Exploring Drivers of Scientific Collaboration

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Translational Research Evaluation Webinar

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WASHINGTON UNIVERSITY IN ST.LOUIS
Institute of Clinical and Translational Sciences

Center for Public Health Systems Science

GEORGE WARREN BROWN SCHOOL OF SOCIAL WORK

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Overview

- Team science as frame for studying collaboration
- Network analysis as technique for studying scientific collaboration
- Exploring drivers of collaboration
  - Mapping collaboration growth
  - Role of discipline
  - Role of mentoring

Team Science

New field emerging that studies scientific teams, collaboration, outcomes of team science

Why team science?

- Increasing trend of team science
- Modern scientific challenges likely to require approaches that cross disciplinary boundaries [1,2,3]
  - Obesity
  - Smoking
  - Alzheimer's
  - etc.
- Focus of *science* of team science is to study large-scale collaborations

1. Borner et al., 2010
2. Falk-Krzesinski et al., 2011
3. Stokols et al., 2008

ARTICLE

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Comprehensive genomic characterization of squamous cell lung cancers

The Cancer Genome Atlas Research Network*

- http://www.nytimes.com/2012/09/10/health/research/for-a-lung-cancer-drug-treatment-may-be-within-reach.html?hpw
- http://www.nature.com/nature/journal/vaop/ncurrent/full/nature11404.html

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Science becoming *Team Science*

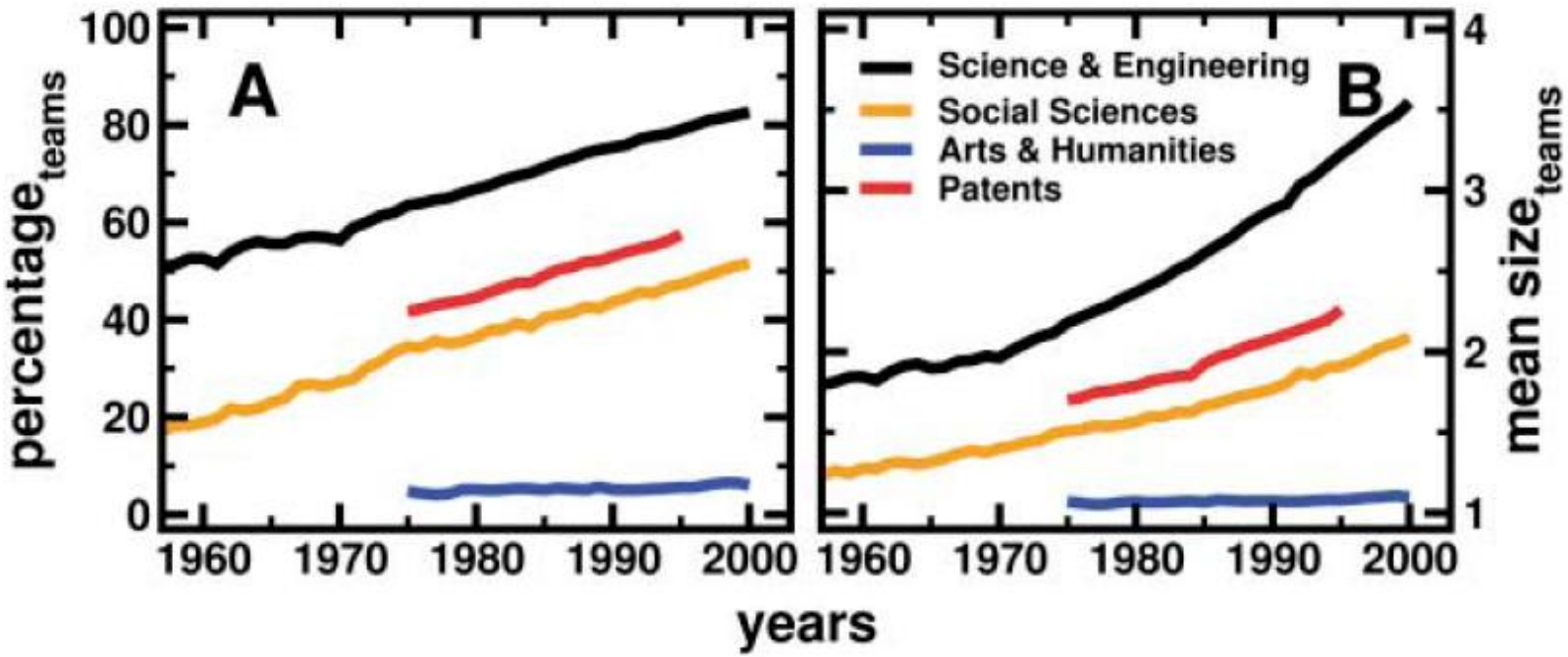

Fig. 1. The growth of teams. These plots present changes over time in the fraction of papers and patents written in teams (**A**) and in mean team size (**B**). Each line represents the arithmetic average taken over all subfields in each year.

(Wuchty, et al., 2007)

Teams have more impact

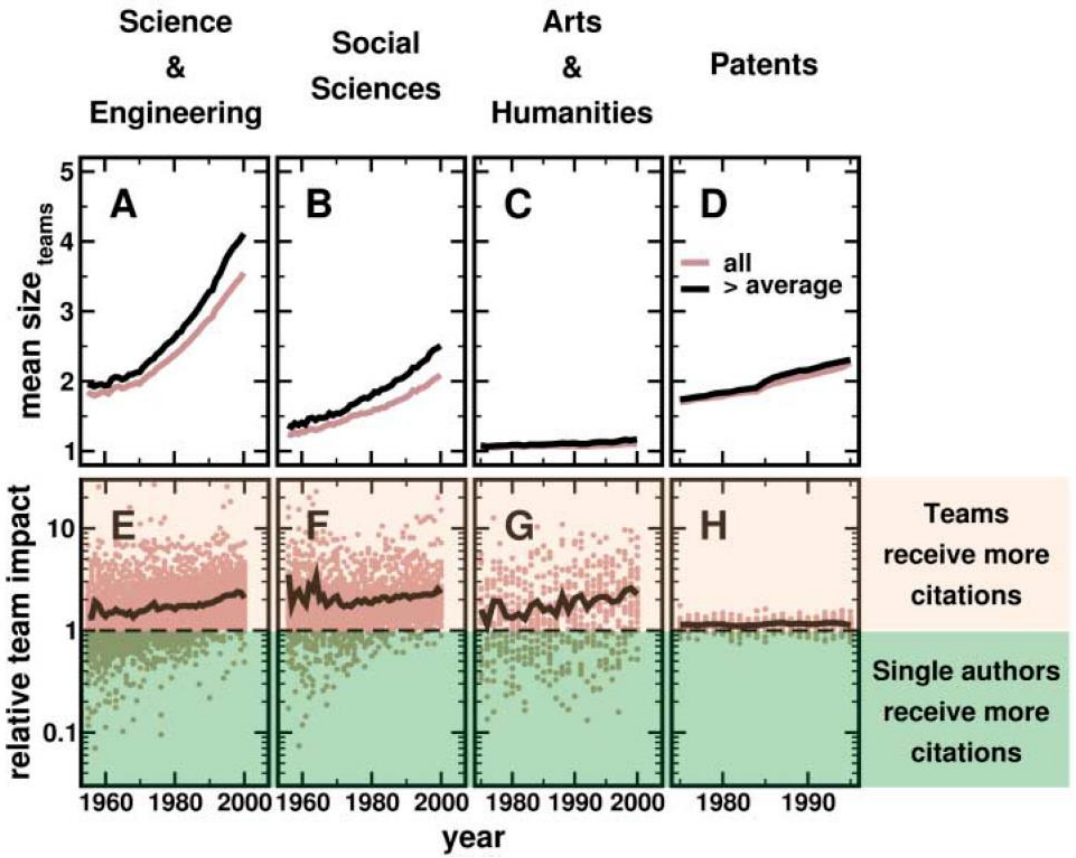

Fig. 2. The relative impact of teams. (**A** to **D**) Mean team size comparing all papers and patents with those that received more citations than average in the relevant subfield. (**E** to **H**) The RTI, which is the mean number of citations received by team-authored work divided by the mean number of citations received by solo-authored work. A ratio of 1 indicates that team- and solo-authored work have equivalent impact on average. Each point represents the RTI for a given subfield and year, whereas the black lines present the arithmetic average in a given year.

Teams as driver of science

> …solo authors did produce the papers of singular distinction in science and engineering and social science in the 1950s, but the mantle of extraordinarily cited work has passed to teams by 2000.

(Wuchty, et al., 2007)

SciTS is:

…the examination of the processes by which scientific teams organize, communicate, and conduct research.

