Non-Representativeness in Population Health Research: Evidence from a COVID-19 Antibody Study

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Abstract

We analyze representativeness in a COVID-19 serological study with randomized participation incentives. We find large participation gaps by race and income when incentives are lower. High incentives increase participation rates for all groups, but increase them more among underrepresented groups. High incentives restore representativeness on race and income, and also on health variables likely to be correlated with seropositivity, such as the uninsured rate, hospitalization rates, and an aggregate COVID-19 risk index.

JEL classification: C83; I14

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1 Introduction

Many study samples are not representative of their target populations because inclusion in the study sample requires participation by those invited to participate. A recent report for the National Academies of Science, Engineering, and Medicine (NASEM, 2022) documents that clinical trials have lower participation rates among racial minorities, despite those minorities making up an equal or greater share of the relevant patient populations. Recent concerns about nonrepresentativeness in health studies have been raised by Einav et al. (2020), Oster (2020), and Bradley et al. (2021), among others. An important non-health example of a nonrepresentative study sample was exhibited in the 2020 U.S. Decennial Census, which likely undercounted racial minorities (U.S. Census Bureau, 2022).

Nonrepresentative samples are a problem because they can lead to biased estimates for the target population. Such bias can be highly consequential. The Census undercount biases demographic estimates for the overall population, a bias which could lead to disparities in the allocation of public funding (Wines and Cramer, 2022). The allocation of public health resources during the COVID-19 pandemic similarly relied on presumed representative estimates of infection rates and vaccine uptake for the overall population. Even if nonrepresentation does not introduce bias, the results of nonrepresentative studies might be less trusted by the under-represented groups in ways that could undermine their well-being (Alsan et al., 2022). Nonrepresentativeness could also make studies less applicable to the under-represented groups if it causes researchers to miss important heterogeneity. The NASEM report argues that, as a consequence of under-representation of racial minorities in clinical trials,

> *"...large swaths of the U.S. population, and those that often face the greatest challenges, are less able to benefit from [new] discoveries because they are not adequately represented in scientific studies." (NASEM, 2022, p. 107)*

We analyze representativeness in a unique COVID-19 serological study. Unlike most studies, the Representative Community Survey Project (RECOVER) COVID-19 serological study experimentally varied financial incentives for participation. The study was conducted on households in Chicago (the target population). Randomly-sampled households were sent a package that contained a self-administered blood sample collection kit, and were asked to return the sample by mail to be tested for the presence of COVID-19 antibodies ("seropositivity"). Households in the sample were randomly assigned one of three levels of financial compensation for participating in the study: $0, $100, or $500.

We find that households in neighborhoods with high shares of minority and poor households are grossly underrepresented at lower incentive levels. High incentives increase participation rates for all groups, but increase them more among underrepresented groups. A $500 incentive restores representativeness in terms of neighborhood-level race and poverty status. Representativeness is also restored in health variables likely to be correlated with seropositivity, such as the uninsured rate, hospitalization rates, and an aggregate COVID-19 risk index. Since incentives were randomly assigned and only revealed after the household

was contacted, the non-contact rates at $0 and $100 should be the same as at $500, implying that differential hesitancy to participate is responsible for much of the non-representativeness that we find at lower incentives.

We are not aware of studies that randomize financial incentives in population health studies. It is well appreciated that racial minorities and lower-income households participate in health research at lower rates.[1] The impact of incentives on survey participation rates conditional on demographic characteristics has been studied in the survey methodology literature (see Groves et al., 2009; Singer and Ye, 2013, and references therein). The incentives used in this literature are typically an order of magnitude smaller than the incentives in the RECOVER study.

More importantly, these studies typically don't start by inviting a sample that is randomly selected from the general population. For example, the Nonresponse Study described in Juster and Suzman (1995) considered a sample of individuals who previously refused to participate in the Health and Retirement Survey. The failure to start by inviting representative samples makes it impossible to answer questions about the effect of incentives on representativeness in population surveys. The only two exceptions to this rule that we are aware of are from a non-health context. Mack et al. (1998) study randomly-assigned incentives of $0, $10, and $20 in the first wave of the Survey of Income and Program Participation. Berlin et al. (1992) randomize incentives in the National Adult Literacy Survey. Both of these studies consider participation rates by race and poverty status and find that incentives have a larger effect on participation rates among minorities and low-income groups.

More recently, Dutz et al. (2021) use Norwegian data to study the effect of incentives on selection on unobservables and non-response bias in labor market statistics. In a companion paper to this one, Dutz et al. (2022) apply the methods developed in Dutz et al. (2021) to the data from the RECOVER study to bound the population average COVID-19 risk score. In contrast, the focus of this paper is on the impact of varying financial incentives on representativeness of participants, including on racial, socio-economic and health variables.

Substantively, our paper contributes to ongoing discussions about the quality of COVID-19 serological studies, and in particular the challenges that stem from nonrepresentativeness. Although serological studies were implemented in part to address bias due to the existence of asymptomatic and untested infections (Aspelund et al., 2020; Manski and Molinari, 2021), systematic reviews and meta analyses have emphasized that they often relied on nonrepresentative ("convenience") samples, exposing them to a different potential source of bias (see, e.g., Bobrovitz et al., 2021; Chen et al., 2021). Due to the exponential nature of transmission models, even small biases can translate into large forecast errors (see, e.g., Ioannidis et al., 2022).

[1] See, e.g., Yancey et al. (2006). This review also surveys strategies to recruit minority research participants, including providing incentives.

2 Study design and implementation

2.1 Background

The RECOVER study was carried out in Chicago between December 2020 and March 2021. The study was designed and conducted in collaboration with two partners from the University of Chicago: NORC, a leading survey and research organization, and the Wilson Antibody Biology Laboratory. The RECOVER study was a pilot study intended to measure participation rates at different levels of compensation across neighborhoods. The results of the pilot were intended to inform the sampling design of a larger study on seropositivity in Chicago. The larger study was never implemented because the advent of vaccines made measuring seropositivity rates a lower public health priority.

2.2 Design and implementation

NORC randomly sampled 882 Chicago addresses from United States Postal Service data. Hence, the sampled households were representative of the population of households with a mailing address in the city. Invited households were sent a package that contained a self-administered blood collection kit, and were asked to return a blood sample to the Wilson Lab to be tested for seropositivity. The package additionally contained a consent form with a short questionnaire, instructions on self-administering and returning a blood sample, a letter explaining the purpose of the study and providing information on financial compensation for participating (i.e., returning a blood sample), and a pre-paid return package.

Households in the sample were randomly assigned one of three levels of compensation: $0, $100, or $500. By virtue of randomization, the incentive groups are probabilistically identical. Balance tests validating the random assignment of compensation levels are presented in Online Appendix Table A.1.

Households were asked to select the adult with the earliest upcoming birthday for participation in the study. The letter informed the household that the returned blood sample would be tested for seropositivity, but that they would not be told the result of the test.[2] Hence, the desire to learn about seropositivity status likely does not contribute to the household's motivation for participating in the study. Online Appendix C contains copies of the written materials and additional details on sampling, randomization, and follow-up procedures.

2.3 Data

Our data on the invited sample consists of the randomly assigned compensation level, participation status, and address for each invited household. Using the address, we merge a set of neighborhood characteristics from external sources into our data. All of these characteristics are observed for each household, independently of whether they participated in the study.

[2]The consent form given to each household states that "You will not be notified of your test results." See Online Appendix C for more details on outreach materials used in the study.

Our analyses are centered on two neighborhood characteristics that feature prominently in discussions of representativeness in scientific studies (NASEM, 2022): race and poverty status. In particular, we focus on the neighborhood-level share of non-White individuals and the share of poor households (below 200% of the poverty line).[3] We additionally consider other neighborhood characteristics, including the shares of working age (ages 25-60) and female individuals, and measures of labor market and health conditions. These characteristics are measured at the zipcode level, and are obtained from the American Community Survey, the Chicago Health Atlas, and the City Health Dashboard (see Online Appendix D for details).

For participating households, we also observe responses to the short questionnaire included with the test kits sent to invited households. The questionnaire asked about the participant's race, gender, age, and their household's interval-censored income (see Online Appendix C for a copy of the questionnaire). We measure race, age, and gender in the individual data using the same definitions as in the neighborhood data. Individual responses for income were bracketed differently than the neighborhood data. For the individual data, we define a poor household as having yearly income below $50,000, which is close to 200% of the poverty line for a family of three ($41,222 in 2020, U.S. Census Bureau, 2021). See Online Appendix D for more detail.

2.4 Participants versus the invited sample

Panel A of Table 1 shows that average neighborhood characteristics for participating households differ markedly from invited households. The average participating household lives in a neighborhood that is 53.2% non-White compared to 63.5% for all invited households. Participating households reside in neighborhoods with fewer poor, unemployed, and uninsured residents, and fewer negative health outcomes. Participating households also reside in neighborhoods with lower COVID risk indices, a particularly important point given the goals of the RECOVER study. A joint test of equality of neighborhood characteristics between the invited and participating households overwhelmingly rejects (p-value $< .01$).

Panel B of Table 1 presents individual characteristics among participating households as reported in the responses to the study questionnaire. The probability that the participant reports to be non-White is even lower than the neighborhood-level non-White share among participants (37.9% versus 53.2%). Participants are also more likely to be of working age than the average resident in a participating households' neighborhood. These differences could arise for several reasons, including within-neighborhood selection of households, within-household selection of the participating member, and differences in measurement between the individual and public data sets due to, for example, differential wording of questions.

[3]Our results are not sensitive to how we define race and poverty status, see Online Appendix B.

Table 1: *Descriptive statistics*

	Participants	Invited
Panel A: *Neighborhood Characteristics (External Sources)*		
Share Non-White (%)	53.2	63.5
	[24.2]	[27.6]
Share poor (%)	30.2	35.8
	[14.3]	[15.9]
Share working age (%)	61.1	59.1
	[8.1]	[8.0]
Share Female (%)	51.4	51.6
	[2.2]	[2.6]
Share unemployed (%)	6.7	8.5
	[4.2]	[5.3]
Share uninsured (%)	7.8	8.6
	[4.3]	[4.2]
Drug-related hospitalization rate (per 10k)	22.1	30.3
	[21.3]	[28.6]
Preventable hospitalization rate (per 10k)	169.7	192.1
	[73.2]	[80.1]
COVID local risk index	4.3	5.3
	[2.6]	[3.0]
Panel B: *Individual Characteristics (RECOVER Questionnaire)*		
Participant is non-White (%)	37.9	
	[48.7]	
Participant's household is poor (%)	32.7	
	[47.1]	
Participant is working age (%)	75.2	
	[43.3]	
Participant is female (%)	58.5	
	[49.5]	
N	125	882

Notes: This table the presents average of participants (first column) and the average characteristics of the invited sample (second column). Panel A presents estimates for neighborhood characteristics obtained by merging addresses to external sources. Panel B presents estimates for individual characteristics as reported in the responses to the study questionnaire. Standard deviations are presented in square brackets below averages.

2.5 Participation rates and incentives

Panel A of Table 2 reports the proportion of households who participated in the RECOVER study by incentive level. Only 6 percent of unincentivized households participated. This rate is similar to participation rates in comparable serological surveys that tested for COVID-19 antibodies.[4] Incentives have a large impact on participation rates, increasing them to 17% at $100, and to 29% at $500.

Panel B of Table 2 shows that the impact of incentives by neighborhood racial composition. We classify a household as being from a majority non-White neighborhood if the neighborhood's share of adults identifying as non-Hispanic White is below 50%, and clas-

[4]In Online Appendix E, we show that in serological studies that randomly sampled subjects in the United States, the average (median) participation rate for studies that used mail outreach is 9.0% (8.3%).

