# Living in Boston During COVID-19: Physical and Mental Health

Report #6 in a Series

Boston Area Research Initiative

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## Partnering Institutions

**The Boston Area Research Initiative** is an interuniversity partnership based at Northeastern University that convenes researchers, policymakers, practitioners, and community leaders to envision and realize the future of the city. Our primary goal is to leverage data and technology to better understand and serve cities, with a focus on enhancing equity, justice, and democracy.

**The Center for Survey Research** (CSR) at the University of Massachusetts Boston is a full-scale academic survey research center. CSR conducts basic and applied research that contributes to knowledge and understanding of important social issues and supports public and private agencies and university scholars in carrying out high quality policy-related research. Its projects include BEACON, a panel study on Boston neighborhoods

**Boston Public Health Commission**, the country's oldest health department, is an independent public agency providing a wide range of health services and programs. Public service and access to quality health care are the cornerstones of our mission—to protect, preserve, and promote the health and well-being of all Boston residents, particularly those who are most vulnerable.

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## Executive Summary

In the Summer of 2020, the Boston Area Research Initiative (BARI) at Northeastern University, the Center for Survey Research (CSR) at University of Massachusetts Boston, and the Boston Public Health Commission (BPHC) conducted a survey that captures the experiences of 1626 Bostonians during the first months of the COVID-19 pandemic, including: their ability and tendency to follow social distancing recommendations; attitudes toward regulations; and the economic and personal impacts of the pandemic. In the fall, we followed up with an additional web-based and mailed survey that asked about continued employment, plans for getting the vaccine, mental health, health care services, social connections, computer resources, and neighborhood context.

This sixth report in a series describes how the pandemic has affected the physical and mental health of Boston's residents. By examining how these impacts were distributed by race and ethnicity, socioeconomic status, and family composition, we reveal a range of inequities in how different populations have experienced increased health challenges due to the pandemic.

*Main Findings*

- Many residents experienced adverse impacts of the coronavirus pandemic on their health.
    - **Almost one in ten of survey respondents believed they had had COVID-19**, and a quarter had been tested for it.
    - **At the time of the survey, respondents felt both their physical and mental health had declined** during the pandemic.
    - Physical and mental health also declined among those questioned both before the pandemic and after it began.
- **The likelihood of adverse health impacts of the pandemic varied with health-related behaviors.**
    - Drinking was associated with worse physical and mental health effects.
    - Exercising was associated with less adverse effects on physical health, but not with change in mental health.
    - Visiting others was associated with less adverse effects on health—both physical and particularly mental health.
- **Adverse health impacts amplified health disparities.**
    - Those with poorer self-reported health reported more adverse effects of the pandemic on their physical health.
    - Those with more symptoms of depression reported more adverse effects of the pandemic on their mental health.

- **The likelihood of adverse health effects of the pandemic varied with sociodemographic characteristics.**
    - **More younger residents** reported adverse impacts on physical and mental health compared to those 50 and older, but the youngest residents also included the highest proportion who said their physical health had improved.
    - **White residents** were more likely to report adverse health impacts—particularly on mental health**—than residents of color**.
    - **Single women** were more likely to have experienced adverse health effects—particularly on physical health—compared to married women and to men.
    - **Those with more education and those who were working** at the time of the survey reported more adverse physical and mental health effects than those with less education and those who were not working; adverse mental health effects of working elevated among those **working mostly at home**.
- **There were some differences in adverse health impact between Boston's neighborhoods.**
    - Some of the neighborhoods with the highest proportions of residents reporting a decline in their physical health since March tended to have more residents who were poor (North Dorchester, Mission Hill) or young (Fenway/Kenmore).
    - Some of the neighborhoods with the highest proportions of residents reporting a decline in mental health tended to have more residents who were White (Beacon Hill) or young (Fenway/Kenmore).

*Conclusions and Next Steps*

Declines in both physical and mental health added to the challenges faced by residents struggling with other adverse consequences of the pandemic. The likelihood of adverse health effects also varied in relation to socioeconomic and family status and in relation to health-related behaviors, as well as by neighborhood. These differences suggest targeted ways in which residents might better be supported during the second wave of the pandemic.

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## 1. Living in Boston During COVID-19: A Neighborhood Survey

The NSF-Beacon survey captures the experiences of 1626 Bostonians during the first months of the COVID-19 pandemic, including: their ability and tendency to follow social distancing recommendations; attitudes toward regulations; and the economic and personal impacts of the pandemic. A follow-up survey of the sample in the fall yielded additional information for 932 respondents on mental health, health care services, social connections, computer resources, and neighborhood context. The two-part survey provides unique insights into how these factors varied across the populations and neighborhoods of a single city—something not currently available from any other source, in Boston or otherwise.

The Center for Survey Research (CSR) at University of Massachusetts Boston conducted the survey over the Summer, in collaboration with the Boston Area Research Initiative (BARI) at Northeastern University, and the Boston Public Health Commission (BPHC). The National Science Foundation's Human-Environment and Geographical Sciences (HEGS) program provided funding through a grant for rapid-response research (RAPID). The survey used a probability-based random sample stratified by 25 neighborhoods and the results presented here were weighted to match the demographic composition of the city. See Appendix A for more detail on the survey methodology.

This is the sixth in a series of reports describing key insights from the survey. The series focuses especially on the racial and socioeconomic inequities that have exacerbated —and may continue to exacerbate— differential impacts of the pandemic and the associated shutdown. In doing so, we consider four crucial classes of factors. The first class is personal characteristics, including race, ethnicity,

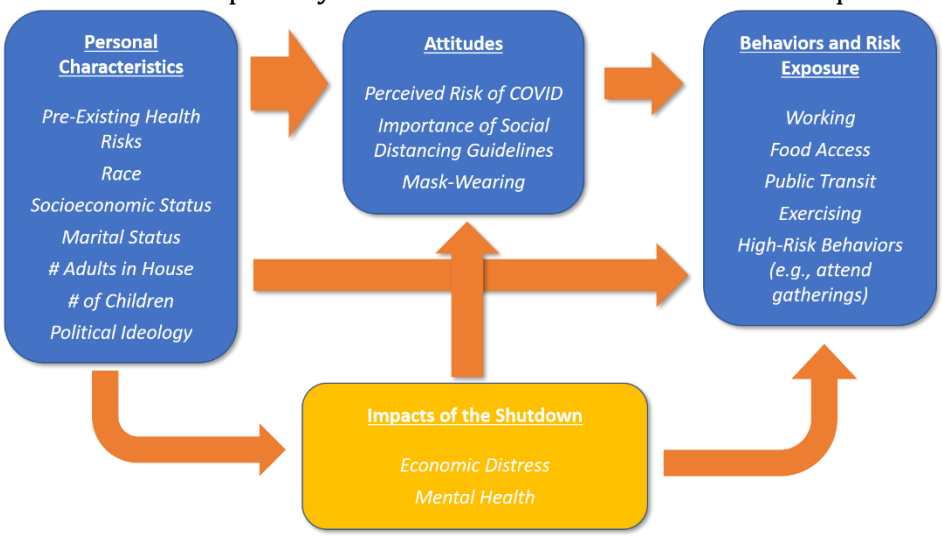



**Figure 1.** Relationships between personal characteristics, attitudes, behaviors, and the impacts of the shutdown explored in our reports. Content for this report highlighted in yellow.

socioeconomic status, pre-existing health, family structure (e.g., number of children), and political ideology. Second are attitudes about the risk of infection and social distancing guidelines, such as mask-wearing. Third are the types of activities that might expose a person to infection. For instance, how often a person goes to work, the grocery store, rides public transit, or visits in other people's houses influences their exposure risk. Fourth, the survey included items on the impacts of the pandemic: employment, economic insecurity, and physical and mental health.

We have designed the series to walk through the relationship between these features, as illustrated in Figure 1. Our first report described inequities in how Bostonians of different racial and socioeconomic backgrounds engaged in necessary day-to-day activities in April and the Summer. The second report examined how attitudes, beliefs and risky behaviors were distributed across communities. The third report described economic impacts—job and income loss--across individuals and neighborhoods, revealing inequities in relation to race/ethnicity, socioeconomic status, and family composition, as well as variation between neighborhoods. The fourth report shed light on how an individual's personal characteristics predict attitudes and perceptions and how these in turn predict the kinds of activities people have engaged in during the pandemic.[1] The fifth report used the data from the second part of our survey to describe willingness to be vaccinated against the coronavirus and the personal characteristics that predicted willingness.

In this sixth report, we first identify the health and mental health effects of the pandemic, in part by making comparisons between the responses to the *Living in Boston During COVID-19* to those among a smaller group of our respondents who were members of an online panel that we surveyed in Fall 2018. We then identify the variation in these health effects in relation to personal characteristics, attitudes and behaviors, and by neighborhood.

## 2. Effects on Physical and Mental Health of Boston's Residents

Health effects of the pandemic were estimated with self-reports of having had COVID-19 and of changes in health and mental health since March 2020, as well as by comparing answers to questions about physical and mental health for a subset of our sample that we had previously surveyed in fall 2018. In the next section we also examine self-reported health impacts in relation to the health-related behaviors of drinking, exercising, and visiting with others.

[1] https://dataverse.harvard.edu/dataset.xhtml?persistentId=doi:10.7910/DVN/TDKDJJ

- *COVID-19 exposure*: whether respondents thought they had had COVID-19 and whether they had been tested for it.
- *Self-assessed health impact*: Responses to single survey questions in Fall 2020 about change in physical and mental health since March 2020.
- *Self-reported health:* self-rated overall health.
- *Mental health:* ratings of feelings of depression and loneliness.
- *Health-related behaviors*: frequency of drinking, frequency of exercising, frequency of visiting in others' homes.

