International Journal of Health Economics and Management
https://doi.org/10.1007/s10754-021-09302-9

RESEARCH ARTICLE

The impact of the non-essential business closure policy on Covid-19 infection rates

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Received: 21 December 2020 / Accepted: 18 March 2021

Abstract
In response to the Covid-19 pandemic, many localities instituted non-essential business closure orders, keeping individuals categorized as essential workers at the frontlines while sending their non-essential counterparts home. We examine the extent to which being designated as an essential or non-essential worker impacts one's risk of being Covid-positive following the non-essential business closure order in Pennsylvania. We also assess the intrahousehold transmission risk experienced by their cohabiting family members and roommates. Using a difference-in-differences framework, we estimate that workers designated as essential have a 55% higher likelihood of being positive for Covid-19 than those classified as non-essential; in other words, non-essential workers experience a protective effect. While members of the health care and social assistance subsector contribute significantly to this overall effect, it is not completely driven by them. We also find evidence of intrahousehold transmission that differs in intensity by essential status. Dependents cohabiting with an essential worker have a 17% higher likelihood of being Covid-positive compared to those cohabiting with a non-essential worker. Roommates cohabiting with an essential worker experience a 38% increase in likelihood of being Covid-positive. Analysis of households with a Covid-positive member suggests that intrahousehold transmission is an important mechanism driving these effects.

Keywords Covid-19 · State policy · Non-essential business closures · Essential workers · Employment · Intrahousehold transmission

Introduction

Reopening the economy during the Covid-19 pandemic involves striking a delicate balance under massive uncertainty. Policymakers face tremendous pressure to balance concerns about harm from the Covid-19 pandemic with concerns about the negative impact of the lockdown on the welfare and livelihoods of people. With over 52 million Americans filing claims for unemployment insurance from March 14 to August 8, 2020 (United

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States Department of Labor 2020), and over 15 million additional Americans filing for Pandemic Unemployment Assistance (assistance available to informal sector workers such as those who are self-employed, seeking part-time employment, or who otherwise would not qualify for regular unemployment compensation) as of August 22, 2020 (United States Department of Labor 2020), the Covid-19 pandemic the has led to an unprecedented level of unemployment in the United States rivaling only the Great Depression.

Globally, 93% of the world's workers reside in countries with some sort of business closure measure in place since the start of 2020 (International Labour Organization 2020), with many jobs shifting into the home. Jobs that have not shifted into the home environment during the pandemic are, for the most part, jobs designated as "essential." Workers of these essential jobs have helped society maintain a semblance of normalcy. The most obvious in this group are health care workers, but employees working in grocery stores, delivery services, factories and farms, restaurants, transportation, and other industries are also considered essential workers. Individually, these workers face the same tradeoff confronted by society at large: on the one hand, essential workers take on greater risk of Covid-19 infection to themselves and their families, but on the other hand, they maintain financial viability. Conversely, non-essential workers and their families may be less at risk of Covid-19 infection, but these workers may be more likely to become unemployed or underemployed.

At the societal level, closure of non-essential businesses has been shown to be effective in reducing Covid-19 mortality (Ciminelli and Garcia-Mandico 2020), but a lockdown of all non-essential workers is unlikely to be cost-effective for an extended period (Fischer 2020). Prior work has already shown that closure of non-essential businesses jeopardized almost a quarter of jobs in the U.S. and reduced total wage income (del Rio-Chanona et al. 2020), had a perverse effect on wage inequality (Schiavone 2020), and increased unemployment mostly among minorities (Fairlie et al. 2020). Furthermore, designating businesses as essential or non-essential shifted consumer activity to favor those categorized as essential. For example, during stay-at-home orders, consumption patterns shifted from restaurants and bars toward groceries and other food vendors, while maintaining a small impact on aggregate levels of activity (Goolsbee and Syverson 2020). Similarly, essential retail—the "frontline" job most in demand during the pandemic—took a much smaller hit in job vacancies, while leisure and hospitality services and non-essential retail saw the biggest collapses (Forsythe et al. 2020).

Importantly, however, essential workers may be at higher risk of exposure to Covid-19 infection (Mutambudzi et al. 2020) and also be at greater risk of infecting others. Individuals most susceptible to infection by essential workers are likely to be those living under the same roof—such as cohabiting family members. Several epidemiologic studies from China have confirmed that intrahousehold transmission is a major route by which children become infected with the virus (Cai et al. 2020; Liu et al. 2020; Tan et al. 2020). One early study found that more than half of all patients with Covid-19 had at least one family member with the disease, and 75–80% of all clustered infections were within families (Chen et al. 2020). Additional work found that household transmission accounted for 30–55% of Covid-19 positive cases after social distancing was implemented (Curmei et al. 2020). These findings suggest that intrahousehold transmission may be an effective target for policy interventions.

In this paper, we examine the extent to which designation as an essential worker versus a non-essential worker impacts one's risk of being positive for Covid-19 following the statewide non-essential business closure order in Pennsylvania. We also assess the intrahousehold transmission risk experienced by cohabiting family members and roommates

of essential workers versus non-essential workers. This is a unique analytic problem, as it requires us to link Covid-19 status, employment sector, and physical address to establish cohabitation status, all at the individual level. Notably, it requires data from not only individuals testing positive for Covid-19 but also those not tested or testing negative. Data from health systems and government agencies lack the level of granularity and visibility into those individuals who have not tested positive, thus making it impossible to assess the impact of non-essential business closures on rates of Covid-19 infection among those working in essential versus non-essential businesses and those who live in proximity to them. Using data collected by Independence Blue Cross (Independence; a large commercial health insurer based in southeast Pennsylvania), we are able to construct a uniquely detailed dataset that merges individual-level Covid-19 status using medical insurance claims, enrollment and demographic information, and employer industry using North American Industry Classification (NAICS) codes, which were used to identify a individuals as essential or non-essential workers. This dataset is also unique in its breadth. Independence provides medical insurance to more than 50% of commercially insured individuals in the Greater Philadelphia area. The analyses presented here represent a substantial portion of essential and non-essential workers in the fifth largest metropolitan area in the United States.

We use a difference-in-differences framework to estimate that essential workers, relative to their non-essential counterparts, have a 55% higher likelihood of being positive for Covid-19. Said differently, non-essential workers experience a substantially lower risk of being positive for Covid-19 compared to their essential counterparts. While members of the health care and social assistance subsector contribute significantly to this overall effect, it is not completely driven by them. We also find evidence of intrahousehold transmission that differs in intensity by essential status.

Background

On March 19, 2020, less than two weeks after declaring a state of emergency for the Commonwealth of Pennsylvania, Governor Tom Wolf and Secretary of Health Rachel Levine issued a statewide order for all non-life-sustaining businesses in Pennsylvania to close their physical locations (Governor Tom Wolf 2020a). These orders were enforced by law; consequences of failed compliance with the order included citations, fines, or license suspensions. Accompanying the order, Governor Wolf included a list of life-sustaining businesses that were permitted to continue physical operations, identified using NAICS codes. In this paper, we refer to those employed by businesses that were permitted to continue operations (such as hospitals, transportation systems, and food manufacturing) as essential workers; those employed by businesses that were forced to temporarily close (including mining activities, construction, and general merchandise stores) are considered non-essential workers.

The criteria for classifying businesses and their employees into essential and non-essential categories were somewhat arbitrary. Although the Department of Homeland Security's Cybersecurity and Infrastructure Security Agency (CISA) published guidance for identifying essential industries (Cybersecurity and Infrastructure Security Agency 2020), ultimately the final decision was made by state-level governance. Classification of some businesses was uniform across states, but others were less clear; early in the pandemic, Pennsylvania was the only state to shutter liquor stores, Delaware permitted florists to

continue with deliveries, and Arizona allowed golf courses to remain open (Andrew 2020). Such differences highlight the substantial influence of policymakers in determining the livelihood of employees in industries that lack clear classification.

Despite existing variation in these classifications, essential workers broadly work in positions of higher risk and lower pay. Many of these industries—including grocery stores, warehousing, public transit, and health care—require employees to work long hours in high-density settings with prolonged close contact with other individuals; such conditions may put these workers at increased risk for exposure to Covid-19 (CDC 2020). Prior reports have also indicated that, compared to their non-essential counterparts, essential workers are more likely to be Black, have a household income of less than $40,000, and are less likely to hold a college degree (Kearney and Munana 2020). In addition, essential workers are more likely to report having more difficulty affording necessities like utilities and food and having more difficulty paying credit card bills (Kearney and Munana 2020). Furthermore, many essential workers in frontline industries are over age 50, live in a household with one or more adults over age 65, and have family care obligations (Rho et al. 2020). Some essential industries—such as building cleaning services—also have a high incidence of uninsured workers (Rho et al. 2020). Thus, essential workers may simultaneously be at greater risk for Covid-19 infection and be less-equipped to support themselves and their families in the event of illness. On the other hand, non-essential workers may face a high risk of having reduced work hours or of becoming unemployed (Lund et al. 2020; Sanchez et al. 2020).

