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# The Impact of Perceived Background Risk on Stress, Health Insurance, and Substance Use: Evidence from Hurricane Katrina

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## Abstract

Using Behavioral Risk Factor Surveillance System data, I find causal evidence that Hurricane Katrina increased stress, smoking, binge drinking, and health insurance coverage in the non-impacted storm surge region. In this region, Hurricane Katrina increased health insurance coverage by 440,000 young adults, the number of smokers by 930,000, and the number of binge drinkers by 510,000. Findings suggest that disasters affect perceptions of background risk in areas with actual risk. Results are robust to varying the location and time of Hurricane Katrina, varying the pre-Hurricane Katrina time window, and excluding counties within 400 miles of New Orleans.

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# I Introduction

Due to its uniqueness, Hurricane Katrina (hereafter referred to as “Katrina”) may have elicited an increase in levels of perceived background risk for individuals residing in areas with actual risk to future hurricanes, even if these individuals were not directly impacted by Katrina. Perceived background risk may have increased in these non-impacted areas vulnerable to future hurricanes after Katrina because individuals became newly aware or reminded of hurricane risks by 24/7 media coverage, or reduced their expectations of the protection that the Federal Emergency Management Agency (FEMA) could provide. Further, perceived background risk may have increased more in areas of greater vulnerability than areas with less vulnerability. In this study, we explore how an exogenous increase in perceived background risk impacts negative emotions (hereafter referred to as “stress”), the demand for health insurance, and substance use.

Katrina was a unique hurricane in terms of severity and media coverage. This uniqueness contributed to Katrina’s ability to alter perceived background risk. It was the deadliest natural disaster in the United States in nearly a century, causing 1,836 deaths in total. The city of New Orleans in Louisiana took the brunt of its impact on August 29, 2005, and the damage extended to states of Mississippi, Alabama, and Florida. 24/7 news coverage transferred images of Katrina-induced death and destruction to households across the United States. A few examples of this ubiquitous news coverage are that the *Los Angeles Times* had a Katrina front-page headline and lead image for 15 days straight, and the *New York Times* had a Katrina front-page headline for 13 out of 15 days (Kimball et al. 2006). In polling conducted a week following Katrina, 93% of Americans believed Katrina to be the worst natural disaster in their lifetime (Gallup News Service 2005a). The public was mostly unhappy with the government’s response, with various aspects of government receiving approval ratings of between 36-42% for their response (Gallup News Service 2005b). The director of FEMA resigned two weeks following the disaster.

To explore the effect of perceived background risk changes on negative emotions, the

demand for health insurance, and substance use, I use individual-level data from the Behavioral Risk Factor Surveillance System from 2004-2006 for 974,100 adults ( $\geq 18$  years of age) residing in the continental United States, and from 2002-2006 for 1,456,794 adults. I exploit the fact that individuals reside in counties with different actual hurricane risks using county-level meteorological and geographical data. After excluding counties directly impacted by Katrina, I use a difference-in-difference (DD) analysis to compare post-Katrina outcome measures for individuals residing in counties differentially at-risk to future hurricanes with individuals residing in counties largely impervious to future hurricanes. I estimate the increase in outcomes, controlling for socio-demographic characteristics, month indicators, state indicators, and time-varying environmental and policy characteristics that could affect the outcomes (e.g. cigarette prices). A key identifying assumption is that the effects of Katrina can be observed across regions of differential hurricane risks exogenous to migration and economic climate, and I provide evidence to support this.

Ceteris paribus, in non-impacted, vulnerable counties, Katrina was associated with an increase in stress of  $\frac{1}{4}$ th of a day per 30 days (6.8% of the mean), an increase in health insurance coverage of 1.0 percentage points (1.2% of the mean), and an increase in smoking of 2.1 percentage points (10.2% of the mean). In counties with the largest surface area exposure to storm surge, binge drinking increased by 2.1 percentage points (14.1% of the mean). I argue that these results exhibit evidence of causality after ruling out the possibility of non-parallel time trends in the pre-Katrina period and observable population shifts across the different non-impacted hurricane risk regions after Katrina. I demonstrate that effect sizes are higher in areas with higher risk, are insensitive to excluding counties within 400 miles of New Orleans, are insensitive to using a synthetic control group analysis, are insensitive to using a longer pre-Katrina time trend, and are insensitive to compensating for other less severe hurricanes.

A key challenge for my identification strategy is potential confounding from migration to and from the disaster area. Outcomes may be different for Katrina evacuees than native

residents. If this is true, then the DD estimators will be biased to the extent that evacuees disproportionately moved into the treatment and control groups. Additionally, a large presence of evacuees could endogenously produce changes in employment and crime that could increase stress levels. For example, the population of the Houston, Texas metropolitan area is estimated to have increased by 7 percent from Katrina evacuees (Hussey, Nikolsko-Rzhevskyy, and Pacurar 2011)—a demographic shift associated with a decline in wages and employment among native Houstonians (McIntosh 2008), as well as an increase in violent crime (Hussey, Nikolsko-Rzhevskyy, and Pacurar 2011).

I address the issue of migration in several ways. First, I exclude counties that were directly impacted by Katrina, as measured by counties receiving Katrina federal assistance through a FEMA disaster declaration, because there was large migration throughout this region. I instead focus on areas that are vulnerable to hurricanes but were not impacted directly by Katrina. For remaining counties, I test for observed differences in socio-demographic characteristics of gender, race/ethnicity, age, education, employment, marital status, and income before and after the adverse event in the control and treatment groups. I find no evidence of a change in population between these two groups based on observable characteristics. As an additional sensitivity analysis, I use information from approximately 1.3 million FEMA disaster aid applications to identify Katrina evacuees and the ZIP code of their post-Katrina dwelling. I use this information to create a county-level variable for evacuees per capita that I include in the analysis as a sensitivity check. Results are unaffected by the inclusion of this control variable. Finally, in another sensitivity analysis, I remove all counties within 400 miles of New Orleans, which includes Houston, home to a large number of refugees and mega-shelters, and find that results are not affected by this removal. In sum, I am able to substantially mitigate confounding from migration.

This paper is related to two strands of literature. The first strand explores the effects of background risk on risk aversion and decision-making in the presence of risk. New risk information, such as from an information campaign on radon exposure, has been found to

raise perceived background risk (Smith and Johnson 1988). One study directly measured an increase in risk aversion in Germany, in particular closer to nuclear reactors, due to a nuclear disaster in Japan (Goebel et al. 2015). Other studies have explored how background risk influences decisions involving financial risk, finding decreased stock market participation (Heaton and Lucas 2000), increased insurance demand (Gollier and Pratt 1996), and decreased risk-taking in experimental games (Cameron and Shah 2013).

Related, several studies use home sales data and DD methodologies to estimate the impact of hurricanes as sources of new risk information on property prices. Following Hurricane Andrew that struck Florida in 1992 and controlling for damage and changes in insurance, property values were found to decline in Dade County, which was directly impacted. Property values also decreased in Lee County, a near-miss county, by less than in Dade County (Carbone, Hallstrom, and Smith 2006; Hallstrom and Smith 2005). These results suggest that households notice disasters, even “near miss” disasters, and update perceived background risk in response to this new information. Market responses follow. These responses appear to be temporary rather than permanent: property value differentials disappeared after five years (Bin and Landry 2013).

The second strand of literature relevant to my research relates to the mental and physical health of individuals directly impacted by large-scale disasters. Using longitudinal data, Smith found that longevity expectations declined for older adults in Dade County due to a direct hit from Hurricane Andrew (Smith 2008). A recent contribution by Currie and Rossin-Slater used vital records data to explore the impact of exposure to hurricanes during pregnancy on the probability of stress-related abnormal birth conditions. Stress was found to be a residual explanation on some abnormal birth outcomes after accounting for migration, changes in medical care, and changes in maternal behavior (Currie and Rossin-Slater 2013).

This paper attempts to explore the effects of an exogenous increase in perceived background risk from Katrina on stress, health insurance, and substance use. The paper exploits Katrina as a unique natural disaster with destructive force not seen in generations. The

remainder of the paper is organized as follows: Section II provides a conceptual model, Section III provides information on hurricanes and the damage they can cause, Section IV describes the data, Section V articulates the empirical strategy, Section VI presents the results, shows evidence of causality, and shows evidence of perceived background risk as the causal mechanism, and Section VII concludes.

## II Conceptual Model

In a world of perfect information, individuals correctly estimate the probability of a disaster and FEMA’s ability to respond. In this state of the world, perceived background risk would not change with a large-scale disaster because the probability of this disaster would have been perfectly anticipated. However, Katrina may have been a source of new information about actual risks in a world of incomplete information, which would increase the level of perceived background risk.

Perceived background risk changes may reduce happiness and increase negative feelings such as stress because people feel more greatly threatened. I explore two potential responses to this decrease in happiness caused by increases in perceived background risk: obtaining insurance to reduce feelings of unease and to limit risk, and engaging in unhealthy behaviors in an attempt to self-medicate perceived background risk.

Individuals may attempt to self-medicate negative emotions from perceived background risk increases by using substances (Pesko and Baum 2014). Increases in financial risk as measured by unemployment have been associated with increases in smoking (Grafova 2011; Ayyagari and Sindelar 2010; Siahpush and Carlin 2006; Barnes and Smith 2009). An additional study found that increases in financial risk as measured by stock market shocks have been associated with increases in cigarette consumption and purchases, independent of other macroeconomic labor conditions (Cotti, Dunn, and Tefft 2014).

Increases in background risk have been found to encourage greater risk aversion in a va-

riety of contexts (Heaton and Lucas 2000; Gollier and Pratt 1996; Cameron and Shah 2013), thus explaining how Katrina-induced perceived background risk increases could increase the demand for health insurance. Demand for insurance may also increase to compensate for an increase in negative feelings. The Oregon Health Insurance study highlights the effect that new health insurance could have on reducing feelings of unhappiness. This study found that while few objective health measures improved because of eligibility for Medicaid (Baicker et al. 2013), this eligibility did increase self-reported happiness (Finkelstein et al. 2012) and decreased screening for depression (Baicker et al. 2013). The finding of increased happiness/reduced depression highlights how new or upgraded health insurance may directly sterilize a decrease in happiness observed after Katrina. However, not all individuals wishing to obtain or upgrade insurance will be able to do so because of prohibitive costs. For these individuals, negative feelings may persist.

One important limitation of this conceptual model is the possibility for new or upgraded health insurance to independently increase substance use because of moral hazard. My results suggest that health insurance responses were observed over a longer time period than substance use responses. Further, the substance use responses were comparatively larger. Both of these results suggest an effect of perceived background risk increases on substance use that is independent of health insurance moral hazard.

In sum, I explore the impact of perceived background risk increases stemming from Katrina on outcomes of negative emotions (hereafter referred to as stress), insurance, and substance use. I hypothesize that in response to Katrina, the level of actual risk predicted increases in perceived background risk, which in turn predicts stress. Insurance could be used to reduce this higher stress, but new or upgraded insurance will be unaffordable to some and for them increases in self-reported stress will remain. While demand for many forms of insurance (e.g. home, health) may increase, the form of insurance I explore in this paper is health insurance due to availability of this outcome in my primary data. Increases in perceived background risk from Katrina also increases substance use. In total, I explore the



influence of perceived background risk on four outcomes: stress, health insurance, smoking, and binge drinking. Individuals may use one or some combination of both strategies to reduce negative emotions from perceived background risk increases.

### III Background on Hurricane Risks

Hurricanes/typhoons are rapidly-rotating storm systems formed over water with sustained winds of at least 74 miles per hour. Storm surge poses the greatest risk from hurricanes and occurs when a column of water pushed inside and in front of the storm is released over land, causing hydraulic impacts and debris collisions far inland. Storm surge from Katrina was as high as 25-28 feet and pushed up to 20 miles inland. The United States is particularly vulnerable to storm surge, as much of the country's densely populated Atlantic and Gulf Coast coastlines are less than 10 feet above sea level (NOAA 2013). Further, residents may be unaware and uninsured against the dangers of coastal storm surge flooding because FEMA special flood hazard areas (SFHAs) are defined only for areas at-risk of fresh water flooding.<sup>1</sup> The percentage of homes in storm surge zones, but not in SFHAs, is greater than 50% for 11 of 14 major coastal metro areas (Botts et al. 2012). A secondary danger of hurricanes is wind damage, which can extend as far inland as Oklahoma, Arkansas, and Tennessee (Kaplan and Demaria 1995) and can spawn tornadoes. Hurricane-induced tornadoes are heavily concentrated in the immediate coastal areas and typically occur within 12 hours before to 48 hours after the hurricane makes landfall (Schultz and Cecil 2009).

Due to warmer climates and geographical considerations, southern coastal states are more prone to being hit by hurricanes than others. In the 10 years prior to Katrina, the states with more than two hurricane landfalls are Florida (9), North Carolina (6), and Louisiana (3). The states of Mississippi, South Carolina, Texas, and Virginia were each hit by one or two hurricanes during this time period. Prior to Katrina, the northeast states of New York,

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<sup>1</sup>SFHAs are defined by FEMA as areas with a 1% or greater chance of fresh water flooding in a given year. Since 1973, flood insurance has been required to purchase homes in the SFHA using a mortgage from a federally regulated or insured lender.