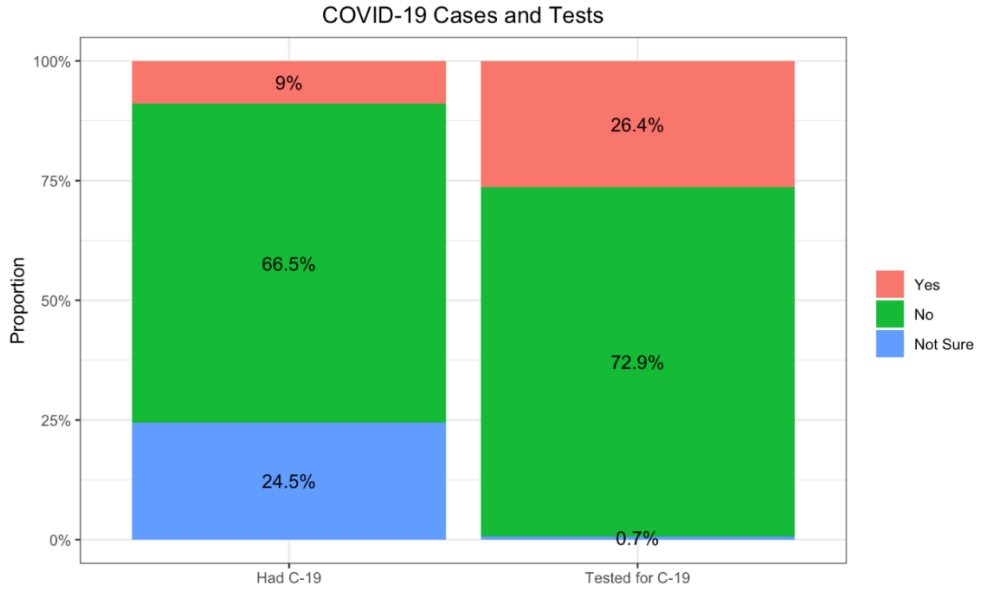
Responses to these questions indicate widespread detrimental effects of the pandemic on physical and mental health.

| |
|---|
| *COVID-19 Exposure (Summer, 2020)* |
| Do you think that you have had the COVID-19 coronavirus? |
| Have you been tested for the COVID-19 coronavirus? |
| *Self-Assessed Health Impact (Fall, 2020)* |
| Since March 2020, has your own physical health gotten better, worse, or stayed about the same? |
| Since March 2020, has your own mental health gotten better, worse, or stayed about the same? |
| *Self-Reported Health (Fall 2018, Summer 2020)* |
| In general, how would you rate your overall health? (Excellent, Very good, Good, Fair, Poor) |
| *Mental Health* |
| During the past 2 weeks, how often have you been bothered by feeling down, depressed or hopeless? (Not at all, Several days, More than half the days, Nearly every day) *(Fall 2018, Summer, 2020)* |
| During the past 2 weeks, how often did you feel left out? *(Fall 2018, Fall 2020)* |
| *Health-Related Behaviors* |
| In the last 7 days, how many days did you have at least one drink of any alcoholic beverage, such as beer, wine, a malt beverage, or liquor? *(Fall 2020)* |
| In the last 7 days, how many days did you do moderate physical activities for at least 10 minutes at a time, such as brisk walking, bicycling, vacuuming, gardening, or anything else that causes small increases in breathing or heart rate? *(Fall 2020)* |
| In the last 7 days, how many days did you visit inside someone else's home? *(Summer 2020)* |

**Table 1**. Survey indicators of health.

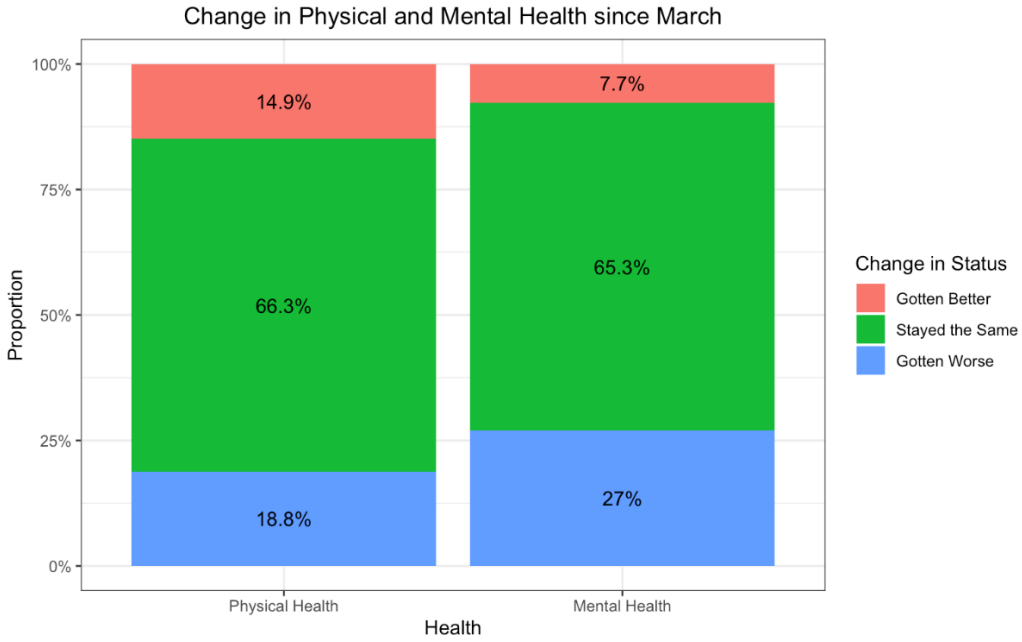
Almost one in ten respondents believed they had had COVID-19 by late Summer 2020 and another quarter thought they might have had it (Figure 1). This case rate—three times higher than the published rate—may indicate interpretations of illnesses since March without having actual test results, as well as the possibility that there are many undiagnosed cases of COVID-19. Just over one-quarter reported actually having been tested for COVID-19.

Figure 1



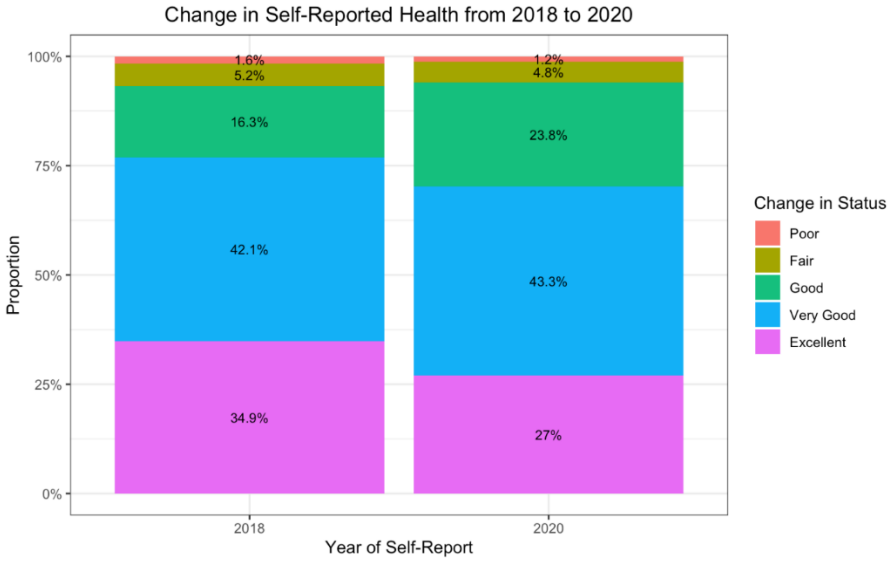

Almost one in five reported their physical health had worsened from March to the Fall, but one in seven said their physical health had improved (Figure 2). More than one-quarter said felt their mental health had gotten worse, while fewer than one in ten said it had improved since March.

Figure 2



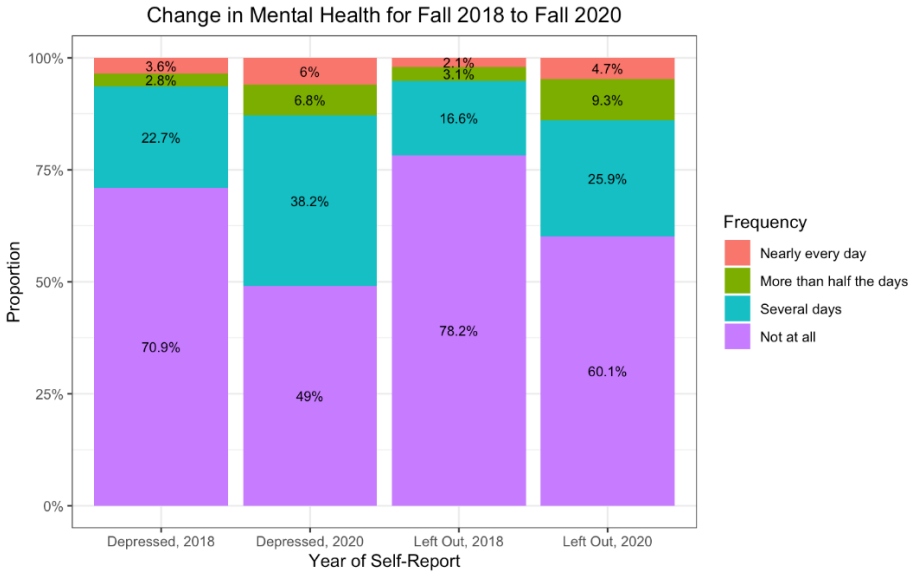
Comparing change in our panel surveyed in Fall 2018 and then again in Summer 2020 indicates only a small decline in self-reported physical health: The percentage rating their health as "very good" or "excellent" declined by only seven percent (Figure 3).

Figure 3




By contrast, the decline in mental health indicators during this period was substantial. There was a 22-percentage point increase in reports of feeling down, depressed, or hopeless in at least several days during the two weeks preceding the survey (Figure 4). The increase from Fall 2018 to Fall 2020 in feeling left out was almost as large.