Data

We use medical claims data, which shed light on the clinical status of an individual member vis-à-vis Covid-19 through a diagnosis code. Beyond information directly related to Covid-19, the medical claims also allow us to capture relevant clinical characteristics, such as whether the member has been diagnosed with a chronic condition in the past 12 months or whether the member has had an acute inpatient hospitalization in the past 12 months. We focus on Covid-19 positivity rather than the downstream risk of hospitalization or death for two reasons. First, the classification of businesses and their workers as essential versus non-essential was not based on individuals' differential risk of a positive diagnosis for Covid-19 translating into hospitalization and/or death; in other words, the non-essential business closure policy was orthogonal to one's risk of hospitalization or death. Second, the downstream risk of hospitalization or death is confounded by various factors including health care utilization (e.g., hospital capacity) and treatment protocols (e.g., Covid-19 standard of care, which has rapidly evolved since the beginning of the pandemic). These factors are less problematic in our study, which focuses on the differential risk of Covid-19 transmission as a result of the non-essential business closure policy.

We also draw on member files, which provide information regarding a member's demographic characteristics. At the member level, we can observe the member's age, gender, and ZIP code of residence. By merging member ZIP codes with data from the Federal Office of Rural Health Policy and the 2018 American Community Survey (ACS) 5-year aggregate ZIP Code tabulation area-level files, we can also observe ZIP Code-level characteristics including the rurality of each member's residence, its racial and ethnic composition, and the percent of members ages 18 to 64 living below the Federal Poverty Line (FPL). The member files also allow us to identify members as either primary policyholders

or as dependents of a primary policyholder (including spouses) and create a flag for members (either primary policyholders or dependents) that share the same address (i.e., are cohabitants).

Our data also shed light on a member's employment status and affiliation by maintaining NAICS codes for employer-based customers. NAICS codes were developed by the Office of Management and Budget (OMB) and adopted in 1997 (United States Census Bureau 2020a). Under NAICS, business establishments are classified according to Sector (2-digit code), Subsector (3-digit code), Industry Group (4-digit code), NAICS Industry (5-digit code), and National Industry (6-digit code) (United States Census Bureau 2020b). Using each employer's 4-digit Industry Group code, we classify individual members who are primary policyholders as essential workers or non-essential workers.

For our analyses, we restrict our sample to primary policyholders and their cohabiting dependents who reside in Pennsylvania and have been continuously enrolled and employed for at least four months from January through April of 2020. We also restrict to members who are commercially insured; in other words, we exclude members who are insured through Medicare or the Affordable Care Act. All analyses are conducted for weeks 7 to 23 of 2020 (February 12, 2020 to June 9, 2020, inclusive), with the end date coinciding with the expiration of the stay-at-home order declared by Governor Wolf (Governor Tom Wolf 2020b). Our final sample comprises 415,958 primary policyholders and 387,412 cohabiting dependents.

Descriptive statistics

Trends

Figure 1a shows the cumulative proportion of members in our sample with a positive diagnosis for Covid-19 over weeks 7 to 23 of 2020. From week 7 to week 9, nearly no members were positive for Covid-19. Beginning in week 10, the proportion of Covid-positive members started to increase at a steady rate. When we stratify members into essential workers versus non-essential workers, we see that this rate of increase, and the cumulative proportion of Covid-positive members, is greater for essential workers compared to their non-essential counterparts.

It is possible that the disparities in Covid-positive rates across the two groups arise from differential testing rates between essential workers and non-essential workers. Specifically, populations with greater exposure to the virus may have been tested more frequently; in Pennsylvania, early guidelines limited testing to people demonstrating Covid-19 symptoms (Moselle and Benshoff 2020). By July 10 (which falls after the end of our study period), testing guidelines were revised to include asymptomatic individuals who suspected contact with an infected person (Pennsylvania Department of Health 2020). As such, we examine the weekly proportion of positive diagnoses among essential workers who were tested and non-essential workers who were tested (Fig. 1b). We find that the positivity rates among essential and non-essential workers who were tested were comparable up until week 14. In fact, prior to week 13, non-essential workers briefly exhibited higher rates of positivity than their essential counterparts. Starting in week 13 and through week 18, a greater proportion of essential workers being tested were receiving positive results compared to non-essential workers being tested. Week 19 and later, the weekly positivity rates across the two

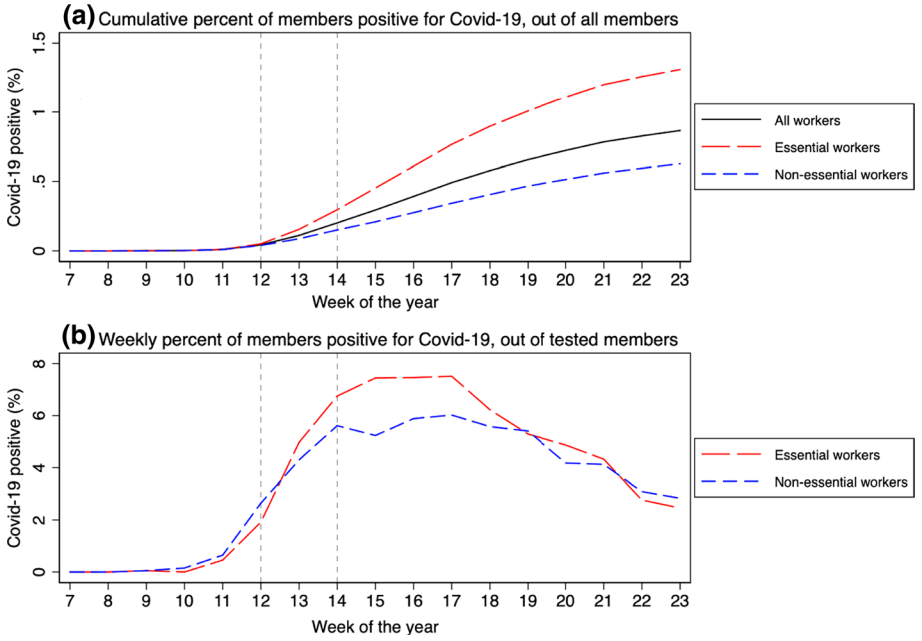

Fig. 1 Trends of Covid-19 positivity, week 7 to week 23 of 2020. *Notes* Panel **a** shows the cumulative percent of members who are positive for Covid-19, out of all Independence members. Panel **b** shows the weekly percent of members who are positive for Covid-19, out of tested Independence members. In both panels, the dotted line at week 12 indicates when the governor's non-essential business closure order was enacted in Pennsylvania, and the dotted line at week 14 marks the beginning of the post-implementation period in our analyses; the latter accounts for the approximately 2-week incubation period of Covid-19

groups become similar again. Overall, the weekly positivity rate among all tested members began to exhibit a gradual decrease beginning in week 18.

Summary statistics

In Table 1, we present summary statistics of all primary policyholders and their cohabitants who meet our inclusion criteria. In Panel A, we see that essential workers comprise 37.2% of primary policyholders, and these members are more likely to be Covid-positive (2.1% positivity) than their non-essential counterparts (0.9% positive). The proportion of essential workers in our sample is similar to that of the overall United States population, which was reported to be 34% according to a poll conducted in April 2020 (Kirzinger et al. 2020). Overall, primary policyholders who are essential workers tend to be younger, are more likely to be female, have slightly more rural representation, are less likely to have a chronic condition, and are less likely to be cohabiting with another Independence member. Comparing ZIP Code-level characteristics shows that essential workers are more likely to live in areas with a greater proportion of Black/African American or Hispanic residents and are more likely to live in an area with a greater proportion of residents living below the FPL.

When we turn to cohabiting dependents of primary policyholders (Panel B), we find that 33.7% live with essential workers, whereas 66.3% live with non-essential workers.

Table 1 Summary statistics for primary policyholders and their cohabitants

	All primary policyholders			Cohabiting dependents			Cohabiting non-essential non-dependents		
	Essential	Non-essential	Difference	Living with essential primary policy-holder	Living with non-essential primary policy-holder	Difference	Living with essential primary policy-holder	Living with non-essential primary policy-holder	Difference
Member-level characteristics	*N* (%)	*N* (%)	*p* value	*N* (%)	*N* (%)	*p* value	*N* (%)	*N* (%)	*p* value
Covid-19 positive	3218 (2.1)	2438 (0.9)	< 0.001	766 (0.6)	1226 (0.5)	< 0.001	123 (1.5)	1279 (0.9)	< 0.001
Age (years)			< 0.001			< 0.001			< 0.001
0–17	8 (0.005)	34 (0.01)	0.23	56,226 (43.0)	109,800 (42.8)	0.09	2 (0.0)	20 (0.0)	0.79
18–50	95,393 (61.6)	149,268 (57.2)	< 0.001	53,970 (41.3)	104,853 (40.8)	0.004	5337 (63.6)	78,364 (54.8)	< 0.001
51–64	48,720 (31.5)	82,797 (31.7)	0.12	17,478 (13.4)	34,834 (13.6)	0.111	2433 (29.0)	50,189 (35.1)	< 0.001
65+	10,688 (6.9)	29,050 (11.1)	< 0.001	2955 (2.3)	7296 (2.8)	< 0.001	616 (7.3)	14,416 (10.1)	< 0.001
Female	86,390 (55.8)	123,653 (47.3)	< 0.001	68,470 (52.4)	139,179 (54.2)	< 0.001	3748 (44.7)	61,840 (43.2)	0.01
Rural[a]	1686 (1.1)	2366 (0.9)	< 0.001	1398 (1.1)	2408 (0.9)	< 0.001	8 (0.1)	1314 (0.9)	< 0.001
Clinical characteristics[b]									
At least one chronic condition[c]	72,289 (46.7)	129,296 (49.5)	< 0.001	44,919 (34.4)	96,031 (37.4)	< 0.001	3781 (45.1)	73,244 (51.2)	< 0.001
At least one acute inpatient hospitalization	6929 (4.5)	11,850 (4.5)	0.36	3860 (3.0)	7734 (3.0)	0.33	330 (3.9)	6899 (4.8)	< 0.001
Member with cohabiting dependent	65,517 (42.3)	128,746 (49.3)	< 0.001	N/A	N/A	N/A	N/A	N/A	N/A
Member with cohabiting non-dependent	12,679 (8.2)	22,631 (8.7)	< 0.001	N/A	N/A	N/A	N/A	N/A	N/A

