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2020 Census Quality Indicators:

A Report from the American Statistical Association

Prepared by the 2020 Census Quality Indicators Task Force

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Executive Summary

The 2020 Census is confronting a perfect storm of adverse circumstances that have led to concern about possible impairment of the quality of the data relative to prior censuses. The Census Quality Indicators Task Force (task force) was brought together under the aegis of the American Statistical Association (ASA). Dating from 1839, the ASA has a long and celebrated history of advocating for and contributing to an accurate census. Building on this role, the task force was established to produce a set of scientifically-sound, publicly-available statistical indicators by which the quality, accuracy, and coverage of the 2020 Census can be assessed. The indicators are intended to be used by the Census Bureau and qualified outside researchers to assess the quality of the census and share that assessment with the public.

The decennial census is foundational to our democracy. The stated goal of the 2020 Census is, "to count everyone once, and once only, and in the right place."[1] The decennial census is required by Article I of the Constitution to apportion seats in the House of Representatives among the states. Besides apportionment, the census has acquired many other uses over time, for example, as the basis for drawing congressional districts in states, distributing over $1.5 trillion annually in federal funds to states and localities, and improving the accuracy of more than one hundred government surveys based on population samples, which, in turn, support research and decision-making in business, government, and academia to identify and solve pressing social problems and inform economic choices. Most of these outcomes are relative; that is, a fixed amount of money or representation is distributed among states and localities. For this reason, even small errors can lead to large distortions in representation and funding if some states and localities are counted more accurately than others. If particular areas are undercounted or overcounted relative to other areas that are more accurately counted, then the allocation of congressional representation and the distribution of resources will not be equitable. Given the importance of the many ways in which census data are used, the American public needs to know whether census information presents an accurate picture of our nation's population.

THE 99% COMPLETION GOAL

To date, the Census Bureau has released information on the percentage of "completed enumerations" by state with a goal of reaching 99 percent completion for each state. However, the percent of completed cases does not suffice to draw conclusions about data quality. For example, included in the tally of completed enumerations are households counted through a proxy response from a neighbor, including cases in which the proxy could provide no information beyond a guess of the number of individuals living in the household. In fact, meeting enumeration goals for a truncated deadline increases the likelihood of operational shortcuts that will jeopardize the quality of the count.

[1] 2020 Census Operational Plan Executive Summary -Version 2.0, February 2018. https://www2.census.gov/programs-surveys/decennial/2020/program-management/planning-docs/2020-oper-plan-exec-summ-2.pdf

A wide array of quality indicators can be produced to assess the performance of the 2020 Census operations and their impact on quality. In the 2020 Census Quality Indicators section, we describe these indicators in a general fashion with several examples to illustrate their intended use. A more detailed set of quality indicators should be identified through discussions with the technical staff at the Census Bureau, who will have to produce this information. The indicators and anticipated availability are as follows:

- *Self-Response Data Collection* – the Census Bureau has released extensive response rate data on self-response rates for a number of geographic levels including state, county, cities, townships, and census tracts. These data need to be analyzed to identify any lack of uniformity across geographic entities such as states, cities, counties, and rural areas, and population groups, which would indicate inequity of the counts across the U.S.
- *Field Data Collection* – quality measures can be calculated for each of the operations described in this report. For example, data from the operation that sends census enumerators knocking on doors when households have not self-responded to the census (Nonresponse Followup or NRFU) will be available **before** apportionment counts are released. Two types of quality indicators that can be produced for NRFU are: (1) indicators based on the NRFU process (referred to as paradata), and (2) indicators based on the outcome of the actual NRFU enumeration.
    - Paradata-based indicators include data regarding the actual process of NRFU such as the number of attempts a particular enumerator makes to enumerate a NRFU case or the time an enumerator spends conducting interviews.
    - Outcome-based indicators include data such as how many households were enumerated by asking a neighbor how many people live in the unit, and how many households were enumerated using administrative records.

The Census Bureau has measured the quality of decennial censuses for decades. Many of these indicators have been used in the past but have only been released to the public at the national level. However, the indicators we are recommending are different in two ways. Because of the truncated timeframe and the effects of the pandemic and multiple natural disasters, we believe it is important for the Census Bureau to make the quality assessment results available to the public at the census tract level in order to ascertain the extent to which some areas may have been counted more accurately than others and determine the data's fitness for various uses. In addition, many of the indicators from the field processes are newly available this decade due to the automation of NRFU. Daily processing and assignment of the NRFU cases produce a wealth of data to evaluate the quality and progress of NRFU that was not available in previous censuses. The Census Bureau's current plan for quality assessment is unknown, and the compressed schedule has eliminated many quality-control steps that the Bureau would have included before releasing the apportionment data. However, the 99 percent completion rate by state publicly released to date is insufficient to measure quality.

The Quality Assessment Methodology section of the report provides examples of how self-response data can be compared for variability across geographic areas. A more in-depth analysis using 2010 data is in Appendix 2.

In addition to recommending the quality indicators themselves, we also make recommendations on further actions that should be taken after these quality indicators are published as follows in brief:

1. The indicators should be readily available and used expeditiously to assess the quality of the 2020 Census.
2. Qualified external researchers should be granted access to the data to help conduct the analyses.
3. Additional assessments should be conducted when more data become available.
4. Early planning for the 2030 Census should build on the lessons of 2020, be conducted in public, and include extensive stakeholder input.
5. The Census Bureau's authorizing statute, Title 13 U.S. Code, should be updated.

Title 13 needs to align better with recent Information Quality Act and OMB guidelines. Adding these requirements to Title 13 would build confidence in the Census Bureau as it moves forward in carrying out its mission as a Statistical Agency. Title 13 should also be examined to determine if further amendments to protect the integrity and independence of the Census Bureau and the decennial census are warranted. The five recommendations are discussed in more detail in the Recommendations section.

ONE EFFECT OF THE PANDEMIC ON QUALITY: COLLEGE TOWNS

According to the Census Bureau's rules of where to count people, college students are counted where they attend college. College students living in dormitories were to be included as part of the enumeration of people who live in group housing, such as dormitories, halfway houses, and nursing homes (Group Quarters). In addition, college students living off-campus were to be included in an early door-to-door operation carried out by mid-April to enumerate them before they left town at the end of the school year. However, due to the pandemic, most students left campus during March before that enumeration was completed. Questions remain on how successfully the Census Bureau obtained school records from each of the colleges indicating where students were supposed to have been living on April 1. In addition, many students may have been counted twice, at school and in the locations they moved to after campuses were shut down, such as at their parents' house.

Introduction

Since the first census was conducted in 1790, every decennial census has faced substantial challenges. And, the 2020 Census faces an unparalleled set of challenges beyond the control of the dedicated professional staff at the Bureau. These include: a nationwide COVID-19 pandemic that greatly delayed the start of field operations; major weather events, such as hurricanes, wildfires, and flooding that have displaced people and hampered field operations; controversies that may have impaired response about the counting of immigrants; sudden alterations in schedules for NRFU and for post-collection data processing and curation, as well as dates to deliver key data for reapportionment and redistricting of U.S. House seats; and ongoing litigation about the schedule and who is to be counted.

The decennial census is a complex, coordinated set of sequential processes, each with its own unique contribution to quality in the final counts. Each process is like a link in a chain. That is, the strength or quality of the final census data depends on all links being strong. Normally the Census Bureau is able to exercise these processes efficiently and demonstrate quality through transparency of their actions, producing a series of quality indicators for the decennial census up to 1-2 years after delivery of the state totals for reapportionment (some indicators are available much sooner) that would measure the relative quality of the census across different geographic areas and demographic groups. However, for 2020, the Bureau has been prevented from providing greater transparency regarding quality assessments, quality controls, and ultimately, the quality of the census counts. Factors such as the compressed timeframes, dropped procedures, the effect of various pending lawsuits, and the outside politicization around certain elements of the 2020 Census have raised questions about quality that must be answered to establish the credibility of the final results.

Against this background, the Census Quality Indicators Task Force (task force) was brought together under the aegis of the American Statistical Association (ASA). Dating from 1839, the ASA has a long and celebrated history of advocating for and contributing to an accurate census. Building on this role, the task force was established to produce a set of scientifically-sound, publicly-available statistical indicators by which the quality, accuracy, and coverage of the 2020 Census can be assessed. The indicators span all processes during data collection and post-data collection operations. For apportionment and redistricting purposes, as well as other important uses of census data, no single indicator can conclusively gauge 2020 Census data quality. Thus, we identify an ensemble of indicators.

The task force identified indicators with the expectation that they, or others like them, will be applied by those with access to the necessary data, including: (1) professionals at the Census Bureau and outside researchers, in order to evaluate the 2020 Census and inform planning and design for the 2030 Census; and (2) stakeholders, in order to determine whether the 2020 Census is fit for a particular use. To inform these indicators and to mitigate current concerns, the data to assess quality indicators for apportionment and redistricting should be made available right now to outside experts who can work with Bureau staff on initial assessments, even if fully informative data are not currently available. The data needed for these assessments are produced by the Census Bureau in the course of conducting the census, and they can be made available in a timely way for assessments.

A Brief Description of 2020 Census Operations

Over the last 230 years, the decennial census has evolved into a complex undertaking that relies on a great number of operations, each designed to obtain a complete and accurate enumeration. The Census Bureau implements numerous cross-checks and quality checks to ensure that these operations are carried out free from error, and that at all times respondent information is protected. The goal is to get a complete and accurate enumeration for all population groups and geographic areas. Of course, no process is perfect, and each decennial census has contained errors, including undercounts and overcounts. The Census Bureau has been very open in each of these censuses and has provided extensive information regarding the quality of each census.

The remainder of this section provides an overview of how the 2020 Census is planned and conducted, as well as how the Census Bureau has adapted to the COVID-19 pandemic. The primary focus in this section is on field operations and post-data collection processing that drive many of the quality indicators that should be used to assess quality affected by the pandemic-driven changes in schedule.

> For readers who are not familiar with the detail of how a census is conducted, we recommend reading the detail in Appendix 1 before examining the quality indicators, because the indicators are closely tied to various census operations and procedures.

Statutory Authority

The 2020 Census is conducted under the authority of Title 13, U.S. Code, which specifies statutory deadlines for it:

- March 31, 2017 is the deadline for submitting the topics planned to be included on the 2020 Census questionnaire to the Congress.
- March 31, 2018 is the deadline for submitting the actual questions planned to be asked on the 2020 Census questionnaire to the Congress.
- April 1, 2020 is designated as “Census Day.” This is the reference date for counting the population of the United States. For example, persons who die before or are born after April 1, 2020 are not included in the count.
- December 31, 2020 is the deadline for delivering the apportionment counts to the President of the United States. A longstanding and important practice is that the Commerce Department also releases state counts to the public on the same day of the transmission to the White House.
- March 31, 2021 is the deadline for providing each state with a redistricting data file to allow the redrawing of Congressional, state, and local voting districts.

