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BROADBAND INTERNET ACCESS, ECONOMIC GROWTH, AND WELLBEING

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ABSTRACT

Between 2000 and 2008, access to high-speed, broadband internet grew significantly in the United States, but there is debate on whether access to high-speed internet improves or harms wellbeing. We find that a ten percent increase in the proportion of county residents with access to broadband internet leads to a 1.01 percent reduction in the number of suicides in a county, as well as improvements in self-reported mental and physical health. We further find that this reduction in suicide deaths is likely due to economic improvements in counties that have access to broadband internet. Counties with increased access to broadband internet see reductions in poverty rate and unemployment rate. In addition, zip codes that gain access to broadband internet see increases in the numbers of employees and establishments. In addition, heterogeneity analysis indicates that the positive effects are concentrated in the working age population, those between 25 and 64 years old. This pattern is precisely what is predicted by the literature linking economic conditions to suicide risk.

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I. Introduction

Between 2000 and 2008, access to high-speed, broadband internet grew significantly in the United States. In 1999 just over half of zip codes in the U.S. had at least one internet service provider (ISP)[1] operating with at least one broadband customer in the zip code. By 2008, over ninety percent of zip codes had at least one ISP operating. Those with access to broadband internet were able to move from dial-up connection speeds of around 56 kilobits per second (kbps)—very slow—to significantly faster broadband connections.[2] As of 1996, the United States Congress had directed the Federal Communications Commission to oversee and support the "reasonable and timely" deployment of broadband technology to all Americans (Rachfal, 2021). American lawmakers saw the spread of broadband technology as a desirable policy outcome in itself and sought to foster and support it.

Over the same period, the age-adjusted rate of deaths by suicide in the United States rose from 10.4 to 11.8 deaths per 100,000 people. From 2001 to 2008, suicide deaths accounted for more than 250,000 deaths, the equivalent of more than 5.5 million years of potential life lost. In recent years, suicide rates have risen even more and have become an urgent health crisis, particularly among adolescents (CDC, 2003).

In this paper we investigate whether the proportion of a county's population with access to broadband internet service has any impact on a variety of measures of wellbeing, including the number of deaths by suicide in that county, self-reported mental and physical health and economic conditions. We also explore how the roll out of Facebook affected suicides. In asking

[1] An ISP is simply the company who provides the broadband service. These can be large national corporations or smaller, regional companies.

[2] The definition of "broadband" speed has changed over time. It is currently 25 megabits per second (Mbps) download speed and 3 Mbps upload speed. In a report in 2000, the FCC defined broadband speed at 200 kbps in at least one direction. For reference, one Mbps is one thousand times faster than one kbps. The standard in 2000 (200 kbps), therefore is equivalent to 0.2 Mbps.

this question, we link three different, but potentially related strands of empirical literature. The first area of research explores the different impacts of the proliferation of broadband internet. Predictably, the spread of a new and powerful technology has impacted several important areas of life from economic outcomes such as unemployment, income, and economic growth (Atasoy, 2013; Dettling, 2017; Hjort & Poulsen, 2019; Kolko, 2012; Stockinger, 2019; Zuo, 2021), to health (Donati et al., 2022; DiNardi et al., 2019; Guldi & Herbst, 2017), to crime (Bhuller et al., 2013), to politics and civic engagement (Falck et al., 2014; Geraci et al., 2018; Braghieri et al., 2022). The second area of research is literature that explores the link between economic conditions and mental health. Unemployment conditions have been shown to impact the risk of suicide. The great recession in 2008 was associated with an increase in suicides (Chang et al., 2013; Norström & Grönqvist, 2015). In addition, increases and decreases in unemployment can have different effects on mental health based on age cohort and the nature of the start of unemployment (Classen & Dunn, 2012; Lin & Chen, 2018). Third, there are a few papers on whether access to high-speed internet positively or negatively affects mental health, and particularly, what role social media plays in mental health, that reveal some conflicting findings (Allcott et al., 2020; Braghieri et al., 2022; Tella et al., 2021; Hosseinmardi, et al., 2021; Donati et al., 2023).

The intersection of these three literatures leaves the total effect of broadband internet on mental health and wellbeing ambiguous. There is some evidence that broadband internet may have deleterious effects on mental health (e.g., Donati et al., 2022). However, the evidence that broadband internet has positive economic effects combined with the evidence that positive economic effects lead to fewer deaths by suicide could mean that broadband internet might have positive effects on mental health. The total effect depends on which force predominates.

Using all-cause mortality data from the National Center for Health Statistics, we find that the introduction of broadband internet during the initial roll out of broadband from 2000 to 2008 is associated with a reduction in the number of deaths by suicide in a county. We find that a ten percent increase in the proportion of county residents with access to broadband internet in a year leads to 0.11 fewer deaths by suicide in a county, which is a 1.02% reduction in suicides overall. As expected, the effect of access to broadband internet on suicides fades after 2008, when rapid proliferation began to slow. Nevertheless, when estimating the effect of the rollout of broadband internet between 2000 to 2018, we find an overall reduction in deaths by suicide of about 1.6% for a 10% increase in access to broadband. In addition, using data from the Center for Disease Control's Behavioral Risk Factor Surveillance System (BRFSS), we some evidence that increased access to broadband internet leads to improved measures of mental and physical health and less binge drinking, suggesting that improvements in mood is an important mechanism.

We further find that this reduction in suicide deaths is likely due to economic improvements in counties that have access to broadband internet. Counties with increased access to broadband internet see reductions in poverty rate and unemployment rate. In addition, zip codes that gain access to broadband internet see increases in the numbers of employees and establishments in those zip codes. In addition, heterogeneity analysis indicates that the positive effects are concentrated in the working age population, those between 25 and 64 years old. This pattern is precisely what is predicted by the literature linking economic conditions to suicide risk.

These results provide important support for existing policies that seek to expand broadband access across the country. While some measures of broadband proliferation appear to be nearly complete as early as 2008, there remains a large digital divide between populations with access to broadband internet and those without (Rachfal, 2021). According to FCC data in 2019, 98.8%

of Americans living in urban areas had access to fixed broadband internet, but only 82.8% of Americans living in rural areas had access to fixed broadband internet.[3] In some states, the percentage of the rural population with access to fixed broadband internet was as low as 63.3%. Our results indicate that closing the digital divide can have tangible mental health benefits.

II. Background

Broadband Internet, Economic Growth, and Mental Health

A robust literature connects access to broadband internet and improved local economic conditions. These improvements occur along two axes: first, broadband internet affects the labor market outcomes of individual workers, and second, broadband internet impacts the behavior of firms. These papers then link to another arm of economic research that explores the ways in which economic conditions impact mental health.

Several papers indicate that the internet generally, and broadband specifically, is a useful tool for job seekers. Kunn and Mansour (2014) find that internet job searches are effective at reducing the length of unemployment periods. This is a contradiction of an earlier study finding internet job search to be ineffective, which the authors attribute to the changing nature of internet job search between their two study periods. More recently, Zuo (2021) uses Comcast's Internet Essentials program to study the effect of broadband internet access. Zuo finds that the program, which was designed to increase broadband access for low-income families, is associated with increased employment, increased labor force participation, decreased unemployment, and increased income. Similarly, Gurtzgen and colleagues (2021) find that broadband access is associated with improved rates of reemployment after the first month of unemployment. These

[3] These data are reported at the census block level. After 2008, the FCC changed the geographic level at which ISPs were required to report their service availability.

recent studies are consistent with prior papers as well (Atasoy, 2013; Dettling, 2015; Hjort & Poulsen, 2019). Bhuller, Kostol, and Vigtel (2020) suggest that these improved outcomes may be a function of improved job searches. Their examination of the roll out of broadband internet in Norway leads them to draw three conclusions. First, broadband leads to improved recruitment processes. Second, that improved match quality is a benefit to job seekers. Finally, broadband internet facilitates better information flow. At the individual level, it seems, access to the additional informational and communications resources of broadband internet is beneficial for employment outcomes.

Beyond individual employment decisions, broadband internet has effects at the larger community level. Kolko (2012) finds that increases in broadband availability leads to local economic growth, population growth, and employment growth. Stockinger (2019) finds that broadband internet changes the nature of employment in some areas. He finds that in West German areas, the introduction of broadband is associated with a substitution away from manufacturing jobs and toward service sector jobs. Conversely, in East German areas, the introduction of broadband internet is associated with growth in both sectors. Kim and Orazem (2016) find that broadband availability can induce firms to locate in more rural areas, particularly those near metropolitan areas.

The precise nature of the link between economic outcomes and broadband internet remains poorly understood. The earliest iterations of internet access did not seem to have large economic effects. Forman et al. (2012) find wage and employment growth from broadband access in only six percent of US counties between 1995 and 2000. Additionally, large scale public investment might not make much difference. Ford and Seals (2021) find null effects of municipal investment in broadband internet on the local labor market (see also Czernich, 2014). Briglauer and

colleagues (2019) find that government programs designed to improve broadband availability do increase availability and speed. However, these increases are not accompanied by increases in job rate or wages. Finally broadband speed has little overall effect on local economic conditions, with some heterogeneity based on the median education and income levels (Hasbi & Bohlin, 2021). The literature indicates that the fact of broadband internet makes a difference in economic outcomes, but perhaps the nature or marginal speed of broadband is less important.

