Combining Information from Multiple Data Systems to Enhance Analyses Related to Health: Examples and Lessons Learned*

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1. REASONS FOR COMBINING INFORMATION (Schenker and Raghunathan 2007, *Stat Med*)

- **Want more information in the face of limited resources**
  - **Cannot conduct a new study for every new problem of interest**
- **Take advantage of different strengths of different surveys**
- **Use one survey to supply information lacking in another**
- **Lower bias and improve precision**

2. THREE PROJECTS THAT INVOLVED COMBINING INFORMATION (PLUS A BIT ABOUT SOME OTHERS)

A. Combining data from a survey of households and a survey of nursing homes to extend coverage (Schenker *et al*. 2002, *Public Health Rep*)

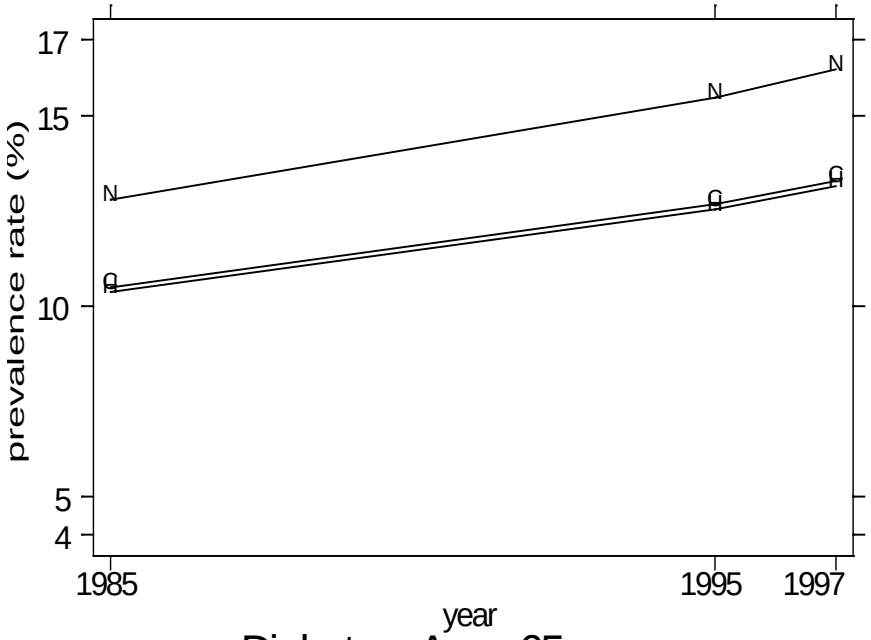
- **Motivation**
  - **More comprehensive estimates of prevalences of chronic conditions for the elderly**
  - **Avoid misleading results due to concentrating on a subset of the population**

- **Surveys used**
  - **National Health Interview Survey (NHIS) for 1985, 1995, 1997 (http://www.cdc.gov/nchs/nhis.htm)**
    - **Principal source of information on the health of the civilian non-institutionalized population of U.S.**
    - **Household members asked about specific conditions**
  - **National Nursing Home Survey (NNHS) for 1985, 1995, 1997 (http://www.cdc.gov/nchs/nnhs.htm)**
    - **Continuing series of nationally representative sample surveys of U.S. nursing homes, their services, their staff, and their residents**
    - **Staff asked to list primary and limited number of other diagnoses for selected residents, with the aid of medical records**