Figure 4

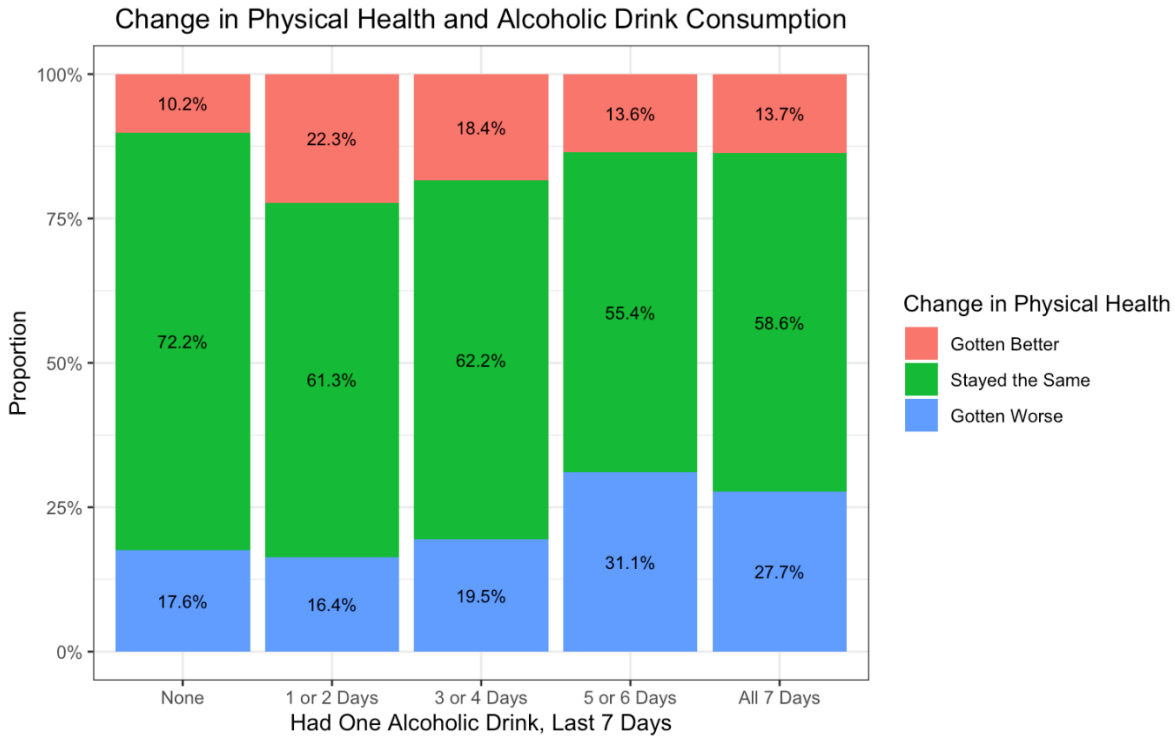


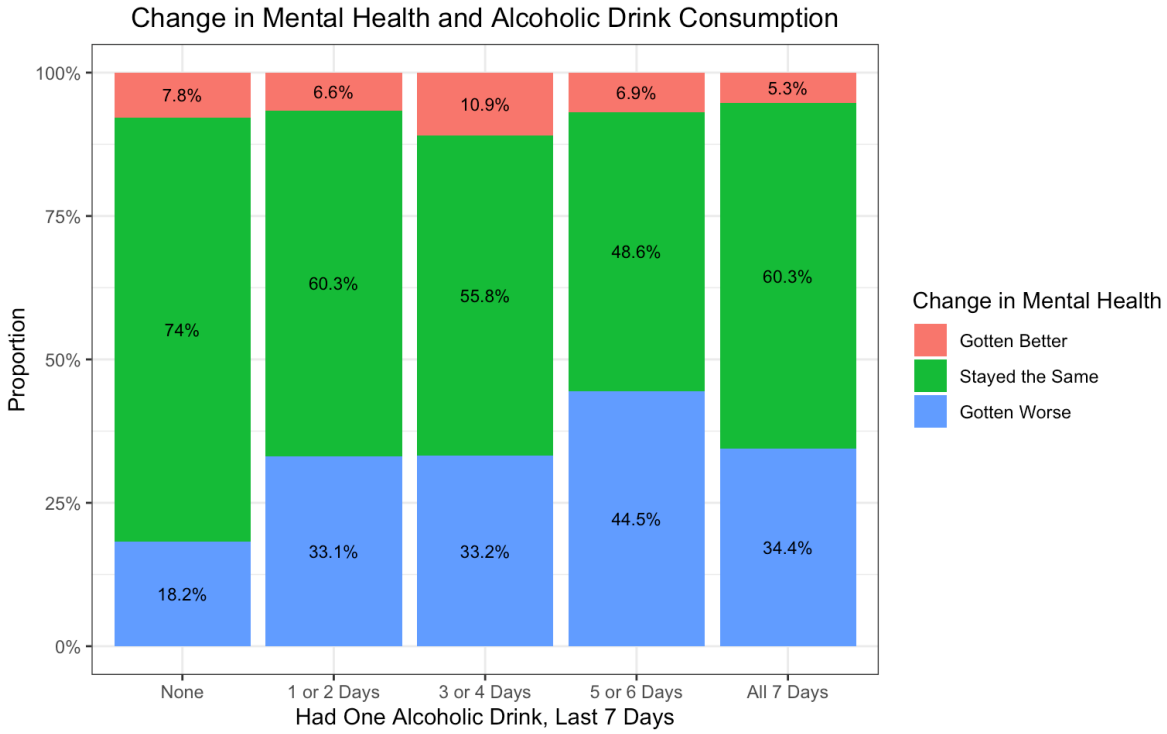
In summary, our data provide strong indications of widespread adverse effects of the pandemic on Bostonians' health with the decline in mental health appearing to have been more severe than with respect to physical health. A supplementary analysis also showed that these effects were not limited to those who believed they had had COVID-19.

### 3. Health-Related Behaviors Associated with the Pandemic's Health Impact

The second part of the survey, conducted in Fall 2020, asked Boston residents about their drinking and exercise patterns. The percentage of those reporting their physical health had worsened since March rose by about ten percentage points among those who drank five or more days a week, compared to those who drank less often (Figure 5). The same type of difference occurred in relation to worsening mental health, but here the major decrease in health occurred between nondrinkers and drinkers.

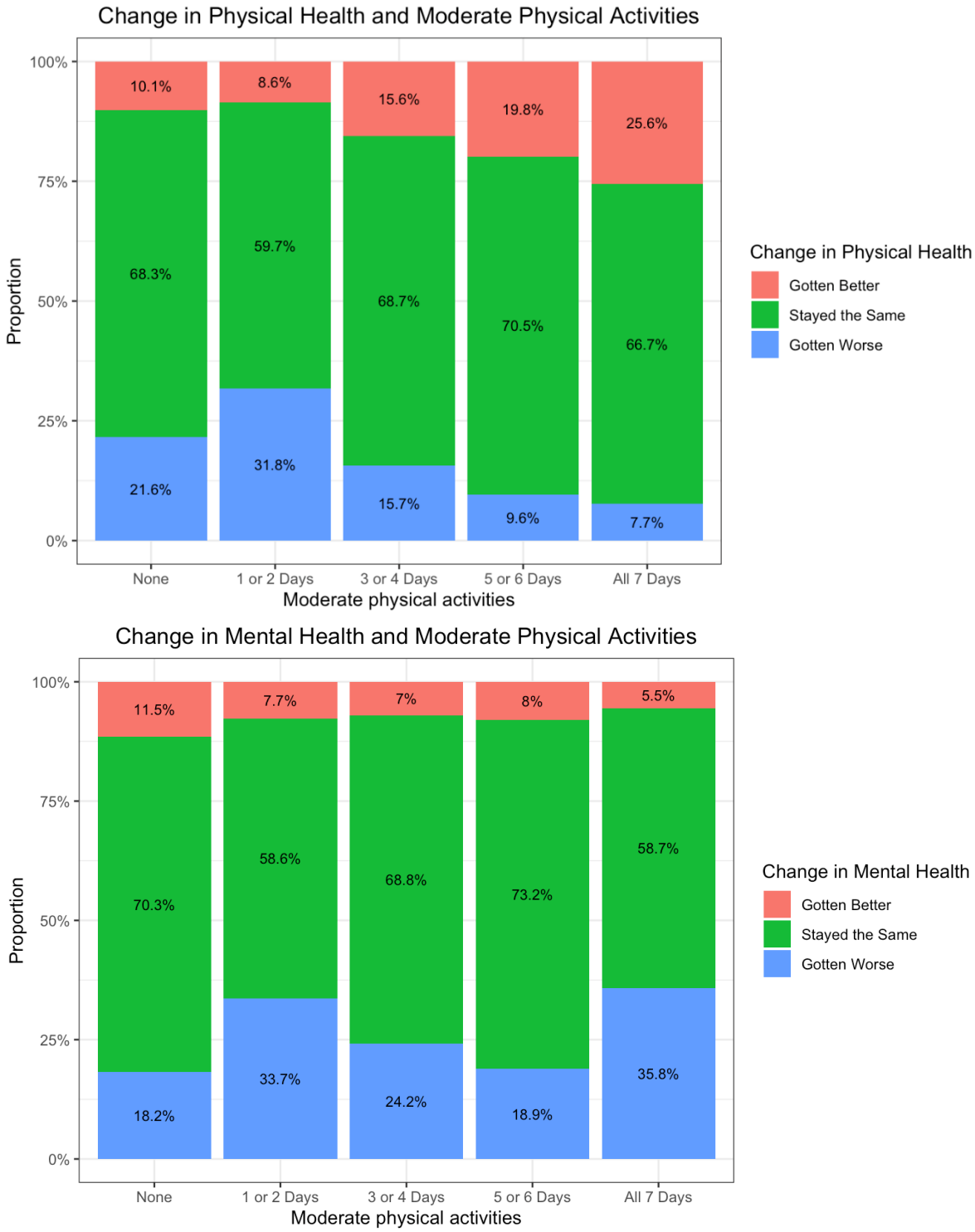
Figure 5





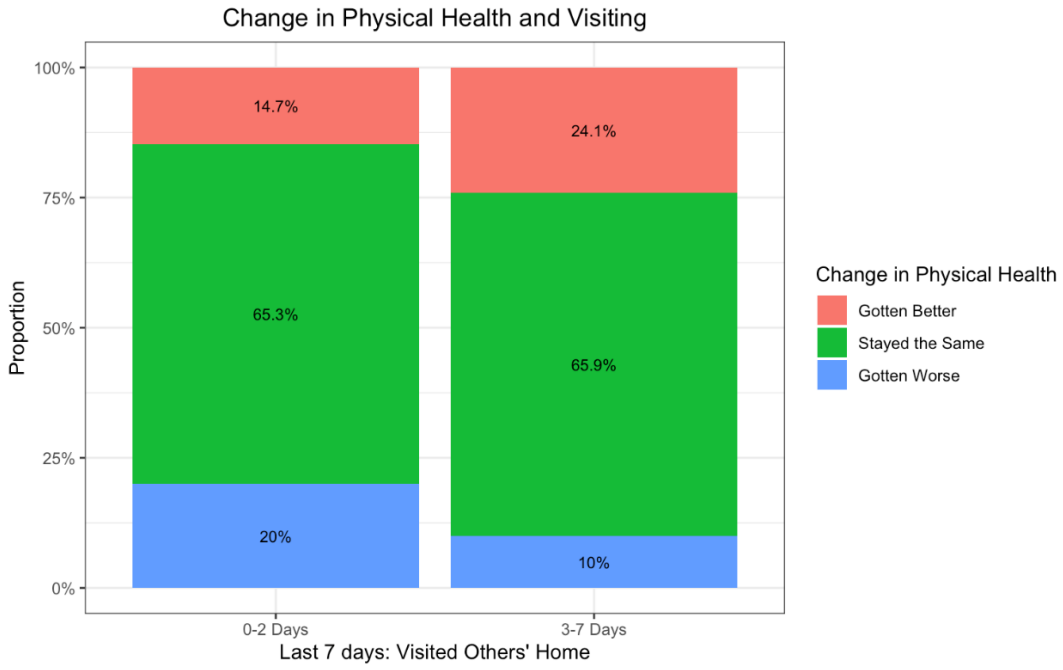

Frequency of exercising, unlike frequency of drinking, had a positive association with the likelihood of having experienced improved physical health (Figure 6). The likelihood of having experienced better physical health increased from only one in ten among those who didn't engage in any moderate physical activities, to one in four among those who exercised every day. However, there was no such association of the frequency of moderate physical exercise with improved mental health. (Findings were similar when responses to a question about the frequency of "vigorous" physical activities were substituted for those offered in response to the question about "moderate" physical activities.)

