

**Taking person, place, and time  
seriously in infectious disease  
epidemiology and diffusion research**

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# **The end of epidemiology**

**(as in “The end of physics”)**

**We know (or think we do) all the potential influences/components of disease transmission -- mechanistic processes**

- cf. cosmology (cosmological constant, dark matter/energy, etc.), social sciences (unknown/poorly specified neurological/mental/social processes)**
- all we have to do is actually study them!**

# Key dimensions of infectious disease epidemiology

- Person (who)
- Place (where)
- Time (when)
- Behavior (how)
- Physical setting/fomites (how)
- Molecular biology of pathogen, infected, & susceptible (how)

# **Incomplete infectious disease epidemiology**

**Most HIV/Hep/STD epidemiology focuses *solely* on behavior**

**Atomistic sampling designs (most traditional sampling schemes)**

- dismember person-person transmission context and structure**
- make study of person, place, & time difficult and shallow**
- invite confounding**

# Research design determines what we can know

Infectious disease (ID) epidemiology should focus on description/prediction/control of transmission events

Initial steps toward a more comprehensive epidemiology of infections involving person-person transmission

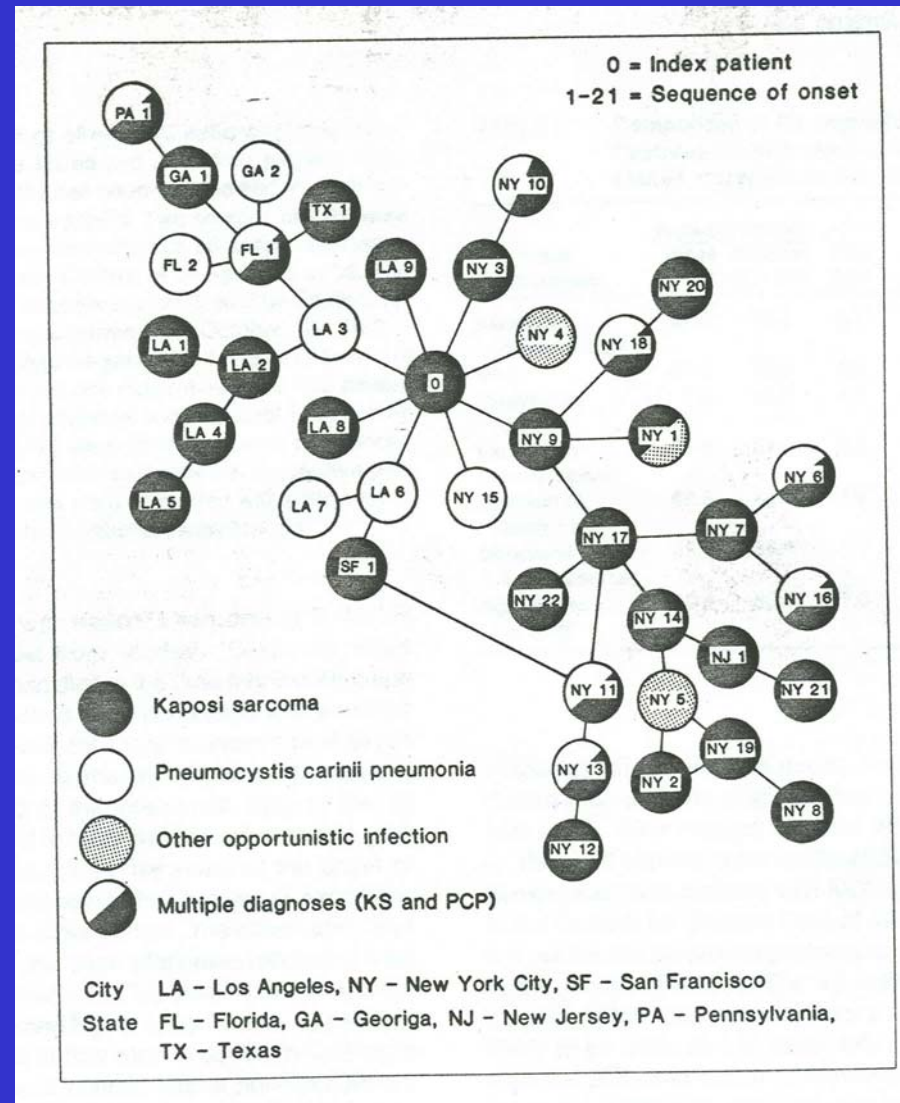
- goals: illustrate, provoke, & stimulate

# Person

## Network structure

- **personal networks** (AKA egocentric, local)
  - **respondent and his/her contacts**
  - **limited measures (e.g., risky contact w/ specific partners, # partners)**
- **social networks** (AKA whole, complete, global, full, sociometric, sociocentric)
  - **a set of persons and the connections among them**

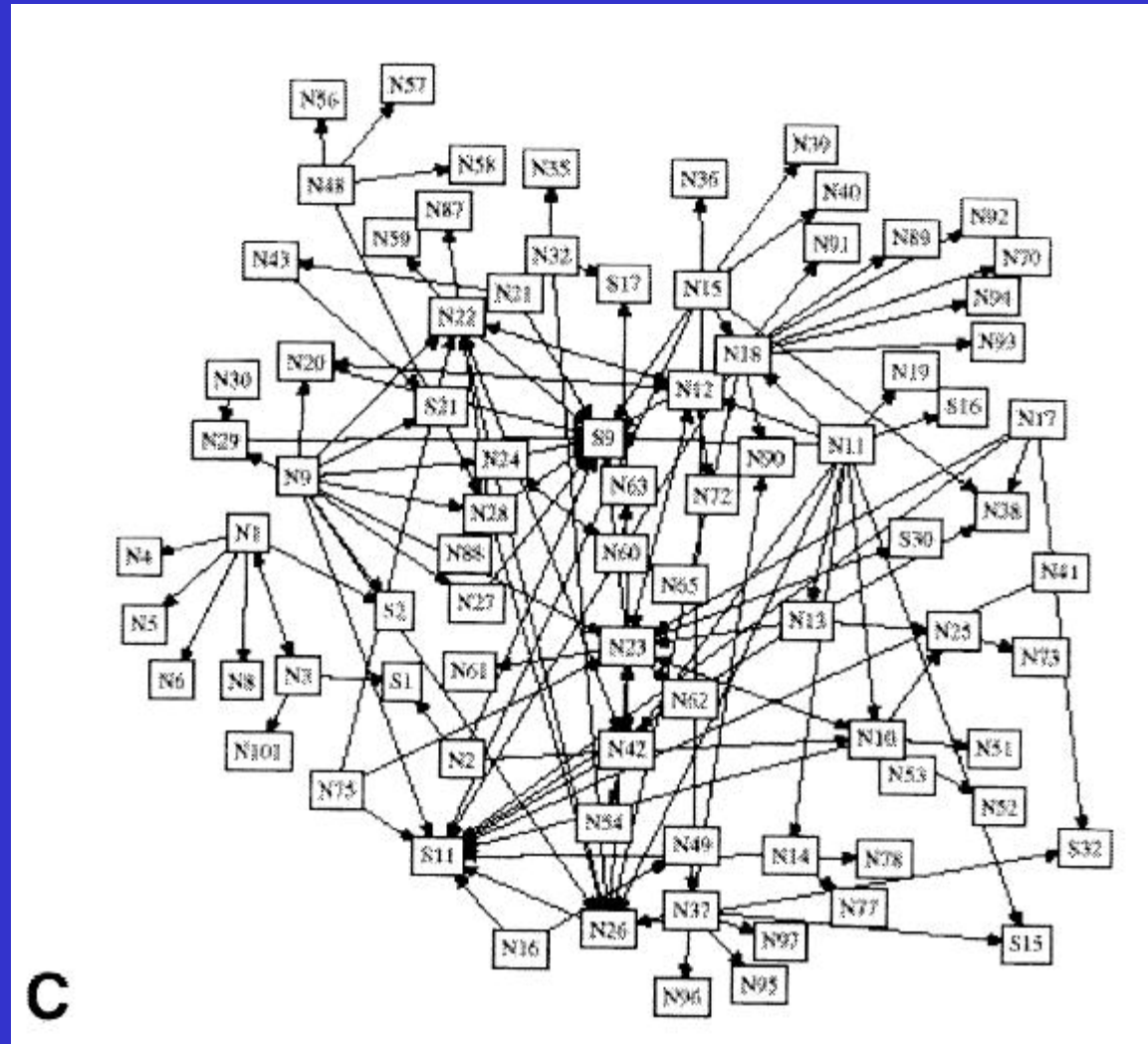
# First AIDS contact investigation in 1982 (Auerbach, Darrow et al., 1984; subsequent analysis by Klovdahl, 1985)



Most crucial evidence for sexual transmission; role of mobility

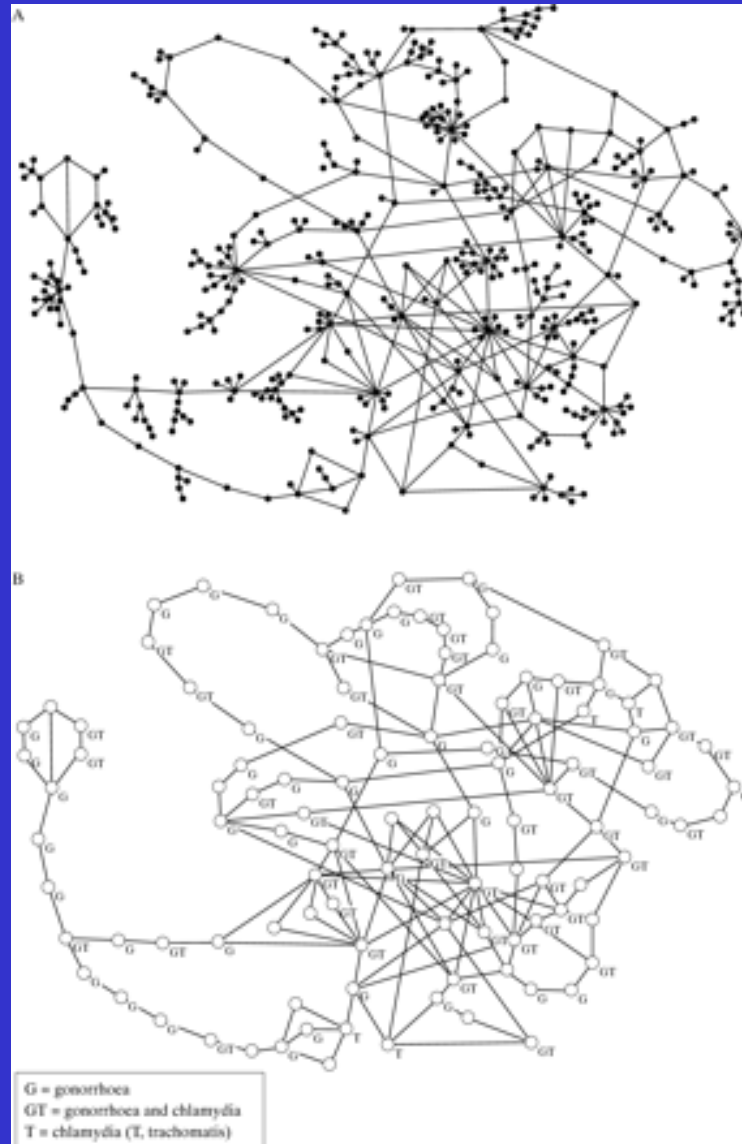
# Syphilis contact tracing among suburban Atlanta heterosexual youth (Rothenberg et al., 1998)