Table 2: *Participation rates (in %) across incentive levels and neighborhood characteristics*

	Incentive level			Incentive difference	
	$0	$100	$500	$100 − $0	$500 − $100
Panel A: *Overall*					
	6.1	16.8	29.1	10.7	12.3
	(1.8)	(1.8)	(2.9)	(2.5)	(3.4)
Panel B: *Racial composition*					
Majority White	8.9	25.9	30.0	17.0	4.1
	(2.8)	(2.8)	(5.3)	(4.0)	(6.0)
Majority non-White	4.4	11.3	28.7	6.9	17.5
	(2.2)	(2.2)	(3.5)	(3.1)	(4.1)
Panel C: *Poverty status*					
Lower poverty	9.7	23.7	31.6	14.0	7.8
	(2.4)	(2.4)	(4.5)	(3.4)	(5.1)
Higher poverty	2.2	9.1	27.3	6.8	18.2
	(2.5)	(2.5)	(3.8)	(3.6)	(4.6)
N	374	374	134		

Notes: This table presents participation rates by incentive group and by racial composition and income level (see text for variable definitions). Overall and subgroup-specific cell counts are presented in Online Appendix Table A.2. Standard errors are presented in parentheses below the estimated rates. The number of invited households in each incentive level is presented in the bottom row.

sify it as majority White otherwise. Only 4.4% of unincentivized households in majority non-White neighborhoods participate, compared to 8.9% in majority White neighborhoods. The $100 incentive increases participation for both groups, but increases it more for households in majority White neighborhoods (p-value .05). The $500 incentive further increases participation for both groups, but increases it more for households in majority *non*-White neighborhoods (p-value .07). At $500, there is no meaningful difference in participation rates between households in majority White and non-White neighborhoods (p-value .84).

Panel C of Table 2 shows similar results for poverty status. We classify a household as being from a higher poverty neighborhood if the neighborhood's share of households below 200% of the poverty line is above the median share of the invited sample, and classify it as from a lower poverty neighborhood otherwise.[5] The results are similar to those in panel B, likely in part because neighborhood racial composition and poverty status are strongly correlated in Chicago (see Online Appendix Table A.3).

3 How financial incentives affect representativeness

Heterogeneity in the effect of incentives on participation suggests that incentives might also affect the representativeness of participants relative to the invited sample. Panel A of Table 3 shows how the average neighborhood characteristics of participating households vary by

[5]In Online Appendix B, we show that the main conclusions are robust to different binary classifications. Small sample sizes prevent us from looking at finer partitions of the data.

incentive level. Larger incentives increase the neighborhood non-White and poverty shares of participating households, and have a similar monotonic impact on other socio-economic and health measures.[6] Tests of equality across incentive levels reject at the 5% level for five out of the nine characteristics, and at the 10% level for seven out of the nine characteristics. A joint test of equality rejects at the 10% level (p-value .06). Panel B of Table 3 shows that the individual characteristics of participants also differ substantially by incentive level. Only 21% of unincentivized participants self-identify as non-White, compared to almost 57% of participants in the $500 incentive arm.

Because we observe neighborhood characteristics for all invited households, we can evaluate representativeness by comparing these characteristics to participating households. For example, households that participate without incentives reside, on average, in neighborhoods where 48.6% of households are non-White, compared to an invited population average of 63.5%. This figure increases to 49.1% with a $100 incentive, and to 62.3% with a $500 incentive. Formal tests strongly reject equality between the invited sample and the unincentivized and $100 participants (p-values less than .01), but not between the invited sample and $500 participants (p-value .80). Other socio-economic characteristics show similar patterns. A joint test across all nine characteristics rejects equality between the invited sample and unincentivized participants (p-value .03), and between the invited sample and the $100 participants (p-value .02), but not between the invited sample and the $500 participants (p-value .35). These results imply that an unincentivized study and a study with a $100 incentive would both be highly nonrepresentative, while a study using a $500 incentive would be representative, at least along the dimensions we observe.

Given the goal of the RECOVER study, a particularly important dimension of nonrepresentativeness is the COVID-19 local risk index. A study with no incentive or a $100 incentive would understate the average COVID-19 risk index in the target population by at least 1.2 points on a 10-point scale, but a study with a $500 incentive would be almost exactly representative. Taken together, our findings suggest one should be cautious in using results from a study with lower incentives to draw inference about seropositivity rates in the population. In Online Appendix Table A.4, we show that this conclusion holds true even if we reweight the unincentivized or $100 participants by neighborhood race and poverty status to achieve representativeness on these dimensions. This suggests that study participation at lower incentives is correlated with these health variables, even conditional on neighborhood racial composition and poverty, casting doubt on reweighting as a solution to nonrepresentativeness.

Nonrepresentativeness relative to the invited sample is caused by differential non-participation. Non-participation occurs for one of two reasons: either a sampled household is unable to be contacted (non-contact), or a contacted household does not participate because the perceived costs of doing so exceed the perceived benefits (hesitancy). Suppose that any contacted household would participate at $500. If this is the case, then all non-participation

[6]Some of the nine characteristics are strongly correlated, but many are not. A full correlation matrix is reported in Online Appendix Table A.3.

Table 3: *Representativeness and composition of participants across incentive groups*

	Incentive level				p-value of	p-value of non-rep		
	$0	$100	$500	Invited	selection	$0	$100	$500
Panel A: *Neighborhood Characteristics (External Sources)*								
Share Non-White (%)	48.6	49.1	62.3	63.5	0.02	0.01	0.00	0.80
	(4.9)	(3.0)	(3.8)	(0.9)				
Share poor (%)	25.8	27.7	36.9	35.8	0.00	0.00	0.00	0.66
	(2.9)	(1.7)	(2.2)	(0.5)				
Share working age (%)	60.4	62.0	59.9	59.1	0.42	0.43	0.00	0.51
	(1.7)	(1.0)	(1.3)	(0.3)				
Share Female (%)	51.2	51.2	51.8	51.6	0.37	0.39	0.19	0.65
	(0.5)	(0.3)	(0.4)	(0.1)				
Share unemployed (%)	6.1	6.2	8.0	8.5	0.08	0.03	0.00	0.53
	(0.9)	(0.5)	(0.7)	(0.2)				
Share uninsured (%)	6.9	7.3	9.2	8.6	0.05	0.04	0.01	0.41
	(0.9)	(0.5)	(0.7)	(0.1)				
Drug-related hospitalization rate (per 10k)	17.4	19.9	28.6	30.3	0.07	0.03	0.00	0.70
	(4.4)	(2.7)	(3.4)	(1.0)				
Preventable hospitalization rate (per 10k)	158.0	158.8	193.8	192.1	0.04	0.04	0.00	0.89
	(15.0)	(9.1)	(11.5)	(2.7)				
COVID local risk index	4.1	3.9	5.3	5.3	0.03	0.05	0.00	0.89
	(0.5)	(0.3)	(0.4)	(0.1)				
Joint test					0.06	0.03	0.02	0.35
Panel B: *Individual Characteristics (RECOVER Questionnaire)*								
Participant is non-White (%)	21.1	31.7	56.8		0.01			
	(10.8)	(6.1)	(7.8)					
Participant's household is poor (%)	13.3	32.1	41.7		0.15			
	(12.1)	(6.2)	(7.8)					
Participant is working age (%)	57.9	75.0	84.2		0.10			
	(9.8)	(5.5)	(7.0)					
Participant is female (%)	68.4	47.5	71.1		0.04			
	(11.1)	(6.2)	(7.9)					
Joint test					0.01			

Notes: This table presents the average characteristics of participants across incentive groups (first three columns), the average characteristics of the invited sample (fourth column), the p-value for equality of participant averages across incentive groups (fifth column), and the p-value for equality of the invited and participant averages for each incentive group (last three columns). Panel A presents estimates for neighborhood characteristics obtained by merging addresses to external sources. Panel B presents estimates for individual characteristics as reported in the responses to the study questionnaire. Standard errors are presented in parentheses.

at $500 must be due to non-contact. Since incentives were randomly assigned and only revealed after the household was contacted, the non-contact rates at $0 and $100 should be the same as at $500, implying that the observed differences in the participation rates by neighborhood race and poverty status must be due to hesitancy. Given that response rates at $500 did not vary much by these neighborhood characteristics, this line of reasoning suggests that differential hesitancy is the main driver of non-participation and thus of non-representativeness. In Online Appendix F, we develop this argument formally.

4 Conclusion

Using data from a serological study with randomized participation incentives, we found large participation gaps by race and income with lower incentives, but not with high incentives. High incentives also help restore representativeness in health variables likely to be corre-

lated with seropositivity, such as the uninsured rate, hospitalization rates, and an aggregate COVID-19 risk index. While large financial incentives appear to be effective in achieving representative samples, they are costly to use, and come with potential ethical concerns. There is a large medical literature that grapples with the tension between encouraging research participation and trying to avoid coercing participation from vulnerable populations (see, e.g. Halpern et al., 2004; Groth, 2010; Largent and Lynch, 2017). Our findings suggest that representativeness and its benefits could be considered when balancing these objectives.

References

Alsan, M., M. Durvasula, H. Gupta, J. Schwartzstein, and H. L. Williams (2022). Representation and Extrapolation:. *NBER working paper*. 2, 41

Aspelund, K., D. M.C., J. Stock, and C. Walker (2020). Identification and estimation of undetected covid-19 cases using testing data from iceland. *working paper*. 3

Berlin, M., L. Mohadjer, J. Waksberg, A. Kolstad, I. Kirsch, D. Rock, and K. Yamamoto (1992). An experiment in monetary incentives. *Proceedings of the Section on Survey Research Methods*, 393–398. 3

Bobrovitz, N., R. K. Arora, C. Cao, E. Boucher, M. Liu, C. Donnici, M. Yanes-Lane, M. Whelan, S. Perlman-Arrow, J. Chen, H. Rahim, N. Ilincic, M. Segal, N. Duarte, J. V. Wyk, T. Yan, A. Atmaja, S. Rocco, A. Joseph, L. Penny, D. A. Clifton, T. Williamson, C. P. Yansouni, T. G. Evans, J. Chevrier, J. Papenburg, and M. P. Cheng (2021, June). Global seroprevalence of SARS-CoV-2 antibodies: A systematic review and meta-analysis. *PLOS ONE 16*(6), e0252617. 3, 35

Bradley, V. C., S. Kuriwaki, M. Isakov, D. Sejdinovic, X.-L. Meng, and S. Flaxman (2021, December). Unrepresentative big surveys significantly overestimated US vaccine uptake. *Nature 600*(7890), 695–700. 2

Chen, X., Z. Chen, A. S. Azman, X. Deng, R. Sun, Z. Zhao, N. Zheng, X. Chen, W. Lu, T. Zhuang, J. Yang, C. Viboud, M. Ajelli, D. T. Leung, and H. Yu (2021, May). Serological evidence of human infection with SARS-CoV-2: A systematic review and meta-analysis. *The Lancet. Global Health 9*(5), e598–e609. 3

Dutz, D., M. Greenstone, A. Hortaçsu, S. Lacouture, M. Mogstad, A. Shaikh, A. Torgovitsky, and W. van Dijk (2022). What drives (gaps in) scientific study participation? evidence from a covid-19 antibody survey. Technical report, Becker Friedman Institute Working Paper. 3

Dutz, D., I. Huitfeldt, S. Lacouture, M. Mogstad, A. Torgovitsky, and W. van Dijk (2021). Selection in surveys. Technical report, National Bureau of Economic Research. 3

Einav, L., A. Finkelstein, T. Oostrom, A. Ostriker, and H. Williams (2020). Screening and selection: The case of mammograms. *American Economic Review 110*(12), 3836–3870. 2

Groth, S. W. (2010). Honorarium or Coercion: Use of Incentives for Participants in Clinical Research. *The Journal of the New York State Nurses' Association 41*(1), 11–22. 10

Groves, R. M., F. J. Fowler Jr., M. P. Couper, J. M. Lepkowski, E. Singer, and R. Tourangeau (2009). *Survey Methodology*. Wiley New York. 3

Halpern, S. D., J. H. T. Karlawish, D. Casarett, J. A. Berlin, and D. A. Asch (2004, April). Empirical assessment of whether moderate payments are undue or unjust inducements for participation in clinical trials. *Archives of Internal Medicine 164*(7), 801–803. 10

Imbens, G. W. and J. D. Angrist (1994). Identification and Estimation of Local Average Treatment Effects. *Econometrica 62*(2), pp. 467–475. 37

Ioannidis, J. P., S. Cripps, and M. A. Tanner (2022). Forecasting for COVID-19 has failed. *International Journal of Forecasting 38*(2), 423–438. 3

Juster, F. T. and R. Suzman (1995). An overview of the health and retirement study. *The Journal of Human Resources 30*(5). 3

Largent, E. A. and H. F. Lynch (2017). Paying Research Participants: Regulatory Uncertainty, Conceptual Confusion, and a Path Forward. *Yale journal of health policy, law, and ethics 17*(1), 61–141. 10