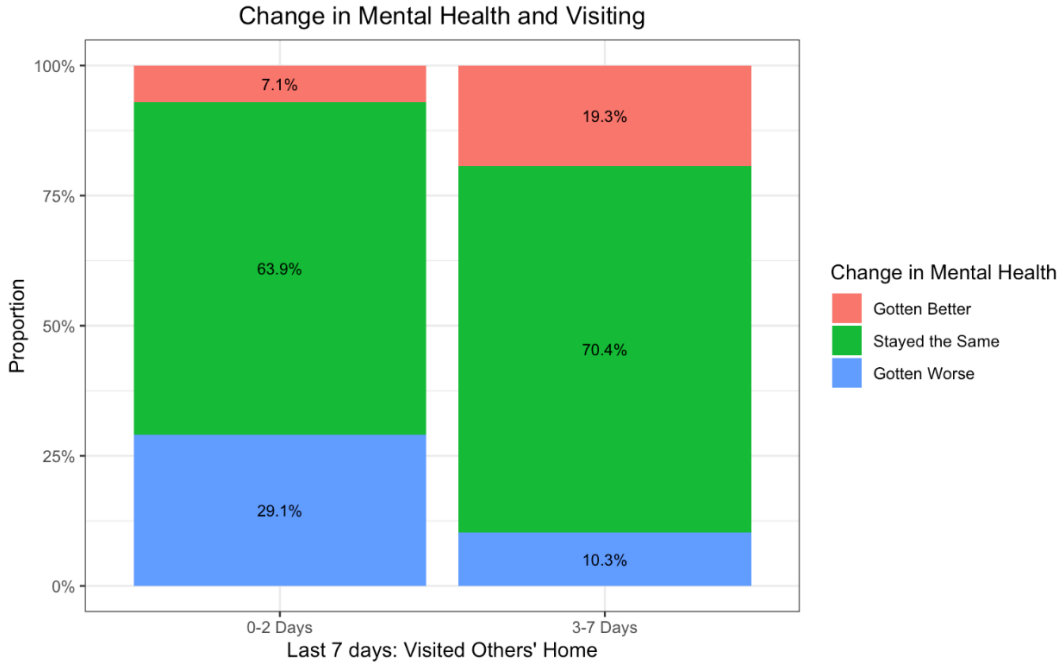
Figure 6


Change in Physical Health and Moderate Physical Activities
100%
75%
50%
25%
0%
Proportion
10.1%
68.3%
21.6%
8.6%
59.7%
31.8%
15.6%
68.7%
15.7%
19.8%
70.5%
9.6%
25.6%
66.7%
7.7%
None
1 or 2 Days
3 or 4 Days
5 or 6 Days
All 7 Days
Moderate physical activities
Change in Physical Health
Gotten Better
Stayed the Same
Gotten Worse
Change in Mental Health and Moderate Physical Activities
100%
75%
50%
25%
0%
Proportion
11.5%
70.3%
18.2%
7.7%
58.6%
33.7%
7%
68.8%
24.2%
8%
73.2%
18.9%
5.5%
58.7%
35.8%
None
1 or 2 Days
3 or 4 Days
5 or 6 Days
All 7 Days
Moderate physical activities
Change in Mental Health
Gotten Better
Stayed the Same
Gotten Worse

Although avoiding visiting other people in their homes was a pandemic social distancing guideline, those who reported having engaged in this behavior more were less likely to report that their health—physical and especially mental—had declined (Figure 7).

Figure 7



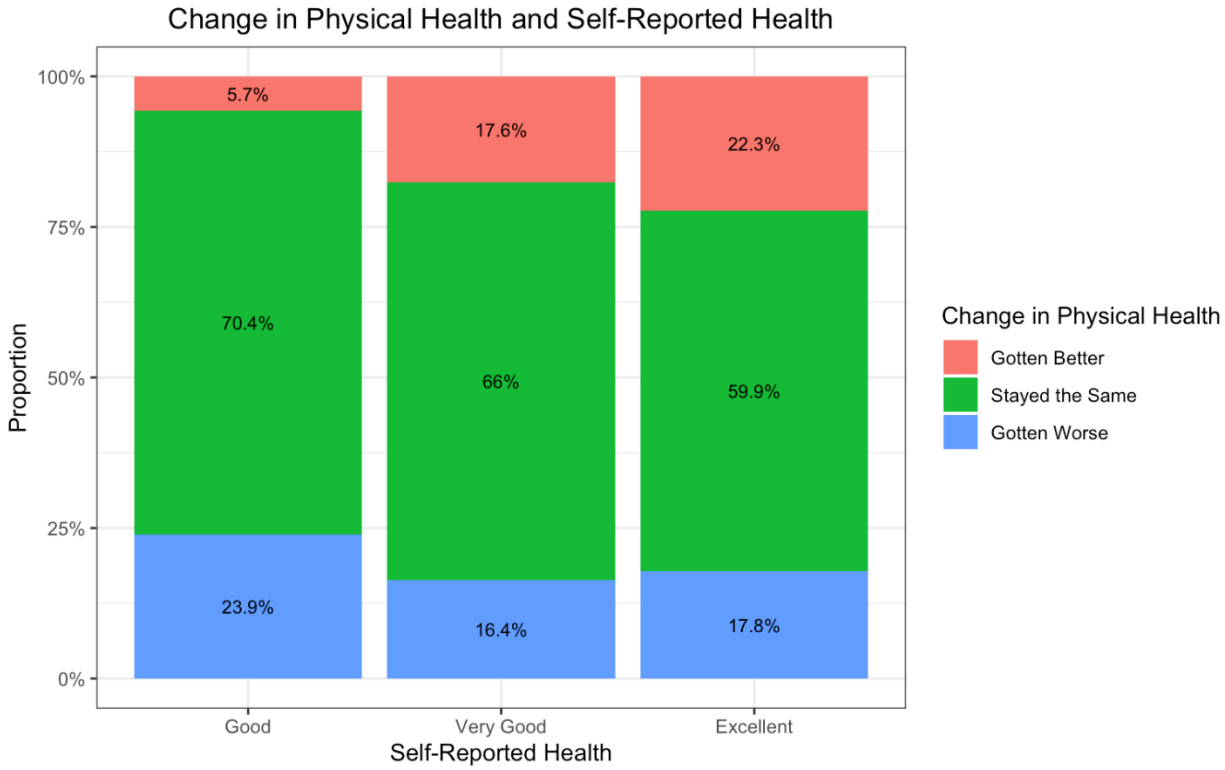



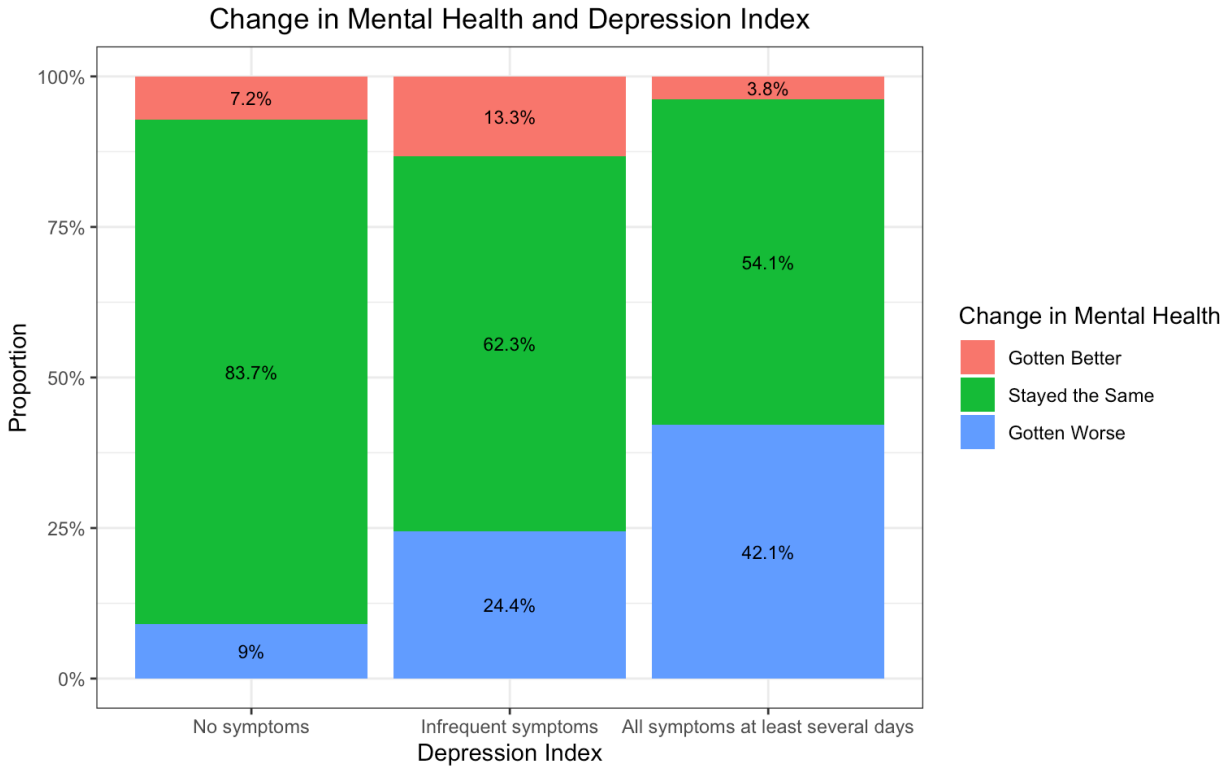
Thus, drinking was associated with the likelihood of having experienced worsening physical and mental health since the start of the pandemic in Boston. By contrast, exercising seemed to help protect physical but not mental health. Visiting with others was associated with improvements in both dimensions of health. We do not know if these visits occurred only with others in a protective "bubble" of friends or family who did not have exposures to others that increased their risk of infection with COVID-19. We also do not know if the frequency of any of these health-related behaviors reflected changes that had already occurred in health after March 2020 or instead helped to shape the course of the pandemic's health effects. Our findings do suggest that these and other behaviors should be considered in relation to understanding and helping to minimize the pandemic's adverse effects on physical and mental health.

## 4. Health Impact Associated with Overall Health

Poorer self-reported health was associated with more adverse impact on physical health (Figure 8). Similarly, more symptoms of problems with mental health were associated with more adverse impact of the pandemic on mental health.

Figure 8






Of course, with these survey data collected at one point in time, we cannot determine whether the poorer current health preceded or followed the pandemic-related declines. However, our smaller panel survey data also shows the same pattern occurred over time: those who reported better physical and mental health in 2018 subsequently were less likely to say that their physical and mental health, respectively, had worsened after the pandemic began.