High  
cyclicality,  
density →  
epidemic  
spread



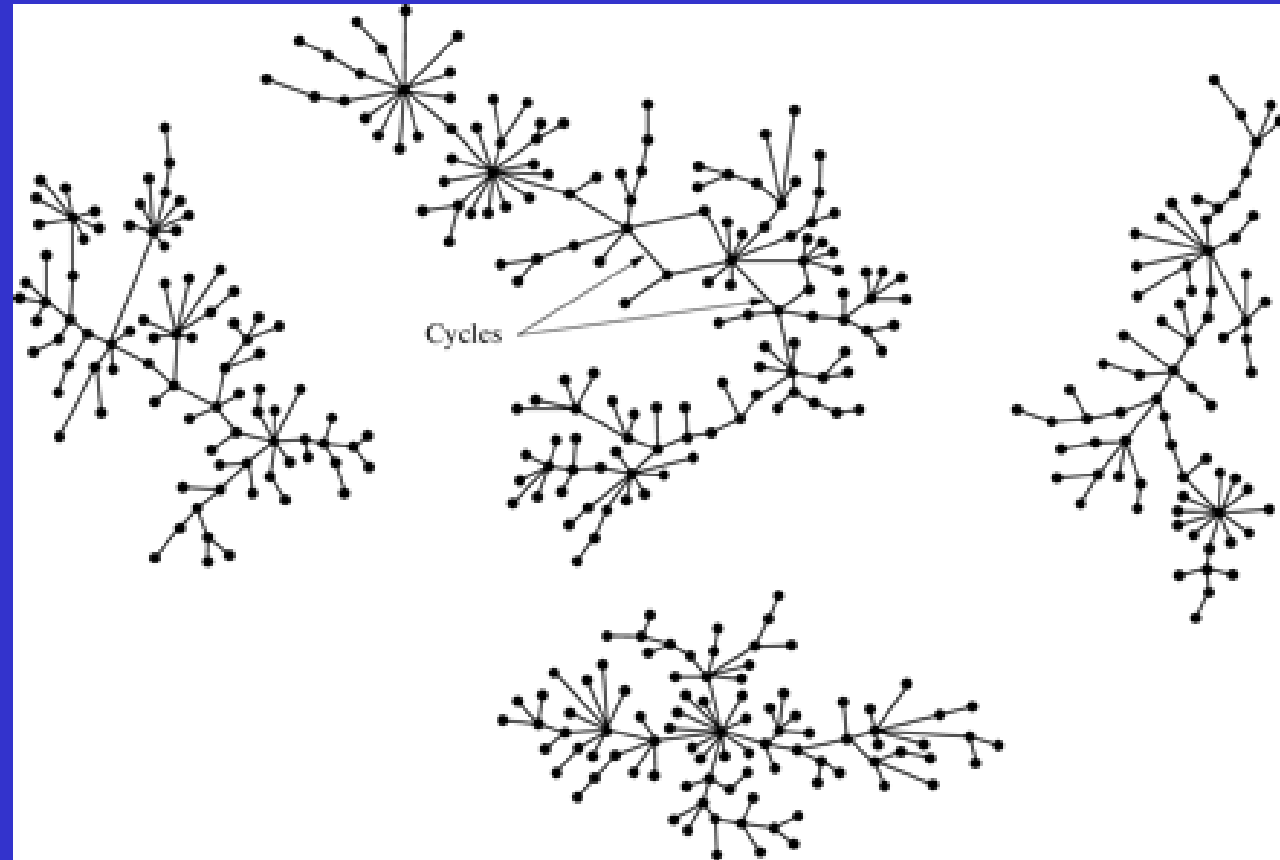
# PPNG contact tracing, Colorado Springs (Potterat, Muth et al., 2002)

High cyclicality,  
density →  
epidemic spread



## Chlamydia contact tracing, Colorado Springs (Potterat, Muth et al., 2002)

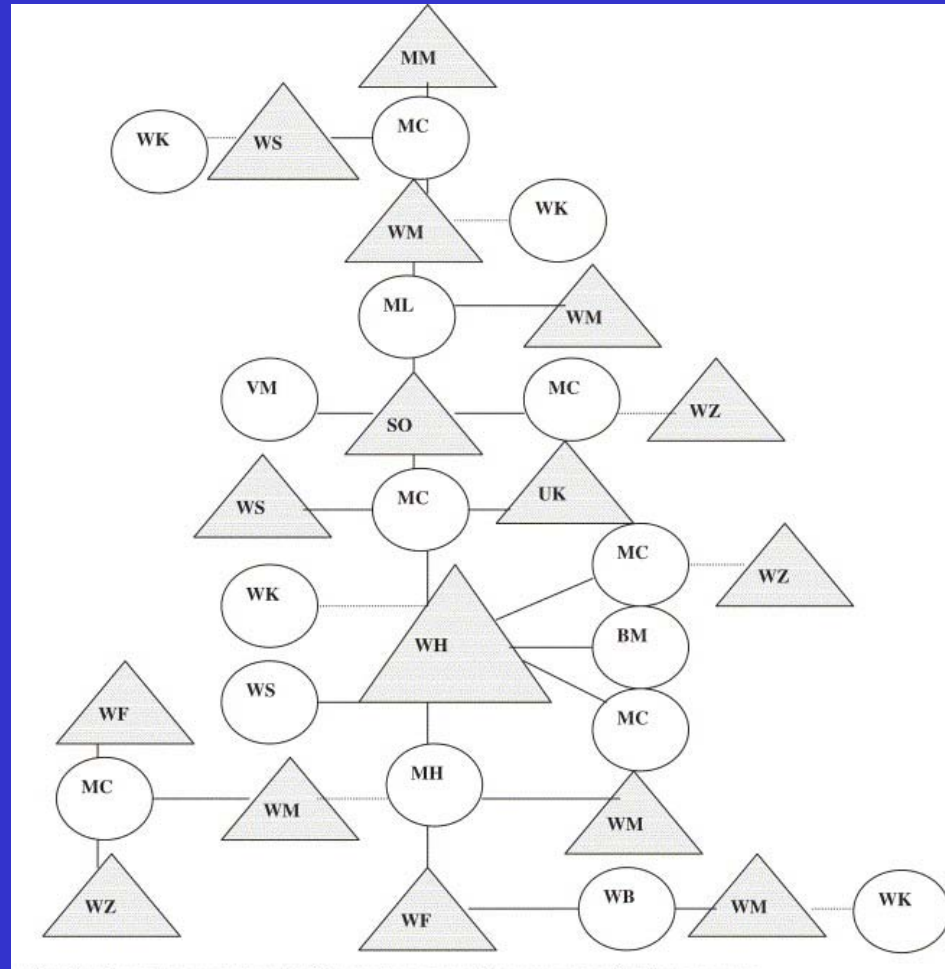
**Dendritic structure → stable to declining transmission**



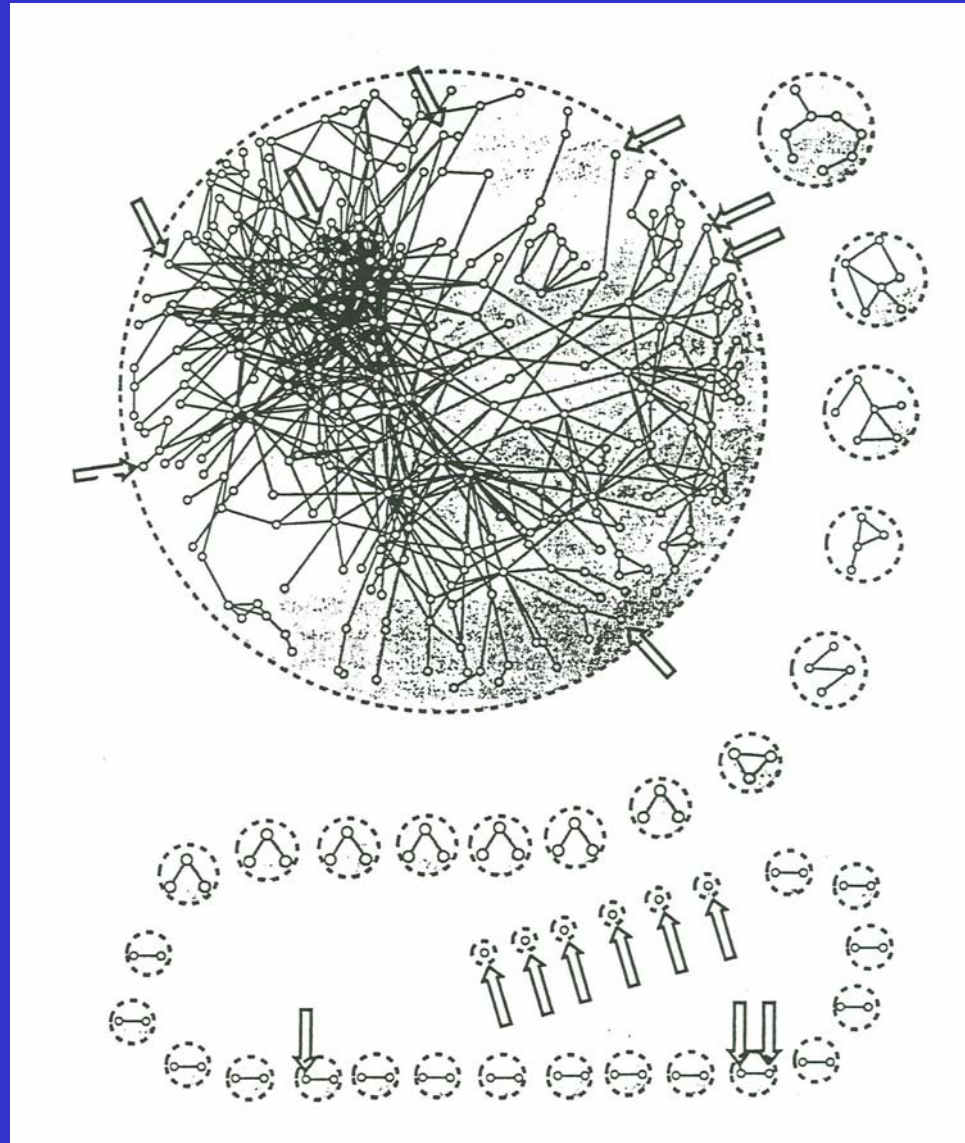
**Cases in large components → higher rate of reinfection, gonorrhea coinfection**