(Börner, et al., 2010)

Team Science initiatives – Key features

- Team science (TS) initiatives are the principal units of analysis in the *science of team science* (SciTS)
    - These include large research, training, and translational programs implemented by public agencies and non-public organizations
- Designed to promote collaborative and often cross-disciplinary approaches to analyzing complex research questions about particular phenomena
    - Intra-center (within) and cross-center (between) collaborations are critically important

(Okamoto, 2012)

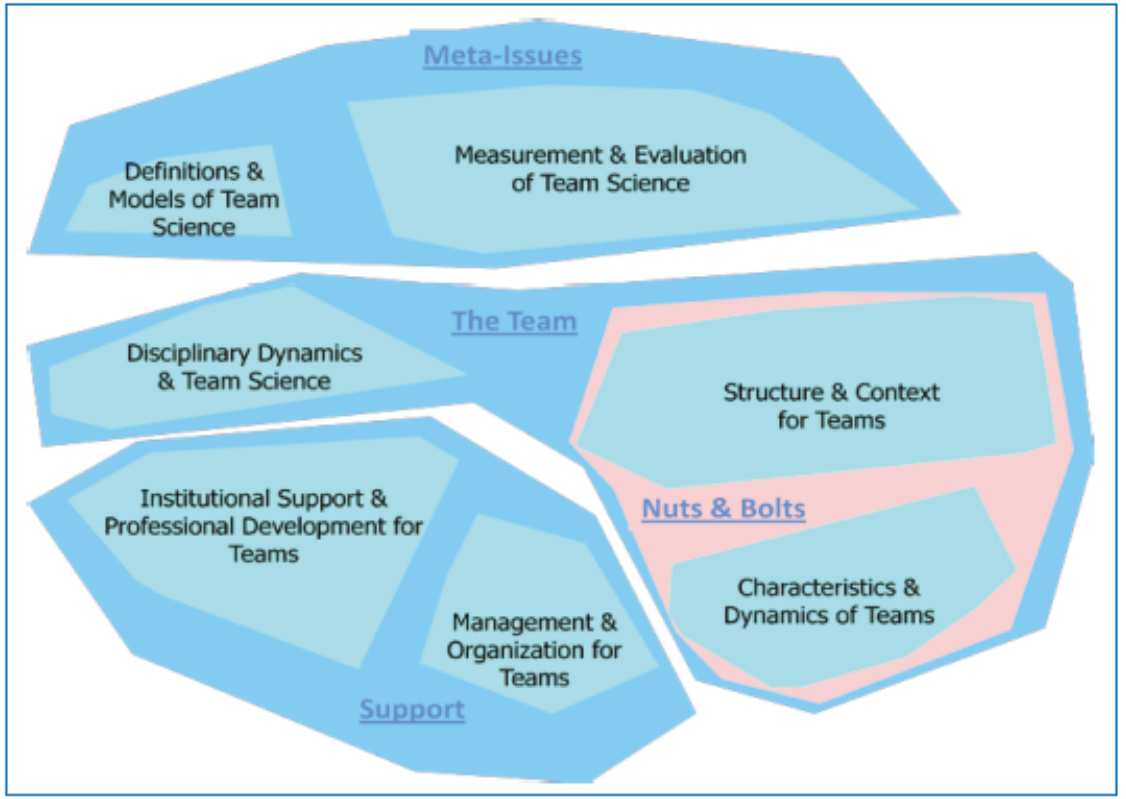

Figure 1. Science of Team Science Concept Map. This final interpreted map summarizes clusters and regions of topics identified as important parts of a comprehensive research agenda for the SciTS.

(Falk-Krzesinski, 2010)

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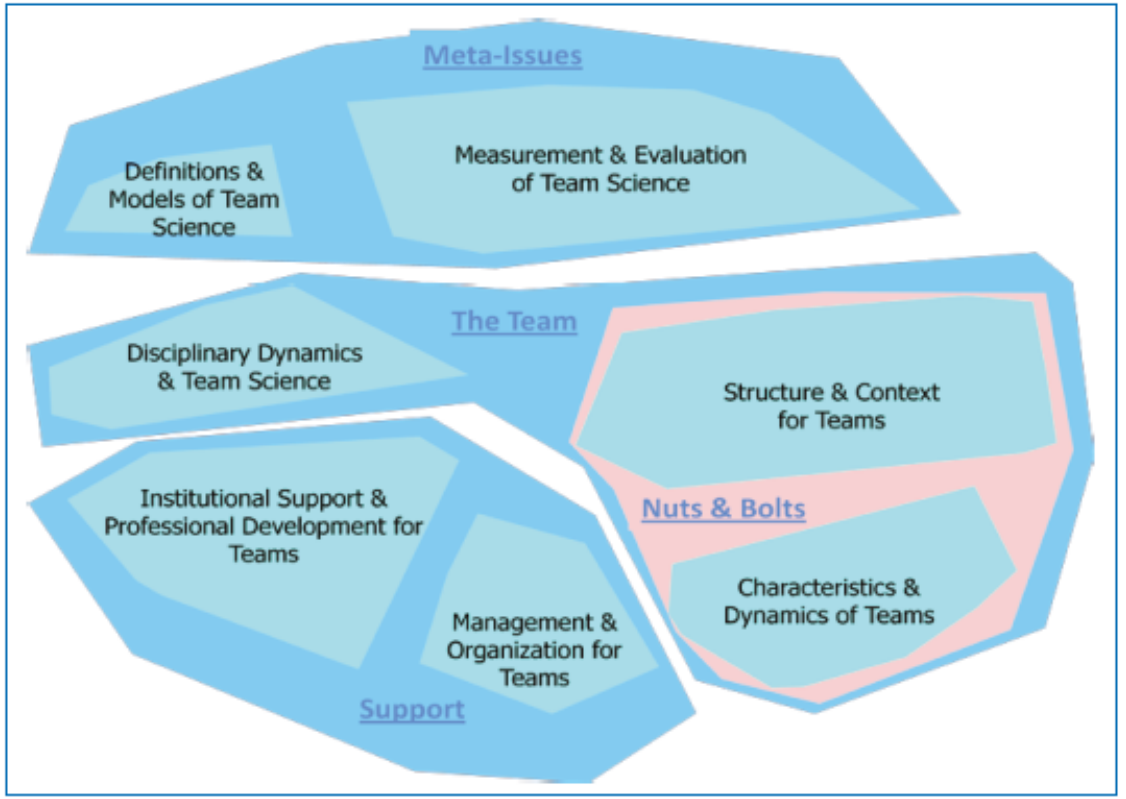
Team Science – Core research questions

- Conceptualizing team science processes and outcomes
- Developing appropriate measures of collaboration, team development, team functioning
- Selective implementation of team science initiatives
- Behavioral aspects of scientific collaboration, teamwork
- Understanding organizational and systemic contexts of teams and team science initiatives
- Translating team science into clinical, community, and policy initiatives

(Stokols, et al, 2008)



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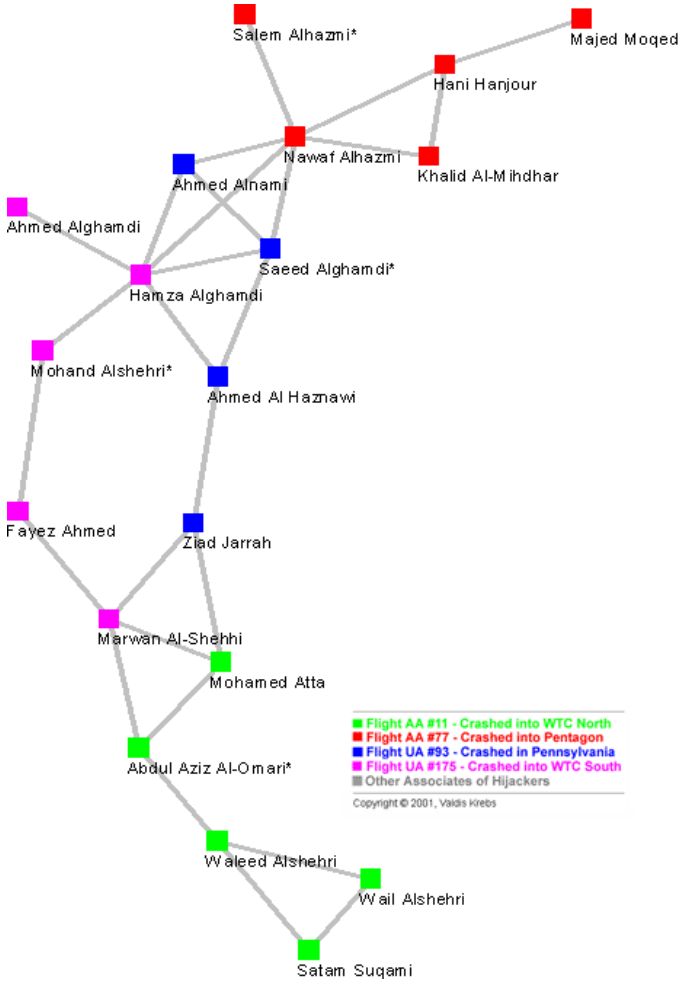
(Falk-Krzesinski, 2010)

Network science

The study of relational and structural aspects of social systems

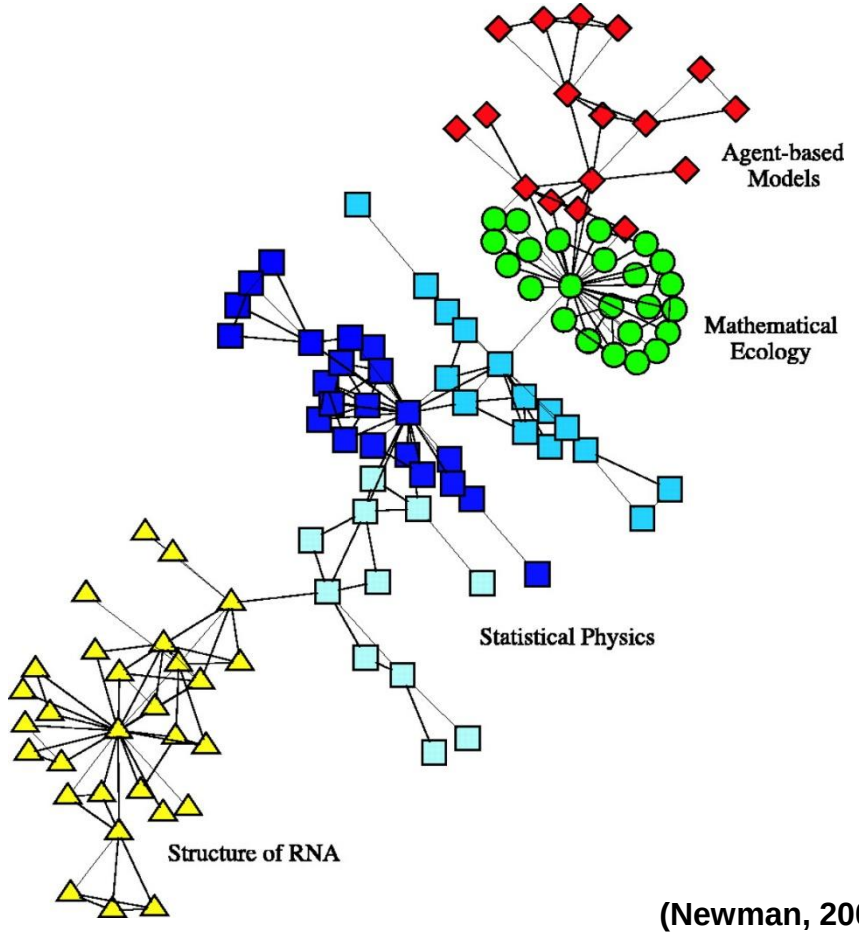
Why network science?