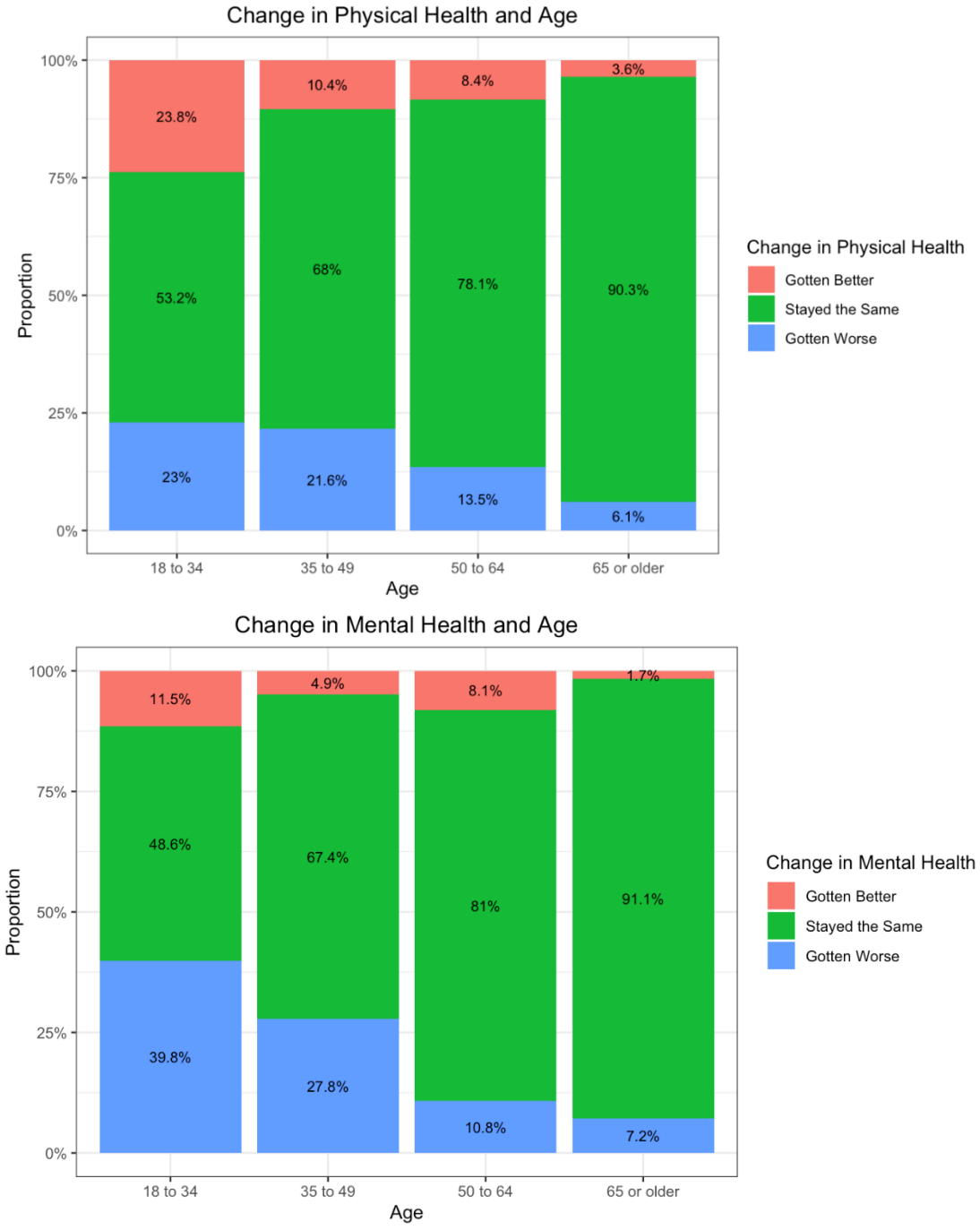
## 5. Health Impact Associated with Sociodemographic Characteristics

The likelihood of adverse health effects as a result of the pandemic varied markedly with sociodemographic characteristics. Age, race and ethnicity, sex and marital status, and educational level and income were all important.

Younger people reported more change in their physical health since March, with only about half of those under 35 years old saying their health had "stayed the same," compared to nine in ten of those 65 or older (Figure 9). Reports of both worse physical health since the onset of the pandemic and better physical health were more common among those who were younger. The same overall pattern occurred with self-reported change in mental health, but here the adverse effects on younger people's mental health

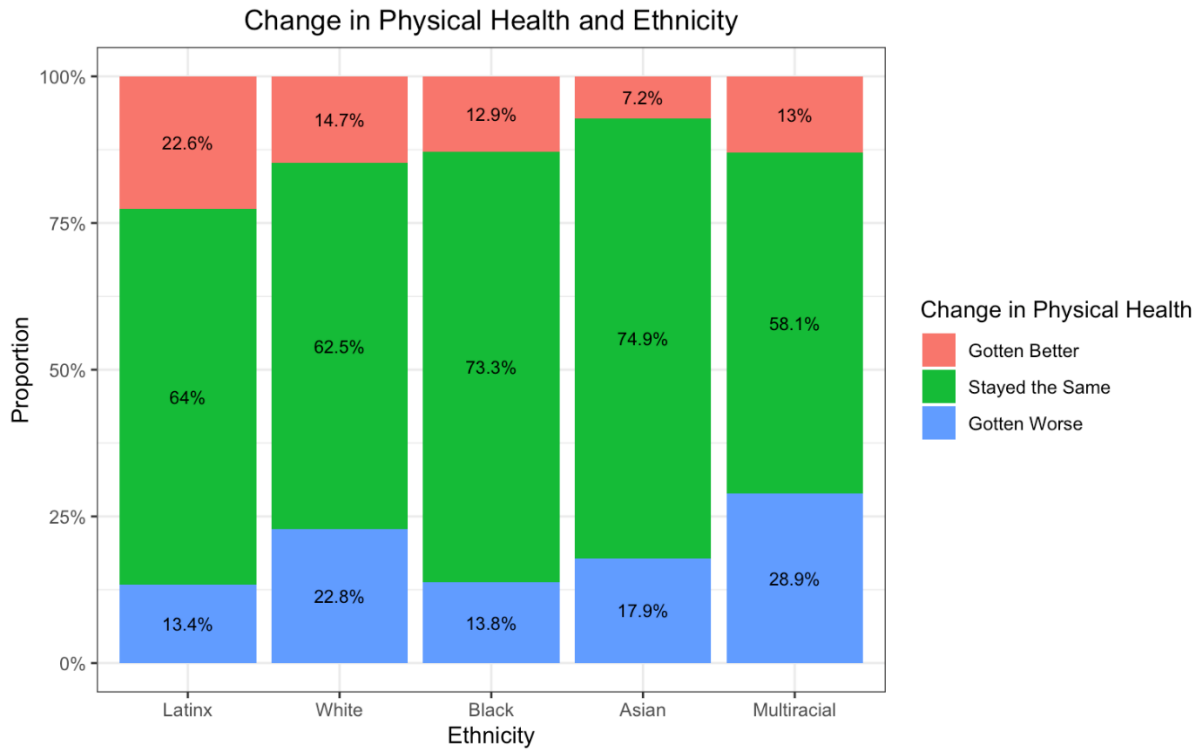
were even more marked. Four in ten of those 18 to 35 years old reported their mental health had "gotten worse" since March, compared to fewer than one in ten of those who were 65 or older.

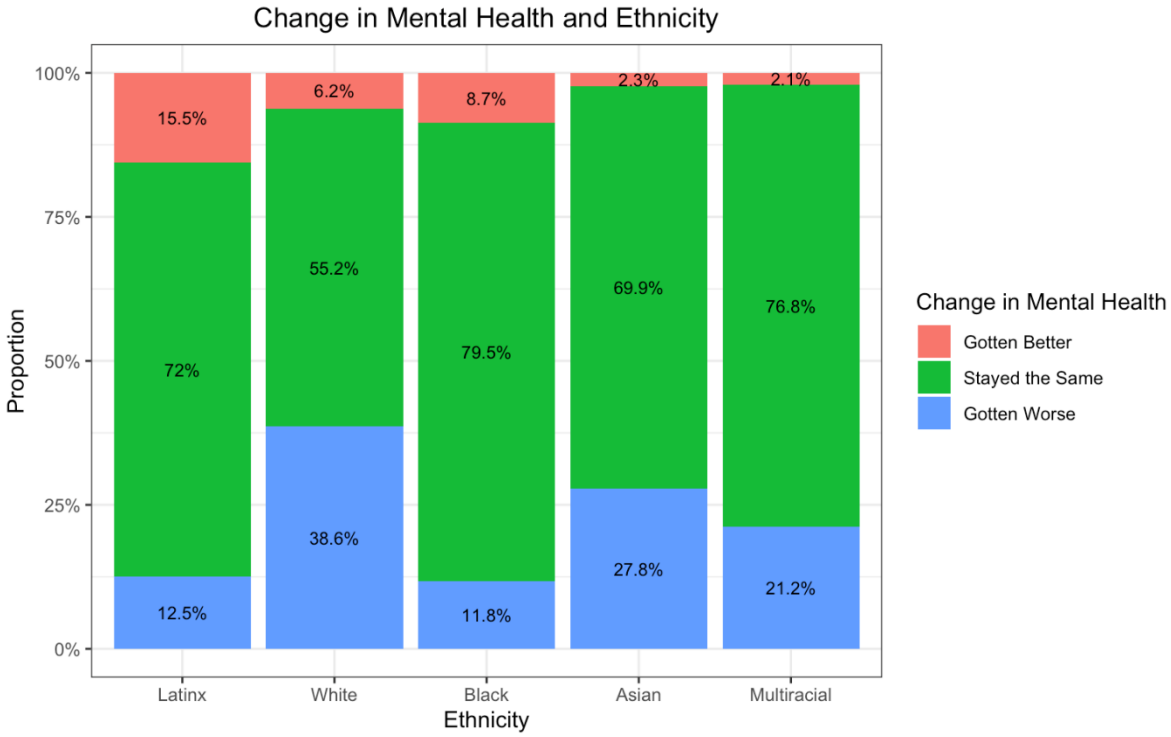
Figure 9



Adverse physical health effects of the pandemic were more common among White non-Hispanic respondents and those who identified as multiracial compared to those who were Latinx, Black, or Asian (Figure 10). More of the Latinx respondents (about one in five) reported their physical health had changed for the better than was true of any other racial/ethnic group. Mental health had declined even more markedly for White non-Hispanic respondents (almost two in five) and Asian respondents (about three in ten) compared to those in other racial or ethnic groups. As with physical health, more Latinx respondents (one in five) reported that their mental health had improved than was the case for the other racial/ethnic groups.

