Social Networks
Diffusion of Innovations

Peter Winch

Health Behavior Change at the Individual, Household and Community Levels
224.689
Social Networks
Social Networks

- **Social network**: A set of individuals (or social entities) connected by different relationships (ex: kinship, friendship) or interactions (ex: sexual, monetary)

- Structure that is derived from “regularities in the patterning of relationships” (Hawe page 971)
Social Network Analysis

- The analysis of social network data
- The study of the **structure** of a network, and how structural properties affect behavior
  - Not simply the characteristics of the individual network members
Sociogram

Individual
Sociogram

Individual

Relational ties
Social Networks

- **Key concept:** We are all embedded in social structures
- These structures enable the exchange of resources or other things (money, information, virus, etc) across members
- The organization of the structure affects how resources flow through the system
Social Networks

- An individual’s position within the structure will:
  - Constrain their behavior by determining access/exposure to resources
  - Affect their ability to influence others
Network measures: individual

- **Degree Centrality:**
  - Number of direct connections a node has

- **Betweenness Centrality:**
  - Node with great influence over what flows in the network, key bridging link between different groups of people.

- **Closeness Centrality:**
  - Measure of closeness of node to all others in the network (mean length of path to all other nodes)
Network measures: individual

Nodes with higher degree centrality
Network measures: individual

Nodes with higher betweenness
Network measures: individual

Nodes with lower closeness centrality
Social Networks

- The structure of the network will:
  - Determine the speed at which resources will flow through the system
  - Affect how thoroughly resources (new ideas/diseases/etc) will penetrate the system
Network measures: network

- Density:
  - Total number of relational ties divided by the total possible number of relational ties
More Dense Social Network

Individual
Density

- Dense networks are good for coordinating activity among the actors
  - Everyone knows everyone else’s business
- However, dense networks also may “entrench particular value systems and norms” (Hawe 973)
  - Social norms generally stronger, harder to break away from
Network measures: network

- **Density:**
  - Total number of relational ties divided by the total possible number of relational ties

- **Distance:**
  - The number of distinct ties that exist on the shortest route between two actors
  - “Six degrees of separation”
Six degrees of separation

- We are all interconnected
- Stanley Milgram, social psychologist, 1960s
- Experiment: Letters to a stockbroker
  - 160 people in Omaha, Nebraska
  - Instructed to send packet to an acquaintance who may know someone who knows someone who knows this stockbroker in Sharon, Massachusetts
  - Decided there were about six degrees of separation
Social Network Data

- How does social network data collection and analysis differ from more “traditional” survey methods?

- Ex: Cross-sectional survey vs. sociometric questionnaire
  - Note: Cross-sectional survey used for comparison purposes only
Cross-sectional survey

Key steps

- Define research questions & population
- Calculate sample size for key indicators
- Select sampling frame and method of sampling
- Design and pre-test questionnaire
- Train and supervise interviewers
- Conduct survey
## Cross-sectional survey: Data management

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<th>V2</th>
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Cross-sectional survey: Analysis

- Typically focus on associations between dependent (outcome) and independent (predictor) variables
- Each case has more or less same importance to the analysis
- Individual cases can be excluded from the analysis, usually with little effect on the overall findings
Sociometric questionnaire

- Questionnaire to elicit the structure of a social network
- The questions are generally about relations with other people, rather than questions about individual knowledge, behavior etc.
Sociometric questionnaire applied to complete network: Steps

- Define the population, and its boundaries
- List all actors in the population/network
- Select one or more questions to be asked regarding each of the other actors in the network
- Create sociometric questionnaire with list of actors and questions
  - Often in table format
Example of sociometric questionnaire

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>How many times a week do you talk to ____?</th>
<th>How many times per month do you seek advice from ____?</th>
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</thead>
<tbody>
<tr>
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<tr>
<td>004</td>
<td>Barack Obama</td>
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</tr>
</tbody>
</table>
Questions for a sociometric questionnaire

- You can’t have very many!
- Examples:
  - Whom do you buy drugs from?
  - Whom do you share drugs with?
  - Whom do you borrow money from?
  - Who helps you find work?
  - Whom have you had sex with?
  - Whom do you go to for advice?
  - Who provides you with support for X?
## Sociometric questionnaire: Full matrix

