



## Do Facebook and Other Social Networks Influence Health and Behavior?

Development of network data and methods for the study of health and health care

### SUMMARY

Social network analysis is an emerging science based on the notion that how a person behaves depends in part on his or her social ties to others. People are part of social networks that can have important consequences for many aspects of human experience, including health and disease.

From 2007 to 2010, a team of researchers at Harvard University, led by Nicholas Christakis, M.D., Ph.D., M.P.H., the principal investigator, built several health-related social network data sets and used them to analyze the role social networks play in health and health care. Thomas Keegan, Ph.D., was the project director.

### Findings

- Health behavior phenomena, like smoking and alcohol use, are shown to spread from person to person to person in a social network.
- Subjective well-being, as measured by positive answers on the depression scale used in the Framingham Heart Study, is shown to spread from person to person in a social network.
- These findings (in the two bullets above) when combined with other results, provide compelling evidence that the spread of important health and behavioral phenomena from person to person exists and can be studied in social network data sets.
- Experimental results in cooperation games have shown that generosity spreads from person to person to person through social contacts.
- Real effects of social networks can be discerned reasonably well using online sources of data such as information placed online by Facebook users.

### Funding

The Robert Wood Johnson Foundation (RWJF) provided a \$652,516 grant to support this project.

## CONTEXT

Social network analysis is an emerging science based on the notion that how a person behaves depends in part on his or her social ties to others. People are part of social networks that can have important consequences for many aspects of human experience, including health and disease. Examples of network effects include:

- Influences of peers on eating habits and substance use
- The effect of a spouse's illness on one's own health

Understanding how health behaviors and health care practices spread within social networks has the potential to contribute to people's understanding of a wide array of health phenomena, improve evaluations of health care interventions, and perhaps radically alter people's current view of health care policy and practices.

### The Grantee's Prior Work

Since the early 2000s Christakis, a professor of medical sociology in the Department of Health Care Policy at Harvard Medical School, has studied the use of network analysis as a way to shed light on health and health care in the United States. His work includes articles in the *New England Journal of Medicine* that:

- Measured the link between a spouse's hospitalization and increased mortality of his or her partner<sup>1</sup>
- Analyzed the spread of obesity in a large social network<sup>2</sup>

Christakis, the principal investigator for this project, is an alumnus of *RWJF's Clinical Scholars* program and a past winner of an *Investigator Awards in Health Policy Research* program award from the Foundation.

### *The Framingham Heart Study Network Data Set*

Since 1948, researchers have conducted a longitudinal study examining the incidence and causes of cardiovascular disease among residents of Framingham, Mass.—the Framingham Heart Study. In order to track and re-locate subjects over time, the researchers collected contact information, including close relatives and some friends.

In the mid-2000s, Christakis and his colleagues digitized the study's contact information, creating a social network data set—the Framingham Heart Study-Network data set (FHS-Net). Because of the large, intergenerational scale of the Framingham Heart Study, many

---

<sup>1</sup> Christakis NA and Alison PD. "Mortality After Hospitalization of a Spouse." *New England Journal of Medicine*. 2006 354(7):719–730. Available [online](#).

<sup>2</sup> Christakis NA and Fowler JH. "The Spread of Obesity in a Large Social Network Over 32 Years." *New England Journal of Medicine*. 2007 357:370–379. Available [online](#).

subject contacts were also themselves subjects, allowing the Christakis team to draw connections between them, such as:

- The spread of health-related behaviors (for example, obesity, smoking, alcohol use, exercise and diet)
- The spread of diseases (diabetes, hypertension and depression)
- The role of social networks in health disparities
- How network phenomena (among both patients and providers) might be exploited to improve health and health care

For more on the Framingham Heart Study and the derivation of the FHS-Net data set, see the [Appendix](#).

### **RWJF's Interest in This Area**

Previous work funded by RWJF and others suggests that knowledge about how health behaviors and health care practices spread within social networks could improve understanding of a wide array of health phenomena, including obesity, epidemics of bad health behaviors and health disparities.

