Does the Residential Energy Consumption Survey Have a Mode Effect?

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Background

- Mixed-mode or multimode data collection is common in sample surveys:
  - Self-administered paper questionnaire
  - Self-administered Web survey
  - Telephone interview
  - In-person interview
- Reasons for using multimode:
  - Response rate
  - Cost
- Disadvantages:
  - Measurement quality (i.e., mode effect)
  - If there is a bias, it is often not easy to measure

Background (cont'd)

- How to mitigate the disadvantages:
  - Questionnaire design
  - Sample allocation to modes
  - Person completing the survey
  - Interview conditions
- How to know there is mode effect:
  - Previous studies
  - Comparing data quality indicators within the study
- This talk presents:
  - Methodology to investigate mode effects
  - Investigation for the Residential Energy Consumption Survey (RECS)

Multimode in Survey Design

- Different approaches in different applications:
  - Concurrent: give options to the sampled cases to choose the mode they like
    - List sample with address or e-mail, or ABS:
      - Send paper questionnaire and cover letter with link to a Web survey
      - When e-mail present, send e-mail with link to Web survey or number to call
    - RDD:
      - Telephone interview with option to fill out Web or paper survey
  - Sequential: begin with an initial mode, then continue with different mode in NRFU
    - Usually start with cheaper mode, follow up with more expensive mode in NRFU
    - Start with mode based on sampling frame, then provide options in NRFU
  - Experimental design:
    - Randomly assign to modes in balanced manner

Mode Effects

- Do people really respond in the same way to the questions posed by different methods; in other words, are the data comparable?
- The only factor to be compared is the mode
- Need to control any other factors to be similar as much as possible:
  - Question formats
  - Sample composition
  - Person completing the survey
  - Data collection period

How to Detect or Test for a Mode Effect

- Five indicators of data quality used in DeLeeuw's (1992) meta analysis:
  - Response validity (answer is checked against information from official records)
  - Item nonresponse
  - Number of statements made in response to an open-ended question
  - Social desirability (on sensitive questions)
  - Similarity of responses on closed question

How to Detect or Test for a Mode Effect (cont'd)

- Check comparability of respondents across modes
  - Sample composition: investigate whether respondents in different modes differ in important background variables
    - Chi-square tests, followed by pairwise comparisons
    - If some variables differ, take into account the differences in the next step of analysis
      - Include the variables as control variables
      - Compare only comparable samples
- Check response patterns
  - Compare item response rates
  - Compare responses on closed question

The Residential Energy Consumption Survey (RECS)

- Sponsored by the Energy Information Administration (EIA), RECS collects data on household energy usage, demographics, and home characteristics from a nationally representative sample of housing units
- The 2015 survey was designed as an in-person survey using an area probability design
- The 2015 in-person data collection was yielding lower response rates than targeted, and staffing some of the more remote areas was a challenge
- The time and cost associated with achieving a sufficient number of completed cases to meet the precision requirements led the EIA to change the RECS mode of data collection

The Residential Energy Consumption Survey (cont'd)

- While the 2015 RECS data collection was underway, a separate and simultaneous RECS National Pilot Study was conducted to test mail and Web modes of data collection on a streamlined version of the RECS questionnaire
- Field work on the 2015 RECS was closed out, and cases that had refused or had not yet been contacted by an interviewer were offered Web and mail questionnaires as in the RECS National Pilot Study
- Data are combined from CAPI, Web, and mail surveys
- Analyses were conducted to investigate the quality of the 2015 RECS and possible effects of the change in mode of data collection

Data Quality Analysis in RECS

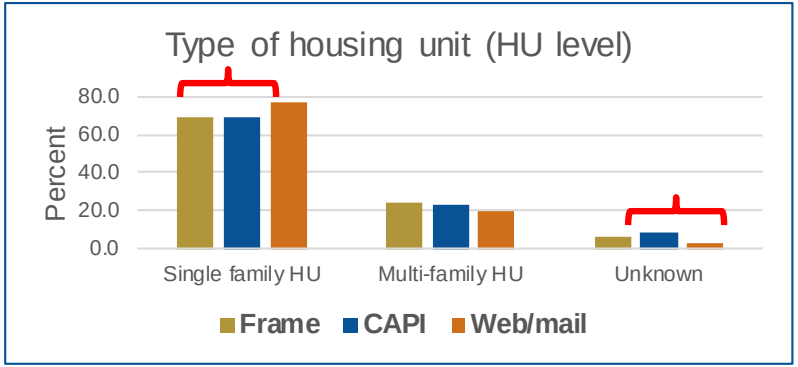
- Investigated mode effect by comparing CAPI vs. Web/mail
- Key questions of interest in checking data quality:
  - Q1: Are there differences in sample characteristics (HU, Census block, SSU, or PSU level) by mode?
  - Q2: Are there differences in unit response rates between modes?
  - Q3: Are there differences in item response rates between modes?
  - Q4: Are there differences in response values by mode?
  - Q5: Are item response rates comparable to the 2009 RECS?
  - Q6: Are response values comparable to other surveys with similar variables?

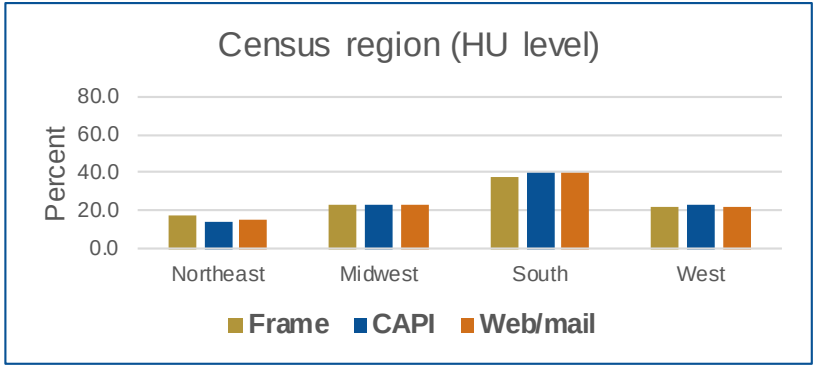
Q1: Are there differences in sample characteristics by mode?

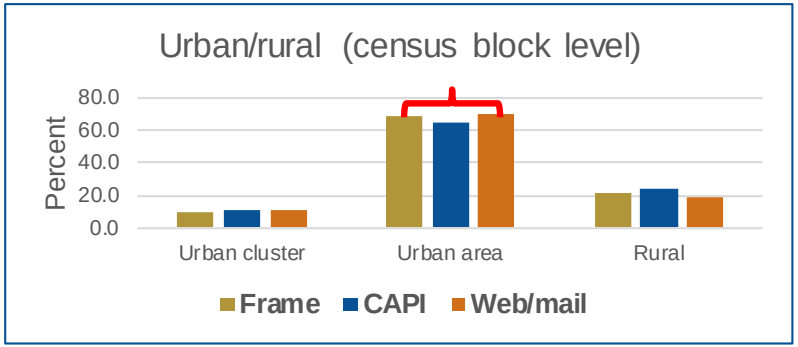
- Univariate test comparing distribution of single variable across modes
  - Chi-square test for categorical variable
  - *t*-test for binary or continuous/count variable
- Multivariate test
  - Logistic regression with mode as dependent variable and frame variables as predictors