Litigation is underway that may result in the Census Bureau not meeting the last two deadlines, due to pandemic-related schedule changes in field operations and post-data collection processing necessary to produce the apportionment and redistricting files.

Early Operations and Self Response

Planning and Research. The Census Bureau began planning for the 2020 Census as part of the 2010 Census. It has carried out extensive testing and planning throughout this decade to develop the publicly-available operational plans used to conduct the 2020 Census.

Building the Address List for the 2020 Census. The Census Bureau maintains a comprehensive address list that includes all of the housing units that were counted in the 2010 Census, referred to as the Master Address File (MAF). Then, the Bureau updates the MAF throughout the decade, including obtaining new addresses from the U.S. Postal Service and local governments.

Self-response to the 2020 Census. Starting in March 2020, most addresses on the MAF received an invitation in the mail to respond to the 2020 Census via internet, mail, or telephone. About 5 percent of the addresses on the MAF were very rural, where the Census Bureau employed an "Update/Leave" strategy – paper questionnaires were hand delivered and the MAF was simultaneously updated.

Field Data Collection

The Census Bureau conducts a number of operations where enumerators are deployed into the "field" to obtain a count to complete the census. This field data collection includes obtaining a response for all housing units that did not self-respond, as well as to enumerate persons that were not eligible to self-respond. Operations include:

A. *Nonresponse Followup or NRFU* – the largest of the field data collection operations is the enumeration of the 50 million housing units that did not self-respond. The workload consists of both vacant and occupied housing units.

    a. NRFU is highly automated. Each day enumerators receive cases on their census-provided smartphones to complete. Daily processing and assignment of the NRFU cases produces a wealth of data (known as paradata) to evaluate the quality and progress of NRFU. This includes data such as: (1) the number of attempts a particular enumerator makes to enumerate a NRFU case; (2) the time an enumerator spends conducting interviews; and (3) the outcomes of the NRFU enumeration, for example whether a NFRU case was completed by a direct interview with a household member or with a proxy such as a knowledgeable neighbor.

    b. NRFU has prescribed rules to bring it to a timely and accurate conclusion. In the early stages of NRFU enumerators are not allowed to obtain proxy responses for occupied housing units. However, as NRFU nears completion, enumerators are allowed to obtain proxy enumerations, and finally to move to a stage called "Closeout" where they are allowed to obtain just minimal information for housing units such as just a count of the number of people in a household with no additional information. These enumerations are referred to as "Pop Count Only."

c. Administrative records are also used to reduce the NRFU workload by removing both vacant units and enumerating occupied housing units after at least one in-person attempt to contact the residents has been made. These records are from sources such as USPS non-delivery records, IRS tax records, Medicare and Medicaid, Social Security, and the Indian Health Service.

d. The outcomes for the housing units included in NRFU are: (1) direct enumeration with a household member; (2) proxy enumeration that obtains more than a population count; (3) proxy enumeration that only obtains a population count (Pop Count Only); and (4) unresolved status.

B. *Group Quarters Enumeration* – Group Quarters (GQ) consist of institutions such as prisons, college dormitories, and long-term care facilities as well as non-institutional facilities such as group homes or halfway houses. The Census Bureau had planned to conduct an early review of the GQ enumeration with experts such as state demographers to detect inaccuracies or undercounts, such as whether GQ were in the right location or appeared to have an incomplete count of the residents. This quality control step was recently canceled by the Census Bureau to save time in the schedule.

C. *Service Based Temporary Non-Sheltered Outdoor Locations Enumeration* – the Census Bureau conducts several operations that are designed to count persons with no permanent residence. Service Based Enumeration (SBE) counts people experiencing homelessness at places where they receive services, such as soup kitchens or shelters. Temporary Non-Sheltered Outdoor Locations (TNSOL) enumeration counts people with no permanent residence who live in facilities such as RV parks as of April 1, Census Day.

D. *Update Enumerate* – the Update Enumerate (UE) operation occurs in areas where the enumerator conducts the enumeration in person while updating the MAF. This operation primarily occurs in Remote Alaska, in tribal areas that request an in-person enumeration, and in parts of northern Maine and Southeastern Alaska.

Post-Data Collection Processing

Post-data collection processing starts with inputs from the computer systems used to support the data collection operations (both self-response and in-field) and performs several edits and quality checks to produce, first, the apportionment counts and then, the redistricting data. The first file created during this process is the Census Unedited File (CUF) which is used to produce the apportionment counts. This file is then improved through additional edits and quality checks to produce the Census Edited File (CEF), which is used to produce the redistricting data. There are critical activities that must be accomplished as part of the creation of the CUF and the CEF as described below.

A. Producing the CUF includes many processes:

a. Identifying potential fraudulent returns from self-responses and recording a final fraud investigation disposition are critical, because the 2020 Census allows multiple opportunities for response, including allowing respondents to go online

and respond with just their address, rather than a Census-provided passcode ("non-ID" response). In previous censuses, respondents were required to use a multi-digit identification code that uniquely identified their housing unit in order to self-respond.

b. Identifying and resolving duplicate enumerations take out households counted more than once.

c. Imputation of the status of unresolved cases as either occupied, vacant, or nonexistent finalizes cases. For those unresolved cases that are assigned a status of occupied, a population count is also imputed.

B. Producing the CEF also requires the conduct of a number of edits and the application of statistical activities to account for missing data (e.g., a respondent did not provide an answer to the Race question).

a. Editing validates the consistency of the 2020 Census responses and makes corrections as necessary. For example, a five-year-old person cannot be the spouse of the first person listed on a questionnaire.

b. Missing data are dealt with through the use of imputation, including whole person imputation where all characteristics need to be imputed or specific characteristic imputation when a question is left blank (item non-response).

c. Comparing the results of the editing and imputation to the 2010 Census will provide valuable insights into the quality of the enumeration processes that resulted in the 2020 Census.

C. A number of quality checks were in the Census Bureau's original plans to ensure that the post-data collection processing systems were not subject to computer errors. An important component of these checks was having internal subject matter experts compare the 2020 results to various benchmarks, such as the Census Bureau's vintage population estimates (Population Estimates Program) for the decennial year and, at the national level, demographic analysis (DA)[2]. Discrepancies resulting from these comparisons are resolved during the quality check process. If any discrepancies are caused by a computer error, it is corrected. However, the Census Bureau has stated that it has to truncate the schedule for post-data collection processing, and it will drop a significant portion of these checks. Unfortunately, there is no quality indicator that can be produced to assess whether undetected computer errors are affecting the accuracy of the apportionment or redistricting data until well after they are released.

[2] The Population Estimates Program provides annual population estimates for geographic and demographic categories, including total population for states, cities and towns. The most current population estimates that are available represent the resident population as of July 1, 2019. Demographic Analysis (DA) refers to a specific set of techniques for developing national population estimates by age, sex, and race from administrative records, to be used to assess the quality of the decennial census.

2020 Census Quality Indicators

WHEN ARE INDICATOR DATA AVAILABLE?

The quality indicators we recommend are those that are available in time to assess the fitness for use of the apportionment and redistricting data. They can be produced from the data collection systems that the Census Bureau is using to ultimately produce the apportionment counts and redistricting data files and will be available when the apportionment and redistricting data files, respectively, are available. Of greatest immediate concern is the effect of the COVID-19 pandemic and the truncated time schedule on the quality of the 2020 Census data for: (1) the apportionment counts currently scheduled for delivery to the President of the United States by December 31, 2020; and (2) the redistricting data currently scheduled to be delivered to each state by March 31, 2021.

Other more formal evaluations of the 2020 Census beyond those recommended here should be conducted that will provide additional information about the quality of the 2020 Census such as the coverage measurement program, but these results will not be available until well after all 2020 Census processing is complete. The indicators included here are intended to be used as the census apportionment and redistricting files are being produced.

The recommended quality indicators cover just the household population, not people living in Group Quarters. The population enumerated in GQ is important, however for previous censuses, the Census Bureau did not measure the coverage of the GQ population, but relied on qualitative evaluations and reviews by outside experts. This process should be continued for the 2020 Census – for example, the cancelled Census Count Review by state demographers should be reinstated even if only for evaluative purposes rather than quality control.

To date, the Census Bureau has released information on the percentage of “completed enumerations” by state and “NRFU operation completion” by the location of various census field areas (Area Census Offices), with a goal of reaching 99 percent completion for each state. However, the percent of completed cases does not suffice to draw conclusions about data quality. For example, included in the tally of completed enumerations are households counted through a proxy response from a neighbor, including cases in which the proxy could provide no information beyond a guess of the number of individuals living in the household. In fact, meeting enumeration goals for a truncated deadline increases the likelihood of operational shortcuts such as overreliance on proxy counts that will jeopardize the quality of the count. In those areas that may be the hardest to count because of distrust of the government, the pandemic, weather events, or other reasons, the rushed schedule to close out the field operations could compromise quality. Hence, indicators enumerating these various outcomes would be indirect quality measures.[3]

[3] The 1990, 2000, and 2010 Censuses all had completion rates above 99 percent. However, the undercounts and differential undercounts were much larger for 1990 – indicating that the completion rate doesn’t predict good coverage.

A wide array of quality indicators can be produced to assess the performance of the 2020 Census operations and their impact on quality. In the following discussion, we describe these indicators in a general fashion with several examples to illustrate their intended use. A more detailed set of quality indicators should be identified through discussions with the technical staff at the Census Bureau, who will have to produce this information. The indicators and anticipated availability are as follows:

A. *Self-Response Data Collection* – the Census Bureau has released extensive response rate data on self-response rates for a number of geographic levels including state, county, cities, townships, and census tracts. This is an exceptionally important indicator of data quality because it is widely recognized that self-response from the household provides the most accurate data, and low self-response is a predictor that an area will be hard-to-enumerate. Additional self-response data does not need to be produced.

