Repeated Cross-Sectional Surveys: Accounting for Instrumentation Changes

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Abstract
Repeated cross-sectional surveys try to maintain continuity in their instruments to allow for trend analysis. However, changes are necessary over time to adapt to improved methodology and to update to current circumstances. Changes may include certain questions being phrased differently across time, the addition or removal of particular response options, or the reorganization of the questions themselves. When conducting trend analysis in repeated cross-sectional surveys, it is necessary to account for potential measurement error spawning from such changes.

The Survey of Prison Inmates (SPI) sponsored by the Bureau of Justice Statistics has been conducted seven times since 1974. The survey provides information about U.S. prisoners on a wide range of topics, such as demographics, current offenses and sentences, criminal history, gun possession and use, drug use and treatment, and mental health history and treatment. In this paper, we assess how similar constructs have changed in the SPI instrument over time and then discuss how those changes impact survey estimates and their comparability. Our analysis will specifically focus on comparing the most recent survey year, 2016, to the most recent prior version, 2004.

Key Words*:* measurement error, repeated cross-sectional survey, Survey of Prison Inmates

1. Introduction

1.1 Background

The Survey of Prison Inmates (SPI) provides a variety of information regarding the U.S. state and federal inmate populations. It was formally known as the Survey of Inmates in State and Federal Correctional Facilities (SISFCF). Covered topics include:

- demographics;
- current offenses and sentences;
- victim characteristics;
- criminal history;
- drug use and treatment; and
- mental and physical health history and treatment.

Prior to 2016, the survey was sponsored by the Bureau of Justice Statistics (BJS) and conducted by the U.S. Census Bureau. It was conducted periodically with survey iterations in 1974, 1979, 1986, and 1991, for which only state prison inmates were surveyed. For

subsequent iterations, conducted in 1997 and 2004[1], the survey was expanded to include both state and federal inmate populations. The 2016 survey was conducted by RTI International and also included both state and federal prisoners.

Prior to 2016, SPI had been conducted every 5 – 7 years. However, due to other survey priorities involving prisoners, after 2004, a 12-year gap occurred before the 2016 SPI. In the intervening years, the user community became increasingly intent on obtaining information about how the prison population had changed in the U.S., At the same time, many of the best practices for measuring important constructs have changed as well.

SPI is collected via computer assisted paper interviews (CAPI). Under CAPI an interviewer uses a computer-programmed instrument to move through the survey instrument. CAPI ensures skip patterns are consistently applied across interviewers and interviews. Moreover, the use of a consistent data collection mode ensures that any changes in the estimates are not due to a mode effect.

1.2 Understanding the Problem/Motivation

Periodic cross-sectional surveys, like SPI, offer analysts the ability to assess how the population of interest has changed over time. However, for this type of comparison to be conducted without also considering measurement differences, the survey items need to be identical or near identical. This constraint is often at odds with the survey designer's desire to incorporate known improvements in question wording or response options. For example, when the U.S. Census Bureau altered how it asked about race and Hispanic origin in the 2000 Census to allow for respondents to indicate more than one race, other federal surveys followed suit to utilize this improved approach. However, for periodic surveys, the new approach was not backward compatible making it difficult to compare with survey iterations conducted prior to 2000. Another example is household income. Methodologists often struggle with whether asking for an exact (or continuous) response yields a more accurate results than asking respondents to place their income within a set of categorical ranges. Research has shown that these two approaches will yield different response distributions. Therefore, regardless of which is better, the act of changing the method across survey iterations can have a profound impact on the ability to assess change over time.

Differences caused by changes in question wording is known as *measurement error*. Measurement error is the difference in the true response value and the self-reported value (Lessler & Kalsbeek 1992). While measurement error can come from various sources – e.g., the mode of interview, the interviewer – changes in question wording is a clear indication for potential measurement error. However, if question wording from a past iteration is known to be inferior based on current research, designers of longitudinal or periodic cross-sectional surveys have a real dilemma on whether to update the wording and risk measurement error or keep the wording unchanged and not incorporate modern methods.

One issue when trying to assess potential measurement error in periodic survey is that changes in the estimates can come from two sources: (1) actual temporal change and (2) measurement error. Unless an experiment is conducted during the current iteration, one's ability to tease out the amount of the change attributable to each source is somewhat

[1] See codebook for Survey of Inmates in State and Federal Correctional Facilities, 2004 for details on methodology.

speculative. When an experiment is not conducted – either due to cost or design limitations – an assessment of measurement error can still be conducted, but the exact impact of measurement error cannot be quantified.

SPI is the only nationally representative survey of prisoners which asks respondents about such a wide-ranging set of issues. As such, it is a key reference used by criminologists to understand how the prison population has changed over time. Therefore, designers of each iteration need to be mindful of the impact that any change to the survey instrument has on one's ability to measure change.