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<tr>
<th></th>
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<th>Herman Cain</th>
<th>Mitt Romney</th>
<th>Barack Obama</th>
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Sociometric questionnaire: Symmetrized lower-half matrix

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<th>Barack Obama</th>
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<td>Barack Obama</td>
<td>10</td>
<td>1</td>
<td>2.5</td>
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</table>
Analysis of the symmetrized lower-half matrix

- Calculation of measures for actors in network: Degree centrality, betweenness, closeness centrality, etc.
- Calculation of measures of network as a whole: Density, cohesion etc.
- Multi-dimensional scaling
- Sociogram
**Full sociometric data vs. ego-centric data**

- In the prior example, network data collected for all individuals in a bounded network
  - Requires a bounded community
  - Requires enumeration of all individuals in that community

- Can also collect “ego-centric” data
  - Data centered around an individual
  - Does not require a bounded community/enumeration
  - Cannot construct a sociogram or examine structure of network; can only examine how individuals’ social ties affect their behavior
Applications of social network analysis in public health

- Many studies on networks of ‘risk groups’:
  - Drug users
  - Sexual partners
  - Obese people — See NEJM 2007; 357(18)
- Diffusion of innovations
  - Contraception/smaller family size
- Implementation of interventions through social networks
Popularity of social network analysis

- Very popular research methodology
- Considered by some as an important future direction for social science research
  - Provide the social science with a solid empirical foundation
  - Put well-known theories and concepts to the test
  - Escape from empty theorizing
Strengths of social network analysis

- Precise measurement of patterns of communication and diffusion
- Measurement of abstract concepts
  - Social support: Has greatly increased appreciation of this concept by practitioners and researchers
  - Social norms/Subjective norms
  - Isolation
- Has produced some surprising findings
  - Strength of weak ties
Strength of weak ties

- Granovetter (1970)
- Looked at people changing jobs and what sources of information they accessed
- Strength of ties:
  - *often* = at least once a week
  - *occasionally* = more than once a year but less than twice a week
  - *rarely* = once a year or less
Strength of weak ties

- 54/100 found jobs through personal contacts
  - 16.7% reported seeing their contact often
  - 55.6% reported seeing their contact occasionally
  - 27.8% rarely

- Why are weak ties important?
Weaknesses of social network analysis

- Has been mostly a research tool, difficult to apply in program settings
- Tendency to conduct studies in atypical, bounded groups for practical reasons
  - Islands, socially-marginalized groups, specialized occupational groups
- Difficult (but possible) to perform on large sample
- Losing one person out of the sample can make a big difference
Weaknesses of social network analysis

- Generally uses cross-sectional data; difficult to determine direction of causality
  - Ex: Do adolescents who smoke seek out other smokers as friends, or do adolescents with friends who smoke then start smoking themselves?

- May be difficult to interpret/give meaning to results without additional ethnographic/qualitative research
  - Ex: Bond 1999
Weaknesses of social network analysis

- Often produces unsurprising findings
  - “People who have many sexual partners are at higher risk of HIV/AIDS”
  - “You are at risk if your partner is infected”

- Can be difficult to share findings with larger audience due to terminology, matrix algebra etc.

- Can be a way to maintain control over communities, rather than empower them
  - “Mystification of the obvious”
How might social network analysis apply to the final assignment?

- Scenario #1: Over-diagnosis of malaria in Tanzania
- Scenario #2: Micronutrient fortification in refugee camps
How might social network analysis apply to the final assignment?

- Both scenarios could target providers: a relatively defined population
- Could ask all the providers in a district in Tanzania:
  - Who do they get information from re: treatment of malaria?
  - Who do they consider to be best sources of information on treatment of malaria?
- Identify opinion leaders
- Get opinion leaders to pass message re: malaria treatment through their networks
Diffusion of innovations

- Public health is constantly trying to introduce ‘innovations’
- Innovations can be:
  - Products: Condoms, mosquito nets, clean delivery kits
  - Behaviors: Hand-washing, not sharing needles
  - Services: Antenatal care, voluntary counseling and testing
Diffusion of innovations