B. *Field Data Collection* – quality measures can be calculated for each of the census field operations. For illustrative purposes, NRFU data that will be available **before** apportionment counts are released are considered here. Two types of quality indicators that can be produced for NRFU are: (1) indicators based on the outcome of the actual NRFU enumeration, and (2) indicators based on the NRFU process (referred to as paradata).

    a. *NRFU enumeration outcome measures* include the final result of how each NRFU housing unit was enumerated. These metrics should be calculated for census tracts, counties, and states, which would allow analysis of the variation across areas. Indicators include, but are not limited to:

        - Percentage enumerated by proxy, excluding vacant and non-existing housing units
        - Percent of enumerations that are pop-count-only
        - Percentage enumerated using administrative records
        - Percentage missing critical information, such as Name or Date of Birth
        - Percentage of addresses in the entire NRFU universe, including vacant and nonexistent HUs identified in the NRFU process, that were obtained during the Closeout phase
        - Percent of addresses that were unresolved after data collection concluded

        Vacant and non-existing housing unit enumeration:

        - Percent of NRFU addresses that are enumerated as vacant housing units
        - Percent of NRFU vacant housing unit enumerations obtained from administrative records
        - Percent of NRFU addresses that are enumerated as nonexistent.
        - Percent of NRFU nonexistent housing unit enumerations obtained from administrative records
        - Vacancy rate calculated based on the total number of occupied and vacant addresses (can this be compared to the ACS given the pandemic)

b. *NRFU process indicators* (sometimes referred to as paradata) offer further information about the field data collection. Paradata includes information on how the NRFU operation was conducted and would include such information as the number of attempts made to enumerate each NRFU case or the number of times an enumerator received a refusal. Another example would be whether the household was not enumerated because of a refusal or a non-contact. Analysis of paradata requires collaboration with professional census staff to determine the availability of such measures at various geographic areas. It is important to assess the variation in such paradata across census tracts as well as to assess any clustering effects for particular areas. Paradata should be summarized by census tract, which would allow for analysis for a wide range of geographic areas.

C. *Post-Data Collection Processing* – the post-data collection processing starts with an input of the data collection files (both self-response and in-field) and performs a number of edits and quality checks to produce first, the apportionment counts by state and subsequently, the redistricting data. The first file created during this process is the Census Unedited File (CUF), which is used to produce the apportionment counts. This file is then improved through additional edits and quality checks to produce the Census Edited File (CEF), which is used to produce the redistricting data.

   a. *CUF Quality Indicators* are available before the apportionment counts are released. These data could be used to calculate the percent of the total records for areas such as census tracts, counties, or states and include:

      - Percent of records identified as duplicate enumerations across different addresses
      - Percent of records that do not contain sufficient information for deduplication
      - Percent of records that required status or count imputation
      - Percent of person records created by count imputation
      - Percent of records that will require whole person imputation
      - Percent of records missing a complete name (first and last)
      - Percent of records from administrative records
      - Percent of administrative records lacking complete names or date of birth

   b. *CEF Quality Indicators* are available before the redistricting data are released. These data could be used to calculate the percent of the total records for areas such as census tracts, counties, or states and include:

      - Percent of whole person imputations
      - Percent of records that required item imputation for Race, Hispanic Origin, Sex, and Age respectively.
      - Percent of records missing date of birth
      - Demographic breakdown of households enumerated by administrative records

Quality Assessment Methods for Indicators

Each set of indicators (e.g., rates of proxy enumerations) will be a marker of quality. Lack of uniformity across geographic entities such as states, cities, counties, and rural areas, and population groups, indicates inequity of the counts across the U.S. Areas that were particularly hard hit by COVID- or weather-related movements of residents, such as college towns, New York City, towns with prisons, and coastal areas, as well as identified hard-to-count areas need particular attention. The distribution of the quality indicators will not be perfectly uniform because no census is 100 percent accurate. However, the 2010 Census can be used as a benchmark, particularly to understand the potential causes of areas that look unusually different (extreme outliers).

A. *Variation across geographic areas* – the distribution of a particular indicator, for example the self-response rate, should be compared for the 2020 and 2010 censuses by aggregating the data by census tract, rolled up to Area Census Offices, counties, cities, and states. Many census uses are harmed when there is variation in the values of various data collection indicators across these geographic areas. A detailed discussion of methods to assess the uniformity of the quality indicators through analyzing variation across geographic areas is included in Appendix 2. The appendix illustrates the methods with a preliminary analysis of the 2020 self-response rates, because these rates have already been reported by the Census Bureau.

B. *Comparison of 2020 Census counts with external estimates* – As mentioned previously, Demographic Analysis (DA) national estimates and the Population Estimates Program at the Census Bureau offer two sources for comparison of 2020 Census results with independent estimates. DA is available at the national level for Black and non-Black populations by age and sex. Undercounts for these population groups can therefore be calculated as (DA-Census)/DA and compared to similar results for the 2010 Census. Appendix 3 shows the Demographic Analysis results for the 2010 Census.

   The Population Estimates Program provides annual population estimates for geographic and demographic categories, including total population for states, cities and towns. The most current population estimates that are available represent the resident population as of July 1, 2019. The Census Bureau may calculate internal estimates with a reference date of April 1, 2020. However, these estimates have been carried forward from the 2010 Census and have levels of uncertainty large enough to make a direct comparison with the 2020 Census results challenging for many areas. Nonetheless, comparisons of the most recent population estimates available for states, cities and towns with the corresponding 2020 Census counts may provide useful information. Large discrepancies may indicate inaccuracies for the 2020 Census and should be explained to the extent possible. For example, a sharp drop in the 2020 Census count relative to the population estimate for a college town may indicate an undercount of the student population that should have been counted in the college town as of April 1, 2020.

Recommendations

We recommend a series of quality indicators to be used to assess the 2020 Census, as discussed in the Quality Indicators section. However, establishing quality indicators is just the first step. These additional recommendations address the actions needed not only to assess the quality of the 2020 Census but to improve the processes around the 2030 and future censuses.

1. **The indicators should be readily available and used expeditiously to assess the quality of the 2020 Census.** The Census Bureau needs to make its data available to carry out an assessment of the quality of the 2020 Census results. Given the current unprecedented circumstances facing the 2020 Census, analyses of the quality of the results should be expedited. Ideally, the results of many quality assessments would be provided before the apportionment numbers are submitted to the President and transmitted to Congress and most certainly before the redistricting files are transmitted to the States. The results of these analyses must be made available to the public, so that there is wide understanding of the quality of the 2020 Census.

2. **Qualified external researchers should be granted access to the data to help conduct the analyses.** Normally, the Census Bureau would conduct these types of analyses itself as part of the 2020 Census operations and post-data collection processing, and as part of the 2020 Census evaluation program that would continue well after the release of the apportionment and redistricting data. However, to accomplish a transparent, timely, and credible assessment, an objective outside group of experts should be given access to the recommended indicator data to complement analyses of the Census Bureau staff and produce assessments more quickly with data that are available. Additional outside researchers could usefully expand on these analyses and could be granted access to the data through the Census Bureau's secure environment, such as a Federal Statistical Research Data Center, so that access to the raw data meets Census Bureau confidentiality policies. The Census Bureau and Office of Management and Budget (OMB) should develop criteria to grant quick access to allow timely understanding of 2020 Census quality. Another important component of this research would be to allow local area experts such as state demographers to review the early tabulations and help the Census Bureau determine if unexpected discrepancies are, in fact, computer processing errors.

3. **Additional assessments should be conducted when more data become available.** The Census Bureau is currently conducting a Post Enumeration Survey (PES), as it has in many previous censuses. If successful, the PES will provide a wealth of information regarding the quality of the 2020 Census. For example, the 2010 Census coverage measurement program allowed for an extensive analysis of quality including: duplication, undercounts, and erroneous enumerations. It is anticipated that these results will become available in early 2022. Understanding the coverage of the census will be important, because the Census Bureau could potentially take actions to make corrections before 2030. While this would not affect apportionment, it could affect funding allocations, especially important to areas that are undercounted.

4. **Early planning for the 2030 Census should build on the lessons of 2020, be conducted in public, and include extensive stakeholder input.** The Census Bureau has faced unprecedented challenges in conducting the 2020 Census including: the COVID-19 pandemic; restructured field data collection operations; dealing with the effects of wildfires and devastating storms; and responding to extensive litigation. The Census Bureau and its stakeholders have valuable insights from these experiences which should guide the planning for the 2030 Census, which may require major redesign. Given all of the concerns that have been expressed regarding the quality of the 2020 Census, the planning for the 2030 census should build early confidence and support from stakeholders. This planning should be very public and guided by extensive stakeholder input, particularly if major changes are being considered. The Census Bureau and the Department of Commerce have the authority to create an environment that supports such an effort, including the establishment of advisory committees under the Federal Advisory Committee Act.

5. **The Census Bureau's authorizing legislation, Title 13 U.S. Code, should be updated.** First, Title 13 needs to align better with recent Information Quality Act and OMB guidelines. For example, the Information Quality Act requires agencies to conduct pre-dissemination review of their information products. During this review, each agency should consider the appropriate level of quality for each of the products that it disseminates based on the likely use of that information. In addition, agencies are required to produce measures of quality that accompany the release of important data, such as the data used for apportionment and redistricting produced by the Census Bureau. Adding these requirements to Title 13 would build confidence in the Census Bureau as it moves forward in carrying out its mission as a Statistical Agency. Secondly, Title 13 should also be examined to determine if further amendments to protect the integrity and independence of the Census Bureau and the decennial census are warranted.

Glossary of Terms

For a larger glossary of census terms, see https://www.census.gov/glossary/

Administrative Records (AR) – Data collected as a byproduct of administering government programs or services; in contrast to Commercial Data.

American Statistical Association (ASA) – A professional association representing statisticians in industry, government, and academia across 90 countries. The organizing body of this report.

Apportionment – The process by which the census count is used to determine the number of representatives from each state in the U.S. House of Representatives.

Census Bureau – A federal agency within the U.S. Department of Commerce, whose primary mission is to conduct the decennial census as codified in Title 13 of the United States Code.

Commercial Data – Data collected or acquired from private companies; in contrast to Administrative Records.

Census Edited File (CEF) – The edited responses to the census questionnaire, which includes Census Bureau imputations; in contrast to the Census Unedited File.

Census Unedited File (CUF) – The unedited responses to the census questionnaire; in contrast to the Census Edited File (CEF).

Coronavirus (COVID-19) – The virus that caused an international pandemic that forced the Census Bureau to suspend field operations from mid-March 2020 to mid-May 2020.

Demographic Analysis (DA) – Any secondary analysis, performed by the Census Bureau, which uses administrative records, such as birth and death records, to validate the Census.

Federal Statistical Research Data Center (FSRDC) – Facilities located throughout the U.S. that provide authorized researchers secure access to data that cannot be released to the public due to privacy concerns.

Group Quarters (GQ) – The location of U.S. residents who do not live in individual housing units, but in a group living arrangement, for example, college residence halls, military barracks, or correctional facilities.

Hard to Count (HTC) – Populations or areas that are unlikely to self-respond to the Census Bureau and are difficult to count by census enumerators. These populations or areas may be geographically isolated, reluctant to participate, or unable to communicate with enumerators.

