Quality of Data Processing

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Disclaimer

- The findings and views expressed here are those of the author(s) and do not necessarily reflect the policies of the Bureau of Labor Statistics (BLS) or the Federal Government.

- **Source:** Workshop 2 speakers, summary document by Alexandra Brown and Andrew Caporaso (JPSM)

- However... all mistakes are mine.
Members of Subgroup

- Joe Schafer, Census Bureau (Lead)
- Wendy Martinez, BLS
- Brian Sauer, Veterans Administration
- Lisa Mirel, National Center for Health Statistics
Three Workshops

Workshop 1: Quality of Input Data
December 1, 2017

Workshop 2: Quality of Data Processing
January 25, 2018

Workshop 3: Quality of Output Data / Synthesis
February 26, 2018
Questions to be Addressed

- In context of integrated data, what should be communicated to users of the final data products:
  - **Fitness for use:**
    - Quality features when deciding to use a data source
    - Quality features to understand strengths and weaknesses of final product

- **Communication:** Best way to communicate quality features to diverse audience
Data Processing – Integrated Data

- **Record linkage**: exact match, privacy-preserving.
- **Using multiple frames**: drawing samples from two or more frames to improve coverage or reduce costs.
- **Statistical matching**: Joining two or more non-overlapping samples by variables shared in common, then applying modeling or imputation techniques to handle missing values.
Data Processing – Integrated Data

- **Models for combining statistics:** Combining estimates from different sources at national, subnational or subpopulation levels, as in small-area estimation.

- **Dimension reduction:** Techniques for summarizing unstructured data (e.g., images, free-form text)

- **Harmonization:** Combining information across data sets in the presence of mode effects, differing definitions or granularities.
Data Processing – Integrated Data

- **Edit and Imputation**: Other types of cleaning after data sources are combined.
- **Adjusting for Representativeness**: Making combined data more representative of the intended population.
- **Estimation**: Computing estimates of population quantities and associated measures of uncertainty.
Data Processing – Integrated Data

- **Disclosure Avoidance**: Techniques for preventing re-identification of de-anonymization of individual records
- **Provenance and Curation of Metadata**: Preserving information about data sources, dictionaries, audit trails, etc.
Prioritizing the Topics

Which of these topics are

- substantially more complicated or qualitatively different when combining multiple data sources?
- less familiar to statisticians and methodologists?
- not well covered by existing standards for quality and transparency?
- not as well covered by existing literature (e.g. on Small Area Estimation or Total Survey Error)?
- not already covered in Workshop 1?
# Prioritization of Topics

<table>
<thead>
<tr>
<th>Topic</th>
<th>Priority (L/H)</th>
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<tbody>
<tr>
<td>1. Record linkage</td>
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<td>2. Multiple frames</td>
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<td>3. Statistical matching / data fusion</td>
<td>H</td>
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<tr>
<td>4. Combining aggregate statistics or estimates (as in SAE)</td>
<td>L</td>
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<tr>
<td>5. Dimension reduction / feature extraction</td>
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<td>6. Harmonization across data sources</td>
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<tr>
<td>7. Edit and imputation</td>
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<tr>
<td>8. Adjusting for representativeness</td>
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<tr>
<td>9. Estimation</td>
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<tr>
<td>10. Disclosure avoidance</td>
<td>H</td>
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<tr>
<td>11. Provenance / curation of metadata</td>
<td>L</td>
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</tbody>
</table>
Workshop 2 – Speakers

- Record Linkage
  - Rebecca Steorts, Duke University
  - William Winkler, Census

- Harmonization of Data Across Sources
  - Ben Reist, Census
  - Don Jang, NORC
  - Scott Holan, University of Missouri
Workshop 2 – Speakers

- Combining Data by Statistical Matching, Imputation, and Modeling
  - Jerry Reiter, Duke University
  - Ed Mulrow, NORC

- Disclosure Avoidance: Frameworks, Techniques, and Quality Issues
  - Latanya Sweeney, Harvard University
  - John Abowd, Census
Rebecca Steorts talked about **entity resolution**.