Connecticut, Massachusetts, and Rhode Island had not seen a hurricane since Hurricane Bob in 1991 (NOAA 2008).

## IV Data

### A Primary Data

The primary data are provided by the Behavioral Risk Factor Surveillance System (BRFSS). State health departments and the Centers for Disease Control and Prevention (CDC) collect these cross-sectional data on risky personal health behaviors via landline telephone surveys of individuals aged 18 years and older. Cell-phone only households are not included, which systematically excludes 8% of adults from participating in the survey in 2005 (Blumberg and Luke 2014). The data are nation- and state-representative of the non-institutionalized population. The data identify 100% of respondents' states and counties of residence and date of interviews, as well as a variety of socio-demographic characteristics including gender, race/ethnicity, age, education, employment/labor force participation, marital status, and income. For the primary analysis, I use data from 2004, 2005, and 2006, with Katrina roughly in the middle, on August 25, 2005. I also perform a sensitivity analysis by adding data from 2002 and 2003 to the pre-Katrina period, and find that baseline results and time trend parallelism changed little when using a longer pre-Katrina time trend. I use the shorter window of time for my primary analysis to reduce the computation burden.

Survey respondents are asked a standard question of recent emotional and mental distress: "Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?" These data are heavily rightward skewed, with 65.6% of individuals reporting having 0 days of stress and 4.8% reporting having 30 days of stress. The remaining 29.6% report integer values between 1 and 29.

For smoking, survey respondents are asked if they have smoked 100 or more cigarettes in

their lifetime and, if so, if they have smoked over the past 30 days. If the individual answers yes to both questions, then I classify them as a smoker. For binge drinking, individuals are asked if they have consumed 5 or more drinks on any one occasion over the past 30 days, but starting in 2006 this number was reduced to 4 or more drinks for women. For health insurance, individuals are asked: “Do you have any kind of health care coverage, including health insurance, prepaid plans such as HMOs, or government plans such as Medicare?”

Summary statistics for the raw data and population weighted data are reported in Appendix Table A1. Men, racial/ethnic minorities, and younger individuals are underrepresented in the raw data, so I use the population weighted data in all regression analyses. In the sample, from 2004 to 2006, 20.2% smoked, and 14.9% binge drank (all three defined over the course of 30 days). Health insurance was held by 83.9%. On average, individuals experienced 3.4 days of stress over the past 30 days.

## B Secondary Data

Data from the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) system are used to determine counties at-risk of storm surge depending on hurricane category strength.<sup>2</sup> I use these data to proxy increases in perceived background risk following Katrina, which I argue is correlated with actual risk. In addition to strength, this system takes into account land elevation, unique bay and river configurations, water depths, rainfall, and physical features such as bridges, roads, and levees. The SLOSH data were overlaid with county borders to determine for each category of hurricane if any part of the county was in the SLOSH plane. Coastal counties are always in the SLOSH plane, and in some areas the SLOSH plane extends deeper inland.

I use the inland wind decay model developed by Kaplan and DeMaria to identify counties outside of the storm surge region but potentially still vulnerable to wind damage, including

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<sup>2</sup>Hurricane categories operate on a scale of 1-5, with five being the worst. Upon landfall, Katrina was a strong category 3 hurricane. From 1851-2004, only three category five hurricanes have struck the United States, (NOAA 2008) although many, including Katrina, have been category 5 hurricanes at some point at sea.

tornado damage, from hurricanes (Kaplan and DeMaria 1995). This model takes into account increased penetration of dangerous wind speeds for stronger hurricanes, but it does not take into account the changing topography or other possible local factors that may affect wind speed. Similar to the SLOSH data, the wind data were overlaid with county borders to determine for each category of hurricane if any part of the county could be affected by strong gale strength wind damage of 47 miles per hour. This wind strength category was chosen because this is the point at which winds begin to cause structural damage. The wind data extend much further inland than in the SLOSH model and vary more greatly by hurricane category strength.

To avoid confounding from the actual disruption in the Katrina-impacted counties, two additional sources of data are used. The first identifies counties that received any federal assistance because of Katrina. These counties include all of Louisiana and Mississippi, west Alabama, and west and south Florida.<sup>3</sup> These counties are excluded from the analysis to avoid capturing disruption from the actual hurricane rather than changes in perceived background risk.

The second source is ZIP code-level FEMA application information for aid as of September 23, 2005, approximately one month after Katrina, providing evacuee information for 1.3 million applicants with valid ZIP codes in the continental United States. I was able to match 97% of these ZIP codes to a county.<sup>4</sup> In my preliminary analysis, confounding from migration is addressed using two mechanisms: 1) removing counties directly impacted by Katrina as measured by counties receiving federal disaster assistance, and 2) controlling in some specifications for FEMA applicants per capita in the post-Katrina period to address the possibility that influxes of evacuees caused changes in outcomes. I also confirm that the population composition did not change between hurricane risk regions in the post-Katrina period.

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<sup>3</sup>In route to striking New Orleans on August 29, 2005, Katrina struck the southern coast of Florida on August 25, 2005.

<sup>4</sup>For cases in which an applicant's ZIP codes overlapped two or more county borders, I partially assigned the application to each county depending on number of residential ZIP codes in each county.

A map showing counties at risk of storm surge and wind damage from a category 3 hurricane, as well as excluded directly impacted counties (that received federal disaster aid), is presented in Figure 1.

[Insert Figure 1]

Also shown in Figure 1 is six regions that I create from counties not impacted by Katrina and not vulnerable to storm surge or wind damage from hurricanes. I use these regions in later synthetic control group analysis.<sup>5</sup>

Other merged data are used to control for environmental differences. Cigarette price data from the Tax Burden on Tobacco (Orzechowski and Walker 2009) and smoke-free air law data from the ImpacTeen project were included in the smoking prevalence model. The American Chamber of Commerce Researchers Association (ACCRA) Cost of Living Index quarterly beer data were aggregated to the state level and was used as a proxy for alcohol prices<sup>6</sup> in the binge drinking model, along with pub smoking restrictions. All monetary values were deflated to 2004 dollars using the consumer price index, city average. Monthly state-level unemployment data are used to construct a state-level unemployment rate to control for spillover effects of unemployment beyond individual-level employment status.

## V Empirical Framework

In this paper, I test the conjecture that perceived background risk increases from Katrina led to stress, health insurance, and substance use increases in non-impacted, but vulnerable areas. In the most basic specification, I separately estimate the amount of stress, or the probability that an individual smokes, binge drinks, or is insured as a function of individual

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<sup>5</sup>Placebo regions include all or most of four census divisions, Pacific coastal counties (which may be unobservably correlated with Atlantic coastal counties that are at-risk of storm surge), and remaining counties not impacted by storm surge or wind damage from a category 3 hurricane.

<sup>6</sup>No price data are provided for New Hampshire and until 2006 for Maine, so these states are subset from the analysis in models of binge drinking. Additionally, Pennsylvania liquor control board restrictions result in the ACCRA prices being much higher than typical prices of beer purchased there (Ruhm et al. 2012), so I discard Pennsylvania as well in models of binge drinking.

controls and DD estimators for post-Katrina counties at risk to hurricanes. Using the BRFSS data and excluding counties directly impacted by Katrina, I estimate this preliminary model:

$$y_{irt} = \alpha + \beta_1 hurricane\_risk_r + \beta_2 post_t + \beta_3 hurricane\_risk_r * post_t + \beta_4 X_{irt} + \epsilon_{irt} \quad (1)$$

where  $y_{irt}$  is one of four outcomes. It is either equal to 1 if individual  $i$  living in region  $r$  at time  $t$  has health insurance, has smoked or binge drank in the past 30 days, or is equal to the number of days of stress over the past 30 days (outcomes analyzed separately).  $X_{irt}$  is a set of controls at the individual level: gender, race/ethnicity, household income, household income squared, top income category, age, age squared, education attainment, marital status, and employment status.  $Post_t$  is equal to 0 before the initial impact of Katrina in Florida in August 25, 2005, and is equal to one 15 days after this initial impact. I use a delay to minimize confounding from supply disruptions in the immediate aftermath of Katrina, which closed the Port of New Orleans for two weeks (Alexander and Irwin 2005).  $Hurricane\_risk_r$  includes three regions: non-impacted counties at-risk of storm surge from a category 3 hurricane, non-impacted counties at-risk of wind damage only from a category 3 hurricane, and control counties in the interior and west.<sup>7</sup> I hypothesize that individuals living in non-impacted counties vulnerable to storm surge experienced increases in stress, health insurance, and substance use following Katrina. Increases in the non-impacted storm surge counties are expected to be greater than increases in the non-impacted wind damage only counties because the relative risk is greater and perceived background risk increases should be larger. Utilizing two treatment groups with varying levels of hurricane risks, each of which is compared to the control group, presents an opportunity to test for internal model validity. In all regressions, survey weights are used and standard errors are clustered within

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<sup>7</sup>In later analyses I recalibrate results for category 1 and category 5 hurricanes.

states.<sup>8</sup>

I re-estimate (1) by adding environmental characteristics of state-level unemployment rates to all models, smoke-free air laws and after-tax cigarette prices to smoking models, and pub smoking restrictions and after-tax alcohol prices to binge drinking models. Following, I iteratively add state indicators and then month indicators. My baseline model is specified as:

$$y_{irstm} = \alpha + \beta_1 hurricane\_risk_r + \beta_2 post_t + \beta_3 hurricane\_risk_r * post_t + \quad (2) \\ \beta_4 X_{irstm} + \beta_5 environment_{st} + \zeta_s + \lambda_m + \epsilon_{irstm}$$

This specification allows me to exploit variation in outcomes within each state, as well as remove seasonal considerations in outcome variables. I found no evidence of heterogeneity within regions by month for these outcomes.

Finally, I estimate each model controlling for Katrina evacuees per capita at the county level in the post-Katrina period. This serves as a check for how sensitive my results are to migration from the impacted counties to the non-impacted counties.

I estimate the probability of smoking, binge drinking, and having health insurance with a logit model. For stress, I use a generalized linear model with a logarithmic link and a Gaussian variance function as chosen by the modified Park test for use with non-negative skewed dependent variables as recommended by Manning and Mullahy (2001). This modeling technique has been used in at least one substance use context to model conditional cigarette demand (Tauras 2006). I apply this modeling technique anew to the number of days that mental health is not good over 30 days. I convert all estimates to marginal effects to assist with interpretation (Buis 2010).

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<sup>8</sup>In all regressions I cluster standard errors using 794 unique clusters provided in the data. These clusters are perfectly nested within states. Since there can be heterogeneity in hurricane risk region within clusters, I also recalculated base model results by creating and using 1,150 unique clusters that are perfectly nested within states and hurricane risk regions. Standard errors remained virtually identical.

## VI Econometric Results

### A Associations

In all analyses, I exclude counties directly impacted by Katrina. The DD estimators for both the storm surge region and wind damage only region are provided for each of the four dependent variables (days of stress, smoking, binge drinking, and health insurance) across four different specifications that iteratively adds controls for socio-demographic characteristics, environmental characteristics, state indicators, month indicators, and a DD estimator for evacuees per capita. My variable of primary interest is the DD estimator for the storm surge region.

These preliminary results for stress and substance use outcomes are provided in Table 1. I initially regress socio-demographic controls and the DD estimators for the storm surge region and wind damage only region on stress in the first column. I show that Katrina was associated with 0.25 days of extra stress (7.4% of the mean) per 30 days in the storm surge region for the period from September 10, 2005 to the end of 2005. I next rule out the possibility that this increase in stress is associated with changing state-level unemployment rates after Katrina (column 2), time-invariant unobservables across states (column 3), and time-invariant unobservables for a given month (column 4). Finally, I find no effect of the number of evacuees per capita being associated with the increase in stress in the storm surge region (column 5). The coefficient on the DD estimator for the storm surge region remained stable across these five specifications. The finding that stress in the wind damage only region had insignificant coefficients roughly 20% of that in the storm surge region provides evidence of internal model validity, as I would not expect the coefficient in this region to be larger than that for the storm surge region due to the higher risks in the storm surge region.

[Insert Table 1]

For the two substance use dependent variables, I repeat the same sequence of estimations. For smoking and binge drinking, price data and smoking restriction data are included as en-



vironmental controls in addition to unemployment rates. Smoking prevalence was associated with Katrina in the non-impacted storm surge counties, increasing by 2.1 percentage points (10.2% of the mean) in the column 4 baseline specification. This effect was roughly three times greater than the insignificant coefficient in the wind damage only region, and remained consistent across the different specifications. Unlike smoking, I do not find evidence of an increase in binge drinking associated with Katrina when using all storm surge counties.<sup>9</sup>

I next turn to analyzing when and for how long increases in stress and smoking occurred. I first re-estimate Table 1 adding data from 2006 to observe if Katrina is associated with increases in stress and smoking through 2006. Due to the revision in how females are asked about binge drinking in 2006, I am unable to calculate a DD estimate for this outcome using the longer time horizon. I show in online Appendix Table A2 that there is no evidence of an association with stress or smoking in the 16 months following Katrina, suggesting that the association is temporary and stress and smoking return to baseline relatively quickly.