Table 1 (continued)

	All primary policyholders			Cohabiting dependents			Cohabiting non-essential non-dependents		
	Essential	Non-essential	Difference	Living with essential primary policy-holder	Living with non-essential primary policy-holder	Difference	Living with essential primary policy-holder	Living with non-essential primary policy-holder	Difference
ZIP code-level characteristics	% (SD)	% (SD)	*p* value	% (SD)	% (SD)	*p* value	% (SD)	% (SD)	*p* value
% White	68.4 (27.3)	71.0 (25.6)	< 0.001	75.7 (22.5)	73.3 (24.7)	< 0.001	67.4 (27.0)	73.9 (23.8)	< 0.001
% Black or African American	20.2 (25.9)	17.9 (24.3)	< 0.001	13.9 (20.9)	16.1 (23.0)	< 0.001	20.7 (25.9)	15.4 (22.3)	< 0.001
% Asian	6.0 (5.2)	6.1 (5.1)	< 0.001	6.0 (4.8)	6.0 (4.9)	0.005	6.4 (5.3)	6.0 (4.9)	< 0.001
% Other race	2.8 (4.4)	2.5 (4.0)	< 0.001	2.1 (3.4)	2.3 (3.8)	< 0.001	2.9 (4.4)	2.2 (3.6)	< 0.001
% Hispanic or Latino	7.9 (9.4)	7.2 (8.6)	< 0.001	6.4 (7.4)	6.7 (8.0)	< 0.001	7.8 (9.1)	6.6 (7.8)	< 0.001
% Below FPL, ages 18–64	12.0 (9.6)	11.1 (9.3)	< 0.001	9.1 (7.8)	9.9 (8.3)	< 0.001	11.9 (9.5)	9.8 (8.3)	< 0.001
Total members	154,809	261,149		130,629	256,783		8388	142,989	

[a]Data come from the Federal Office of Rural Health Policy data files and the 2018 American Community Survey (ACS) 5-year aggregate ZIP Code tabulation area-level files

[b]Clinical characteristics are measured using a 12-month lookback window

[c]Chronic conditions include acquired hypothyroidism; acute myocardial infarction; Alzheimer's disease; Alzheimer's disease and related disorders or senile dementia; anemia; asthma; atrial fibrillation; benign prostatic hyperplasia; breast cancer; cataract; cerebral palsy; chronic kidney disease; chronic obstructive pulmonary disease and bronchiectasis; colorectal cancer; cystic fibrosis and other metabolic developmental disorders; diabetes type 1; diabetes type 2; endometrial cancer; epilepsy; fibromyalgia, chronic pain, and fatigue; glaucoma; heart failure; hip/pelvic fracture; hepatitis A; hepatitis B; hepatitis C; hepatitis D; hepatitis E; hyperlipidemia; hypertension; ischemic heart disease; leukemias and lymphomas; lung cancer; migraine and chronic headache; mobility impairments; multiple sclerosis and transverse myelitis; muscular dystrophy; osteoporosis; peripheral vascular disease; prostate cancer; rheumatoid arthritis/osteoarthritis; sensory blindness and visual impairment; sensory deafness and hearing impairment; spina bifida and other congenital anomalies of the nervous system; spinal cord injury; stroke/transient ischemic attack; and traumatic brain injury and nonpsychotic mental disorders due to brain damage

Mirroring what we saw with the primary policyholders, dependents who live with essential workers are more likely to be Covid-positive (0.59%) compared to those who live with non-essential workers (0.48%).

Panel C shows summary statistics for members who are cohabiting with another primary policyholder but are neither their dependents nor essential workers themselves; we refer to this group of members as non-essential non-dependents. We see that the overwhelming majority (94.5%) of these members are living with other non-essential workers and only 5.5% are living with essential workers. Those cohabiting with essential workers, compared to those cohabiting with non-essential workers, have a higher likelihood of being Covid-positive (1.47% vs 0.89%).

Effect of being an essential worker

To quantify the average effect of the non-essential business closure order in Pennsylvania on the likelihood of being Covid-positive among essential workers versus non-essential workers, we estimate a difference-in-differences model on our sample of primary policyholders. We restrict our sample to primary policyholders because we can only identify the employer industry of primary policyholders, and thus classify them as essential versus non-essential workers. To account for the approximately 2-week incubation period of Covid-19 (Lauer et al. 2020), we define week 14 of 2020 (starting April 1, 2020) as the beginning of the post-implementation period, which is two weeks after the business closure order was enacted.[1] Our difference-in-differences model is a fixed-effects regression as follows:

$$Y_{ijt} = \beta_0 + \beta_1\left(Essential_j * Post_t\right) + \beta_2 Essential_j + \beta_3 \mathbf{X}_i + \beta_4 Week_t + \beta_5 County_i + \beta_6 Industry_j + \varepsilon_{ijt} \quad (1)$$

Y_{ijt} is a binary indicator for member i in industry subsector j in week t and indicates whether the member is positive for Covid-19. $Essential_j$ is an indicator variable that equals 1 if subsector j in which the member is employed is deemed essential by the governor's business closure order, and 0 otherwise. $Post_t$ equals 1 for weeks 14 through 23, and 0 otherwise. $\mathbf{X}_i$ is a vector of member characteristics, including age, gender, cohabitation status, clinical characteristics, rurality, and socioeconomic characteristics based on the member's ZIP Code. $Week_t$, $County_i$, and $Industry_j$ are week, county, and industry fixed effects, respectively. We control for industry fixed effects specifically at the subsector level (3-digit NAICS code) to allow for within-industry variation of essential versus non-essential workers (since the latter is defined at the 4-digit industry group level). The main effect for $Post_t$ is omitted because it is perfectly collinear with the week fixed effects. β_1 is the difference-in-differences estimator that captures the effect of the business closure order on the likelihood of being Covid-positive for essential workers.

Table 2 presents results from the difference-in-differences estimation. We find that being an essential worker is associated with a 0.75% point increase in one's likelihood of being Covid-positive (column (1)). Given an average positivity rate of 1.36%, this corresponds to a 55% increase in likelihood of being Covid-positive for essential workers compared to non-essential workers.

[1] As a robustness check, we also estimate a model in which we define week 12 of 2020 as the start of the post-implementation period.

Table 2 Effect of essential status on likelihood of being positive for Covid-19

	(1) All primary policyholders	(2) Restricted to primary policyholders < 65 years	(3) Excluding primary policyholders in health care and social assistance subsector	(4) Restricted to primary policyholders in health care and social assistance subsector
Essential × post	0.00751*** (0.00011)	0.0073*** (0.00012)	0.00209*** (0.00012)	0.01241*** (0.00137)
Essential	−0.00369*** (0.00011)	−0.00357*** (0.00012)	−0.00088*** (0.00011)	−0.00186 + (0.00105)
Age < 18	−0.00448 + (0.00265)	−0.00464 + (0.00267)	−0.00464* (0.00229)	−0.00795 (0.02579)
Age 51−64	0.00017** (0.00006)	0.00016** (0.00006)	0.00005 (0.00006)	0.00076*** (0.00022)
Age 65+	−0.00111*** (0.0001)		−0.00145*** (0.00009)	0.00119** (0.00039)
Female	−0.00003 (0.00006)	0.00003 (0.00006)	0 (0.00005)	0.00036 (0.00022)
Rural	−0.00051 + (0.00029)	−0.00046 (0.0003)	−0.0002 (0.00027)	−0.00225* (0.00098)
At least one chronic condition	0.00246*** (0.00006)	0.00253*** (0.00006)	0.00188*** (0.00005)	0.00497*** (0.0002)
At least one acute inpatient hospitalization	0.00483*** (0.00013)	0.00453*** (0.00015)	0.00489*** (0.00012)	0.00483*** (0.00043)
Member with cohabiting dependent	0.00073*** (0.00006)	0.00065*** (0.00006)	0.0007*** (0.00005)	0.00066** (0.0002)
Member with cohabiting non-dependent	−0.00033** (0.0001)	−0.00037** (0.00012)	0.00002 (0.00009)	−0.00169*** (0.00038)
% Black or African American	0.01078*** (0.00018)	0.01097*** (0.00019)	0.00926*** (0.00018)	0.01491*** (0.00059)
% Asian	0.01131*** (0.00059)	0.0108*** (0.00062)	0.00891*** (0.00055)	0.02106*** (0.00203)
% Other race	0.0077*** (0.00205)	0.01134*** (0.00215)	0.00415* (0.00192)	0.00564 (0.00739)
% Hispanic or Latino of any race in ZIP Code	0.00694*** (0.00095)	0.00591*** (0.001)	0.00579*** (0.00088)	0.01579*** (0.00355)
% Below FPL in ZIP Code	−0.00909*** (0.00056)	−0.01015*** (0.00058)	−0.00623*** (0.00053)	−0.0177*** (0.0018)
Week FE	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	No
Mean of DV	0.0136	0.0137	0.0100	0.0302
Observations	415,958	376,220	341,118	74,840

The table presents results of estimating Eq. (1) using a sample of all primary policyholders (column (1)), primary policyholders less than 65 years (column (2)), primary policyholders not in the health care and social assistance subsector (column (3)), and primary policyholders in the health care and social assistance subsector only (column (4)). Robust standard errors are reported in parentheses

$+p<0.10$; $*p<0.05$; $**p<0.01$; $***p<0.001$

To account for the possibility that some primary policyholders may no longer be active members of the workforce (i.e., retired) but continue to receive health insurance benefits through their previous employers, we repeat this estimation and restrict the sample to primary policyholders who are less than 65 years of age. This is particularly important to examine since older age is a documented risk factor for Covid-19 (Jordan et al. 2020), and thus could bias our findings away from the null. In Table 2 column (2), we see that our results are robust to this additional restriction. In this group, we find that being an essential worker is associated with a 53% increase in likelihood of being Covid-positive (0.73% point increase over an average positivity rate of 1.37%).