# Sexual network, NW Tanzania gold mining town (Desmond et al., 2005)

- several week observation period
- many commercial partnerships
- no cycles

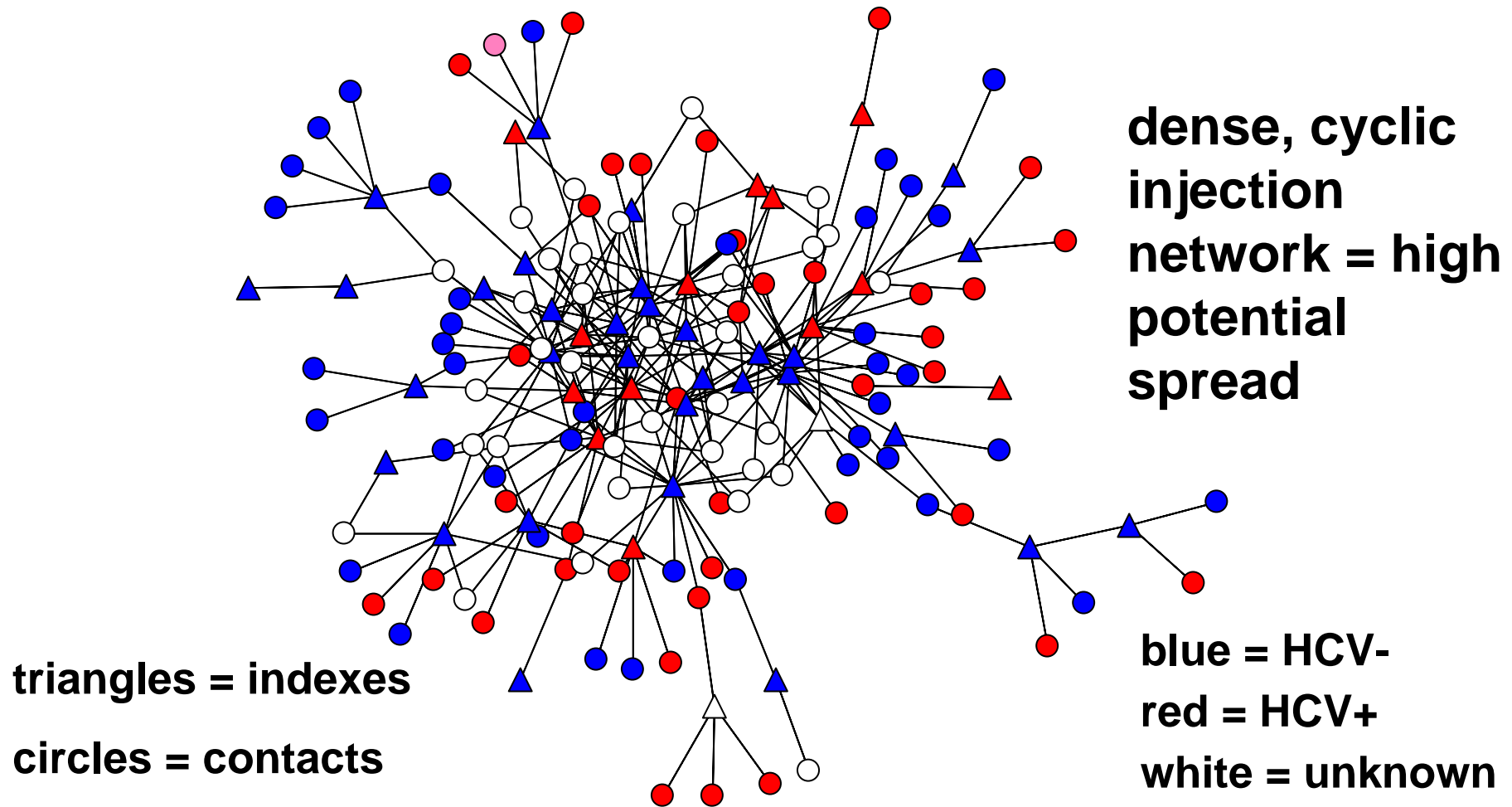


# Prostitutes, IDUs, & their partners in Colorado Springs (Darrow, Potterat et al., 1999)



**HIV+ on  
periphery,  
low potential  
spread**

## Seattle IDUs by HCV serostatus (Brewer, Hagan et al., 2006)



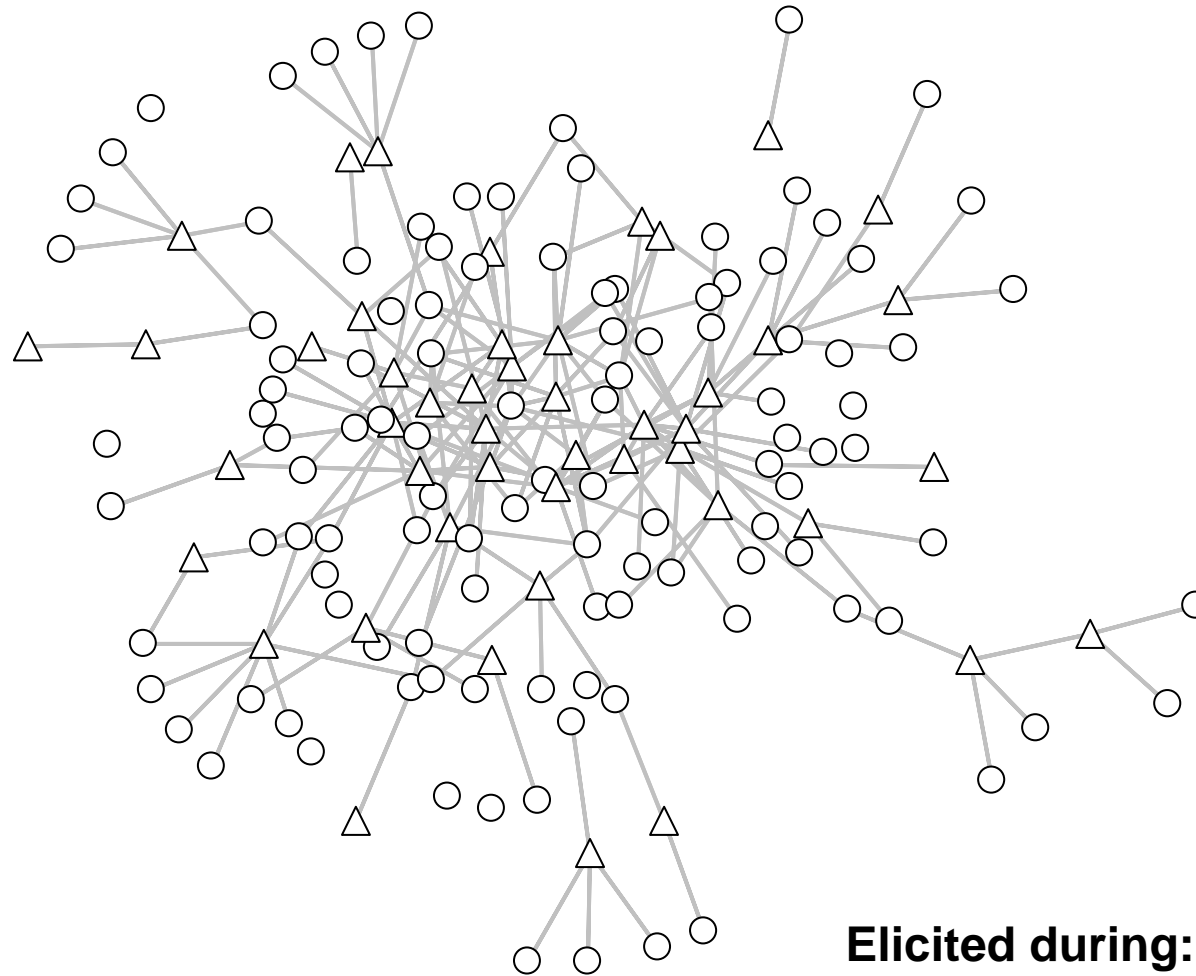
adjacency x HCV status similarity  
QAP matrix correlation  $r = .01$ ,  $p > .10$

# **Network sampling and measurement challenges**

**missing nodes (persons) and missing links (partnerships)**

- persons never interviewed**
- partners never reported (primarily forgotten)**

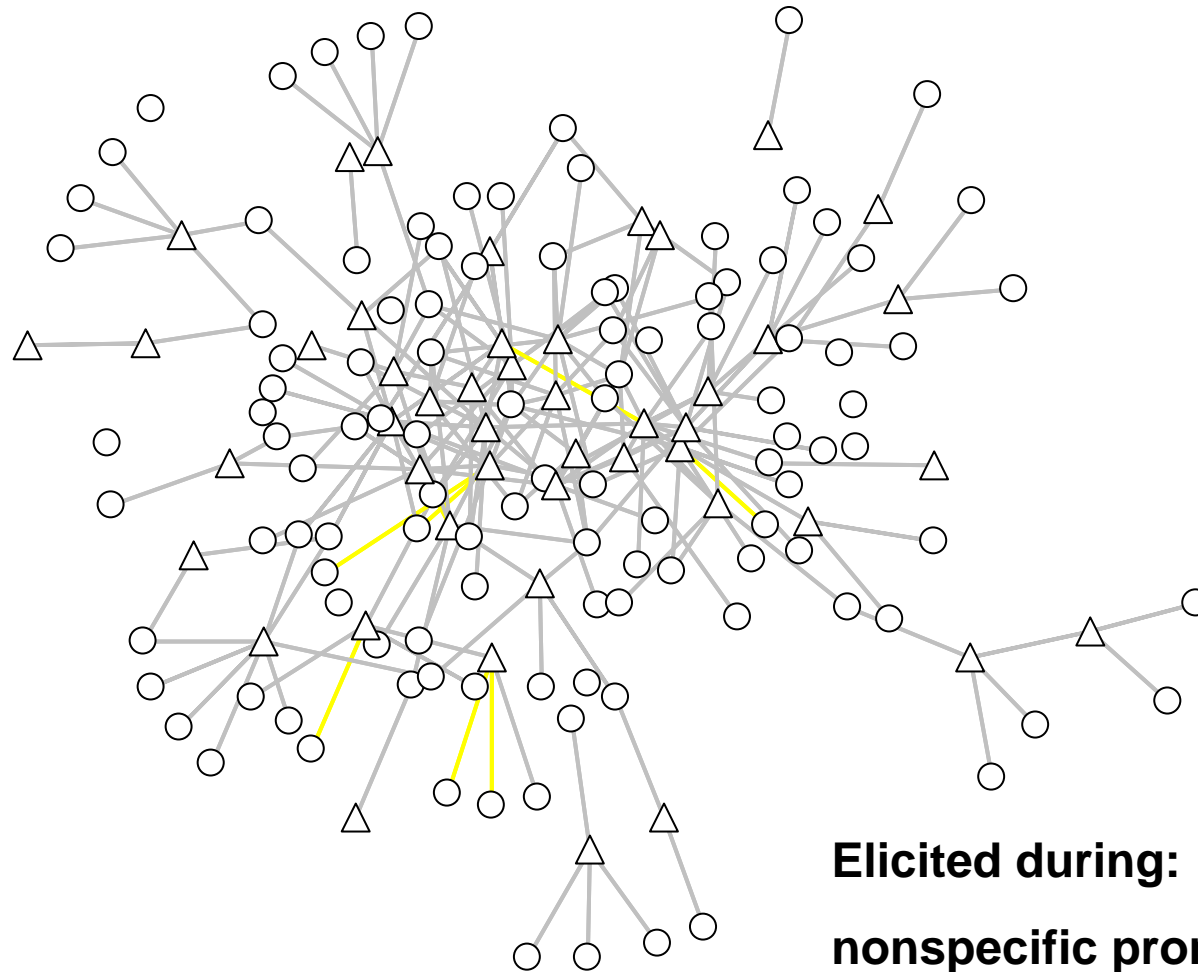
# Impact of elicitation techniques - injection partners, Seattle (Brewer, Hagan et al., 2006)



**conservative assessment**

**Elicited during:  
free recall (or unknown) -  
typical extent**

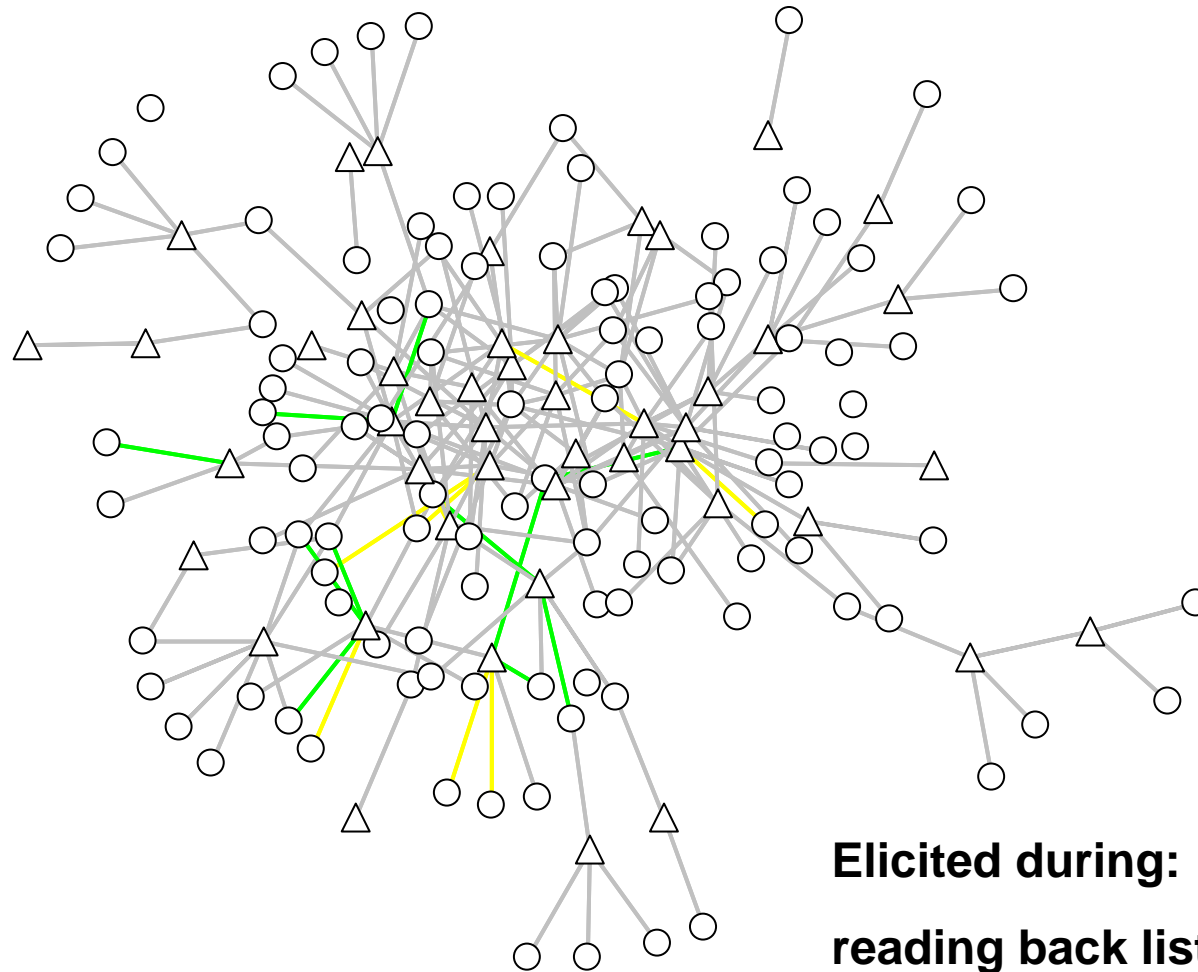
# Impact of elicitation techniques - injection partners, Seattle (Brewer, Hagan et al., 2006)