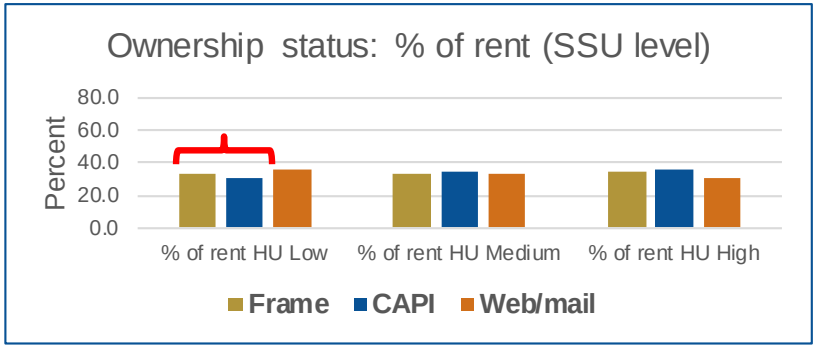
- If some variables differ, comparable groups may be constructed using matching; for example, propensity score matching (*R* MatchIt package)

Q1: Are there differences in sample characteristics by mode? (cont'd)









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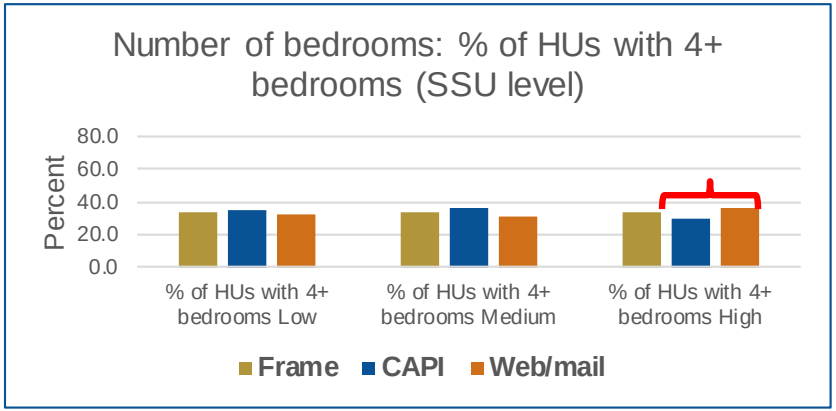

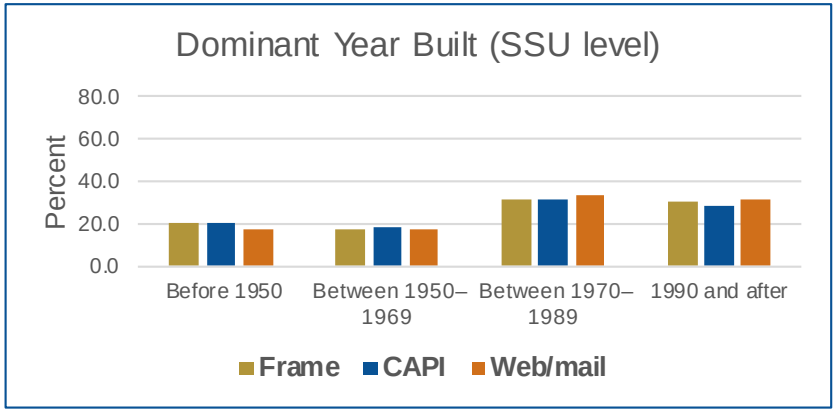

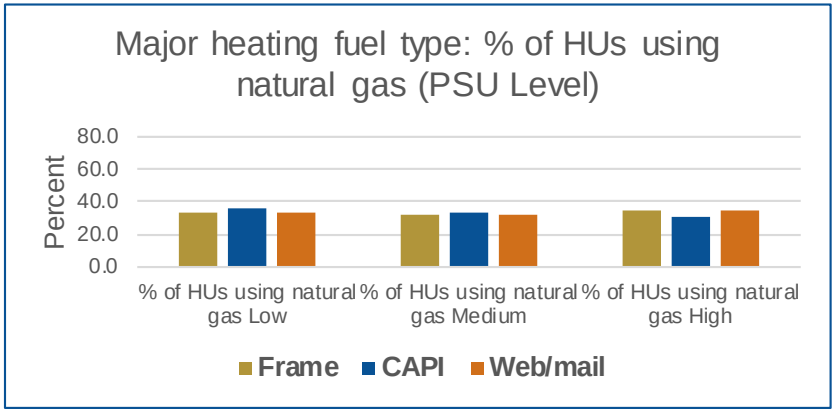

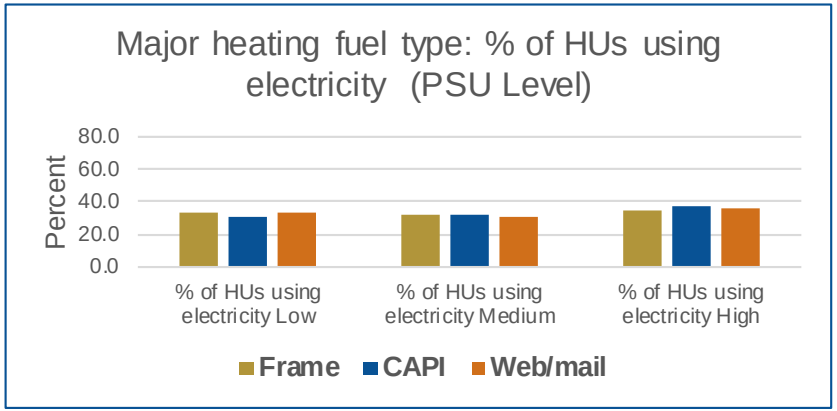

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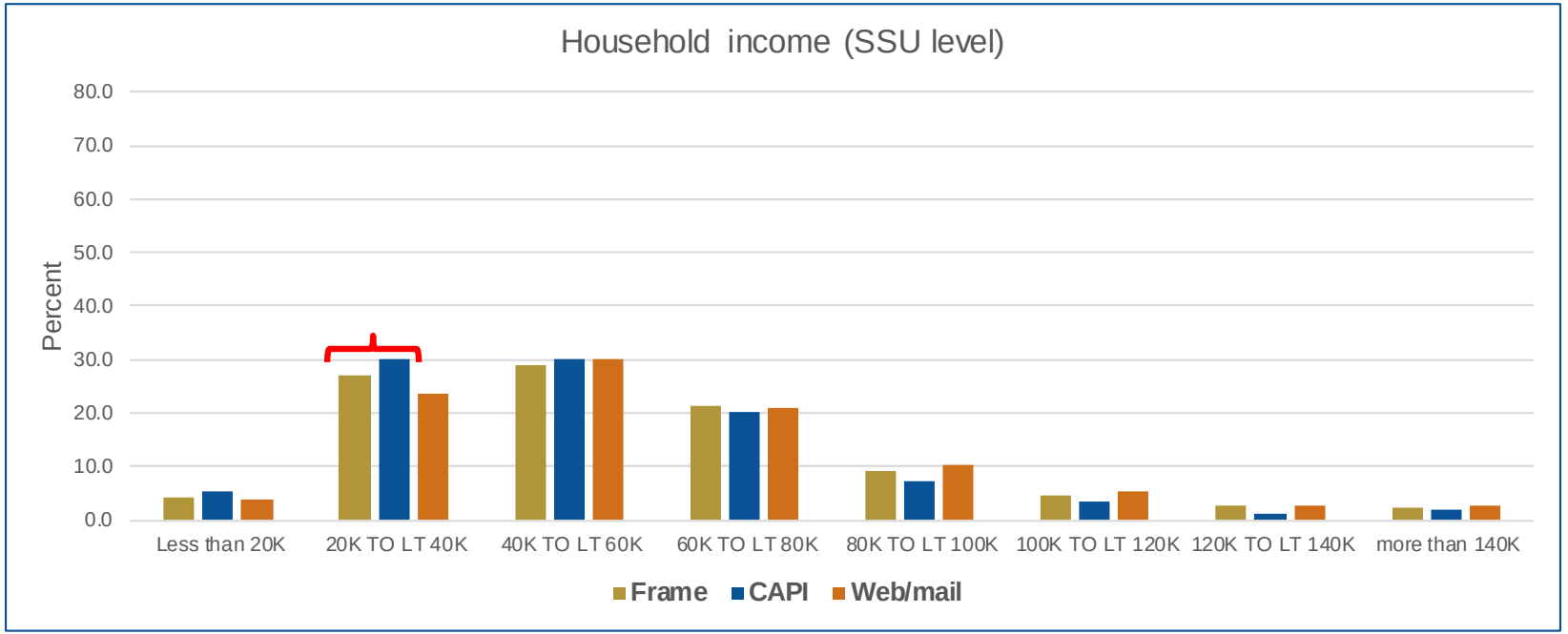