Mack, S., D. Huggins, Vicki andKeathley, and M. Sundukchi (1998). Do monetary incentives improve response rates in the survey of income and program participation? . *Proceedings of the Section on Survey Research Methods*, 529–534. 3

Manski, C. and F. Molinari (2021). Estimating the covid-19 infection rate: Anatomy of an inference problem. *Journal of Econometrics 220*(S2), 181–192. 3

NASEM (2022). *Improving Representation in Clinical Trials and Research: Building Research Equity for Women and Underrepresented Groups*. Washington, DC: The National Academies Press. 2, 5, 41

Oster, E. (2020). Health recommendations and selection in health behaviors. *American Economic Review: Insights 2*(2), 143–160. 2

Singer, E. and C. Ye (2013). The use and effects of incentives in surveys. *The ANNALS of the American Academy of Political and Social Science 645*(1), 112–141. 3

Torgovitsky, A. (2019, January). Partial identification by extending subdistributions. *Quantitative Economics 10*(1), 105–144. 39

U.S. Census Bureau (2021). Poverty thresholds. https://www.census.gov/data/tables/time-series/demo/income-poverty/historical-poverty-thresholds.html. 5, 34

U.S. Census Bureau (2022). Press Release Number CB22-CN.02: Census Bureau Releases Estimates of Undercount and Overcount in the 2020 Census. https://www.census.gov/newsroom/press-releases/2022/2020-census-estimates-of-undercount-and-overcount.html#:~:text=The%20Black%20or%20African%20American%20alone%20or%20in%20combination%20population,significant%20undercount%20rate%20of%204.99%25. 2

Vytlacil, E. (2002). Independence, Monotonicity, and Latent Index Models: An Equivalence Result. *Econometrica 70*(1), 331–341. 37

Wines, M. and M. Cramer (2022, March). 2020 Census Undercounted Hispanic, Black and Native American Residents. *The New York Times*. 2

Yancey, A. K., A. N. Ortega, and S. K. Kumanyika (2006). Effective Recruitment and Retention of Minority Research Participants. *Annual Review of Public Health 27*, 1–28. 3

Appendix (for online publication)

A Additional exhibits

Table A.1: *Balance test*

	Incentive level			p-value
	$0	$100	$500	of equality
Share Non-White (%)	62.3	63.1	67.6	0.16
	[27.6]	[27.6]	[27.6]	
Share poor (%)	35.3	35.5	38.1	0.20
	[15.9]	[15.9]	[15.9]	
Share working age (%)	59.4	59.0	58.7	0.65
	[8.0]	[8.0]	[8.0]	
Share Female (%)	51.5	51.7	51.8	0.45
	[2.6]	[2.6]	[2.6]	
Share unemployed (%)	8.3	8.5	9.1	0.36
	[5.3]	[5.3]	[5.3]	
Share uninsured (%)	8.6	8.6	9.0	0.59
	[4.2]	[4.2]	[4.2]	
Drug-related hospitalization rate (per 10k)	29.1	30.4	33.2	0.38
	[29.0]	[28.8]	[28.9]	
Preventable hospitalization rate (per 10k)	188.7	191.6	203.1	0.21
	[80.4]	[80.5]	[80.9]	
COVID local risk index	5.2	5.3	5.7	0.17
	[3.0]	[3.0]	[3.0]	
Joint test				0.80
N	374	374	134	

Notes: This table presents the average neighborhood characteristics for the invited sample by incentive group. Standard deviations are presented in square brackets below the estimated means. The last column presents the p-value for the null hypothesis of equality of means across incentive groups. The number of invited households per incentive group is presented at the bottom of the table.

Table A.2: *Sample sizes*

		Incentive level		
	Pooled	$0	$100	$500
Invited	882	374	374	134
Participants	125	23	63	39
and Majority white	62	13	37	12
and Majority minority	63	10	26	27
and Lower poverty	84	19	47	18
and Higher poverty	41	4	16	21

Notes: This table presents cell counts (pooled and by incentive level) for the invited sample, for participants, and for participants in the subgroups examined in Panels B and C of Table 2.

Table A.3: *Correlation between neighborhood characteristics*

	Share Non-White (%)	Share poor (%)	Share working age (%)	Share Female (%)	Share unemployed (%)	Share uninsured (%)	Drug-related hosp. rate (per 10k)	Preventable hosp. rate (per 10k)	COVID local risk index
Share Non-White (%)	1.000	0.907	-0.720	0.447	0.859	0.629	0.586	0.749	0.935
Share poor (%)	0.907	1.000	-0.669	0.322	0.821	0.692	0.662	0.765	0.890
Share working age (%)	-0.720	-0.669	1.000	-0.513	-0.690	-0.468	-0.373	-0.431	-0.827
Share Female (%)	0.447	0.322	-0.513	1.000	0.567	-0.118	0.479	0.437	0.535
Share unemployed (%)	0.859	0.821	-0.690	0.567	1.000	0.355	0.736	0.825	0.883
Share uninsured (%)	0.629	0.692	-0.468	-0.118	0.355	1.000	0.112	0.327	0.550
Drug-related hosp. rate (per 10k)	0.586	0.662	-0.373	0.479	0.736	0.112	1.000	0.872	0.639
Preventable hosp. rate (per 10k)	0.749	0.765	-0.431	0.437	0.825	0.327	0.872	1.000	0.763
COVID local risk index	0.935	0.890	-0.827	0.535	0.883	0.550	0.639	0.763	1.000

Notes: This table presents, for the invited sample, the degree of correlation between the nine neighborhood characteristics we consider.

Table A.4: *Representativeness of participants across incentive groups - reweighting*

		$0		$100		$500	
	Invited	UNW	RW	UNW	RW	UNW	RW
Share Non-White (%)	63.5	48.6	60.3	49.1	59.9	62.3	59.6
	(0.9)	(4.9)	(5.4)	(3.0)	(3.1)	(3.8)	(4.1)
Share poor (%)	35.8	25.8	31.8	27.7	35.0	36.9	35.2
	(0.5)	(2.9)	(2.4)	(1.7)	(1.9)	(2.2)	(2.4)
Share uninsured (%)	8.6	6.9	7.3	7.3	8.9	9.2	8.7
	(0.1)	(0.9)	(0.6)	(0.5)	(0.6)	(0.7)	(0.7)
Drug-related hospitalization rate (per 10k)	30.3	17.4	23.4	19.9	25.5	28.6	27.4
	(1.0)	(4.4)	(3.4)	(2.7)	(3.0)	(3.4)	(4.4)
Preventable hospitalization rate (per 10k)	192.1	158.0	173.1	158.8	180.0	193.8	189.5
	(2.7)	(15.0)	(13.2)	(9.1)	(9.1)	(11.5)	(13.9)
COVID local risk index	5.3	4.1	5.1	3.9	5.0	5.3	5.0
	(0.1)	(0.5)	(0.6)	(0.3)	(0.3)	(0.4)	(0.5)

Notes: This table presents the average neighborhood characteristics of participants across incentive groups with and without reweighting. The first column presents the average in the invited sample. The next three pairs of columns present unweighted ('UNW') and reweighted ('RW') averages for unincentivized participants and participants in the $100 and the $500 incentive groups. We compute the probability of participation by racial composition and poverty status of the neighborhood and reweight participants by the inverse of this probability. Standard errors are shown in parentheses; we compute these via bootstrapping for reweighted estimates.

B Robustness results

B.1 Robustness to measures of race and poverty status

Appendix Table B.1 presents the same results as in Table 3 for different measures of race (Panel A) and poverty (Panel B). We see that the findings and conclusions discussed in Section 2.5 are not sensitive to how we defined these measures: relative to households that participate without incentives, households that participate with $500 are more likely to reside in neighborhoods with higher shares of racial minorities and poverty, and these patterns are often monotonic across all three incentive levels.

Table B.1: *Representativeness of participants across incentive groups: Robustness to alternative definitions*

	Incentive level				p-value of	p-value of non-rep		
	$0	$100	$500	Invited	selection	$0	$100	$500
Panel A: *Racial composition*								
Share Non-White (%)	48.6	49.1	62.3	63.5	0.02	0.01	0.00	0.80
	(4.9)	(3.0)	(3.8)	(0.9)				
Share Black (%)	20.6	16.1	27.3	30.0	0.13	0.17	0.00	0.61
	(5.6)	(3.4)	(4.3)	(1.1)				
Share Hispanic (%)	18.4	21.2	24.5	24.4	0.50	0.20	0.25	1.00
	(4.2)	(2.5)	(3.2)	(0.8)				
Panel B: *Poverty status*								
Share poor [below 2x PL] (%)	25.8	27.7	36.9	35.8	0.00	0.00	0.00	0.66
	(2.9)	(1.7)	(2.2)	(0.5)				
Share below PL (%)	12.3	13.9	18.8	17.9	0.00	0.00	0.00	0.51
	(1.5)	(0.9)	(1.2)	(0.3)				
Share below 1.5xPL (%)	19.1	21.0	28.2	27.3	0.00	0.00	0.00	0.64
	(2.2)	(1.3)	(1.7)	(0.4)				
Share below 1.85xPL (%)	23.9	25.7	34.5	33.4	0.00	0.00	0.00	0.65
	(2.7)	(1.6)	(2.1)	(0.5)				
Share below 3xPL (%)	38.2	39.5	50.8	49.6	0.00	0.01	0.00	0.70
	(3.7)	(2.3)	(2.9)	(0.7)				

Notes: This table presents the average neighborhood characteristic of participants across incentive groups (first three columns), the average characteristic of the invited sample (fourth column), the p-value for equality of participant averages across incentive groups (fifth column), and the p-value for equality of the invited and the participant averages for each incentive group (last three columns). Standard errors are presented below in parentheses. Panel A examines alternative measures on the racial composition of neighborhoods. Panel B examines alternative measures on the poverty status of neighborhoods.

B.2 Robustness to binarizing racial composition and poverty status

Appendix Table B.2 presents the same results as in Panel B of Table 2 for different binarizations of our considered measure of race. The first set of results is as in the main paper, and the second and third set of results respectively change the cutoff to 45% and 55%. Appendix Table B.3 presents the same results as in Panel C of Table 2 for different binarizations of our considered measure of poverty. The first set of results is as in the main paper, and the following three results vary how we define a household as poor (150% or 200% of the

poverty line), and whether the share of households in the neighborhood is greater than the median share (roughly 34%) or greater than 30%. We consistently find the same results and conclusions.

Table B.2: *Participation rates (in %) across incentive levels and neighborhood racial composition: robustness*

	Incentive level			Incentive difference	
	\$0	\$100	\$500	\$100 − \$0	\$500 − \$100
Majority non-white (above 50%)					
Majority white	8.9	25.9	30.0	17.0	4.1
	(2.8)	(2.8)	(5.3)	(4.0)	(6.0)
Majority minority	4.4	11.3	28.7	6.9	17.5
	(2.2)	(2.2)	(3.5)	(3.1)	(4.1)
Majority non-white (above 45%)					
Majority white	7.2	25.4	30.3	18.2	4.9
	(3.0)	(3.0)	(5.9)	(4.3)	(6.6)
Majority minority	5.6	12.5	28.7	6.9	16.2
	(2.1)	(2.1)	(3.4)	(3.0)	(4.0)
Majority non-white (above 55%)					
Majority white	8.7	24.6	33.3	15.9	8.8
	(2.5)	(2.5)	(4.7)	(3.6)	(5.4)
Majority minority	3.7	10.1	26.5	6.4	16.5
	(2.4)	(2.4)	(3.7)	(3.4)	(4.4)

Notes: This table presents participation rates by incentive group and alternative racial composition definitions. Standard errors are presented in parentheses below the estimated rates.