The SPI questionnaire has been carefully modified with each iteration to minimize the impact that such changes may have on data comparability. Changes have been introduced for several reasons. For instance, there has been an interest in capturing information on evolving issues in criminal justice. Recent modifications include enhanced questions on the medical and mental health histories of inmates. Similarly, response options for types of drugs used prior to incarceration or treatment types have been updated to reflect current trends and practices. In addition, advances in survey methodology may alter the best practices for asking about certain constructs such as race

When changes are made, even when cognitive testing is done in advance, the full impact often cannot be fully assessed until data collection is complete. When assessing the impact, it may be possible to quantify and identify methods to account for these differences. In this paper we present a set of items for which changes to the question wording was changed in 2016 compared to prior iterations of SPI. We assess what the impact of the change was on estimates, whether an adjustment could be made to assess trends, and whether the proposed adjustment was able to address any measurement error.

2. Methods

To illustrate the potential impact of measurement error on SPI survey items in 2016 relative to prior iterations, we looked at three constructs:

1. Personal income in month prior to arrest
2. Current incarceration status
3. Number of incarcerations

The 2016 SPI was not able to include a split sample experiment to assess the impact of the changes made to these, and other, items. Therefore, we use alternative methods to attempt to quantify the impact of measurement error.

Our approach to identifying potential measurement error and, when possible assessing the impact of any implemented adjustments, consisted of five steps:

1. Create a constructed variable for each survey year with comparably defined levels
2. Produce weighted distributions for each survey year
3. Calculate the percent change between survey years. For 2016 and 2004 the percentage change was computed as $\frac{per_{2004-k}-per_{2016-k}}{per_{2016-k}}$ where per_{2004-k} and per_{2016-k} are the percentage distribution values for level *k* of the construct in 2004 and 2016, respectively.
4. Assess the difference in the percent change to determine if the change is solely due to temporal change or additional due to measurement error and determine if a

correction to the construct can be made to correct for potential measurement error.

5. If a correction can be made, compute the percent change between the two survey years after the adjustment was implemented.

2.1 Personal income in month prior to incarceration

In all SPI iterations, personal income in month prior to arrest was collected. However, in 2004 (and prior iterations), personal income was asked using a set of categorical response options while in 2016 respondents were first given the option to provide an exact amount and give the categorical response options only if an exact amount could not be provided.

In 2004 the question wording was:

S7Q11c. **SHOW CARD H**

Which category on this card represents your personal monthly income from ALL sources for the month before your arrest, that is, from *(Insert month prior to the month of arrest)* first to *(Insert month prior to the month of arrest)(Insert number of last day of the month)(Insert year of arrest, unless prior month is December. If prior month is December, use year prior to year)*?

(0) No income
(1) $1 - 199
(2) 200 - 399
(3) 400 - 599
(4) 600 - 799
(5) 800 - 999
(6) 1,000 - 1,199
(7) 1,200 - 1,499
(8) 1,500 - 1,999
(9) 2,000 - 2,499
(10) 2,500 - 4,999
(11) 5,000 - 7,499
(12) 7,500 or more
(D) Don't know

In 2016, the question wording for the continuous measure was:

SES17 Think about all of the income you received during the 30 days before your arrest including from any illegal activities. What was your total income for that 30 day period?

If the inmate selected "Don't know" or "Refused" for the continuous income measure, the inmate was then asked the following categorical question:

> **SES17a** Would you say the income you received in those 30 days was...
>
> 1 Less than $200
> 2 $200 - $599
> 3 $600 - $999
> 4 $1000 -$1999
> 5 $2000 - $4999, or
> 6 $5000 or more?
> DK/REF

Given the question wording from 2004 and 2016, our constructed variable for personal income in month prior to arrest was defined as: 1) None, 2) Less than $200, 3) $200-$599, 4) $600-$999, 5) $1000-$1999, 6) $2000-$4999, or 7) $5000 or more.

2.2 Current incarceration status

Both the 2016 and 2004 surveys feature variables constructed by the CAPI, which describe the current incarceration status[2] of each inmate. Each survey year's current incarceration status variable incorporates various questions, such as the inmate's status at the time of their arrest (e.g., on probation, on parole, on escape) and whether they report being sentenced for any new offenses when they were admitted to prison.

One way of categorizing inmates by their current incarceration status in 2004 and 2016 is by noting whether they are: unsentenced, sentenced without a criminal justice status at the time of their arrest (new court commitment), and sentenced with a criminal justice status at the time of their arrest (e.g., on probation, on parole). From a measurement perspective, the 2004 and 2016 instruments are similar in how they handle unsentenced[3] and sentenced without a criminal justice status at the time of arrest. However, the system variable handled inmates with a status at the time of their arrest (e.g., on probation, on parole) differently which may have introduced measurement error.

In **figure 1**, we depict how inmates with a criminal justice status at the time of their arrest were categorized in 2004. As **figure 1** shows, the 2004 system variable distinguishes between inmates who report having new sentences for only probation or parole violations, and those with new sentences for other offenses. Those who only have new sentences for these violations are regarded as not having new sentenced offenses in 2004. The rest of the inmates who say 'Yes' to being sentenced for any new offense in 2004 are categorized as having new sentenced offenses in the system variable.