Q1: Are there differences in sample characteristics by mode? (cont'd)

$$logit[P(CATI = 1)] = X\beta$$

Predictors	Wald F-test *p*-value
Type of housing unit (HU level)	0.050
Census region (HU level)	0.079
Urban/rural (census block level)	0.110
Ownership status: % of rent (SSU level)	0.327
Number of bedrooms: % of HUs with 4+ bedrooms (SSU level)	0.491
Dominant Year Built (SSU level)	0.543
Household income (SSU level)	0.022
Major heating fuel type: % of HUs using natural gas (PSU Level)	0.700
Major heating fuel type: % of HUs using electricity (PSU Level)	0.984

Q1: Are there differences in sample characteristics by mode? (cont'd)

- Matched respondents across modes (*R* MatchIt package)

Variable	Before Matching				After Matching			
	CAPI	Web/mail	Difference	*p*-value	CAPI	Web/mail	Difference	*p*-value
Type of housing unit (HU level)								
Single family HU	68.71	77.13	-8.4241	0.000	68.71	74.44	-5.7305	0.000
Multi-family HU	23.17	19.98	3.18889	0.005	23.17	21.88	1.28858	0.302
Unknown	8.12	2.88	5.23519	0.000	8.12	3.67	4.44196	0.000
Census region (HU level)								
Northeast	14.24	14.87	-0.6278	0.543	14.24	10.86	3.37918	0.001
Midwest	23.45	23.69	-0.2369	0.878	23.45	18.88	4.57557	0.000
South	39.65	39.62	0.03174	0.986	39.65	41.2	-1.5494	0.331
West	22.66	21.83	0.83291	0.525	22.66	29.07	-6.4054	0.000
Urban/rural (census block level)								
Urban cluster	11.55	10.77	0.78222	0.491	11.55	11.57	-0.022	0.985
Urban area	64.45	69.8	-5.3519	0.002	64.45	65.54	-1.0873	0.514
Rural	24.00	19.43	4.56967	0.001	24.00	22.89	1.10929	0.393
Ownership status (SSU level % of rent tercile)								
% of rent HU Low	30.51	36.01	-5.4959	0.000	30.51	30.68	-0.1659	0.899
% of rent HU Medium	33.97	33.46	0.50422	0.717	33.97	34.35	-0.3852	0.780
% of rent HU High	35.52	30.53	4.99167	0.000	35.52	34.97	0.55105	0.682

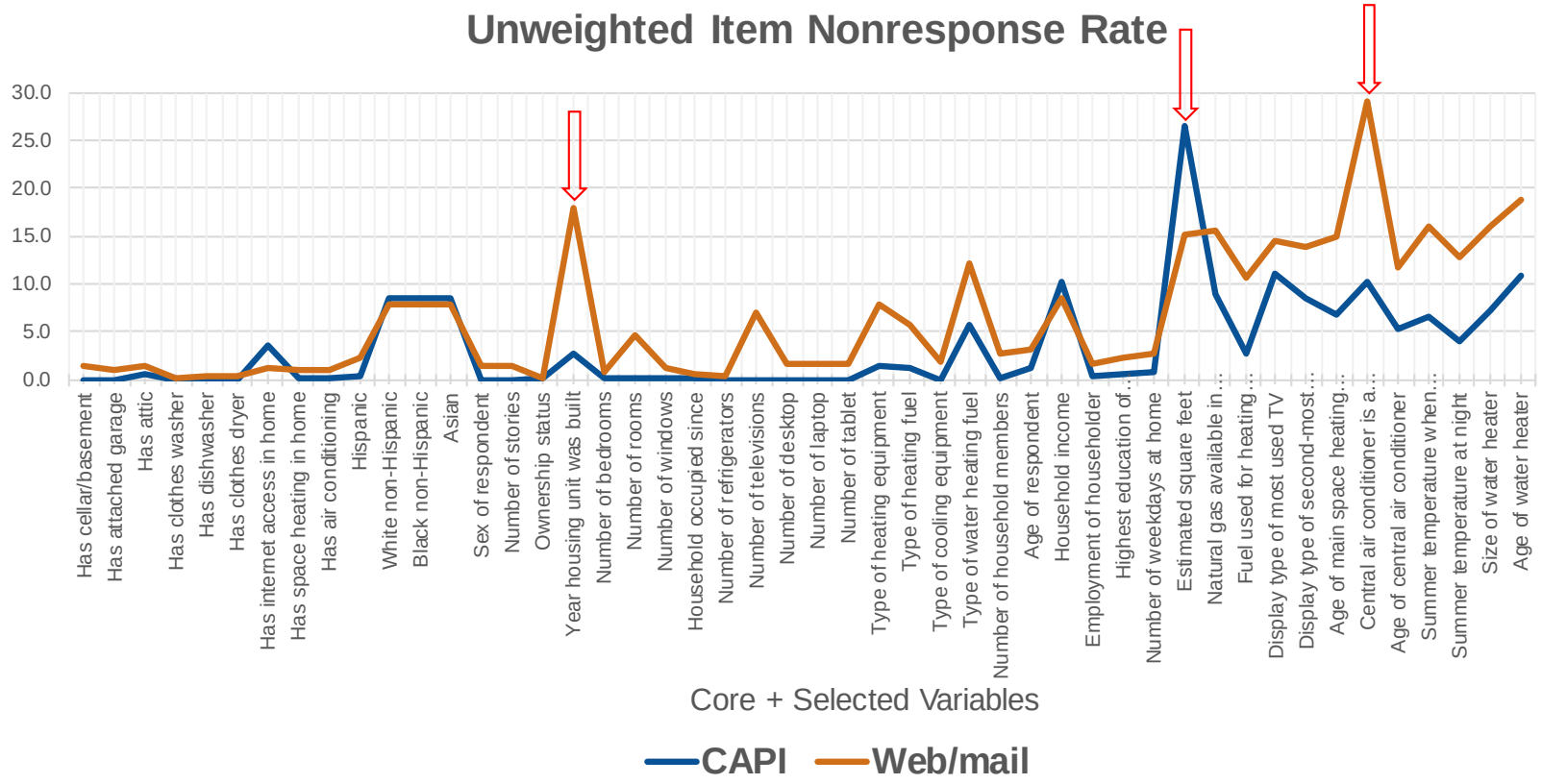
Q1: Are there differences in sample characteristics by mode? (cont'd)