Next, we examine whether and the extent to which this effect is being driven by those who are employed in the health care industry, as these members may disproportionately be exposed to others who are positive for Covid-19. For this, we conduct two additional analyses. First, we repeat our estimation of Eq. (1) for a sample that excludes members who are employed in the health care and social assistance subsector. Second, we use a sample that is comprised only of these members who are employed in the health care and social assistance subsector. We include the social assistance subsector along with the health care subsector because this is the highest level of granularity we can attain using the 3-digit NAICS code. Examples of employers in this subsector include hospital systems, nursing homes, social assistance, and daycare centers. In this subsector, 98% of primary policyholders are designated as essential workers and 2% of primary policyholders are designated as non-essential workers, according to the Pennsylvania governor's business closure order.

The results of these analyses are shown in columns (3) and (4) of Table 2. When we exclude members who are employed in the health care and social assistance subsector, we find that being an essential worker is associated with a 21% increase in one's likelihood of being Covid-positive (0.21% point increase over an average positivity rate of 0.10%), relative to being a non-essential worker. While smaller in magnitude than the estimated effect for the full sample, this result is still statistically significant at the 0.1% level. In comparison, being an essential worker who is employed in the health care and social assistance subsector is associated with a 41% increase in one's likelihood of being Covid-positive (1.24% point increase over an average positivity rate of 3.02%), relative to being a non-essential worker employed in the same subsector. The magnitude of the percentage point increase (1.24% points) is meaningfully larger than that of the estimated effect for the full sample (0.75% points). These findings suggest that while those employed in the health care and social assistance subsector contribute significantly to the overall effect, the effect is not completely driven by these members.

Effect of cohabiting with an essential worker

The current clinical literature suggests that Covid-19 primarily spreads through close person-to-person contact (Chu et al. 2020). Thus, we examine whether one's risk of being Covid-positive after the business closure order varies depending on whether the individual cohabits with an essential worker as opposed to a non-essential worker. We separately examine the effects of cohabitation for (a) dependents of primary policyholders and for (b) non-essential non-dependents cohabiting with another primary policyholder.

Effect on dependents cohabiting with an essential worker

First, we examine whether and the extent to which dependents of essential workers are at greater risk of being Covid-positive relative to dependents of non-essential workers. In other words, are family members of essential workers at greater risk of being positive for Covid-19? We repeat our estimation of Eq. (1) with an analysis sample that comprises all cohabiting dependents of primary policyholders. Column (1) of Table 3 shows that dependents who are cohabiting with an essential worker are 0.09% points more likely to be Covid-positive than dependents who are cohabiting with a non-essential worker. Given an average positivity rate of 0.51% among all dependents, this corresponds to a 17% increase in likelihood of being Covid-positive for dependents of essential workers compared to dependents of non-essential workers.

Because it is not possible to determine whether the dependents themselves are essential versus non-essential workers, next we consider a narrower sample of dependents that is restricted to those who are less likely to be attached to the labor force. Specifically, we examine the risk for cohabiting dependents who are either under 18 years of age or are 65 years or older (column (2)). In this sample, we continue to find that dependents who are cohabiting with an essential worker are more likely to be Covid-positive than those who are cohabiting with a non-essential worker (0.05% point increase), which corresponds to a 23% increase in their likelihood of being Covid-positive. When we further restrict the sample to only cohabiting dependents who are under 18 (i.e., children who are minors), we find that minor dependents experience a 0.03% point increase (or a 18% increase) in their likelihood of being Covid-positive (column (3)).

Effect on non-essential non-dependents cohabiting with an essential worker

Next, we examine whether and the extent to which non-dependent cohabitants who are non-essential workers are more likely to be Covid-positive when they live with an essential worker as opposed to a non-essential worker. For the most part, we can think of these individuals as roommates who are not family members (although it is possible that two family members may both be primary policyholders on separate insurance policies with Independence). For the sample of all non-essential primary policyholders who are cohabiting with another Independence primary policyholder, we again estimate Eq. (1) and show these results in column (4) of Table 3.

We find that non-essential non-dependents cohabiting with an essential worker experience a 0.35% point increase in their likelihood of being Covid-positive relative to those cohabiting with a non-essential worker. Given an average positivity rate of 0.93%, this corresponds to a 38% increase in likelihood of being Covid-positive for individuals with a roommate who is an essential worker. Interestingly, the magnitude of this increase in risk is greater for roommates (i.e., non-dependents) than for family members (i.e., dependents).

Effect of cohabiting with a Covid-19 positive essential worker

To examine whether our analyses above actually represent the transmission of Covid-19 from one individual to another who are living in the same household, we conduct additional analyses in which we focus on a sample of households with at least one Covid-positive member. After identifying this set of households, we remove from the analysis sample the Covid-positive index member, which we define as the household member with the

earliest diagnosis date. This leaves us with an analysis sample of individuals cohabiting with a Covid-positive member who may either be an essential or a non-essential worker. In 167 households (0.04% of the full sample), two members of the same household are diagnosed with Covid-19 on the same date. Of these, 161 households have Covid-positive members with a concordant essential status (i.e., both members are either essential workers or non-essential workers) and 6 households have Covid-positive members with discordant essential status (i.e., one member is an essential worker and the other is a non-essential worker). For these 167 households, we randomly assign one of the two Covid-positive members as the index member and remove that individual from the analysis sample. We also drop the 6 discordant households from our analyses and find our results to be robust.

Column (5) of Table 3 reports the results of estimating Eq. (1) for this sample of individuals cohabiting with a Covid-19 positive index member. We find that those cohabiting with a Covid-positive essential worker have a likelihood of Covid-positivity themselves that is 0.45% points higher than those cohabiting with a Covid-positive non-essential worker (column (1)). Given a relatively high positivity rate in this population (7.4%), this corresponds to a 6.1% increase in likelihood of being Covid-positive for those living with a Covid-positive essential worker in comparison to those living with a Covid-positive non-essential worker. This suggests that intrahousehold transmission of Covid-19 is high regardless of whether the index member is an essential worker or not, and that the risk of transmission seems slightly higher when the index member is an essential worker.

Robustness

We conducted several additional analyses to assess the robustness of our main findings. First, we find that our difference-in-differences estimates are highly stable across the inclusion of fewer versus more control variables and fixed effects. For our main model with the sample of primary policyholders, as we move from a sparser model with only week fixed effects (Table 4 column (1)) to models in which we add member- and ZIP Code-level controls (column (2)), and county fixed effects (column (3)), the effect remains remarkably robust and consistent. This is also the case for all other models estimated above (see tables in the Appendix).

The main effect is also robust to defining week 12 of 2020 as the start of the post-implementation period as opposed to week 14. Week 12 marks the very beginning of the business closure order and does not account for the time it takes for the virus to spread, incubate, and manifest via symptoms. Since the criteria for receiving a diagnostic test for Covid-19 during the study period was relatively strict and largely limited test availability to symptomatic individuals or those with close contact with a known Covid-positive individual (Pennsylvania Department of Health 2020), using week 12 to define the beginning of the post period may provide an underestimate of the true effect as it does not sufficiently account for a "lead-in" period. We find that our main results remain highly robust, with a 0.65% point increase in likelihood of being Covid-positive associated with being an essential worker as opposed to a non-essential worker (column (4)); this effect is only marginally smaller in magnitude than what we estimated previously in Sect. 5.