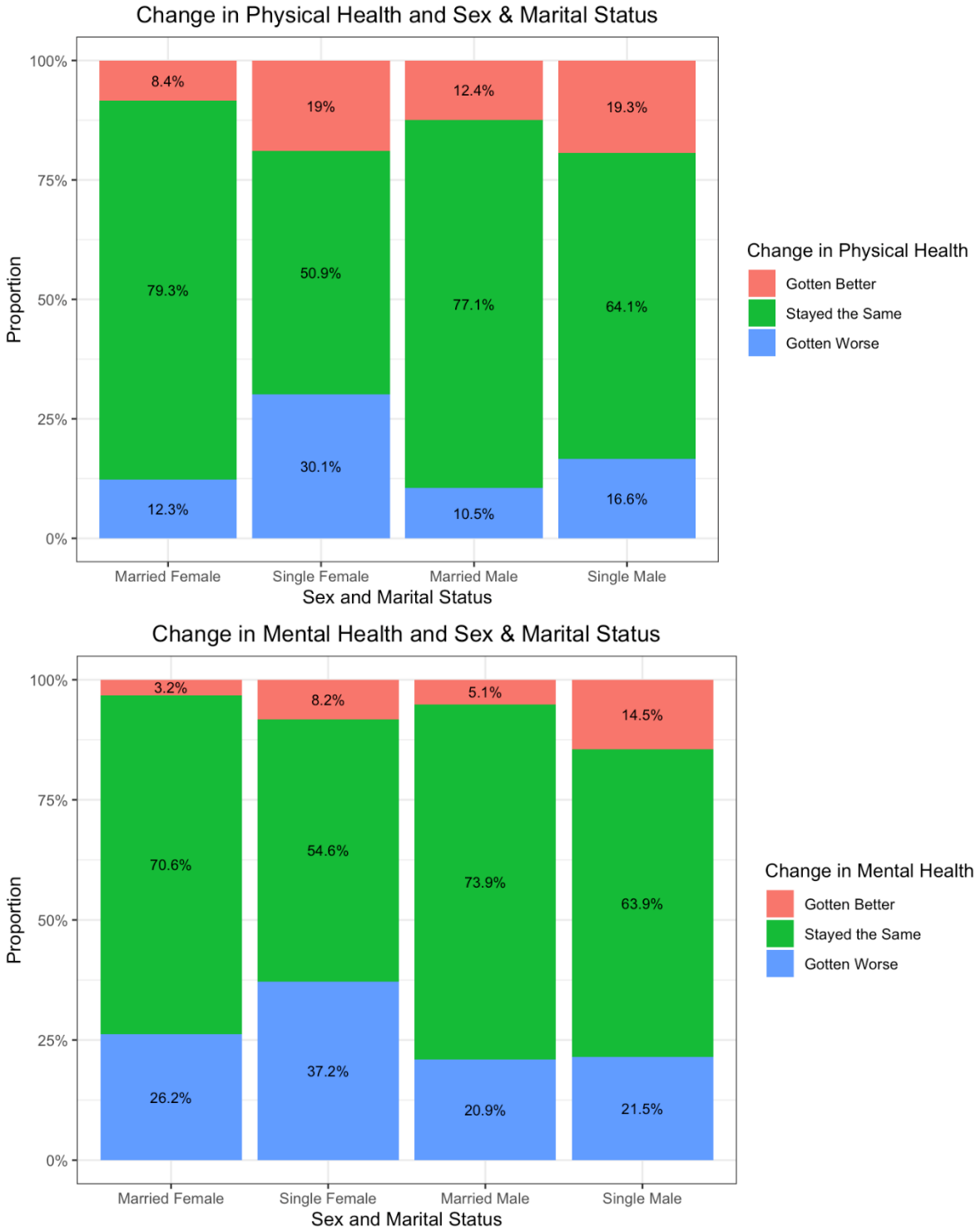
Figure 10





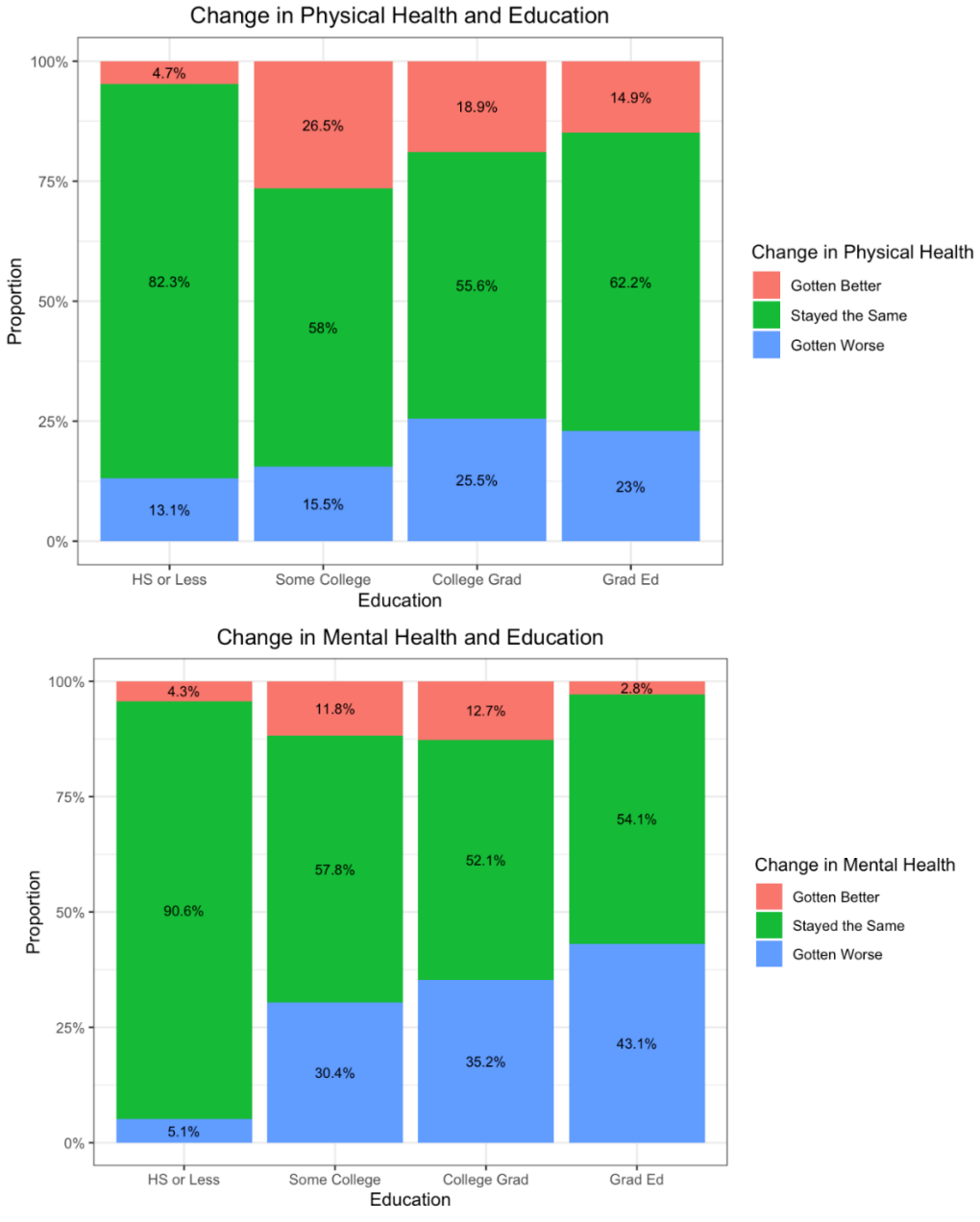

The association of sex and marital (partner) status with health impacts varied in relation to each other. Single women were most likely to report worsened physical health (about one-third) and worsened mental health (almost one in four) (Figure 11). Married men were the least likely to report that either their physical health (one in ten) or their mental health (one in five) had gotten worse. By contrast, singles—both men and women—were the most likely to report that their physical health (one in five) had improved. Single men were the most likely to report that their mental health had improved (about one in six), but this was not true for single women.

Figure 11


Change in Physical Health and Sex & Marital Status
100%
75%
50%
25%
0%
Proportion
8.4%
79.3%
12.3%
19%
50.9%
30.1%
12.4%
77.1%
10.5%
19.3%
64.1%
16.6%
Married Female
Single Female
Married Male
Single Male
Sex and Marital Status
Change in Physical Health
Gotten Better
Stayed the Same
Gotten Worse
Change in Mental Health and Sex & Marital Status
100%
75%
50%
25%
0%
Proportion
3.2%
70.6%
26.2%
8.2%
54.6%
37.2%
5.1%
73.9%
20.9%
14.5%
63.9%
21.5%
Married Female
Single Female
Married Male
Single Male
Sex and Marital Status
Change in Mental Health
Gotten Better
Stayed the Same
Gotten Worse

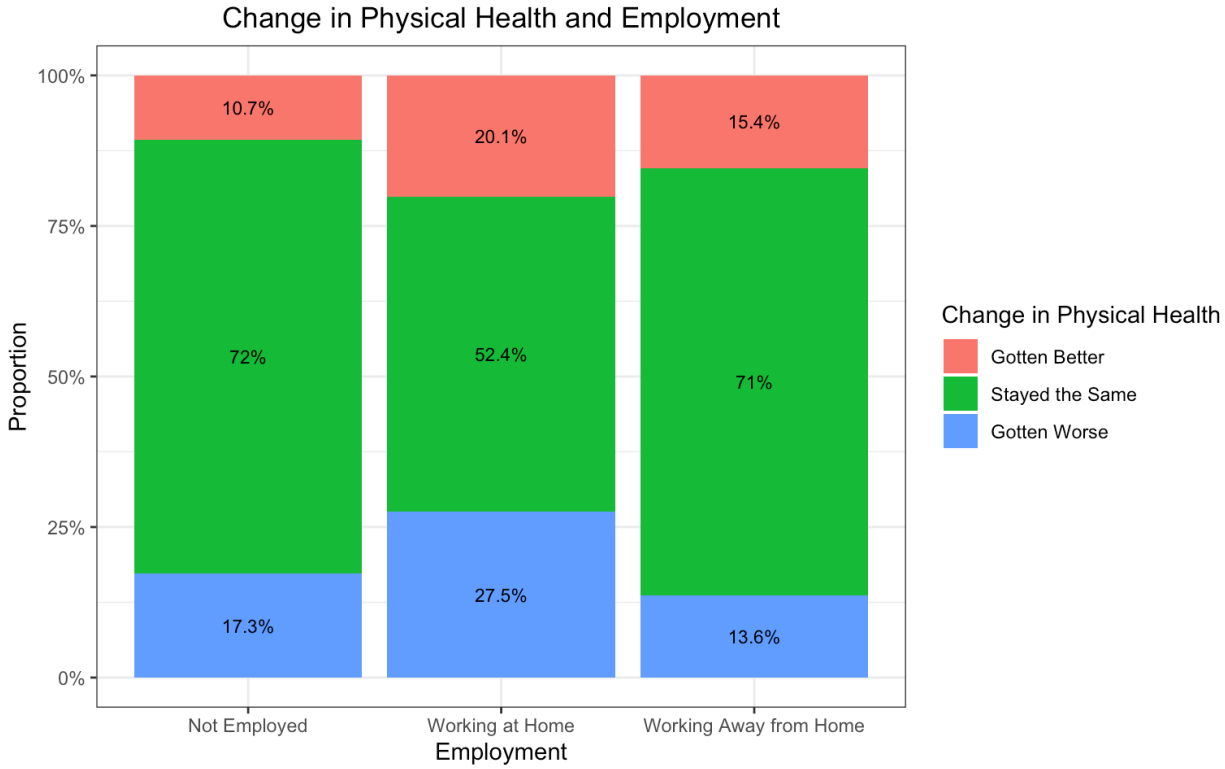
The likelihood of both adverse physical and mental health impacts increased with level of education (Figure 12). Adverse physical health effects were more common by about ten percentage points among those with a college degree compared to those with less education, while adverse mental health effects were at least six times more common among those with at least some college (three in ten) than among those with no more than a high school education (one in twenty).