**Elicited during:**  
**nonspecific prompting -**  
**yellow**

**conservative assessment**

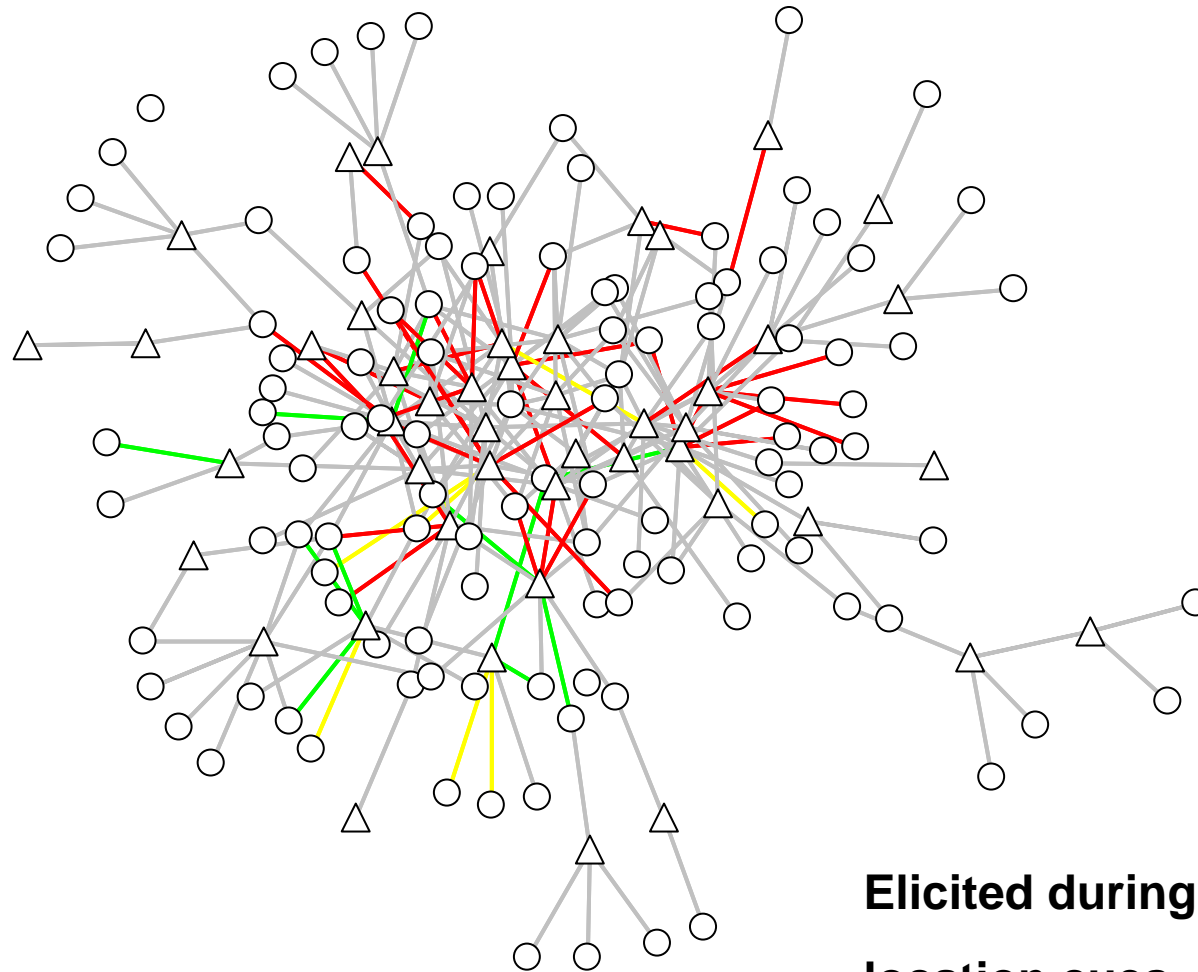
# Impact of elicitation techniques - injection partners, Seattle (Brewer, Hagan et al., 2006)



**Elicited during:  
reading back list of elicited  
partners - green**

**conservative assessment**

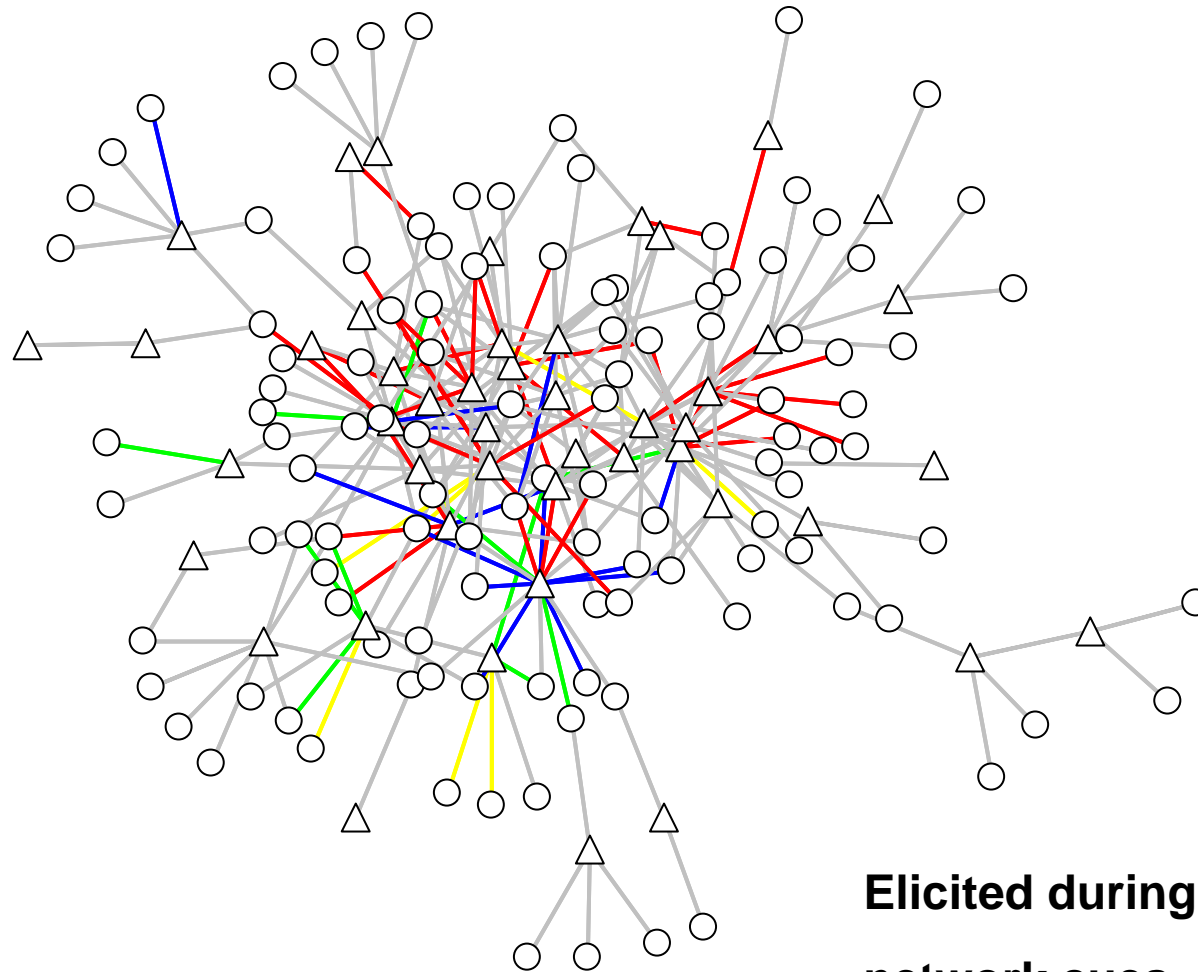
# Impact of elicitation techniques - injection partners, Seattle (Brewer, Hagan et al., 2006)



**Elicited during:**  
**location cues - red**

**conservative assessment**

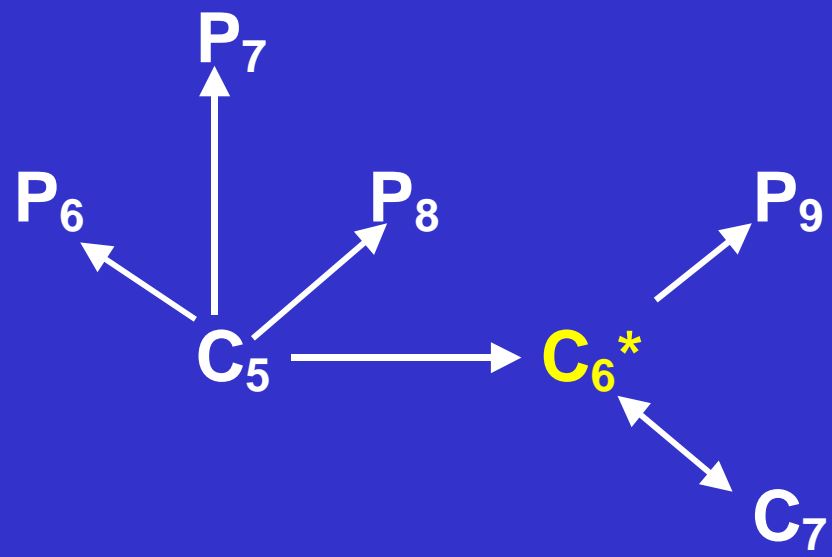
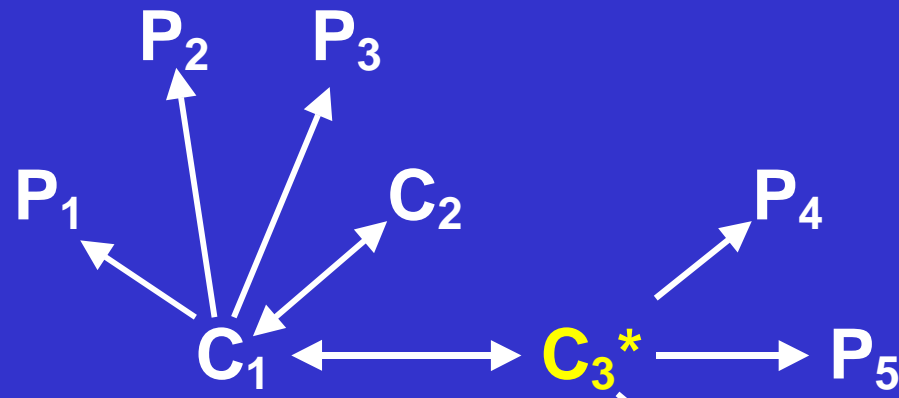
# Impact of elicitation techniques - injection partners, Seattle (Brewer, Hagan et al., 2006)