Finally, we also find that the main effect is robust to smaller geographic units and the inclusion of additional geographic controls. In column (5) of Table 4, we restrict the sample to include only those members residing in the Philadelphia 5-county area, which allows us to include ZIP Code fixed effects in lieu of county fixed effects and ZIP Code-level

Table 3 Effect of cohabiting with essential worker on likelihood of being positive for Covid-19

	(1) All cohabiting dependents	(2) Cohabiting dependents, < 18 or 65 + years	(3) Cohabiting dependents, < 18 years	(4) Cohabiting non-essential non-dependents	(5) Cohabitants of first Covid-positive member in household
Essential × post	0.00086*** (0.00007)	0.00045*** (0.00006)	0.00027*** (0.00005)	0.00349*** (0.00032)	0.00453** (0.00167)
Essential	− 0.00064*** (0.00007)	− 0.00029*** (0.00007)	− 0.00021*** (0.00005)	− 0.00039 (0.00025)	− 0.00888*** (0.00171)
Age < 18	− 0.00183*** (0.00004)	− 0.00300*** (0.00006)		− 0.00522 + (0.00299)	− 0.01912*** (0.00097)
Age 51–64	0.00124*** (0.00005)			0.00034*** (0.00008)	0.01933*** (0.00118)
Age 65+	0.00087*** (0.00011)			− 0.00148*** (0.00013)	0.01027*** (0.00181)
Female	0.00013*** (0.00003)	− 0.00006* (0.00003)	0.00005* (0.00002)	− 0.00016* (0.00008)	0.00242** (0.00083)
Rural	− 0.00031 + (0.00018)	− 0.00026 (0.00016)	− 0.00013 (0.00013)	− 0.00132** (0.00041)	0.01441 (0.01262)
At least one chronic condition	0.00099*** (0.00004)	0.00021*** (0.00003)	0.00008** (0.00003)	0.00185*** (0.00008)	0.01114*** (0.0009)
At least one acute inpatient hospitalization	0.00361*** (0.0001)	0.00564*** (0.00011)	0.0039*** (0.00011)	0.00499*** (0.00017)	0.02719*** (0.00207)
% Black or African American	0.00243*** (0.00013)	0.00123*** (0.00011)	0.00087*** (0.00009)	0.00855*** (0.00027)	− 0.00756** (0.00248)
% Asian	0.00456*** (0.00038)	0.00181*** (0.00033)	0.0002 (0.00028)	0.00813*** (0.00082)	0.02981*** (0.00881)
% Other race	0.00128 (0.00134)	− 0.00147			
(0.00116)	0.001 (0.00097)	0.01166*** (0.00301)	0.06123 + (0.03204)		
% Hispanic or Latino of any race in ZIP Code	0.00134* (0.00061)	0.00098 + (0.00053)	0.00047 (0.00044)	0.00285* (0.00138)	− 0.04437** (0.01577)
% Below FPL in ZIP Code	0.00054 (0.0004)	− 0.00029 (0.00034)	− 0.00056* (0.00029)	− 0.00761*** (0.00085)	0.02178** (0.0082)
Week FE	Yes	Yes	Yes	Yes	Yes
County FE	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes
Mean of DV	0.00514	0.00198	0.00146	0.00926	0.0739
Observations	387,412	176,277	166,026	151,377	10,117

The table presents results of estimating Eq. (1) using a sample of all cohabiting dependents (column (1)), cohabiting dependents less than 18 years or 65 years or older (column (2)), cohabiting dependents less than 18 years (column (3)), cohabiting non-essential non-dependents (column (4)), and cohabitants of the first Covid-positive member in the household (column (5)). Robust standard errors are reported in parentheses

$+p < 0.10$; $*p < 0.05$; $**p < 0.01$; $***p < 0.001$

controls. With this estimation, we find a 0.82% point increase in the likelihood of essential workers being Covid-positive relative to non-essential workers, which corresponds to a 57% increase in essential workers' risk of being Covid-positive.

Discussion and conclusions

Our findings suggest that essential workers and their cohabitants (whether dependents or other primary policyholders sharing the same address) are at substantially higher risk of being positive for Covid-19 than are non-essential workers and their cohabitants. Conversely, non-essential workers and their cohabitants experience a protective effect against the risk of Covid-19 infection as a result of the non-essential business closure policy. In our sample, essential workers are 55% more likely to be Covid-positive than non-essential workers. Family members (i.e., dependents) who live with essential workers are 17% more likely to be Covid-positive compared to family members living with non-essential workers. Also at increased risk for Covid-19 are roommates (non-dependents) who are not essential workers themselves but are living with an essential worker; these individuals are 38% more likely to be Covid-positive than are roommates of non-essential workers. However, conditional on the presence of a Covid-positive household member, the increased risk of transmission to other members of the household when the first Covid-positive member in the household is an essential worker (as opposed to a non-essential worker) is marginal; there is a 6% increase in one's likelihood of becoming Covid- positive when living with a Covid-positive essential worker as opposed to a Covid-positive non-essential worker.

We acknowledge there are several limitations to our analyses. First, our analyses are based on data from a single insurer and its commercially insured members. Given that Independence is the largest health insurer in the Philadelphia, Pennsylvania area, our findings are likely to be representative of commercially insured individuals in this region, but may not be completely generalizable to other populations. Notably absent from our sample are uninsured individuals or those who were previously commercially insured but recently lost their health insurance, since health insurance in this setting is tied to employment. In this population, the distribution of essential workers and non-essential workers may be different from what is observed in our sample of commercially insured individuals. If we were to assume that those who are not commercially insured are in fact more likely to serve as essential workers (e.g., part-time workers at grocery stores, PRN (*pro re nata*) home health aides, delivery drivers), then our estimates may be biased towards the null and offer a conservative estimate regarding the risk borne by essential workers of becoming positive for Covid-19. Another limitation is that our data do not allow us to fully account for potential differences among members in their socioeconomic status or other factors that may impact both one's likelihood of being an essential worker and living in an environment with higher risks of Covid transmission. Nevertheless, by accounting for several observable characteristics (including socioeconomic characteristics at the ZIP Code level, county fixed effects, and industry fixed effects), we are able to partially account for these potential differences. Our additional analyses (in the Sect. "Robustness") also show that the estimation results remain robust to the inclusion of these and additional factors, such as ZIP Code fixed effects.

Finally, it is possible that the information regarding dependents' addresses may not be completely accurate, as members may not always update dependents' addresses when there is a change. In some cases, dependents who were previously living elsewhere may have recently started cohabiting with the primary policyholder (e.g., college students who moved back in

Table 4 Robustness checks

	(1) All primary policyholders	(2) All primary policyholders	(3) All primary policyholders	(4) All primary policyholders; Post period beginning week 12	(5) All primary policyholders; Restricted to Philadelphia 5-county
Essential × post	0.00751*** (0.00011)	0.00751*** (0.00011)	0.00751*** (0.00011)	0.00655*** (0.00012)	0.00820*** (0.00012)
Essential	0.00021* (0.00009)	−0.00006 (0.00009)	−0.00001 (0.00009)	−0.00399*** (0.00013)	−0.00394*** (0.00012)
Age < 18		−0.00474 + (0.00266)	−0.00454 + (0.00266)	−0.00448 + (0.00265)	−0.00501 + (0.00283)
Age 51–64		0.00016** (0.00006)	0.00028*** (0.00006)	0.00017** (0.00006)	0.00013* (0.00007)
Age 65+		−0.00116*** (0.0001)	−0.00114*** (0.0001)	−0.00111*** (0.0001)	−0.00125*** (0.0001)
Female		0.00026*** (0.00005)	0.00026*** (0.00005)	−0.00003 (0.00006)	−0.00005 (0.00006)
Rural		−0.00083** (0.00028)	−0.00015 (0.00029)	−0.00051 + (0.00029)	
At least one chronic condition		0.00263*** (0.00006)	0.00262*** (0.00006)	0.00246*** (0.00006)	0.00262*** (0.00006)
At least one acute inpatient hospitalization		0.00495*** (0.00013)	0.00493*** (0.00013)	0.00483*** (0.00013)	0.00504*** (0.00014)
Member with cohabiting dependent		0.00078*** (0.00006)	0.00087*** (0.00006)	0.00073*** (0.00006)	0.00073*** (0.00006)
Member with cohabiting non-dependent		−0.00038*** (0.0001)	−0.00041*** (0.0001)	−0.00033** (0.0001)	−0.00040*** (0.0001)
% Black or African American		0.01323*** (0.00017)	0.01168*** (0.00018)	0.01078*** (0.00018)	
% Asian		0.01667*** (0.00054)	0.01171*** (0.00059)	0.01131*** (0.00059)	
% Other race		0.02353*** (0.00198)	0.01067*** (0.00204)	0.0077*** (0.00205)	
% Hispanic or Latino of any race in ZIP Code		0.002* (0.00092)	0.00683*** (0.00095)	0.00694*** (0.00095)	
% Below FPL in ZIP code		−0.00494*** (0.00052)	−0.00954*** (0.00056)	−0.00909*** (0.00056)	
Week FE	Yes	Yes	Yes	Yes	Yes
County FE	No	No	Yes	Yes	No
Industry FE	No	No	No	Yes	Yes
ZIP Code FE	No	No	No	No	Yes

Table 4 (continued)

	(1) All primary policyholders	(2) All primary policyholders	(3) All primary policyholders	(4) All primary policyholders; Post period beginning week 12	(5) All primary policyholders; Restricted to Philadelphia 5-county
Mean of DV	0.0136	0.0136	0.0136	0.0136	0.0144
Observations	415,958	415,958	415,958	415,958	376,896

The table presents results of estimating Eq. (1) using a sample of all primary policyholders. All columns include week fixed effects. Column (2) adds member- and ZIP Code-level controls, and column (3) adds county fixed effects. Column (4) defines week 12 (as opposed to week 14) of 2020 as the start of the post-implementation period. Column (5) restricts the sample to those residing in the Philadelphia 5-county area and includes ZIP Code fixed effects, which precludes the inclusion of ZIP Code-level controls and county fixed effects. Robust standard errors are reported in parentheses

$+p<0.10$; $*p<0.05$; $**p<0.01$; $***p<0.001$

with their parents when universities depopulated their campuses); our analyses would have failed to capture these dependents as cohabitants, leaving them out of the analysis sample altogether in estimating the effect of cohabiting with an essential worker. In other cases, dependents who were previously living with the primary policyholder may have left (e.g., children who moved out of their parents' home but did not update their addresses with Independence); our analyses would have counted these dependents as cohabitants. However, doing so would have biased our results towards the null since it is less likely that the primary policyholder would have served as a transmission vector for this dependent who is not located under the same roof. Furthermore, even if these dependents were not cohabiting with the primary policyholder, their likelihood of in-person interaction may be higher than not, which would serve as another potential vector of transmission.