[2] See Appendix A for the full levels of the 2004 and 2016 current incarceration status system variables

[3] There were some minor differences between how unsentenced inmates were assigned in 2004 versus 2016, such as how the 2004 system variable has only one unsentenced level, while the 2016 system variable has two such levels. However, these differences do not produce any measurement error, since all unsentenced inmate levels are assigned to "Other" in our constructed variable designed to span 2016 and 2004.

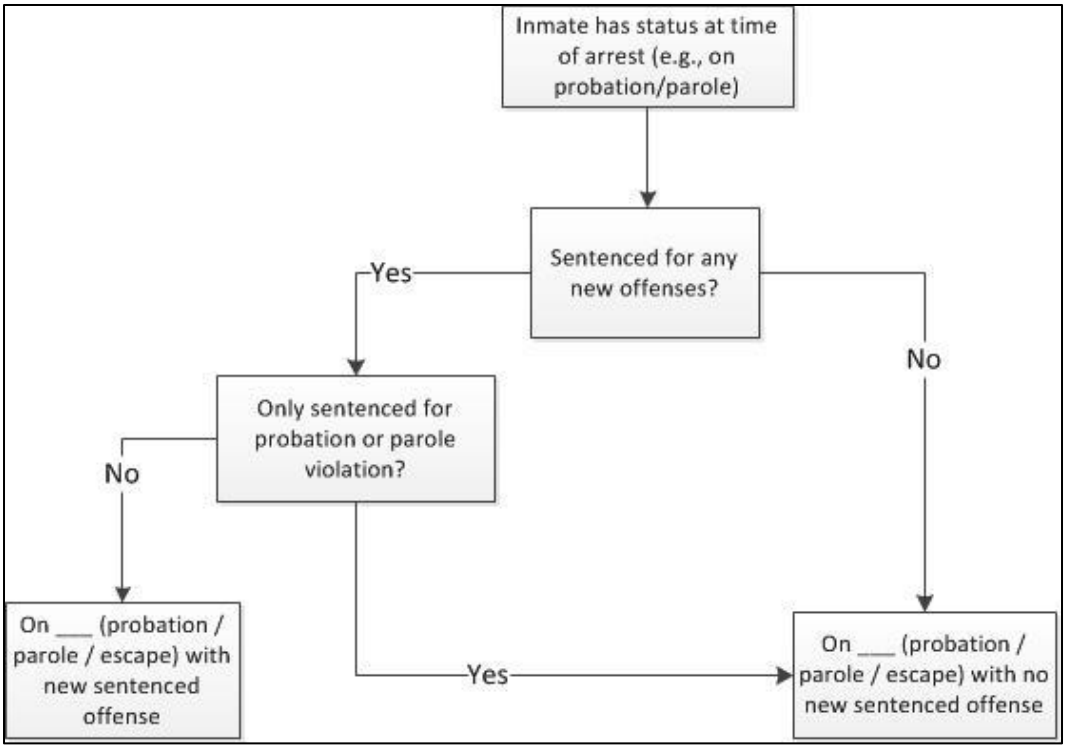

Figure 1: Flowchart of current incarceration status system variable (2004) for inmates with a criminal justice status at the time of their arrest.

Figure 2 depicts how the current incarceration status system variable was assigned in 2016. Here, each inmate in 2016 who says 'Yes' to being sentenced for any new offenses was classified as having new sentenced offenses in the system variable. Unlike in 2004, the 2016 system variable does not analyze the new sentenced offenses themselves when determining whether the inmate does or does not have new offenses.