Table B.3: *Participation rates (in %) across incentive levels and neighborhood poverty status: robustness*

	Incentive level			Incentive difference	
	\$0	\$100	\$500	\$100 − \$0	\$500 − \$100
Share below 200% PL is above median					
Lower poverty	9.7	23.7	31.6	14.0	7.8
	(2.4)	(2.4)	(4.5)	(3.4)	(5.1)
Higher poverty	2.2	9.1	27.3	6.8	18.2
	(2.5)	(2.5)	(3.8)	(3.6)	(4.6)
Share below 200% PL is above 30%					
Lower poverty	10.4	23.4	26.1	13.0	2.7
	(2.7)	(2.7)	(5.0)	(3.8)	(5.7)
Higher poverty	3.2	12.0	30.7	8.9	18.6
	(2.3)	(2.3)	(3.6)	(3.2)	(4.3)
Share below 150% PL is above median					
Lower poverty	9.7	23.7	32.1	14.0	8.4
	(2.4)	(2.4)	(4.5)	(3.4)	(5.1)
Higher poverty	2.2	9.4	26.9	7.2	17.5
	(2.5)	(2.5)	(3.8)	(3.6)	(4.6)
Share below 150% PL is above 30%					
Lower poverty	9.6	23.7	31.7	14.1	8.0
	(2.3)	(2.3)	(4.3)	(3.3)	(4.9)
Higher poverty	1.8	8.4	27.0	6.6	18.6
	(2.6)	(2.6)	(3.9)	(3.7)	(4.7)

Notes: This table presents participation rates by incentive group and alternative poverty status definitions. Standard errors are presented in parentheses below the estimated rates.

C Study implementation

This appendix describes the design and implementation of the RECOVER serological study. The study was designed and implemented in collaboration with NORC at the University of Chicago, and the University of Chicago Wilson Antibody Biology Laboratory. Appendix C.1 discusses the construction of the sampling frame and the sampling and randomization procedures. Appendix C.2 describes outreach and follow-up procedures, and additionally discusses the materials sent to invited households. These materials are reproduced in Appendix C.3. This study, its design, and its implementation were approved by the IRB at the University of Chicago (IRB20-0721).

C.1 Sampling and randomization procedures

NORC constructed a sampling frame of approximately 1.2 million household addresses in the city of Chicago based on address data from the United States Postal Service Computerized Delivery Sequence File (CDSF).[7] The CDSF contains a record for every mail delivery point in the U.S. and these records are updated monthly.

NORC then randomly sampled 882 household addresses from the sampling frame for the RECOVER study. All addresses had an equal probability of being randomly sampled. These 882 household addresses were randomly (and with equal probability) assigned to one of three compensation arms: 374 addresses were assigned to the $0 arm, 374 addresses were assigned to the $100 arm, and 134 addresses were assigned to the $500 arm.

C.2 Outreach and follow up procedures

Each household in the RECOVER study sample was sent a package that contained a self-administered blood collection kit, an invitation, and a consent form with a short questionnaire. All households received material that was identical in all aspects except for minor modifications relating to compensation for participating (i.e. returning a blood sample) depending on the assigned incentive arm. In particular, households in the $0 arm were not told about financial compensation for participating, and households in the $100 and $500 compensation arms were notified that they would receive $100 and $500 for participating, respectively.

The blood collection kit included instructions on self-administering and returning a blood sample.[8] The written material explained the purpose of the study, provided information on financial compensation for participating (if applicable), and explained which member of the household should participate and how to participate, and provided contact information. Invitees were additionally provided a toll-free phone number to call with any questions about the study, procedures, their participation, or rights as a research participant. Appendix

[7] The software program used to create the sampling frame is retained by NORC.

[8] On the instruction card, a link to video instructions for taking the sample was provided (https://vimeo.com/286513641), and invitees were reminded that they could call the toll-free line to have a phone interviewer from NORC walk them through the sample-taking process.

Exhibits C.1, C.2, and C.3 respectively depict the invitations sent to households in the $0, $100 compensation, and $500 compensation arms.

The consent form noted that the purpose of the study was to learn how many people had already been exposed to the virus, that the study had received IRB approval, that participants' data would be securely stored, that they would not receive the result of the test, and that compensation (if offered) would be received when the Wilson laboratory received the blood sample. The consent form concluded with a request for the participant's signature and a short questionnaire. The first two pages of the consent form differed slightly depending on the assigned incentive arm. Appendix Exhibits C.4, C.5, and C.6 respectively depict the first page of the consent forms sent to households in the $0, $100 compensation, and $500 compensation arms. Appendix Exhibits C.7, C.8, and C.9 respectively depict the second page of the consent forms sent to households in the $0, $100 compensation, and $500 compensation arms. The third and fourth pages of the consent form were uniform across compensation arms and are respectively depicted in Appendix Exhibits C.10 and C.11.

After all packages were sent, NORC additionally sent up to three reminder postcards to all sampled households who had not yet returned a kit. Appendix Exhibits C.12, C.13, and C.14 respectively depict the postcards sent to households in the no compensation, $100 compensation, and $500 compensation arms. NORC also conducted up to three weekly phone calls to these households.[9] If a non-usable sample was received by the laboratory, NORC contacted households to inform them that their sample was not usable. Households were offered the option of receiving a replacement kit to attempt to take their sample again.[10] If households refused to receive a replacement kit, the interviewer would explain that they would not receive payment. If households agreed to receive a replacement kit, a new kit was mailed to the participant. There was no additional payment or penalty for having to retake one's sample. As soon as the second sample was received by the laboratory, the participant was sent their payment, even if this second sample was also unusable.

[9]Since the sampling frame itself does not contain any telephone number information, phone numbers were appended to the sample once it was selected using data from commercial providers.

[10]Reasons for a non-usable sample include an empty or not-attempted kit or a kit with insufficient blood sample. The research team was informed by the kit manufacturer that their product returns a total of 1.8% unusable samples. When empty or not-attempted kits were sent back, NORC also attempted to assist the participant in understanding the required conditions of participation and compensation via phone call.

C.3 Materials

Exhibit C.1: *Invitation sent to households, incentive level $0*

THE UNIVERSITY OF CHICAGO

HELP US LEARN ABOUT COVID-19 IN CHICAGO!

Dear Fellow Chicagoan,

We launched the RECOVER study to learn about how many Chicagoans have had COVID-19. You can help your community by helping us understand how the virus has affected different parts of the city.

It is fast, easy, and safe to take part in this study.

You are among a small number of people scientifically chosen to represent others in your area.

Your participation is important!

HERE'S HOW IT WORKS:

1 **Collect a small blood sample at home in just a few minutes using the kit you received.**

2 **Mail the kit to our research team using the pre-paid packaging.**

We know your time is valuable. We thank you for your participation!

- **Who can participate?** To make sure the study represents all Chicagoans, one adult per household – the one with the next upcoming birthday – can take part.
- **Is there a deadline?** Please return your kit within 10 business days of receiving this invitation. Samples must be mailed back the same day that they are taken.
- **Where can I learn more?** For more information, visit the study website at recover.uchicago.edu or call us toll-free at 800-483-2565 (Se Habla Español).
  Your unique access code is:

Your participation is a way to help our community, neighbors, and friends overcome this pandemic together. We hope you will join us and participate in this important study!

Michael Greenstone, PhD, Lead Principal Investigator
On behalf of the RECOVER Study team, a collaboration between the University of Chicago Social Sciences Division (SSD), Biological Sciences Division (BSD), and Department of Medicine

Exhibit C.2: *Invitation sent to households, incentive level $100*

THE UNIVERSITY OF CHICAGO

HELP US LEARN ABOUT COVID-19 IN CHICAGO!

Dear Fellow Chicagoan,

We launched the RECOVER study to learn about how many Chicagoans have had COVID-19. You can help your community by helping us understand how the virus has affected different parts of the city.

It is fast, easy, and safe to take part in this study.

You are among a small number of people scientifically chosen to represent others in your area.

Your participation is important!

We know your time is valuable.

As thanks for your participation, we will send you a check for

$100

after we receive your kit.

HERE'S HOW IT WORKS:

1 **Collect a small blood sample at home in just a few minutes using the kit you received.**

2 **Mail the kit to our research team using the pre-paid packaging.**

- **Who can participate?** To make sure the study represents all Chicagoans, one adult per household – the one with the next upcoming birthday – can take part.
- **Is there a deadline?** Please return your kit within 10 business days of receiving this invitation. Samples must be mailed back the same day that they are taken.
- **Where can I learn more?** For more information, visit the study website at recover.uchicago.edu or call us toll-free at 800-483-2565 (Se Habla Español).
  Your unique access code is:

Your participation is a way to help our community, neighbors, and friends overcome this pandemic together. We hope you will join us and participate in this important study!

Michael Greenstone, PhD, Lead Principal Investigator
On behalf of the RECOVER Study team, a collaboration between the University of Chicago Social Sciences Division (SSD), Biological Sciences Division (BSD), and Department of Medicine

Exhibit C.3: *Invitation sent to households, incentive level $500*

THE UNIVERSITY OF CHICAGO

HELP US LEARN ABOUT COVID-19 IN CHICAGO!

Dear Fellow Chicagoan,

We launched the RECOVER study to learn about how many Chicagoans have had COVID-19. You can help your community by helping us understand how the virus has affected different parts of the city.

It is fast, easy, and safe to take part in this study.

You are among a small number of people scientifically chosen to represent others in your area.

Your participation is important!

We know your time is valuable.

As thanks for your participation, we will send you a check for

$500

after we receive your kit.

HERE'S HOW IT WORKS:

1 **Collect a small blood sample at home in just a few minutes using the kit you received.**

2 **Mail the kit to our research team using the pre-paid packaging.**

- **Who can participate?** To make sure the study represents all Chicagoans, one adult per household – the one with the next upcoming birthday – can take part.
- **Is there a deadline?** Please return your kit within 10 business days of receiving this invitation. Samples must be mailed back the same day that they are taken.
- **Where can I learn more?** For more information, visit the study website at recover.uchicago.edu or call us toll-free at 800-483-2565 (Se Habla Español).
  Your unique access code is:

Your participation is a way to help our community, neighbors, and friends overcome this pandemic together. We hope you will join us and participate in this important study!

Michael Greenstone, PhD, Lead Principal Investigator
On behalf of the RECOVER Study team, a collaboration between the University of Chicago Social Sciences Division (SSD), Biological Sciences Division (BSD), and Department of Medicine

Exhibit C.4: *Consent form: key information, incentive level $0*

THE UNIVERSITY OF CHICAGO
RECOVER Study

Investigators: Michael Greenstone, Magne Mogstad, Azeem Shaikh, Alex Torgovitsky, Ali Hortaçsu, Sarah Cobey, Patrick Wilson
University of Chicago, 1126 E. 59th Street, Chicago, IL 60637
Phone Number: (773) 702-0759 | Protocol Number: IRB20-0721

Consent Form for Participation in a Research Study

KEY INFORMATION

You are being invited to participate in a research study about COVID-19 in Chicago. The purpose of this section is to give you key information to help you decide whether to participate.

WHAT IS THE STUDY ABOUT?
The purpose of this study is to learn how many people have already been exposed to the virus that causes COVID-19, known as SARS-CoV-2, including those that had mild or no symptoms. We will conduct antibody tests in blood samples collected from a random sample of Chicagoans.

WHAT DOES PARTICIPATION INVOLVE?
Participation involves taking a small blood sample, using the kit we sent you. This is done from your home and completed in just a few minutes. The kit is safe and easy to use. You will mail the sample back to our laboratory, following the instructions provided in the kit box.

WHO CAN PARTICIPATE?
One adult (18+) from your household can participate. It is important that our sample is random. We ask that the adult with the next upcoming birthday participates. If that person is not available or does not want to participate, we ask that no other person in the household participates.

WHAT ARE KEY REASONS I MIGHT CHOOSE TO PARTICIPATE?
We hope that you will participate in this study to help us understand how the disease has spread in Chicago. We know your time is valuable, and we appreciate your participation.

WHAT ARE KEY REASONS I MIGHT CHOOSE NOT TO PARTICIPATE?
This study involves collecting a small blood sample by self-administering a finger prick. You may feel momentary, mild discomfort which will fade within a minute or two. You may decide not to participate if you are not comfortable self-administering the finger prick.

ARE THERE ANY COSTS FOR PARTICIPATING?
No. You will not incur any costs for participation.

WHAT ABOUT CONFIDENTIALITY?
Study data will be handled confidentially. While there are always risks of data breach in any research study, our data is stored on secure servers that minimize this risk.

DO I HAVE TO TAKE PART IN THE STUDY?
Participation is completely voluntary. You will not lose any services, benefits, or rights that you normally have if you choose not to participate, or if you choose to leave the study at any time.

QUESTIONS?
Call to speak to a member of our team: 800-483-2565. For questions about your rights as a research subject, call the Biological Sciences Division (BSD) Institutional Review Board (IRB): 773-702-6505.

If you would like to participate, please return the final page of this consent form with your sample. We will not be able to process your sample without a signed consent form.