What has been needed is more and richer data sets and innovative statistical methods to enable researchers to thoroughly explore the spread of health problems, outcomes and care processes—both good and bad—within complex, real-world social networks that evolve across time.

RWJF program staff thought it was possible that an understanding of social linkages between relatives, friends, co-workers, neighbors and physicians could drive a valuable rethinking of aspects of health policy, clinical care, research and evaluation.

### **THE PROJECT**

Under this grant, Christakis and his team built several health-related social network data sets and used them to analyze the role social networks play in health and health care.

#### **Expanding FHS-Net**

The team expanded and updated the FHS-Net data set by:

- Adding more than 4,000 new cases from the original Framingham Heart Study cohort to the network
- Completing entry of data from the 2005–08 examination of the heart study, bringing the data set nearer to the present time

- Assigning a geographic code to all individuals in the data (thus facilitating a spatial mapping of the network data)
- Deriving a parallel network of doctors who cared for patients in the FHS-Net

Researchers placed a version of this core data set (FHS-Net Social Networks) in the public domain as part of NIH's dbGaP initiative (database of Genotype and Phenotype initiative). The data set, which was modified to protect the privacy of the heart study subjects, is available [online](#).

## Developing New Data Sets

Christakis and his research team also developed new data sets:

- Collaborating with Lei Jin, Ph.D., a former *RWJF Scholar in Health Policy Research* at the Chinese University of Hong Kong, the team created a hospital network data set. It included data on more than 5,000 hospitals and Medicare claims for 32 million patients for the period 2006–07. Researchers used the data to map patient-sharing networks of hospitals in the United States and develop measures of competition between and cooperation among hospitals.
- With Laszlo Barabasi, Ph.D., of Northeastern University, the team developed the Human Disease Network of more than 2,000 diseases, based on Medicare hospitalization records for 32,000,000 people over a four-year period, 1990–93. In the network, data is arranged at the patient level and a link exists when one patient has two diseases. The data set is available [online](#).

In the final year of this RWJF grant, mid-2009, researchers entered into a separate collaboration with Barabasi to explore the feasibility of developing new data sets based on cell phone networks.

- The team developed a social network data set based on Facebook membership. It characterizes the tastes and network ties of a sample of 1,700 undergraduates at an American university followed annually for four years, 2006–09.

## Communications

Christakis and his colleagues published 18 papers based solely or in part on funded work, including three on FHS-Net. Other papers addressed social networks and loneliness, depression, alcohol consumption, health screening and analysis methods. See the Bibliography for details.

The team sponsored meetings in 2008 and 2009 on the methodology of social network analysis. Each two-day “Meeting on Methodology for Empirical Research of Social Interactions, Social Networks and Health” brought together researchers from around the world in the areas of econometrics, statistics and social networks analysis. For more information about these meetings see the [Bibliography](#).

## FINDINGS

Keegan identified the following as researchers' most significant findings. The source for each finding is included with the finding:

- **Health behavior phenomena, like smoking and alcohol use, are shown to spread from person to person to person in a social network.** (“[The Collective Dynamics of Smoking in a Large Social Network](#),” *New England Journal of Medicine*, 2008; and “[The Spread of Alcohol Consumption Behavior in a Large Social Network](#),” *Annals of Internal Medicine*, 2010.)
- **Subjective well-being, as measured by positive answers on the depression scale used in the Framingham Heart Study, is shown to spread from person to person in a social network.** (“[Dynamic Spread of Happiness in a Large Social Network: Longitudinal Analysis Over 20 Years in the Framingham Heart Study](#),” *British Medical Journal*, 2008.)
- **These findings—the two bullets above—when combined with other results—provide compelling evidence that the spread of important health and behavioral phenomena from person to person exists and can be studied in social network data sets.** (“[Estimating Peer Effects on Health in Social Networks](#),” *Journal of Health Economics*, 2008.)
- **Experimental results in cooperation games have shown that generosity spreads from person to person to person through social contacts.** (“[Cooperative Behavior Cascades in Human Social Networks](#),” *PNAS: Proceedings of the National Academy of Sciences*, 2010.)
- **Real effects of social networks can be discerned reasonably well using online sources of data such as information placed online by Facebook users.** This makes the world online social networks a valuable source of data about people and their well-being. (“[Tastes, Ties, and Time: A New Social Network Dataset Using Facebook.com](#),” *Social Networks*, 2008.)