The societal tradeoffs between health and economic viability seen during the Covid-19 pandemic evoke economic estimates of the "value of a statistical life" (Viscusi 1993). Previously, most of this literature has concentrated on valuing mortality risk by estimating compensating differentials for on-the-job risk exposure in labor markets. Because increases in health risks can be detrimental, economists believe that there must be some other aspect of the job that compensates for the added risk (Viscusi and Aldy 2003)—for example, receiving higher pay or greater job satisfaction. In contrast, the designation of some workers as essential and others as non-essential during the pandemic has increased the health risk profile of some jobs while reducing it for others, all while other underlying aspects of these jobs (e.g., monetary compensation) remain minimally affected. Thus, in the case of the Covid-19 pandemic, rather than a *risk-income* tradeoff, the value of a statistical life approach takes more of a *risk–risk* tradeoff and focuses our attention on the net effect of a policy or regulation on a population's risk exposure (Viscusi 1994). For example, by designating grocery stores as essential businesses, policymakers ensured access to food (and thus, reduced the risk of food insecurity) while raising the risk of exposure to and spread of the virus for those who work in that industry. Given these consequential tradeoffs, policymakers must assess the benefits of increased health risks when deciding on the extent of economic activity. These policy choices ultimately involve a balancing of increased health risk and other risks.

As policymakers weigh the risks and benefits of reopening economies and allowing for the resumption of regular in-person interactions, person-to-person transmission of Covid-19 remains a primary concern. Our estimates illustrate the differential impact of Covid-19 on essential versus non-essential workers, though we note that the magnitude of the differences in risk experienced by essential versus non-essential workers will decrease as the overall positivity rate decreases over time. Even when accounting for the influence of health care workers on Covid-positivity, we find that a worker's essential status puts the individual—and their family members—at higher risk for Covid-19 infection. Thus, our results show that the designation of a workplace as essential or non-essential by state-level governance is one that may have serious health and safety implications for the workers affected. These findings should be taken into consideration as bodies of government determine how best to lead society forward as the Covid-19 pandemic persists.

Appendix

See Tables 5, 6,7, 8, 9, 10, 11, 12, 13 and 14

Table 5 Summary statistics for Covid-positive primary policyholders and cohabitants of first Covid-19 positive member in household

	Covid-positive primary policyholder			Cohabitants of first Covid-positive member in household		
	Essential	Non-essential	Difference	Living with essential index member	Living with non-essential index member	Difference
Member-level characteristics	*N* (%)	*N* (%)	*p* value	*N* (%)	*N* (%)	*p* value
Covid-19 positive	3218 (100.0)	2438 (100.0)	*N/A*	340 (7.5)	408 (7.3)	0.67
Age (years)			< 0.001			< 0.001
0–17	0 (0.0)	0 (0.0)	*N/A*	1435 (31.8)	1738 (31.0)	0.44
18–50	1934 (60.1)	1325 (54.3)	< 0.001	1984 (43.9)	2502 (44.7)	0.46
51–64	1036 (32.2)	874 (35.8)	0.004	768 (17.0)	1058 (18.9)	0.02
65 +	248 (7.7)	239 (9.8)	0.006	330 (7.3)	302 (5.4)	< 0.001
Female	2077 (64.5)	1171 (48.0)	< 0.001	2288 (50.7)	2855 (51.0)	0.76
Rural[a]	7 (0.2)	5 (0.2)	1.0	2 (0.04)	15 (0.3)	0.01
Clinical characteristics[b]						
At least one chronic condition[c]	1892 (58.8)	1538 (63.1)	0.001	1874 (41.5)	2519 (45.0)	< 0.001
At least one acute inpatient hospitalization	223 (6.9)	246 (10.1)	< 0.001	188 (4.2)	242 (4.3)	0.73
Member with cohabiting dependent	1352 (42.0)	1216 (49.9)	< 0.001	N/A	N/A	N/A
Member with cohabiting non-dependent	260 (8.1)	186 (7.6)	0.567	N/A	N/A	N/A
ZIP code-level characteristics	% (SD)	% (SD)	*p* value	% (SD)	% (SD)	*p* value
% White	53.6 (30.7)	55.4 (30.5)	0.03	58.6 (30.3)	63.0 (28.6)	< 0.001
% Black or African American	33.3 (31.2)	31.5 (31.1)	0.04	29.0 (30.3)	24.5 (28.4)	< 0.001
% Asian	6.5 (5.6)	6.5 (5.5)	0.81	6.5 (5.5)	6.6 (5.3)	0.45
% Other race	3.9 (5.4)	3.8 (5.5)	0.66	3.3 (4.8)	3.3 (4.7)	0.75

Table 5 (continued)

	Covid-positive primary policyholder			Cohabitants of first Covid-positive member in household		
	Essential	Non-essential	Difference	Living with essential index member	Living with non-essential index member	Difference
% Hispanic or Latino	9.9 (11.3)	9.6 (11.3)	0.44	8.6 (9.9)	8.6 (9.8)	0.78
% Below FPL, ages 18–64	15.9 (10.5)	15.5 (10.6)	0.18	13.8 (9.9)	12.8 (9.6)	< 0.001
Total members	3218	2438		4517	5600	

An index member is the first member in the household with a positive diagnosis for Covid-19

[a]Data come from the Federal Office of Rural Health Policy data files and the 2018 American Community Survey (ACS) 5-year aggregate ZIP Code tabulation area-level files

[b]Clinical characteristics are measured using a 4-month lookback window

[c]Chronic conditions include acquired hypothyroidism; acute myocardial infarction; Alzheimer's disease; Alzheimer's disease and related disorders or senile dementia; anemia; asthma; atrial fibrillation; benign prostatic hyperplasia; breast cancer; cataract; cerebral palsy; chronic kidney disease; chronic obstructive pulmonary disease and bronchiectasis; colorectal cancer; cystic fibrosis and other metabolic developmental disorders; diabetes type 1; diabetes type 2; endometrial cancer; epilepsy; fibromyalgia, chronic pain, and fatigue; glaucoma; heart failure; hip/pelvic fracture; hepatitis A; hepatitis B; hepatitis C; hepatitis D; hepatitis E; hyperlipidemia; hypertension; ischemic heart disease; leukemias and lymphomas; lung cancer; migraine and chronic headache; mobility impairments; multiple sclerosis and transverse myelitis; muscular dystrophy; osteoporosis; peripheral vascular disease; prostate cancer; rheumatoid arthritis/osteoarthritis; sensory blindness and visual impairment; sensory deafness and hearing impairment; spina bifida and other congenital anomalies of the nervous system; spinal cord injury; stroke/transient ischemic attack; and traumatic brain injury and nonpsychotic mental disorders due to brain damage

Table 6 Effect of essential status on likelihood of being positive for Covid-19 for all primary policyholders

	(1)	(2)	(3)	(4)	(5)
Essential × post	0.00751*** (0.00011)	0.00751*** (0.00011)	0.00751*** (0.00011)	0.00751*** (0.00011)	0.00751*** (0.00011)
Essential	0.00021* (0.00009)	0.00018* (0.00009)	−0.00006 (0.00009)	−0.00001 (0.00009)	−0.00369*** (0.00011)
Age < 18		−0.00454 + (0.00266)	−0.00474 + (0.00266)	−0.00454 + (0.00266)	−0.00448 + (0.00265)
Age 51–64		−0.00014* (0.00006)	0.00016** (0.00006)	0.00028*** (0.00006)	0.00017** (0.00006)
Age 65+		−0.00158*** (0.0001)	−0.00116*** (0.0001)	−0.00114*** (0.0001)	−0.00111*** (0.0001)
Female		0.00068*** (0.00005)	0.00026*** (0.00005)	0.00026*** (0.00005)	−0.00003 (0.00006)
Rural		−0.00439*** (0.00027)	−0.00083** (0.00028)	−0.00015 (0.00029)	−0.00051 + (0.00029)
At least one chronic condition		0.00272*** (0.00006)	0.00263*** (0.00006)	0.00262*** (0.00006)	0.00246*** (0.00006)
At least one acute inpatient hospitalization		0.00512*** (0.00013)	0.00495*** (0.00013)	0.00493*** (0.00013)	0.00483*** (0.00013)
Member with cohabiting dependent		0.00004 (0.00006)	0.00078*** (0.00006)	0.00087*** (0.00006)	0.00073*** (0.00006)
Member with cohabiting non-dependent		−0.00068*** (0.0001)	−0.00038*** (0.0001)	−0.00041*** (0.0001)	−0.00033** (0.0001)
%Black or African American			0.01323*** (0.00017)	0.01168*** (0.00018)	0.01078*** (0.00018)
%Asian			0.01667*** (0.00054)	0.01171*** (0.00059)	0.01131*** (0.00059)
%Other race			0.02353*** (0.00198)	0.01067*** (0.00204)	0.0077*** (0.00205)
%Hispanic or Latino of any race in ZIP Code			0.002* (0.00092)	0.00683*** (0.00095)	0.00694*** (0.00095)
%Below FPL in ZIP code			−0.00494*** (0.00052)	−0.00954*** (0.00056)	−0.00909*** (0.00056)
Bucks County				0.00072*** (0.00012)	0.00066*** (0.00012)
Chester County				−0.00086*** (0.00013)	−0.00037** (0.00013)
Delaware County				0.00125*** (0.00012)	0.00128*** (0.00013)
Montgomery County				0.00035** (0.00012)	0.00051*** (0.00012)
Philadelphia County				0.00286*** (0.00012)	0.00253*** (0.00013)
Administration and support and waste management and remediation services					0.00066* (0.00033)
Agriculture, forestry, fishing and hunting					−0.00042 (0.00041)
Arts, entertainment, and recreation					−0.00005 (0.0006)
Construction					0.00009 (0.00031)
Educational services					−0.00119*** (0.00028)