Exhibit C.5: *Consent form: key information, incentive level $100*

THE UNIVERSITY OF CHICAGO
RECOVER Study

Investigators: Michael Greenstone, Magne Mogstad, Azeem Shaikh, Alex Torgovitsky, Ali Hortaçsu, Sarah Cobey, Patrick Wilson
University of Chicago, 1126 E. 59th Street, Chicago, IL 60637
Phone Number: (773) 702-0759 | Protocol Number: IRB20-0721

Consent Form for Participation in a Research Study

KEY INFORMATION

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WHAT DOES PARTICIPATION INVOLVE?
Participation involves taking a small blood sample, using the kit we sent you. This is done from your home and completed in just a few minutes. The kit is safe and easy to use. You will mail the sample back to our laboratory, following the instructions provided in the kit box.

WHO CAN PARTICIPATE?
One adult (18+) from your household can participate. It is important that our sample is random. We ask that the adult with the next upcoming birthday participates. If that person is not available or does not want to participate, we ask that no other person in the household participates.

WHAT ARE KEY REASONS I MIGHT CHOOSE TO PARTICIPATE?
We hope that you will participate in this study to help us understand how the disease has spread in Chicago. We know your time is valuable. To thank you for your participation, we will send you a check for **$100** when our laboratory receives your blood sample.

WHAT ARE KEY REASONS I MIGHT CHOOSE NOT TO PARTICIPATE?
This study involves collecting a small blood sample by self-administering a finger prick. You may feel momentary, mild discomfort which will fade within a minute or two. You may decide not to participate if you are not comfortable self-administering the finger prick.

ARE THERE ANY COSTS FOR PARTICIPATING?
No. You will not incur any costs for participation.

WHAT ABOUT CONFIDENTIALITY?
Study data will be handled confidentially. While there are always risks of data breach in any research study, our data is stored on secure servers that minimize this risk.

DO I HAVE TO TAKE PART IN THE STUDY?
Participation is completely voluntary. You will not lose any services, benefits, or rights that you normally have if you choose not to participate, or if you choose to leave the study at any time.

QUESTIONS?
Call to speak to a member of our team: 800-483-2565. For questions about your rights as a research subject, call the Biological Sciences Division (BSD) Institutional Review Board (IRB): 773-702-6505.

If you would like to participate, please return the final page of this consent form with your sample. We will not be able to process your sample or compensate you without a signed consent form.

Exhibit C.6: *Consent form: key information, incentive level $500*

THE UNIVERSITY OF CHICAGO
RECOVER Study

Investigators: Michael Greenstone, Magne Mogstad, Azeem Shaikh, Alex Torgovitsky, Ali Hortaçsu, Sarah Cobey, Patrick Wilson
University of Chicago, 1126 E. 59th Street, Chicago, IL 60637
Phone Number: (773) 702-0759 | Protocol Number: IRB20-0721

Consent Form for Participation in a Research Study

KEY INFORMATION

You are being invited to participate in a research study about COVID-19 in Chicago. The purpose of this section is to give you key information to help you decide whether to participate.

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The purpose of this study is to learn how many people have already been exposed to the virus that causes COVID-19, known as SARS-CoV-2, including those that had mild or no symptoms. We will conduct antibody tests in blood samples collected from a random sample of Chicagoans.

WHAT DOES PARTICIPATION INVOLVE?
Participation involves taking a small blood sample, using the kit we sent you. This is done from your home and completed in just a few minutes. The kit is safe and easy to use. You will mail the sample back to our laboratory, following the instructions provided in the kit box.

WHO CAN PARTICIPATE?
One adult (18+) from your household can participate. It is important that our sample is random. We ask that the adult with the next upcoming birthday participates. If that person is not available or does not want to participate, we ask that no other person in the household participates.

WHAT ARE KEY REASONS I MIGHT CHOOSE TO PARTICIPATE?
We hope that you will participate in this study to help us understand how the disease has spread in Chicago. We know your time is valuable. To thank you for your participation, we will send you a check for **$500** when our laboratory receives your blood sample.

WHAT ARE KEY REASONS I MIGHT CHOOSE NOT TO PARTICIPATE?
This study involves collecting a small blood sample by self-administering a finger prick. You may feel momentary, mild discomfort which will fade within a minute or two. You may decide not to participate if you are not comfortable self-administering the finger prick.

ARE THERE ANY COSTS FOR PARTICIPATING?
No. You will not incur any costs for participation.

WHAT ABOUT CONFIDENTIALITY?
Study data will be handled confidentially. While there are always risks of data breach in any research study, our data is stored on secure servers that minimize this risk.

DO I HAVE TO TAKE PART IN THE STUDY?
Participation is completely voluntary. You will not lose any services, benefits, or rights that you normally have if you choose not to participate, or if you choose to leave the study at any time.

QUESTIONS?
Call to speak to a member of our team: 800-483-2565. For questions about your rights as a research subject, call the Biological Sciences Division (BSD) Institutional Review Board (IRB): 773-702-6505.

If you would like to participate, please return the final page of this consent form with your sample. We will not be able to process your sample or compensate you without a signed consent form.

Exhibit C.7: *Consent form: detailed information, page 1, incentive level $0*

DETAILED INFORMATION

INTRODUCTION
We are a team of researchers from the University of Chicago, conducting a study to learn how many people in Chicago have been exposed to the virus that causes COVID-19, known as SARS-CoV-2, including those that had mild or no symptoms. We will conduct antibody tests in blood samples collected from a random sample of Chicagoans. You are among approximately 3000 households invited to participate.

ELIGIBILITY
If you received an invitation box in the mail, it means that your household has been randomly selected. One adult (age 18+) from your household can participate. It is important that our sample is random. For this reason, we ask that the adult with the next upcoming birthday participates. If that person is not available or does not want to participate, we ask that no other person in the household participates. Past history of COVID-19 testing, diagnosis, or exposure does not matter. As long as the person is 18+, resides in Chicago, and has the next birthday, they are eligible.

WHAT IS INVOLVED IN THE STUDY?
Participants will self-administer a finger prick to take a small blood sample, following the instructions provided in the box. The kit is safe and easy to use and takes about 5-10 minutes to complete. Participants will mail their sample to our laboratory where it will be tested for antibodies against the virus that causes COVID-19, which may indicate prior exposure to the virus. This test does not indicate active infection. This study does not involve genetic testing. You will not be notified of your test results. We may contact you about your participation in the study, or to invite you to participate in later phases of the research.

WHAT ARE THE BENEFITS?
We hope that you will participate in this study to help us understand how the disease has spread in Chicago. We know your time is valuable, and we thank you for your participation.

WHAT ARE THE RISKS?
The discomfort of self-administering the finger prick is minimal and will fade within a minute or two. The kit is safe and commercially available, used routinely to collect at-home blood samples. As with any finger prick, there is a small risk of bruising, tenderness, and a rare risk of infection. While there are always risks of data breach in any research study, we take all possible precautions to minimize this risk including storing data on secure servers only accessible to authorized personnel.

ARE THERE ANY COSTS FOR PARTICIPATING?
No. You will not incur any costs for participation. You will use pre-paid packaging in the box to return your sample to our laboratory. There will be no costs to you or your insurance company for the costs of tests or services that are being performed solely for the purposes of this study. You or your insurance company remain responsible for costs related to your usual medical care.

WILL I BE PAID FOR MY PARTICIPATION?
No, you will not be compensated for your participation.

HOW WILL YOU MAINTAIN CONFIDENTIALITY?
Data you provide will be handled confidentially. While there are always risks of data breach in any research study, our data is stored on secure servers that minimize this risk and we will strip the data of identifiable information, such as your name. We will retain a link (or "key") to the identifiable information in password-protected, encrypted computer files accessible only to

Exhibit C.8: *Consent form: detailed information, page 1, incentive level $100*

DETAILED INFORMATION

INTRODUCTION
We are a team of researchers from the University of Chicago, conducting a study to learn how many people in Chicago have been exposed to the virus that causes COVID-19, known as SARS-CoV-2, including those that had mild or no symptoms. We will conduct antibody tests in blood samples collected from a random sample of Chicagoans. You are among approximately 3000 households invited to participate.

ELIGIBILITY
If you received an invitation box in the mail, it means that your household has been randomly selected. One adult (age 18+) from your household can participate. It is important that our sample is random. For this reason, we ask that the adult with the next upcoming birthday participates. If that person is not available or does not want to participate, we ask that no other person in the household participates. Past history of COVID-19 testing, diagnosis, or exposure does not matter. As long as the person is 18+, resides in Chicago, and has the next birthday, they are eligible.

WHAT IS INVOLVED IN THE STUDY?
Participants will self-administer a finger prick to take a small blood sample, following the instructions provided in the box. The kit is safe and easy to use and takes about 5-10 minutes to complete. Participants will mail their sample to our laboratory where it will be tested for antibodies against the virus that causes COVID-19, which may indicate prior exposure to the virus. This test does not indicate active infection. This study does not involve genetic testing. You will not be notified of your test results. We may contact you about your participation in the study, or to invite you to participate in later phases of the research.

WHAT ARE THE BENEFITS?
We hope that you will participate in this study to help us understand how the disease has spread in Chicago. We know your time is valuable. To thank you for your participation, we will send you a check for $100 when our laboratory receives your blood sample.

WHAT ARE THE RISKS?
The discomfort of self-administering the finger prick is minimal and will fade within a minute or two. The kit is safe and commercially available, used routinely to collect at-home blood samples. As with any finger prick, there is a small risk of bruising, tenderness, and a rare risk of infection. While there are always risks of data breach in any research study, we take all possible precautions to minimize this risk including storing data on secure servers only accessible to authorized personnel.

ARE THERE ANY COSTS FOR PARTICIPATING?
No. You will not incur any costs for participation. You will use pre-paid packaging in the box to return your sample to our laboratory. There will be no costs to you or your insurance company for the costs of tests or services that are being performed solely for the purposes of this study. You or your insurance company remain responsible for costs related to your usual medical care.

WILL I BE PAID FOR MY PARTICIPATION?
Yes. We know your time is valuable and to thank you for your participation, we will send you a check for $100 when we receive your blood sample at our laboratory. For each participant, the compensation amount was determined by a lottery.

Exhibit C.9: *Consent form: detailed information, page 1, incentive level $500*

DETAILED INFORMATION

INTRODUCTION
We are a team of researchers from the University of Chicago, conducting a study to learn how many people in Chicago have been exposed to the virus that causes COVID-19, known as SARS-CoV-2, including those that had mild or no symptoms. We will conduct antibody tests in blood samples collected from a random sample of Chicagoans. You are among approximately 3000 households invited to participate.

ELIGIBILITY
If you received an invitation box in the mail, it means that your household has been randomly selected. One adult (age 18+) from your household can participate. It is important that our sample is random. For this reason, we ask that the adult with the next upcoming birthday participates. If that person is not available or does not want to participate, we ask that no other person in the household participates. Past history of COVID-19 testing, diagnosis, or exposure does not matter. As long as the person is 18+, resides in Chicago, and has the next birthday, they are eligible.

WHAT IS INVOLVED IN THE STUDY?
Participants will self-administer a finger prick to take a small blood sample, following the instructions provided in the box. The kit is safe and easy to use and takes about 5-10 minutes to complete. Participants will mail their sample to our laboratory where it will be tested for antibodies against the virus that causes COVID-19, which may indicate prior exposure to the virus. This test does not indicate active infection. This study does not involve genetic testing. You will not be notified of your test results. We may contact you about your participation in the study, or to invite you to participate in later phases of the research.

WHAT ARE THE BENEFITS?
We hope that you will participate in this study to help us understand how the disease has spread in Chicago. We know your time is valuable. To thank you for your participation, we will send you a check for $500 when our laboratory receives your blood sample.

WHAT ARE THE RISKS?
The discomfort of self-administering the finger prick is minimal and will fade within a minute or two. The kit is safe and commercially available, used routinely to collect at-home blood samples. As with any finger prick, there is a small risk of bruising, tenderness, and a rare risk of infection. While there are always risks of data breach in any research study, we take all possible precautions to minimize this risk including storing data on secure servers only accessible to authorized personnel.

ARE THERE ANY COSTS FOR PARTICIPATING?
No. You will not incur any costs for participation. You will use pre-paid packaging in the box to return your sample to our laboratory. There will be no costs to you or your insurance company for the costs of tests or services that are being performed solely for the purposes of this study. You or your insurance company remain responsible for costs related to your usual medical care.