Variable	Before Matching				After Matching			
	CAPI	Web/mail	Difference	*p*-value	CAPI	Web/mail	Difference	*p*-value
Number of bedrooms (SSU level % of HUs with 4+ bedrooms tercile)								
% of HUs with 4+ bedrooms Low	34.3	32.01	2.28218	0.125	34.3	35.21	-0.9166	0.548
% of HUs with 4+ bedrooms Medium	35.79	31.31	4.48033	0.003	35.79	34	1.79159	0.221
% of HUs with 4+ bedrooms High	29.91	36.67	-6.7625	0.000	29.91	30.79	-0.875	0.526
Dominant Year Built (SSU level)								
Before 1950	20.85	17.66	3.18793	0.008	20.85	18.65	2.19507	0.067
Between 1950–1969	18.49	17.8	0.68595	0.548	18.49	17.44	1.04748	0.362
Between 1970–1989	31.82	33.31	-1.495	0.256	31.82	33.93	-2.1165	0.133
1990 and after	28.85	31.23	-2.3789	0.101	28.85	29.97	-1.1261	0.434
Household income (SSU level)								
Less than 20K	5.29	3.94	1.35207	0.052	5.29	5.19	0.09675	0.886
20K TO LT 40K	30.09	23.58	6.51142	0.000	30.09	27.92	2.17022	0.091
40K TO LT 60K	30.27	30.01	0.26437	0.864	30.27	31.69	-1.4227	0.365
60K TO LT 80K	20.39	20.86	-0.466	0.683	20.39	20.52	-0.1298	0.919
80K TO LT 100K	7.36	10.54	-3.1843	0.000	7.36	7.77	-0.4124	0.563
100K TO LT 120K	3.44	5.45	-2.0029	0.000	3.44	3.44	0.0019	1.000
120K TO LT 140K	1.28	2.82	-1.5418	0.006	1.28	1.72	-0.44	0.400
more than 140K	1.87	2.81	-0.9328	0.125	1.87	1.74	0.13595	0.768

Q1: Are there differences in sample characteristics by mode? (cont'd)

Variable	Before Matching				After Matching			
	CAPI	Web/mail	Difference	p-value	CAPI	Web/mail	Difference	p-value
Natural gas as major heating fuel type (PSU Level % of HUs using natural gas tercile)								
% of HUs using natural gas Low	35.72	32.95	2.76412	0.078	35.72	35.52	0.20027	0.893
% of HUs using natural gas Medium	33.47	32.09	1.37938	0.278	33.47	33.74	-0.2665	0.839
% of HUs using natural gas High	30.81	34.95	-4.1435	0.005	30.81	30.74	0.0662	0.963
Electricity as major heating fuel type (PSU Level % of HUs using electricity tercile)								
% of HUs using electricity Low	30.58	33.36	-2.7759	0.073	30.58	28.57	2.01245	0.148
% of HUs using electricity Medium	32.44	31.29	1.14562	0.390	32.44	32.54	-0.0999	0.941
% of HUs using electricity High	36.98	35.35	1.63023	0.311	36.98	38.89	-1.9126	0.214

Q3: Are there differences in item response rates between modes?



Q4: Are there differences in response values by mode?

a) Univariate test comparing proportions/means of (binary/continuous) variables across modes
b) Univariate test comparing distribution of (categorical) variables across modes
   - Chi-square test overall distribution
   - *t*-test for individual category
c) Multivariate test controlling for covariates
   - Regress survey outcome with mode and control covariates as predictors
d) Univariate tests on comparable samples
   - Construct comparable samples using matching technique
   - Conduct tests a) or b) on the matched samples

Q4: Are there differences in response values by mode? (cont'd)

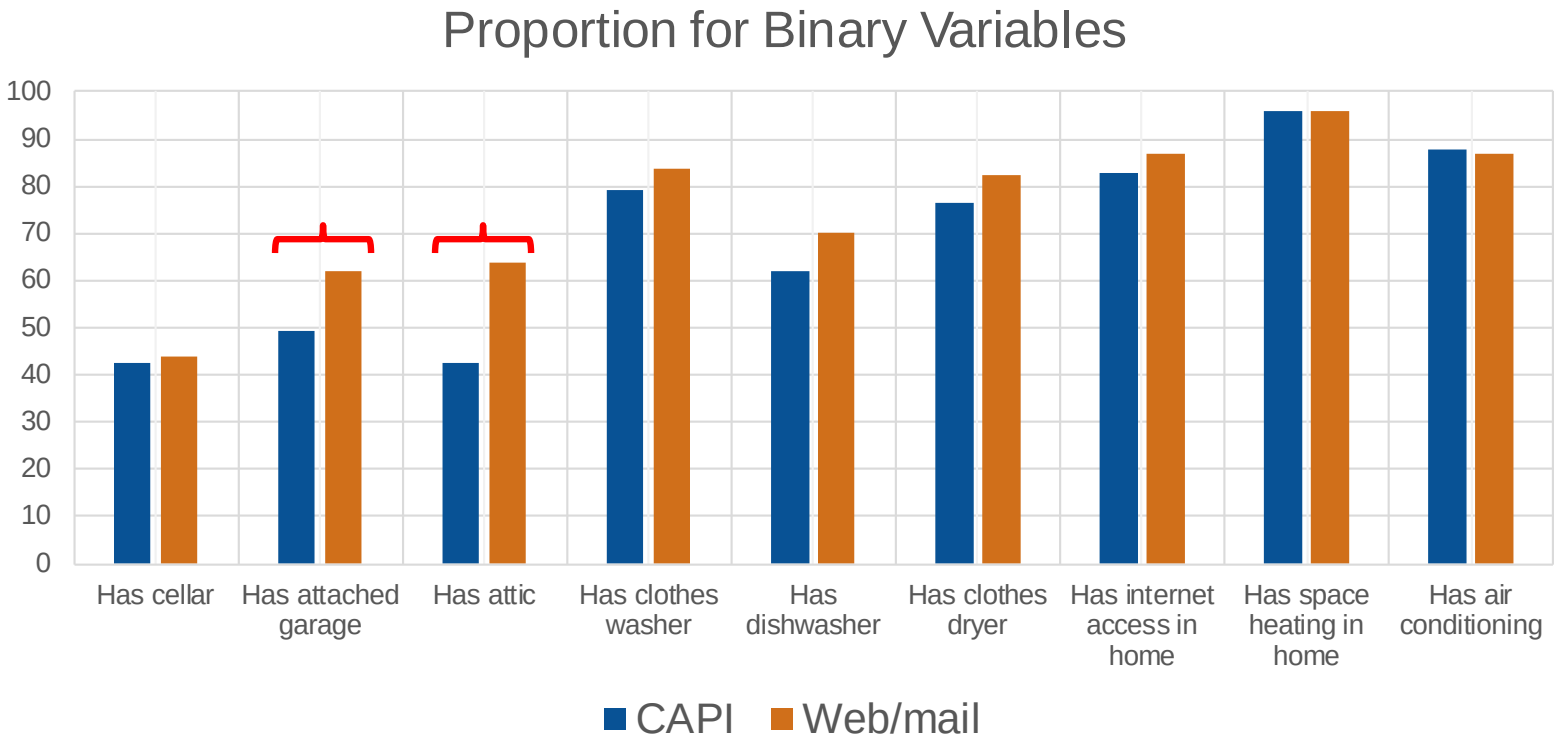
Selected Survey Item (Continuous Core Variables)	Before Matching				After Matching			
	CAPI	Web/mail	Difference	*p*-value	CAPI	Web/mail	Difference	*p*-value
Number of stories	1.40	1.46	-0.059	0.006	1.40	1.41	-0.003	0.904
Number of televisions	2.22	2.39	-0.163	0.000	2.22	2.38	-0.161	0.001
Number of desktop computers	0.44	0.54	-0.095	0.000	0.44	0.51	-0.068	0.008
Number of laptop computers	0.94	1.04	-0.096	0.002	0.94	0.98	-0.039	0.269
Number of tablet computers	0.85	1.02	-0.169	0.000	0.85	0.99	-0.137	0.001
Age of respondent	49.80	53.01	-3.215	0.000	49.80	51.52	-1.718	0.004