Table 6 (continued)

	(1)	(2)	(3)	(4)	(5)
Finance and insurance					−0.00079** (0.00029)
Health care and social assistance					0.0065*** (0.00028)
Information					−0.00125*** (0.00031)
Management of companies and enterprises					−0.00278*** (0.00072)
Manufacturing					0.00025 (0.0003)
Mining, quarrying, and oil and gas extraction					−0.00059 (0.00086)
Other services (Except Public Administration)					0.00173*** (0.00028)
Professional, scientific, and technical services					−0.0007* (0.00029)
Real estate and rental and leasing					0.00076* (0.00034)
Retail trade					0.00011 (0.0003)
Transportation and warehousing					0.00723*** (0.00032)
Utilities					−0.00115*** (0.00032)
Wholesale trade					−0.0004 (0.00032)
Week FE	Yes	Yes	Yes	Yes	Yes
Mean of DV	0.0136	0.0136	0.0136	0.0136	0.0136
Observations	415,958	415,958	415,958	415,958	415,958

The table presents results of estimating Eq. (1) using a sample of all primary policyholders. All columns include week fixed effects. Column (2) adds member-level controls, column (3) adds ZIP Code-level controls, column (4) adds county fixed effects, and column (5) adds industry fixed effects. Robust standard errors are reported in parentheses

$+p<0.10$; $*p<0.05$; $**p<0.01$; $***p<0.001$

Table 7 Effect of essential status on likelihood of being positive for Covid-19 for primary policyholders less than 65 years

	(1)	(2)	(3)	(4)	(5)
Essential × post	0.0073*** (0.00012)	0.0073*** (0.00012)	0.0073*** (0.00012)	0.0073*** (0.00012)	0.0073*** (0.00012)
Essential	0.00022* (0.00009)	0.00016 + (0.00009)	− 0.00008 (0.00009)	− 0.00003 (0.00009)	− 0.00357*** (0.00012)
Age < 18		− 0.00463 + (0.00268)	− 0.00479 + (0.00267)	− 0.00457 + (0.00267)	− 0.00464 + (0.00267)
Age 51–64		− 0.00016** (0.00006)	0.00015* (0.00006)	0.00029*** (0.00006)	0.00016** (0.00006)
Female		0.0007*** (0.00006)	0.00027*** (0.00006)	0.00026*** (0.00006)	0.00003 (0.00006)
Rural		− 0.00437*** (0.00028)	− 0.0007* (0.00029)	− 0.00005 (0.0003)	− 0.00046 (0.0003)
At least one chronic condition		0.00282*** (0.00006)	0.00272*** (0.00006)	0.0027*** (0.00006)	0.00253*** (0.00006)
At least one acute inpatient hospitalization		0.00494*** (0.00015)	0.00469*** (0.00015)	0.00468*** (0.00015)	0.00453*** (0.00015)
Member with cohabiting dependent		− 0.00007 (0.00006)	0.0007*** (0.00006)	0.0008*** (0.00006)	0.00065*** (0.00006)
Member with cohabiting non-dependent		− 0.0006*** (0.00012)	− 0.0004*** (0.00012)	− 0.00043*** (0.00012)	− 0.00037** (0.00012)
% Black or African American			0.01365*** (0.00018)	0.01194*** (0.00019)	0.01097*** (0.00019)
% Asian			0.01656*** (0.00057)	0.01106*** (0.00062)	0.0108*** (0.00062)
% Other race			0.02772*** (0.00208)	0.01401*** (0.00214)	0.01134*** (0.00215)
% Hispanic or Latino of any race in ZIP Code			0.00097 (0.00097)	0.00606*** (0.00099)	0.00591*** (0.001)
% Below FPL in ZIP code			− 0.00544*** (0.00055)	− 0.01077*** (0.00058)	− 0.01015*** (0.00058)
Bucks County				0.00056*** (0.00013)	0.00047*** (0.00013)
Chester County				− 0.00097*** (0.00013)	− 0.0005*** (0.00013)
Delaware County				0.00127*** (0.00013)	0.00124*** (0.00013)
Montgomery County				0.00022 + (0.00012)	0.00035** (0.00012)
Philadelphia County				0.0031*** (0.00013)	0.00271*** (0.00013)
Administration and support and waste management and remediation services					0.0002 (0.00034)
Agriculture, forestry, fishing and hunting					− 0.00053 (0.00043)
Arts, entertainment, and recreation					− 0.0004 (0.00063)
Construction					0.00008 (0.00032)
Educational services					− 0.00131*** (0.00029)
Finance and insurance					− 0.0009** (0.0003)

Table 7 (continued)

	(1)	(2)	(3)	(4)	(5)
Health care and social assistance					0.00614*** (0.00029)
Information					−0.00144*** (0.00032)
Management of companies and enterprises					−0.0029*** (0.00073)
Manufacturing					0.0001 (0.00031)
Mining, quarrying, and oil and gas extraction					−0.00057 (0.0009)
Other services (except public administration)					0.00184*** (0.00029)
Professional, scientific, and technical services					−0.00081** (0.0003)
Real estate and rental and leasing					0.00015 (0.00035)
Retail trade					−0.00008 (0.00031)
Transportation and warehousing					0.00751*** (0.00033)
Utilities					−0.00104** (0.00034)
Wholesale trade					−0.00045 (0.00033)
Week FE	Yes	Yes	Yes	Yes	Yes
Mean of DV	0.0137	0.0137	0.0137	0.0137	0.0137
Observations	376,220	376,220	376,220	376,220	376,220

The table presents results of estimating Eq. (1) using a sample of primary policyholders less than 65 years. All columns include week fixed effects. Column (2) adds member-level controls, column (3) adds ZIP Code-level controls, column (4) adds county fixed effects, and column (5) adds industry fixed effects. Robust standard errors are reported in parentheses

$+p<0.10$; $*p<0.05$; $**p<0.01$; $***p<0.001$

Table 8 Effect of essential status on likelihood of being positive for Covid-19 for primary policyholders not in the health care and social assistance subsector

	(1)	(2)	(3)	(4)	(5)
Essential × post	0.00209*** (0.00012)	0.00209*** (0.00012)	0.00209*** (0.00012)	0.00209*** (0.00012)	0.00209*** (0.00012)
Essential	0.00005 (0.00009)	0.00012 (0.00009)	0.00028** (0.00009)	0.00037*** (0.00009)	−0.00088*** (0.00011)
Age < 18		−0.00398 + (0.00229)	−0.00431 + (0.00229)	−0.00418 + (0.00229)	−0.00464* (0.00229)
Age 51–64		−0.00005 (0.00006)	0.00018** (0.00006)	0.00026*** (0.00006)	0.00005 (0.00006)
Age 65+		−0.00171*** (0.00009)	−0.00136*** (0.00009)	−0.00136*** (0.00009)	−0.00145*** (0.00009)
Female		−0.00033*** (0.00005)	−0.00061*** (0.00005)	−0.00061*** (0.00005)	0 (0.00005)
Rural		−0.00324*** (0.00026)	−0.00052* (0.00026)	0.00013 (0.00027)	−0.0002 (0.00027)
At least one chronic condition		0.00207*** (0.00005)	0.00203*** (0.00005)	0.00202*** (0.00005)	0.00188*** (0.00005)
At least one acute inpatient hospitalization		0.00512*** (0.00012)	0.00496*** (0.00012)	0.00495*** (0.00012)	0.00489*** (0.00012)
Member with cohabiting dependent		0.00021*** (0.00005)	0.00081*** (0.00005)	0.00086*** (0.00005)	0.0007*** (0.00005)
Member with cohabiting non-dependent		−0.00017 + (0.00009)	0.00009 (0.00009)	0.00006 (0.00009)	0.00002 (0.00009)
% Black or African American			0.0113*** (0.00017)	0.01016*** (0.00018)	0.00926*** (0.00018)
% Asian			0.0122*** (0.00051)	0.00864*** (0.00055)	0.00891*** (0.00055)
% Other race			0.01607*** (0.00186)	0.00712*** (0.00192)	0.00415* (0.00192)
% Hispanic or Latino of any race in ZIP Code			0.00283*** (0.00085)	0.00624*** (0.00088)	0.00579*** (0.00088)
% Below FPL in ZIP code			−0.00362*** (0.00051)	−0.00722*** (0.00053)	−0.00623*** (0.00053)
Bucks County				0.00065*** (0.00011)	0.00044*** (0.00011)
Chester County				−0.00024* (0.00012)	−0.00009 (0.00012)
Delaware County				0.00114*** (0.00012)	0.00098*** (0.00012)
Montgomery County				0.00031** (0.00011)	0.00034** (0.00011)
Philadelphia County				0.00227*** (0.00012)	0.00184*** (0.00012)
Administration and support and Waste management and remediation services					0.00041 (0.00028)
Agriculture, forestry, fishing and hunting					−0.00057 (0.00035)
arts, entertainment, and recreation					−0.00014 (0.00051)
Construction					−0.00038 (0.00026)