*“The body of work supported by this grant has demonstrated how the health states of one person, and thus the effects of health policy on each person, affect the health of other individuals to whom he or she is connected,” says Principal Investigator Nicholas Christakis*

See the [Bibliography](#) for details on journal articles cited above.

## SIGNIFICANCE OF THE PROJECT

“The body of work supported by this grant has demonstrated how the health states of one person, and thus the effects of health policy on each person, affect the health of other individuals to whom he or she is connected,” says Principal Investigator Christakis.

“Since we began publishing work in this area, interest in social network effects on health has increased dramatically.”

## LESSONS LEARNED

1. **In undertaking social network research, look first for quality data.** In this project researchers found that the quality of their network research in the health domain is very dependent upon the quality of the health data on individuals that can be linked to the network data. (Principal Investigator/ Christakis)
2. **Ideally, any large population health studies should include social network measures from their inception.** This would provide enormous value to social network research and—because of network effects on individual health—to basic health and health services research. (Principal Investigator/ Christakis)

## AFTERWARD

The research team is continuing to improve the data sets that were the focus of this project and to conduct research on evidence of health and other outcomes in these data sets. Substantial support for this work comes from the National Institutes of Health, which awarded Christakis an \$11 million grant in 2008, during the RWJF grant. Their work includes:

- Using the project’s hospital network data set (see [Developing New Data Sets](#)) to investigate how the characteristics of local patient-sharing networks and hospitals’ network positions influence the adoption of new technology and patient treatment outcomes in hospitals
- Research based on the physicians’ network derived from the FHS-Net data set (see [Expanding FHS-Net](#))

---

**Prepared by: James Wood**

Reviewed by: Bob Narus and Molly McKaughan

Program officer: Lori A. Melichar

Grant ID # 058729

Program area: Pioneer

---

## APPENDIX

### The Framingham Heart Study and the Framingham Heart Study Network Data Set (FHS-Net)

#### *The Framingham Heart Study*

This is a landmark set of related cohort studies that have been ongoing for decades, with the goal of identifying common factors contributing to cardiovascular disease. It is a project of the National Heart, Lung and Blood Institute, and Boston University.

In 1948, 5,209 people (the majority of all adult residents of the town of Framingham, Mass.) were impaneled into the so-called Original Cohort, and they have participated in a rigorous longitudinal study ever since.

In 1971, the so-called Offspring Cohort, composed of most of the then-living offspring of the Original Cohort, and their spouses, was impaneled. This cohort of 5,124 individuals has been studied every few years since, with almost no loss to follow-up outside of death (only 20 of the cohort have died).

Participants in all these cohorts come into a central facility every two years for detailed physician-administered examinations, lab tests and survey data collection (e.g., regarding health behaviors and socioeconomic attributes).

The Framingham Heart Study is maintained by the National Heart Lung and Blood Institute, and Boston University. More information about it is available [online](#).

#### *The Framingham Heart Study Network (FHS-Net)*

Christakis and his team used data from seven survey waves during the period 1971 to 2003—centered in 1973, 1981, 1985, 1989, 1992, 1997 and 1999—and also have collected data from additional waves.

To create the data set used in this project, researchers computerized information about the Offspring Cohort that was in archived, handwritten “tracking sheets.” These sheets contain valuable social network information because they systematically and comprehensively identify relatives and friends named by the subject in response to questions about who might be in a position to know how to locate them in the near future. The tracking sheets collect complete information about all first-order relatives (parents, spouse, siblings, children), whether alive or dead. In addition they record, at each wave, at least one “close friend.” Finally, they record where a person lives and works, which can be used to identify neighbors and co-workers.

A key fact is that, given the compact nature of the Framingham population in the study period, many of those individuals linked to the subjects also happen to be participants in one or more Framingham cohort.