Terrorist collaboration network



(Krebs, 2001)

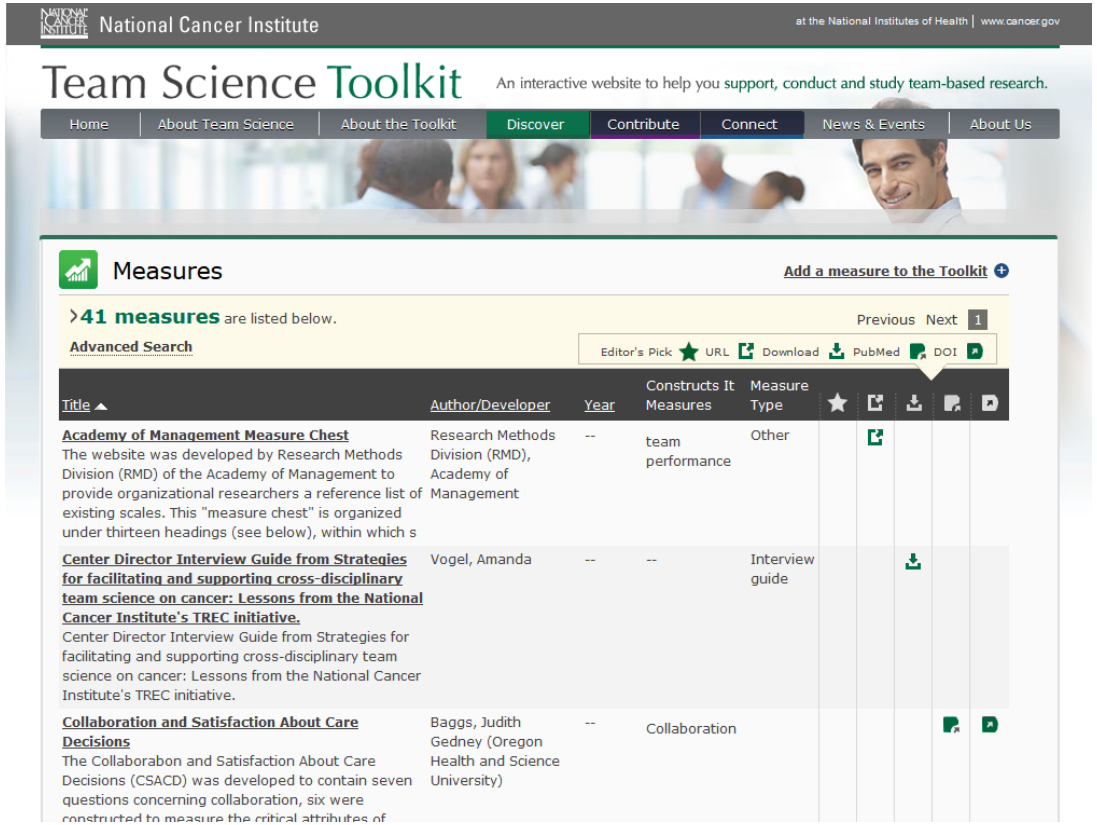
Scientist collaboration network



(Newman, 2004)

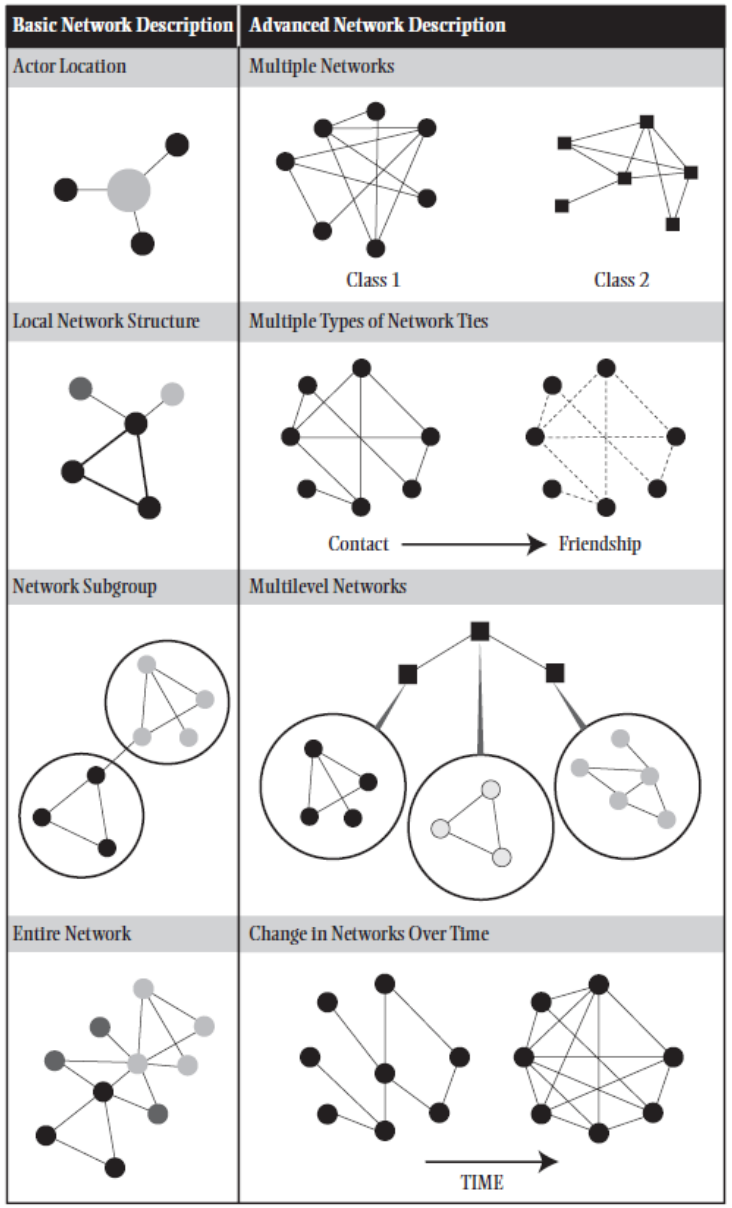
Need for network metrics of collaboration

- Collaboration is inherently relational
- SciTS has focused on individuals' attitudes about cross-disciplinary science
- Need to identify more network measures for collaboration



Network Approaches

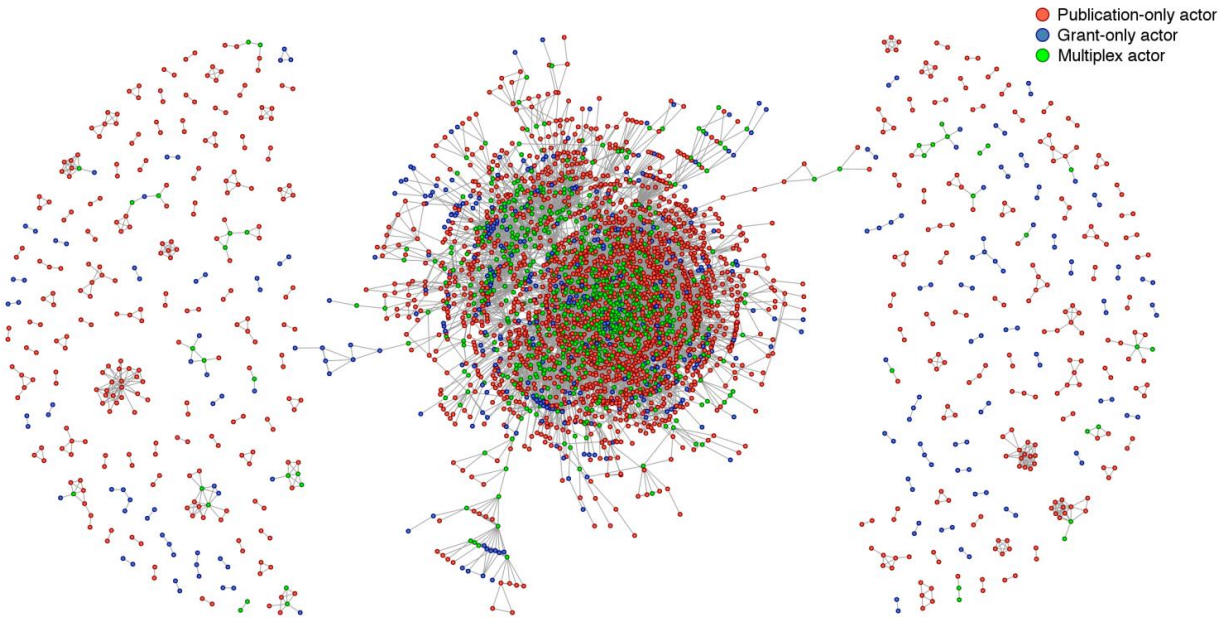
- Actor location
- Local structure
- Subgroups
- Overall network
- Multiple relations
- Multiple levels
- Change over time



(Luke, Dhand, Carothers, 2017)