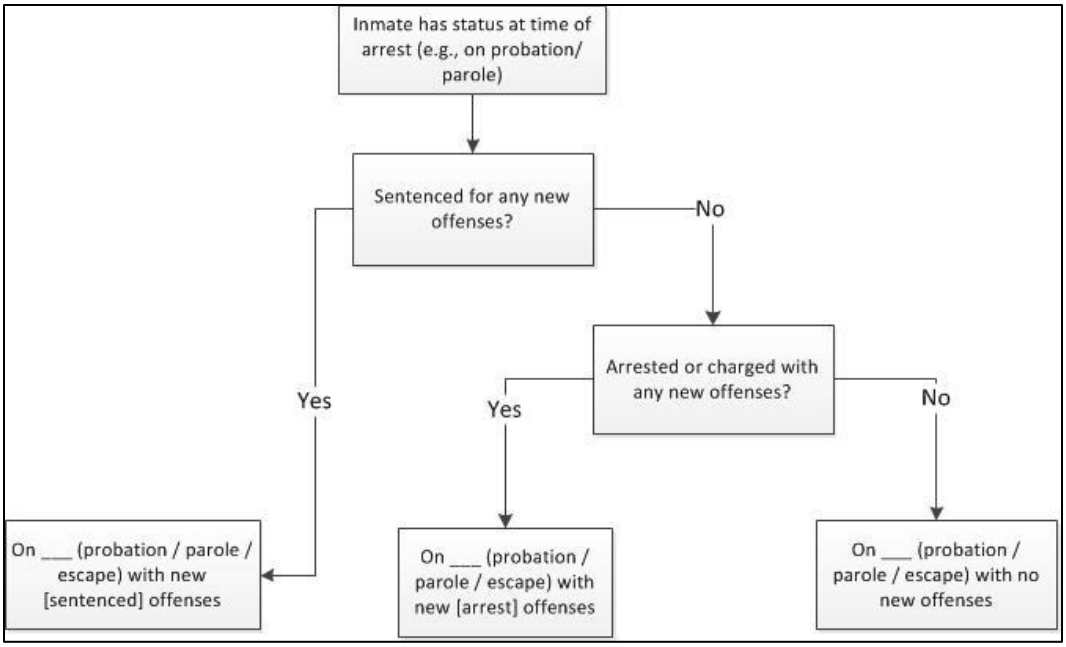

Figure 2: Flowchart of current incarceration status system variable (2016) for inmates with a criminal justice status at the time of their arrest.

The constructed variable intended to span survey periods for current incarceration status was defined as: 1) New court commitment, 2) On probation with new sentence, 3) On parole with new sentence, 4) On probation without new sentence, 5) On parole without new sentence, or 6) Other.

Due to differences in how the 2004 and 2016 current incarceration status system variables were coded in their respective CAPI (see **figure 1** and **figure 2**), measurement error was potentially introduced. Some inmates who would be assigned to category 2) in 2016 would be assigned to category 4) in 2004. Likewise, a portion of the inmates who would be assigned to category 3) in 2016 would be assigned to category 5) in 2004. While the system variable automatically made these assignments, the 2016 instrument allowed us to decompose the inmates with a status at the time of their arrest who had new sentenced offenses (see **Appendix A** for detailed categorizations) in a way that was similar to the coding for the 2004 system variable (see **figure 1**). Specifically, in 2016, if any inmates were on probation/parole/escape and their only new sentenced offense was a probation or parole, we categorized them as having no new sentenced offenses in our constructed variable. This was intended to mitigate any measurement error between the 2004 and 2016 surveys.

2.3 Number of incarcerations

The number of incarcerations reflect the number of times an inmate has been sentenced to serve time in a correctional facility, including the current incarceration.

In 2004 (and prior years), inmates were asked about their number of prior incarcerations, excluding their current sentence. The surveys featured a criminal history calendar, on which inmates filled out details about each of their most recent prior incarcerations. These details included which offenses they were sentenced for at that time, what type of facility they were sentenced to, the date they were first admitted to that facility for those offenses, and how long they served for those offenses.

In 2016, the questions were streamlined such that, rather than filling out a criminal history calendar, inmates were asked their lifetime number of incarcerations, including their current sentence, at 1) juvenile correctional facilities, 2) local/county jails, and 3) state/federal prisons.

In **figure 3**, we depict how the number of *prior* incarcerations of each inmate was asked in 2004. In 2004, we obtained the number of prior incarcerations by summing the number of prior sentences to incarceration for minor crimes[4] as both a juvenile and an adult, plus the number of prior sentences to incarceration for non-minor crimes[5] as both a juvenile and adult.

[4] As detailed in the 2004 codebook, minor crimes include:

1) Drunkenness
2) Vagrancy
3) Loitering
4) Disorderly conduct
5) Minor traffic crimes (Excludes driving while intoxicated and hit and run)

[5] Non-minor crimes include anything besides the five minor crimes detailed in footnote 5