**Elicited during:**  
**network cues - blue**

**conservative assessment**

# STD contact tracing, Colo. Springs (Brewer, Potterat et al., 2005)



C = case

P = not  
infected/ix'd

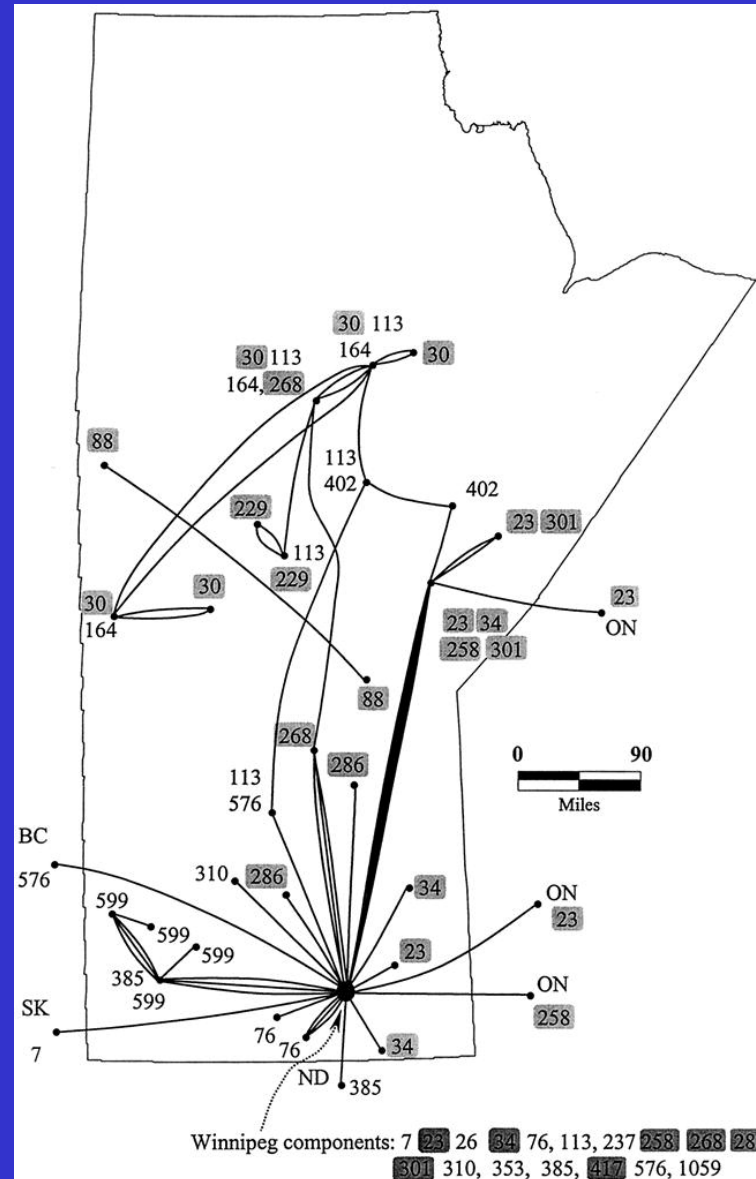
\* = elicited by  
supp. tech.

## **Person and place**

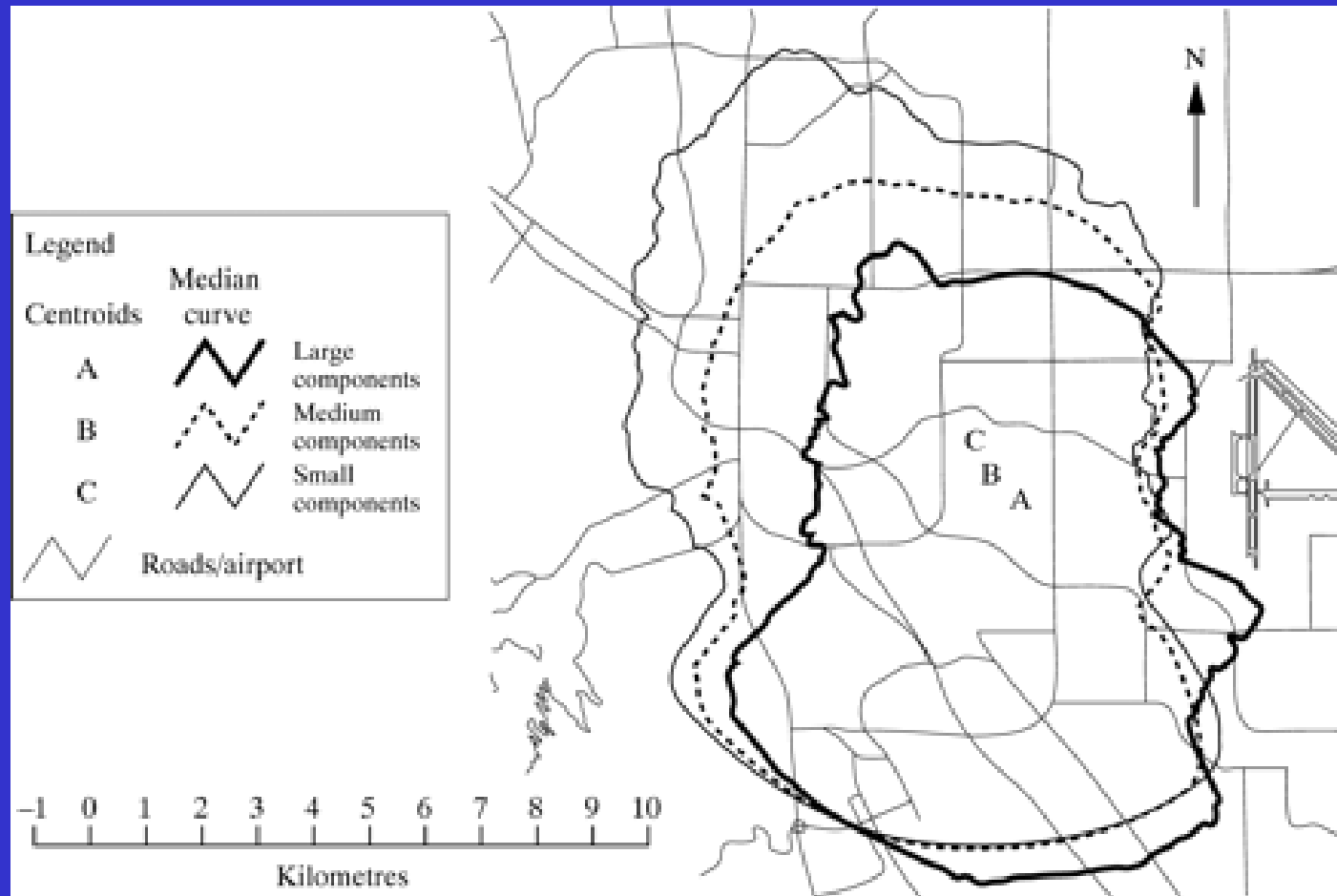
**Spatial substrate/facilitation of and  
constraint on network structure**

# Ct/Gc contact tracing, Manitoba, Canada (Wylie & Jolly, 2001)

Sociogeographically  
channeled  
transmission; cities  
as roundhouses



# Colorado Springs chlamydia contact tracing (Potterat, Muth et al., 2002)



**Persons in large components & disease both geographically focused**

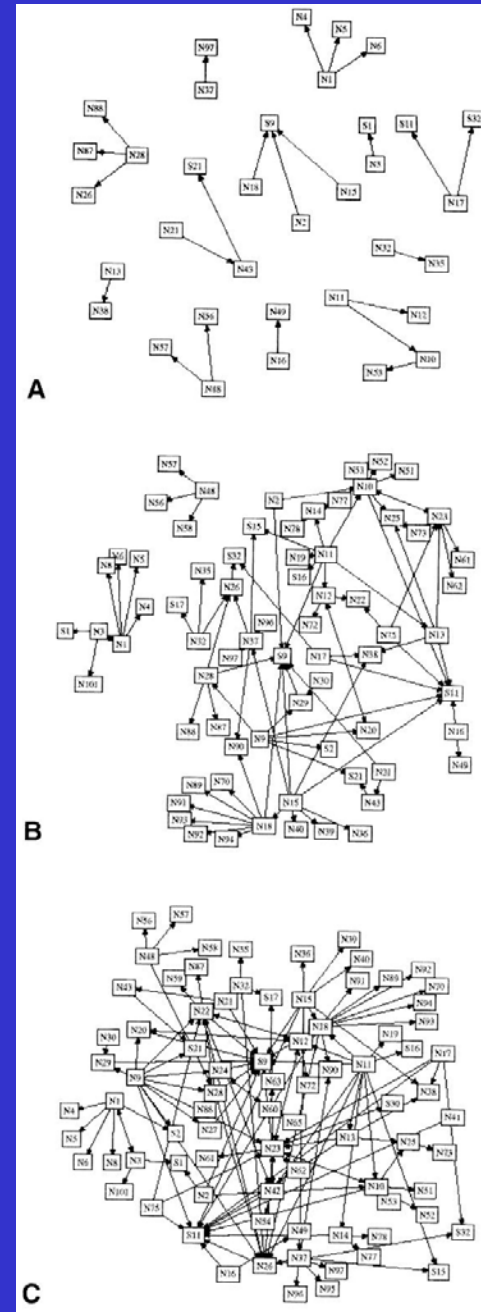
## **Person and time**

**Nearly all networks studied to date are partially false analytic constructions**

- nodes and links cumulated over time (from long data collection periods, recall periods), misrepresent possible transmission paths**
- despite successes from network analysis, amalgamations have element of uninterpretability**

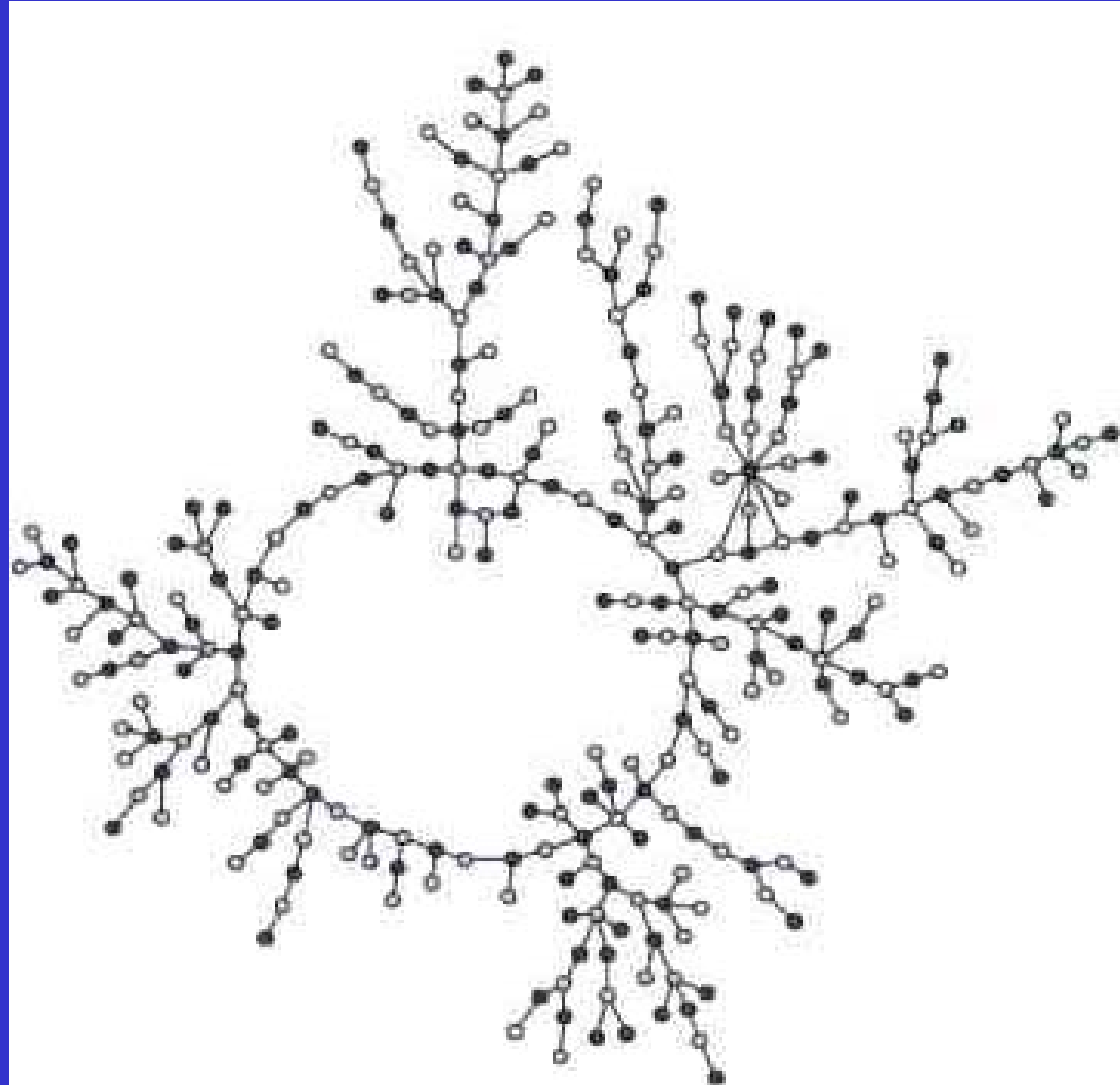
# Syphilis contact tracing among suburban Atlanta heterosexual youth (Rothenberg et al., 1998)