Imputation – The editing of census responses by the Census Bureau to account for missing or incorrect information.

Local Update of Census Addresses (LUCA) and the New Construction Program – The update of the Master Address File, led by local governments, to help ensure the file is as complete and accurate as possible.

Master Address File (MAF) – The list of all U.S. households maintained by the Census Bureau from which U.S. residents will be counted when the census is conducted.

Nonresponse Followup (NRFU) – Operations conducted by the Census Bureau, such as phone-calling and door-knocking, in order to retrieve responses from residents that did not self-respond online, by telephone, or by mail.

Paradata – Administrative records that arise from the implementation of the census operations.

Population Estimates Program (PEP) – The annual update of the most recent decennial census using administrative records, such as birth and death records.

Title 13 – The Census Bureau's authorizing statute, Title 13, U.S. Code, which provides authorization for the Census Bureau's work and mandates strong confidentiality protections for the data that the Bureau collects from people, businesses, and other sources.

Appendix 1.
Background on Key Census Operations

Planning and Research

The Census Bureau began planning for the 2020 Census as part of the 2010 Census. It has carried out extensive testing and planning throughout this decade to develop the operational plans to be used to conduct the 2020 Census. The Census Bureau openly documented its progress, including in the release of four Operational Plans. The first version was released in 2015, with the final fourth version being released in 2018. Each release was informed by research and testing. The research and testing culminated in an end-to-end test that was conducted with a reference date of April 1, 2018 which was in effect a dress rehearsal of the complete plans for the 2020 Census. The research and testing included evaluating and implementing some major innovations for the 2020 Census including how to deploy automation to eliminate paper-based methods that had been used in previous censuses, and how to improve the questions that obtained Race and Hispanic ethnicity.

Building the Address List for the 2020 Census

The Census Bureau maintains a comprehensive address list that includes all of the housing units that were counted in the 2010 Census. The Census Bureau refers to this address list as the Master Address File (MAF). The Census Bureau updates this file throughout the decade, including a program to obtain new addresses from local governments. The Census Bureau also employs a program specified in Title 13 to allow local government officials to review the MAF and identify missing addresses. This program is called Local Update of Census Addresses (LUCA). In previous censuses the Census Bureau has employed an address canvassing operation about one or two years in advance of Census Day to essentially walk each street in the United States to update the MAF. For 2020, the Census Bureau employed state-of-the-art geospatial tools to conduct most of this canvassing in an office environment. In 2019, the Census Bureau only had to physically canvass about 35 percent of the MAF. The Census Bureau published interim quality indicators of the progress of the canvassing and the types of addresses added or deleted. Further, indicators of quality will depend on the evaluation program described below.

Self-response to the 2020 Census

Starting in March 2020, most addresses on the MAF received an invitation in the mail to respond to the 2020 Census. For these addresses responses could be submitted via the Internet, mail, or by telephone. About 80 percent of the addresses were sent a document asking for a response via the Internet. The remaining 20 percent were sent a questionnaire and given a choice to either use the Internet or mail back the questionnaire. All addresses were eligible to use the telephone as an additional option.

About 5 percent of the addresses on the MAF were not suitable for mail delivery. For areas that contained these addresses (mostly very rural), the Census Bureau employed an “Update/Leave” strategy where Census Bureau enumerators delivered a questionnaire and simultaneously updated the MAF. As will be discussed below, this operation was disrupted by the COVID-19 pandemic.

The Census Bureau published cumulative self-response rates on a daily basis for a number of areas, including states, counties, cities, townships, and census tracts. These data have been well received by 2020 Census stakeholders, including the Congress, local government leaders, city planners, and researchers. In addition, valuable analysis of self-response patterns has been conducted and made widely available.

Field Data Collection

The Census Bureau conducts a number of operations where census workers called enumerators are deployed into the “field” to obtain a count to complete the census. This field data collection includes obtaining a response for all housing units that did not self-respond, as well as to enumerate persons that were not eligible to self-respond. This includes:

A. Nonresponse Followup

The largest of the field data collection operations is the enumeration of those housing units that do not self-respond via one of the options described above. There are over 50 million housing units that Nonresponse Followup (NRFU) must enumerate. This massive workload requires recruiting and hiring a workforce estimated to consist of over 260,000 enumerators along with building the temporary infrastructure to manage the enumerators. Initially, NRFU was scheduled to start on May 12, 2020 and conclude by July 31, 2020. As will be discussed below this schedule was modified as a result of the COVID-19 pandemic. The workload consists of both vacant and occupied housing units, as very few self-responses are obtained from vacant housing units.

Several important features of the infrastructure to support NRFU are the Area Census Office (ACO) and the Census Field Supervisor area (CFS). There are 248 CFOs designed to have essentially the same proportion of the NRFU workload. Each CFS is responsible for managing approximately 20 enumerators to complete the census for about 4,000 addresses. The CFS are managed by staff at the ACO that is responsible for their area.

Unlike previous censuses which relied on paper-based methods to conduct NRFU, the 2020 Census is highly automated relying on mobile technology and advanced operations research optimization algorithms. Enumerators are equipped with an iPhone and their supervisors – the CSF – are equipped with a tablet. Each day enumerators receive cases on their smartphones to complete, and the CFS receives information about the progress of the enumerators they supervise. In addition, the work is optimized with respect to the distance from the unfinished NRFU cases and where the enumerators live.

Importantly daily processing and assignment of the NRFU cases produces a wealth of data to evaluate the quality and progress of NRFU that was not available in previous censuses. This includes data regarding the actual process of NRFU such as the number of attempts a particular enumerator makes to enumerate a NRFU case or the time an enumerator spends conducting interviews. This is referred to as paradata. The automated systems also provide information on a daily basis to the outcomes of the NRFU enumeration, for example whether a NFRU case was completed by a direct interview with a household member or with a proxy such as a knowledgeable neighbor.

NRFU has prescribed rules to bring it to a timely and accurate conclusion. In the early stages of NRFU enumerators are not allowed to obtain proxy responses for occupied housing units. However, as NRFU nears completion, enumerators are allowed to obtain proxy enumerations, and finally to move to a stage called “Closeout” where they are allowed to obtain just minimal information for housing units such as just a count of people. These enumerations are referred to as “Pop Count Only.” As initially planned, if a CFS area reached a NRFU completion level of 85 percent, it was eligible to move into the Closeout phase. As of July 9, 2020, about two months after the start of NRFU all CFS areas became eligible for the Closeout phase. At the end of the Closeout phase it was anticipated that there would be a small number of NRFU cases for which no information was available. These cases are referred to as “unresolved.” The level of unresolved cases in previous censuses that had followed similar Closeout procedures was very small – under 0.4 percent. Unresolved cases receive additional processing that will be discussed in the post-data collection processing section below.

Administrative records are also used to reduce the NRFU workload by removing both vacant and occupied housing units after at least one in-person attempt has been made. These records are from sources such as USPS non-delivery records, IRS tax records, Medicare and Medicaid, Social Security, and the Indian health service. The Census Bureau conducted extensive research to identify situations when such administrative records could be used to provide a high quality enumeration of an occupied or vacant housing unit in NRFU.

Finally, college students are counted where they attend college. College students living in dormitories were to be enumerated as part of the group quarters enumeration described below. For college students living off-campus a special early NRFU was planned to be carried out by mid-April to enumerate them before they left town at the end of the school year, however as discussed below this operation was cancelled due to the COVID-19 pandemic.

As discussed above, the outcomes for the housing units included in NRFU are: (1) Direct enumeration with a household member; (2) Proxy enumeration that obtains more than a population count; (3) Proxy enumeration that only obtains a population count or Pop count only; and (4) unresolved status. The Census Bureau has made only limited information available regarding the progress of NRFU. The completion or resolution rate which is essentially a measure of how many unresolved cases are left to be completed is available for States and ACOs. This limited information is not informative about the quality of NRFU. This report identifies a number of additional quality indicators that must be evaluated.

B. Group Quarters Enumeration

GQ consist of institutions such as prisons and long-term care facilities as well as non-institutional facilities such as college dormitories, group homes or halfway houses. GQ enumeration is based on building a list of all such entities along with contact information in advance of Census Day, along with the best way to enumerate them. For example, some GQ have good records and these are provided to the Census Bureau to reflect the status as of April 1, 2020. Other GQ are visited by an enumerator to obtain a direct count of all of the residents. The Census Bureau had planned to conduct an early review of the GQ enumeration with experts such as State Demographers to detect inaccuracies or undercounts. This process would have covered such issues as whether GQ were in the right location, or appeared to have an incomplete count of the residents. This operation was recently canceled by the Census Bureau.

C. Service Based Temporary Non-Sheltered Outdoor Locations Enumeration

The Census Bureau conducts several operations that are designed to count persons with no permanent residence. Service Based Enumeration (SBE) to count the homeless and Temporary non-Sheltered Outdoor Locations (TNSOL) enumeration. SBE counts the homeless at places where they receive services such as soup kitchens or shelters. TNSOL counts people with no permanent residence who live in facilities such as RV parks where they are living as of Census Day. Both of these operations were designed to be carried out over a one-to two day period in early April of 2020.

D. Update Enumerate

The Update Enumerate (UE) operation occurs in areas where the enumerator conducts the enumeration in person while updating the MAF. This operation primarily occurs in Remote Alaska, in other tribal areas that request an in-person enumeration, and some additional areas in northern Maine and parts of Southeastern Alaska. There are fewer areas that fall under this type of enumeration in the 2020 Census than were included in 2010 Census.

Post-Data Collection Processing

Post-data collection processing starts with inputs from the computer systems used to support the data collection operations (both self-response and in-field) and performs several edits and quality checks to produce, first, the apportionment counts and then, the redistricting data. The first file created during this process is the Census Unedited File (CUF) which is used to produce the apportionment counts. This file is then improved through additional edits and quality checks to produce the Census Edited File (CEF), which is used to produce the redistricting data. There are critical activities that must be accomplished as part of the creation of the CUF and the CEF as described below.

A. Producing the CUF includes many processes:
    a. Identifying potential fraudulent returns from self-responses and recording a final fraud investigation disposition is critical, because the 2020 Census allows multiple opportunities for response, including allowing respondents to go online and respond with just their address, rather than a Census-provided passcode (“non-ID” response).

In previous censuses, respondents were required to use a multi-digit identification code that uniquely identified their housing unit in order to self-respond.

b. Identifying and resolving duplicate enumerations takes out households counted more than once

c. Imputation of the status of unresolved cases as either occupied, vacant, or nonexistent finalizes cases. For those unresolved cases that are assigned a status of occupied, a population count is also imputed.

