2.

this effort into programming CAI instruments to perform consistency checks during the interviews. Moreover, data from the interviews can immediately flow to central servers, giving analysts immediate access to new fieldwork data.

In international data collection, these qualities of CAI can be particularly important. Simultaneous, uniform quality control across multiple sites is one of the most efficient ways to create comparable data records from multiple sites. Electronic interview records also greatly facilitate re-interview of individuals who move, making this tool especially important for longitudinal study designed to track migrants.

Finally, the "paradata" (data about the data collection processes) these tools create are highly valuable for both quality control and implementation of responsive survey design tools. The availability and analysis of paradata has revolutionized the science of quality control in survey data collection (Couper and Lyberg, 2005; Couper, 2009). These paradata also provide the key means of exercising responsive survey design to increase the quality and efficiency of survey data collection. Responsive survey design is described in more detail below.

To provide uniform quality control across multiple data collection sites and rapid harmonization and analysis of the data, use a high quality CAI software, such as Blaise—the most flexible, robust and safe CAI software currently available. Michigan has used Blaise successfully worldwide for more than 15 years (including China, Ghana, Nepal and Saudi Arabia). Producers and users of this software are constantly innovating to increase the ability to collect high quality longitudinal measures across multiple family members and substantive domains spanning behaviors, beliefs and feelings.

D. CREATING HIGH QUALITY LONGITUDINAL DATA BY MINIMIZING ATTRITION

Attrition out of a longitudinal study is a major threat to success of such a study (Groves and Couper, 1998; Lepkowski and Couper, 2002; Groves, 2006; Couper and Ofstedal, 2009; Cobben and Bethlehem, 2009; Schoeni and others, 2013; Schouten, Trappmann, Gramlich and Mosthaf, 2015). Individuals who either cannot be relocated or who refuse to participate are rarely selected through pure randomization. Typically, those who are lost are selected on criteria associated with one or more of the objectives of the study. Migration is the most obvious example—if those who move are lost from the study it becomes impossible to provide unbiased estimates of associations that are somehow shaped by migration.

1. *Excellent Re-contact Information*

Collection of excellent re-contact information during the baseline study is a crulsy ati2onand sfullyTp l1

- Controlling the length of interviews to reduce burden;
- Re-contact at short intervals, between rounds (include information about how the study is used);
- Re-contact with multiple family members;
- Change mode of contact (e.g. face-to-face to phone);
- Continuing contact with those temporarily away no matter where;
- Track across long distances, including borders (representative subsamples of movers, if necessary).

These steps can greatly reduce attrition across all different types of longitudinal surveys. Some special situations require special steps. The literature on reducing attrition in longitudinal studies offers many specialized steps for special situations. Because armed conflict is a major disruption in efforts toward SDG outcomes, situations of armed conflict are an important example (Axinn, Ghimire and Williams, 2012).

E. TOOLS FOR STANDARDIZED QUALITY CONTROL AND DATA MANAGEMENT

Computerization of survey data collection unleashed a series of technological breakthroughs that make a new science of data collection possible. As early as the 1990s, the use of computers allowed both face-to-face and telephone interview survey questionnaires to move from paper held by an interviewer to software on a computer used by an interviewer. A decade or so later, internet technologies supported the construction of computerized management tools—tools that though residing at a central location could use the internet to reach inside the computers being used by interviewers, even interviewers long distances away, to keep track of the interviewers' work. These tools, sometimes described as "sample management systems," created data about the data collection process, or "paradata" (Couper, 2005; Couper, 2009; Couper and Lyberg, 2005).

Creation and analysis of paradata provided a boon to data collection quality control. Analysis of interviewer key strokes and time stamps through the questionnaire provides the means for quick detection of fabrication, identification of interviewer driven errors, and identification in questionnaire problems (Couper, 2009; Kreuter, Couper and Lyberg, 2010). Paradata also gave the field of survey methodology

paradata, and making design decisions during data collection based on patterns evident in the paradata. Groves and Heeringa (2006) defined five steps that responsive survey designs generally follow:

1. Pre-identify a set of design features potentially affecting costs and errors of survey statistics (e.g., number of calls made to a sampled unit, or over-sampling of certain ethnic groups);