Progressive cumulation of persons and partnerships over time



# Cumulated romantic network, midwestern US high school (Moody, 2002)

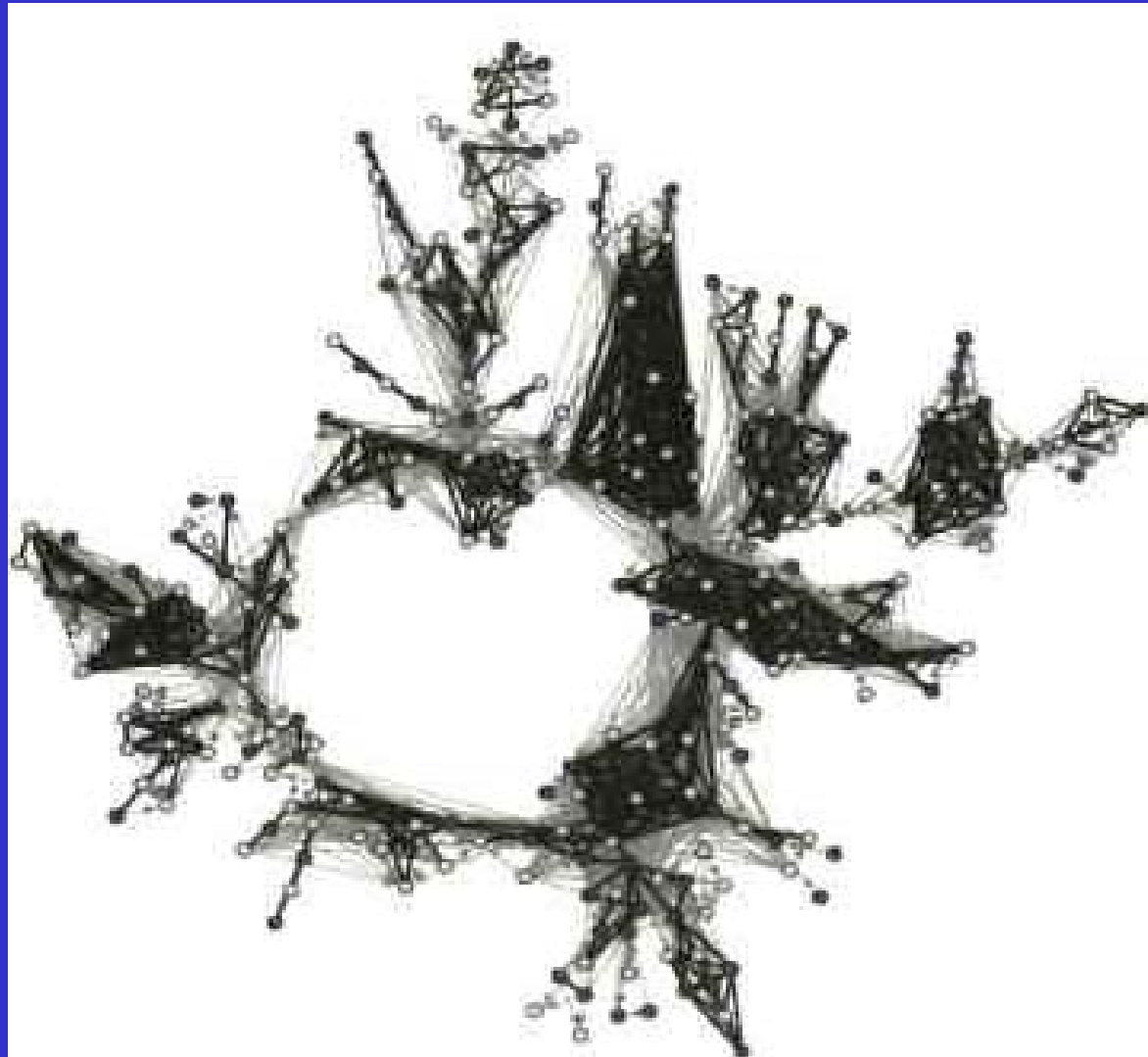
**54% of all romantically involved students directly or indirectly linked to each other when considered statically**



# Time-ordered romantic network, midwestern US high school (Moody, 2002)

Partnership timing fragments network, inhibiting transmission (network isn't a true sexual network, though)

Time ordered paths (black = bidirectional, gray unidirectional)

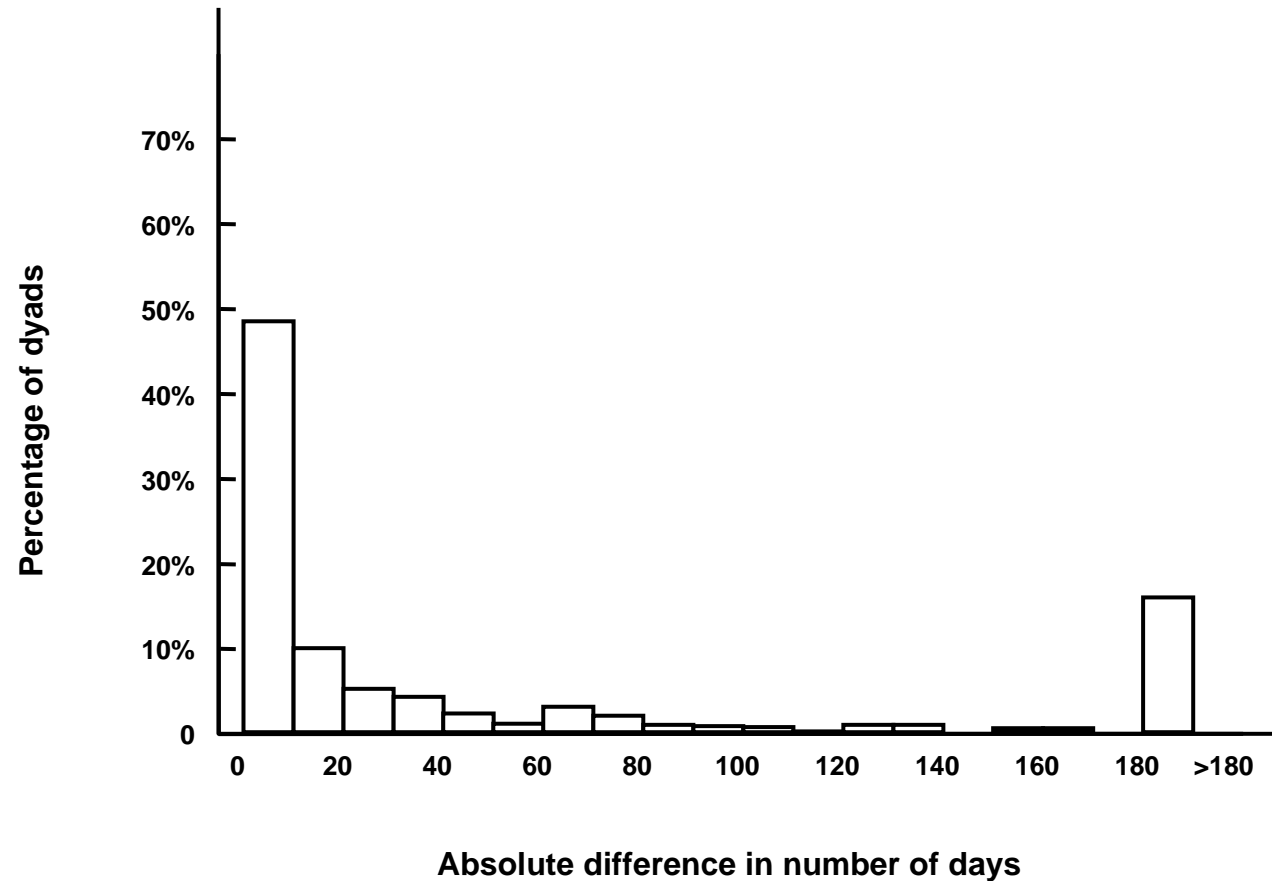


**Analysis of time-ordered networks and concurrency requires reliable and valid data on partnership timing**

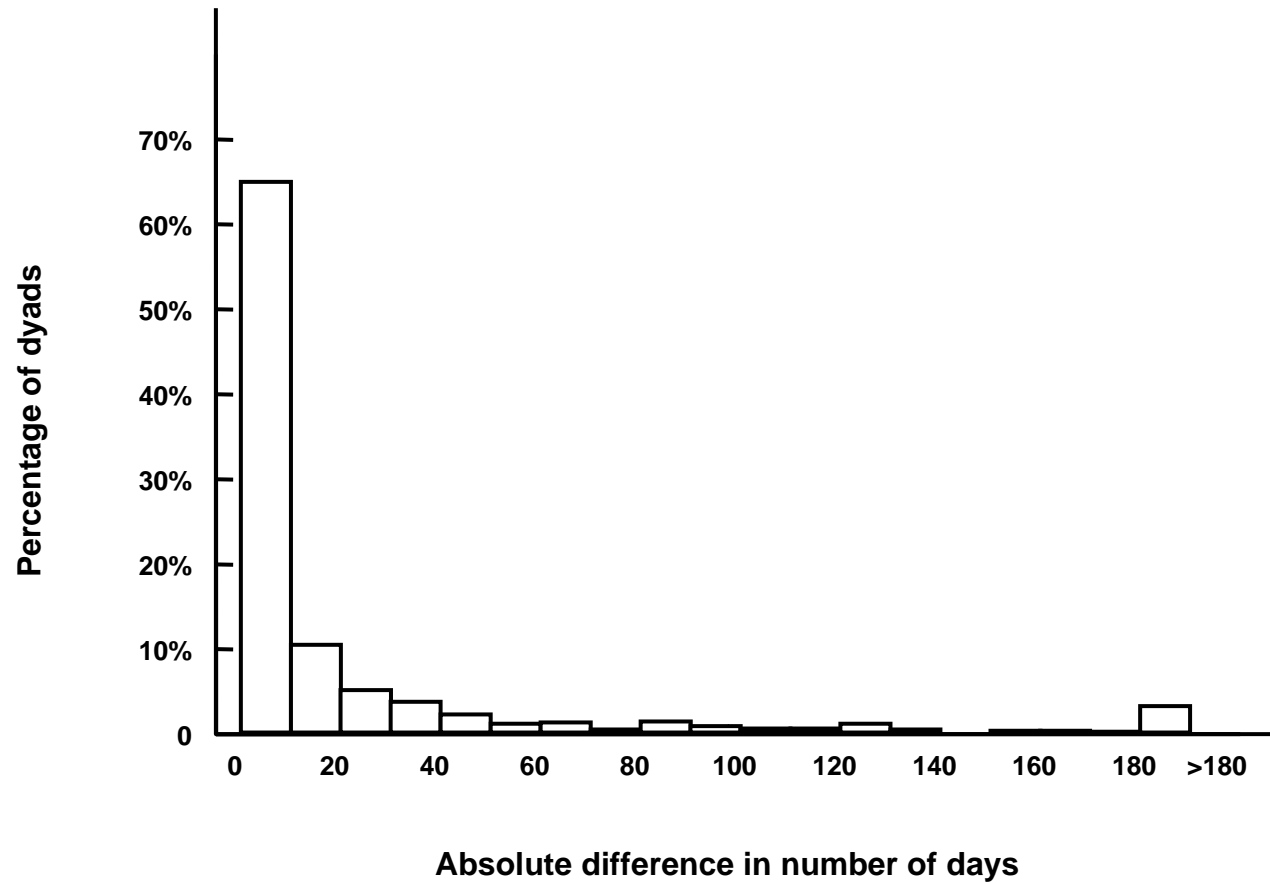
**Reliability:**

- agreement between partners who report contact with each other**
- consistency of reports across interviews of same person**