WILL I BE PAID FOR MY PARTICIPATION?
Yes. We know your time is valuable and to thank you for your participation, we will send you a check for $500 when we receive your blood sample at our laboratory. For each participant, the compensation amount was determined by a lottery.

Exhibit C.10: *Consent form: detailed information, page 2*

HOW WILL YOU MAINTAIN CONFIDENTIALITY?
Data you provide will be handled confidentially. While there are always risks of data breach in any research study, our data is stored on secure servers that minimize this risk and we will strip the data of identifiable information, such as your name. We will retain a link (or "key") to the identifiable information in password-protected, encrypted computer files accessible only to authorized members of the research team, all of whom receive training in maintaining strict standards of confidentiality.

The study data and key will be retained for at least 10 years after study funding ends. Your name and any identifying information will not be used in any publications or presentations. The laboratory may retain a portion of your blood sample for future testing. Data and specimens that are stripped of identifying information may be used for future research by our team or other investigators without additional informed consent.

Authorized representatives from the University of Chicago and NORC at the University of Chicago may review your research data for purposes such as monitoring or managing the conduct of this study. Your records may be reviewed by federal agencies whose responsibility is to protect human subjects in research including the Office of Human Research Protections (OHRP). Your records may be viewed by representatives of the University including the Institutional Review Board (a committee that oversees the research) and the Office of Clinical Research.

WHAT ARE MY RIGHTS AS A PARTICIPANT?
Participation is completely voluntary. You will not lose any services, benefits, or rights you normally have if you choose not to participate, or if you choose to leave the study at any time. If you decide not to sign this consent form, you will not be able to participate in the study. You will be given a copy of this document after you have signed. Your consent does not have an expiration date.

If the need arises, we will tell you about significant new information that may affect your willingness to stay in this study. If you would like to speak to a member of our study team, you may contact: **800-483-2565**. For questions about your rights as a research subject, you may contact the University of Chicago Biological Sciences Division (BSD) Institutional Review Board (IRB) at 773-702-6505.

PARA ESPAÑOL: Si desea ver este formulario de consentimiento en español, puede visitar recover.uchicago.edu e iniciar sesión con el código de acceso único de la carta de invitación, o llamar a este número para hablar con un miembro de nuestro equipo: 800-483-2565

Exhibit C.11: *Consent form and questionnaire*

RETURN THIS PAGE WITH THE COMPLETED BLOOD SAMPLE KIT.

CONSENT: I have read and understood the information in the consent form, including the objectives of the study and procedures. I understand that my participation is voluntary, and that I do not have to sign this form if I do not want to be part of this research study.

By signing below, I confirm my eligibility and I agree to participate in this study.

* REQUIRED FIELD

First name: * _____

Middle name: _____

Last name: * _____

Signature: * _____

Date: * _____ **Time:** * _____

Email: * _____ **Phone #:** * _____

We will only use your email & phone number to contact you about your participation in this study.

Please provide the following information that will help us better analyze COVID-19 infection rates in Chicago:

1. **What is your age?** * _____ years
2. **What is your gender?** *
   - ☐ Male
   - ☐ Female
   - ☐ Other
   - ☐ Prefer not to answer
3. **Which one or more of the following best describes your race? Please check all that apply.** *
   - ☐ White
   - ☐ Black or African American
   - ☐ American Indian or Alaska Native
   - ☐ Asian
   - ☐ Native Hawaiian or Pacific Islander
   - ☐ Other
   - ☐ Prefer not to answer
4. **Are you of Hispanic, Latino, or Spanish origin?** *
   - ☐ Yes
   - ☐ No
   - ☐ Prefer not to answer
5. **What was your household's approximate total income from all sources in 2019?** *
   - ☐ Less than $20,000
   - ☐ $20,000 to less than $50,000
   - ☐ $50,000 to less than $100,000
   - ☐ $100,000 or more
   - ☐ Prefer not to answer

Would you like to be contacted in the future about other COVID-19 research opportunities?

If yes, you may be contacted by other researchers and provided with more information and a separate consent form. Your answer to this question will not affect your participation in this study.

- ☐ Yes, I would like to be contacted about other COVID-19 research studies
- ☐ No, please do not contact me about other COVID-19 research studies

LAB USE ONLY **KIT CODE:** ___ ___ ___ - ___ ___ ___ - ___ ___ ___ **TEST CODE:** ___ ___ ___

Exhibit C.12: *Reminder postcard, incentive level $0*

Exhibit C.13: *Reminder postcard, incentive level $100*

Exhibit C.14: *Reminder postcard, incentive level $500*

D Data sources and variable definitions

Our empirical analysis uses data collected from the serology study described in Section 2. We also link the study data to a set of neighborhood (five digit zipcodes) characteristics we collect from three sources: the American Community Survey, the Chicago Health Atlas, and the City Health Dashboard. Below, we provide additional information on how we collect and use this data to define the individual and neighborhood characteristics we consider.

D.1 Individual characteristics

As described in Section 2, the RECOVER study included a short questionnaire that households were asked to complete. The questionnaire elicited the participant's age, their gender, their race, whether they are Hispanic, and their household's approximate total income from all sources in 2019 (less than $20,000, $20,000 to less than $50,000, $50,000 to less than $100,000, and $100,000 or more). Although completion of the questions was required to receive compensation, all questions excluding age included a 'Prefer not to answer' option. See Exhibit C.11 of Appendix C for a copy of the questionnaire.

Of the 125 participants, 121 (97%) provided at least one response that was not 'Prefer not to answer,' and 109 (87%) provided responses to all questions that were not 'Prefer not to answer' for all questions. Specifically regarding race and income, 119 (95%) of participants provided a response to race that was not 'Prefer not to answer,' and 109 (87%) provided a response to income that was not 'Prefer not to answer.' In our analyses of individual characteristics, we drop responses that are either missing or 'Prefer not to answer.'

For participants for which we observe valid responses, we measure whether they are non-White (race is not White or they are Hispanic), whether they are poor (their household yearly income is below $50,000), whether they are of working age (ages 25-60), and whether they are female.

D.2 Neighborhood characteristics

American Community Survey. We obtain neighborhood demographics from the 2019 American Community Survey 5-year estimates (2015-2019). We collect, for each neighborhood: (1) the share of individuals not identifying as non-Hispanic white, (2) the share of households below 200% the poverty line, (3) the share of individuals between 25 and 60 years old, and (4) the share of individuals who identify as female.

Chicago Health Atlas. We obtain zipcode-level health measures from the Chicago Health Atlas, a portal developed by the Chicago Department of Public Health and Population Health Analytics Metrics Evaluation Center at University of Illinois Chicago. More specifically, we obtain the uninsurance rate and two diagnosis-specific hospitalization rates. The uninsurance rate is defined as the average percentage of residents without health insurance between 2016 and 2020. Diagnose-specific hospitalization rates are defined as the age-adjusted number of hospitalizations discharges for a given diagnosis per 10,000 people in 2017, excluding

discharges to Veterans Administration hospitals. We obtain these hospitalization rates for the following diagnoses: (1) drug-related (which include amphetamines, cannabis, cocaine, drug-induced mental disorders, hallucinogens, opioids, sedatives, hypnotics, anxiolytics, tranquilizers, barbiturates, and other drugs); and (2) preventable (defined as conditions that could be managed in a clinic setting).

City Health Dashboard. We obtain additional health and labor market measures from the City Health Dashboard, a portal developed by NYU Langone Health. The dashboard provides data at the census tract level, which we aggregate to the ZIP code level via population-weighted averages using Census relationship files. The following measures are obtained from this source: (1) annual unemployment rate, defined as the percentage of individuals at least 16 years that were unemployed and seeking work at any point in 2020; and (2) COVID-19 local risk index, which measures, on a scale between 1 and 10, the potential for COVID-19 infection and risk for more severe COVID-19 outcomes and risks at the zipcode-level.

D.3 Aligning individual and neighborhood characteristics

We constructed individual and neighborhood characteristics to minimize differences in definitions. Measures of race and gender naturally align. For our measure of poverty, we choose the cutoff at 200% of the poverty line–rather than 150% or 100%–to more closely align with the income bins elicited in the study's questionnaire. In particular, for a household of three, 200% of the poverty line was $41,122 in 2020 (U.S. Census Bureau, 2021), which, relative to other cutoffs, is closer to the $50,000 cutoff from the study's questionnaire. Finally, for our measure of age, we consider an indicator for working age because the ACS does not provide a natural neighborhood-level measure of average age but does provide the share of working age individuals. As we show in Appendix B, our results are not sensitive to how we define neighborhood characteristics.

E Comparable COVID-19 serological surveys

Bobrovitz et al. (2021) perform a systematic review of serological studies with the goal of identifying and subsequently synthesizing studies that tested for COVID-19 antibodies. We use their metadata to identify studies that, like ours, invited a random sample of subjects from a pre-specified geographic region in the United States to be tested for COVID-19 antibodies. Our goal in doing so is to understand common practices of such serological surveys and to contextualize our serological survey. In what follows, we first describe our process of identifying such studies using metadata from Bobrovitz et al. (2021)'s systematic review. We then discuss the data we collected for each study we identify. We conclude by presenting our findings.

E.1 Identification of comparable serological studies

Bobrovitz et al. (2021) identify 968 serosurveys conducted between January 1, 2020 and December 31, 2020 that, among other requirements, tested participants for COVID-19 antibodies and reported a sample size, study date, location, and seroprevalence estimate (see Figure 1 of Bobrovitz et al. (2021) for additional details). The metadata for these studies is publicly-available.

We seek to identify studies which invited a random sample of subjects from a geographic region in the United States to be tested for COVID-19 antibodies. We accomplish this goal in two steps. First, we use variables constructed by Bobrovitz et al. (2021) to restrict to studies that were (1) conducted in the United States, (2) used an appropriate sample frame, and (3) used a probability sample.[11] Nineteen studies satisfy these restrictions.

Second, we restrict to the subset of these studies that (1) were published in a scientific journal, (2) defined the target population to be subjects in a geographic region (up to age restrictions, such as excluding children), and (3) invited either the entire target population or a random subsample of the target population. Thus, of the nineteen studies, we excluded three studies that were not from scientific journals, two studies whose target population were respectively prisoners and hospital and/or clinic patients, two studies that constructed their invited samples using market research firms that maintain proprietary samples, and three studies that constructed their invited samples using participants from other surveys. The remaining nine studies satisfy our requirements, and constitute our analysis sample of studies.

E.2 Measuring survey implementation and participation rates

For each study in our analysis sample, we use the metadata of Bobrovitz et al. (2021) to collect (when possible) the outreach method, the number of invited subjects, the number of

[11] Bobrovitz et al. (2021) code a study as using an appropriate sample frame if the sample frame 'described and it approximated the target population' (see item 1 of the metadata) and code a study as using a probability sample if the study used a probability sampling method or the entire sample (see item 2 of the metadata). See the supplementary materials of Bobrovitz et al. (2021) for additional details.

participant subjects, and the offered incentive for participation. Outreach methods could be mail, in-person, online, phone, or any combination of these. We take the number of invited subjects to be the number of subjects who were initially invited to participate in the study, and take the number of participant subjects to be the number of subjects who submitted to be tested for COVID-19 following the study's implementation. The unit for subjects is defined based on the unit targeted by the initial serosurvey invitation. For example, if invites were sent to households but the invitation allowed multiple individuals within a household to participate, subjects correspond to households. When the study includes mail-only as an outreach method and reports invited and participant numbers for mail-only, we use the mail-only results. Two members of the research team independently performed these data collection steps, and there were no conflicts.

E.3 Results of our systematic review

We obtained outreach methods and number of invited subjects and participants for all nine studies. The average participation rate over the nine studies is 12.5% (median: 11.3%, min: 0.4%, max: 23.6%). Four studies either exclusively used mail or reported mail-only results, and the average participation rate for these is 9.0% (median: 8.3%, min: 3.1%, max: 16.5%). These participation rates are comparable to the participation rates we obtained in our serosurvey without financial incentives (6.2%) and with $100 in financial incentives (16.8%). The participation rate we obtain when offering $500 in financial incentives (29.1%) is greater than the maximum participation rate of these studies.

Only three studies explicitly reported financial incentives (or lack thereof) for participation. The offered incentive (participation rate) for each of these three studies was: $10 (16.5%), $50-$100 (7.8%), and $60-$100 (11.3%). For the latter two studies, variations in the amounts were non-random and were used to increase participation rates for certain groups.