Ways to examine drivers of collaboration

- Mapping collaboration ties
- Role of discipline
- Mentoring



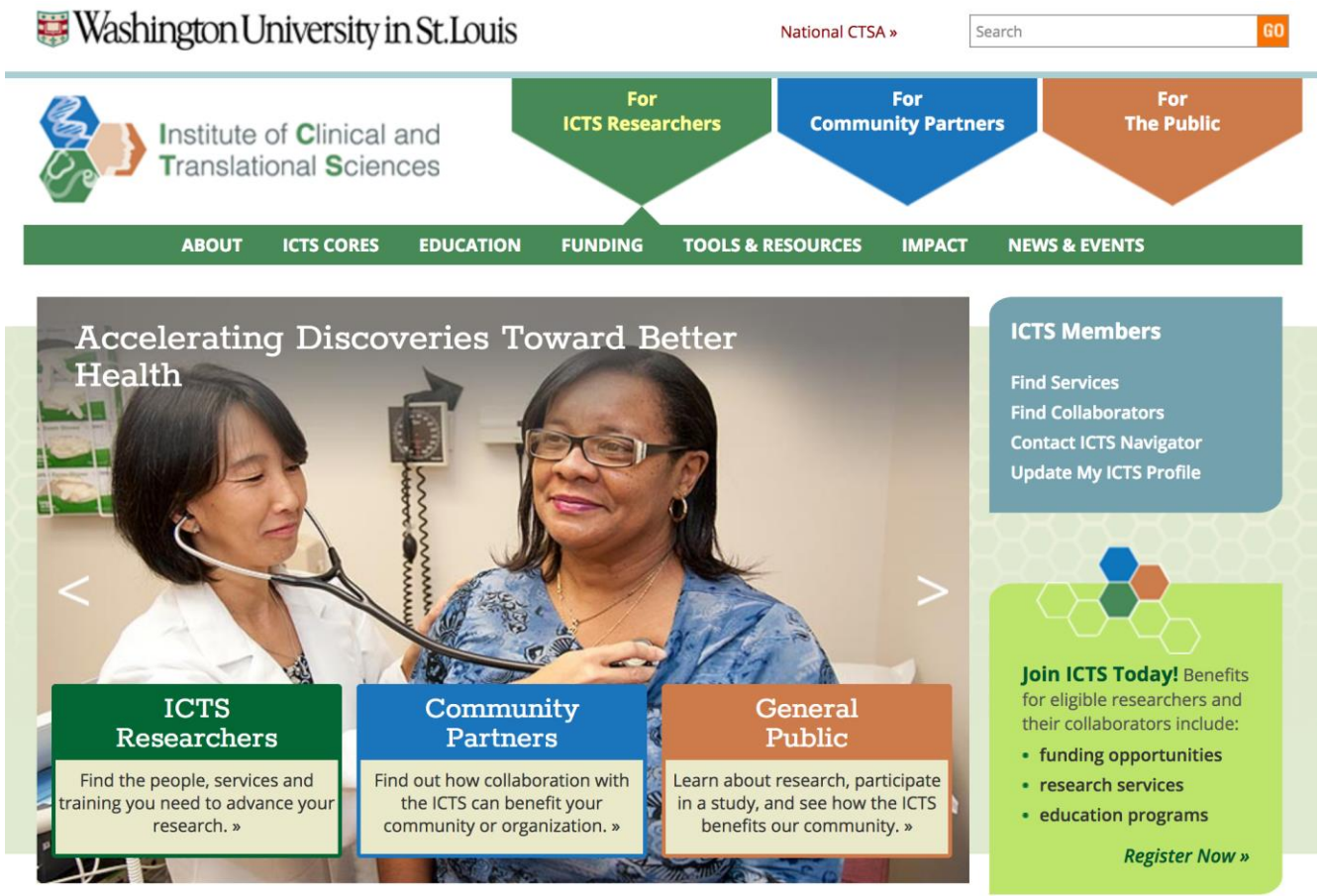
University of Florida's collaboration network, 2013 (https://theresekennellyokraku.com/)

Mapping Collaborations

Using network analysis to describe patterns of scientific collaboration, using data from the evaluation of the Institute of Clinical and Translational Sciences

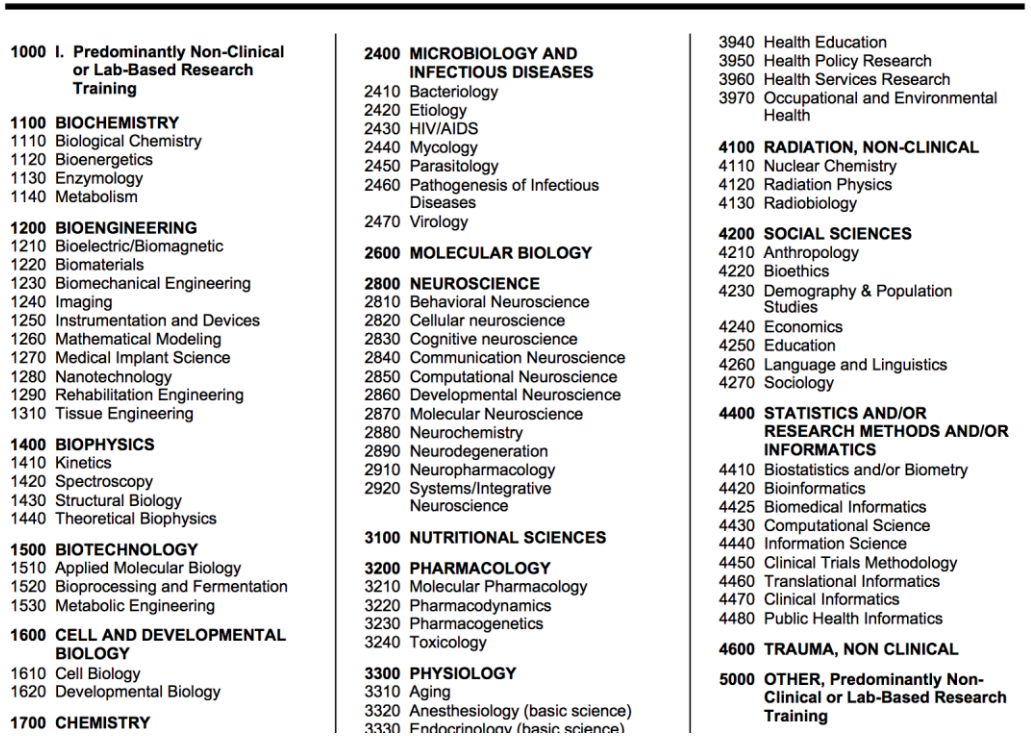
Institute of Clinical and Translational Sciences

- CTSA-funded since late 2007
- Particular strengths in genomics, T3 & T4 science, especially implementation science
- Provides access to 24 core units
  - Human Imaging
  - Research Design & Biostatistics
  - Clinical Trials
  - etc.
- Tracking & Evaluation
  - Traditional monitoring, common metrics
  - Moving beyond bibliometrics
  - RoI analyses
  - Using network science methods to evaluate ICTS



Methods-What you need for network analysis of collaborations

- Network members
  - Formal ICTS membership required
- Network relationships
  - Grant submissions (key personnel)
  - Publication co-authorships
  - Other possibilities (self-report, observation)
- Member characteristics (predictors)
  - Rank, department, discipline, gender, etc.



1000 I. Predominantly Non-Clinical or Lab-Based Research Training

1100 BIOCHEMISTRY
1110 Biological Chemistry
1120 Bioenergetics
1130 Enzymology
1140 Metabolism

1200 BIOENGINEERING
1210 Bioelectric/Biomagnetic
1220 Biomaterials
1230 Biomechanical Engineering
1240 Imaging
1250 Instrumentation and Devices
1260 Mathematical Modeling
1270 Medical Implant Science
1280 Nanotechnology
1290 Rehabilitation Engineering
1310 Tissue Engineering

1400 BIOPHYSICS
1410 Kinetics
1420 Spectroscopy
1430 Structural Biology
1440 Theoretical Biophysics

1500 BIOTECHNOLOGY
1510 Applied Molecular Biology
1520 Bioprocessing and Fermentation
1530 Metabolic Engineering

1600 CELL AND DEVELOPMENTAL BIOLOGY
1610 Cell Biology
1620 Developmental Biology

1700 CHEMISTRY

2400 MICROBIOLOGY AND INFECTIOUS DISEASES
2410 Bacteriology
2420 Etiology
2430 HIV/AIDS
2440 Mycology
2450 Parasitology
2460 Pathogenesis of Infectious Diseases
2470 Virology

2600 MOLECULAR BIOLOGY

2800 NEUROSCIENCE
2810 Behavioral Neuroscience
2820 Cellular neuroscience
2830 Cognitive neuroscience
2840 Communication Neuroscience
2850 Computational Neuroscience
2860 Developmental Neuroscience
2870 Molecular Neuroscience
2880 Neurochemistry
2890 Neurodegeneration
2910 Neuropharmacology
2920 Systems/Integrative Neuroscience

3100 NUTRITIONAL SCIENCES

3200 PHARMACOLOGY
3210 Molecular Pharmacology
3220 Pharmacodynamics
3230 Pharmacogenetics
3240 Toxicology

3300 PHYSIOLOGY
3310 Aging
3320 Anesthesiology (basic science)
3330 Endocrinology (basic science)

3940 Health Education
3950 Health Policy Research
3960 Health Services Research
3970 Occupational and Environmental Health

4100 RADIATION, NON-CLINICAL
4110 Nuclear Chemistry
4120 Radiation Physics
4130 Radiobiology

4200 SOCIAL SCIENCES
4210 Anthropology
4220 Bioethics
4230 Demography & Population Studies
4240 Economics
4250 Education
4260 Language and Linguistics
4270 Sociology

4400 STATISTICS AND/OR RESEARCH METHODS AND/OR INFORMATICS
4410 Biostatistics and/or Biometry
4420 Bioinformatics
4425 Biomedical Informatics
4430 Computational Science
4440 Information Science
4450 Clinical Trials Methodology
4460 Translational Informatics
4470 Clinical Informatics
4480 Public Health Informatics