But how quickly? In online Appendix Table A3, I remove wind damage only counties and present a breakdown of the results for the first three quarters after the disaster. In my baseline specification Katrina was only associated with increases in stress and smoking in the storm surge region in the quarter immediately following the disaster. In Table 2, I further decompose the associations for the first 90 days after Katrina. I find that Katrina was associated with stress in only the first 30 day interval after Katrina (Sept. 9-Oct. 9, 2005). During this period of time, individuals in the storm surge region experienced nearly a half of an extra day of stress per 30 days (13.2% increase from the mean). Coefficients remain positive in periods 2 and 3, but decline to  $\frac{1}{5}$ th and then to  $\frac{1}{7}$ th of an extra day of stress, and these differences are no longer statistically significant. Smoking declined to baseline more slowly, potentially due to addiction, as statistically significant differences were observed in the first two 30-day intervals post-Katrina. Binge drinking did not increase in any of the first three months, consistent with earlier findings of no increase in the 4 months

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<sup>9</sup>In upcoming analyses, I demonstrate that binge drinking did substantively increase in storm surge counties with above the median surface area exposure to storm surge from hurricanes.

post-Katrina when using the full sample of storm surge counties. To answer how quickly stress and smoking returned to baseline, it appears that stress remained elevated for roughly one month and smoking for two.

[Insert Table 2]

Results for health insurance are presented in Table 3. I separately explore results in both the 4 month (i.e. 2004-2005 sample) and 16 month (i.e. 2004-2006 sample) period after Katrina because many health insurance contracts are active for a year or longer. This structural feature of health insurance contracts may contribute to measuring observed changes in health insurance coverage over a longer period of time. DD estimators for four months after Katrina are presented in panel A and sixteen months after Katrina are presented in panel B. The baseline specification (column 4) suggests that coverage increases by 1.0 percentage points (1.2% from the mean) in the storm surge region relative to the control region in both the 4 month and 16 month period after Katrina, although this difference is only significant across all specifications in the longer term.<sup>10</sup> The coefficient is also positive, but smaller, for the wind damage only region. Katrina may have encouraged individuals residing in non-impacted vulnerable counties to newly obtain health insurance or not allow existing health insurance coverage to lapse.

[Insert Table 3]

I stratify health insurance results by age. Most United States citizens 65 and older have access to government-provided health insurance through Medicare, so I do not expect changes to occur within this population in response to Katrina. Young adults, however, are the population least likely to be insured and so changes in their demand for health insurance could lead to more uptake of parent's employer sponsored insurance, purchases made on the open market, or migration to employment with health insurance benefits. In online Appendix

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<sup>10</sup>The association is significant in the 4 month post-Katrina period when state and month indicators are not used.

Table A4, I present a breakdown of the health insurance results for age categories of 18-30, 31-64, and  $\geq 65$ . I find that in the four months after Katrina, Katrina was associated with a self-reported health insurance coverage increase of 3.2 percentage points (4.5% of the mean) in the storm surge region relative to the control region for the 18-30 year old population. This is in comparison to an insignificant increase of 0.2 percentage points for the other two age groups. In sum, it appears from this analysis that Katrina was associated with an immediate increase in health insurance coverage among young adults  $\leq 30$  years of age residing in the storm surge region compared to the control region.

In these results, level of perceived background risk has been explored by comparing effects in regions of different hurricane risks: storm surge counties, wind damage only counties, and control counties. I further explore the influence of perceived background risk on these results by excluding the wind damage only counties and dividing storm surge counties into a high-exposure group with above the median surface area exposure to storm surge from hurricanes (7.2%). Surface area exposure is an imperfect measure of risk because it does not capture where individuals actually live, work, and visit, which may be disproportionately clustered in or out of the storm surge plane. Nevertheless, to the extent that residents are equally dispersed throughout a county, a high amount of the county being vulnerable to storm surge is predicted to increase perceived background risk for more people.

In the baseline specification (column 4), stress increased by  $\frac{1}{3}$ rd of an extra day per 30 days (9.8% of the mean) in counties with high surface area exposure to hurricanes. Smoking increased by roughly similar percentage points in both regions. Binge drinking is also found to increase in high risk counties by 2.1 percentage points (14.1%). Health insurance increased by 1.3 percentage points (1.6% of the mean) in the high exposure storm surge counties in the 4 months after Katrina and by 1.4 percentage points (1.7% of the mean) in the 16 months after Katrina, although is only statistically significant in the latter case. Outside of smoking, these results suggest that responses were larger in the high exposure storm surge counties than in the low exposure storm surge counties. This provides evidence that larger risk (which

may be correlated with perceived background risk) is associated with larger stress, health insurance, and substance use responses.

[Insert Table 4]

Katrina was associated with substantive increases in stress, health insurance, and substance use. Approximately 44.4 million adults lived in the storm surge counties in 2005, so estimates suggest that these individuals experienced a total of 19.8 million days of extra stress in the first 30 days. Approximately 440,000 young adults were insured for at least a year that would not otherwise have been. Approximately 930,000 individuals smoked in the first quarter than would have if Katrina had not occurred. Binge drinking increased in high exposure storm surge counties by 510,000 individuals. While these substance use effects were short-lived, in the conclusion I discuss how even short-term smoking may have life-threatening consequences for both smokers and others.

## B Causal Evidence

A key assumption in a DD model for claims of causality is that the event must be uncorrelated with pre-existing differences in outcome trends. If this assumption is violated, then the DD estimators will be biased. I test for this by estimating (3) using a flexible functional form for time, 13 quarters from 2004 to 2006,<sup>11</sup> and controlling for socio-demographic characteristics, time varying controls, and time invariant state and month characteristics. In particular, I estimate:

$$y_{irstm} = \alpha + \beta_1 hurricane\_risk_r(D_{t-7} + \dots + D_0 + \dots + D_{t+6}) + \beta_2 X_{irstm} + \beta_3 environment_{ist} + \zeta_s + \lambda_m + \epsilon_{irstm} \quad (3)$$

Following, I examine the joint significance of the interactions between the regions and the

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<sup>11</sup>I divide the 3rd quarter of 2005, when Katrina made landfall, into two separate quarters.

quarters in the pre-Katrina period to determine if the parallel time trends assumption is violated.

The parallel time trends assumption is met for all outcomes. Results available in online Appendix Table A5 show that smoking and health insurance coverage were not different between the storm surge region and control region in the pre-Katrina period in any quarter (compared to the first quarter) or jointly (i.e. across all quarters). Stress was different in one quarter (compared to the first quarter), and binge drinking in four quarters, but joint tests of significance found that the time trends were not jointly different for any outcome across these two regions in the pre-Katrina period. In results available upon request, I also redid the time trend analysis excluding wind damage only counties and dividing storm surge counties into groups with above and below the median of storm surge surface area exposure and again found that the time trend did not differ in the pre-Katrina period. Results were identical for both analyses when using a period of 2002-2006, with the exception that health insurance also had a divergent time trend. A linear regression of the coefficients suggests that health insurance declined over the longer pre-Katrina period in the storm surge region relative to the control region, which underestimates the causal effect.

Graphical evidence from (3), replacing quarter time intervals with month time intervals, is provided in Figure 2. To produce this graph, I first subtracted the predicted value for the storm surge region from the predicted value for the control region for each month for each outcome. Following, to standardize these predicted value differences, I subtracted the predicted value means and divided by the predicted value standard deviations. Spikes in the outcomes can be interpreted as that outcome being relatively large in the storm surge region relative to the control region.

[Insert Figure 2]

The graphical evidence shows discontinuous increases for stress, health insurance, and substance use responses in the storm surge region relative to the control region following Katrina. The differences appear to decay relatively quickly for stress and less quickly for

smoking and health insurance coverage. The graphical evidence also suggests a temporary increase in stress in the pre-period in the treatment region relative to the control region. As shown in online Appendix Table A5, I did not find the trends in the pre-period statistically significant different between the treatment and control regions, but any increase in the treatment region would have the effect of biasing difference-in-difference estimates towards the null of no effect. However, binge drinking is not displayed on this graph for 2006 because of the question wording change affecting women, but in online Figure 1, I provide graphical evidence for women in 2004-2005 and for men in 2004-2006. This graph suggests that the response following Katrina was similar for both women and men in 2005, and for men the temporary increase in binge drinking subsided four months after Katrina. This graphical evidence suggests that stress declined to baseline first, followed by substance use a few months later. Health insurance coverage remained elevated throughout the study period.

Another key assumption for valid inference is that observable population characteristics for each region should not diverge between the pre-Katrina period and the post-Katrina period. Table 5 provides results testing for possible divergence in the post-Katrina period in observable characteristics (e.g. gender, race/ethnicity) between the different hurricane risk regions. In 14 tests that I performed across post-Katrina periods of 4 months and 16 months, only one socio-demographic group exhibits statistically significant changes between the regions after Katrina at a 10 percent level.<sup>12</sup> This is within the range that can be expected from random chance. It appears that excluding counties directly impacted by Katrina has provided a stable population across remaining regions after Katrina,<sup>13</sup> therefore meeting a key assumption for DD modeling and suggesting that evacuees did not disproportionately move into any region.

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<sup>12</sup>In the 16 months after Katrina, results suggest that an increase in Asian Americans and individuals with missing race/ethnicity in the storm surge region relative to other regions contributed to the significant change of race/ethnicity at a 10 percent level. I am unaware of any reason for this population to have increased its presence in the storm surge region following Katrina, so assume that this is a Type 1 error.

<sup>13</sup>When non-impacted counties are not excluded and included as their own region, this test fails for race/ethnicity in the 4 months after Katrina, and for race/ethnicity, education and employment in the 16 months after Katrina. Excluding directly impacted counties, which I do in all analyses, is important for addressing confounding from migration.

[Insert Table 5]

In a later section, I investigate the possibility of Katrina evacuees affecting the composition of the hurricane risk regions in ways that lead to spurious results. I remove all counties within 400 miles of New Orleans, including Houston, which sheltered an unusually high number of evacuees. I find that my results are unaffected by using this more restrictive sample.

I perform two sets of falsification exercises. The first uses a date of Katrina of one year prior. If there are any differential time trends between the storm surge and wind damage only counties and control counties, then I may observe significant, spurious effects in the year prior to Katrina. The results are presented in online Appendix Table A6 and suggest that the model passes the test for the storm surge region, with none of the coefficients statistically significant. However, there is evidence that the time trend for stress may be different between the wind damage only region and the control region. This finding is not particularly troublesome given that I use the wind damage only counties solely as a validity check on my main results of interest for the storm surge counties.

For a second falsification exercise, I perform a synthetic control group analysis (Abadie, Diamond, and Hainmueller 2010). I adopt this methodology for use with survey data. The idea behind the synthetic control method is that a combination of units often provides a better comparison for the unit exposed to the intervention than any single unit alone. I used survey data and control variables of socio-demographic characteristics, environmental characteristics, and state indicators to produce predicted values for each dependent variable in each month in each of seven regions.<sup>14</sup> I used all 20 pre-Katrina lagged levels of the predicted values for the outcome as matching variables and constructed a synthetic control group to calculate a DD estimate for the storm surge region. Following this, I perform a

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<sup>14</sup>These regions are presented in the bottom of Figure 1 and include non-impacted storm surge counties, four census divisions, Pacific coastal counties, and remaining counties that were not impacted by Katrina and are not vulnerable to storm surge or wind damage from a category 3 hurricane. I use regions rather than state because of a heavy computation burden in producing risk adjusted monthly predicted values for all states.

series of placebo studies by iteratively applying this same process to estimate the effect of Katrina in each of the other six regions previously used in the donor pool.<sup>15</sup> That is, I proceed as if individuals living in other regions, rather than the storm surge region, had reason to suddenly increase stress, health insurance, and substance use responses following Katrina. This iterative procedure produces estimated effects of Katrina in each region. I hypothesize that the estimated effect should be largest in the storm surge counties compared to the placebo regions.

Results from the synthetic control group analysis for all storm surge counties (Table 6, panel A) are in line with baseline results.<sup>16</sup> Stress was found to increase to 0.19 days per 30 days in storm surge counties using the synthetic control group analysis compared to 0.23 days per 30 days in baseline results. Smoking increased to 2.6 percentage points (compared to 2.1), binge drinking to 1.0 percentage points (compared to 1.0), and health insurance coverage to 1.3 percentage points (compared to 1.0). The effect sizes in the storm surge counties were the largest for all outcomes except stress, where the effect size was the second largest. This means that only 1 falsification exercise out of 24 failed (4.2%). Also of comfort is that except for the storm surge counties, there is no discernible pattern of effect sizes being larger or smaller in any one region in particular.

[Insert Table 6]

In line with earlier estimates, effect sizes are larger in counties with greater storm surge surface area exposure (Table 6, panel B). I redo the synthetic control group analysis excluding counties with less than or equal to the median surface area exposure. In high exposure counties, stress now increases 0.35 days per 30 days, smoking 3.4 percentage points, binge drinking 2.4 percentage points, and health insurance coverage to 1.4 percentage points. For all four outcomes effect sizes in the high exposure storm surge region are the largest, meaning that 0 out of 24 falsification exercises fail.