- Theory developed by Everett Rogers
- Trying to understand how diffusion of ideas/innovations happens through a population
  - Diffusion: “The process in which an innovation is communicated through certain channels over time among members of a social system”
- Originally looked at farming techniques in midwest U.S.
Diffusion of innovations

- Theory also examines:
  - Why some innovations diffuse and others do not
  - Factors that affect how quickly innovations are adopted
  - Who is likely to adopt quickly or slowly
A nutritional intervention that diffused slowly

- **1601**: Captain Lancaster tests lemon juice (Vit. C) as treatment for scurvy in sailors
  - 1 intervention and 3 comparison ships sailing from England to India
  - Sailors on the intervention ship got 3 teaspoons of lemon juice daily
  - By halfway through voyage, 100 of 278 sailors on comparison ships had died, vs. 0 deaths on intervention ships
A nutritional intervention that diffused slowly

- **1601**: Captain Lancaster tests lemon juice as treatment for scurvy in sailors
- **1747**: James Lind, British Navy physician, does confirmatory study on effects of orange and lemon juice vs. 5 other treatment regimens
- **1795**: British Navy adopts policy for preventing scurvy on long sea voyages
- **1865**: British Board of Trade adopts same policy for the merchant marine
Why did Vitamin C diffuse slowly?
Why did Vitamin C diffuse slowly?

- **Observability**: (Compare to empirical efficacy)
  - Active ingredient not visible
  - No immediate effect of ingesting food rich in Vitamin C
  - Intervention and its effects took place at sea, out of sight of most people, less visible on land
  - Difficult to understand how the intervention has its effect

- **Network pressure**:
  - Weak communication with other network members, little pressure from others in network to adopt
  - Hierarchical system, information diffuses from top down, rather than between all network members
Spread of an innovation, from 2000 BC to 500 BC

http://commons.wikimedia.org/wiki/File:Chariot_spread.png CC BY-SA
Spread of the chariot

- 3500 BC: Earliest depiction of wagon on pot found in Bronocice, Poland
- 2000 BC (RED): Earliest known spoke-wheeled chariots (Sintashta-Petrovka culture)
- 1900 BC (ORANGE): Early spread of the chariot (Andronovo culture)
- 1600 BC (GREEN/CYAN): Spread to Mesopotamia, China, Punjab and the Gangetic plain (Rigveda), eastern and northern Europe
- 1000-500 BC (BLUE): Arrival in Western Europe
What slowed diffusion of this innovation?
Factors that slowed spread of the chariot: Complexity

- **Complexity**: How difficult is it to understand and use?

1. **Wheel**:
   - Difficult to make round wheel from tree trunk
   - Wheels from tree trunks are heavy, tend to split
   - Specialized tools, skills to make spoked wheels

2. **Horse**: Knowledge of how to care for and work with horses

3. **Chariot**: Skills in
   - Constructing chariot
   - Driving/steering chariot
One or more archers or spear throwers

Multiple horses

One driver

Spoked wheels
Spoked wheel

Displayed in: National Museum of Iran, Tehran

Date: Late 2nd millennium BC

Origin: Excavated at Chogha Zanbil, Iran

http://en.wikipedia.org/wiki/File:Wheel_Iran.jpg CC BY-SA
What do these names have in common?

- **English**
  - Wainwright, cartwright, wheelwright
- **French**
  - Charron
- **German**
  - Stellmacher, Wagner
Hidden complexity slows spread of apparently simple innovations

<table>
<thead>
<tr>
<th>Innovation</th>
<th>Chariots</th>
<th>Condoms</th>
<th>Recycling</th>
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<td>Source of complexity</td>
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Hidden complexity slows spread of apparently simple innovations

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<tr>
<td><strong>Source of complexity</strong></td>
<td>Wheel making &amp; repair, training of horses</td>
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<td>Negotiation of condom use between partners, condom purchase and disposal</td>
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Hidden complexity slows spread of apparently simple innovations

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<tbody>
<tr>
<td><strong>Source of complexity</strong></td>
<td>Wheel making &amp; repair, training of horses</td>
<td>Negotiation of condom use between partners, condom purchase and disposal</td>
<td>Identifying specific materials, Sorting of mixed material items</td>
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</table>
Characteristics of innovations that affect their diffusion/adoPTION