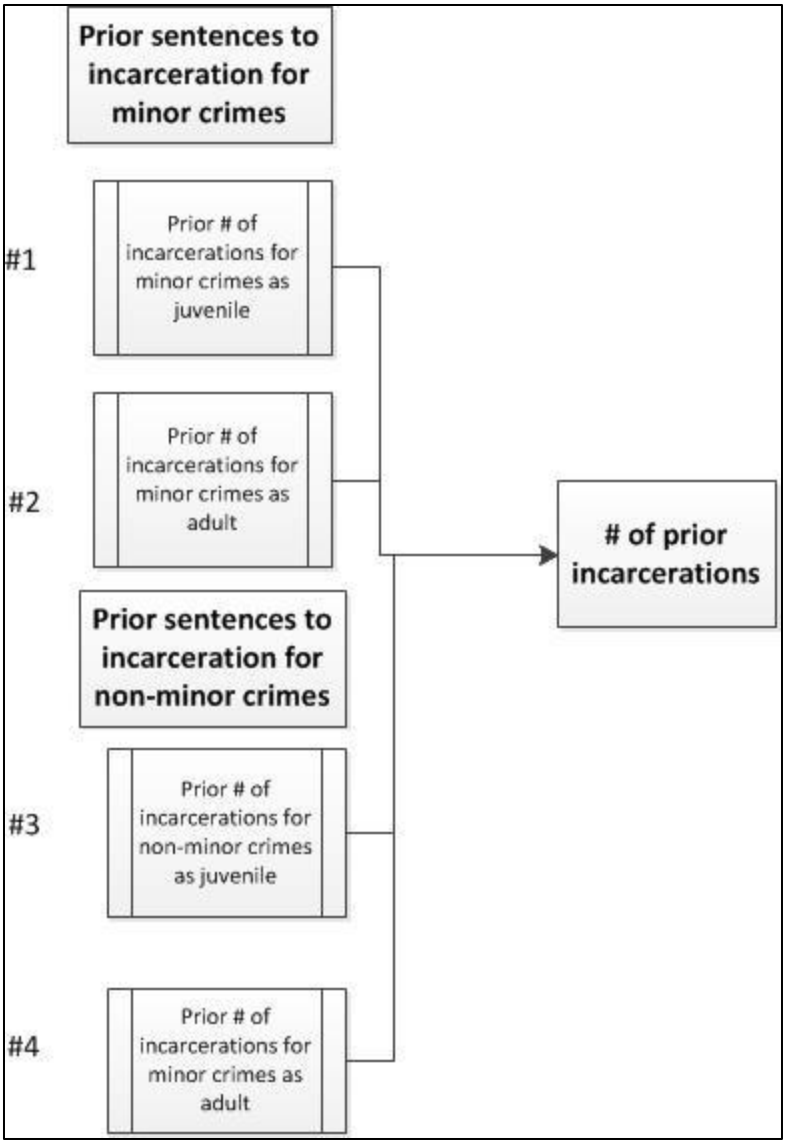

Figure 3: Flowchart of original definition of the number of incarceration in 2004.

Figure 4 depicts how we obtained an inmate's number of *lifetime* incarcerations in 2016 by combining the number of total times sentenced to serve time in a juvenile correctional facility, the number of times sentenced to a local/county jail, and the number of total times sentenced to serve time in a state or federal prison.

The 2016 survey asked the total number of times an inmate was sentenced to serve time in a state or federal prison including both the inmate's prior incarcerations to prison as well as the inmate's current incarceration (as seen in **figure 4**). On the other hand, the four 2004 survey questions looked only at prior incarcerations.

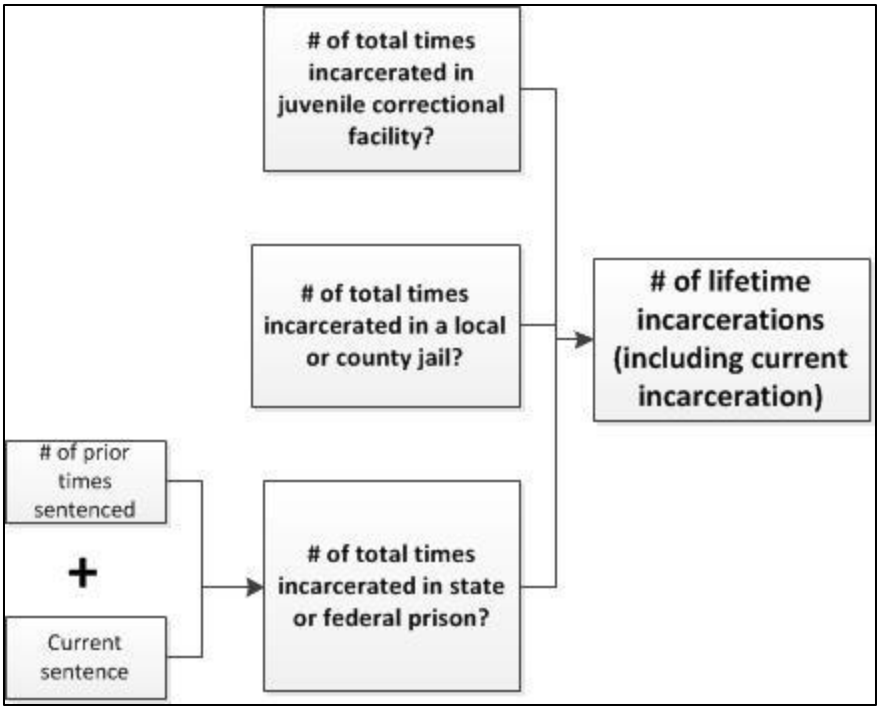

Figure 4: Flowchart of original definition of the number of incarceration in 2016.

To compensate for the inclusion of the inmate's current incarceration in the 2016 survey but not the 2004 survey, we attempted to remove the current sentence from our incarceration total in 2016. To do this, we subtracted one from the sum of the number of sentences to serve time in 1) a juvenile correctional facility, 2) a local or county jail, and 3) a state or federal prison in 2016 if the inmate was currently sentenced. Otherwise, if the inmate was unsentenced, we set their number of prior incarcerations equal to the sum of the number of times they've been sentenced to serve time in each of these facility types.

The constructed variable used to compare periods for number of prior incarcerations was defined as: 1) 0 incarcerations, 2) 1 incarceration, 3) 2 to 4 incarcerations, 4) 5 to 9 incarcerations, or 5) 10 or more incarcerations.