2. Identify a set of indicators of the cost and error properties of those features (e.g., costs per call attempt, response rates as a function of number of calls attempted, or response rates over time for various ethnic groups);

3. Monitor those indicators in initial phases of data collection;

4. Alter the active features of the survey in subsequent phases based on cost/error tradeoff decision rules (e.g., ask interviewers to increase their efforts for a particular ethnic group, or ensure that all cases have been called a certain number of times); and

5. Combine data from the separate design phases into a single estimator.

Responsive survey designs rely on carefully designed collection of paradata that are relevant for a given survey (i.e., predictive of key survey outcomes, including response to the survey request). Using these paradata, statistical models can be used to both evaluate the success of data collection up to any given point and predict the actions most likely to produce effective data collection going forward. The collection and analysis of paradata is an extremely active area of research in survey methodology (Kreuter, 2013; Luiten and Schouten, 2013; Lundquist and Särndal, 2011; Peytchev, Baxter and Carley-Baxter, 2009; Schouten and others, 2012; Schouten, Calinescu and Luiten; 2013; Wagner, 2008) and

sample of the population for more intensive longitudinal study. Such designs offer the complementary strengths of breadth and depth.

1. *Creating synergy among census, administrative records, repeated cross-sections, and longitudinal data*

To create high complementarity across multiple data sources, repeating at least some subset of measures across data types is a high priority. It is now standard practice to repeat census-style demographic measures of age, sex and race in cross-sectional surveys to assess the extent to which any specific sample matches the full census population. In a similar way, it is important to replicate key substantive measures from administrative records or national sample surveys in longitudinal studies of sub-populations to assess the extent of match across data sources.

2.

REFERENCES

Axinn, W.G. and J.S. Barber (2001). Mass education and fertility transition. *American Sociological Review*, vol.66, No. 4, pp. 481-505.

Axinn, W.G., C.F. Link and R.M. Groves (2011). Responsive survey design, demographic data collection, and models of demographic behavior. *Demography*, vol. 48, No. 3, pp. 1127-1149.

Axinn, W.G., D.J. Ghimire and N. Williams (2012). Collecting survey data during armed conflict. *Journal of Official Statistics*, vol. 28, No. 2, pp. 153-171.

Axinn, W.G. and L.D. Pearce (2006). *Mixed Method Data Collection Strategies*. New York: Cambridge University Press.

Brauner-Otto, S.R., W.G. Axinn and D.J. Ghimire (2007). The spread of health services and fertility transition. *Demography*, vol. 44, No. 4, pp. 747-770.

Brick, J. M. and D. Williams (2013). Explaining rising nonresponse rates in cross-sectional surveys. *The ANNALS of the American Academy of Political and Social Science*, vol.645, No. 1, pp. 36-59.

Couper, M. P. (2005). Technology trends in survey data collection. *Social Science Computer Review*, vol. 23, No. 4, pp. 486-501.

Couper, M. P. (2009). The role of paradata in measuring and reducing measurement error in surveys. *NCRM Network for Methodological Innovation*.

Couper, M. P. and L. Lyberg (2005). The use of paradata in survey research. Proceedings of the 55th session of the International Statistical Institute, Sydney, Australia.

Couper, M.P. and M.B. Ofstedal (2009). Keeping in contact with mobile sample members. In *Methodology of longitudinal surveys*. P. Lynn, ed. Chichester, UK: John Wiley & Sons, Ltd. doi: 10.1002/9780470743874.ch11

Groves, R. M. (2006). Nonresponse rates and nonresponse bias in household surveys. *Public Opinion Quarterly*, vol. 70, No. 5, pp. 646-675.

Groves, R.M. and M.P. Couper (1998). *Nonresponse in Household Interview Surveys*. New York: John Wiley and Sons.

Groves, R. M. and S. G. Heeringa (2006). Responsive design for household surveys: tools for actively controlling survey errors and costs. *Journal of the Royal Statistical Society: S5e s TfAa Statistias in*

collection. In *Proceedings of the Joint Statistical Meetings, American statistical association* (pp. 282-296).

Lepkowski, J.M. and M.P. Couper (2002). Nonresponse in the second wave of longitudinal household surveys.