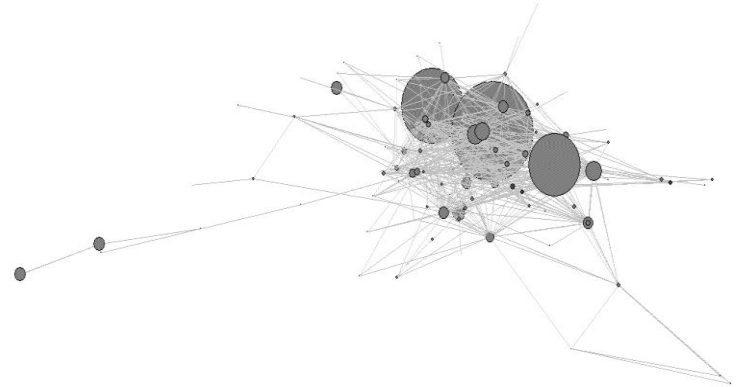| Variable	Coefficient	estimate	Std. Dev.	T value	P value	VIF
Intercept	β_0	1.179546	0.8459	1.39	0.1635	0
Lab service value	β_1	0.125102	0.0290	4.31	<.0001	1.95202
Radiology service value	β_2	0.3823	0.0445	8.60	<.0001	2.84985
Trans. Service value	β_3	0.268445	0.0461	5.83	<.0001	2.26245
Tenure	β_4	0.12085	0.00863	14.01	<.0001	1.79635
Tenure^2	β_5	-0.005436	0.000857	-6.34	<.0001	1.67049
Rural location	β_6	0.231534	0.1817	1.27	0.2028	1.04608
Market Share	β_7	0.03138	0.0123	2.55	0.0109	1.09640
Nurse ratio	β_8	1.289451	0.2252	5.73	<.0001	1.08793
Between. centrality	β_9	4.917475	1.0422	4.72	<.0001	1.42364
In-degree centrality	β_{10}	0.000499	0.000073	6.81	<.0001	6.68474
Out-degree centrality	β_{11}	-0.00006	0.000057	-1.00	0.3197	5.90712

Conclusions

- The value of different HIE services for each practice is unique
- Practices learn how to use HIE through experience and shared physicians and enhance their level of use as they learn more about HIE
- Nurses are an important driver of HIE use. They are the real end-users
- Competition affects HIE use
- Referred patients increases HIE use

Policy implications

- The financial incentives to enhance the use of HIE should be tailored for each practices based on their specialty, needs, *market share* and *experience* with HIE

- Training programs to use HIE should target *Nurses* and doctors with multiple affiliations

Survival analysis of HIE adoption

- How long it takes for a practice to adopt HIE? and how this time can be reduced?

Results

Parameter	Coefficient	Estimate	Standard Error	p-value	VIF
Intercept	β_0	7.527131	0.028957	<0.0001	0
Between. Centrality	β_1	-1.807089	0.837932	0.0312	1.06920
In-Degree centrality	β_2	-0.683314	0.109088	<0.0001	4.76307
Out-degree centrality	β_3	0.000152	0.002379	0.9492	6.05724
Service demand	β_4	-0.000127	0.000022213	0.0005	2.55557
Practice efficiency	β_5	-0.088004	0.000958	<0.001	1.42841
Rural location	β_6	-0.111545	0.012691	<0.0001	1.05932
Market share	β_7	-0.017720	0.004283	<0.0001	1.09157
% of common patients with large practices	β_8	-0.00008523	0.000001739	<0.0001	3.16754
% of common physicians with large practices	β_9	-0.094151	0.019978	0.0005	2.07404

Conclusions

- Knowledge about HIE a significant driver of HIE adoption
- HIE adoption is very well informed decision and is driven by perceived value of HIE for each practice
- Big brothers are significantly reducing adoption time

Policy implications

- Larger practices should first be incentivized to join HIE
- Advertising/training programs should be designed to educate physicians on the benefits of HIE and how to use it

Ongoing Research

- Patient privacy and disclosure of medical information of HIE system
- The outcomes of HIE in reducing costs and increasing quality of healthcare
- Designing pricing strategies of HIE platforms

Thank you!

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