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<sup>15</sup>The storm surge region is added to the donor pool for these placebo analyses.

<sup>16</sup>Baseline results refer to column 4 in Table 1 for stress, smoking, and binge drinking, column 4 in Table 3, panel A for health insurance, and all results in Table 4 for high exposure storm surge counties.



Finally, in online Appendix Table A7, I check the sensitivity of my baseline results to using a longer pre-Katrina time trend starting in 2002. Stress was found to increase to 0.30 days per 30 days in storm surge counties using the longer pre-Katrina time trend compared to 0.23 days per 30 days in baseline results.<sup>17</sup> Smoking increased to 2.6 percentage points (compared to 2.1), binge drinking to 0.7 percentage points (compared to 1.0), and health insurance coverage to 1.0 percent points (unchanged from before). In sum, using a longer pre-Katrina time trend results in a strengthening of the effect size for stress and smoking, and an attenuation of the effect size for binge drinking, but coefficients do not change dramatically.

Taken together, these results suggest that associations reported earlier for stress, smoking, binge drinking, and health insurance exhibit evidence of causality. Parallel time trends appear to be met by finding that a flexible functional form for time did not vary across regions in the pre-Katrina period, and falsification exercises provide additional assurances. I find no evidence of a changed population composition after Katrina.

## C Mechanism

I now turn to providing evidence that perceived background risk mediates the impact of Katrina on the demand for stress, health insurance, and substance use. I go beyond efforts I made when constructing the model to avoid confounding economic disruption and actual risk, which is correlated with perceived background risk. Media attention may have contributed to individuals that live in counties vulnerable to hurricanes to focus on being harmed by a future hurricane rather than on the small probability of this occurring (Sunstein 2003). Economists have also found evidence for the substantial overweighting of small probabilities in deductible choices for home and auto insurance (Barseghyan et al. 2013).

Flood and home insurance rates may increase (with some delay) after Katrina. These greater costs, rather than perceived background risk, could be the mechanism explaining the increase in stress. As shown in Table 2, the data suggests increases in stress in the first 30

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<sup>17</sup>This coefficient is now significant at the 5% level compared to a 10% level found using the 2004-2005 time period.

days after Katrina, but not in subsequent days. Flood and home insurance rates were unlikely to adjust so quickly. Assuming that potential increases in flood and home insurance rates were not anticipated, the immediate and short-term stress increase suggests that perceived background risks rather than flood and home insurance rates are the mechanism underlying the increase in stress.

I next remove counties within 400 miles from New Orleans. These counties arguably have stronger economic ties with New Orleans than counties further away, and so post-Katrina responses in these areas may be associated with changes in economic climate rather than changes in perceived background risk. Since directly impacted counties are already excluded, this additional restriction removes some counties in Texas and Florida that are nearer to New Orleans, as well as some wind damage only and control counties. Included in this removal is Houston, which as of May 2006 still had 153,000 Katrina evacuees, 15 times more than any other Texas city (Pullin 2006). The primary purpose of this test is to observe if results are strongly influenced by counties with stronger economic ties to New Orleans, a major shipping city, which would suggest that economic disruption is a mechanism underlying the relationship between Katrina and outcomes.<sup>18</sup>

Results in Table 7 are largely unchanged from baseline results. To the extent that economic disruption is correlated with proximity to New Orleans after Katrina, this finding provides evidence that economic disruption is not driving the observed stress, health insurance, and substance use responses.

[Insert Table 7]

I perform another test that compares responses in areas of differential risk by removing

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<sup>18</sup>Many of the counties with large numbers of evacuees and arguably stronger economic ties are already excluded from the analysis because they were directly impacted by Katrina. Further, most of the economic disruption occurred in the immediate days after Katrina, and I already exclude the first 15 days from the analysis. DD estimators are independent of state-level unemployment rates and individual employment status. Finally, results hinging on economic disruption or migration would require either to be disproportionately larger in the storm surge region compared to the control region. In particular, it seems unlikely that economic disruption in the storm surge region was greater considering that the storm surge region has greater availability of other ports and less reliance on the Mississippi River than the control region.

the wind damage only counties and testing for heterogeneity in responses to Katrina by hurricane probability regions. This adds to the tests I performed earlier comparing responses in storm surge areas to wind damage only areas, and comparing responses in counties with greater surface area exposure to those with less exposure. To perform this test, I divide the storm surge counties into a region south of, and including, North Carolina and a region north of, and including, Virginia.<sup>19</sup> If perceived background risk is a mechanism through which Katrina affects outcomes, then I expect to find larger responses in the southern region with a higher probability of any hurricane.<sup>20</sup>

Table 8 supports this theory. The DD estimators in models of stress, smoking, and binge drinking are larger in southern storm surge counties, the region with a greater chance of any hurricane in a given year, than in the north. The coefficients on stress, smoking, and binge drinking are respectively 1.5, 2.2, and 2.5 times larger in the southern regions. These differences became larger when I removed counties with below the median surface area exposure. However, in both regions the increase in health insurance does not display this same variation depending on hurricane probability region, remaining near the one percentage point increase range observed in the baseline results. Taken together, these results provide evidence that perceived background risk is a possible mechanism through which Katrina affects stress, smoking, and binge drinking.

[Insert Table 8]

One source of omitted variable bias that could affect the observed increase in health insurance coverage is policy changes increasing health insurance eligibility; for example, states expanding their public health insurance programs. Health insurance effect sizes are estimated independent of individual-level employment status, student status, and state-level

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<sup>19</sup>After excluding Louisiana and Mississippi, these southern states have experienced 81% of all hurricane landfalls of any category strength, and 83% of all hurricane landfalls of category 3 and higher strength (Tropical Meteorology Project).

<sup>20</sup>This test assumes that Katrina was unique and individuals living in the southern region, which is more frequently struck by hurricanes, still learned new information from Katrina. If hurricane experience in the southern region attenuates stress, health insurance, and substance use increases, this will bias coefficients toward the null in this region. Despite this possibility, I find larger effects in the southern region.

unemployment rates, hence removing changes in these factors as contributors to the increase in health insurance coverage. Between July 2005 to July 2006, Colorado, Maine, and New Jersey increased their income eligibility for low-income families, and Virginia and Nevada increased their eligibility for pregnant women (Kaiser Family Foundation 2007). In Table 8, I observe a 1.0 percentage point increase in health insurance in the region North Carolina and South that did not have a state expanding their Medicaid programs, which is identical to the baseline result in Table 3. The identical effect size suggests that health insurance coverage increased independent of expanding public health insurance programs in select states.

Additionally, I test if perceived background risk mediates the relationship between Katrina and outcomes by recalibrating the model and comparing results for category 1 and 5 hurricanes instead of a category 3 hurricane. While the percentage of individuals residing in the storm surge region for a category 1 or 5 hurricane changes little (from 19.9% to 20.2%), the percentage of individuals residing in the wind damage only counties varies greatly (14.1% to 29.6%) due to wider reach of wind damage from hurricanes. The number of control counties are reduced when the wind damage only counties increase, so DD estimators in this sensitivity analysis are calculated using different control counties. If perceived background risk is a mechanism through which Katrina affects outcomes, then I would expect the DD estimators to be larger for a category 5 hurricane than for a category 1 hurricane, as well as larger in the storm surge region than in the wind damage only region.

Results from this sensitivity analysis are presented in Table 9. Regardless of hurricane category strength, results are broadly consistent with baseline findings. For all four outcomes, the DD estimate becomes larger for the category 5 storm surge region compared to the category 1 storm surge region. This provides additional evidence that perceived background risk is a mechanism underlying the causal relationship between Katrina and outcomes.

[Insert Table 9]

In one final sensitivity analysis, I explore if destruction from other hurricanes occurring during the busy 2005 Atlantic hurricane season is a source of omitted variable bias influencing

earlier results. Two hurricanes made landfall after Katrina in 2005—Hurricane Rita in Louisiana and Texas on September 24, and Hurricane Wilma in Florida on October 24. Similar to how I removed counties receiving any FEMA disaster aid assistance due to Katrina, I also remove counties receiving any disaster aid assistance due to these other hurricanes. Results are presented in Table 10 and are similar to baseline results in Tables 1, 3, and 4. The coefficient on binge drinking in the high exposure region was attenuated somewhat, from a 2.1 percentage point increase in Table 4 to a 1.7 percentage point increase excluding Hurricane Rita and Wilma counties, and this effect is no longer statistically significant. Outside of this, there are no other substantial differences from excluding Hurricane Rita and Wilma counties.

[Insert Table 10]

I provide evidence that perceived background risk is a possible mechanism through which Katrina affects stress, substance use, and health insurance. I exploit disproportionate risks from hurricanes by considering: 1) storm surge versus wind damage only, 2) storm surge counties with high versus low surface area exposure to hurricanes, 3) hurricane category strengths with larger as opposed to smaller impacts, and 4) regions with higher versus lower probabilities of any hurricane. With few exceptions, these results suggest that when “risk” is increased, so are the effect sizes on outcomes of stress, smoking, binge drinking, and health insurance. This points to perceived background risk as a possible mechanism since perceived background risk may have increased post-Katrina in areas with actual objective risk, and differentially based on the level of the objective risk. Further, other possible mechanisms such as uncontrolled migration and economic considerations do not appear to drive the results to the extent that these are correlated with distance from New Orleans (within 400 miles). In sum, there is evidence that perceived background risk changes for individuals residing in non-impacted areas with hurricane risks mediate the causal relationship between Katrina and outcomes.

## VII Conclusion

This study uses an unprecedented large-scale disaster, Katrina, as a natural experiment to study how increases in perceived background risk affect stress, health insurance, and substance use. A DD analysis is used to exploit differences in risks from hurricanes across counties of residence. I find causal evidence that Katrina increased stress in storm surge counties compared to the control counties by 6.8%, smoking by 10.2%, and binge drinking in the highly vulnerable storm surge counties by 14.1%. Health insurance increased by 1.2% in the 16 months following Katrina in the storm surge region, contributing to an estimated 440,000 young adults holding health insurance for at least a year that would not otherwise have been insured.

The effects of Katrina on stress, smoking, and binge drinking appear to have been short-lived; nevertheless, even short-term use of these substances has health consequences and negative externalities according to a report issued by Doe and colleagues (2009). Smoking immediately increases blood pressure, heart rate, and constricts blood vessels, leading to increased risk for sudden strokes and myocardial infarction. Additionally, smoking immediately increases susceptibility to pneumonia. Smoking and second-hand smoke interferes with drug breakdown processes for certain blood-thinners, antidepressants, and anti-seizure medications, causing prescription drugs to not work as effectively and for drugs to potentially stay in the body at dangerous concentrations for longer. Finally, infants and children are especially susceptible to secondhand smoke exposure, so temporary smoking may have affected outcomes of birth weight, sudden infant death syndrome, and infant middle ear and respiratory infections (Doe et al. 2009). Impaired driving is a possible consequence of short-term increases in binge drinking.

It appears that perceived background risk is informative in increasing demand for health insurance among young adults. With the Affordable Care Acts' emphasis on enrolling individuals, in particular young adults, into health insurance plans on a voluntary basis, results from this study suggest that an effective strategy for motivating young adults to enroll may

be to alter perceived background risk by focusing on actual risks, such as risks of not being insured and from natural disasters.

Research suggests that the most effective government response to the public's miscalculating of small probabilities may be information and education (Becker and Rubinstein 2011; Sunstein 2003). An example of a benefit of information and education is that following a Mississippi River flood, home prices fell only in flooded areas outside the SFHA, but prices did not fall in the SFHA. This may have been because individuals in the SFHA were more likely to know of flooding risks *ex-ante* because of notification and insurance requirements, and so home prices already reflected accurate background risk (Carolyn 2010). Similarly, stress, health insurance, and substance use responses to Katrina may not have been as dramatic if individuals were better informed of accurate risks in advance. Mandating notification for home owners and renters living in the storm surge plane similar to the notification individuals receive when living in SFHAs may help prevent sudden stress, health insurance, and substance use responses to unusually destructive hurricanes.

Studying the simultaneous relationships among explored and omitted responses to large-scale disasters may be a ripe area for future research. In this study, I did not attempt to disentangle how outcomes may have impacted each other. For example, while I calculate the causal impact that Katrina had on stress in the treatment region, this effect may have been greater if individuals did not reduce risk with health insurance purchases or self-medicate with substances. Similarly, increased smoking following Katrina may precipitate increased binge drinking, and health insurance and substance use may impact each other. I also cannot rule out the possibility that other outcomes affected by post-Katrina perceived background risk changes influence the results for the outcomes that I do document; for example, property values may have declined in the storm surge region in response to Katrina, driven by changes in perceived background risk, and that contributed to changes in my observed outcomes. It is worth noting that due to possible simultaneous relationships, a policy option affecting any one behavioral health response could have spillover effects on others. It is also worth noting

that possible simultaneous relationships do not affect my primary conclusion that Katrina increased stress, health insurance, and substance use in substantive ways in non-impacted areas vulnerable to future hurricanes.