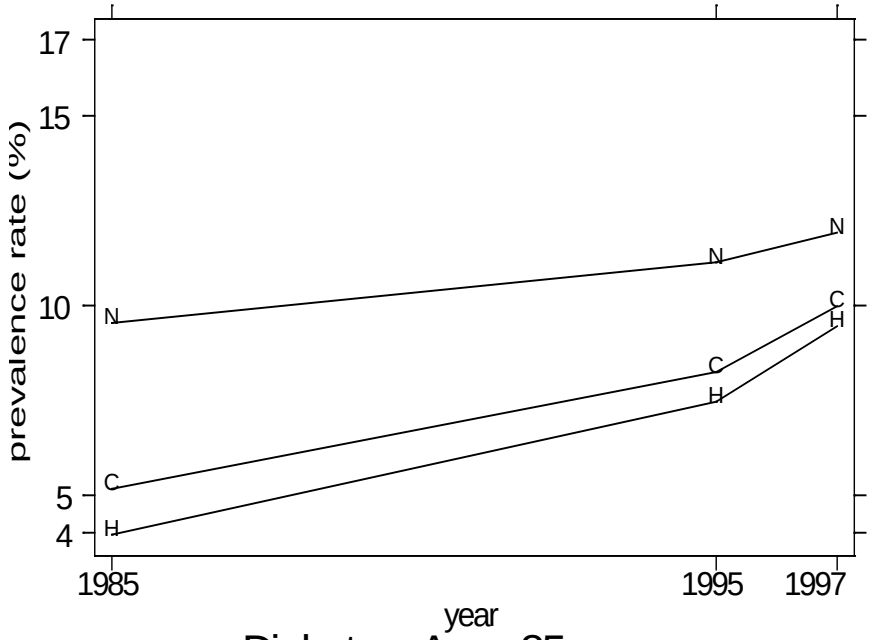
- **Estimated distribution into households and nursing homes during time of study**
  - **Ages 65+: 95% in households, 5% in nursing homes**
  - **Ages 85+: 79% in households, 21% in nursing homes**
- **Calculated combined, design-based prevalence estimates for chronic conditions**
- **Relatively simple problem**
  - **Target populations for the two surveys (nearly) disjoint**

- **Separate and combined estimated prevalence rates for diabetes, by age group, 1985, 1995, and 1997**

(H = households; N = nursing homes; C = combined)



Diabetes, Ages 65+



Diabetes, Ages 85+

B. Using information from an examination-based health survey to improve on analyses of self-reported data in a larger interview-based survey (Schenker *et al*. 2010, *Stat Med*)

- **Motivation**
  - Data on health conditions often from large surveys (e.g., NHIS) using questions such as:

    "Has a doctor or other health professional ever told you that you have <condition of interest>?"

    OR

    "What is your <height/weight>?"
  - Such self-reported data might not accurately reflect prevalences of health conditions

- **Method for improving on analyses of self-reported data**
  - **National Health and Nutrition Examination Survey (NHANES) (http://www.cdc.gov/nchs/nhanes.htm)**
    - ♦ **Program of studies designed to assess health and nutritional status of adults and children in U.S.**
    - ♦ **Asks self-report questions during an interview**
    - ♦ **Also obtains clinical measures for many interviewees based on a physical examination**
  - **Fitted "measurement error" models to NHANES data predicting clinical outcome from self-report answer and covariates**
  - **Used the fitted models to multiply impute clinical outcomes for persons in the NHIS**

- **Comparison of 1999-2002 NHIS Estimated Prevalence Rates for Persons of Ages 20 Years and Above: Self-Reported (SR) Data versus Multiply Imputed Clinical (MICL) Data**

Categories		Hypertension		Diabetes		Obesity	
		SR	MICL	SR	MICL	SR	MICL
Education	< HS Grad.	30.9	39.5	11.1	14.2	25.7	30.1
	HS Grad.	22.9	30.1	6.6	8.8	23.5	28.1
	> HS Grad.	16.5	22.8	4.2	6.5	18.7	23.1
Race/ Ethnicity	Hispanic	14.1	20.8	6.9	9.7	23.2	28.2
	N.H. Black	26.7	35.1	8.8	11.3	29.9	34.8
	N.H. White	20.8	27.6	5.6	7.9	19.8	23.1

Note: Certain records were excluded from the data for this study due to missing covariate values. NHANES sample size = 6,110. NHIS sample size = 105,252.

- **Ratios of Estimated Standard Errors of Estimated Prevalence Rates for Persons of Ages 20 Years and Above Based on Data from Survey Years 1999-2002: (NHANES Clinical) ÷ (NHIS Multiply Imputed Clinical)**

Categories		Hypertension	Diabetes	Obesity
Education	< HS Grad.	2.2	3.2	2.4
	HS Grad.	1.9	2.1	3.5
	> HS Grad.	2.7	1.9	4.1
Race/ Ethnicity	Hispanic	3.3	3.9	2.8
	N.H. Black	2.1	3.3	2.9
	N.H. White	2.5	2.2	3.7

Note: Certain records were excluded from the data for this study due to missing covariate values. NHANES sample size = 6,110. NHIS sample size = 105,252.