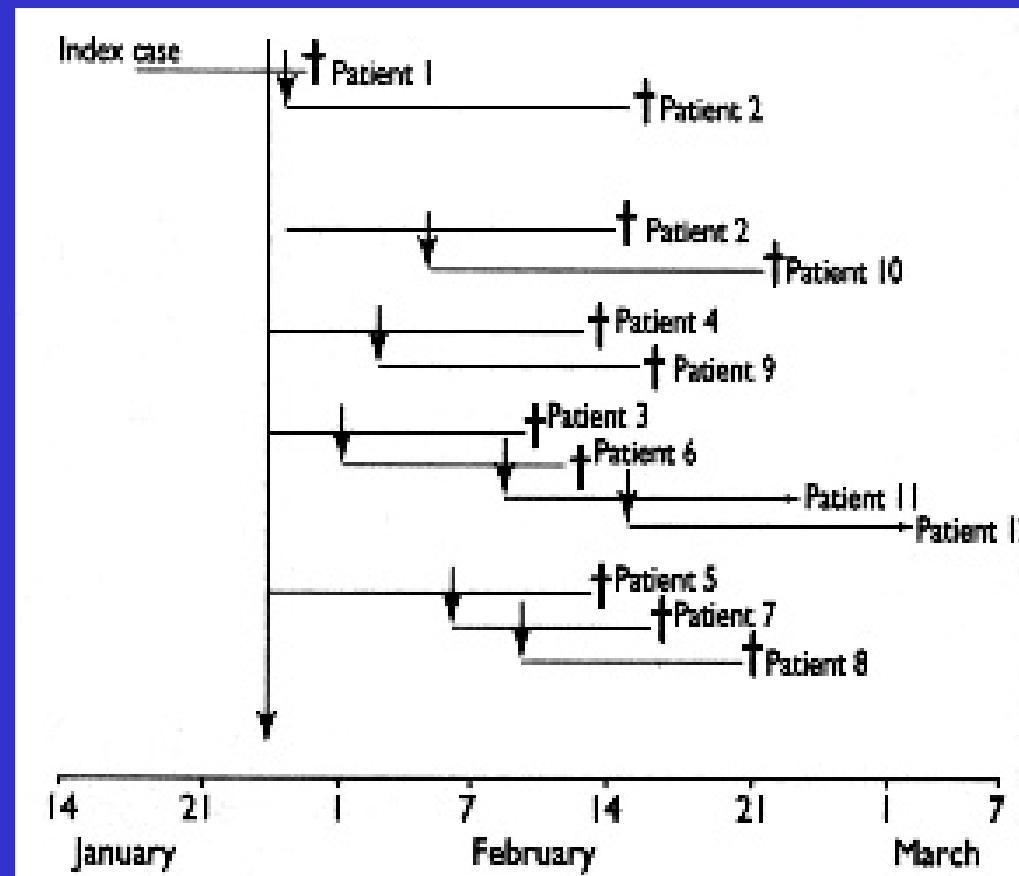
# Agreement in reported date of first sex - contact tracing data sets (Brewer, Rothenberg et al., 2006)



# Agreement in reported date of last sex - contact tracing data sets (Brewer, Rothenberg et al., 2006)



# Lassa fever: Person, time, and fomites in a Nigerian hospital (Fisher-Hoch et al., 1995)

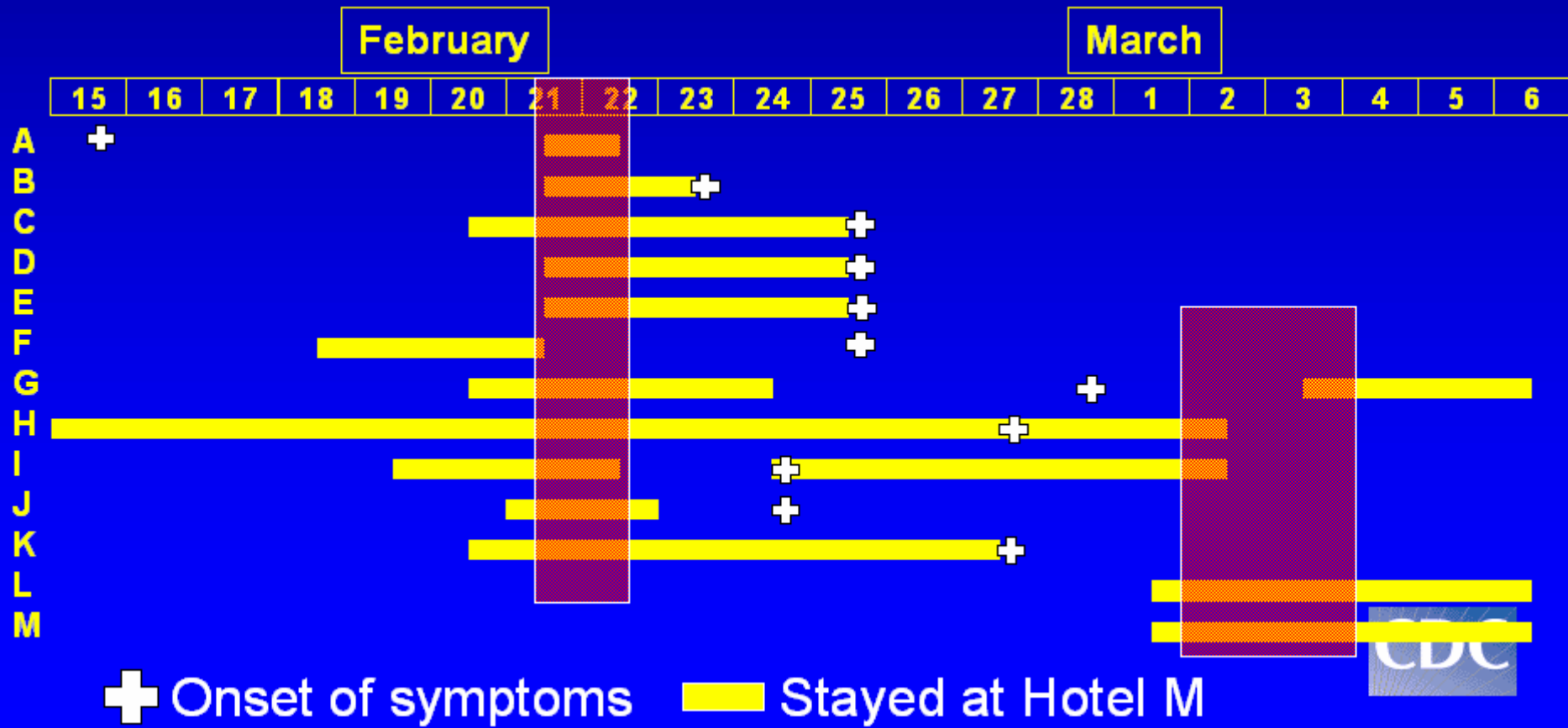


5 temporally ordered clusters of infections defined by shared medicines and syringes



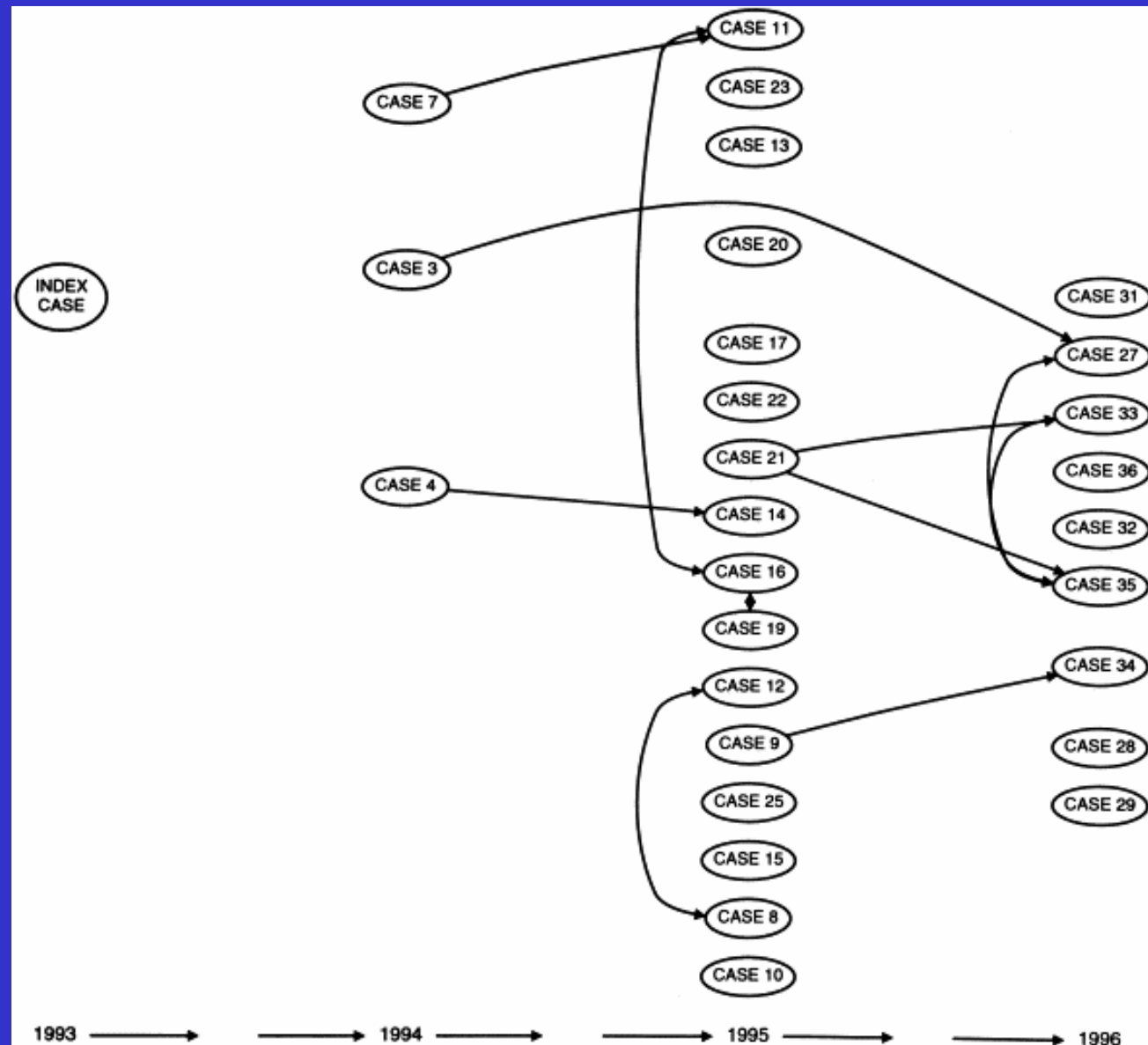
# SARS: person, place, & time (CDC, 2003)