B. Producing the CEF also requires the conduct of a number of edits and the application of statistical activities to account for missing data (e.g., a respondent did not provide an answer to the Race question).

a. Editing validates the consistency of the 2020 Census responses and makes corrections as necessary. For example, a five-year-old person cannot be the spouse of the first person listed on a questionnaire.

b. Missing data are dealt with through the use of imputation, including whole person imputation where all characteristics need to be imputed or specific characteristic imputation when a question is left blank (item non-response).

c. Comparing the results of the editing and imputation to the 2010 Census will provide valuable insights into the quality of the enumeration processes that resulted in the 2020 Census.

C. A number of quality checks were in the Census Bureau's original plans to ensure that the post-data collection processing systems were not subject to computer errors. An important component of these checks was having internal subject matter experts compare the 2020 results to various benchmarks, such as the Census Bureau's vintage population estimates (Population Estimates Program) for the decennial year[4]. Discrepancies resulting from these comparisons are resolved during the quality check process. If any discrepancies are caused by a computer error, it is corrected. However, the Census Bureau has stated that it has to truncate the schedule for post-data collection processing, and it will drop a significant portion of these checks. Unfortunately, there is no quality indicator that can be produced to assess whether undetected computer errors are affecting the accuracy of the apportionment or redistricting data until well after they are released.

COVID-19 and Other Schedule Changes

The COVID-19 pandemic and recent decisions by the Census Bureau and the Department of Commerce have resulted in significant revisions of the schedule by which the Census had planned to conduct the 2020 Census. The first schedule change occurred in mid-March when the Census Bureau stopped all field data collection operations in response to the COVID-19 pandemic. The result of such actions were to suspend, reschedule, or cancel all of the field data operations described above, as follows:

[4] The Population Estimates Program provides annual population estimates for geographic and demographic categories, including total population for states, cities and towns. The most current population estimates that are available represent the resident population as of July 1, 2019.

- Update/Leave operations were suspended and restarted in June 2020
- SBE and TNSOL operations were rescheduled for late September 2020
- Update Enumerate operations including in remote Alaska and in tribal areas were suspended and restarted on a flow basis in June 2020
- Early NRFU intended to count college students was canceled and the Census Bureau decided to count college students primarily through administrative records that are maintained by each university or college
- NRFU initially scheduled for May12 to July 31, 2020 was rescheduled for August 11 to October 30, 2020.
- Post-data collection processing initially scheduled for August 1 to December 31, 2020 was rescheduled for November 1, 2020 to April 30, 2021
- To accommodate these schedule changes, the Census Bureau requested that the statutory deadline for delivering apportionment be extended from December 31, 2020 to April 30, 2021. For redistricting data, the Census Bureau that the statutory deadline for delivering redistricting data be extended from March 31, 2021 to July 31, 2021

The Census Bureau announced on August 3, that the 2020 Census schedule would be revised again in order to meet the statutory deadlines of December 31, 2020 and March 31, 2021 for delivering apportionment and redistricting data, respectively. The changes were as follows:

- NRFU was scheduled to be completed by September 30, 2020. For most ACOs this would allow NRFU to be completed from August 11 through September 30, dropping a month of data collection from the schedule
- Post-data collection processing was scheduled to be completed from October 1 to December 31, 2020 dropping two months from the time allowed in the original schedule to accomplish this important task. Notably the Census Bureau dropped 21 days of expert review and computer error remediation.

However, within weeks of the August 3, 2020 announcement, several lawsuits were filed seeking to block the Census Bureau and the Department of Commerce from implementing the new schedule and to adhere to the initial plans that had been announced to respond to the COVID-19 pandemic. At this time the outcome of this litigation is pending.

Appendix 2.
Methods to Measure Geographic Variation

This appendix illustrates some of the statistical methods that may be used to assess quality indicators by beginning an analysis of the 2020 self-response rates. This first section describes analyses comparing the 2020 rates with those in 2010. A second section illustrates how other data sources may be merged to help interpret observed patterns.

The Census Bureau has released the "2020 self-response rates," both graphically and in a form suitable for download and analysis. The 2020 self-response rates are defined as the number of households reporting online, by mail, or by phone, expressed as a percent of total housing units in the geographic area. Rates are provided according to the planned 2020 tract definitions, with the exception of small tracts and those tracts lacking a self-response option. Rates are also provided for states, counties, congressional districts, towns or townships, consolidated cities, incorporated places, tribal areas, and tribal census tracts, again with similar exclusions. The analysis here is restricted to tracts, counties, and states. The analysis also excludes the data for Puerto Rico. The Census Bureau prepared comparable 2010 rates according to the same 2020 tract definitions. They are available from a link on the same page as the 2020 results, although 2010 rates are missing for about 0.6 percent of the tracts.

In general, high self-response is an ideal goal for a decennial census; self-response produces more accurate data overall and avoids additional burden on NRFU. In past censuses, however, self-response has not been uniformly distributed geographically. Figure 1 compares the distributions of self-response rates in 2020 and 2010 at the tract level.

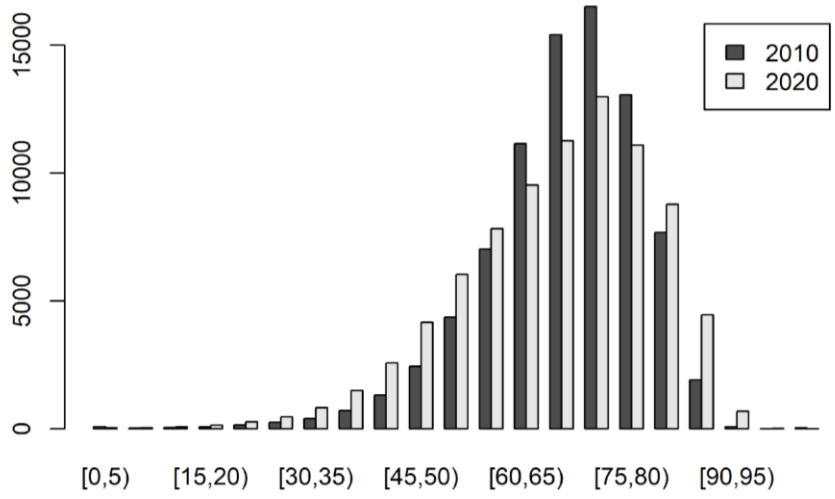

Figure 1. Bar chart comparing tract-level percent self-response in 2010 and 2020.

The two distributions of response rates are somewhat different, with a higher concentration of tracts falling in the interval between 60 percent and 80 percent in 2010 than in 2020. In 2020, more of the tracts either fall above 80 percent or below 60 percent. In other words, in 2020 there is greater variation between tracts in the proportion of housing units to be resolved in NRFU.

Figure 2 plots the 2010 and 2020 self-response rates at the tract level, showing a strong statistical relationship. A variety of statistical techniques could be applied to the data to further elaborate the relationship between response rates in the two censuses. Note that a few tracts in 2010 exhibit response rates of either 0 percent or 100 percent.

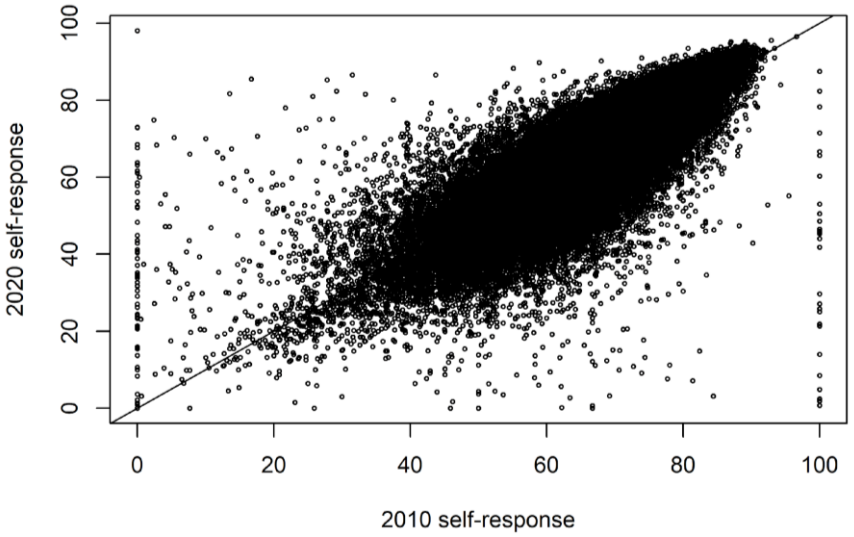

Figure 2. Scatter plot comparing tract-level percent self-response in 2010 and 2020.

Figure 3 displays the same data in a different form, known as a Bland-Altman plot, by showing the net increase in the response rate from 2010 to 2020 on the y-axis, plotted against their average on the x-axis. The few distinct points with either 0 percent or 100 percent response in 2010 are evident as two lines. These and a small number of other distinct points lying far away from the middle of the distribution can be investigated as outliers, in contrast to the swarm of points indicating small change. There are outliers in both directions, that is, tracts that have either substantially decreased or increased their self-response, which in the latter case is unlikely to indicate difficulty in 2020. In contrast to Figure 2, Figure 3 treats variation in the response rates equally rather than viewing the 2020 outcome as variable relative to a fixed 2010 value. Figures 2 and 3, although simple graphs, can also be of more help in studying subsets of tracts, such as tracts within a single state.

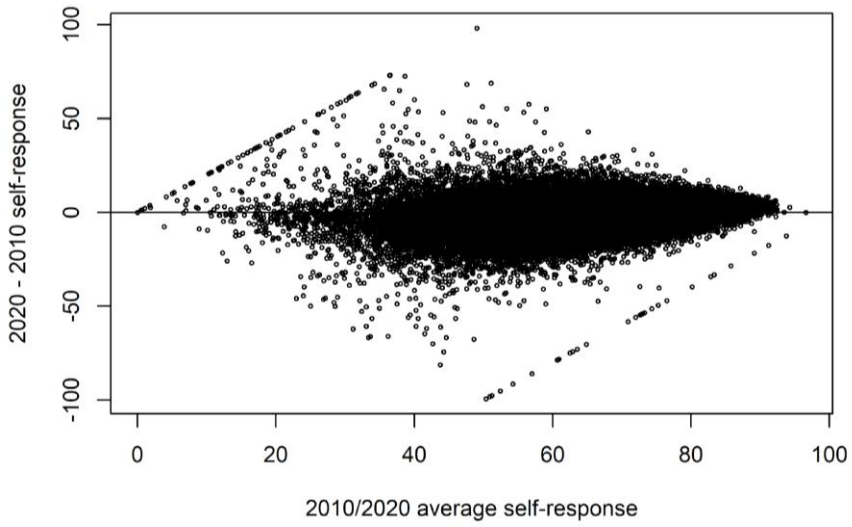

Figure 3. Bland-Altman plot comparing tract-level difference in percent self-response in 2010 and 2020 to their average.