For broadband internet to have a positive effect on mental health through employment outcomes, employment must have an impact on mental health. Economic conditions have been shown to impact mental health. Specifically, increases and decreases in unemployment are associated with changes in rates of deaths by suicide (Breuer, 2015; Chang et al., 2013; Norström & Grönqvist, 2015). This association is strongest in working age populations, but is not symmetrical (Chang & Chen , 2017; Lin & Chen, 2018). And while the effects are concentrated in the working age populations, job losses are associated with worsening mental health among adolescents as well (Gassman-Pines et al., 2014). Further, the association between unemployment and suicide deaths appears to be driven primarily by unemployment duration or sudden, mass layoffs (Classen & Dunn, 2012).

Given the link between broadband access and positive economic conditions, and the link between positive economic conditions and decreased risk of death by suicide, we would expect broadband internet to have a positive effect on mental health. However, increased access to broadband internet is associated with several other effects with more ambiguous links to mental health.

Donati and colleagues (2022) measured the impact of broadband on mental health directly. Using data from Italy, they found that individuals in the cohort born between 1985 and 1995,

who had broadband access, had statistically significantly more adverse mental health conditions. As a possible mechanism—and probable confirmation of many people's suspicions that social media is bad for mental health—Braghieri et al. (2022) leverage the roll out of Facebook on college campuses to measure the causal effect of social media and find that social media increases poor mental health. Geraci and colleagues (2018) find that broadband access causes people to substitute away from valuable offline activities and civic engagement. The authors connect this substitution effect to other literature that suggests that increased domestic entertainment options have degraded social connection and lead to worsening mental health. DiNardi et al. (2019) further find that access to broadband internet is associated with increased body weight, increased binge drinking, and increased smoking. The authors also find that broadband access is associated with increased exercise, but only among white women. These papers collectively indicate that broadband access can cause degrading mental health as people withdraw from offline social activities to more toxic online socialization.

However, other research has associated broadband internet with positive health and social outcomes. Bauernschuster, Falck, and Woessmann (2011) find that broadband internet access is associated with increased social capital. In addition to general increases in social capital, the authors also find that broadband access is associated with increased participation in out of school activities for children. While McNamee and colleagues (2019) find that significant use of social media has negative mental health consequences, they also find that limited use of social media can have positive effects on peer relationships. Guldi and Herbst (2017) attribute seven percent of the decrease in teen pregnancy between 1999 and 2007 to increased access to broadband. This result, however, can be reconciled with the above results indicating that individuals are socializing offline less. Bellou (2015), however, uses state-level consumer access to broadband

and finds that broadband internet increased marriage rates for the population aged between 21 and 30 years. Increased marriage rates could be associated with increased social capital and social connectedness. These studies indicate that context and usage might be important factors in the overall effect of broadband internet on mental health.

Since Facebook became generally available in 2006, discussion of internet use also implies use of social media. The literature on the effects of social media is mixed. Some studies indicate that social media is associated with declines in mental health (Braghieri et al., 2022). Other studies, however, indicate that concerns about polarization and anger on social media may be unfounded (Hosseinmardi et al., 2021; Tella et al., 2021; Asimovic et al., 2021). Haidt and colleagues (n.d.) provide a systematic overview of the potential links between social media and mental health. They report that there is some association between social media and poor mental health. However, there appears to be mixed evidence of the harms and benefits of social media, as distinct from "screen time" generally.

In all, the established relationships among broadband internet and economic growth, broadband internet and mental health, and economic growth and mental health leave significant ambiguity about whether and in which direction access to broadband internet will influence suicide deaths.

Broadband Proliferation in the United States 2000 to 2008

The technical specifications required to designate an internet connection "broadband" have changed over time. However, the FCC defines broadband internet generally as a dedicated, high-speed connection that is "always faster than traditional dial up service." (FCC Report 00-290, 2000). Between 1999 and 2008, broadband services spread rapidly through the United States. Figure A1 shows the proportion of zip codes in the U.S. served by at least one ISP offering

broadband service. By 2008, over 90% of zip codes had at least one ISP offering services. Figure 1 shows the levels of broadband access at the county level in the years 2000 and 2008. Again, by 2008 most U.S. counties had significant levels of broadband access. The FCC would later change the geographic level at which ISPs report their service provision. This allows for a more granular look at where, and for whom broadband internet remains unavailable (Rachfal, 2021). However, for the purposes of this analysis, internet proliferation at the zip code level proceeded rapidly between 2000 and 2008. When aggregated to the county level, the transformation is particularly stark.

III. Data

Mortality Data

Our outcome variables are derived from the restricted all-cause mortality data from the National Center for Health Statistics, which have counts of annual suicides by cause at the county level. We identify a death as a death by suicide if it is coded in the 113 Causes of Death, 10^{th} revision table to be the result of intentional self-harm. This classification is further limited to individuals who are five years and older. Deaths are then aggregated to the county-year level for most analyses, with the exception of our social media analysis, which uses county-month data.

To understand whether access to broadband internet affects mood more generally, we also conduct supplementary analyses with data from the CDC's Behavioral Risk Factor Surveillance System (BRFSS) Selected Metropolitan/Micropolitan Area Risk Trends Data, a nationally representative survey of more than 400,000 adults annually at the county level. The survey asks questions about respondent's self-reported mental health, as well as drinking behaviors.

Internet Availability

Our treatment of interest is broadband availability at the county level. Between 2000 and 2008, the Federal Communications Commission required ISPs providing high-speed internet to file Form 477 disclosures. Form 477 recorded any zip code in which an ISP served at least one customer. As a result, the FCC provides data identifying every zip code in each year in which at least one ISP provided high-speed internet service to at least one customer. The FCC then provides the number of ISPs serving each zip code in which broad band service is available.[4] Reports are available in June and December each year from 1999 to 2008. In 2009, the FCC changed the level of reporting from zip code to census tracts, and, in 2014, the reporting level changed again to census block group.

In addition, Corredor-Waldron and Currie (2024) show that upward trends in poor mental health are driven by medical screening practices changing in 2011 and the International Classification of Disease (ICD-10) codes around mental health changing in 2015. Due to these changes, and consistent with existing literature, we limit our primary analysis to 2000 to 2008. However, we also estimate measures of broadband internet access at the county level across all years and show these results as well. We use the measures of broadband availability from June of each year, as this is the measure that reflects the broadband availability that would impact behavior during that year. For example, the December measure could include ISPs that begin serving customers in late November, which would have no impact on residents' behaviors during the year. However, if the June measure includes an ISP that begins service only in May, that ISP would still have most of the year to impact residents' behavior.

[4] The data are bottom coded such that all zip codes with service from 1, 2, or 3 ISPs are coded identically.

To determine which zip codes do not have internet access, we merge the yearly Form 477 data with a database of all zip codes in the United States. Any zip code that does not appear in the Form 477 data is then determined to not have had broadband internet in that year. Any zip code that does appear in the Form 477 data is coded as having broadband access. We then use a zip code to county walk across from the Department of Housing and Urban Development to assign zip codes to Counties. Finally, we aggregate the zip code availability of broadband internet up to the county level, weighted by zip code population. The resulting measure is an approximate proportion of the population of a county with access to broadband internet. This measure is necessarily an overestimate of the proportion of the population with access to broadband internet because a zip code is considered treated if one ISP served one customer in the zip code. Therefore, all of our estimated effects should be considered lower bounds.

Census Data

We use data from the American Population Survey as well as the Decennial Census to construct county level controls for total population, Black population, Hispanic population, poverty rate, unemployment rate and quartiles of income. In addition, we conduct several robustness and heterogeneity tests based on county-year demographic variation.

Zip Code Level Data

Our results suggest that any impact on deaths by suicide caused by broadband internet availability is likely mediated through economic impacts. To further tease out these effects, we conduct several analyses using zip code level business and employment data from the U.S. Bureau of Labor Statistics. Using annual zip code level data, we can examine the direct impact of broadband internet on the number of employees, the number of establishments, and the total annual payroll at the zip code level.

Analytical Data Set

Summary statistics for the final analytical dataset are presented in Table 1. The dataset comprises 28,197 county-year observations from 3,118 counties. The mean number of deaths by suicide in each year is about ten. However, when measured as a rate per 100,000 county residents, the mean number of suicides is about 13.4.

The mean of the broadband availability measure is quite high at 0.932. However, the high mean does not reflect the full level of variation in broadband availability, which are shown in Figures 1 and 2. The mean of county level broadband availability increases from 0.743 in 2000 to 0.985 in 2008.[5] Similarly, the number of ISPs in a county is a population weighted average of the number of ISPs per zip code across a county. The mean number of ISPs at 4.6 likely reflects the fact that densely populated areas with large numbers of ISPs would skew the data toward the higher counts.