C. Combining information from two health surveys to enhance small-area estimation (Raghunathan *et al*. 2007, *J Amer Statist Assoc*; Davis *et al*. 2010, *Public Health Rep*)

- **Project led by National Cancer Institute, with collaboration by:**
  - **National Center for Health Statistics**
  - **National Center for Chronic Disease Prevention and Health Promotion**
  - **University of Michigan**
  - **University of Pennsylvania**
  - **Information Management Services**

- **Motivation**
  - **Interest in local (e.g., county-level, state-level) prevalences of cancer risk factors and screening**
  - **Different surveys have different strengths**
  - **Combining information from surveys could improve small-area estimates**

- **Surveys used**
  - ♦ **Behavioral Risk Factor Surveillance System (BRFSS) (http://www.cdc.gov/brfss/)**
    - **+ Large; almost all counties in sample**
    - **- Telephone survey**
      - **⇒ Non-coverage of non-telephone households; high nonresponse rates**
  - ♦ **NHIS**
    - **+ Face-to-face survey**
      - **⇒ Includes non-telephone households (and a question identifying type of household); higher response rates**
    - **- Smaller; only about 25% of counties in sample**
- **Problem can be viewed as one of coverage error and missing data**

- **Project developed Bayesian methods to combine information from the two surveys; also incorporated telephone coverage rates from the census**

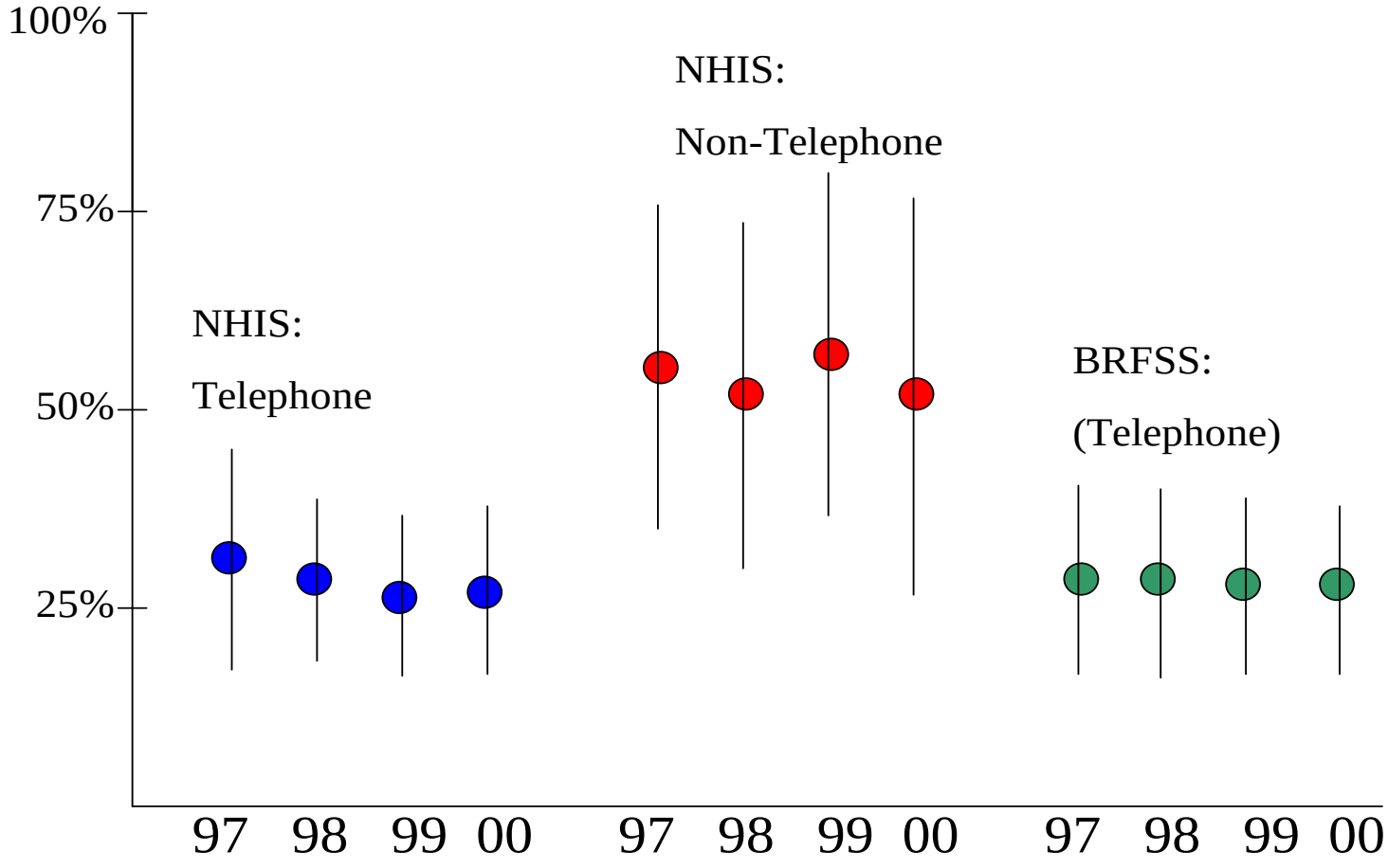
- **National Cancer Institute released estimates for two time periods: 1997-99 and 2000-03 (http://sae.cancer.gov/)**