4600 TRAUMA, NON CLINICAL

5000 OTHER, Predominantly Non-Clinical or Lab-Based Research Training

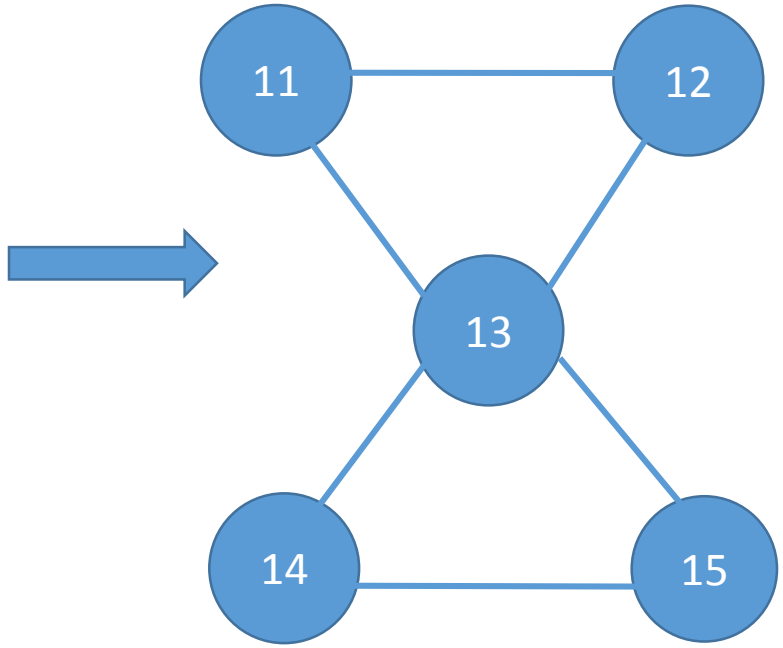
NIH Discipline Codes:
https://www.hhs.gov/sites/default/files/forms/phs-2271

From (affiliation) data to networks

Raw Data

Member ID	Publication Title
11	Cool cancer treatment report
12	Cool cancer treatment report
13	Cool cancer treatment report
13	Nifty Alzheimer's gene report
14	Nifty Alzheimer's gene report
15	Nifty Alzheimer's gene report

Network

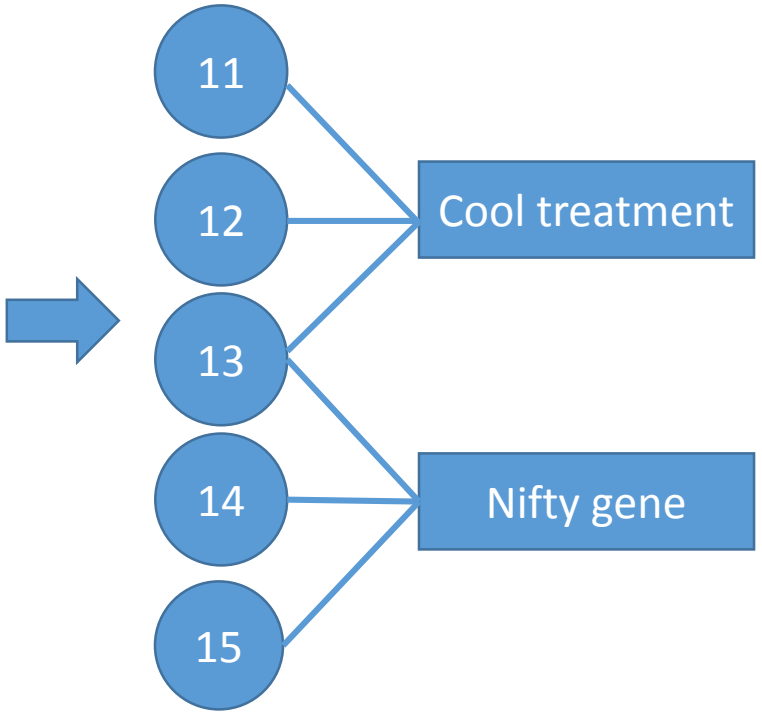


From (affiliation) data to networks

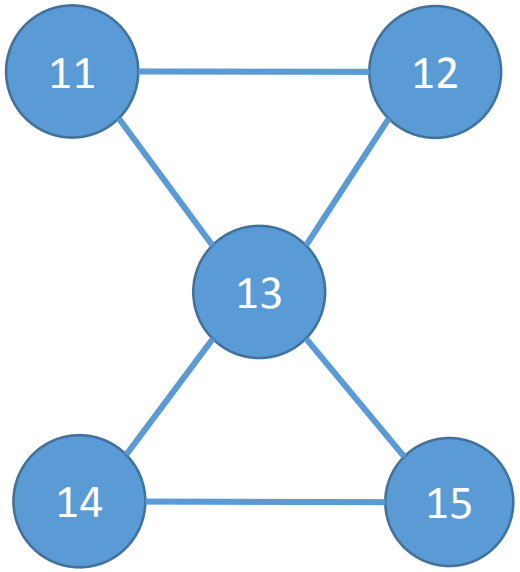
Raw Data

Member ID	Publication Title
11	Cool cancer treatment report
12	Cool cancer treatment report
13	Cool cancer treatment report
13	Nifty Alzheimer's gene report
14	Nifty Alzheimer's gene report
15	Nifty Alzheimer's gene report

Relationships between people & pubs

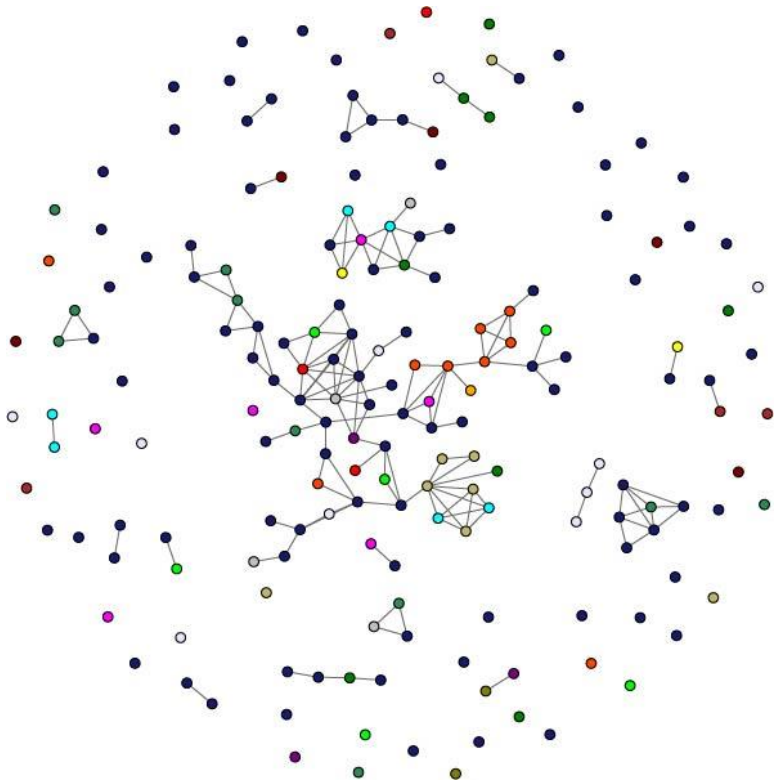


Relationships between people

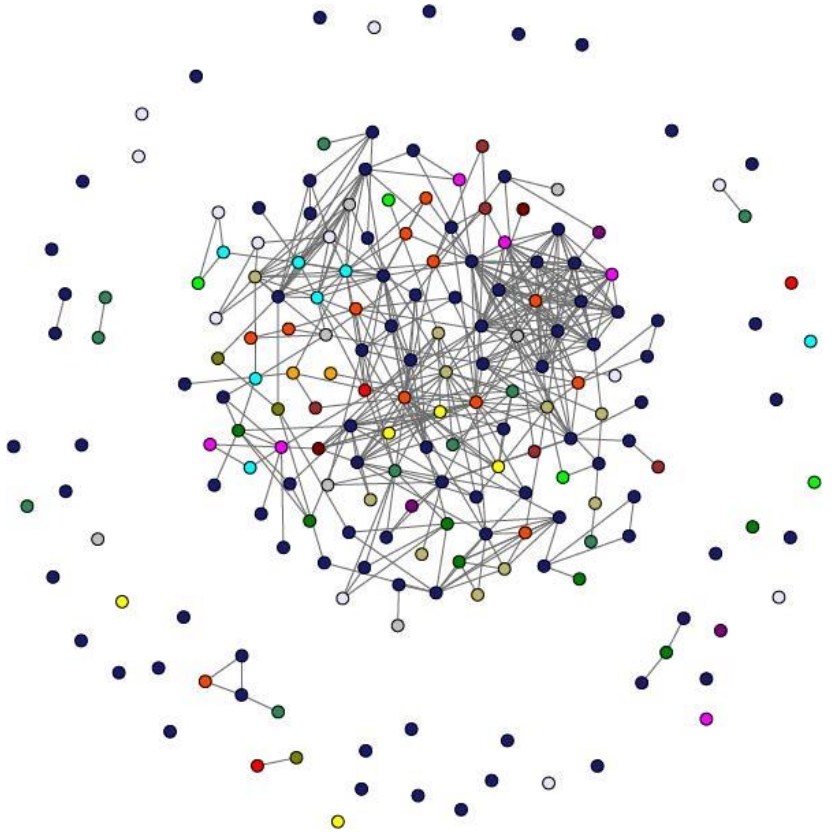


ICTS grant submission collaborations

2007



2010



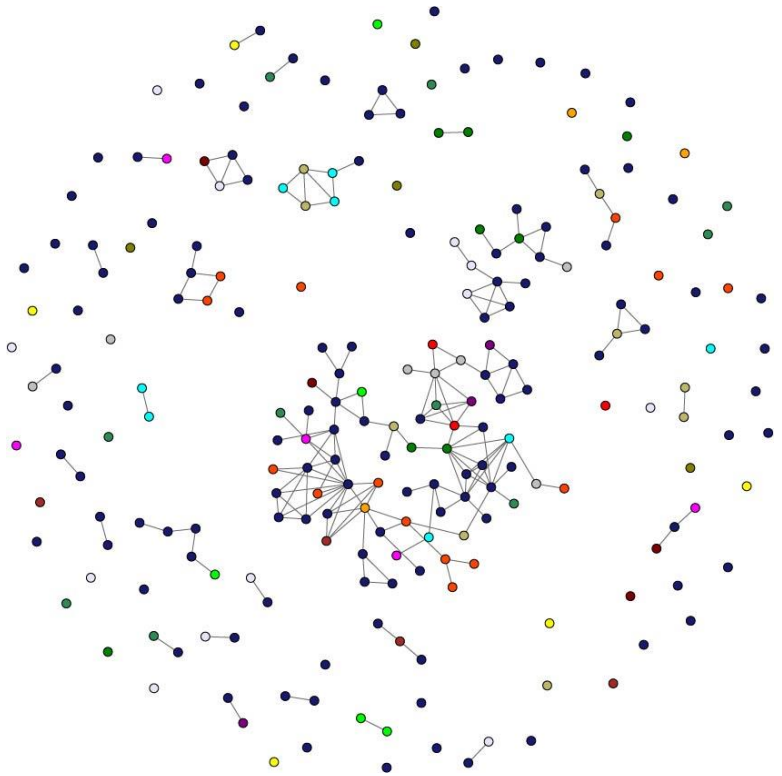
Grant submissions

Year	Size	Density	Avg. Degree	Modularity	Δ Modularity
Cohort Model					
2007	186	.009	1.65	.140	
2010	193	.023	4.41	.054	- 61%
Growth Model					
2007	186	.009	1.65	.140	
2010	493	.011	5.51	.071	- 49%