The results of this study provide evidence that perceived background risk increases impact stress, health insurance, and substance use. Natural disasters are only one example of something that can alter perceived background risk. Crime and terrorism affect background risk on a macro-level, and on a micro-level so do employment and relationships. Perceived background risk stemming from these risks may also have large-scale secondary effects.



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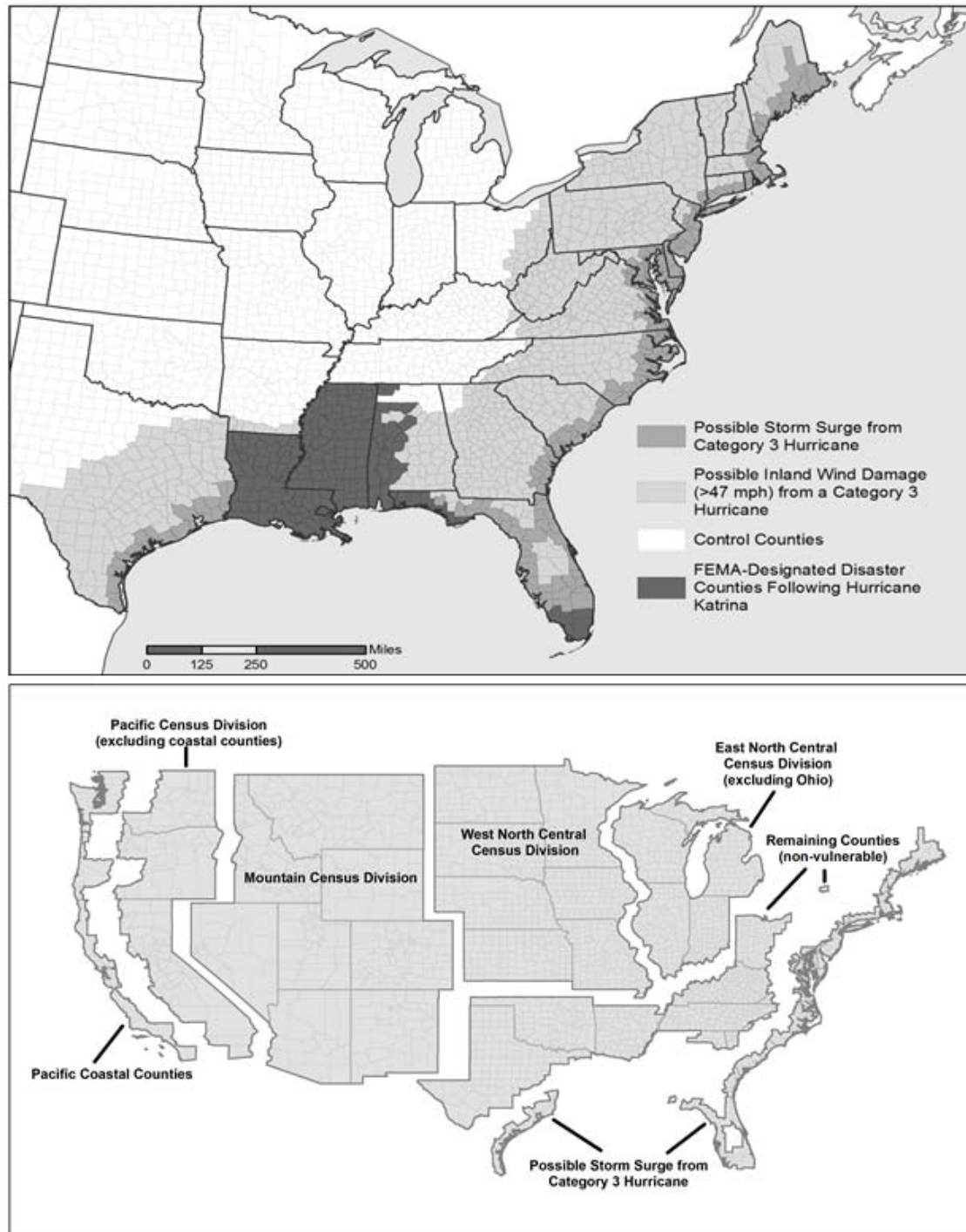


FIGURE 1. HURRICANE RISK REGIONS, DIRECTLY IMPACTED COUNTIES, AND SYNTHETIC CONTROL REGIONS

*Notes:* The storm surge counties are identified using the Sea, Lake, and Overland Surges from Hurricanes (SLOSH) system maintained by the National Oceanic and Atmospheric Administration. The wind damage only counties are identified as counties outside of the storm surge region that are vulnerable to strong gale strength wind speeds of 47 MPH from hurricanes (Kaplan and DeMaria 1995).

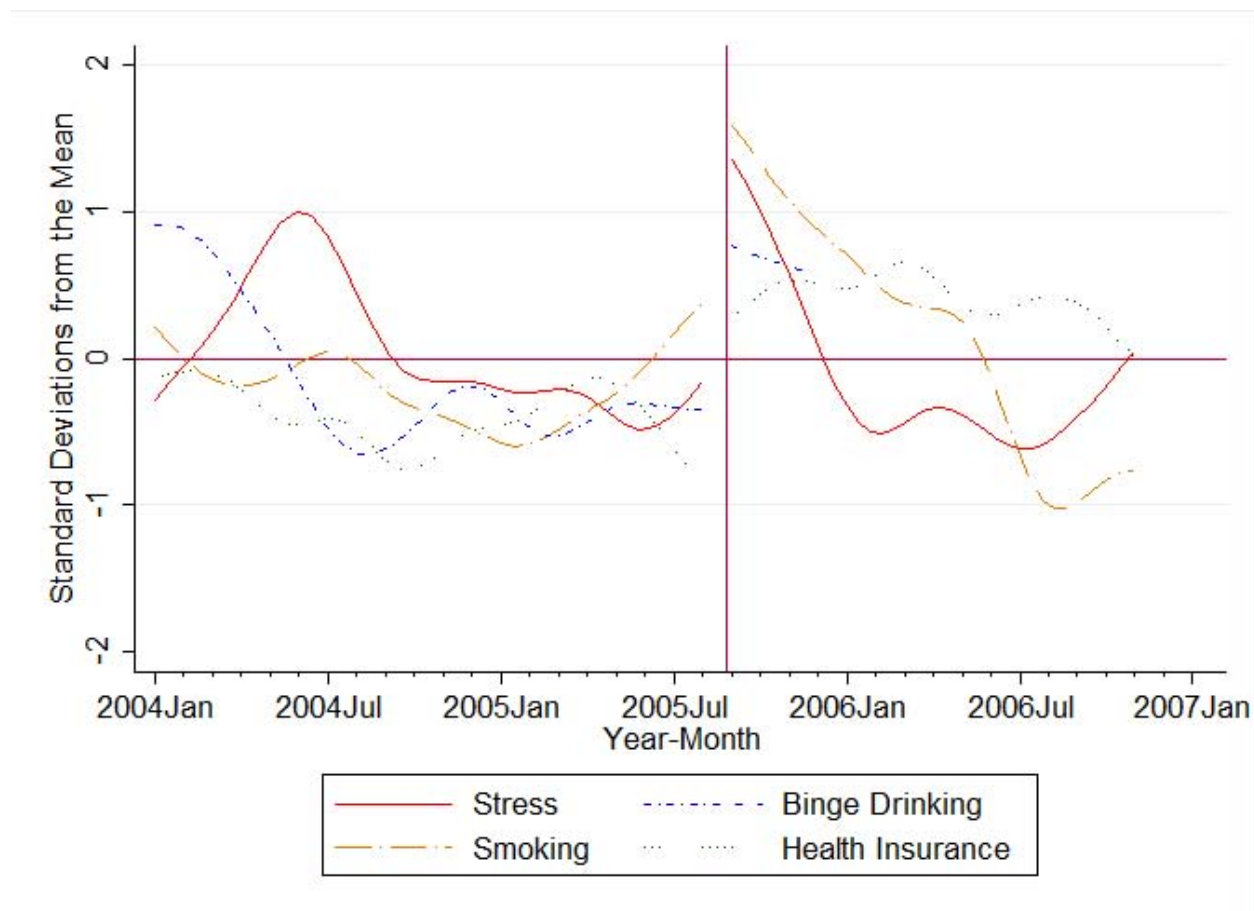


FIGURE 2. ADJUSTED DIFFERENCE BETWEEN STORM SURGE REGION AND CONTROL REGION

*Notes:* This graph shows local polynomial smoothed plots (bandwidth of 1.5) of the differences in predicted values between the storm surge region and the control region. A spike represents an increase in the storm surge region relative to the control region. The data are risk-adjusted with socio-demographic characteristics, environmental characteristics, and state indicators. The outcomes are standardized by subtracting the predicted value means and dividing by the predicted value standard deviations. The vertical line is the date of Hurricane Katrina.

TABLE 1—STRESS AND SUBSTANCE USE, 2004-2005

	Stress (mean=3.395)									
	(1)	(2)	(3)	(4)	(5)					
(1) Storm Surge Region x Post	0.249*	0.245*	0.251*	0.232*	0.252*					
	(0.144)	(0.145)	(0.141)	(0.141)	(0.141)					
(2) Wind Only Region x Post	0.050	0.046	0.054	0.038	0.060					
	(0.118)	(0.119)	(0.117)	(0.117)	(0.118)					
(3) Evacuees Per 1,000 x Post					-0.028					
					(0.030)					
Difference between (1) and (2)	0.199	0.199	0.197	0.195	0.192					
N			584,986							
Socio-demographic Characteristics	Yes	Yes	Yes	Yes	Yes					
Environmental Characteristics	No	Yes	Yes	Yes	Yes					
State Indicators	No	No	Yes	Yes	Yes					
Month Indicators	No	No	No	Yes	Yes					
Evacuees per Capita	No	No	No	No	Yes					
	Smoking (mean=0.206)					Binge Drinking (mean=0.146)				
	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)
(1) Storm Surge Region x Post	0.021***	0.022***	0.022***	0.021***	0.021***	0.010	0.011	0.010	0.010	0.011
	(0.008)	(0.008)	(0.007)	(0.007)	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
(2) Wind Only Region x Post	0.007	0.009	0.008	0.007	0.007	0.010	0.012*	0.010	0.011	0.012
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
(3) Evacuees Per 1,000 x Post					0.000					-0.001
					(0.002)					(0.001)
Difference between (1) and (2)	0.014*	0.013	0.014*	0.014*	0.014*	0.000	-0.001	-0.001	-0.001	-0.001
N			592,839					550,573		
Socio-demographic Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Environmental Characteristics	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
State Indicators	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Month Indicators	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Evacuees per Capita	No	No	No	No	Yes	No	No	No	No	Yes

*Notes:* This table presents marginal effects of DD estimators compared to the reference category of post x control region. Stress is estimated using GLM with a log-link and Gaussian distribution, and the other outcomes are estimated using logit. Survey data are used for all results and standard errors are clustered at the sub-state level. Additional parameter estimates are provided for the baseline specification, column 4, in online Appendix Table A1. \*\*\* Significant at the 1 percent level. \*\* Significant at the 5 percent level. \* Significant at the 10 percent level.

TABLE 2—STRESS AND SUBSTANCE USE IN 30 DAY INTERVALS

	Stress	Smoking	Binge Drinking
	(1)	(2)	(3)
(1) Storm Surge Region x Period 1	0.446* (0.254)	0.026** (0.012)	0.007 (0.014)
(2) Storm Surge Region x Period 2	0.185 (0.264)	0.023* (0.013)	0.008 (0.014)
(3) Storm Surge Region x Period 3	0.145 (0.251)	0.008 (0.013)	0.017 (0.014)
Difference between (1) and (2)	0.261	0.003	-0.001
Difference between (1) and (3)	0.301	0.018	-0.010
N	449,540	455,305	439,862
Mean	3.379	0.202	0.149
Socio-demographic Characteristics	Yes	Yes	Yes
Environmental Characteristics	Yes	Yes	Yes
State Indicators	Yes	Yes	Yes
Month Indicators	Yes	Yes	Yes

*Notes:* This table presents marginal effects of DD estimators compared to the reference category of period x control region. Stress is estimated using GLM with a log-link and Gaussian distribution, and the other outcomes are estimated using logit. Survey data are used for all results and standard errors are clustered at the sub-state level. Results are similar when controlling for evacuees per 1,000, and are available upon request. Period 1 = Sept. 9, 2005 - Oct. 8, 2005. Period 2 = Oct. 9, 2005 - Nov. 7, 2005. Period 3 = Nov. 8, 2005 - Dec. 7, 2005. \*\*\* Significant at the 1 percent level. \*\* Significant at the 5 percent level. \* Significant at the 10 percent level.