- **Relative advantage**: Is it better than what is used currently?
- **Compatibility**: Does it fit with values and needs of potential adopters?
- **Complexity**: How difficult is it to understand and use?
- **Trialability**: Can people try it out before deciding to adopt it?
- **Observability**: Can the benefits be readily observed?
- **Network pressure**: Once others in your network adopt it, there is pressure for you to adopt?
### Examples

<table>
<thead>
<tr>
<th></th>
<th>Vit. C (citrus) for scurvy</th>
<th>Chariots</th>
<th>Mosquito nets</th>
<th>Cell phones</th>
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<td>Relative advantage</td>
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<td>Network pressure</td>
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<td>Final assignment scenarios</td>
<td>Not treating every fever as malaria</td>
<td>Micronutrient supplements</td>
<td>Energy-saving bulbs</td>
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<td><strong>Relative advantage</strong></td>
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<td><strong>Network pressure</strong></td>
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Threshold & critical mass

- **Threshold**: Individual Level
  - The number of people who must be engaged in an activity before a given individual will join that activity

- **Critical Mass**: System Level
  - The point at which enough individuals in a system have adopted an innovation so that further adoption becomes self-sustaining
  - The tipping point
Timing of adoption / first use of innovation

Cumulative adoption/use at least once of innovation

Five categories of adopters of innovations

- **Innovators** – venturesome, educated, multiple info sources;
- **Early adopters** – social leaders, popular, educated;
- **Early majority** – deliberate, many informal social contacts;
- **Late majority** – skeptical, traditional, lower socio-economic status;
- **Laggards** – neighbors and friends are main info sources, fear of change
Innovators - Venturesome

- Interest in new ideas leads them out of local circle of peer networks
- Clique of innovators regardless of geographical distance
- Control of substantial financial resources
- Ability to understand and apply technical knowledge
- Must cope with high degrees of uncertainty
Early Adopters - Respect

- More integrated part of local social system
- Greatest degree of opinion leadership
- The person to check with
- Sought by change agents
- Respected by their peers
- Makes judicious innovation-decisions
Early Majority - Deliberate

- Interact frequently with peers
- Seldom hold leadership opinion positions
- Will deliberate for some time
- Innovation-decision period is longer
- Most numerous - one-third of the members of the system
Late Majority - Skeptical

- Adopt just after the average member of a system
- Adoption because of economic necessity
- Also increasing pressures from peers
- Skeptical and cautious in their approach
- Peer pressure necessary
- Most of the uncertainty must be removed
Laggards - Traditional

- Last in a system to adopt
- Point of reference is the past
- Many are near isolates in the social network of their system
- Interact primarily with others who have traditional values
- Suspicious of innovations and change agents
Use of diffusion of innovations in public health

- Descriptive framework
  - Describe how public health innovations have diffused, analyze case studies

- Intervention design:
  - Identify “opinion leaders” – early adopters
    - Most trusted, looked to by others
  - Get them to spread public health messages, model behavior to influence the behavior of others
    - HIV: Kelly et al., Lancet 1997; 350(9090)
Do we want complete diffusion?

- For some innovations, we want complete diffusion (100%)
  - Ex: Polio vaccination, antenatal care, iodized salt

- However, for others, we want awareness of the innovation to diffuse to 100%, but we don't want actual use/practice to be 100%
  - Ex: Cesarean sections
  - Challenging when there is uncertainty around the “correct” rate of actual use
Limitations of diffusion of innovations

- Pro-innovation bias: All innovation is good and the faster people adopt the better
  - Many innovations are now coming back to haunt us (ex: pesticides, cars, shopping malls)
- Individual blame against those who do not adopt
- Possibility for diffusion to widen existing inequalities
Limitations of diffusion of innovations

- Descriptive or proscriptive?
  - To what extent does this describe a natural process, and to what extent can we intervene to change this process?
Additional resources

▪ **Social Network Analysis**
  – 1st term class: 380.733.01 Communication Network Analysis in Public Health Programs
  – Wasserman, Faust (1994) *Social Network Analysis: Methods and Applications*

▪ **Diffusion of Innovations**
  – Rogers (1962) *Diffusion of Innovations*