Q4: Are there differences in response values by mode? (cont'd)

Regress continuous outcome: $Y = \beta_0 + \beta_1 Mode + \cdots + \beta_k \beta_k + \varepsilon$

Selected Survey Item as Dependent Variable in Regression (Continuous Core Variables)	Mode Coefficient	p-value
Number of stories	-0.01	0.83
Number of televisions	-0.11	0.01
Number of desktop computers	-0.06	0.02
Number of laptop computers	-0.04	0.19
Number of tablet computers	-0.11	0.00
Number of household members	0.21	0.00
Age of respondent	-2.54	0.00

Q4: Are there differences in response values by mode? (cont'd)



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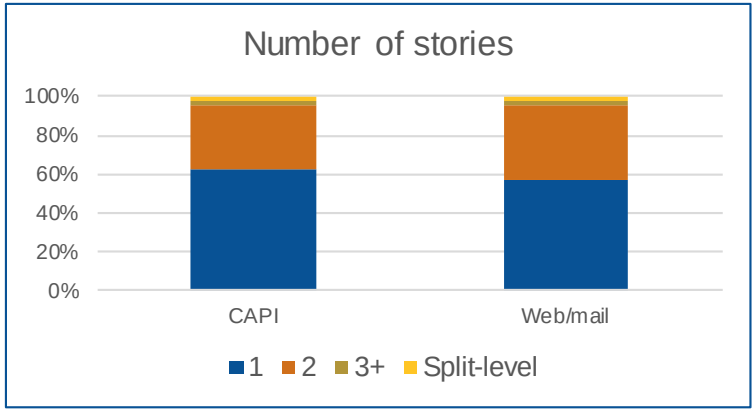

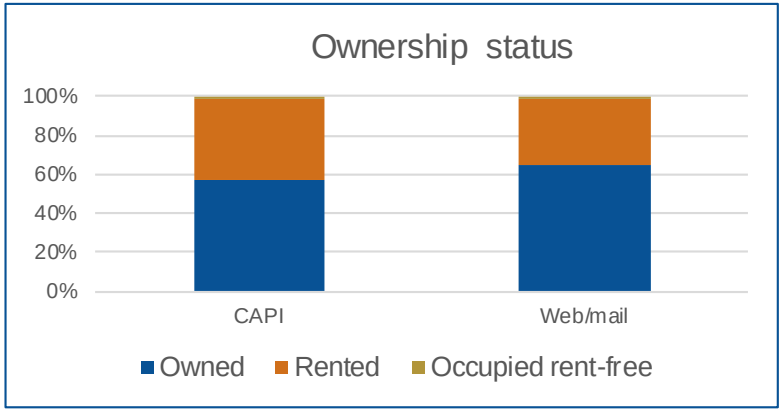

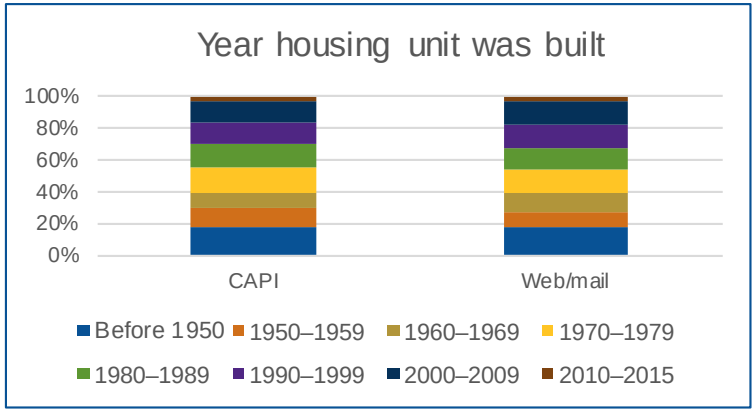

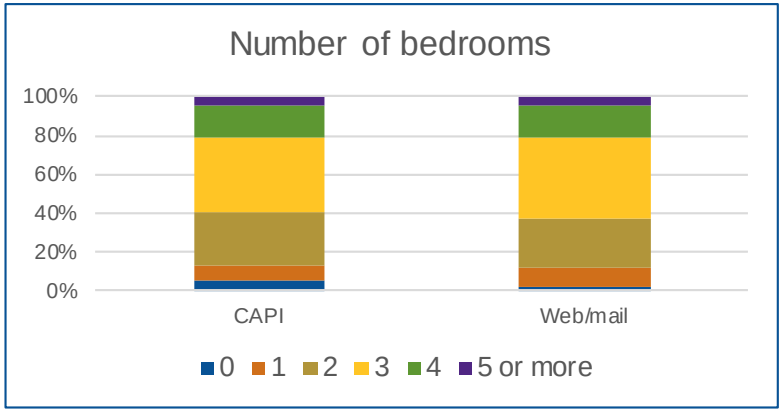

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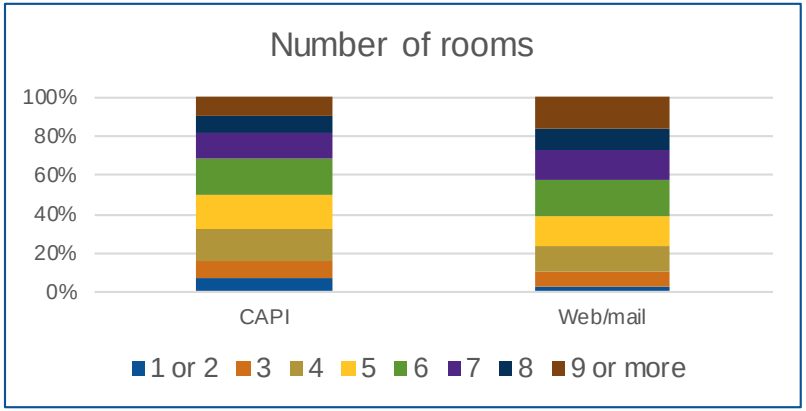