TABLE 3—HEALTH INSURANCE

	Health Insurance (mean=0.838)				
	(1)	(2)	(3)	(4)	(5)
Panel A. <i>2004-2005 sample</i>					
(1) Storm Surge Region x Post	0.013*	0.013*	0.010	0.010	0.011
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
(2) Wind Only Region x Post	0.008	0.008	0.005	0.005	0.006
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
(3) Evacuees Per 1,000 x Post					-0.001
					(0.001)
Difference between (1) and (2)	0.005	0.005	0.005	0.005	0.005
N			595,084		
Socio-demographic Characteristics	Yes	Yes	Yes	Yes	Yes
Environmental Characteristics	No	Yes	Yes	Yes	Yes
State Indicators	No	No	Yes	Yes	Yes
Month Indicators	No	No	No	Yes	Yes
Evacuees per Capita	No	No	No	No	Yes
Panel B. <i>2004-2006 sample</i>					
	Health Insurance (mean = 0.839)				
	(1)	(2)	(3)	(4)	(5)
(1) Storm Surge Region x Post	0.010**	0.010**	0.009**	0.010**	0.011**
	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
(2) Wind Only Region x Post	0.008**	0.008*	0.006	0.007*	0.008**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
(3) Evacuees Per 1,000 x Post					-0.001
					(0.001)
Difference between (1) and (2)	0.002	0.002	0.003	0.003	0.003
N			916,932		
Socio-demographic Characteristics	Yes	Yes	Yes	Yes	Yes
Environmental Characteristics	No	Yes	Yes	Yes	Yes
State Indicators	No	No	Yes	Yes	Yes
Month Indicators	No	No	No	Yes	Yes
Evacuees per Capita	No	No	No	No	Yes

*Notes:* This table presents marginal effects of DD estimators compared to the reference category of post x control region. The outcomes are estimated with logit. Survey data are used for all results and standard errors are clustered at the sub-state level. Additional parameter estimates are provided for the baseline specification, panel A column 4, in online Appendix Table A1. \*\*\* Significant at the 1 percent level. \*\* Significant at the 5 percent level. \* Significant at the 10 percent level.

TABLE 4—HIGH EXPOSURE COUNTIES, 2004-2005

	Stress	Smoking	Binge Drinking	Health Insurance
	(1)	(2)	(3)	(4)
(1) >Median Exposed Storm Surge Land Area x Post	0.331* (0.189)	0.018** (0.009)	0.021** (0.010)	0.013 (0.009)
(2) ≤ Median Exposed Storm Surge Land Area x Post	0.125 (0.170)	0.022** (0.009)	-0.002 (0.010)	0.007 (0.008)
Difference between (1) and (2)	0.206	-0.004	0.023*	0.006
N	449,540	455,305	439,862	456,999
Mean	3.379	0.202	0.149	0.840
Socio-demographic Characteristics	Yes	Yes	Yes	Yes
Environmental Characteristics	Yes	Yes	Yes	Yes
State Indicators	Yes	Yes	Yes	Yes
Month Indicators	Yes	Yes	Yes	Yes

*Notes:* This table presents marginal effects of DD estimators compared to the reference category of post x control region. Stress is estimated using GLM with a log-link and Gaussian distribution, and the other outcomes are estimated using logit. The median storm surge surface area in storm surge counties is 7.2%. Survey data are used for all results and standard errors are clustered at the sub-state level. Results are similar when controlling for evacuees per 1,000, and are available upon request. \*\*\* Significant at the 1 percent level. \*\* Significant at the 5 percent level. \* Significant at the 10 percent level.

TABLE 5—BALANCE CHECK

	Post-Hurricane Katrina
<i>Panel A: Years 2004-2005</i>	
(1) Sex x Region	0.42
(2) Race/Ethnicity x Region	0.44
(3) Age x Region	0.19
(4) Education x Region	0.19
(5) Employment/Labor Force x Region	0.18
(6) Marital Status x Region	0.22
(7) Income x Region	0.74
Observations	595,084
<i>Panel B: Years 2004-2006</i>	
(1) Sex x Region	0.86
(2) Race/Ethnicity x Region	0.09
(3) Age x Region	0.18
(4) Education x Region	0.33
(5) Employment/Labor Force x Region	0.14
(6) Marital Status x Region	0.29
(7) Income x Region	0.94
Observations	916,932

*Notes:* Each column presents the  $p$ -value from the joint significance test of each category when interacted with the regions of control, wind damage only, and storm surge. An indicator for post-Hurricane Katrina is used as the dependent variable and the models are estimated with logit. Survey data are used for all results and standard errors are clustered at the sub-state level.

TABLE 6—SYNTHETIC CONTROL GROUP ANALYSIS

	Stress	Smoking	Binge Drinking	Health Insurance
	(1)	(2)	(3)	(4)
<i>Panel A: Storm surge and control samples</i>				
(1) East North Central Census Division (excluding Ohio)	-0.049	-0.013	0.001	0.007*
(2) West North Central Census Division	0.207**	0.009	-0.005	-0.014
(3) Mountain Census Division	-0.063	0.021*	0.008*	-0.004
(4) Pacific Census Division (excluding coastal counties)	-0.298	-0.006	-0.006	0.001
(5) Pacific Coastal Counties	-0.190	-0.047	0.001	-0.001
(6) Remaining Non-Vulnerable Counties	-0.075	-0.012	-0.004	-0.005
(7) Storm Surge Counties	0.190*	0.026**	0.010**	0.013**
<i>Panel B: &gt;Median exposed storm surge land area and control samples</i>				
(1) East North Central Census Division (excluding Ohio)	-0.011	-0.011	-0.003	0.008*
(2) West North Central Census Division	0.171*	0.008	-0.006	-0.012
(3) Mountain Census Division	-0.019	0.012*	0.005*	-0.001
(4) Pacific Census Division (excluding coastal counties)	-0.289	-0.001	-0.004	-0.006
(5) Pacific Coastal Counties	-0.294	-0.047	0.004	-0.004
(6) Remaining Non-Vulnerable Counties	0.030	-0.011	-0.011	-0.005
(7) >Median Exposed Storm Surge Land Area	0.348**	0.034**	0.024**	0.014**

*Notes:* Results are for the first 90 days after Hurricane Katrina. The median storm surge surface area in storm surge counties is 7.2%. \*\* Largest effect. \* 2nd largest effect.

TABLE 7—RESPONSES  $\geq 400$  MILES FROM NEW ORLEANS, 2004-2005

	Stress	Smoking	Binge Drinking	Health Insurance
	(1)	(2)	(3)	(4)
<i>Panel A: Storm surge, wind damage only, and control samples</i>				
(1) Storm Surge Region x Post	0.255*	0.021***	0.010	0.010
	(0.142)	(0.008)	(0.007)	(0.007)
(2) Wind Only Region x Post	0.042	0.009	0.008	0.003
	(0.121)	(0.007)	(0.008)	(0.006)
Difference between (1) and (2)	0.213	0.012	0.002	0.007
N	567,188	574,693	532,595	576,862
Mean	3.386	0.205	0.147	0.841
Socio-demographic Characteristics	Yes	Yes	Yes	Yes
Environmental Characteristics	Yes	Yes	Yes	Yes
State Indicators	Yes	Yes	Yes	Yes
Month Indicators	Yes	Yes	Yes	Yes
<i>Panel B: Storm surge and control samples</i>				
(1) > Median Exposed Storm Surge	0.339*	0.019**	0.018*	0.012
Land Area x Post	(0.191)	(0.009)	(0.010)	(0.008)
(2) $\leq$ Median Exposed Storm	0.159	0.018**	0.000	0.006
Surge Land Area x Post	(0.173)	(0.009)	(0.010)	(0.008)
Difference between (1) and (2)	0.180	0.001	0.018	0.006
N	438,981	444,561	429,205	446,201
Mean	3.382	0.201	0.149	0.843
Socio-demographic Characteristics	Yes	Yes	Yes	Yes
Environmental Characteristics	Yes	Yes	Yes	Yes
State Indicators	Yes	Yes	Yes	Yes
Month Indicators	Yes	Yes	Yes	Yes

*Notes:* This table presents marginal effects of DD estimators compared to the reference category of post x control region. Stress is estimated using GLM with a log-link and Gaussian distribution, and the other outcomes are estimated using logit. The median storm surge surface area in storm surge counties is 7.2%. Survey data are used for all results and standard errors are clustered at the sub-state level. \*\*\* Significant at the 1 percent level. \*\* Significant at the 5 percent level. \* Significant at the 10 percent level.

TABLE 8—HIGH PROBABILITY STATES, 2004-2005

	Stress	Smoking	Binge Drinking	Health Insurance
	(1)	(2)	(3)	(4)
<i>Panel B: Storm surge and control samples</i>				
(1) Storm Surge Region (North Carolina and South) x Post	0.321 (0.311)	0.033** (0.015)	0.020 (0.016)	0.010 (0.012)
(2) Storm Surge Region (Virginia and North) x Post	0.210 (0.129)	0.015** (0.007)	0.008 (0.008)	0.010 (0.007)
Difference between (1) and (2)	0.111	0.019	0.012	0.000
N	449,540	455,305	439,862	456,999
Mean	3.379	0.202	0.149	0.840
Socio-demographic Characteristics	Yes	Yes	Yes	Yes
Environmental Characteristics	Yes	Yes	Yes	Yes
State Indicators	Yes	Yes	Yes	Yes
Month Indicators	Yes	Yes	Yes	Yes
<i>Panel B: &gt;Median exposed storm surge land area and control samples</i>				
(1) >Median Exposed Storm Surge Land Area (North Carolina and South) x Post	0.601 (0.446)	0.044** (0.020)	0.050** (0.021)	0.009 (0.017)
(2) >Median Exposed Storm Surge Land Area (Virginia and North) x Post	0.250 (0.174)	0.008 (0.009)	0.012 (0.012)	0.012 (0.008)
Difference between (1) and (2)	0.351	0.036*	0.038*	-0.003
N	392,243	397,349	393,730	398,766
Mean	3.397	0.203	0.149	0.839
Socio-demographic Characteristics	Yes	Yes	Yes	Yes
Environmental Characteristics	Yes	Yes	Yes	Yes
State Indicators	Yes	Yes	Yes	Yes
Month Indicators	Yes	Yes	Yes	Yes

*Notes:* This table presents marginal effects of DD estimators compared to the reference category of post x control region. Stress is estimated using GLM with a log-link and Gaussian distribution, and the other outcomes are estimated using logit. The median storm surge surface area in storm surge counties is 7.2%. Survey data are used for all results and standard errors are clustered at the sub-state level. \*\*\* Significant at the 1 percent level. \*\* Significant at the 5 percent level. \* Significant at the 10 percent level.

TABLE 9—CATEGORY 1 AND 5 HURRICANES, 2004-2005

	Stress	Smoking	Binge Drinking	Health Insurance
	(1)	(2)	(3)	(4)
<i>Panel A: Category 1 Hurricane</i>				
(1) Storm Surge Region x Post	0.234*	0.020***	0.009	0.009
	(0.137)	(0.007)	(0.007)	(0.007)
(2) Wind Only Region x Post	-0.060	0.007	0.012	0.000
	(0.130)	(0.007)	(0.009)	(0.007)
Difference between (1) and (2)	0.294*	0.012	-0.003	0.009
N	584,986	592,839	550,573	595,084
Mean	3.395	0.206	0.146	0.838
Socio-demographic Characteristics	Yes	Yes	Yes	Yes
Environmental Characteristics	Yes	Yes	Yes	Yes
State Fixed Effects	Yes	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes	Yes
<i>Panel B: Category 5 Hurricane</i>				
(1) Storm Surge Region x Post	0.317*	0.023**	0.014	0.010
	(0.185)	(0.009)	(0.009)	(0.008)
(2) Wind Only Region x Post	0.158	0.018*	0.001	0.010
	(0.177)	(0.009)	(0.010)	(0.008)
Difference between (1) and (2)	0.159	0.006	0.014	0.000
N	433,944	439,434	424,114	441,052
Mean	3.377	0.199	0.151	0.841
Socio-demographic Characteristics	Yes	Yes	Yes	Yes
Environmental Characteristics	Yes	Yes	Yes	Yes
State Indicators	Yes	Yes	Yes	Yes
Month Indicators	Yes	Yes	Yes	Yes

*Notes:* This table presents marginal effects of DD estimators compared to the reference category of post x control region, with the control region dependent on the hurricane category strength. Stress is estimated using GLM with a log-link and Gaussian distribution, and the other outcomes are estimated using logit. Survey data are used for all results and standard errors are clustered at the sub-state level. \*\*\* Significant at the 1 percent level. \*\* Significant at the 5 percent level. \* Significant at the 10 percent level.