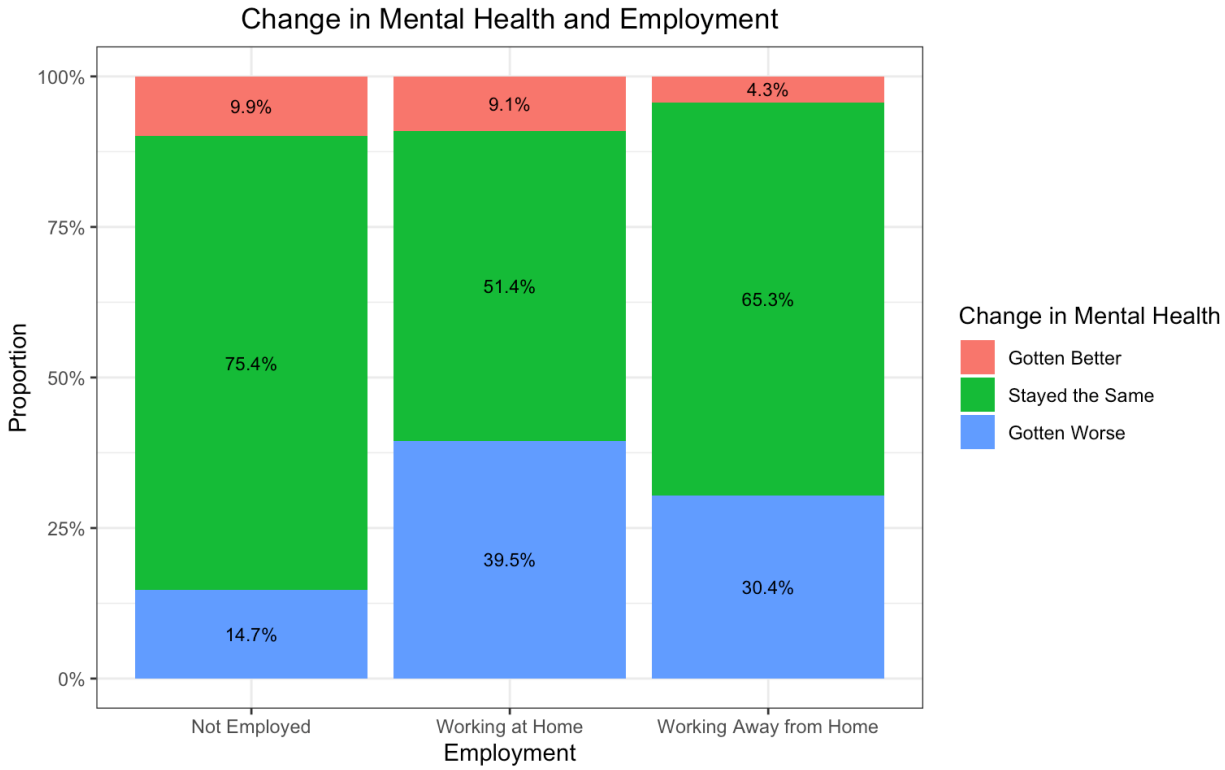
Figure 12



Effects on physical and mental health also varied in relation to employment status. Those who were working primarily from home in the Fall were more likely to have experienced a decline in their physical health than either those who were working more outside of the home or those who were not working (Figure 13). Declines in mental health were much more common among those who were employed in the Fall than among others, and even much more among those who were working primarily from home compared to those leaving home for work at least three days per week.

Figure 13





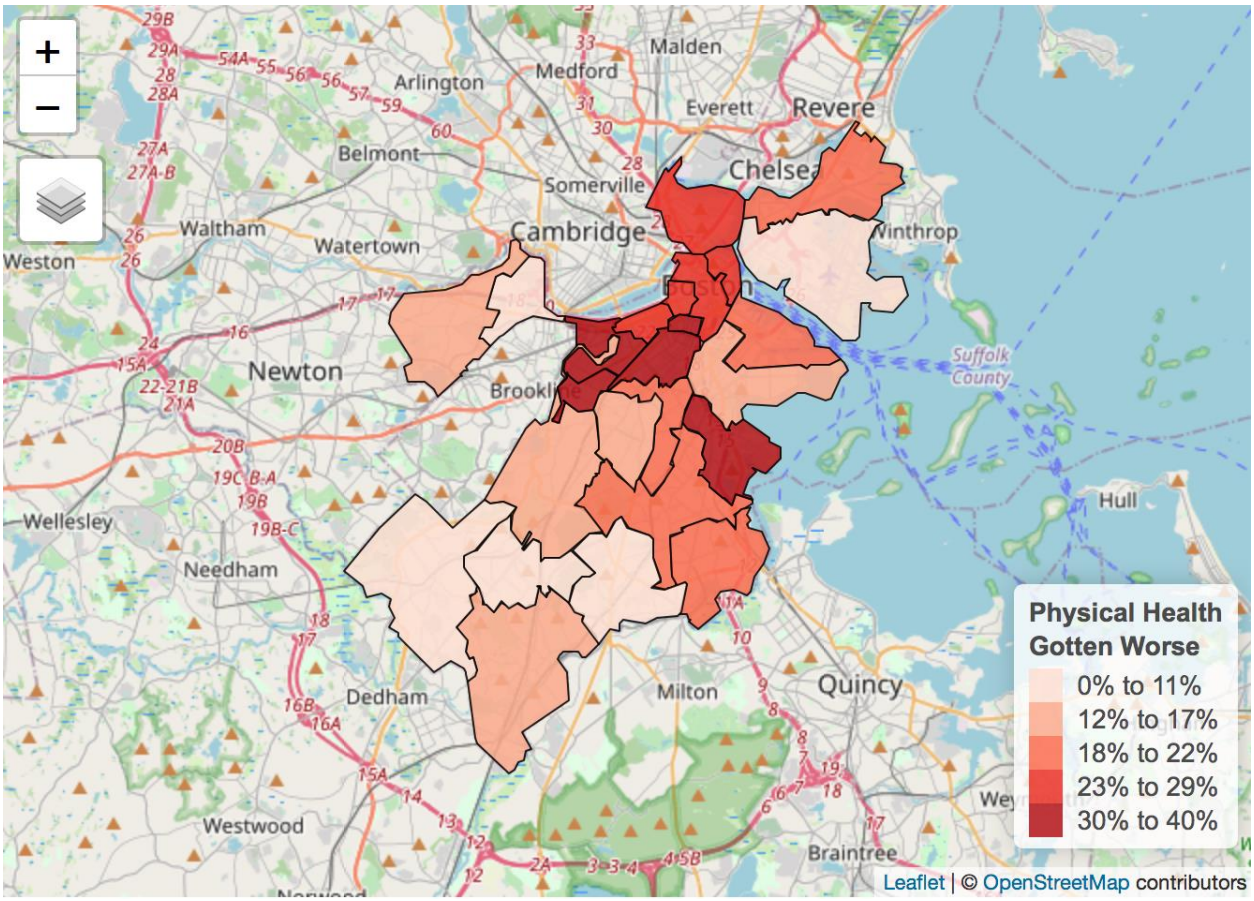

In summary, the perceived impact of the coronavirus pandemic varied in relation to Boston residents' personal characteristics. Younger residents, single women, Whites, those with more education and those who were working all reported more adverse impacts on their physical and/or mental health. Contingent effects need more examination in further analyses.

## 6. Health Impact Varied by Neighborhood

Health impact also varied by neighborhood. The pattern of neighborhood variation reflected some of the apparent effects of personal characteristics, although the different mix of these characteristics in different neighborhoods makes this pattern complex. Some of the neighborhoods with the highest proportions of residents reporting a decline in physical health tended to have more residents who were poor (North Dorchester, Mission Hill) or young (Fenway/Kenmore) (Figure 14).

Figure 14

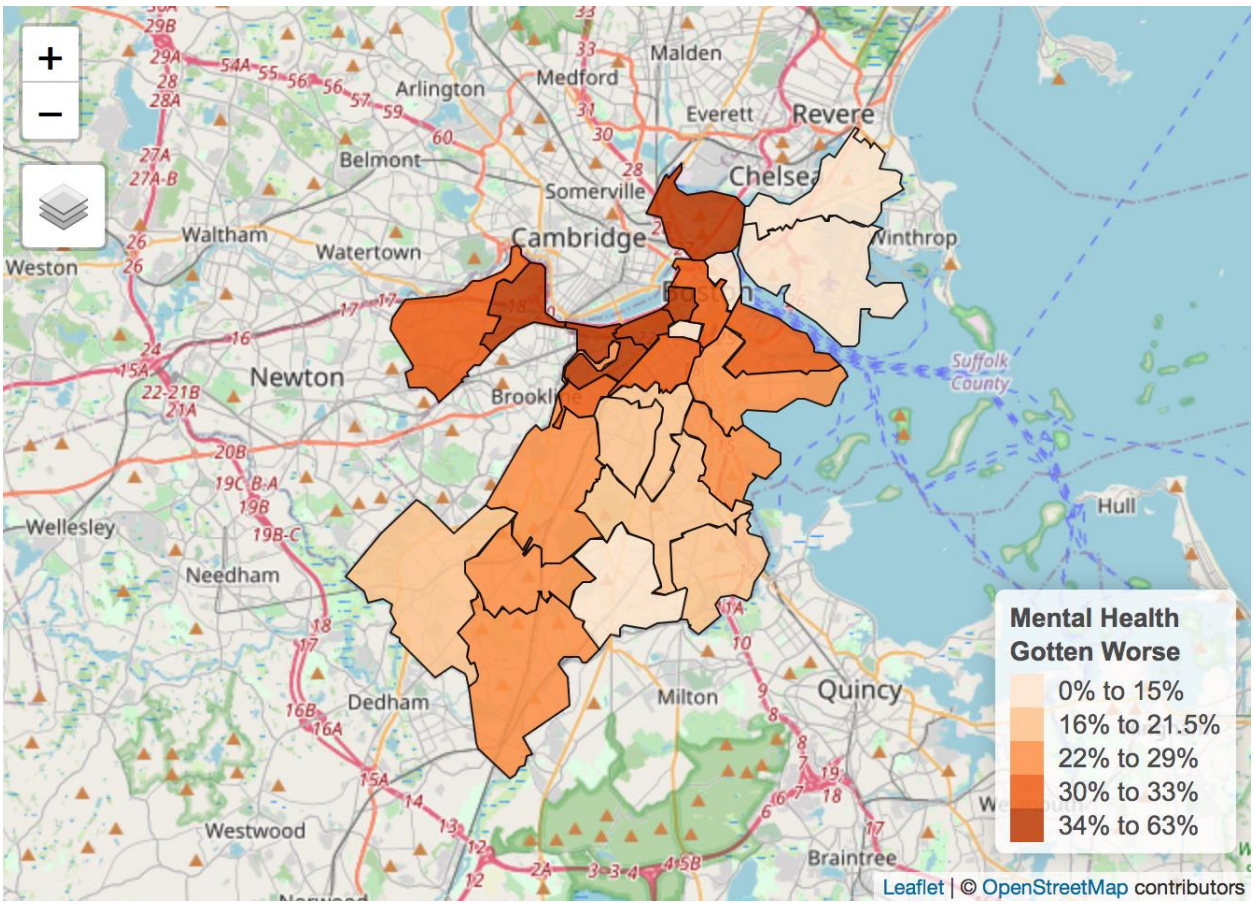
Change in Physical Health by Neighborhood




Some of the neighborhoods with the highest proportions of residents reporting a decline in mental health tended to have more residents who were White (Beacon Hill) or young (Fenway/Kenmore) (Figure 15).