IV. Empirical Framework

County Level Increases in Broadband Access

We seek to measure the impact of increasing broadband internet access in a county on the prevalence of deaths by suicide within that county. Our model specification is represented in equation (1).

$$Suicides_{ct} = \beta_0 + \beta_1 Broadband_{ct} + \beta_2 X_{ct} + \gamma_c + \delta_t + \epsilon_{ct} \quad (1)$$

$Suicides_{ct}$ is the number of deaths by suicide in county *c* in year *t*. $Broadband_{ct}$ is the proportion of the population of county c that has access to broadband internet in year t. X_{ct} is a vector of county-year controls including total population, Black population, Hispanic population,

[5] Figure A1 shows the proportion of zip codes with broadband access. In contrast, our measure of broadband availability is population weighted at the county level based on zip codes with access to broadband.

median income, poverty rate, and unemployment rate. γ_c are county fixed effects. δ_t are year fixed effects. β_1 is the coefficient of interest.

Zip Code Level Increases in Broadband Access

In addition to our primary model, we consider different potential mechanisms by investigating zip code level economic effects. This model is represented by equation (2):

$$Y_{zt} = \beta_0 + \beta_1 Broadband_{zt} + \beta_2 X_{zt} + \gamma_z + \delta_t + \epsilon_{zt} \quad (2)$$

Y_{zt} is the outcome of interest: employees, establishments, or annual payroll in a zip code *z* in year, *t*. X_{zt} is a vector of zip code- year control variables for total population, median income, White population, Hispanic population, percent of households renting, and median home value. γ_z are zip code fixed effects, and δ_t are year fixed effects.

Identification Assumptions

As Table 1 indicates, the mean proportion of county population with access to broadband internet is fairly high across our entire sample. Our identification strategy, therefore, requires that counties were there are small increases in broadband internet access—i.e. counties that already have large proportions of their population with access—are good counterfactuals for counties in which there are larger increases in broadband internet access. This requires us to make a series of assumptions about dosage effects, as well as about the absences of population sorting and omitted variables.

Our treatment variable, $Broadband_{ct}$, is a continuous variable between 0 and 1 representing the proportion of a county's population with access to broadband internet. Because the treatment variable is continuous, our specification is subject to assumptions beyond those traditionally made in a difference in differences model (Callaway et al., 2021). One of these is the strong parallel trends assumption. The assumption is that lower dose units must be a good

counterfactual for higher dose units. Our results would be biased if, for instance, the lower dose groups would have a different reaction to the higher dose, if they had received the higher dose. We must assume that each dosage group would have the same response to each dose, regardless of the dose received. We cannot test this assumption directly. However, because our treatment measure is the proportion of a county's population with access to broadband internet, the "dosage" increases represent an additional proportion of people gaining access to broadband internet. Therefore, an increase of 0.01 represents the same proportion of people gaining access to broadband internet regardless of whether the current proportion of the population with access is 0.3 or 0.8. This proportion is also the same regardless of the raw population of the county. Due to the fact that the change in proportion is necessarily limited by the county's initial state, each county will likely receive different levels of change. However, these different doses represent timing variation rather than heterogeneous dosage effects. Therefore, we make this strong parallel trends assumption in our main specification and interpret our results as an average causal response (ACR) accordingly in our primary specification. However, we also utilize a dynamic event study model that allows us to estimate the results non-parametrically using smaller bins of treated units to address potential threats to identification from underlying heterogeneity.

Our identification strategy requires us to make additional assumptions beyond the strong parallel trends assumption. First, we assume that the roll out of broadband internet is not accompanied by sorting between zip codes or counties with differential broadband availability. Our results would be biased if the arrival of broadband internet in an area was also accompanied by population changes that would also change the number of suicides in a county. For instance, if the arrival of broadband internet in county was accompanied by changes in demographics or a reduction in population, we might see a reduction in deaths by suicide simply as a result of

demographic changes. Alternatively, if broadband internet availability causes an influx of new people to a county, we might observe an increase in deaths by suicide due to an increase in population. We conduct a series of balance tests and robustness tests to probe for potential sorting effects that may be driving our results.

Second, our model assumes that there are no omitted variables. As with potential residential sorting, our results may be biased if some additional factor outside of our data is responsible for the any effect we observe. Our treatment is at the county level, so we are able to account for some potential omitted variables by including county and year fixed effects in our model. Further, we conduct several robustness tests, such as placebo tests, in order to ensure that our results are not a function of omitted variables.

V. Results

This section presents our primary results as well as the results of several heterogeneity, robustness, and falsification tests. Overall, we find that increased access to broadband internet results in a decrease in the number and rate of deaths by suicide in a county, that these results are likely driven by positive economic changes in a county and positive changes in mood, and that these results are robust to several different specification tests.

The Effect of Broadband Internet on Deaths by Suicide

Table 2 presents the effects of broadband internet availability on suicides. Panel A reports the results from 2000 to 2008. Column 1 reports our preferred specification of the result of increased broadband availability on the number of deaths by suicide using OLS regression. Column 2 reports results using Poisson regression. Both regressions include population, race and ethnicity, poverty, unemployment, and income quartile controls, along with county and year fixed effects. As shown in Column 1, a 10% increase in the population's access to high-speed

internet is associated with 0.105 fewer suicides, a 1% reduction in deaths by suicide in that county-year.

Panel B reports the results on suicides from 2009-2018, and Panel C reports the results from our entire sample period between 2000-2018. Unfortunately, there was a change in unit of geography for the FCC's broadband filings between 2008 and 2009 from zip code to census tracts, so we report these results separately and together in Panel C. The largest reduction in suicides is seen in Panel A between 2000-2008, which makes sense since this is when most of the change in internet access across the U.S. occurred. The results in Panel B for 2009-2018 and positive and largely not statistically significant at conventional levels. As a result, we use this time period from 2000-2008 as our primary focus in the rest of the paper. However, results in Panel C for 2000-2018 are very similar to the results in Panel A (for 2000-2008). A 10% increase in broadband availability over 2000-2018 leads to a 1.63% reduction in suicides. Later in the paper we also explore how the roll out of social media affected outcomes.

Since difference in differences designs with continuous treatments can be biased because of the negative weighting problem and heterogeneous treatment effects (Callaway, Bacon and Sant'Anna 2024), we estimate an event study using a new dynamic non-parametric estimator developed by Chaisemartin, Haultfoeuille, and Pasquier (2023) to address these potential threats to validity.[6] Figure 2 presents the results of our event study, showing the effect of a 4% increase in broadband internet access in year 1 on the number of suicides in the following years. The omitted category is year 0. While the reduction in suicides after an increase in broadband access is only marginally significant, the pattern of results suggests that access to broadband internet initially decreases the number of suicides in the three years following the rollout. The drop in

[6] We use the did_multiplegt estimator. A 3% increase is the average percentage of increase in broadband internet a county experienced in a year between 2000-2008.

suicides in the year before treatment (year 0) is likely an artifact of our data – we only observe whether a zip code got broadband once per year in June, and some of the sample likely was treated the year before (after June).

Potential Mechanisms

Table 3 shows the effects of broadband availability on self-reported mental and physical health outcomes from the CDC's BRFSS. The BRFSS asks questions about 1) the number of days of poor physical health a respondent has experienced in the past month, 2) the number of days of poor mental health a respondent has experienced in the past month, 3) the number of days a respondent was drinking in the past month, and 4) the number of days a respondent was binge drinking in the past month. We merged the BRFSS data by county and year with our data on the roll out of broadband internet.

Self-reported diagnoses and mood states are well-validated measures of clinical depression (e.g. Maske, et al., 2016). Our results in Table 3 suggest that local increases in access to broadband internet are associated with lower levels of depression and alcohol consumption in the population. While we cannot know the mental health of those who died by suicide from our vital statistics data, the association of broadband internet to lowering two major risk factors for suicide suggests mood states may be an important mechanism of action.

Table 4 presents the effect of increased broadband availability on several county level economic outcomes. Each column includes all controls and fixed effects included our preferred specification. Column 1 reports that the result of a 10% increase in a county's population with access to broadband internet is a reduction in poverty rate of 0.089 percentage points. Column 2 indicates that a ten percentage point increase in broadband availability results in a reduction of unemployment in the county of 0.013 percentage points.

The existing literature links reductions in unemployment to lower suicide risk. Ruhm (2000) finds that a one percent rise in unemployment rates is associated with a 1.3 percent rise in state suicide rates (Marcotte & Hansen, 2023). Assuming that the relationship between unemployment rate and suicide rate is symmetrical, our results imply the following effects. A 10% increase in the county's population with access to broadband internet leads to a 0.013 percentage point reduction in the county's unemployment rate, a 0.24% reduction. This reduction in the unemployment rate would then be associated with a 0.312% reduction in the suicide rate.