Overall, there were 34,992 observed social and family ties to the project's 5,124 subjects, yielding an average of 6.83 ties per subject. These ties include several members of the subjects' nuclear families. For example, 86 percent of subjects' spouses were directly and repeatedly observed, and 55 percent of the 5,124 subjects were connected via friendship to another person who was observed in the network.

This is the only data set in existence that has this many people followed and repeatedly measured for this many years, with longitudinal information on network-tie formation and disruption.

## BIBLIOGRAPHY

(Current as of date of the report; as provided by the grantee organization; not verified by RWJF; items not available from RWJF.)

### Articles

#### Journal Articles

Arbesman S and Christakis NA. “Leadership Insularity: A New Measure of Connectivity Between Central Nodes in Networks.” *Connections*. 2010; 30(1):4–10. Available [online](#).

Christakis NA and Fowler JH. “The Collective Dynamics of Smoking in a Large Social Network.” *New England Journal of Medicine*. 2008; 358(21):2249–2258. Available [online](#).

Fowler JH and Christakis NA. “Dynamic Spread of Happiness in a Large Social Network: Longitudinal Analysis Over 20 Years in the Framingham Heart Study.” *British Medical Journal*. 2008; 337:a2338 (doi:10.1136/bmj.a2338). Available [online](#).

Fowler JH and Christakis NA. “Estimating Peer Effects on Health in Social Networks.” *Journal of Health Economics*. 2008; 27(5):1400–1405. Available [online](#).

Fowler JH and Christakis NA. “Cooperative Behavior Cascades in Human Social Networks,” *PNAS: Proceedings of the National Academy of Sciences*. 2010; 107(9):5334–5338. Available [online](#).

Fowler JH, Dawes CT and Christakis NA. “Model of Genetic Variation in Human Social Networks.” *PNAS: Proceedings of the National Academy of Sciences*. 2009; 106(6):1720–1724. Available [online](#).

Hidalgo CA, Blumm N, Barabasi AL and Christakis NA. “A Dynamic Network Approach for the Study of Human Phenotypes.” *PLoS Computational Biology*. 2009; 5(4): e1000353 (doi:10.1371/journal.pcbi.1000353). Available [online](#).

Lee DS, Park J, Kay KA, Christakis NA, Oltvai ZN and Barabasi AL. “The Implications of Human Metabolic Network Topology for Disease Comorbidity.” *PNAS: Proceedings of the National Academy of Sciences*. 2008; 105(29):9880–9885. Available [online](#).

Lewis K, Kaufman J, Gonzalez M, Wimmer A and Christakis NA. “Tastes, Ties, and Time: A New Social Network Dataset Using Facebook.com.” *Social Networks*. 2008; 30(4):330–342. Available [online](#).

Mednick SC, Christakis NA and Fowler JH. “The Spread of Sleep Loss Influences Drug Use in Adolescent Social Networks.” *PLoS One*. 2010; 5(3):e9775. Available [online](#).

Onnela JP, Arbesman S, Gonzalez MC, Barabasi AL and Christakis NA. “Geographic Constraints on Social Network Groups.” *PLoS One*. 2011; April 6(4):e16939. Available [online](#).

Rosenquist JN, Fowler JH and Christakis NA. “Social Network Determinants of Depression.” *Molecular Psychiatry*. 2011; 16:273–281. Available [online](#).

Rosenquist JN, Murabito J, Fowler JH and Christakis NA. “The Spread of Alcohol Consumption Behavior in a Large Social Network.” *Annals of Internal Medicine*. 2010; 152(7):426–433. Available [online](#).

Smith KP and Christakis NA. “Social Networks and Health.” *Annual Review of Sociology*. 2008; 34:405–429. Available [online](#).

O’Malley AJ and Christakis NA. “Longitudinal Analysis of Large Social Networks: Estimating the Effects of Health Traits in Changes in Friendship Ties.” *Statistics in Medicine*. 2011; 30:950–964. Available [online](#).

## Books & Chapters

### *Books*

Christakis NA and Fowler JH. *Connected: The Surprising Power of Our Social Networks and How They Shape Our Lives*. New York: Little Brown, 2009. Table of contents and 32-page excerpt available [online](#).