Figure 15

Change in Mental Health by Neighborhood




## 7. Conclusions

The *Living in Boston during COVID-19* survey captures how the impact of the pandemic on physical and mental health varies across neighborhoods and populations. In this sixth report we have concentrated on the extent of health impact and how impacts on both physical and mental health varied between individuals in relation to their pre-existing health status, as well as in relation to their age, race and ethnicity, family status, education, and employment status. We have also shown that health impacts varied in relation to the health-related behaviors of drinking, exercising, and visiting others. Some of these patterns were reflected in differences in health impacts between neighborhoods.

There are several important lessons in these patterns. First, adverse effects—particularly on mental health--were widespread and they were more likely to occur among those in poorer health. Health-related behaviors like exercising and socializing, and not drinking, and social circumstances like working from home and being single (for women) also predicted the likelihood of adverse mental health effects.

Surprisingly, more education and being employed---predictors of less economic harm from the pandemic—also predicted more reports of adverse effects on mental health. Being young, usually associated with better physical health, instead predicted more adverse effects of the pandemic on both physical and mental health—even though many did not feel adversely affected. These patterns suggest that adverse health effects, and particularly adverse mental health effects were more likely to be felt among those who would not have expected to face severe challenges like those created by the pandemic.

Preserving Boston's social health during the pandemic requires attention to the ways that altered social circumstances impact mental as well as physical health. Our survey clarifies the very different ways that various groups of Bostonians and different neighborhoods have been impacted by the pandemic. Efforts to help must take account of the tradeoffs we have identified between reducing the risk of infection, lessening economic harm, and sustaining our mental and physical health. Strategies that are most effective in reducing the risk of infection may at the same time reduce economic well-being as well as the ability to maintain social ties that in turn help maintain mental health. In subsequent analyses, we will examine more closely the contingencies involved in the pandemic's disparate health impacts.

## Appendix A. NSF Beacon Survey Methodology

The NSF-Beacon survey is a collaboration of the Boston Area Research Initiative (BARI) at Northeastern University, the Center for Survey Research (CSR) at University of Massachusetts Boston, and the Boston Public Health Commission (BPHC), funded by the National Science Foundation's Human-Environment and Geographical Sciences (HEGS) program through a grant for rapid-response research (RAPID) for collecting ephemeral data during or following a crisis. The survey captures the experiences of 1370 Bostonians during the first months of the COVID-19 pandemic, including ability and tendency to follow social distancing recommendations, attitudes towards regulations, and economic and personal impacts of the pandemic. The design allows for a unique observation of neighborhood-level estimates for these factors.

### I. Sample Design and Final Sample

The NSF-Beacon survey used a stratified random sample that divided the city of Boston into 25 distinct neighborhoods. The neighborhoods were defined in collaboration with members of the Mayor's Office and other experts based on social, demographic, and historical salience. They were constructed to conform to census block group boundaries, meaning that metrics associated with census geographies (including from the U.S. Census Bureau) could be linked with the data. The Marketing Systems Group (MSG) was contracted to draw a simple random sample of residential addresses from within each neighborhood. They used the most recent United States Postal Service Computerized Delivery Sequence File (CDSF) to draw Address-Based Samples (ABS) of residential addresses. Four neighborhoods with a higher proportion of Black or Latinx populations were oversampled (Hyde Park, Mattapan, Lower Roxbury, and East Boston-Eagle Hill). As shown in Table 1, there were unbalanced sample sizes and selection probabilities across neighborhoods, meaning analysis of the data requires survey weights to correct for these differences. In addition to the survey being administered to the sample obtained for the NSF-Beacon study, we also invited participants in the previously constructed Beacon panel, which had been recruited using the same 25 neighborhood stratified sample design.

### II. Data Collection Methodology

Paper copies of the survey, plus instructions for completing and returning, and a $2 cash incentive were mailed to all sampled addresses. For three neighborhoods known to have higher percentages of Hispanic households, the materials mailed, including the survey instrument, were in both English and Spanish. All recipients were also given the option of completing the survey online and an associated URL. A randomly assigned half of the mailed questionnaires had instructions for the oldest adult 18+ in the household to complete the survey while the other random half had instructions for the youngest adult 18+ to complete the survey. In this manner, an attempt was made to randomize the age of the respondent within the household completing the survey. Approximately two weeks after the initial mailing of materials, a second mailing was sent to nonrespondents, though with no additional incentive.

**Table 1. NSF-Survey neighborhood sampling specifications**

| Neighborhood | # of Sampled Addresses | Prob. of Selection | # of Completed Surveys | Response Rate[1] |
|---|---|---|---|---|
| Allston | 192 | 0.01702 | 51 | 28.81% |
| Back Bay | 194 | 0.01871 | 53 | 31.36 |
| Beacon Hill | 204 | 0.03593 | 53 | 30.11 |
| Brighton | 187 | 0.00839 | 58 | 31.87 |
| Central | 198 | 0.06119 | 50 | 27.78 |
| Central Northeast | 196 | 0.02839 | 58 | 33.14 |
| Central West | 200 | 0.01665 | 55 | 32.35 |
| Charlestown | 190 | 0.02286 | 62 | 34.25 |
| Dorchester Central | 189 | 0.01042 | 39 | 21.08 |
| Dorchester North | 188 | 0.02661 | 42 | 23.86 |
| Dorchester South | 191 | 0.01671 | 60 | 32.97 |
| East Boston | 189 | 0.02501 | 43 | 24.29 |
| East Boston-Eagle Hill | 355 | 0.04189 | 93 | 27.84 |
| Fenway/Kenmore | 195 | 0.01169 | 39 | 21.91 |
| Hyde Park | 364 | 0.02967 | 59 | 17.10 |
| Jamaica Plain | 188 | 0.01138 | 71 | 39.66 |
| Jamaica Plain-Mission Hill | 191 | 0.02737 | 55 | 30.73 |
| Lower Roxbury | 372 | 0.05977 | 57 | 17.59 |
| Mattapan | 362 | 0.02704 | 61 | 17.58 |
| Roslindale | 188 | 0.01820 | 73 | 40.11 |
| Roxbury | 188 | 0.01511 | 37 | 20.67 |
| Seaport | 192 | 0.04554 | 40 | 22.47 |
| South Boston | 191 | 0.01150 | 45 | 24.86 |
| South End | 188 | 0.01070 | 57 | 32.02 |
| West Roxbury | 189 | 0.01407 | 59 | 32.24 |
| | | | | |
| **Total** | **5481** | | **1370** | **26.88%** |

## III. Data Collection Results

The final sample included 1370 completed surveys (1208 paper, 162 online; 30 were completed in Spanish). The number of completed surveys ranged from 37 in Roxbury to 93 in East Boston-Eagle Hill. Overall response rate was 26.88% and ranged from a low of 17.10% in Hyde Park to a high of

40.11% in Roslindale. Full details on each neighborhood sample are presented in Table 1. An additional 256 completed surveys were obtained from members of the previously constructed Beacon panel, bringing the total number of completed surveys to 1626.

## IV. Weighting of survey data

The sample requires weighting to account for both differing probabilities of selection and response rates across neighborhoods, especially insofar as these differences create a sample that is demographically and geographically non-representative. We created two survey weights, one for sample design factors including probability of selection and number of adults in the household adjusted for nonresponse bias across neighborhoods, the other which adds a post-stratified weight to account for demographic non-representativeness. Additionally, we conducted this process twice. First, we did it only for respondents to the NSF-Beacon survey. Second, we replicated the procedures for the dataset that combined the NSF-Beacon survey responses with respondents from the previously constructed Beacon panel (values reported in Table 2 for weighting are highly similar for the NSF-Beacon responses alone and the merged data set).

*Weights for Nonresponse Bias*

Weighting for nonresponse began by neighborhood with the inverse of the probabilities of selection adjusted for the response rates displayed by neighborhood according to the equation (see Table 1 for values):

Wb = (Inverse of probability of selection) / (neighborhood response rate)

The final nonresponse adjusted weight further multiplies the base weight by the number of adults 18+ in the household (capped at 4 to prevent excessively large weights). Finally, these weights are adjusted so that the percentage of the total 18+ population in Boston that belongs in each neighborhood agreed with control percentages computed from the 2014-2018 5-year American Community Survey (ACS) data from the Census Bureau. These weights sum to the ACS estimate of the total 18+ population in the city of Boston. Therefore, the final nonresponse adjusted weight can be defined as:

$W_{NR}$ = ($W_b$)(number of adults in household)(ACS population adjustment factor) 16

*Post-Stratified Weights*

As shown in Table 2, even after nonresponse weights, the respondents to the survey were not demographically representative of Boston's population. Most notably, people with education beyond 4-year college degrees were overrepresented and those with a high school education or less were underrepresented. Women were also overrepresented relative to men and White non-Hispanics were overrepresented relative to Blacks and Hispanics. There was also a smaller age bias with too many 65+ people and too few 18-34. A final adjustment to the survey weights was implemented to adjust for differential survey nonresponse by age, gender, race/Hispanic origin, and education. Control percentages for these categories were computed from the 2014-2018 5-year ACS data. Post-stratification factors were then computed to match weighted survey data to citywide percentages. The final post-stratified weight can be expressed as:

$W_{PS} = (W_{NR})$(post-stratified factors)

It should be noted, though, that a small amount of trimming of weights, less than one percent of all sample cases, was employed to prevent some extreme values in the post-stratified weights. As shown in Table 2, this additional adjustment process brought the weighted survey estimates much more in line with ACS citywide estimates.

*Weights for the second mail and web-based survey.*

For the follow-up survey, where 932 of the original 1626 respondents answered questions, new post-stratification factors were developed to again match weighted survey data to the 2014-2018 5-year ACS.

**Table 2. Comparison of ACS controls to nonresponse and post-stratified weights**

| | ACS | Nonresponse | Post-stratified |
|---|---|---|---|
| **Age** | | | |
| 18-34 | 46.90% | 38.40% | 46.20% |
| 35-49 | 21.3 | 20.1 | 21.5 |
| 50-64 | 18.4 | 22.1 | 18.6 |
| 65+ | 13.4 | 19.4 | 13.7 |
| | | | |
| **Gender** | | | |
| Male | 47.60% | 38.00% | 47.60% |
| Female | 52.4 | 62 | 52.4 |
| | | | |
| **Education** | | | |
| High School including GED or less | 33.60% | 16.40% | 32.50% |
| Some college including 2-year degree | 17.8 | 14.8 | 18 |
| 4-year college degree | 26.5 | 29.3 | 27 |
| Beyond 4-year college degree | 22.1 | 39.5 | 22.5 |
| | | | |
| **Race/Hispanic origin** | | | |
| White non-Hispanic | 49.40% | 57.50% | 49.40% |
| Black non-Hispanic | 20.6 | 15.8 | 20.6 |
| Hispanic | 16.9 | 12.4 | 16.9 |
| Other | 13.1 | 14.3 | 13.1 |