In addition, Norstrom and Groqvist (2015) find an average elasticity of unemployment and suicide rate of 0.06 across countries. This elasticity would lead to a reduction of suicide rate of 0.01872 percent. Our coefficient suggests a 1.01 percent reduction in suicide rate, which is larger than prior literature might predict.

However, it may be the nature of the reduction in unemployment caused by broadband internet that is responsible for our coefficient. Classen and Dunn (2012) find that the connection between unemployment and suicide rate is driven significantly by unemployment duration. They find additionally mass layoff events are associated with increased numbers of suicide deaths. The effect size that we observe may be a function of counties with broadband internet managing to avoid these types of traumatic employment events. Indeed, research on broadband internet and labor market matching (Bhuller et al., 2020) suggests that shortening unemployment periods could be a significant way in which broadband may lower suicide rates.

Figure 3 presents the results from a Sun and Abraham (2021) dynamic event study analysis of the effect of broadband availability on zip code level economic activity.[7] Figure 3 suggests that increased broadband internet availability has statistically significant effects on the number of

[7] Using custom Stata command, "eventstudyinteract" (Sun, 2021), which accounts for treatment effects heterogeneity.

establishments, number of employees , and annual payroll at the zip code level. These effects then persist for several years after the initial introduction of broadband. To ensure that our results are not being driven by large cities becoming larger, Table A2 reports the results on absolute levels of employees, establishments, and annual payroll on zip codes with below average population. These results further bolster the impression that any impact of broadband availability is likely a result of economic effects that operate even in smaller zip codes. These results, taken together, are evidence that economic improvements are the mechanisms for our findings of reduced deaths by suicides.

The Effects of the Roll Out of Social Media on Suicides

In addition to a small literature on the effects of broadband internet access, there is another body of work on social media access and mental health. For example, using the roll out of Facebook across the United States between 2004 and 2006 and a unique data set on college student's self-reported mental health, Braghieri, Levy and Makarin (2022) find that Facebook negatively impacts measures of student's self-reported mental health.

We next address whether the roll out of social media might affect suicide outcomes, especially in the later time period. Using the same data on the roll out of Facebook from Braghieri, Levy and Makarin (2022), we produce population-weighted estimates at the county-month level of the percentage of college students who would have access to Facebook in each county in each month.[8] We repeat this for suicide decedents of all ages (which would encompass the spillover effects of Facebook) in Column 1 of Table 5, as well as just college-age students between the ages of 18-22 in Column 2 of Table 5. The coefficients on deaths by suicide in Panel A are small and not statistically significant. In Panel B, we do an exploratory mediation analysis

[8] Unfortunately, our suicide data is at the county level, necessitating aggregating the roll out of Facebook up to the county level.

to see whether the roll out of Facebook mediates the effect of access to broadband internet on suicide. The coefficients are nearly identical, suggesting that the rollout of Facebook did not have a significant effect on suicides, and that the roll out of social media is unlikely to have caused the negative effect on suicides we observe with the rollout of broadband internet. However, it is important to note that social media might affect mental health without increasing suicides over this period since suicide is a relatively rare outcome for this age group.

Heterogeneity in Effects of Broadband Access

If our results were a function of economic effects of broadband internet, we would expect to see larger effects in the populations that are most affected by the introduction of broadband internet. Table 6 presents heterogeneity analysis by decedent characteristics. Panel A presents results based on education level. The effect is statistically significant for all levels of education beyond high school. Heterogeneity analysis for education level was only conducted for individuals 25 years and older, these results are consistent with benefits accruing mostly to populations with the skills necessary to take advantage of industries that would be most positively impacted by information technology improvements. The positive and significant coefficients for all education levels above High School graduate, however, do indicate that the benefits of broadband internet are not simply limited to highly educated workers.

Panel B reports results by decedent age. Here results are strongly clustered in working age adults. The coefficients for adults aged 25 to 64 are large and statistically significant, while the age groups before and just after working age show no statistically significant results. This is suggestive evidence that the employment effects of broadband internet are driving our observed mental health effects. Table A4 also shows the age adjusted suicide rate, which is nearly twice as

large as our main estimates because younger people are less likely to die by suicide when they receive broadband internet.

Panel C reports the results by race and gender. The results are largest for White individuals, which are the group with the highest suicide rate. However, there is also some reduction in suicides for Hispanic individuals. We also see a much larger reduction in suicides for men than women. Given that men have higher suicide rates as well, the findings indicate that the availability of broadband internet reduces suicides for the groups most vulnerable to suicides.

Table 7 shows our main results by different county level characteristics. The results are stronger in non-metropolitan counties, and counties with above-median unemployment, population density, income, education, and percentage of the population that is Black. This indicates that our statistically significant, negative primary result is driven by counties that are relatively rural with higher unemployment. This is also further evidence that our results may be driven by economic effects.

Robustness Checks

One lingering concern is that our results might simply reflect population sorting or omitted variables bias. Table 8 reports the results of our investigations of possible population movement around the proliferation of broadband internet. The worry here is that our results are simply a function of broadband moving into areas with lower or declining populations, and, therefore, simply reflecting smaller populations. Column 1 reports the change in population that follows from the increase in broadband availability from 0% of a county's population to 100% of a county's population. Column 2 reports the change when we drop the ten percent of counties with the most population loss at any time between 2000 and 2008. Column 3 reports the change when we drop the ten percent of counties with the greatest over all change in population,

calculated by subtracting the maximum population from the minimum population. This measure captures counties that lost population and counties that gained population. Column 4 reports the population change when we drop the ten percent of counties with the largest population gain between 2000 and 2008. Finally, column 5 reports that population change when we drop counties with any negative change between 2000 and 2008. All coefficients are negative and relatively small compared to the mean population. Columns 6-8 of Table 4 reports the results of a balance test for county demographics. The coefficients for Hispanic and White populations are statistically significant but very small. We also show these results from 2000-2008 with and without demographic, income, unemployment, and state linear time trend controls in Table A1, and the results are quite similar across specifications. The coefficient in Column 5, which includes state linear time trends, remains negative and statistically significant. We interpret this result as our primary specification being robust when accounting for state level trends that might influence both the roll-out of broadband, but also county level wellbeing. To further alleviate the concern that population movement is driving our results, Table A3 reports the results of our primary specification on different subsamples of our data. Our results are robust to omitting counties with different types of population change.

Tables 4 and 8 indicate there might be some differences between the counties where broadband internet existed in 2000 and the counties to which it became available by 2008. However, the magnitudes of the coefficients (3,000 people and .14% White or 0.5% Hispanic) are very small compared to the differences among counties. The coefficients are small, even compared to the differences between county means in 2000 and 2008.

Table 9 presents the results of placebo tests on causes of death one would not expect to be affected by the roll out of broadband internet. Reassuringly, the introduction of broadband

internet access has no significant effect on deaths from appendix disease, leukemia, Lyme disease, or sexually transmitted diseases (STDs). Finally, Figure 4 presents the results of a randomization inference test. The Kernel density estimate of the randomization inference coefficients does not include our primary result of -1.05. This result gives us confidence that we are not measuring our result by chance.

VI. Discussion

It has been of great interest recently to understand the costs and benefits of the increased use of the internet in modern life (Geraci et al., 2018). Due to the confluence of different technologies such as broadband internet, social media, smart phones, and other new school and work norms, it can be difficult to isolate different causal effects for each change. We attempt to isolate the causal effect of broadband internet on mental health by isolating the initial roll out of fast, broadband internet from 2000 to 2008 and focusing on a variety of outcomes related to mental, physical and economic wellbeing. We also attempt to understand how the early roll out of social media during this period affected suicides.

We find that increased access to broadband internet in a county leads to a reduction in poverty, and an increase in income, employment, and the number of employees and establishments by zip code. We also find a reduction in deaths by suicide and an improvement in mood and binge drinking behavior. An increase of 10% of a county's population that has access to broadband internet is accompanied by a 1% decrease in the number of deaths by suicide in that county-year (about 0.11 deaths). These results are robust to conducting the analysis using a wide variety of estimators, specifications and on different subsamples of data. In addition, the concentration of the effect in working age adults is consistent with existing literature on the economic effects of broadband and the mental health effects of positive economic outcomes.

Our back-of-the-envelope calculation implies that across the entire 3,130 counties in our sample, the roll out of broadband internet would result in between 98.8 and 189.3 fewer deaths by suicide per year.[9] While this effect is modest, we believe it is significant for several different reasons. First, loss of human life has significant and devastating consequences for all members of a community, and all deaths are worth preventing wherever possible. Second, death by suicide is an extreme outcome. These results could indicate other mental health improvements that result from the introduction of broadband internet but are not visible in our data. As such, we might regard these results as a lower bound of the benefits of broadband internet. Third, due to our imprecise measure of broadband availability, these coefficients may be a lower bound of the true effect.