Taken together, our results yield three conclusions. First, participation rates in serological surveys that invite a random sub-sample of subjects from a geographic region in the United States are typically low and consistent with the participation rates we obtained in our study. Second, mail is a common form of outreach in serological surveys, with 44% of studies employing this method. Third, financial incentives for participation are rarely explicitly mentioned. In the few studies that do explicitly mention financial incentives, the amounts range from $10-100 and are either assigned uniformly or varied non-randomly.

F Decomposing non-contact and hesitancy

Nonrepresentativeness relative to the invited sample is caused by differential non-participation. Non-participation occurs for one of two reasons: either a sampled household is unable to be contacted (non-contact), or a contacted household does not participate because the perceived costs of doing so exceed the perceived benefits (hesitancy). This Appendix develops and applies a method for separating the roles of non-contact and hesitancy in determining non-participation (and nonrepresentativeness).

F.1 A model of study participation

F.1.1 Model

Let $R_i(z) \in \{0,1\}$ denote whether household i would participate if assigned incentive z. Participation is a two-step process in which the household is first *contacted*, and then *decides* to participate. Let $C_i(z) \in \{0,1\}$ denote whether household i would be contacted under incentive level z, and let $D_i(z)$ denote whether they would decide to participate if contacted. Then household i's participation decision is $R_i(z) = C_i(z)D_i(z)$. We will estimate the model separately by demographic groups without any cross-group restrictions, so we suppress demographic conditioning in the notation.

We impose three baseline assumptions on this model. First, since the assigned incentive is only revealed after the household is contacted and opens the package, we assume that contact does not depend on z, so that $C_i(z) \equiv C_i$. Second, we assume that $D_i(z)$ is non-decreasing in z for all i, so that households are more likely to participate under higher incentives. This is the Imbens and Angrist (1994) monotonicity assumption, which Vytlacil (2002) showed is equivalent to assuming that $D_i(z) = \mathbb{1}[H_i \leq z]$ for some latent variable H_i. Together, these two assumptions imply that

$$R_i(z) = C_i \mathbb{1}[H_i \leq z]. \tag{1}$$

We interpret $z - H_i$ as household i's net benefit from participating, and call H_i their *hesitancy* to participate. Here, a household's hesitancy is the reservation payment they are willing to accept for participation in the study. If contacted, the household participates if the offered financial incentive exceeds their hesitancy. Third, we assume that the assigned incentive, Z_i, is independent of (C_i, H_i), which is justified by random assignment of incentives.

F.1.2 Contact and hesitancy rates

We define the *contact rate* as $\gamma \equiv \mathbb{P}[C_i = 1]$ and the *non-contact rate* as $1 - \gamma$. We define the *hesitancy rate* as $\eta(z) \equiv \mathbb{P}[H_i > z | C_i = 1]$, which is the probability that a household would not participate under incentive z if they were contacted. We measure the hesitancy rate conditional on being contacted in order to hold fixed the implementation protocol of

the scientific study. Variation in $\eta(z)$ allows us to learn about the distribution of hesitancy (reservation payments) for contacted households.

F.1.3 Identification and estimation

The researcher does not observe (C_i, H_i), but only the incentive level, Z_i, and the participation decision $R_i \equiv R_i(Z_i)$ under this incentive level. From these observables, they can estimate the *participation rate*

$$\rho(z) \equiv \mathbb{P}[R_i = 1 | Z_i = z] = \mathbb{P}[C_i = 1, H_i \leq z], \tag{2}$$

where the equality follows from the model (1) and random assignment of the incentive, Z_i. Measuring the contact and hesitancy rates requires determining the relative contribution of the unobservables C_i and H_i to ρ, while allowing these unobservables to be dependent.

We consider what can be said about the contact and hesitancy rates under assumptions on the magnitude of the hesitancy rate at the highest incentive, $\bar{z}$. In the RECOVER survey, $\bar{z} =$ \$500 is large, suggesting that $\eta(\bar{z})$ is small, and that non-participation in the \$500 treatment arm is primarily or solely due to non-contact. Since contact is not affected by the incentive level, the participation model allows us to infer the hesitancy rates at lower incentives as well.

To see how this works, suppose that we know $\eta(\bar{z})$ exactly and decompose it as

$$\eta(\bar{z}) = \frac{\mathbb{P}[C_i = 1, H_i > \bar{z}]}{\mathbb{P}[C_i = 1]} = \frac{\mathbb{P}[C_i = 1] - \overbrace{\mathbb{P}[C_i = 1, H_i \leq \bar{z}]}^{= \rho(\bar{z}) \text{ by } (2)}}{\underbrace{\mathbb{P}[C_i = 1]}_{\equiv \gamma}} = 1 - \frac{\rho(\bar{z})}{\gamma}.$$

Rearranging shows that the contact rate γ (and non-contact rate $1 - \gamma$) is identified:

$$\gamma = \frac{\rho(\bar{z})}{1 - \eta(\bar{z})}. \tag{3}$$

Hesitancy rates at other incentive levels can then be identified by the following argument:

$$\begin{aligned} \eta(z) &= \mathbb{P}[z < H_i \leq \bar{z} | C_i = 1] + \mathbb{P}[H_i > \bar{z} | C_i = 1] \\ &= \frac{\rho(\bar{z}) - \rho(z)}{\gamma} + \eta(\bar{z}) = \left(\frac{\rho(\bar{z}) - \rho(z)}{\rho(\bar{z})} \right) (1 - \eta(\bar{z})) + \eta(\bar{z}), \end{aligned} \tag{4}$$

where the second equality used (2), and the third equality substituted in the identified contact rate from (3). We estimate (3) and (4) through their sample analogs by substituting the estimated participation rates $\rho(z)$ and $\rho(\bar{z})$.

Our baseline estimates set $\eta(\bar{z}) = 0$, which corresponds to the assumption that any household would have participated at \$500 incentive had they been aware of it (had they been contacted). Given the generosity of the incentive, we view this as a reasonable assumption.

However, we also report estimates that allow $\eta(\bar{z})$ to vary in the set $[0, \alpha]$, where α is a number smaller than $1-\rho(\bar{z})$, the largest value that keeps γ a proper probability via (3). Although we have suppressed demographic conditioning, we emphasize that when we estimate the model separately by demographic group, $\eta(\bar{z})$ can take any value lower than the upper bound α for each group, and can vary across groups. Under this assumption, bounds on γ and $\eta(z)$ are given by

$$\rho(\bar{z}) \leq \gamma \leq \frac{\rho(\bar{z})}{1-\alpha} \quad \text{and} \quad \frac{\rho(\bar{z}) - \rho(z)}{\rho(\bar{z})} \leq \eta(z) \leq \frac{\rho(\bar{z}) - \rho(z)(1-\alpha)}{\rho(\bar{z})}. \tag{5}$$

The widest "worst-case" bounds are obtained at $\alpha = 1-\rho(\bar{z})$. These bounds are sharp (best possible, given the assumptions) for any choice of α, as long as observed participation rates $\rho(z)$ are increasing in z.

Proof of sharpness: Equations (3) and (4) show that γ and $\eta(z)$ are point identified for any value of $\eta(\bar{z})$ such that these expressions remain in the $[0, 1]$ interval for each z. From (3), we see that $\gamma \in [0, 1]$ if and only if $\eta(\bar{z}) \in [0, 1 - \rho(\bar{z})]$. When $\eta(\bar{z}) = 0$, (4) reduces to $(\rho(\bar{z}) - \rho(z))/\rho(\bar{z})$, which is between 0 and 1 as long as $\rho(z)$ is an increasing function of z. On the other hand, when $\eta(\bar{z}) = 1 - \rho(\bar{z})$, (4) reduces to $\eta(z) = 1 - \rho(z)$, which is also between 0 and 1. We conclude that if $\rho(z)$ is increasing in z, then setting $\rho(\bar{z}) = \alpha$ for any $\alpha \in [0, 1-\rho(\bar{z})]$ implies that γ and $\eta(z)$ are point identified via (3) and (4). Taking the union of these points across all $\alpha \in [0, 1 - \rho(\bar{z})]$ produces the bounds given in (5).

It remains to be shown that the model can rationalize the data when $\eta(\bar{z})$ is set to any $\alpha \in [0, 1 - \rho(\bar{z})]$, and $\rho(z)$ is given, and weakly increasing. To show this, we take α as given and construct a distribution of (C_i, H_i) that is independent of Z_i and (i) reproduces the given $\rho(z)$ for each z, when responses are determined via (1), while (ii) satisfying $\eta(\bar{z}) = \alpha$. The construction proceeds by reversing the logic of the identification argument. First, set the marginal contact rate to be

$$\gamma \equiv \mathbb{P}[C_i = 1] = \frac{\rho(\bar{z})}{1-\alpha}.$$

Next, set the hesitancy rate at each z to be

$$\eta(z) = \left(\frac{\rho(\bar{z}) - \rho(z)}{\rho(\bar{z})} \right) (1-\alpha) + \alpha.$$

Any increasing function defined on a subset of the real line and contained between 0 and 1 can be extended (perhaps non-uniquely) to a proper distribution function.[12] As noted above, both γ and $\eta(z)$ are within 0 and 1, and $\eta(z)$ is decreasing in z, because $\rho(z)$ is increasing in z. Extend $1-\eta(z)$ to a proper distribution function Φ. We use Φ to define a joint distribution

[12] The proof is trivial in the scalar case; see Lemma 2 of Torgovitsky (2019) for a generalization to the vector case.

of (C_i, H_i) that is independent of Z_i and given by

$$\mathbb{P}[C_i = 1, H_i \leq h] = \gamma\Phi(h)$$
$$\text{and} \qquad \mathbb{P}[C_i = 0, H_i \leq h] = (1-\gamma)\Phi(h).$$

This joint distribution satisfies (i) and (ii) by construction. *Q.E.D.*

F.2 The causes of low and unequal participation rates in RECOVER

We now use the method above to separately estimate non-contact and hesitancy in the RECOVER study. We then use the variation in assigned incentives to learn about the distribution of hesitancy (reservation payments).

F.2.1 Baseline estimates

Table F.1 reports our baseline estimates, which are constructed under the assumption that all households would choose to participate at \$500 if they were aware of the study ($\eta(\bar{z}) = 0$).

The first column of Table F.1 shows estimates of the non-contact rate. Under our baseline assumption, all households who did not participate at \$500 did so because they were not contacted, and so our estimates of the non-contact rate are the complement of the participation rates at \$500 shown in Table 2 in the main body. Participation rates of 29% under the \$500 incentive arm correspond to non-contact rates of 71% and we find no large or statistically significant differences in non-contact rates across households by neighborhood racial composition and poverty status.

The second column of Table F.1 shows estimates of the hesitancy rate when no financial incentive is offered. With no financial incentive, 79% of contacted households would not participate. This figure increases to 85% for households in majority non-White neighborhoods and 92% for households in higher poverty neighborhoods. These findings suggest that the perceived costs of participation are empirically relevant barriers to participation, especially for minority and lower-income households.

Variation in assigned incentives allows us to learn about the distribution of hesitancy and how it varies across groups. The third column of Table F.1 shows that a \$100 incentive sharply decreases the overall hesitancy rate from 79% to 42%. However, the decrease is largely driven by households in majority White and lower poverty neighborhoods: in majority White neighborhoods, only 14% of contacted households decline to participate when offered the \$100 incentive. Hesitancy rates remain substantial among households in majority non-White and higher poverty neighborhoods. Whereas reservation payments for contacted households in minority and lower-income neighborhoods are somewhat more likely to exceed \$0, they are 2.5-4 times more likely to exceed \$100. These findings suggest that the perceived costs of participation are high in general, and much higher for minoity and lower-income households.

In interpreting what may explain these differences in hesitancy, we can rule out differences in perceived benefits of learning one's seropositivity status as an explanation for these

Table F.1: *Estimated non-contact and hesitancy rates*

	Non-contact rate	Hesitancy rate At $0	Hesitancy rate At $100
All	0.71	0.79	0.42
	(0.66, 0.76)	(0.68, 0.89)	(0.28, 0.56)
Majority non-White	0.71	0.85	0.61
	(0.66, 0.76)	(0.73, 0.97)	(0.47, 0.74)
Majority White	0.70	0.70	0.14
	(0.60, 0.80)	(0.50, 0.90)	(-0.20, 0.47)
Difference	0.01	0.14	0.47
	(-0.09, 0.12)	(-0.08, 0.36)	(0.14, 0.80)
Higher poverty	0.73	0.92	0.67
	(0.67, 0.78)	(0.79, 1.05)	(0.52, 0.81)
Lower poverty	0.68	0.69	0.25
	(0.60, 0.77)	(0.53, 0.86)	(0.00, 0.49)
Difference	0.04	0.22	0.42
	(-0.05, 0.14)	(0.01, 0.44)	(0.14, 0.69)

Notes: This reports estimates of non-contact and hesitancy rates under the baseline assumption that all contacted households would choose to participate if offered $500. 90% CIs are shown in parentheses.