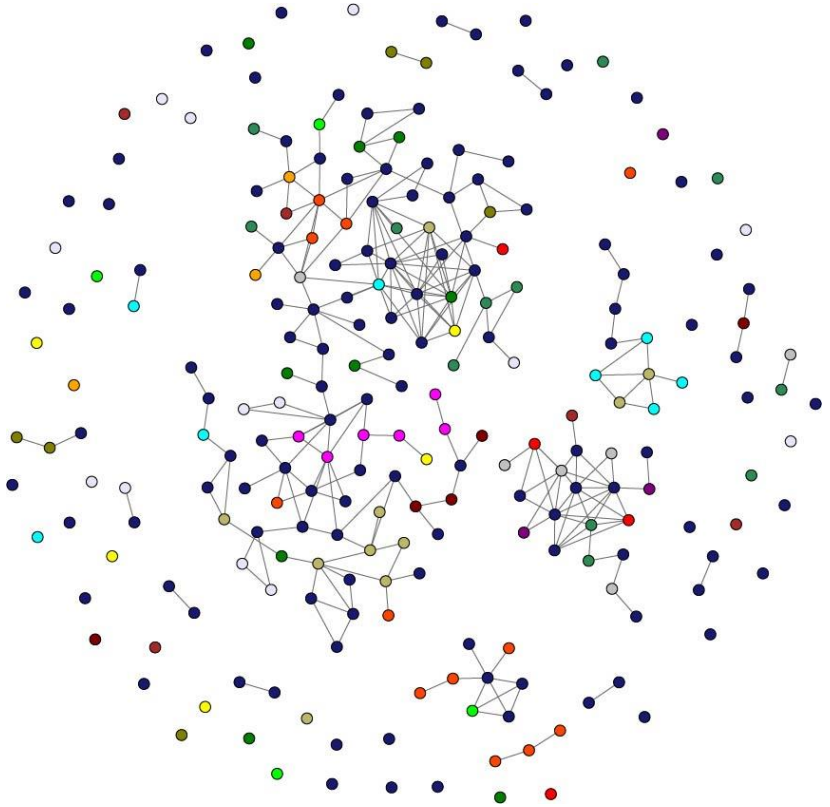
Modularity: Newman & Girvan, 2004

Publication co-authorship collaborations

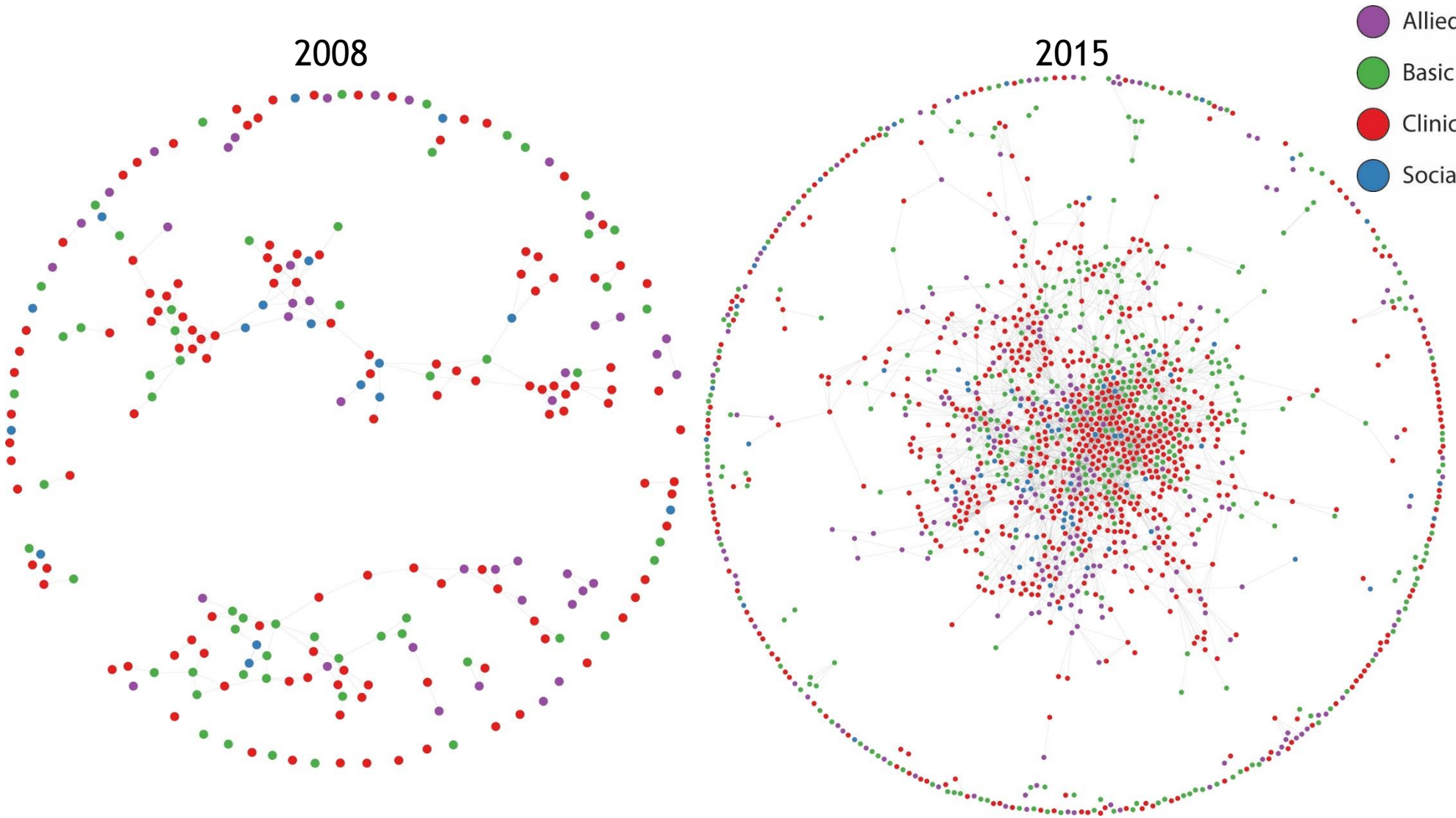
2007



2011



Publication co-authorship collaborations



Publication co-authorships

Year	Size	Density	Avg. Degree	Modularity	Δ Modularity
Cohort Model					
2007	224	0.007	1.61	0.093	
2011	234	0.009	2.14	0.071	-23%
Growth Model					
2007	224	0.007	1.61	0.093	
2011	833	0.004	3.57	0.125	35%

Network Development

- Generally speaking, collaboration became more cross-disciplinary over time
- Pattern was stronger for grants than publications
  - Publications can take many years
  - Any change after 4 years is encouraging
- Pattern was stronger for Cohort model than Growth model
  - More recent cohorts tend to be younger
  - Greater pressure for them to publish in their own field until obtaining tenure

Network Analysis and Evaluation

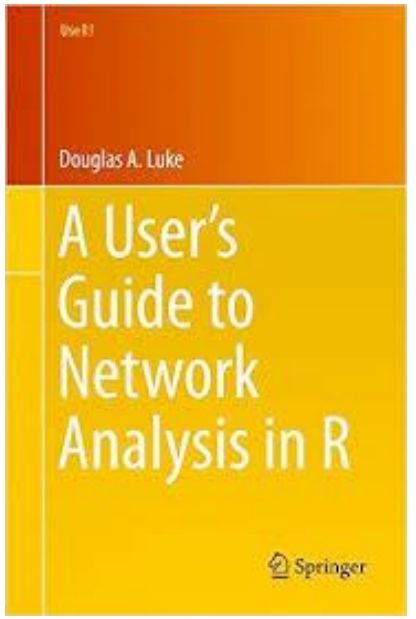
- Use of standard network statistics (average degree) good for examining general increase in collaborations
- Use of modularity measure was crucial in examining the success of the ICTS goal of increasing rates of *cross-disciplinary* collaboration
- Next steps
  - Collect more current data
  - Longitudinal SIENA models: significance testing

Modeling collaboration

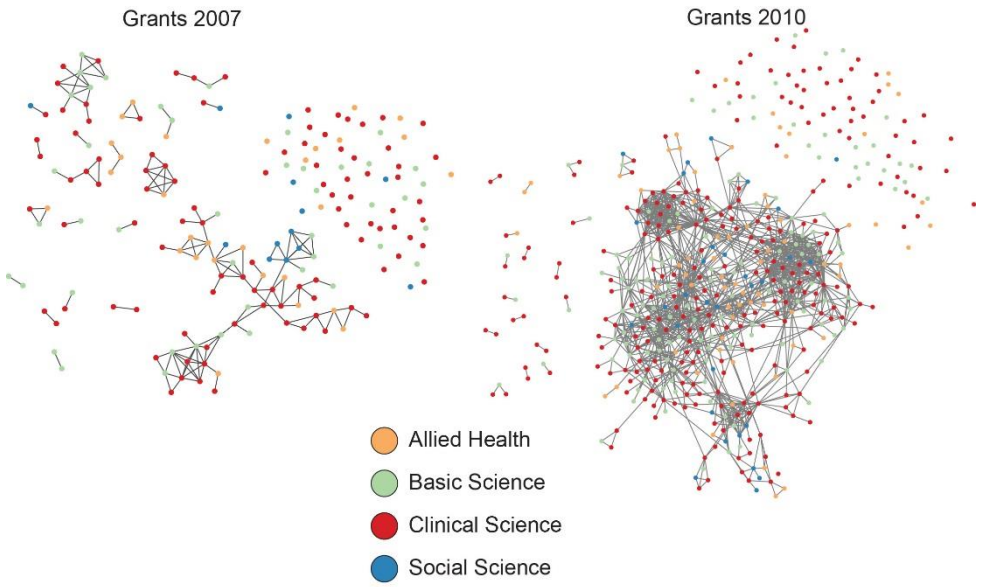
Does scientific discipline influence likelihood of collaboration?