  - Smoking, mammography, and pap smear

  - Counties, health service areas, and states

- **Current work involves more recent years and including component for cell-phone-only households**

- **Means and standard deviations of county-level direct estimates of current-smoking rates for men, 1997 – 2000**



- **Summaries of Bayesian BRFSS-alone and BRFSS/NHIS county-level estimates of prevalence rates for current smoking among adult males in 2000, by range of telephone non-coverage rates (based on work described in Raghunathan et al. 2007)**

Range of Telephone Non-Coverage Rates (%)	Mean of County-Level Estimates (%)	
	BRFSS-Alone	BRFSS/NHIS
< 2	20.6	20.4
2 – 3	21.1	23.0
3 – 5	21.9	24.3
5 – 8	23.0	25.7
8 – 10	24.1	26.6
10 – 15	24.4	27.7
15 – 20	25.4	29.8
≥ 20	24.1	30.8

D. Other Projects

- **Combining multiple years of survey data (e.g., NCHS 2012, Appendix VI)**
  - **Increases sample size $\Rightarrow$ can increase precision**
  - **Need to check comparability of variables**
  - **Need to be careful about weights, strata, PSUs**

- **NCHS record linkage program (http://www.cdc.gov/nchs/data_access/data_linkage_activities.htm)**
  - **Enables researchers to examine factors that influence disability, chronic disease, health care utilization, morbidity, and mortality**
  - **Data being linked to various NCHS surveys**
    - **Environmental Protection Agency air quality data**
    - **National Death Index death certificate records**
    - **Medicare enrollment and claims data**
    - **Social Security benefit data**
  - **Analytic issues:**
    - **Accounting for sample design**
      - **e.g., Schenker et al. (2011, *Stat Med*)**
    - **Adjusting for cases not linked**

3. LESSONS LEARNED ABOUT COMBINING INFORMATION

- **Technical lessons**
  - Can yield gains, especially when the data systems have complementary strengths
  - Comparability is crucial
  - Use care in dealing with different sample designs
  - Try to find good predictors
  - Might need to deal with small samples, sparse data

- **Administrative lessons**
  - Sharing data and estimates among multiple organizations can require a lot of work
  - Important to educate secondary users on methods used and limitations of results

4. POTENTIAL APPLICATIONS TO "BIG DATA"?

- **Advantages and disadvantages of Big Data**

  + **Big**
  + **Timely**
  + **Predictive (sometimes)**
  + **Cheap (?)**

  - **Unknown population representation**
  - **Issues of data quality**
  - **Typically not very multivariate (at the person level)**
  - **Privacy and confidentiality issues**
  - **Difficult to assess accuracy and uncertainty**

- **Combine Big Data with carefully collected small data to take advantage of strengths of both?**

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