3. Results

For each construct, we present the relative change between the 2004 estimates and the 2016 estimates. Exact estimate values are not presented in this paper because the results of the 2016 survey have not been published yet. The relative change provides an indication of how the estimate distribution has shifted between periods. When an adjustment was determined to be possible, the adjusted relative change is presented as well.

3.1 Personal income in month prior to arrest

As depicted in **figure 5**, the proportion of inmates in personal income categories under $2000 decreased from 2004 to 2016. Meanwhile, the proportion of inmates in income categories over $2000 increased from 2004 to 2016. In other words, the monthly income inmates reported in 2016 was greater than the monthly income reported in 2004.

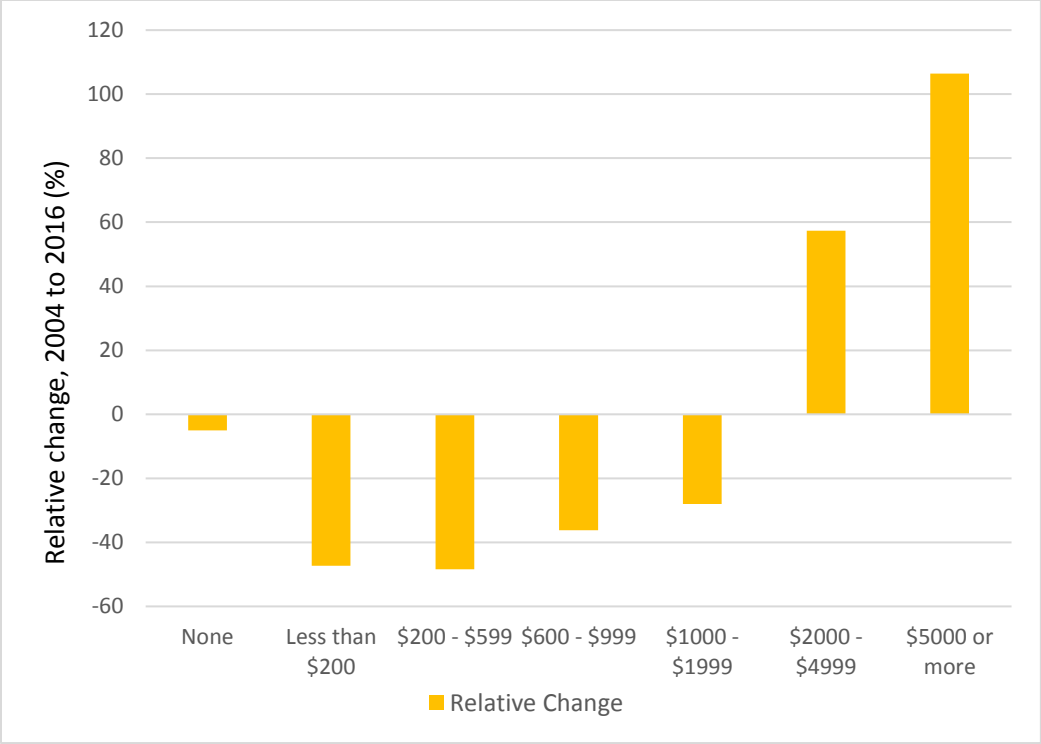

Figure 5: Personal income in month before arrest: relative change from 2004 to 2016.

3.2 Current incarceration status

As depicted in **figure 6**, the proportion of inmates classified as New court commitments or On probation with new sentences increased from 2004 to 2016 while the proportion of inmates classified as On parole with new sentences, On probation without new sentences, On parole without new sentences, and Other each decreased from 2004 to 2016.

Because the main difference between the 2016 measure and 2004 measure was the exclusion of probation and parole violations, assuming an inmate reported these as their only new sentenced offenses, the following adjustment was made. If an inmate with a status at the time of their arrest (e.g., on probation or on parole) reported being sentenced for any new offenses, and noted that these new offenses were only for a probation or parole violation, then we marked them as having no new sentenced offenses. After making the adjustment to account for the measurement error was implemented, the pattern of change remained the same, although, for the most part, the magnitude of the change decreased (**figure 6**).