Another statistical display of the results, Figure 4 displays a LOESS (locally estimated scatterplot smoothing) regression line of the prediction of 2020 response based on 2010. Like Figure 2, LOESS treats the 2010 tract results as fixed rather than viewing variation in the two censuses as equivalent. The results confirm the impression from Figure 2 that the relationship is quite strong, with little indication of regression to the mean except at the extremes of 2010 self-response.

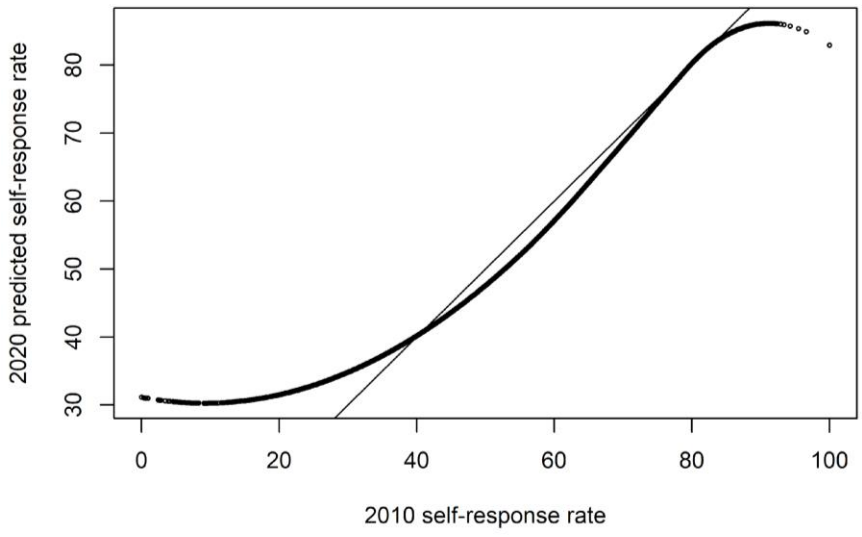

Figure 4. Loess regression prediction of 2020 tract-level percent self-response based on 2010 percent self-response, with an x=y line.

The 2020 Census was the first in which the primary mode for self-response was online, with the opportunity to respond by mail or phone offered as alternatives. With national self-response rates in 2020 approximating those in 2010, an interesting question is whether the internet option led to simply a splitting of the self-response among the households that would have responded without the online option. The next two figures provide some evidence on that question. In Figure 5, the change in total self-response is plotted against the 2020 internet response rate. Although there is wide variation in the outcome at the tract level, the overall pattern suggests that getting a high initial internet response increases the chance that 2020 will show an overall gain over 2010. More strongly, if the internet response starts low, then there is a reduced chance that mail and phone response will compensate sufficiently to reach the 2010 outcome, on average. A second view of the relationship results from changing the x-axis to the percent of the 2020 self-response that occurred online, as in Figure 6.

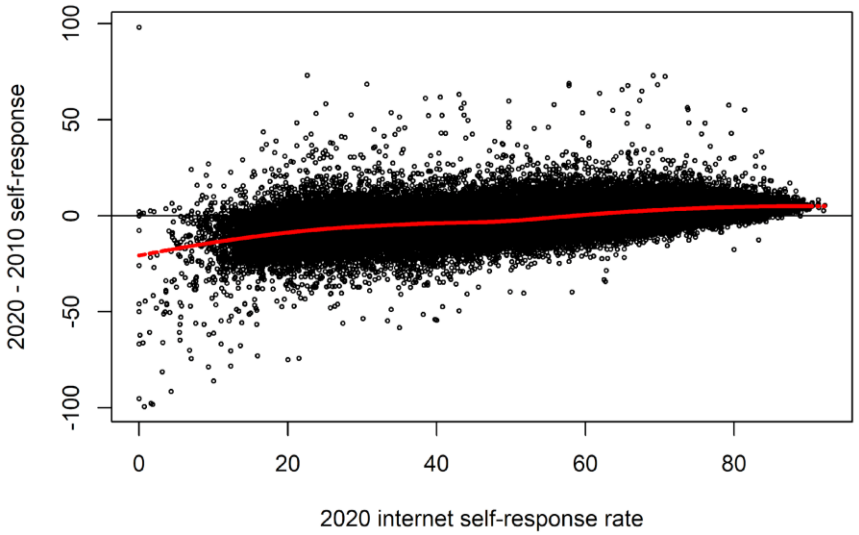

Figure 5. Change in tract-level percent self-response, 2010 to 2020, plotted against 2020 internet percent response. A LOESS fit is shown in red.

Figure 7 isolates the LOESS fit in Figure 6, changing the vertical scale to clarify the actual percentage point shift for different values on the x-axis. A substantial number of tracts fall in a region where the predicted self-response shortfall is 3 percentage points or more. Figures 5 and 6 both suggest that if the internet response rate is comparatively low, and the remaining forms of self-response, mail and phone, must make up the shortfall, then the tract will not achieve the same self-response rate as in 2010, on average.

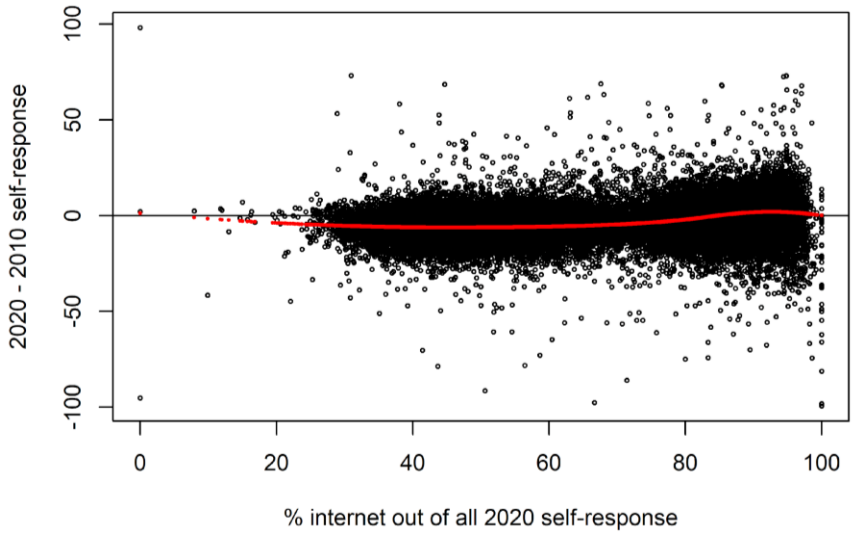

Figure 6. Change in tract-level self-response rates, 2010 to 2020, plotted against 2020 internet response as a percent of total self-response.

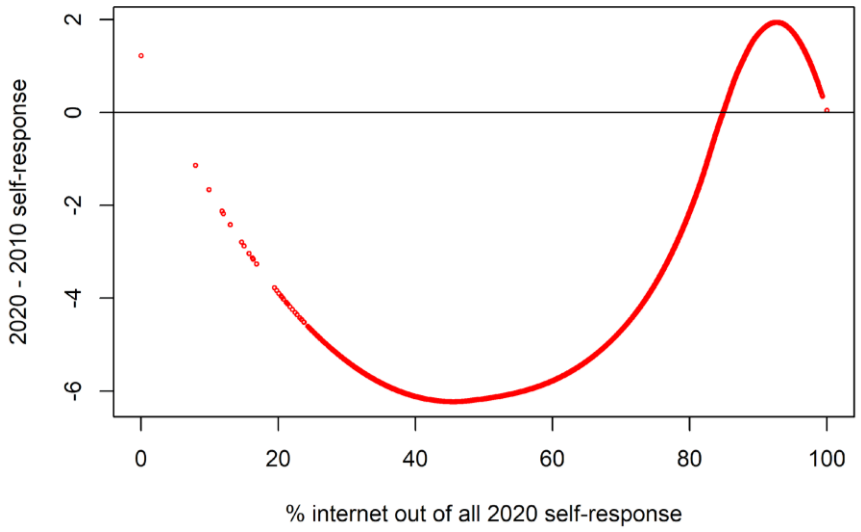

Figure 7. Loess fit of the change in tract-level percent self-response, 2010 to 2020, plotted against 2020 internet response as a percent of total self-response.

Figures 8 through 13 present the analogous analysis for counties as Figures 1, 3, 4, 5, 6, and 7. Overall, the results for tracts and counties are similar. Figure 8 again shows a similar but more dispersed distribution of self-response in 2020 than in 2010. The changes in self-response rates in Figure 9 show less variation at the county level than at the tract level, as do the changes in Figures 10, 11, and 12, but the patterns are otherwise close to each other. Figure 13 again indicates that counties with a low internet response are likely not to reach their 2010 levels, falling short by 3 percentage points or more.

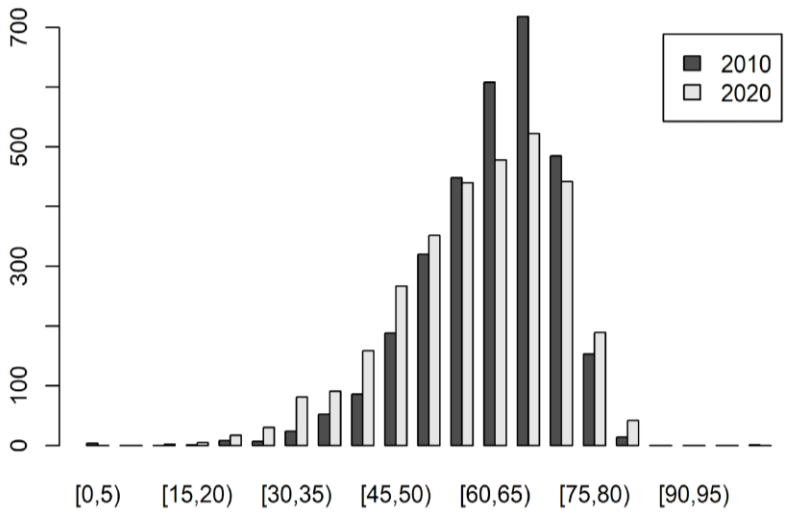

Figure 8. Bar chart comparing county-level self-response in 2010 and 2020.