Unfortunately, our outcome is measured at the county level, while the FCC broadband data for this period is presented at the zip code level. Because we count all residents of a zip code as having access to broadband once any ISP is operating in that zip code, we are likely overestimating broadband access. Our model regards an entire zip code as treated as soon as one ISP provides any service in that zip code. However, this is likely not the true case. Even when some residents or businesses in a zip code gain access to broadband internet, it is likely that a significant number of other residents and businesses still did not have access. Therefore, we are estimating a causal response including populations that may not have been treated. Further inquiry will be necessary to fully understand how broadband access truly proliferated at the county level, and how to measure the impact of the digital divide as it currently exists.

[9] The full sample in our preferred specification comprises 3,130 counties and across all counties in all years and the average increase in the proportion of a county with access to broadband internet is three percent. The two estimates are based on the results in Column 1 of Panels A and C in Table 2.

One advantage of our analysis, however, is its limited timeline. Due to some particularities of the FCC data, as well as changes in medical screening practices and changes in ICD-10 codes for mental health, we limit our analysis to 2000 to 2008. This provides an advantage, however, in allowing our analysis of the effects of broadband internet to stand separately from other analyses that seek to evaluate other "online" phenomena. The first iPhone was released in June of 2007, and Facebook became generally available in September of 2006. Both of these events occur after our measure of broadband proliferation is largely complete. While the era of the smart phone and the era of social media likely also have mental health impacts, our analysis allows us to separate those impacts for the effects of the underlying broadband technology.

The primary implication of our findings is that the positive mental health downstream effects from the economic benefits of the roll out of broadband internet outweighed the potential negative mental health consequences of broadband internet. This supports the current federal policy goal of supporting and promoting the continued proliferation of broadband internet to areas that currently do not have access to fast, high quality, broadband internet.

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Table 1: Summary Statistics

	(1) Full Sample	(2) Year 2000	(3) Year 2008
Deaths by Suicide	10.38	9.380	11.53
	(28.77)	(26.07)	(34.03)
Suicide Rate per 100,000	13.43	12.78	14.15
	(13.24)	(12.45)	(13.65)
Total Population	93401.7	89370.6	97084.7
	(302588.1)	(291090.4)	(308652.7)
Percent White	0.866	0.871	0.860
	(0.163)	(0.163)	(0.164)
Percent Black	0.0896	0.0888	0.0906
	(0.146)	(0.146)	(0.146)
Percent Hispanic	0.0710	0.0620	0.0796
	(0.125)	(0.120)	(0.130)
Median Income	61247.0	78576.9	44181.5
	(21057.8)	(19472.7)	(11463.9)
Poverty Rate	0.143	0.133	0.152
	(0.0586)	(0.0559)	(0.0606)
Unemployment Rate	0.0531	0.0436	0.0586
	(0.0192)	(0.0169)	(0.0212)
Only HS Education	0.363	0.413	0.272
	(0.142)	(0.137)	(0.120)
Population Density	412.6	403.6	426.8
	(1846.1)	(1774.0)	(1970.6)
ISPs in County	4.595	1.020	9.111
	(3.578)	(0.998)	(3.082)
Broadband Coverage in County	0.923	0.736	0.976
	(0.162)	(0.283)	(0.0628)
N	28197	3136	3132

Notes: This table displays the means of the coefficients for a variety of summary statistics. Standard deviations are in parentheses. Column 1 reports means and standard deviations for 2000 to 2008. Column 2 presents the means and standard deviations for the year 2000 only. Column 3 presents the means and standard deviations for the year 2008 only.

Table 2: Effect of Broadband Availability on Suicides

	(1) Deaths by Suicide (OLS)	(2) Deaths by Suicide (Poisson)
	Panel A: 2000-2008	
Broadband Available	-1.0526***	-0.1257***
in County	(0.1605)	(0.0456)
Observations	28113	27904
Mean of Dependent Variable	10.3846	10.4623
	Panel B: 2009-2018	
Broadband Available	1.9638	0.3400
in County	(4.8546)	(0.3777)
Observations	31281	31155
Mean of Dependent Variable	13.5870	13.6420
	Panel C: 2000-2018	
Broadband Available	-2.0155***	-0.0483
in County	(0.2481)	(0.0462)
Observations	59394	59321
Mean of Dependent Variable	12.0712	12.0860

Notes: This table reports the results of primary difference in differences analysis of the effect of increased access to broadband internet on suicides. Panel A reports results for 2000 to 2008. Panel B reports results from 2009 to 2018. Panel C reports results for 2000 to 2018. Column 1 reports the effect on deaths by suicide in a county, estimated by ordinary least squares. Column 2 reports the effect on deaths by suicide estimated by Poisson pseudo maximum likelihood with total population as the exposure variable. Column 3 reports the effect on deaths by suicide per 100,000 residents. We include controls for Black population, Hispanic population, poverty rate, unemployment rate, and quartile of income. Column 1 includes an additional control for total population. All models include county and year fixed effects. Robust standard errors are clustered at the county level.

. Standard errors are in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Table 3: Effect of Broadband Availability on Reported Mental and Physical Health

	(1) Days of Poor Physical Health	(2) Days of Poor Mental Health	(3) Number of Days You Were Drinking	(4) Binge Drinking Days
Broadband Available in County	-0.4672***	-0.5941***	-0.5499***	-0.4957
	(0.1570)	(0.1460)	(0.1931)	(0.4439)
Observations	1023176	1025809	509282	591529
Mean of Dependent Variable	3.3434	3.3295	5.3664	1.0842
Number of Clusters	373	373	378	378

Notes: This table reports the results of our analysis using BRFSS data of the effect of the rollout of broadband internet on different mental health outcomes. Each column represents a different Poisson regression where the outcome is the column title. We use data from 2002-2008 for this analysis. Column 1 presents the effect of county broadband availability on the estimated number of days of poor health in the last 30 days. Column 2 reports the effect on the number of days of poor mental health in the past 30 days. Column 3 reports the number of days having at least one alcoholic drink in the past 30 days. Column 4 reports the number of times in the past 30 days the interview subject had consumed 5 or more drinks on one occasion. All columns include county level controls for population, proportion of the population identified as Black or Hispanic, and unemployment rate. Further controls for sex, age, race, marital status, number of children, education level, employment, and income of the individual being interviewed are also included. All four regressions use weights generated to provide representative county level estimates. Robust standard errors are clustered at the county level. All columns include county, year, and month fixed effects. Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Table 4: Effect of Broadband Availability on County Economic and Demographic Factors

	(1) Poverty Rate	(2) Unemployment Rate	(3) Median Income	(4) Median House Value	(5) Median House Value 2006 and Before	(6) Black	(7) Hispanic	(8) White
Broadband Available in County	-0.0089***	-0.0013**	4884.3983***	-13638.4124***	-9089.5406***	-0.0008	-0.0057***	0.0014**
	(0.0012)	(0.0006)	(292.8821)	(1601.5916)	(810.7162)	(0.0005)	(0.0007)	(0.0005)
Observations	28113	28113	28113	28050	21813	28113	28113	28113
Mean of Dependent Variable	0.1432	0.0531	61262.1973	101291.6373	91960.0712	0.0895	0.0711	0.8674
Clusters	3130	3130	3130	3123	3123	3130	3130	3130

Notes: This table reports the effect of county level broadband availability on county level economic and demographic characteristics from 2000 to 2008. Each column represents a different ordinary least squares regression with the outcome as the column title. Column 1 reports the effect on county poverty rate and includes controls for population, Black and Hispanic population, unemployment rate, and quartiles of income. Column 2 reports the effect on unemployment rate and includes controls for population, Black and Hispanic population, poverty rate, and quartiles of income. Column 3 reports the effect on median income and includes controls for population, Black and Hispanic population, poverty rate and unemployment rate. Column 4 reports results for median house value and includes controls for population, Black and Hispanic population, poverty rate, unemployment rate, and median income. Column 5 limits the analysis from column 4 to the years 2000-2006. Column 6 reports the effect on the proportion of a county's population identified as Black. Column 6 includes controls for population, Hispanic population, poverty rate, unemployment rate, and quartiles of income. Column 7 reports the effect on the proportion of a county's population identified as Hispanic and includes controls for population, Black population, poverty rate, unemployment rate, and quartiles of income. Column 8 reports the effect on the proportion of a county's population identified as White. Column 8 includes controls for population, Black and Hispanic population, poverty rate, unemployment rate, and quartiles of income. Robust standard errors are clustered at the county level. All columns include county and year fixed effects.