TABLE 10—EXCLUDING SIMULTANEOUS HURRICANE AREAS, 2004-2005

	Stress	Smoking	Binge Drinking	Health Insurance
	(1)	(2)	(3)	(4)
<i>Panel A: Storm surge, wind damage only, and control samples</i>				
(1) Storm Surge Region x Post	0.231*	0.020***	0.008	0.009
	(0.139)	(0.007)	(0.007)	(0.007)
(2) Wind Only Region x Post	0.092	0.002	0.004	0.011
	(0.120)	(0.006)	(0.007)	(0.006)
Difference between (1) and (2)	0.139	0.018	0.004	-0.002
N	569,592	577,204	535,113	579,367
Mean	3.414	0.206	0.146	0.848
Socio-demographic Characteristics	Yes	Yes	Yes	Yes
Environmental Characteristics	Yes	Yes	Yes	Yes
State Indicators	Yes	Yes	Yes	Yes
Month Indicators	Yes	Yes	Yes	Yes
<i>Panel B: Storm surge and control samples</i>				
(1) > Median Exposed Storm Surge	0.303*	0.016*	0.017	0.011
Land Area x Post	(0.181)	(0.009)	(0.010)	(0.008)
(2) ≤ Median Exposed Storm	0.148	0.020**	-0.001	0.005
Surge Land Area x Post	(0.168)	(0.008)	(0.010)	(0.007)
Difference between (1) and (2)	0.155	-0.004	0.018	0.006
N	441,444	447,097	431,748	448,746
Mean	3.398	0.202	0.149	0.846
Socio-demographic Characteristics	Yes	Yes	Yes	Yes
Environmental Characteristics	Yes	Yes	Yes	Yes
State Indicators	Yes	Yes	Yes	Yes
Month Indicators	Yes	Yes	Yes	Yes

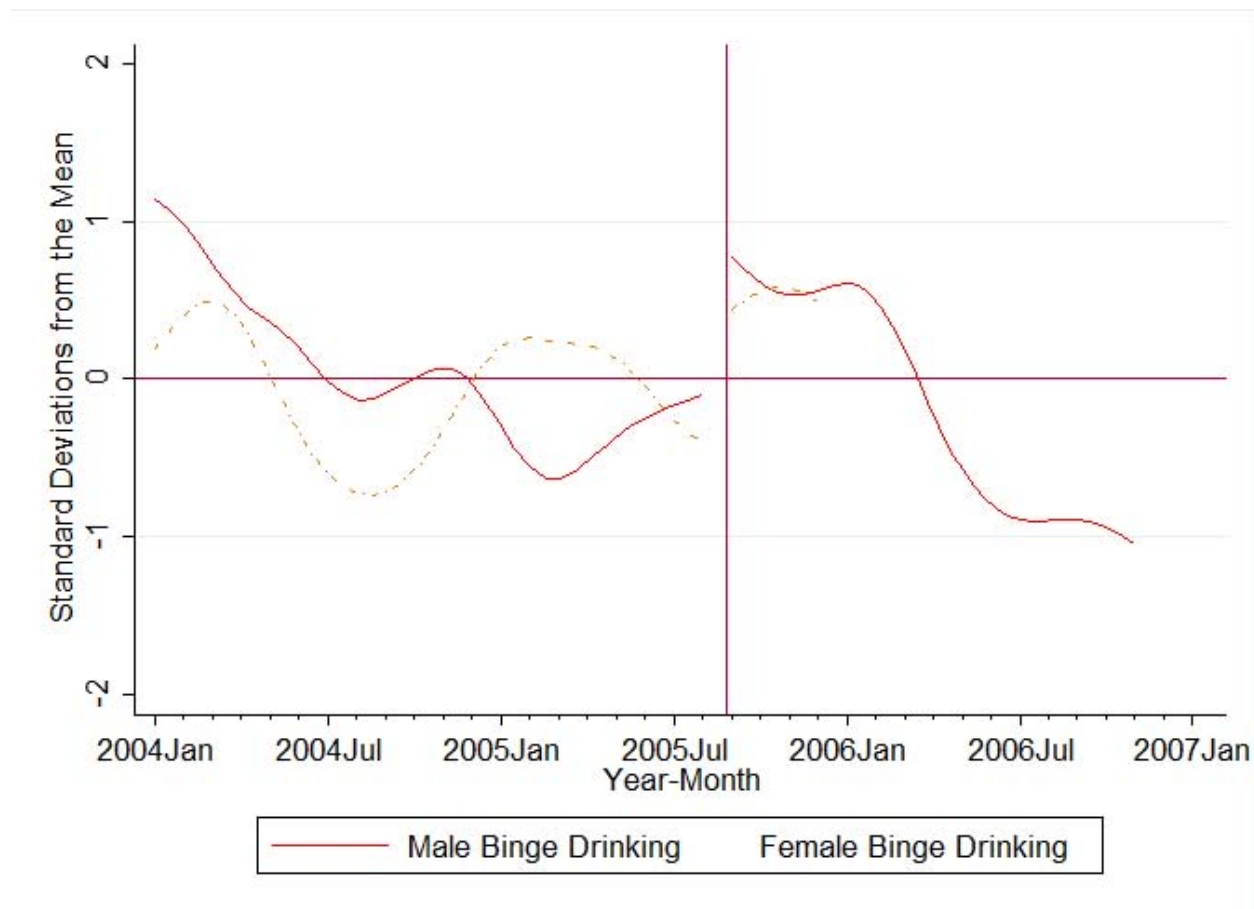
*Notes:* This table presents marginal effects of DD estimators compared to the reference category of post x control region. Stress is estimated using GLM with a log-link and Gaussian distribution, and the other outcomes are estimated using logit. The median storm surge surface area in storm surge counties is 7.2%. Survey data are used for all results and standard errors are clustered at the sub-state level. \*\*\* Significant at the 1 percent level. \*\* Significant at the 5 percent level. \* Significant at the 10 percent level.



TABLE A1—SAMPLE DESCRIPTIVE STATISTICS FOR CONTINENTAL UNITED STATES, NON-HURRICANE KATRINA DISASTER AREAS, 2004-2006

	Unweighted		Weighted	
	Mean	Standard Deviation	Mean	Standard Deviation
<b>BRFSS</b>				
Male (%)	0.385	0.486	0.485	0.500
Female (%)	0.615	0.486	0.515	0.500
White non-Hispanic (%)	0.810	0.392	0.705	0.456
Black non-Hispanic (%)	0.071	0.257	0.089	0.284
Asian non-Hispanic (%)	0.012	0.111	0.028	0.166
Native American non-Hispanic (%)	0.014	0.118	0.010	0.101
Hispanic (%)	0.062	0.241	0.137	0.344
Missing Race/Ethnicity (%)	0.030	0.171	0.031	0.174
Age	51.669	17.092	45.668	17.645
Junior High (%)	0.035	0.184	0.045	0.207
Some High School (%)	0.067	0.250	0.076	0.265
High School (%)	0.305	0.461	0.295	0.456
Some College (%)	0.264	0.441	0.261	0.440
College (%)	0.325	0.468	0.319	0.466
Missing Education (%)	0.003	0.051	0.004	0.061
Employed (%)	0.567	0.496	0.612	0.487
Unemployed (%)	0.041	0.197	0.052	0.222
Student (%)	0.022	0.146	0.045	0.208
Not Student, Not in Labor Force (%)	0.368	0.482	0.286	0.452
Missing Employed Status (%)	0.003	0.055	0.005	0.068
Married (%)	0.553	0.497	0.594	0.491
Divorced (%)	0.163	0.369	0.111	0.315
Widowed (%)	0.122	0.328	0.065	0.247
Unmarried and Other Marital Status (%)	0.158	0.365	0.226	0.418
Missing Marital Status (%)	0.004	0.062	0.004	0.062
Real Household Income (without imputation)	44,179	26,156	46,634	26,803
Real Household Income (with imputation)	43,374	25,251	45,588	25,904
Top Household Income Category (%)	0.194	0.395	0.228	0.420
Stress (Days Mental Health Not Good over Past 30 Days) (%)	3.396	7.662	3.391	7.473
Current Smoker (%) (Past 30 Days)	0.196	0.397	0.203	0.402
Binge Drinker (%) (Past 30 Days)	0.113	0.317	0.149	0.356
Health Insurance (%)	0.877	0.328	0.839	0.368
<b>Merged Outside Data</b>				
State-Level Unemployment Rate (%)	4.851	1.050	5.095	0.960
Real Price of Pack of Cigarettes (in dollars)	3.852	0.711	3.841	0.708
Real Price of 6-Pack of Heineken Beer (in dollars)	7.228	0.363	7.224	0.318
State-Level Smoke-Free Air Law Index (scale of 1-9)	2.829	3.053	3.312	3.410
State-Level No Pub Smoking Restrictions (%)	0.772	0.419	0.697	0.460
Reside in Counties At-Risk for Storm Surge from Category 3 Hurricane (%)	0.200	0.400	0.201	0.401
Reside in Counties At-Risk for Wind Damage from Category 3 Hurricane Only (%)	0.238	0.426	0.255	0.436
County-Level Hurricane Katrina Evacuees Per 1,000	0.610	1.286	1.033	2.300

Notes: All prices are in 2004 dollars.



ONLINE FIGURE 1. ADJUSTED DIFFERENCE BETWEEN STORM SURGE REGION AND CONTROL REGION FOR BINGE DRINKING

*Notes:* This graph shows local polynomial smoothed plots (bandwidth of 1.5) of the differences in binge drinking predicted values between the storm surge region and the control region. A spike represents an increase in the storm surge region relative to the control region. The data are risk-adjusted with socio-demographic characteristics, environmental characteristics, and state indicators. The outcomes are standardized by subtracting the predicted value means and dividing by the predicted value standard deviations. The definition of binge drinking changed for women in 2006, so I provide graphs for females in 2004-2005 and men in 2004-2006. The vertical line is the date of Hurricane Katrina.

ONLINE APPENDIX TABLE A1—ADDITIONAL PARAMETER ESTIMATES, 2004-2005

	Dependent Variable			
	Stress	Smoking	Binge Drinking	Health Insurance
Male	-	-	-	-
Female	0.1860*** (0.0148)	-0.3000*** (0.0144)	-1.2447*** (0.0187)	0.2807*** (0.0187)
White non-Hispanic	-	-	-	-
Black non-Hispanic	-0.2333*** (0.0220)	-0.4859*** (0.0266)	-0.6014*** (0.0380)	0.0842*** (0.0308)
Asian non-Hispanic	-0.3501*** (0.0604)	-0.5514*** (0.0777)	-0.9800*** (0.0830)	-0.3325*** (0.0737)
Native American non-Hispanic	0.1096** (0.0452)	0.3269*** (0.0596)	-0.0188 (0.0783)	-0.2803*** (0.0701)
Hispanic	-0.4841*** (0.0332)	-0.8362*** (0.0352)	-0.1457*** (0.0370)	-0.6229*** (0.0303)
Missing Race/Ethnicity	0.1277*** (0.0297)	0.0733* (0.0392)	-0.2034*** (0.0579)	-0.3241*** (0.0488)
Age	0.0689*** (0.0029)	0.0956*** (0.0031)	0.0101** (0.0042)	-0.0538*** (0.0039)
Age Squared	-0.0009*** (0.0000)	-0.0013*** (0.0000)	-0.0005*** (0.0000)	0.0010*** (0.0000)
Junior High	-	-	-	-
Some High School	0.1057*** (0.0387)	0.5920*** (0.0513)	0.0880 (0.0817)	0.3545*** (0.0510)
High School	-0.0588 (0.0374)	0.1282*** (0.0487)	0.0896 (0.0750)	-
Some College	-0.0050 (0.0381)	-0.1201** (0.0496)	0.1013 (0.0752)	0.8550*** (0.0488)
College	-0.2645*** (0.0398)	-0.8945*** (0.0509)	-0.1048 (0.0759)	1.2034*** (0.0517)
Missing Education	-0.3530** (0.1536)	-0.2824 (0.1864)	-0.1424 (0.2516)	0.4196** (0.1658)
Employed	-	-	-	-
Unemployed	0.4200*** (0.0222)	0.2834*** (0.0310)	-0.0461 (0.0443)	-0.7880*** (0.0359)
Student	0.1399*** (0.0334)	-0.5848*** (0.0508)	-0.1856*** (0.0511)	0.3587*** (0.0511)
Not Student, Not in Labor Force	0.4988*** (0.0153)	0.0252 (0.0189)	-0.3241*** (0.0298)	0.2300*** (0.0266)
Missing Employed Status	-0.0311 (0.1266)	-0.1202 (0.1650)	-0.1296 (0.2526)	-0.0597 (0.1677)
Married	-	-	-	-
Divorced	0.3610*** (0.0179)	0.7228*** (0.0197)	0.5282*** (0.0272)	-0.3040*** (0.0260)
Widowed	0.2287*** (0.0282)	0.6428*** (0.0294)	0.4034*** (0.0614)	-0.0038 (0.0445)
Unmarried and Other Marital Status	0.2229*** (0.0193)	0.4870*** (0.0223)	0.5204*** (0.0262)	-0.4637*** (0.0261)
Missing Marital Status	0.1511 (0.1103)	0.0983 (0.1336)	-0.0180 (0.1891)	-0.0190 (0.1508)
Real Household Income (in 1,000s of dollars)	-0.0216*** (0.0014)	-0.0053*** (0.0020)	0.0080*** (0.0030)	0.0192*** (0.0024)
Real Household Income Squared in 1,000s of dollars)	0.0001*** (0.0000)	-0.0000* (0.0000)	-0.0001 (0.0000)	0.0002*** (0.0000)
Top Income Category	-0.0538 (0.0489)	0.0766 (0.0584)	0.1766** (0.0730)	-0.7807*** (0.0937)
Pre	-	-	-	-
Post	-0.0376 (0.0264)	-0.0511* (0.0309)	-0.0185 (0.0409)	-0.0590 (0.0424)
Control	-	-	-	-
Wind Only Region	-0.0307 (0.0398)	-0.0351 (0.0481)	0.0745 (0.0614)	0.0212 (0.0560)
Storm Surge Region	-0.0250 (0.0439)	-0.0168 (0.0528)	0.1198* (0.0679)	-0.0747 (0.0622)
Post x Control Region	-	-	-	-
Post x Wind Only Region	0.0109 (0.0356)	0.0512 (0.0435)	0.0921 (0.0642)	0.0477 (0.0568)
Post x Storm Surge Region	0.0692* (0.0414)	0.1434*** (0.0498)	0.0832 (0.0628)	0.0944 (0.0659)
State-Level Unemployment Rate	0.0150 (0.0165)	0.0135 (0.0208)	0.0356 (0.0271)	-0.0013 (0.0262)
Real Price of Pack of Cigarettes	-	-0.0509 (0.0477)	-	-
State-Level Smoke-Free Air Law Index	-	-0.0021 (0.0072)	-	-
Real Price of 6-Pack of Heineken Beer (in dollars)	-	-	-0.0076 (0.0472)	-
State-Level No Pub Smoking Restrictions	-	-	0.0447 (0.0607)	-
Constant	0.5321*** (0.1268)	-1.9310*** (0.2327)	-1.3958*** (0.4125)	0.3510* (0.1904)
Observations	584,986	592,839	550,573	595,084
Model Type	GLM, Log-Link, Gaussian Distribution	Logit	Logit	Logit

*Notes:* This table presents additional regression coefficients for the baseline specification (Table 1, column 4 and Table 3, panel A, column 4). Survey data are used for all results and standard errors are clustered at the sub-state level. \*\*\* Significant at the 1 percent level. \*\* Significant at the 5 percent level. \* Significant at the 10 percent level.