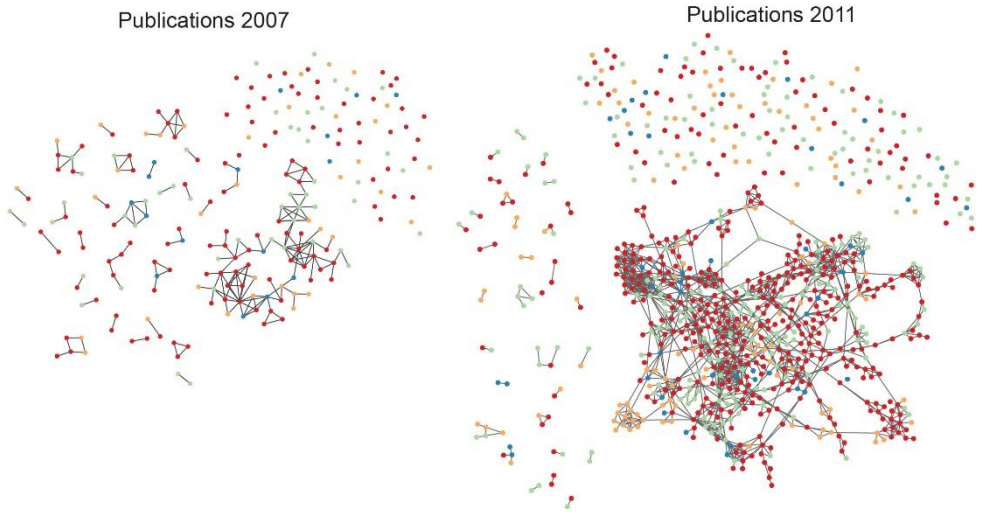
Methods – Statistical modeling of networks

- Same participants & relationships
- Analysis
  - Statistical modeling of network structure
    - ERGM (exponential random graph modeling)
  - Allows us to identify what predicts collaboration
    - Demographics (academic position, length of time in ICTS, etc.)
    - Academic Discipline



Network Visualizations





PLOS ONE

RESEARCH ARTICLE

Academic Cross-Pollination: The Role of Disciplinary Affiliation in Research Collaboration

Amar Dhand[1,2]*, Douglas A. Luke[2], Bobbi J. Carothers[2], Bradley A. Evanoff[3]

1 Department of Neurology, Washington University School of Medicine, St. Louis, Missouri, United States of America, 2 George Warren Brown School of Social Work, Center for Public Health Systems Science, Washington University in St. Louis, St. Louis, Missouri, United States of America, 3 Department of Internal Medicine, Division of General Medical Sciences, Washington University School of Medicine, St. Louis, Missouri, United States of America

* dhanda@neuro.wustl.edu

CrossMark click for updates

Modeling Grants

	2007[a]		2010[b]	
	Structural	+ Discipline	Structural	+ Discipline
Edges (constant)	-5.42 (1.36)	***-5.83 (1.45)***	***-6.17 (.28)***	***-5.99 (.28)***
Academic Position				
Non-faculty	Ref	Ref	Ref	Ref
Instructor	.16 (.47)	.25 (.48)	***.59 (.12)***	***.57 (.12)***
Assistant Professor	.23 (.40)	.30 (.42)	***.84 (.11)***	***.84 (.12)***
Associate Professor	.15 (.40)	.23 (.43)	***.91 (.12)***	***.90 (.11)***
Professor	.39 (.40)	.46 (.42)	***1.10 (.12)***	***1.11 (.12)***
MD degree	-.10 (.13)	-.05 (.13)	***.18 (.04)***	***.13 (.04)***
PhD degree	-.07 (.12)	-.08 (.12)	***.14 (.04)***	***.19 (.04)***
Same Institution	.05 (.20)	.05 (.20)	-.05 (.07)	***-.01 (.07)***
Year entering ICTS			***-.38 (.03)***	***-0.38 (.03)***
Structural terms				
GWD	-.38 (.53)	-.25 (.52)	***-1.44 (.31)***	***-1.44 (.32)***
GWESP	2.27 (.21)	***2.25 (.21)***	***2.60 (.08)***	***2.60 (.09)***
GWDSP	-.24 (.11)	***-.20 (.10)***	***-.09 (.01)***	***-.09 (.01)***
Discipline				
Clinical-Clinical		Ref		Ref
Allied Health-Allied Health		***.86 (.21)***		***.48 (.09)***
Basic Science-Basic Science		.27 (.28)		***-.19 (.09)***
Social Sciences-Social Sciences		***1.16 (.27)***		-.22(.31)
Clinical-Allied Health		.03 (.22)		***-.25 (.06)***
Clinical-Basic Science		.09 (.21)		***-.29 (.05)***
Clinical-Social Sciences		-.94 (.53)		***-.43 (.09)***
Allied Health-Social Sciences		-.62 (.88)		-.04 (.14)
Basic Science-Allied Health		-1.03 (.56)		***-.63 (.10)***
Basic Sciences-Social Sciences		.26 (.33)		***-.39 (.13)***
Fit				
AIC	1371	1353	12889	12514
BIC	1456	1508	13006	12717

(Dhand, et al, 2016)

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(Dhand, et al, 2016)

Modeling Grants

	2007[a]		2010[b]	
	Structural	+ Discipline	Structural	+ Discipline
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Same Institution	.05 (.20)	.05 (.20)	-.05 (.07)	***-.01 (.07)***
Year entering ICTS			***-.38 (.03)***	***-0.38 (.03)***
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GWDSP	-.24 (.11)	***-.20 (.10)***	***-.09 (.01)***	***-.09 (.01)***
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Fit				
AIC	1371	1353	12889	12514
BIC	1456	1508	13006	12717

(Dhand, et al, 2016)

Modeling Publications

	2007[a]		2011[c]	
	Structural	+ Discipline	Structural	+ Discipline
Edges (constant)	***-6.87 (1.47)***	***-6.59 (1.53)***	***-4.35 (.25)***	***-3.93 (.25)***
Academic Position				
Non-faculty	Ref	Ref	Ref	Ref
Instructor	-.24 (.47)	-.28 (.48)	***-.39 (.07)***	***-.39 (.08)***
Assistant Professor	-.05 (.44)	-.12 (.44)	.08 (.05)	.08 (.06)
Associate Professor	.01 (.44)	-.06 (.44)	***.21 (.06)***	***.22 (.06)***
Professor	.07 (.44)	-.01 (.45)	***.46 (.06)***	***.48 (.06)***
MD degree	.04 (.11)	.03(.13)	***.18 (.04)***	.03 (.04)
PhD degree	.02 (.11)	.02 (.11)	***.18 (.04)***	***.25 (.04)***
Same Institution	.35 (.22)	.34 (.23)	***.43 (.06)***	***.47 (.06)***
Year entering ICTS			***-.06 (.01)***	***-.08 (.02)***
Structural terms				
GWD	.44 (.47)	.44 (.47)	***-3.57 (.21)***	***-3.38 (.20)***
GWESP	***2.34 (.18)***	***2.34 (.18)***	***2.54 (.06)***	***2.52 (.07)***
GWDSP	-.02 (.07)	-.03 (.07)	***-.28 (.02)***	***-.28 (.02)***
Discipline				
Clinical-Clinical		Ref		Ref
Allied Health-Allied Health		.17 (.40)		.12 (.20)
Basic Science-Basic Science		.29 (.23)		***-.60 (.11)***
Social Sciences-Social Sciences		.85 (.49)		***.71 (.19)***
Clinical-Allied Health		-.24 (.20)		***-.91 (.17)***
Clinical-Basic Science		-.24 (.17)		***-.49 (.06)***
Clinical-Social Sciences		-.12 (.25)		-.13 (.09)
Allied Health-Social Sciences		.10 (.43)		-.98 (.64)
Basic Science-Allied Health		***-.85 (.43)***		***-1.92 (.49)***
Basic Sciences-Social Sciences		-.14 (.37)		***-.54 (.15)***
Fit				
AIC	1754	1757	14307	14153
BIC	1843	1920	14436	14379

(Dhand, et al, 2016)