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Table 5: The Roll Out of Facebook

	(1) Deaths by Suicide – All Ages	(2) Deaths by Suicide – 18-22 Year Olds
	Panel A: Facebook Roll Out	
Facebook is available in the County	0.0292	-0.0046
	(0.0355)	(0.0116)
Observations	52470	52560
Mean of Suicides	1.6082	0.1636
	Panel B: Mediation Analysis of Facebook's Effects on Suicides	
Broadband Available in County	-0.1140	-0.0259
	(0.1393)	(0.0480)
Facebook Available in County	0.0283	-0.0048
	(0.0355)	(0.0117)
Observations	52434	52524
Mean of Suicides	1.6091	0.1637

Notes: This table reports the effect of Facebook on monthly suicide deaths in 2003, 2004, and 2005. Panel A reports the effect of the roll out of Facebook on college campuses. The treatment variable is the proportion of undergraduate students in a county with access to Facebook in each month. Column 1 presents the effect on all suicides in a county month. Column 2 reports the effect on suicides by individuals 18 to 22 years old. Panel B presents a mediation analysis of the effect of broadband availability when controlling for Facebook availability. Column 1 presents the results for all suicide deaths in a month. Column 2 reports results for only decedents between 18 and 22 years old. All results include controls for population, Black and Hispanic population, poverty rate, unemployment rate, and quartiles of income. All models include year and county fixed effects. Robust standard errors are clustered at the county level.

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Table 6: Heterogeneity by Decedent Characteristic

Number of Suicides					
Panel A: Education Level					
	(1)	(2)	(3)	(4)	
	< High School	High School	Some College	College+	
Broadband Available in County	-0.0437	-0.4537***	-0.2917***	-0.2711***	
	(0.0500)	(0.0875)	(0.0537)	(0.0561)	
Observations	28113	28113	28113	28110	
Mean Deaths by Suicide	1.4914	3.6926	1.7368	1.5608	
Clusters	3130	3130	3130	3129	
Panel B: Age					
	(5)	(6)	(7)	(8)	(9)
	Age 10-24	25-44	45-64	65-84	85+
Broadband Available in County	0.0267	-0.1633**	-0.9274***	0.0328	-0.0185
	(0.0446)	(0.0816)	(0.1036)	(0.0441)	(0.0193)
Observations	28064	28098	28113	28113	28103
Mean Deaths by Suicide	1.4013	3.7550	3.5057	1.4591	0.2632
Clusters	3124	3128	3130	3130	3128
Panel C: Race, Ethnicity, Gender					
	(10)	(11)	(12)	(13)	(14)
	White	Black	Hispanic	Male	Female
Broadband Available in County	-0.9314***	-0.0070	-0.0739**	-0.7986***	-0.2538***
Observations	28113	26416	27306	28113	28110
Mean Deaths by Suicide	8.7471	0.6737	0.6770	8.2613	2.1234
Clusters	3130	2939	3038	3130	3129

Notes: This table presents the effect of county level broadband availability broken out by decedent characteristics. Panel A presents results based on education level for decedents 25 years old or older. Each category in Panel A is mutually exclusive. Column 1 reports results for decedents without a high school diploma. Column 2 reports results for decedents with a high school diploma. Column 3 reports results for decedents with some college education but no diploma. Column 4 reports results for decedents with a college degree or more. Panel B presents results based on decedent age at death. Each category in Panel B is mutually exclusive. Column 5 reports results for individuals aged 10 to 24. Column 6 reports results for individuals aged 25 to 44. Column 7 reports results for individuals aged 45 to 64. Column 8 reports results for individuals aged 65-84. Column 9 reports results for all individuals 85 and above. Panel C presents effects based on decedent race, ethnicity, or gender. Column 10 presents results for White individuals. Column 11 reports results for Black individuals. Column 12 reports results for Hispanic individuals. Race and ethnicity are mutually exclusive. Column 13 presents results for male individuals. Column 14 presents results for female individuals. Male and female are mutually exclusive. All columns include controls for county population, county Black and Hispanic population, county poverty rate, county unemployment rate, and quartiles of income. All models include county and year fixed effects. Robust standard errors are clustered at the county level.
Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 7: County Level Heterogeneity in the Effect of Broadband on Suicide: Dependent Variable—Deaths by Suicide

	(1) Above Median Population	(2) Below Median Population	(3) Above Median Population Density	(4) Below Median Population Density	(5) Metropolitan Counties	(6) Non-Metropolitan Counties	(7) Above Median Unemployment	(8) Below Median Unemployment
Broadband Availability in County	-1.1288*	-1.0486***	-1.2611***	-1.0254***	0.9810	-2.4288***	-1.1230***	-1.0027***
	(0.6149)	(0.1510)	(0.4108)	(0.1495)	(0.7522)	(0.2018)	(0.2050)	(0.1615)
Observations	28113	28113	28113	28113	28122	28122	28113	28113
Mean of Deaths by Suicide	10.3845	10.3845	10.3845	10.3845	10.3845	10.3845	10.3845	10.3845
	(9) Above Median Income	(10) Below Median Income	(11) Above Median Poverty	(12) Below Median Poverty	(13) Above Median Education	(14) Below Median Education	(15) Above Median Black	(16) Below Median Black
Broadband Availability in County	-1.4224***	-0.9466***	-1.0134***	-1.1091***	-1.1827***	-0.9046***	-1.1021***	-1.0309***
	(0.3153)	(0.1400)	(0.1519)	(0.2222)	(0.1737)	(0.1808)	(0.2182)	(0.1637)
Observations	28113	28113	28113	28113	28113	28113	28113	28113
Clusters	3130	3130	3130	3130	3130	3130	3130	3130

Notes: This table presents heterogeneity analysis by county characteristics. The dependent variable is the number of deaths by suicide. For each characteristic, counties were labeled as above or below median based on mean values for the period from 2000 to 2008. Interaction terms are combined to reflect accurate standard errors. All columns include controls for population, Black and Hispanic populations, poverty rate, unemployment rate, and quartiles of income. Robust standard errors are clustered at the county level. All columns include county and year fixed effects.

Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Table 8: Population Movement

	(1) Whole Sample Population	(2) Drop Counties with Most Population Loss	(3) Drop Counties with Greatest Population Change (max - min)	(4) Drop Counties with the Greatest Population Gain	(5) Drop Counties with Any Negative Change between 2000 and 2008
Broadband Available in County	-2943.7289***	-3906.8210***	-3130.4203***	-1050.7436***	-4110.4558***
	(645.8271)	(645.3207)	(887.3793)	(241.6007)	(1324.1701)
Observations	28113	25296	25316	25209	17914
Mean of Dependent Variable	93622.6579	88729.4229	103304.6582	53330.1568	118892.8505
Clusters	3130	2817	2814	2804	1994

Notes: This table reports the effect of county level broadband access on county population. The dependent variable is total county population. Each column represents a different sub-sample of counties. Column 1 reports results for all counties in our sample. Column 2 reports results when counties with the greatest negative change are omitted. Column 3 reports results when counties with the greatest change in either direction are omitted. Column 4 reports results when counties with the greatest positive change are omitted. Column 5 reports results when counties with any negative change in any year between 2000 and 2008 are omitted.
Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 9: Effect of Broadband Availability on Other Placebo Causes of Death

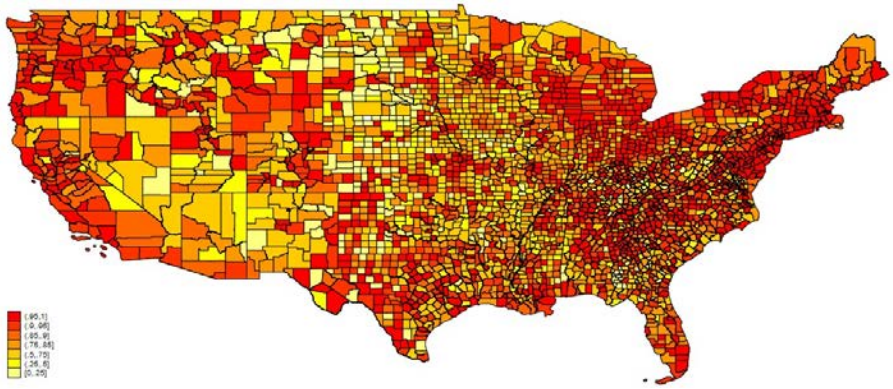
	(1) Appendix Deaths	(2) Car Accident Deaths	(3) Leukemia Deaths	(4) STD Deaths
Broadband Available in	0.0058	0.1158	0.0408	0.0011
County	(0.0123)	(0.2330)	(0.1247)	(0.0044)
Observations	28050	28050	28050	27996
Mean of Deaths by Condition	0.1408	14.2041	6.9447	0.0126
Clusters	3123	3123	3123	3117

Notes: This table repeats the analysis from Table 2, panel A, column 1 substituting different placebo causes of death for suicide deaths as the dependent variable. Robust standard errors are clustered at the county level. All columns include county year fixed effects. Standard errors in parentheses