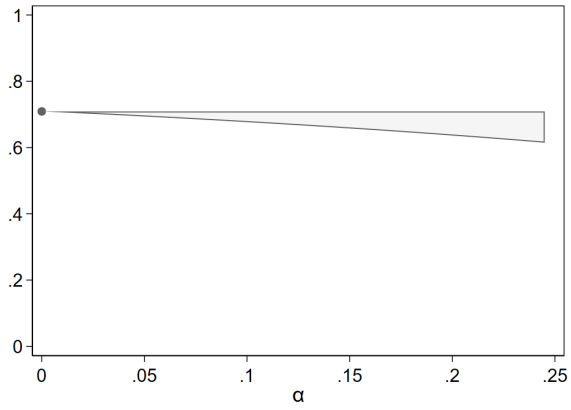
differences in hesitancy, since participants were informed that they would not be told their test result. A substantial qualitative literature instead points to differences in trust in the healthcare system and differences in concern about privacy as potential factors limiting study participation among racial minorities (see, e.g., Chapter 4 of NASEM, 2022; Alsan et al., 2022).

F.2.2 Decomposing the causes of unequal participation

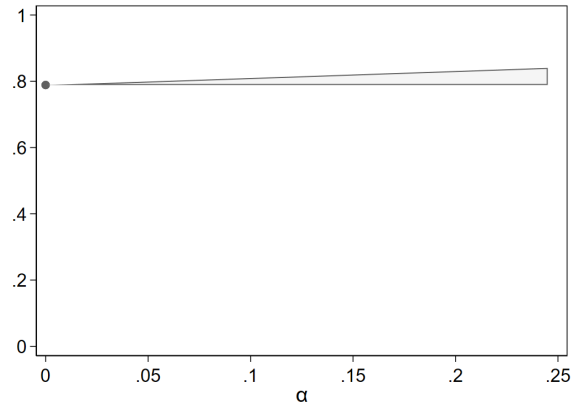
A decomposition exercise helps clarify the relative importance of non-contact and hesitancy in explaining unequal participation by racial composition and income level. Suppose that majority non-White households had the same hesitancy at $0 as majority White households. Then, instead of a participation rate of .043 at $0, majority non-White households would have a $(1-.71)\times(1-.70) = .085$ participation rate, only slightly lower than the .090 participation rate for majority White households, and eliminating 89% of the participation gap. The same calculation for the $100 incentive brings participation for majority non-White households from 11.3% to 24.8%, relative to 25.8% for majority White households, eliminating 93% of the participation gap. Similarly, if higher poverty households had the same hesitancy as lower poverty households, their participation would rise from 3.2% to 8.4% at $0 and 12.0% to 20.3% at $100, compared to 10.4% at $0 and 23.4% at $100 for higher income households. In all cases, setting hesitancy rates equal across households largely closes participation gaps across racial composition and income level. These results suggest that unequal participation

Figure F.1: *Bounds on non-contact and hesitancy rates*

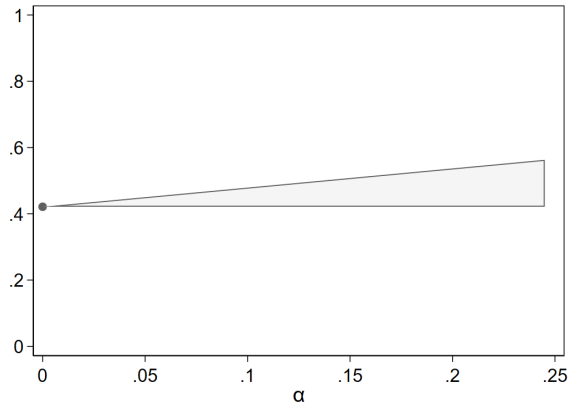
(a) *Non-contact rate*



(b) *Hesitancy rate at $0*



(c) *Hesitancy rate at $100*



Notes: These figures report estimates of the bounds in (5) for different levels of α.

rates are primarily driven by differences in hesitancy.

F.2.3 Sensitivity analysis

The estimates in Table F.1 use the assumption that all contacted households would choose to participate if offered the $500 incentive. That is, the hesitancy rate at $500 is zero or, in our notation, $\eta(\bar{z}) = 0$. In this section, we conduct a sensitivity analysis that estimates bounds on the same parameters under the weaker assumption that $\eta(\bar{z}) \leq \alpha$.

Figure F.1 plots the estimated bounds on the overall non-contact and hesitancy rates for α up to .25. For example, allowing $\alpha = .20$ means assuming that up to 20% of contacted households decline to participate at $500 because they find the incentive not high enough to overcome their perceived costs. Even under this conservative assumption, Figure F.1a shows that non-contact rates remain high at 64%. Higher hesitancy rates at $500 also rationalize higher hesitancy rates at lower incentive values (see (5)), reinforcing the conclusion that hesitancy is also an important source of non-participation. At $\alpha = .20$, between 79% and 83% of contacted households would not participate without an incentive.

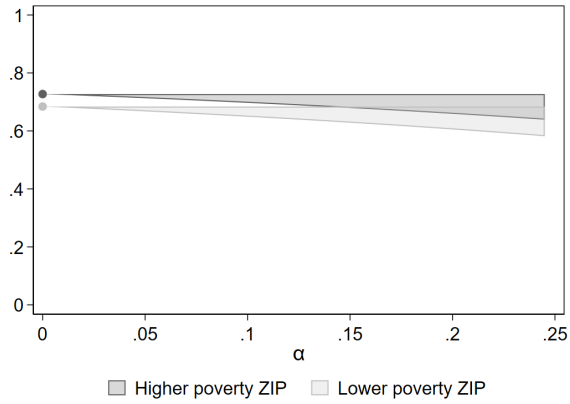
Figure F.2 plots estimated bounds by demographic group. For any α, the share of contacted households who decline to participate at \$500 can take any value lower than α for each group, and this share is allowed to vary freely across demographic groups. For example, we allow for households in higher poverty neighborhoods to decline to participate at \$500 at higher (or lower) rates than households in lower poverty neighborhoods. Figures F.2a and F.2b show that the bounds on non-contact rates by demographic group largely overlap for all $\alpha \leq .25$, reinforcing the conclusion that non-contact rates do not vary systematically by demographics. Figures F.2c–F.2f show that the opposite is true for hesitancy rates: even at $\alpha = .25$, hesitancy rates at both \$0 and \$100 differ markedly by both racial composition and poverty status. These results are consistent with the conclusions from the baseline case.[13]

As discussed in Appendix Section F.1, the largest value that we can set α to while still rationalizing the model is $1 - \rho(\bar{z})$, which we estimate to be 71% among the overall population. This value of α represents the "worst-case" assumption that everyone in the \$500 incentive arm was contacted, but 71% declined to participate because \$500 was not a sufficient incentive. If this were true, then non-contact rates would be zero, and hesitancy rates at lower incentives would be even larger; for example between 79% and 94% at \$0. Thus, even without taking a stand on α, we can conclude that hesitancy is an important barrier to participation. However, our view is that allowing for the possibility that 71% of contacted households would not trade \$500 for a quick at-home blood sample is unreasonable. Under smaller—but still large—values of α, we find non-contact to also be an important cause of non-participation.

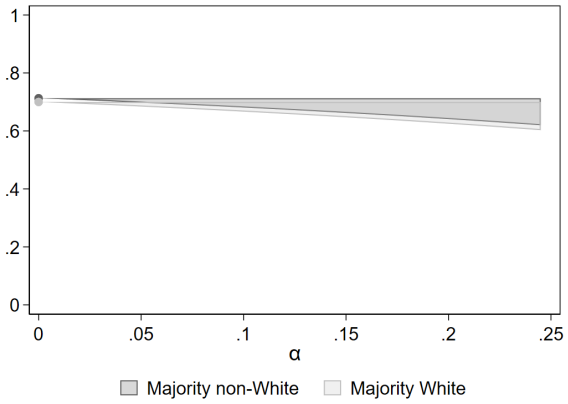
[13]The choice of letting α go as high as .25 was for illustrative purposes. These conclusions continue to hold even if we allow α to be as high as .45. Even at this value, it is still the case that hesitancy rates at \$0 and \$100 do not intersect–and thus differ–by racial composition and poverty status.

Figure F.2: *Bounds on non-contact and hesitancy rates by demographics*

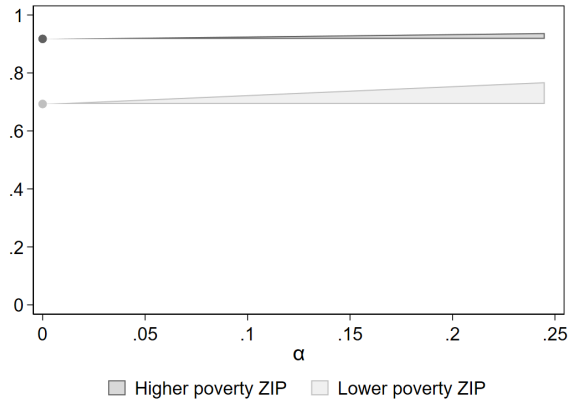
(a) *Non-contact rate by income level*



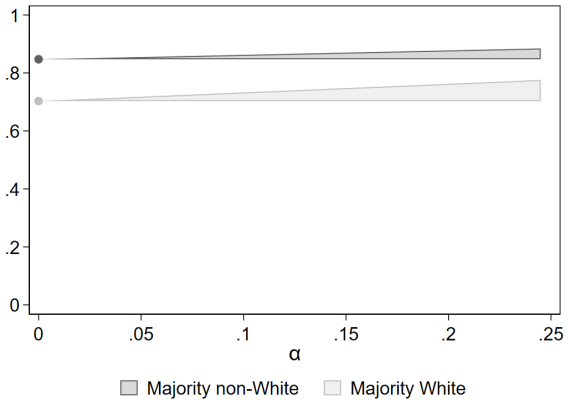
(b) *Non-contact rate by racial composition*



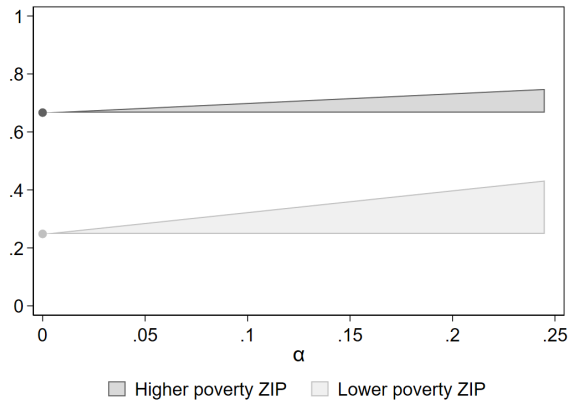
(c) *Hesitancy rate at $0 by income level*



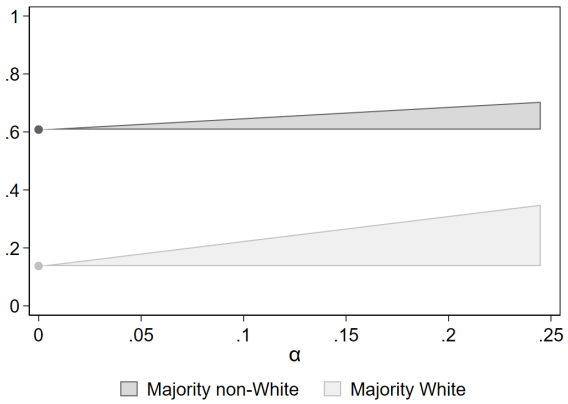
(d) *Hesitancy rate at $0 by racial composition*



(e) *Hesitancy rate at $100 by income level*



(f) *Hesitancy rate at $100 by racial composition*



Notes: These figures report estimates of the bounds in (5) for different levels of α broken down by demographic group.