Defined as practice of joining multiple data sets by removing duplicate entries, often in the absence of a unique identifier.

**Issues:**
- Entity is same across data sets?
- Matching in a quick and automated way
- Metrics to evaluate quality of the match
Record Linkage

- One approach to entity resolution is de-duplication – first combining into single data set.
- Another is record linkage with researcher reviewing record linkage uncertainty of graphical structure – requires quadratic number of comparisons.
- Both approaches typically match on a unique identifier, if exists.
- Exact matching – features of records are compared.
- How close do they have to be for a match?
- Systematic method for evaluation needed.
Record Linkage Metrics

- Recall = 1 – False Negative Rate
- Precision = 1 – False Positive Rate
- Computational run time and complexity
- Robustness
  - Choices of training/testing data
  - Tuning parameters
  - Models
Record Linkage

- **Take-Away Messages**
  - Need for high-quality data sets where true matches are known
  - Transparency – statistical agencies showing what they are producing and how they do it
  - Additive error (Winkler) – 5% error in each of two linked data sets and a 5% matching error, the resulting data set has 15% error
Harmonization

**Harmonization** is “the process of mapping and synchronizing data derived from multiple sources into a coherent data file for analysis.” (Jang)

**Challenges:**

- Data sources are hard to link
- Data can vary in who/what they represent
- No universal data quality measures to evaluate harmonized data
- Integration and harmonization requires significant resources
Harmonization

- Ben Reist: Using survey estimates to assess the quality of administrative record data.
- Treating survey data as the ‘gold standard’ is a strong assumption.
- Can be used to adjust/improve estimates from administrative records
Harmonization

- Don Jang: Example with the Scientists and Engineers Statistical Data System – NSF
- Leverages estimates from 3 surveys.
- Harmonization is implemented at the question level – naming, formats, coding and editing rules are standardized across surveys.
- Response rates also have to be coordinated for weighting.
Jerry Reiter: Statistical matching is used to blend data sets without unique identifiers.

May be used to match data sets without overlapping observations.

Goal – Learn associations Y and Z

One file contains X and Y, X and Z.

Joint distribution cannot be estimated from data alone.
Statistical Matching

- Some form of external information is needed.
  - Assumptions made about association between Y and Z given X – most common is conditional independence.
  - Another data set with Y and Z
  - Constraints on associations from other sources
Statistical Matching

- Quality measures to report:
  - What assumptions were made
  - What models were used
  - Quality of model fit
  - Results of sensitivity analysis
  - Provide metadata for files used
  - Steps taken to harmonize X variables (e.g., asked in similar ways?)
  - Edits performed
  - Potential for selection bias
  - ...

Disclosure Avoidance

- Latanya Sweeney focused on protecting privacy while preserving data utility.
- 1997 – Sweeney was able to re-identify the governor of Massachusetts:
  - Data on health care utilization – public-use data file not compromising privacy
  - Voter registration data available for purchase
Disclosure Avoidance

- Matched on overlapping fields: Zip code, birth date, and gender
- In 1990 Census data, 87% of Americans are unique based on date of birth, gender, and zip code
- Suggests improving disclosure prevention where people expose vulnerability in current approach and develop method to address it.
Disclosure Avoidance

- Should report what disclosure prevention methods were applied.
- John Abowd suggests one introduce random noise that is statistically independent of any of the other distributions used.
- Necessary but not sufficient condition to prevent disclosure.
Summary Messages

- Data harmonization is a fundamental first step in blending multiple data sources.
- Data producers must be transparent about each step:
  - Original need to collect data
  - Harmonization steps
  - Matching procedures
  - Models used and assumptions
  - Evaluation techniques used
  - How privacy was maintained
- Decisions captured in metadata – users can judge utility
Contact Information

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