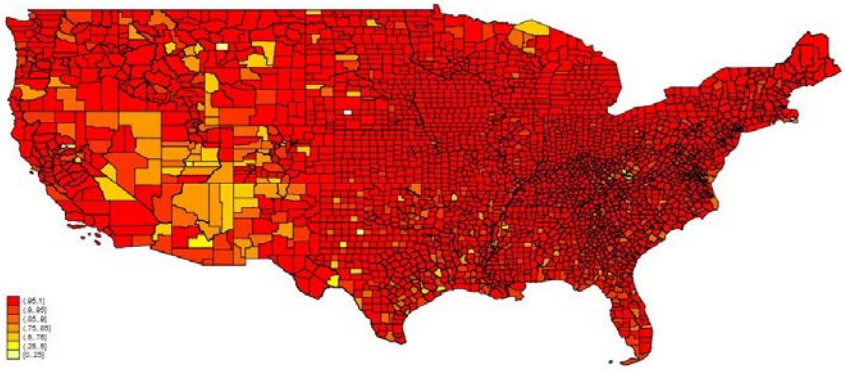
* $p < .1$, ** $p < .05$, *** $p < .01$

Figure 1: Maps of County Broadband Coverage in 2000 and 2008:

2000:

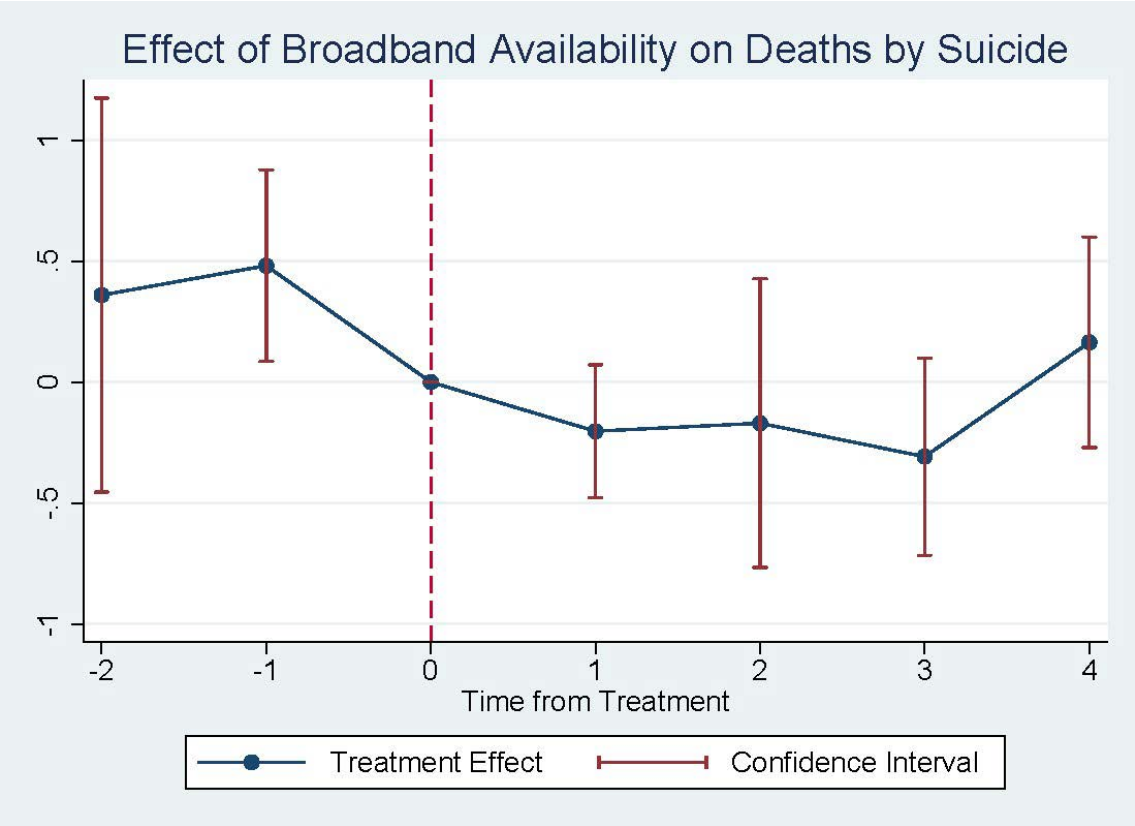


2008:



Notes: This figure shows county level broadband availability. Broadband availability is the proportion of a county's population living in a zip code with at least one broadband provider operating. Panel A shows county level broadband availability in 2000. Panel B shows county level broadband availability in 2008.

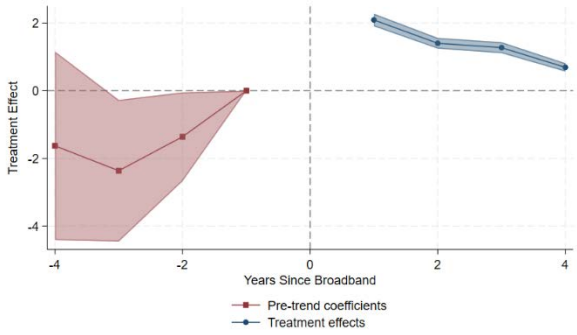
Figure 2: Event Study of the Effects of Broadband Internet Access on Suicides



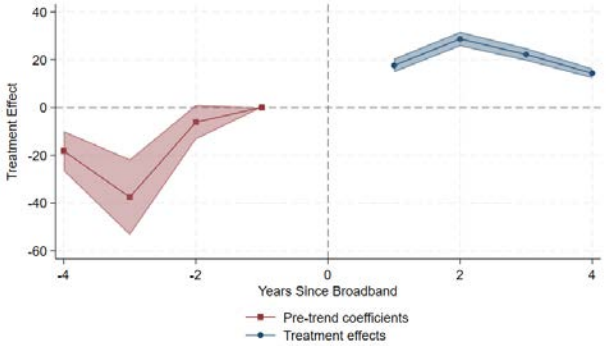
Notes: This event study shows the effect of a 4% increase in broadband internet access in time 1 on the number of suicides in the following years using the dynamic estimator did_multiplegt created by Chasemartin et al (2020). We use 25 bins. The omitted category is year 0. Standard errors are clustered at the county level.