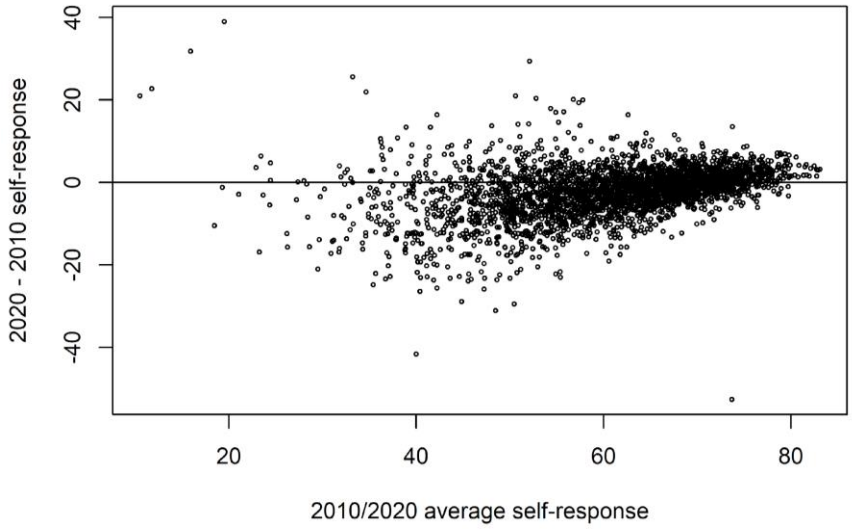

Figure 9. Bland-Altman plot comparing the difference in county-level self-response in 2010 and 2020 to their average.

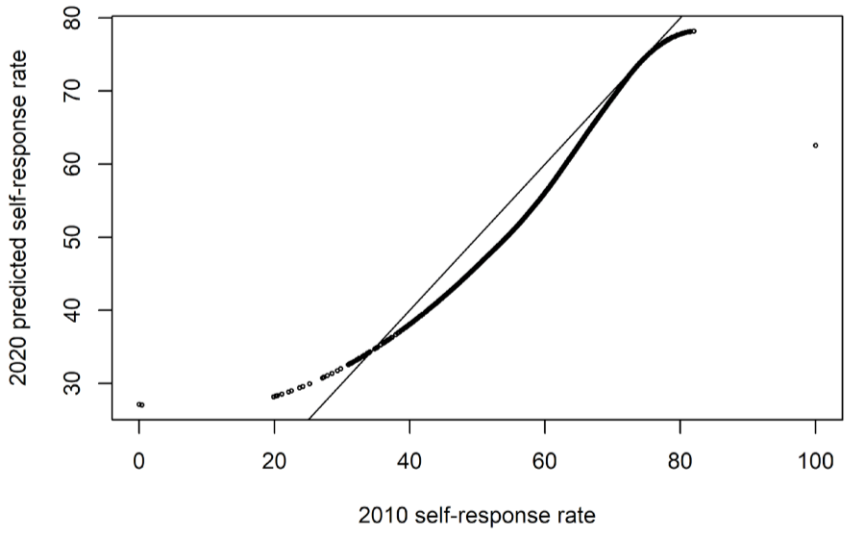

Figure 10. Loess regression prediction of 2020 county-level self-response based on 2010 self-response rate, with an x=y line.

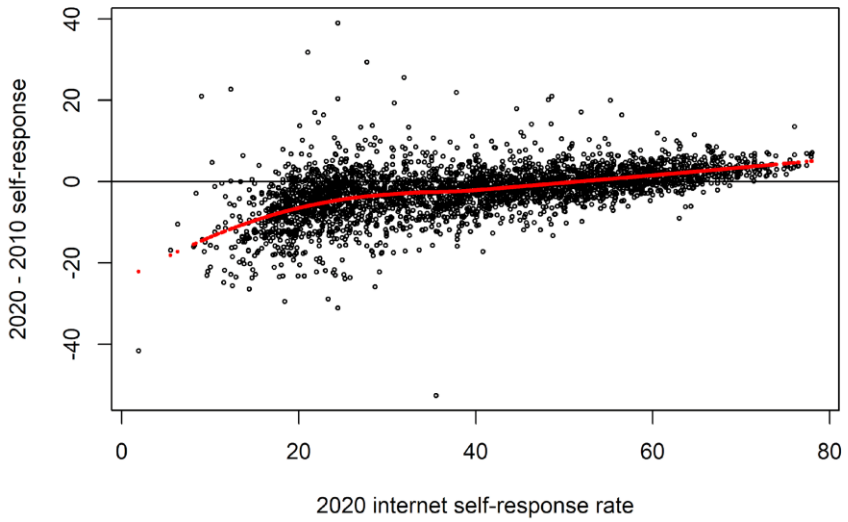

Figure 11. Change in county-level self-response rates, 2010 to 2020, plotted against 2020 internet response rate. A LOESS fit is shown in red.

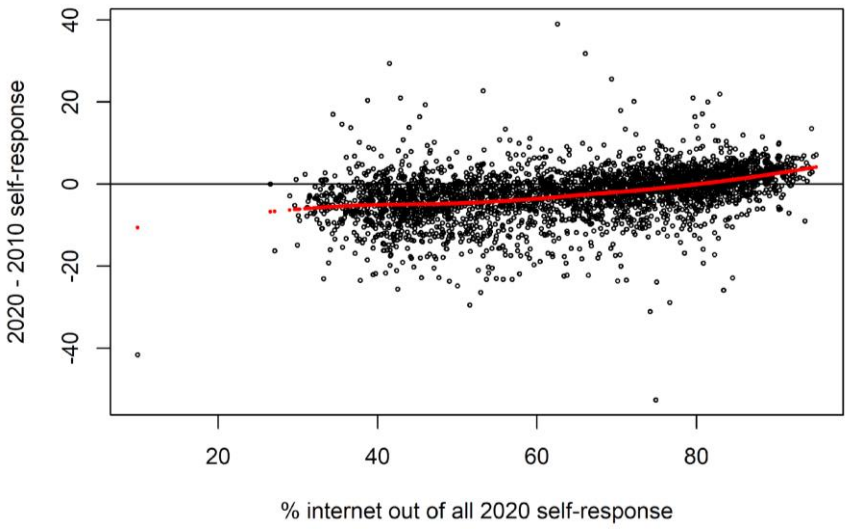

Figure 12. Change in county-level self-response rates, 2010 to 2020, plotted against 2020 internet response rate as a percent of total self-response.

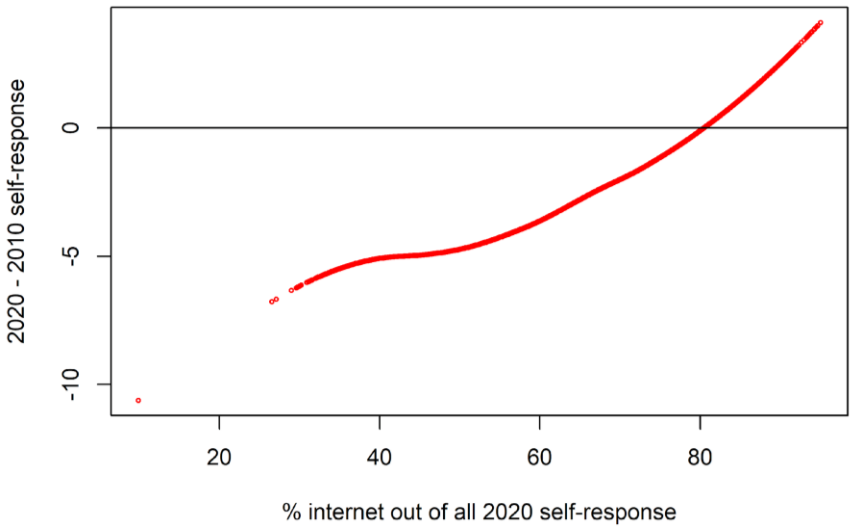

Figure 13. Loess fit of the change in county-level self-response rates, 2010 to 2020, plotted against 2020 internet response rate as a percent of total self-response.

With far fewer points to analyze, graphical displays present a less clear picture for states. Nonetheless, Figure 14 shows the same relative increase in dispersion for states relative to 2010 as tracts and counties, although the variation at the state level in both 2010 and 2020 is less than for tracts and counties. The same effect of low internet self-response appears in Figures 15, 16, and 17.

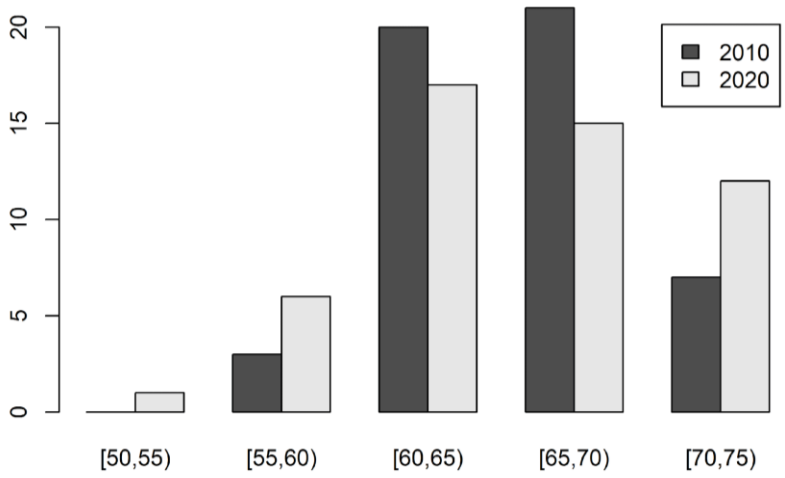

Figure 14. Bar chart comparing state-level self-response in 2010 and 2020.

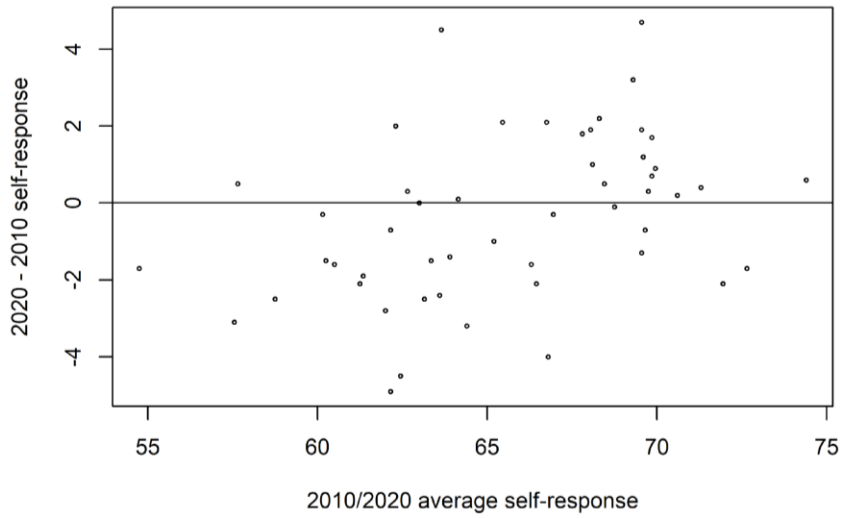

Figure 15. Bland-Altman plot comparing the difference in state-level self-response in 2010 and 2020 to their average.