ONLINE APPENDIX TABLE A2—STRESS AND SMOKING, 2004-2006

	Stress (mean = 3.392)				
	(1)	(2)	(3)	(4)	(5)
(1) Storm Surge Region x Post	-0.023 (0.094)	-0.029 (0.095)	-0.017 (0.089)	-0.025 (0.089)	-0.020 (0.086)
(2) Wind Only Region x Post	-0.041 (0.078)	-0.045 (0.078)	-0.044 (0.077)	-0.052 (0.077)	-0.049 (0.077)
(3) Evacuees Per 1,000 x Post					-0.005 (0.023)
Difference between (1) and (2) N	0.018	0.016	0.028	0.027	0.028
Socio-demographic Characteristics	Yes	Yes	Yes	Yes	Yes
Environmental Characteristics	No	Yes	Yes	Yes	Yes
State Indicators	No	No	Yes	Yes	Yes
Month Indicators	No	No	No	Yes	Yes
Evacuees per Capita	No	No	No	No	Yes
	Smoking (mean = 0.203)				
	(1)	(2)	(3)	(4)	(5)
(1) Storm Surge Region x Post	0.005 (0.005)	0.007 (0.005)	0.006 (0.005)	0.005 (0.005)	0.006 (0.005)
(2) Wind Only Region x Post	0.001 (0.004)	0.002 (0.004)	0.002 (0.004)	0.001 (0.004)	0.002 (0.004)
(3) Evacuees Per 1,000 x Post					-0.001 (0.001)
Difference between (1) and (2) N	0.004	0.005	0.004	0.004	0.004
Socio-demographic Characteristics	Yes	Yes	Yes	Yes	Yes
Environmental Characteristics	No	Yes	Yes	Yes	Yes
State Indicators	No	No	Yes	Yes	Yes
Month Indicators	No	No	No	Yes	Yes
Evacuees per Capita	No	No	No	No	Yes

*Notes:* This table presents marginal effects of DD estimators compared to the reference category of post x control region. Stress is estimated using GLM with a log-link and Gaussian distribution, and the other outcomes are estimated using logit. Survey data are used for all results and standard errors are clustered at the sub-state level. \*\*\* Significant at the 1 percent level. \*\* Significant at the 5 percent level. \* Significant at the 10 percent level.

ONLINE APPENDIX TABLE A3—STRESS AND SMOKING IN QUARTER INTERVALS

	Stress	Smoking
	(1)	(2)
(1) Storm Surge Region x Period 1	0.247* (0.135)	0.021*** (0.007)
(2) Storm Surge Region x Period 2	-0.237 (0.169)	0.006 (0.010)
(3) Storm Surge Region x Period 3	-0.027 (0.155)	0.011 (0.008)
Difference between (1) and (2)	0.484**	0.016
Difference between (1) and (3)	0.274	0.011
N	687,714	696,327
Mean	3.384	0.198
Socio-demographic Characteristics	Yes	Yes
Environmental Characteristics	Yes	Yes
State Indicators	Yes	Yes
Month Indicators	Yes	Yes

*Notes:* This table presents marginal effects of DD estimators compared to the reference category of period x control region. Stress was estimated using GLM with a log-link and Gaussian distribution, and smoking using logit. Survey data are used for all results and standard errors are clustered at the sub-state level. Results for binge drinking are not shown because the definition of binge drinking changed for women in 2006. Results are similar when controlling for evacuees per 1,000, and are available upon request. Period 1 = Sept. 9 - end of 2005. Period 2 = 1Q of 2006. Period 3 = 2Q of 2006. \*\*\* Significant at the 1 percent level. \*\* Significant at the 5 percent level. \* Significant at the 10 percent level.

ONLINE APPENDIX TABLE A4—HEALTH INSURANCE AND AGE

	Ages 18-30	Ages 31-64	Ages $\geq 65$
	(1)	(2)	(3)
<i>Panel A: Years 2004-2005</i>			
(1) Storm Surge Region x Post	0.032 (0.022)	0.002 (0.008)	0.002 (0.006)
(2) Wind Only Region x Post	0.012 (0.033)	0.001 (0.007)	0.006 (0.005)
Difference between (1) and (2)	0.019	0.000	-0.004
N	78,311	371,206	141,330
Mean	0.709	0.850	0.974
Socio-demographic Characteristics	Yes	Yes	Yes
Environmental Characteristics	Yes	Yes	Yes
State Indicators	Yes	Yes	Yes
Month Indicators	Yes	Yes	Yes

*Notes:* This table presents marginal effects of DD estimators compared to the reference category of post x control region. The health insurance outcome is stratified by age and is estimated with logit. Survey data are used for all results and standard errors are clustered at the sub-state level. \*\*\* Significant at the 1 percent level. \*\* Significant at the 5 percent level. \* Significant at the 10 percent level.

ONLINE APPENDIX TABLE A5—PRE-HURRICANE KATRINA TIME TRENDS CHECK

		Stress	Smoking	Binge Drinking	Health Insurance
		(1)	(2)	(3)	(4)
(1)	1Q 2004*Storm Surge Region	-	-	-	-
(2)	2Q 2004*Storm Surge Region	1.123* (0.071)	0.982 (0.075)	0.876 (0.083)	0.957 (0.096)
(3)	3Q 2004*Storm Surge Region	1.059 (0.067)	1.031 (0.079)	0.812** (0.076)	1.019 (0.104)
(4)	4Q 2004*Storm Surge Region	1.016 (0.062)	0.977 (0.072)	0.839* (0.076)	0.985 (0.098)
(5)	1Q 2005*Storm Surge Region	1.005 (0.062)	0.945 (0.071)	0.816** (0.075)	0.965 (0.094)
(6)	2Q 2005*Storm Surge Region	0.995 (0.061)	0.965 (0.071)	0.873 (0.081)	1.029 (0.100)
(7)	partial 3Q 2005 *Storm Surge Region	1.019 (0.075)	1.077 (0.095)	0.822* (0.086)	0.925 (0.102)
(8)	Control	-	-	-	-
(9)	Storm Surge Region	0.929 (0.053)	0.978 (0.068)	1.337*** (0.117)	0.919 (0.081)
(10)	<i>p</i> -value of the joint significance of the storm surge region quarter time trend in pre-Katrina period (1-7)	0.433	0.781	0.307	0.951
(11)	<i>p</i> -value of the joint significance of the wind only region quarter time trend in pre-Katrina period	0.516	0.730	0.698	0.889
(12)	Observations	901,544	913,359	841,157	916,932

*Notes:* This table presents odds ratios of individual quarters in the pre-Hurricane Katrina period, as well as tests of joint significance. The difference between the storm surge region and the control region in the first quarter is used as the reference (row 1), and the deviations from this difference in future quarters are reported by the odds ratios in rows 2-7. Survey data are used for all results and standard errors are clustered at the sub-state level. Unreported results include non-interacted quarters, socio-demographic characteristics, environmental characteristics, and state indicators. \*\*\* Significant at the 1 percent level. \*\* Significant at the 5 percent level. \* Significant at the 10 percent level.

ONLINE APPENDIX TABLE A6—YEAR PRIOR FALSIFICATION EXERCISE, 2004-2005

	Stress	Smoking	Binge Drinking	Health Insurance
	(1)	(2)	(3)	(4)
<i>Panel A: Storm surge, wind damage only, and control samples</i>				
(1) Storm Surge Region x Post	-0.126 (0.111)	0.000 (0.006)	-0.004 (0.006)	-0.002 (0.005)
(2) Wind Only Region x Post	-0.223** (0.096)	0.000 (0.005)	-0.004 (0.006)	0.003 (0.005)
Difference between (1) and (2)	0.097	0.000	0.000	-0.005
N	585,874	593,766	551,186	596,014
Mean	3.386	0.206	0.146	0.838
Socio-demographic Characteristics	Yes	Yes	Yes	Yes
Environmental Characteristics	Yes	Yes	Yes	Yes
State Indicators	Yes	Yes	Yes	Yes
Month Indicators	Yes	Yes	Yes	Yes
<i>Panel B: Storm surge and control samples</i>				
(1) > Median Exposed Storm Surge Land Area x Post	-0.034 (0.146)	0.002 (0.007)	-0.001 (0.008)	0.000 (0.007)
(2) ≤ Median Exposed Storm Surge Land Area x Post	-0.233* (0.133)	-0.004 (0.007)	-0.007 (0.008)	-0.003 (0.007)
Difference between (1) and (2)	0.199	0.006	0.007	0.004
N	449,832	455,605	440,100	457,302
Mean	3.372	0.202	0.149	0.840
Socio-demographic Characteristics	Yes	Yes	Yes	Yes
Environmental Characteristics	Yes	Yes	Yes	Yes
State Indicators	Yes	Yes	Yes	Yes
Month Indicators	Yes	Yes	Yes	Yes

*Notes:* This table presents marginal effects of DD estimators compared to the reference category of post x control region. Stress is estimated using GLM with a log-link and Gaussian distribution, and the other outcomes are estimated using logit. The median storm surge surface area in storm surge counties is 7.2%. Survey data are used for all results and standard errors are clustered at the sub-state level. \*\*\* Significant at the 1 percent level. \*\* Significant at the 5 percent level. \* Significant at the 10 percent level.



ONLINE APPENDIX TABLE A7—LONGER PRE-PERIOD, 2002-2005

	Stress	Smoking	Binge Drinking	Health Insurance
	(1)	(2)	(3)	(4)
<i>Panel A: Storm surge, wind damage only, and control samples</i>				
(1) Storm Surge Region x Post	0.304** (0.135)	0.026*** (0.007)	0.007 (0.007)	0.010 (0.007)
(2) Wind Only Region x Post	0.138 (0.114)	0.007 (0.006)	0.008 (0.007)	0.003 (0.006)
Difference between (1) and (2)	0.166	0.020**	-0.001	0.007
N	907,391	1,046,627	970,576	1,050,113
Mean	3.383	0.215	0.152	0.841
Socio-demographic Characteristics	Yes	Yes	Yes	Yes
Environmental Characteristics	Yes	Yes	Yes	Yes
State Indicators	Yes	Yes	Yes	Yes
Month Indicators	Yes	Yes	Yes	Yes
<i>Panel B: Storm surge and control samples</i>				
(1) > Median Exposed Storm Surge Land Area x Post	0.458** (0.186)	0.027*** (0.009)	0.018* (0.009)	0.011 (0.008)
(2) ≤ Median Exposed Storm Surge Land Area x Post	0.108 (0.170)	0.023** (0.009)	-0.006 (0.010)	0.008 (0.008)
Difference between (1) and (2)	0.351	0.005	0.024*	0.003
N	703,382	804,994	779,119	807,633
Mean	3.390	0.210	0.155	0.843
Socio-demographic Characteristics	Yes	Yes	Yes	Yes
Environmental Characteristics	Yes	Yes	Yes	Yes
State Indicators	Yes	Yes	Yes	Yes
Month Indicators	Yes	Yes	Yes	Yes

*Notes:* This table presents marginal effects of DD estimators compared to the reference category of post x control region. Stress is estimated using GLM with a log-link and Gaussian distribution, and the other outcomes are estimated using logit. Stress was part of an optional module in 2002 completed in only 20 states. The median storm surge surface area in storm surge counties is 7.2%. Survey data are used for all results and standard errors are clustered at the sub-state level. \*\*\* Significant at the 1 percent level. \*\* Significant at the 5 percent level. \* Significant at the 10 percent level.