Figure 3: Sun and Abraham Zip Code Effects

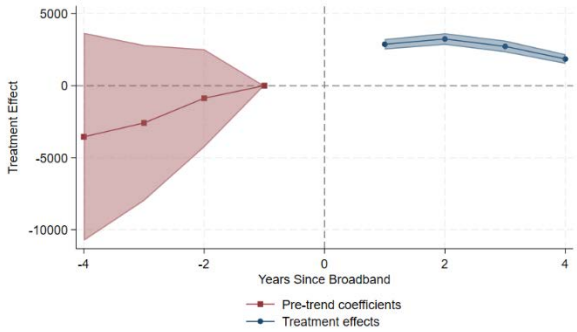
Establishments



Employees

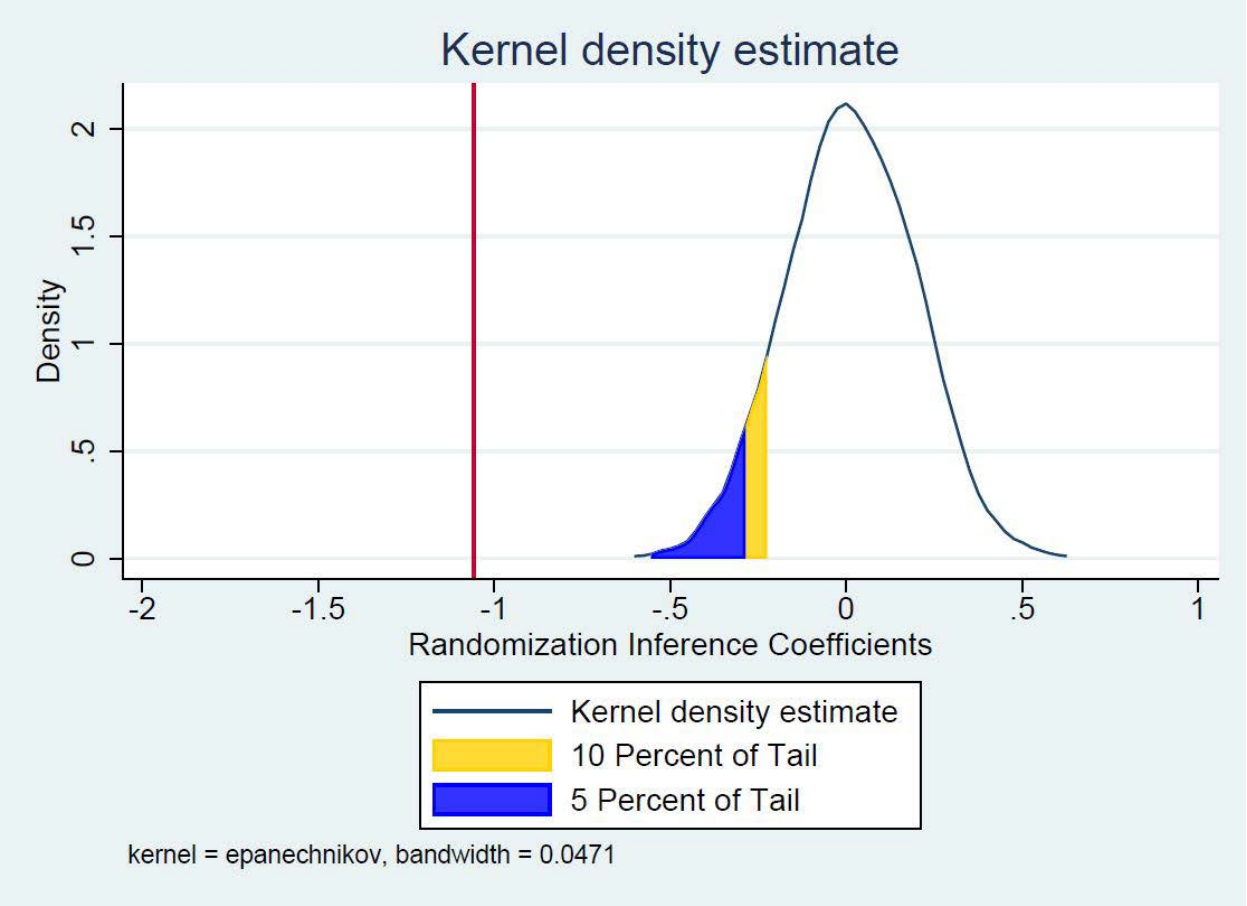


Annual Payroll



Notes: This figure shows the Sun and Abraham coefficients of the effect of a zip code gaining broadband availability. Panel 1 shows the effect on the number of employees in a zip code. Panel 2 shows the effect on the number of commercial establishments in a zip code. Panel 3 shows the effect on annual payroll in a zip code. All models include controls for total population, Black population, Hispanic population, median income, median home value, and the proportion of households renting their home. Robust standard errors are clustered at the zip code level.

Figure 4: Kernel Density Plot of Randomization Inference Test



Notes: This figure reports the results of a randomization inference test of the effect of broadband internet on suicides. The dependent variable is number of suicides per county. The red vertical bar represents the estimated effect of broadband internet on suicides from our primary specification from column 1 in Table 2. The blue shaded area represents the five percent tail of the randomization inference tests. The yellow shaded area represents the rest of the ten percent tail of the randomization test.

Appendix

Table A1: Effect of Broadband Availability on Suicides (2000-2008)

	(1) Suicides	(2) Suicides	(3) Suicides	(4) Suicides	(5) Suicides
Broadband Available in County	-1.2683***	-1.2602***	-1.0646***	-1.0526***	-0.7160***
	(0.1900)	(0.1808)	(0.1643)	(0.1605)	(0.2131)
Total Population Controls	X	X	X	X	X
Demographic Controls		X	X	X	X
Poverty and Income Controls			X	X	X
Unemployment Controls				X	X
State Linear Time Trends					X
Observations	28119	28119	28113	28113	28113
percent					
Mean of the Dependent Variable	10.3823	10.3823	10.3845	10.3845	10.3845
Clusters	3131	3131	3130	3130	3130

Note: This table reports the results of the primary difference in differences analysis of the effect of increased access to broadband internet on suicides. Column 1 reports the results with only population controls. Column 2 reports results including controls for total population, and Black and Hispanic population. Column 3 reports results with controls for total population, Black and Hispanic populations, poverty rate, and quartiles of income. Column 4 reports results with controls for total population, Black and Hispanic population, quartiles of income, and poverty and unemployment rates. Robust standard errors are clustered at the county level. Column 5 reports results from a specification that includes state level linear time trends. All specifications include county and year fixed effects. Standard errors in parentheses

* $p < .1$, ** $p < .05$, *** $p < .01$

Table A2: Zip Code Effects on Zip Codes with Below Median Population

	(1) Employees	(2) Establishments	(3) Annual Payroll
Broadband Available in Zip Code	60.2602***	4.2513***	150.7892
	(3.6509)	(0.1288)	(279.9130)
Observations	172642	182377	175876
Mean of Dependent Variable	356.4005	23.7501	15028.0160
Clusters	21947	22068	21957

Note: This table reports the effect of broadband availability on zip code level economic activity in zip codes with below median population. Column 1 reports the effect on the number of employees in a zip code. Column 2 reports the effect on the number of establishments in a zip code. Column 3 reports the effect on the annual payroll in a zip code. Robust standard errors are clustered at the zip code level. All models include zip code and year fixed effects, along with controls for population, Black population, Hispanic population, median income, median home value, and the proportion of the population renting their home.
Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table A3: Effect of Broadband Availability Estimated on Different Sub-Samples of Data

	Suicides					
	(1)	(2)	(3)	(4)	(5)	(6)
	Primary Specification	Drop 10% of counties with most negative one year change in population	Drop 10% counties with most population loss, 2000 to 2008	Drop 10% of counties with largest total change in population (max-min)	Drop 10% of counties with most positive one year change in population	Drop 2007 and 2008
Broadband Available in County	-1.0526***	-0.6672***	-0.8790***	-0.7535***	-0.9731***	-0.9568***
	(0.1605)	(0.1262)	(0.1731)	(0.1066)	(0.1508)	(0.1356)
Observations	28113	25286	25200	25299	25292	21862
Mean of Dependent Variable	10.3845	7.0412	9.9752	5.3692	8.1366	10.1156

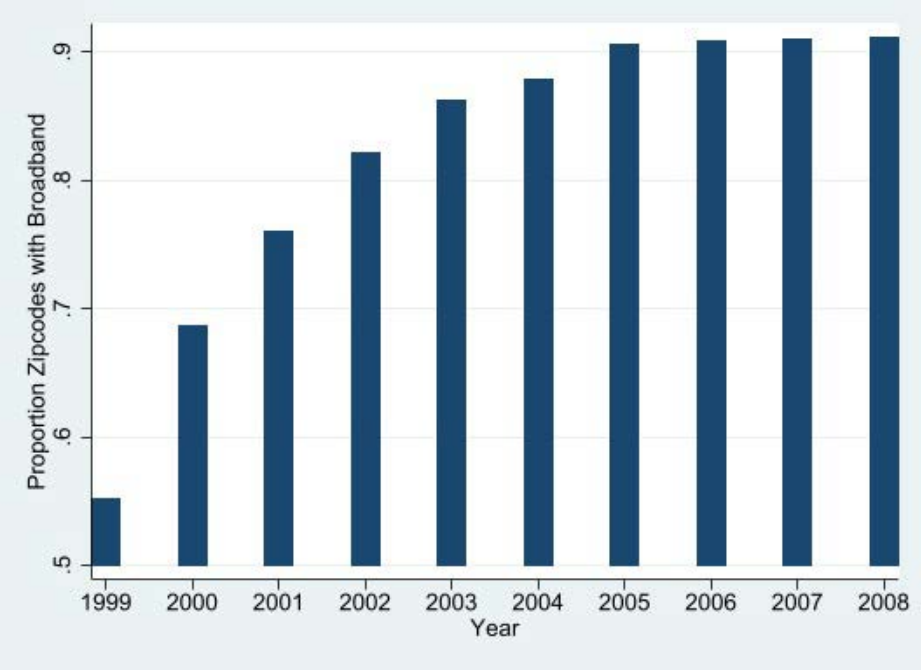
Note: This table reports the effect of county level broadband internet on deaths by suicides using different sub-samples of data. Column 1 reports the results from column 1 in panel A of Table 2. Column 2 reports the effect estimated when we drop the ten percent of counties with the greatest loss of population in one year. Column 3 reports the results without the ten percent of counties that experience the greatest loss of population between 2000 and 2008. Column 4 presents results when the ten percent of counties with the largest change in total population, measured by subtracting the lowest population value for each county from the highest population value. Column 5 reports results excluding the ten percent of counties with the largest one-year increase in population. Column 6 reports results without data from 2007 and 2008. All columns include county and year fixed effects and controls for total population, Black population, Hispanic population, poverty rate, unemployment rate, and quartiles of income. Robust standard errors are clustered at the county level.
Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A4: Effect of Broadband Availability on Suicide Rate (2000 – 2008)

	(1) Crude Suicide Rate	(2) Age Adjusted Suicide Rate
Broadband Available in County	-1.9415	-2.0419*
	(1.2178)	(1.1582)
Observations	27996	27996
Mean of Dependent Variable	13.4386	13.3253
Clusters	3117	3117

Note: This table replicates the analysis from Table 2, panel A. Column 1 reports the effect on the crude rate of deaths by suicide in a county. Column 2 reports the effect on the age adjusted rate of deaths by suicide in a county. The age adjusted rate was calculated using the U.S. 2000 standard population provided by the Centers for Disease Control. Both columns include controls for Black population, Hispanic population, poverty rate, unemployment rate, and quartile of income. In addition, both columns include county and year fixed effects. Robust standard errors are clustered at the county level.
Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Figure A1: Proportion of Zip Codes with Access to Broadband Internet



Notes: This figure shows the proportion of zip codes with at least one broadband service provider operating. The figure is not weighted by population and represents the zip code level coverage of broadband internet between 1999 and 2008.