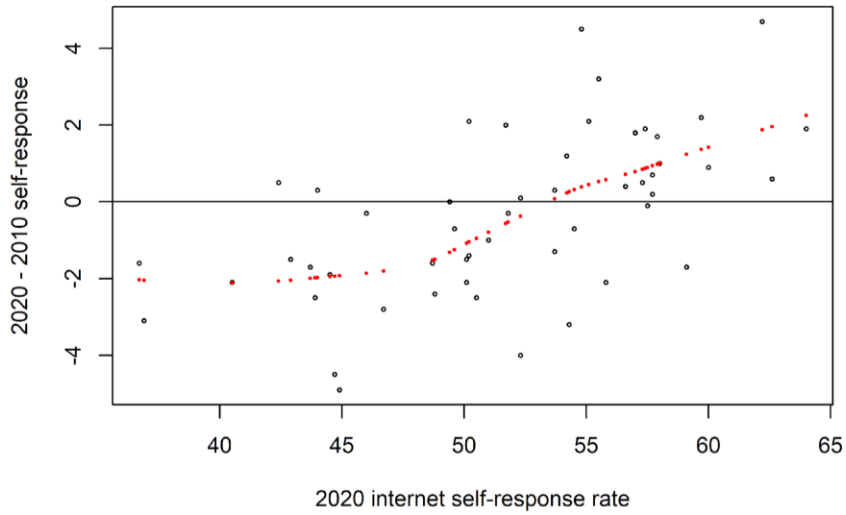

Figure 16. Change in state-level self-response rates, 2010 to 2020, plotted against 2020 internet response rate. A LOESS fit is shown in red.

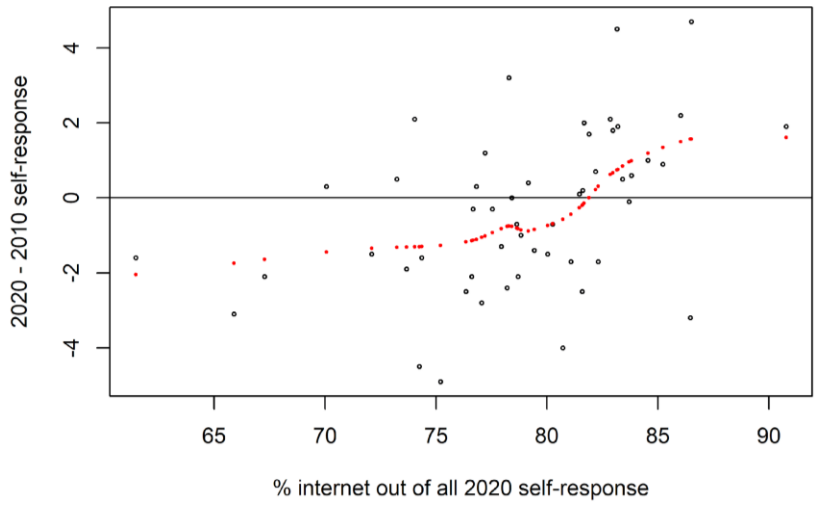

Figure 17. Loess fit of the change in state-level self-response rates, 2010 to 2020, plotted against 2020 internet response rate as a percent of total self-response.

Although the preceding plots present quite similar relationships at the tract, county, and state level in this case, the same may not be true for other quality indications. Instead, the example may be viewed as supporting the value of analyzing quality indicators at different geographic levels to understand the implications at each.

Analyzing Quality Measures with Auxiliary Data Based on 2010 Geography

The ability to link data at the tract level enables the analyses illustrated by Figures 2 through 7. Changes in the definition of tracts across time represents a potential obstacle to tract-level analysis comparing 2010 and 2020. After a census, the Census Bureau publishes crosswalk files relating the tract-level geography to the previous census. Although such a file would be useful for our purpose, we do not expect this file until after the CEF is finalized, at the earliest. The planned 2020 tract definitions may be subject to some revision as well. A small study illustrates that for the purposes of statistical analysis, this obstacle may be reasonably addressed for 2010-based tracts, which are the basis of the Census Bureau's Planning Data Base (PDB), for example, except for revisions in the PDB to a small number of tracts.

The tract-level 2020 PDB includes the variable, Low Response Score, and a wealth of characteristics from the 2014-2018 American Community Survey (ACS). The original file reports on 73,058 unique tracts, although 1,256 of them are missing a value for the Low Response Score. Of the 83,174 tracts for which the Census Bureau has provided 2010 self-response rates based on 2020 tract definitions, only 60,960 of them can be matched exactly to the 2010-based tracts in the PDB. Restricting an analysis to the exactly matching tracts would overlook a substantial number.

But for statistical purposes, the remaining 12,098 tracts in the PDB can be combined by the first 4 digits of their 6-digit tract code, averaging their Low Response Scores. (The rationale for this approach is that tracts ending in two digits other than "00" were originally part of a tract with the same first four digits that once ended in "00", so tracts sharing the first four digits are related. A refinement of the averaging can incorporate weights based on the number of households.) In many cases, there is only one 2010 tract with the same 4 digits. Keeping these tracts and combining other tracts on the basis of the leading 4 digits results in 8,716 scores summarized to the 4-digit level, after dropping those combined tracts for which the Low Response Rate is missing. When matched to the remaining 22,214 tracts with 2020 self-response rates, 21,626 out of the 22,214 are successfully matched to 2010 on basis of the 4-digit level tract code. Consequently, over 99 percent of the 2020 tracts ((60,960+21,626)/ (60,960+22,214)) with reported self-response rates can be matched to Low Response Rates in the PDB either exactly or on the basis of 4-digit level code.

The data for even somewhat more tracts can be matched in this way if an analysis of Low Response Scores is not required. More generally, there are 9,490 unique 4-digit tract codes in the remaining 12,098 tracts in the PDB, and 21,751 out of the 22,214 remaining tracts can be matched to them. The following regression analyses used the previous set, however, so that Low Response Score could be included in the analysis.

As a modest test of whether matching on 4-digit tract code for tracts that could not be matched on all 6 digits is satisfactory, three linear regression equations were computed to compare the results for the two types of tracts, as well as for counties and states. One regression uses Low Response Scores, which were not available for counties and states. The results in Table 1 suggest that in this case the matching strategy appears to yield substantially equivalent, if not exactly the same, results.

Table 1. Comparison of regression models predicting percent 2020 self-response for counties, states, and two sets of tracts according to matching strategy to the PDB

Coefficient	Exactly matched tracts (n=60,960)	Tracks aligned by first 4 digits (n=21,625)	Counties (n=3,143)	States (n=51)
Model 1				
Intercept	-4.700	3.423	-5.428	-5.290
2010 % self-response	1.049	.936	1.051	1.080
Model 2				
Intercept	-8.001	-4.621	-8.414	-9.567
2010 % self-response	0.886	0.827	0.961	1.022
ACS % broadband	0.219	0.228	0.157	0.121
Model 3				
Intercept	3.083	6.167		
2010 % self-response	0.826	0.789		
ACS % broadband	0.198	0.206		
Low Response Score	-0.267	-0.319		

Appendix 3.
Demographic Analysis from the 2010 Census

Table A. U.S. Resident Population and the Components of Demographic Analysis by Race and Sex: April 1, 2010
(In thousands)

Series and component	Total population	Black			Non-Black		
		Both sexes	Male	Female	Both sexes	Male	Female
Revised Middle Series Estimates (May 2012)							
Total population	308,346	41,196	20,136	21,060	267,150	132,920	134,229
Population aged 0-64 years	268,646	37,676	18,720	18,956	230,970	117,093	113,878
Births	249,847	37,659	19,084	18,576	212,188	108,914	103,274
Deaths	14,846	3,283	2,020	1,263	11,563	7,402	4,160
Net international migration	34,074	3,385	1,726	1,659	30,688	15,891	14,798
Armed forces overseas	429	86	69	17	343	309	34
Population aged 65 years and over	39,699	3,520	1,416	2,104	36,180	15,828	20,352
Population aged 65-74 years	21,405	2,072	915	1,156	19,334	9,156	10,178
Births	26,465	3,287	1,665	1,622	23,178	11,917	11,261
Deaths	8,332	1,460	861	600	6,872	4,150	2,722
Net international migration	3,272	245	112	134	3,027	1,389	1,639
Armed forces overseas	-	-	-	-	-	-	-
Population aged 75 years and over							
Medicare-based estimates	18,294	1,448	500	948	16,846	6,672	10,174
Original Middle Series Estimates (December 2010)							
Total population	308,475	41,270	20,168	21,103	267,205	133,204	134,001
Population aged 0-64 years	268,518	37,794	18,780	19,015	230,724	117,251	113,473
Births	249,891	37,979	19,246	18,733	211,912	108,774	103,138
Deaths	14,829	3,308	2,036	1,272	11,521	7,380	4,141
Net international migration	33,889	3,210	1,640	1,570	30,680	16,169	14,511
Armed forces overseas	433	86	69	17	347	311	36
Population aged 65 years and over							
Medicare-based estimates	39,957	3,476	1,388	2,088	36,481	15,953	20,528
Differences (Revised - Original)							
Total population	-129	-74	-32	-43	-55	-284	228
Population aged 0-64 years	128	-118	-60	-59	246	-158	405
Births	-44	-320	-162	-157	276	140	136
Deaths	17	-25	-16	-9	42	22	19
Net international migration	185	175	86	89	8	-278	287
Armed forces overseas	-4	-	-	-	-4	-2	-2
Population aged 65 years and over	-258	44	28	16	-301	-125	-176

- Represents zero or rounds to 0.

Notes:

Estimates may not sum to totals shown because of rounding.

In this table, Black is the sum of the Black alone population aged 0-29 years and the Black population aged 30 years and over. Estimates of the population aged 30 years and over are classified as Black and non-Black, with no further distinction as to whether Black refers to Black alone or Black alone or in combination with other races.

Births, deaths, and net international migration for the population aged 0-64 years refer to events occurring between April 1, 1945 and March 31, 2010. Births deaths, and net international migration for the population aged 65-74 years refer to events occurring between April 1, 1935 and March 31, 1945.

Net international migration includes the international migration of both native and foreign-born populations. Specifically, it includes: (a) the net international migration of the foreign born, (b) the net international migration of the native born, and (c) the net migration between the United States and Puerto Rico.

Source: U.S. Census Bureau, Population Division, 2010 Demographic Analysis.

Release date: May 2012