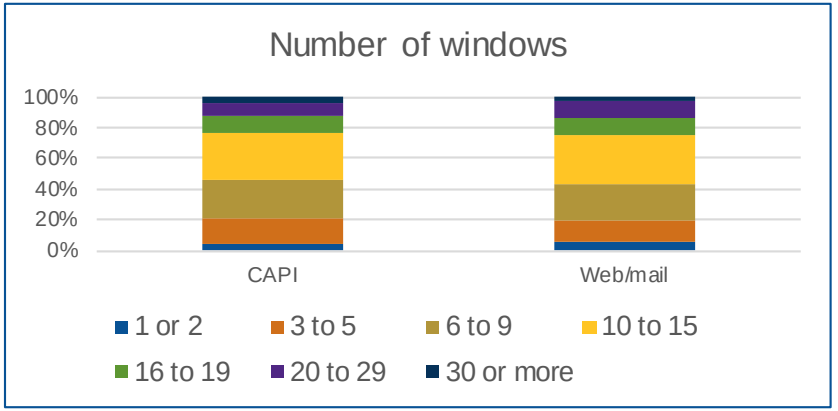

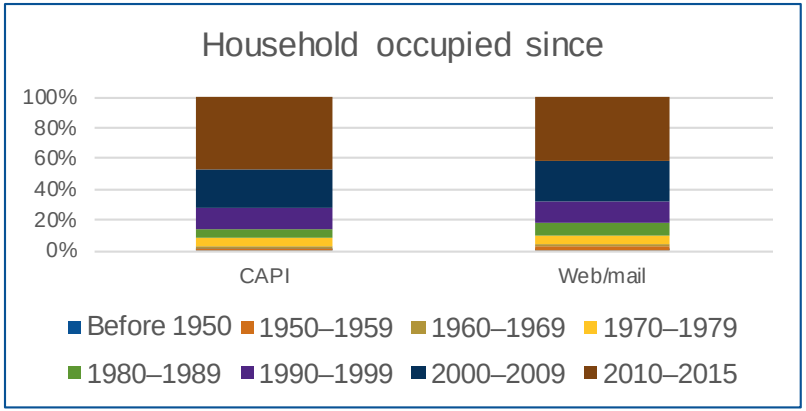

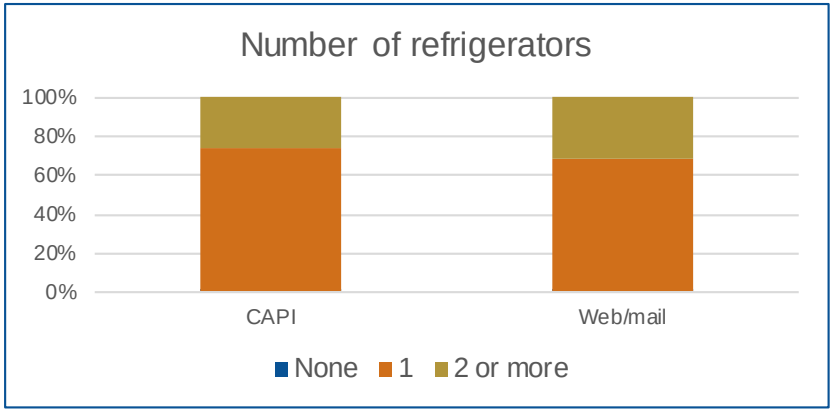

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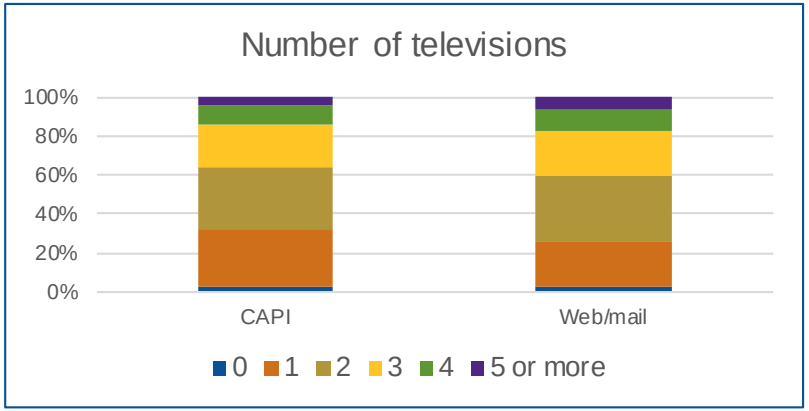