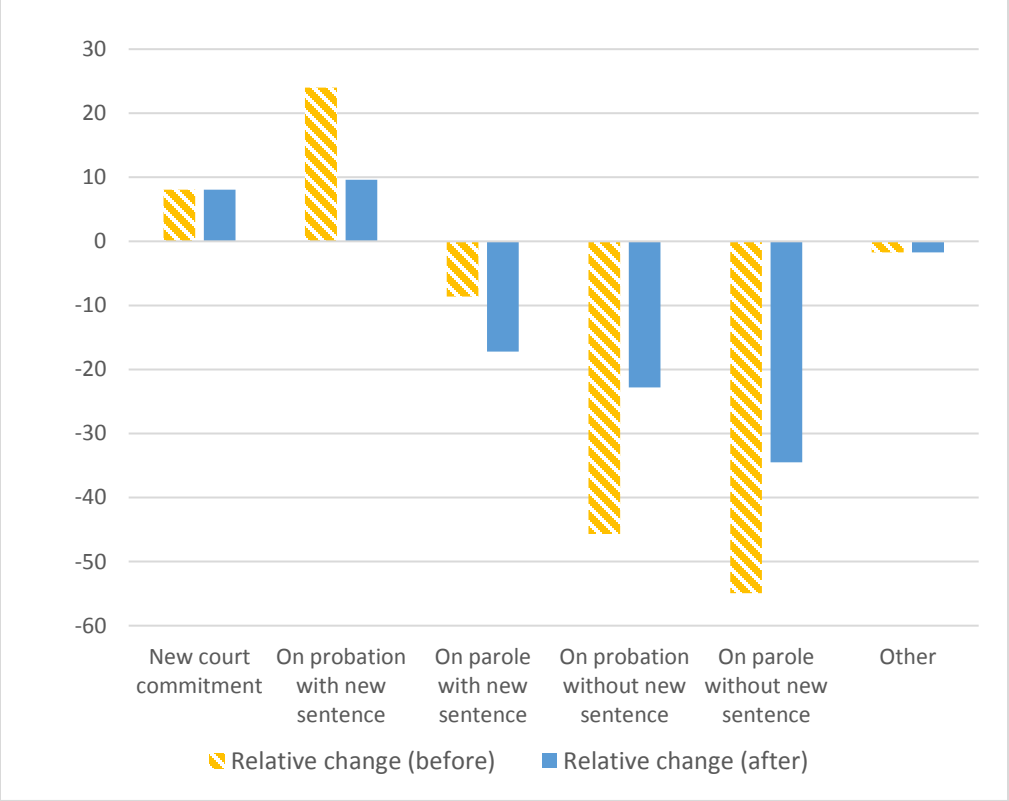

Figure 6: Current incarceration status: relative change from 2004 to 2016 before and after adjustment.

3.3 Number of incarcerations

As shown in **figure 7**, the proportion of inmates with 0 incarcerations or 1 incarceration decreased from 2004 to 2016. Meanwhile, the proportion of inmates increased for those indicating 2 to 4 incarcerations, 5 to 9 incarcerations, or 10 or more incarcerations.

Because the main difference between the 2004 measure and the 2016 measure was the exclusion of the current incarceration in 2004, an adjusted measure was created in 2016 which subtracted one incarceration from the total number provided. The relative change, accounting for the adjustment, had the same general pattern as the unadjusted estimates, except that the magnitude of change was less (**figure 7**).

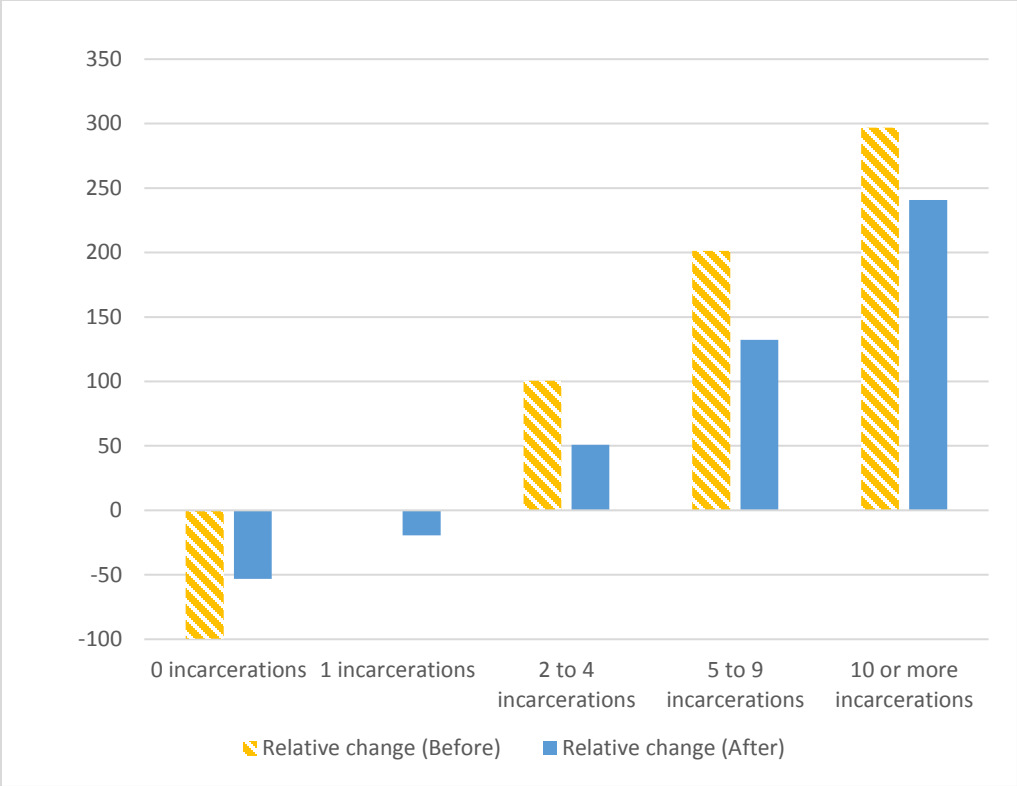

Figure 7: Number of incarcerations: relative change from 2004 to 2016 before and after adjustment.