## The Hong Kong connection: Hotel M



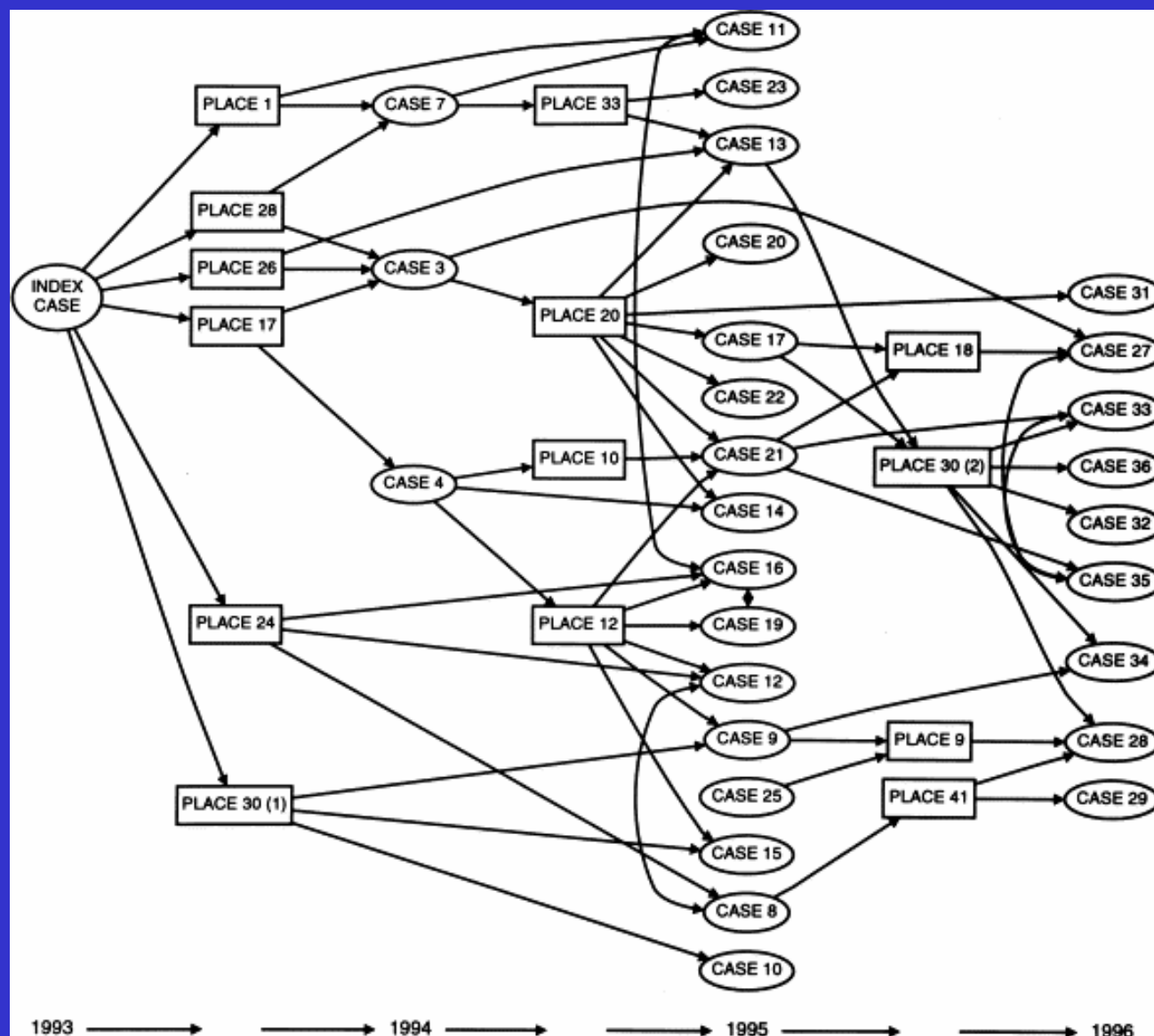
## TB in Houston: person & time (Klovdahl et al., 2001)

All cases had identical DNA fingerprints, but only 50% had known contact with another case



## TB in Houston: person, place, & time (Klovdahl et al., 2001)

Nearly all cases linked by places frequented in common or direct/indirect contact



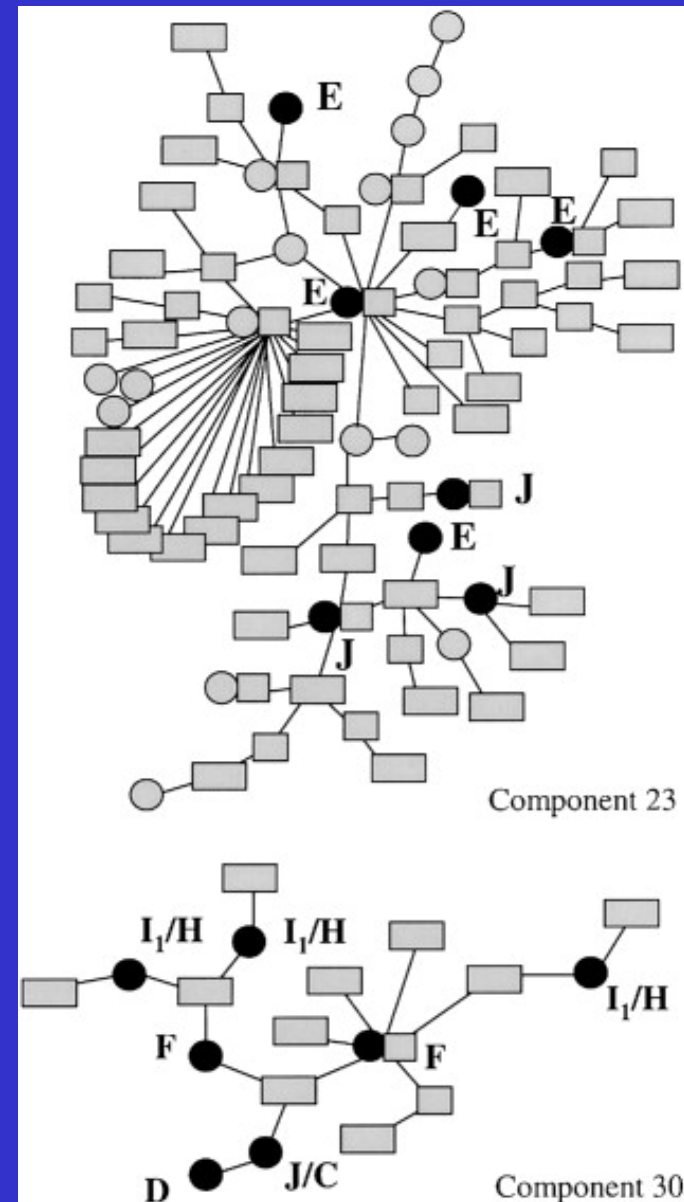
## **Person and molecular biology**

### **Combining network and molecular data**

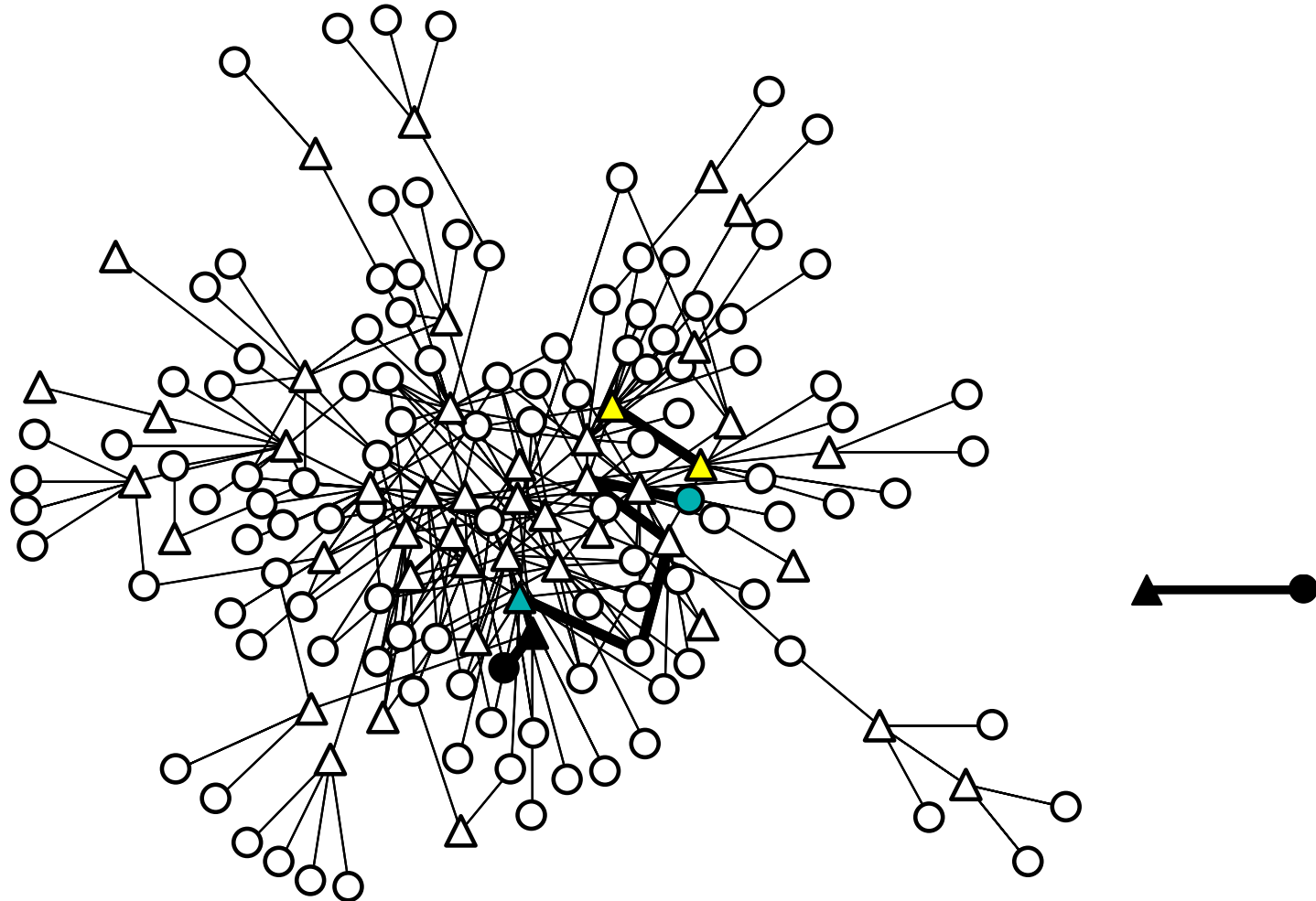
- **validate reported exposures**
- **reconstruct course of transmission**
- **identify particular behaviors & contextual factors (place, time, physical setting/fomites) associated with transmission**

# Chlamydia contact tracing, Manitoba - person and Ct genotype (Cabral, Jolly et al., 2003)

**Genotypic concordance within components**



# HCV transmission pairs in Seattle IDUs: person & HCV DNA (Brewer, Hagan et al., 2006)



Same color nodes, thick links = transmission pairs

**Transmission may also be interrupted or obscured by immunological factors, e.g.:**

- **male clearance of chlamydia** (Parks et al.; Potterat et al.)?
- **transient infections of HCV and HIV?**
- **CCR5-conferred immunity to HIV?**
- **herd immunity for HIV (lack of highly viremic response to reinfection)**

# Miscarriage of HIV epidemiology in sub-Saharan African and other poor countries

Despite billions of dollars invested in research, key modes of transmission poorly specified (Gisselquist et al.)

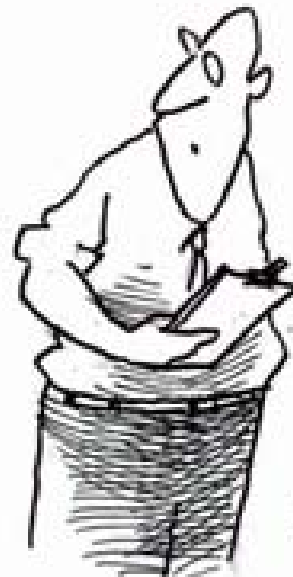
Basic evidence lacking:

- no contact tracing
- no attention to place or time
- no broad inventory of exposures
- no linking of DNA sequencing to above

Outcome: know (almost) nothing

HOW DO YOU SPELL  
"BLOODBORNE  
RETROVIRUS" ?

HM, NO IDEA...  
JUST PUT "SEX"  
INSTEAD.



MARK  
JONES  
05

# Conclusions

**Examples pointed in right direction, but greater comprehensiveness needed**

**Main recommendations:**

**Return to epidemiologic fundamentals**

- **re-emphasize investigation of all key components of ID transmission**

**Apply right design for question**

- **discard atomistic sampling and focus for many topics**

**To illuminate diffusion processes in the social sciences more brightly:**

- focus on specific events defined by time, place, and communication mode**
- static networks in unanchored social space insufficient**