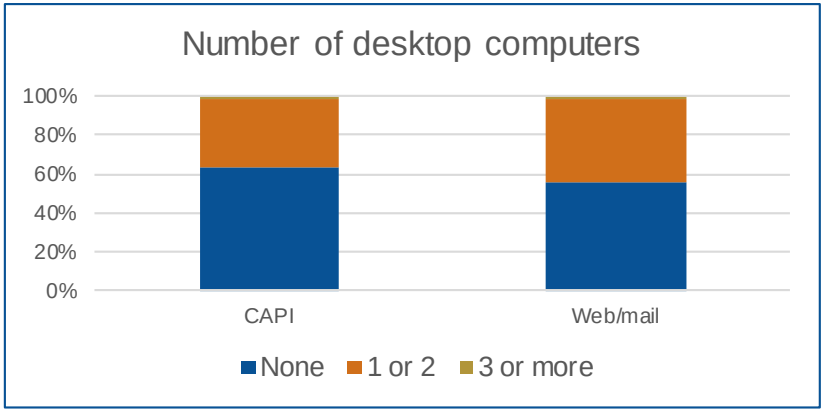

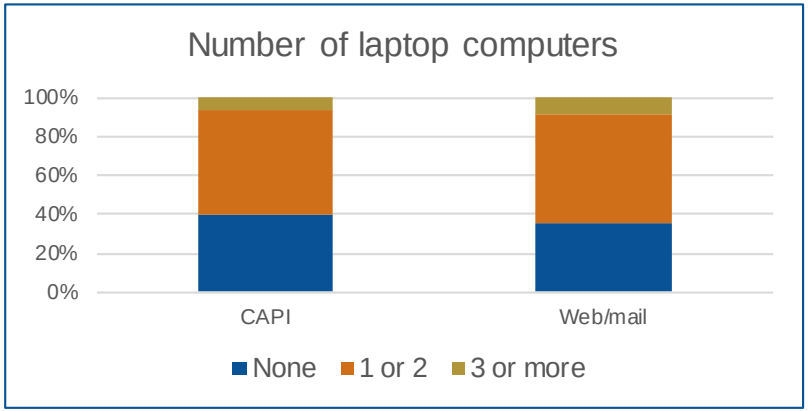

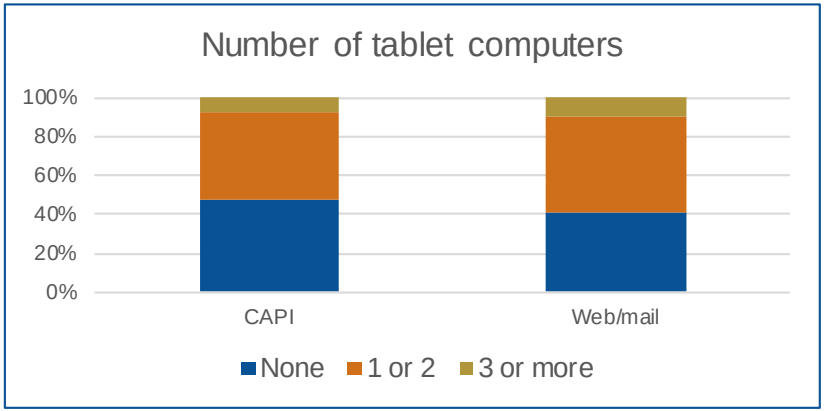

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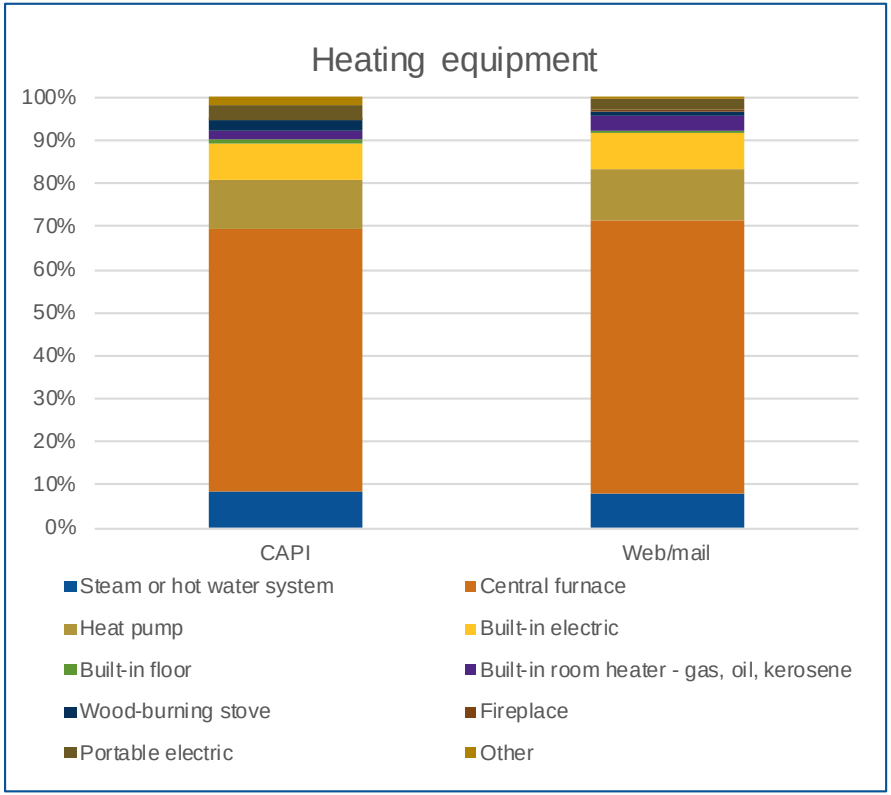

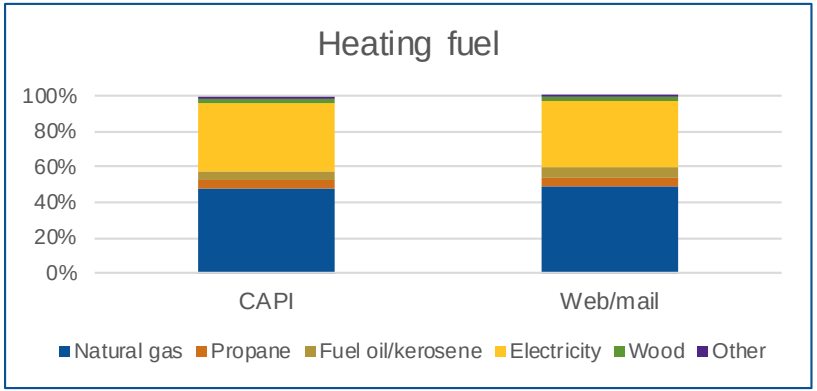

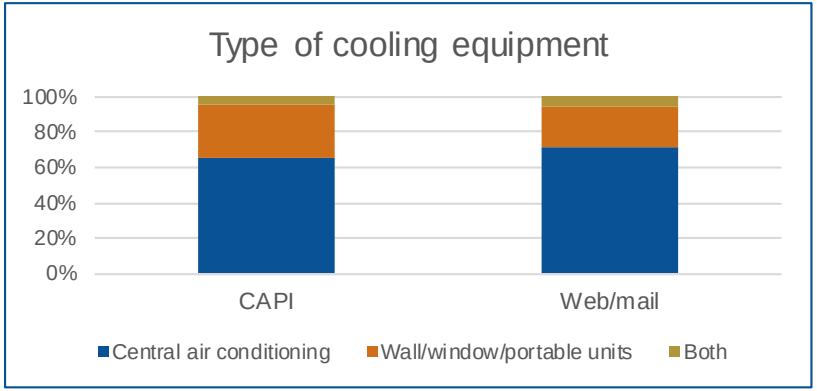

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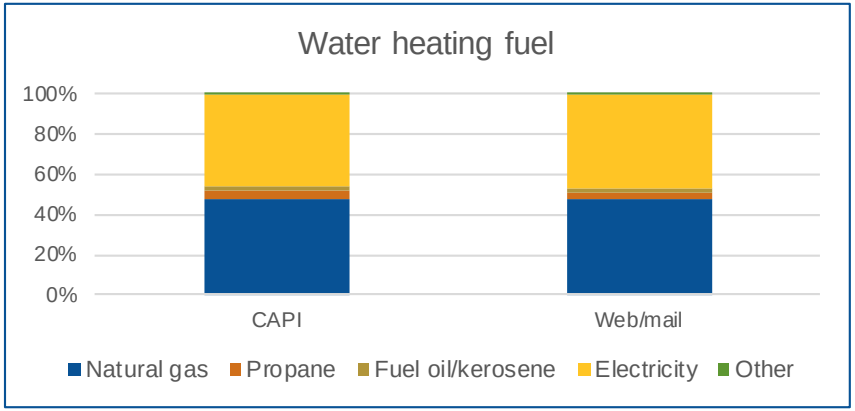
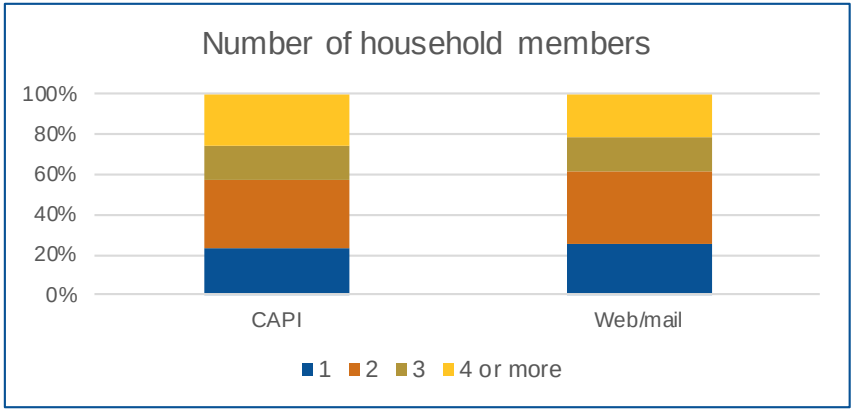
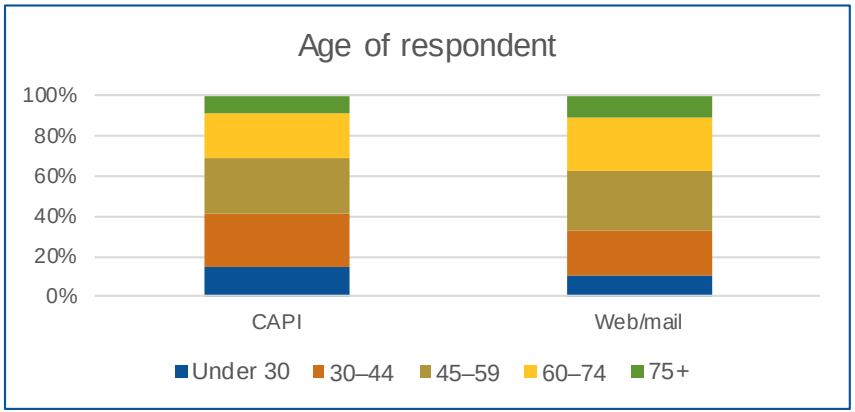
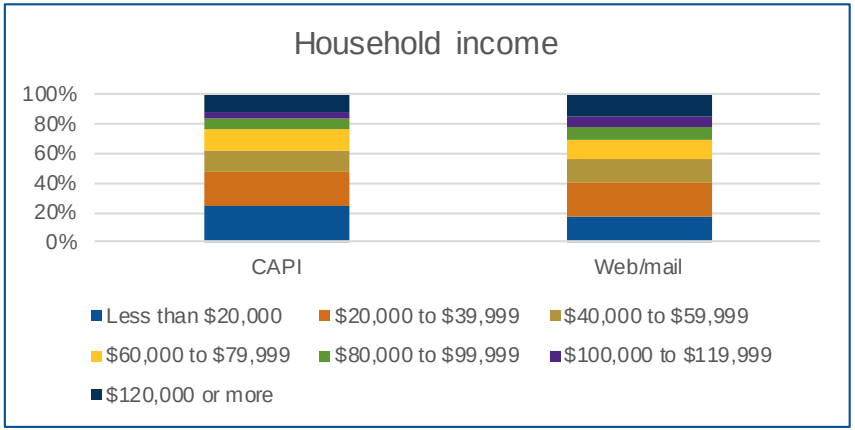
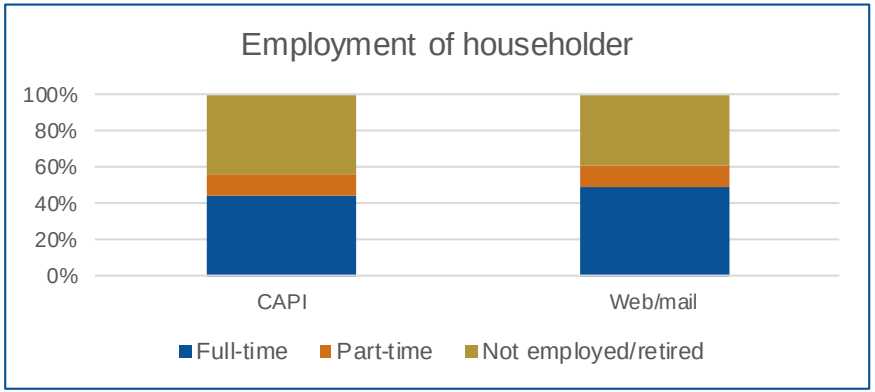