Mentoring

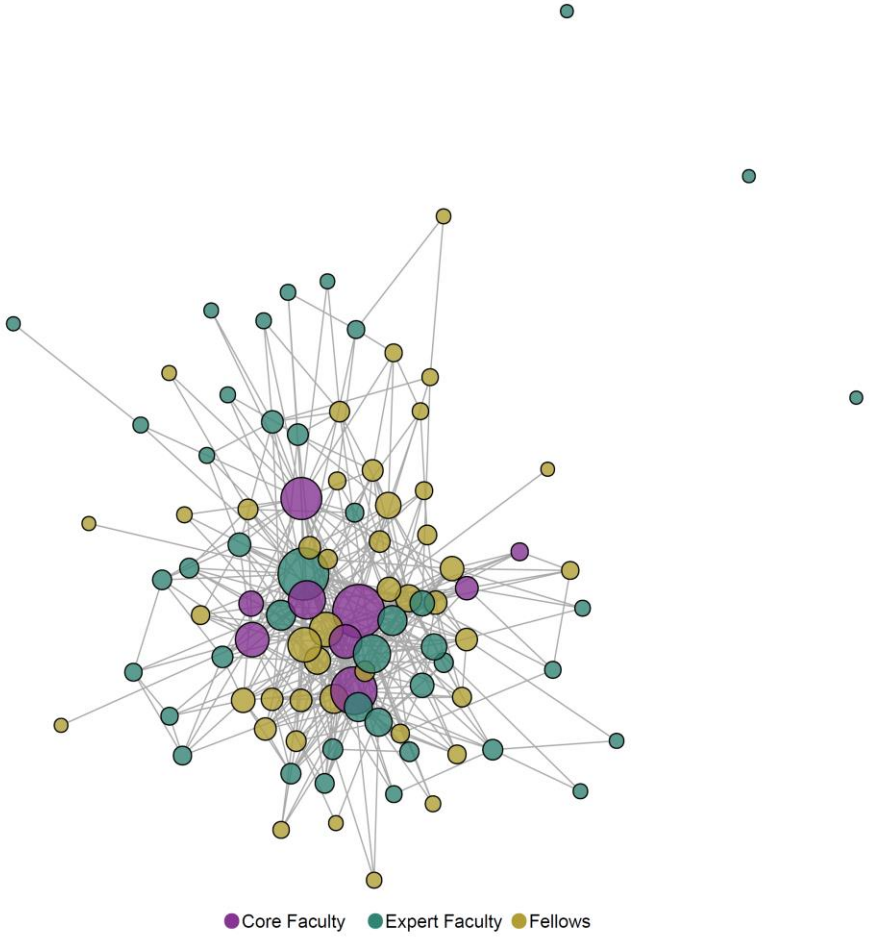
How does mentoring influence subsequent collaboration?

IRI – Training the next generation of implementation science scholars

- Dissemination & Implementation (D&I) Core
- Annual Implementation Research Institute (IRI)
  - Two-year fellowship
  - One week on-site training each year
  - Individualized mentoring

IRI – Evaluation of mentoring & collaboration

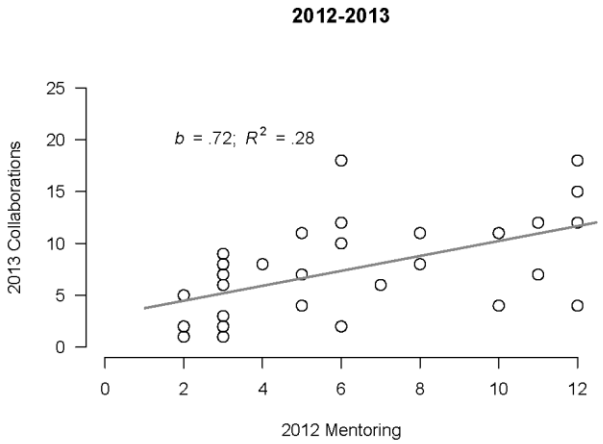
- Annual network survey
  - Fellows & faculty
  - Mentor relationships
  - Collaboration relationships
    - Develop new research
    - Grant submission
    - Presented research
    - Paper publication

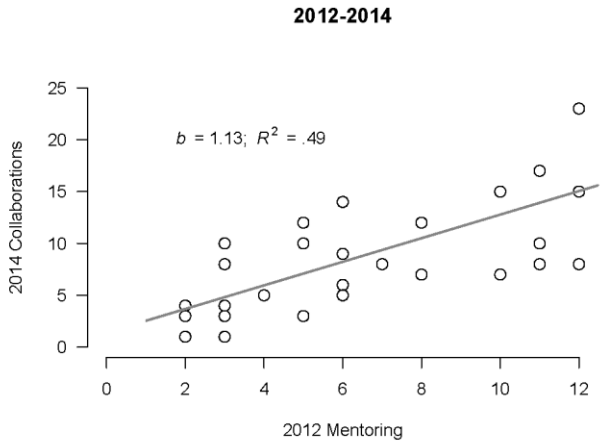


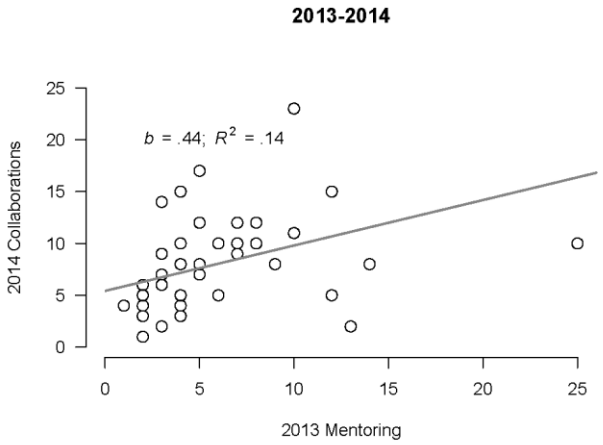
IRI Collaboration Ties - 2014

Luke et al, 2016

Mentoring predicts subsequent collaboration







- Mentoring predicted later collaboration relationships
- Relationship was stronger with a 2-year lag (2012 → 2014) than a 1-year lag (2012 → 2013 or 2013 → 2014)

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Implementation Science

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Forging a link between mentoring and collaboration: a new training model for implementation science

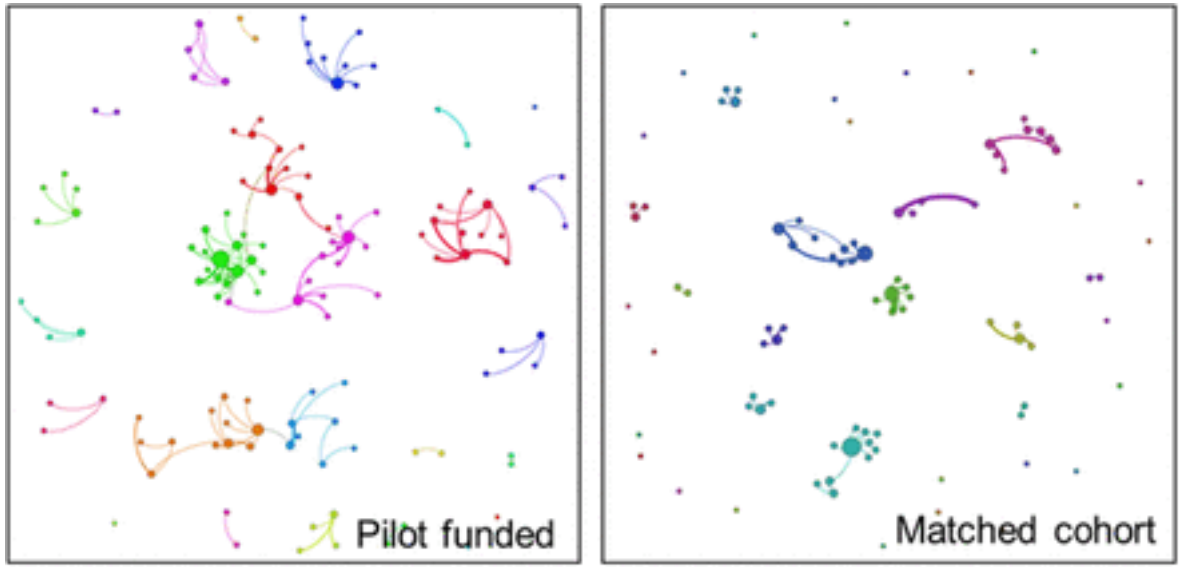
Douglas A. Luke[1*], Ana A. Baumann[1], Bobbi J. Carothers[1], John Landsverk[2] and Enola K. Proctor[1]

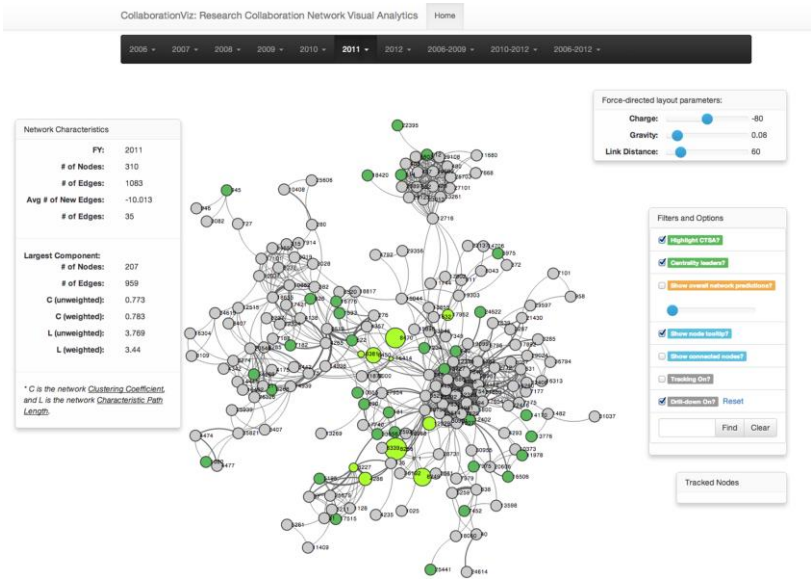
Lessons Learned

- Network survey issues for large-scale initiatives
  - Low response rates
  - Data management of free-recall responses
- Currently restricted to administrative data
- Value of analysis increases over time
  - Observe progression of networks
  - Change takes time
- Level of complexity
  - Can get as complex as you want
  - Simple maps still useful for evaluation, especially over time
- Currently limited in measurement of discipline
  - Once at sign-up
  - One category only
- Examining career development

Other approaches

- Other CTSAs are exploring network aspects of translational science
- Example – South Carolina
  - Using research ‘speed dating’ to foster collaborations
  - (Ranwalla, et al., 2016)
- Example - Arkansas
  - Interactive visualization of biomedical collaborations
  - (Bian, et al, 2014)





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Questions?