4. Discussion

For each construct, our ability to understand the full extent of the measurement error was hampered by the manner in which changes were made. When the source of the error could be defined clearly, then an adjustment was possible; however, when the source or the impact of changes was less clear, then no adjustment was possible.

For personal income in the month before arrest, in 2016, when an exact income value was provided there were several outliers with extremely high incomes. Overall, the 2016 income distribution had a greater percentage of respondents that selected high incomes. When taking occupation into account, several inmates reported incomes that looked like annual incomes rather than monthly incomes. However, because respondents were asked to include income obtained through illegal sources, we could not be certain that annual incomes were being reported rather than incomes which included illegal sources. In 2004, the respondents selected the middle categorical option as the mode, a common finding for questions with a large number of response options (Narayan & Krosnick 1996; Moors 2008).

Due to difficulty isolating where adjustments were needed, we determined no adjustment should be made. Some of the income distribution in 2016 is due to temporal change (i.e., inflation), but it is likely that the 2016 estimates are overstated compared to what they would have been had only the 2004 approach been utilized.

For incarceration status, the unadjusted 2016 distribution indicated a larger number of inmates on probation with new sentences compared to prior years. Because we were able to pinpoint the source of the measurement error to inmates on probation or parole not being assigned an incarceration status consistently with 2004 we were able to apply a logical adjustment to these specific cases. In this case, we re-assigned probation and parole inmates from a "new offense" to having "no new sentence." As expected, this adjustment shifted the distribution to fewer inmates to the "on probation or parole without a new sentence" categories. After making the adjustment, the relative change in the inmates on probation or parole without a new sentence was still lower than 2004. This indicates there is likely a true change in the distribution over the past 12 years.

Comparing the number of incarcerations distribution between 2016 and 2004, 2016 inmates appeared to have more sentences to incarceration than prior years. Since 2016 asked the number of lifetime sentences, which includes the current sentence, a logical adjustment to equate the construct definitions between 2016 and prior periods was to subtract one from incarceration totals of currently sentenced inmates. Even after making this adjustment, inmates still had a greater number of incarcerations in 2016 compared to 2004. The overhaul to the criminal history section makes it difficult to analyze how much of this increase stems from the instrumentation changes for this construct, and how much of it stems from changes among the inmate populations themselves. Our solution only addressed one of the potential sources of error, while the impact of other sources remains unknown.

5. Conclusions

The introduction of measurement error through instrument changes is a serious concern for designers of periodic cross sectional surveys. Analysts interested in assessing change over time need to be certain any differences measured are due to temporal change rather than how the survey is administered or a question is worded. However, over time, the optimal manner for asking about some constructs changes, and it may be important to incorporate these changes into the new study. Even when improving how constructs are measured, measurement error can be introduced in serial cross-sectional surveys.

Measurement error can impact trend analysis, or result in misleading comparisons if not recognized properly. Even when sources of measurement error are properly recognized, solutions may not be feasible. In some cases, measurement error can be reduced, if not eliminated. For SPI, the goal of recognizing and adjusting for measurement error was achieved for both incarceration totals and current incarceration status in 2016. In other cases, such as personal income in month prior to arrest, nothing can be done. When no adjustment can be made it is important to document these measurement differences so that researchers do not incorrectly interpret differences as temporal change.

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Appendix A

In 2004, the current incarceration status system variable records whether an inmate should be classified as:

1) Awaiting trial/sentencing OR Not awaiting trial/sentencing,
2) New court commitments,
3) On Parole w/ new offenses,
4) On Parole w/ no new offenses,
5) On Probation from court w/ new offenses,
6) On Probation from court w/ no new offenses,
7) On Probation from prison w/ new offenses,
8) On Probation from prison w/ no new offenses,
9) On Escape w/ new offenses, or
10) On Escape w/ no new offenses.

In 2016, the current incarceration status system has the following levels:

1) Inmate awaiting trial or waiting to be sentenced (and not on parole, probation, or escape at the time of their arrest),
2) Inmate NOT sentenced, NOT convicted/awaiting sentencing, NOT awaiting trial AND being held for other authorities, a civil commitment, safekeeping, or another reason,
3) Inmate NOT incarcerated for a parole or probation violation and NOT on parole or probation at time of arrest (New Court Commitment),
4) On Escape with NO new offenses,
5) On Escape WITH new [sentenced] offenses,
6) On Escape WITH new [arrest] offenses,
7) Parole Violator with NO new offenses,
8) Parole Violator WITH new [sentenced] offenses,
9) Parole Violator WITH new [arrest] offenses,
10) Probation Violator with NO new offenses,
11) Probation Violator WITH new [sentenced] offenses,
12) Probation Violator WITH new [arrest] offenses
13) Inmate with NO offenses recorded in any of the applicable sections where offenses are collected