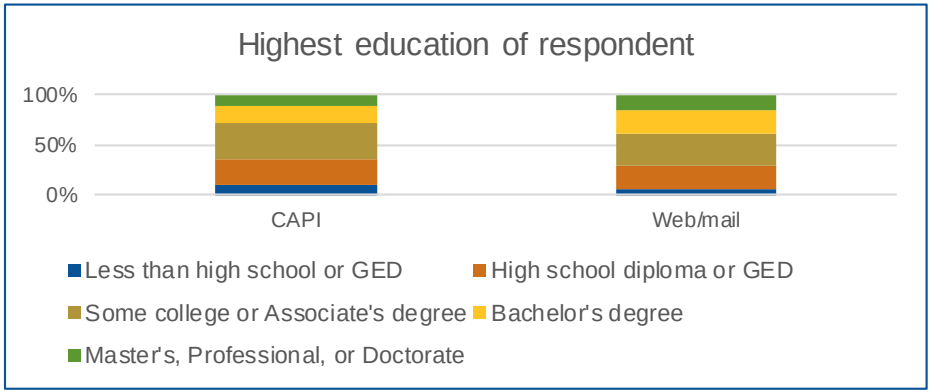


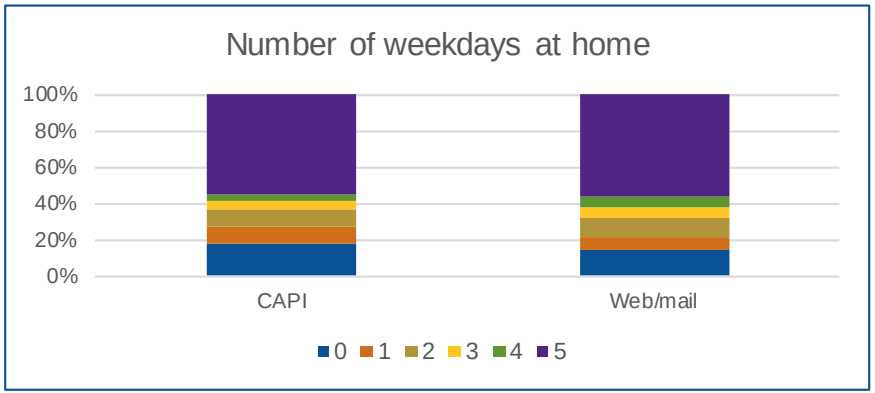


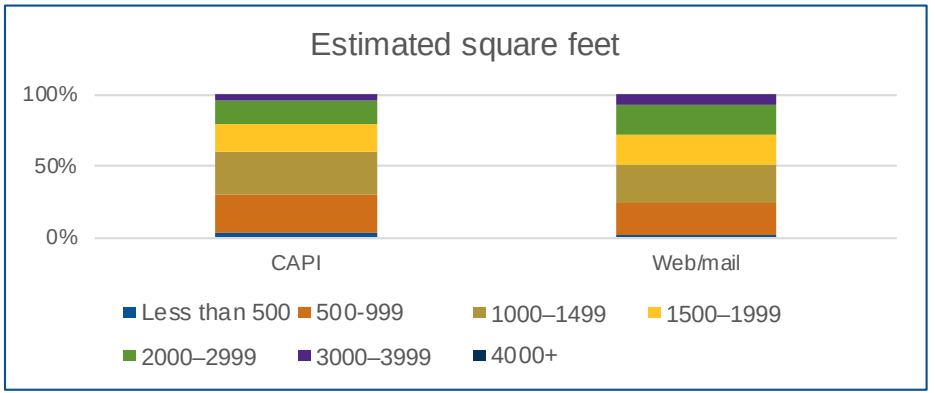


Q4: Are there differences in response values by mode? (cont'd)









Conclusion & Discussion

- In RECS, the differences in survey outcomes across modes were small but statistically significant; however, only the attic and attached garage variables may have practical importance
- For these large differences, we do not judge whether one mode is more biased relative to the target population
- In RECS, differences in item nonresponse rates are small between CAPI and Web/mail, except in a handful of variables for which the presence of an interviewer in CAPI might have an impact on survey response

Conclusion & Discussion (cont'd)

- For survey questions asking respondents to recall their memory of data or measurement of an item, or required special knowledge, the nonresponse among Web/mail respondents tended to be higher
- If a survey will be administered using multiple modes, the instrument designer should take into account potential mode effects as much as possible, especially for mode-sensitive questions
- To investigate potential mode effects, different methods of data quality analysis can be used for different data situations
- If mode effects exist and lead to potential measurement bias, however, it may not be easy to measure such bias
- If mode effects exist, weighting adjustments and poststratification may be used to account for mode effects