Table 8 (continued)

	(1)	(2)	(3)	(4)	(5)
Educational services					−0.00133*** (0.00024)
Finance and insurance					−0.00091*** (0.00025)
Information					−0.00126*** (0.00026)
Management of companies and enterprises					−0.00301*** (0.00061)
Manufacturing					0.00004 (0.00025)
Mining, quarrying, and oil and gas extraction					−0.00102 (0.00073)
Other services (Except Public Administration)					0.00183*** (0.00024)
Professional, scientific, and technical services					−0.00093*** (0.00025)
Real estate and rental and leasing					0.00067* (0.00029)
Retail trade					−0.00025 (0.00026)
Transportation and warehousing					0.00777*** (0.00028)
Utilities					−0.00124*** (0.00027)
Wholesale trade					−0.00044 (0.00027)
Week FE	Yes	Yes	Yes	Yes	Yes
Mean of DV	0.0100	0.0100	0.0100	0.0100	0.0100
Observations	341,118	341,118	341,118	341,118	341,118

The table presents results of estimating Eq. (1) using a sample of primary policyholders not in the health care and social assistance subsector. All columns include week fixed effects. Column (2) adds member-level controls, column (3) adds ZIP Code-level controls, column (4) adds county fixed effects, and column (5) adds industry fixed effects. Robust standard errors are reported in parentheses.

$+p<0.10$; $*p<0.05$; $**p<0.01$; $***p<0.001$

Table 9 Effect of essential status on likelihood of being positive for Covid-19 for primary policyholders in the health care and social assistance subsector only

	(1)	(2)	(3)	(4)
Essential × post	0.01241*** (0.00137)	0.01241*** (0.00137)	0.01241*** (0.00137)	0.01241*** (0.00137)
Essential	−0.00004 (0.00105)	−0.00026 (0.00105)	−0.00118 (0.00105)	−0.00186 + (0.00105)
Age < 18		−0.01259 (0.02582)	−0.00829 (0.0258)	−0.00795 (0.02579)
Age 51–64		−0.00008 (0.00021)	0.00045* (0.00021)	0.00076*** (0.00022)
Age 65+		0.0004 (0.00039)	0.00096* (0.00039)	0.00119** (0.00039)
Female		0.00033 (0.00022)	0.00031 (0.00022)	0.00036 (0.00022)
Rural		−0.01012*** (0.00092)	−0.00336*** (0.00094)	−0.00225* (0.00098)
At least one chronic condition		0.00513*** (0.0002)	0.00492*** (0.0002)	0.00497*** (0.0002)
At least one acute inpatient hospitalization		0.00496*** (0.00043)	0.00484*** (0.00043)	0.00483*** (0.00043)
Member with cohabiting dependent		−0.00071*** (0.0002)	0.0005* (0.0002)	0.00066** (0.0002)
Member with cohabiting non-dependent		−0.00175*** (0.00038)	−0.00161*** (0.00038)	−0.00169*** (0.00038)
% Black or African American			0.01797*** (0.00055)	0.01491*** (0.00059)
% Asian			0.03189*** (0.00184)	0.02106*** (0.00203)
% Other race			0.03298*** (0.00719)	0.00564 (0.00739)
% Hispanic or Latino of any race in ZIP code			0.00549 (0.00348)	0.01579*** (0.00355)
% Below FPL in ZIP code			−0.01156*** (0.00169)	−0.0177*** (0.0018)
Bucks County				0.00138** (0.00043)
Chester County				−0.00394*** (0.0005)
Delaware County				0.00226*** (0.00046)
Montgomery County				0.00109* (0.00043)
Philadelphia County				0.00504*** (0.00043)
Industry FE	No	No	No	No
Week FE	Yes	Yes	Yes	Yes
Mean of DV	0.0302	0.0302	0.0302	0.0302
Observations	74,840	74,840	74,840	74,840

The table presents results of estimating Eq. (1) using a sample of primary policyholders in the health care and social assistance subsector only. All columns include week fixed effects. Column (2) adds member-level controls, column (3) adds ZIP Code-level controls, and column (4) adds county fixed effects. Robust standard errors are reported in parentheses

$+p < 0.10$; $*p < 0.05$; $**p < 0.01$; $***p < 0.001$

Table 10 Effect of cohabiting with essential worker on likelihood of being positive for Covid-19 for all cohabiting dependents

	(1)	(2)	(3)	(4)	(5)
Essential × post	0.00086*** (0.00007)	0.00086*** (0.00007)	0.00086*** (0.00007)	0.00086*** (0.00007)	0.00086*** (0.00007)
Essential	− 0.00002 (0.00005)	0.00003 (0.00005)	− 0.00008 (0.00005)	− 0.00004 (0.00005)	− 0.00064*** (0.00007)
Age < 18		− 0.00185*** (0.00004)	− 0.00184*** (0.00004)	− 0.00184*** (0.00004)	− 0.00183*** (0.00004)
Age 51–64		0.00111*** (0.00005)	0.00123*** (0.00005)	0.00125*** (0.00005)	0.00124*** (0.00005)
Age 65+		0.00086*** (0.00011)	0.00088*** (0.00011)	0.00088*** (0.00011)	0.00087*** (0.00011)
Female		0.0001** (0.00003)	0.00013*** (0.00003)	0.00013*** (0.00003)	0.00013*** (0.00003)
Rural		− 0.00148*** (0.00017)	− 0.00063*** (0.00017)	− 0.0002 (0.00018)	− 0.00031 + (0.00018)
At least one chronic condition		0.00101*** (0.00004)	0.00101*** (0.00004)	0.00101*** (0.00004)	0.00099*** (0.00004)
At least one acute inpatient hospitalization		0.00375*** (0.0001)	0.00364*** (0.0001)	0.00361*** (0.0001)	0.00361*** (0.0001)
% Black or African American			0.00354*** (0.00012)	0.00264*** (0.00013)	0.00243*** (0.00013)
%Asian			0.00713*** (0.00035)	0.00464*** (0.00038)	0.00456*** (0.00038)
%Other race			0.0075*** (0.0013)	0.00165 (0.00134)	0.00128 (0.00134)
%Hispanic or Latino of any race in ZIP Code			− 0.0004 (0.00059)	0.00146* (0.00061)	0.00134* (0.00061)
%Below FPL in ZIP code			0.00266*** (0.00038)	0.00045 (0.0004)	0.00054 (0.0004)
Bucks County				0.00024** (0.00007)	0.00021** (0.00007)
Chester County				0.00008 (0.00008)	0.00017* (0.00008)
Delaware County				0.00068*** (0.00007)	0.00065*** (0.00008)
Montgomery County				0.00041*** (0.00007)	0.00041*** (0.00007)
Philadelphia County				0.00157*** (0.00008)	0.00146*** (0.00008)
Administration and support and waste management and remediation services					0.00002 (0.00027)
Agriculture, forestry, fishing and hunting					0.00078* (0.00031)
Arts, entertainment, and recreation					0.00178*** (0.00047)
Construction					0.00021 (0.00025)
Educational services					0.00046* (0.00023)
Finance and insurance					0.0004 + (0.00024)
Health care and social assistance					0.00153*** (0.00023)

Table 10 (continued)

	(1)	(2)	(3)	(4)	(5)
Information					0.00048* (0.00024)
Management of companies and enterprises					−0.00022 (0.00046)
Manufacturing					0.00102*** (0.00024)
Mining, quarrying, and oil and gas extraction					0.00126* (0.00051)
Other services (Except Public Administration)					0.00082*** (0.00023)
Professional, scientific, and technical services					0.00048* (0.00024)
Real estate and rental and leasing					0.00093*** (0.00026)
Retail trade					0.0004 (0.00025)
Transportation and warehousing					0.00224*** (0.00025)
Utilities					0.0003 (0.00025)
Wholesale trade					0.00049 + (0.00026)
Week FE	Yes	Yes	Yes	Yes	Yes
Mean of DV	0.00514	0.00514	0.00514	0.00514	0.00514
Observations	387,412	387,412	387,412	387,412	387,412

The table presents results of estimating Eq. (1) using a sample of all cohabiting dependents. All columns include week fixed effects. Column (2) adds member-level controls, column (3) adds ZIP Code-level controls, column (4) adds county fixed effects, and column (5) adds industry fixed effects. Robust standard errors are reported in parentheses

$+p<0.10$; $*p<0.05$; $**p<0.01$; $***p<0.001$

Table 11 Effect of cohabiting with essential worker on likelihood of being positive for Covid-19 for cohabiting dependents less than 18 years or 65 years or older

	(1)	(2)	(3)	(4)	(5)
Essential × post	0.00045*** (0.00006)	0.00045*** (0.00006)	0.00045*** (0.00006)	0.00045*** (0.00006)	0.00045*** (0.00006)
Essential	− 0.00003 (0.00005)	0.00002 (0.00005)	− 0.00003 (0.00005)	− 0.00002 (0.00005)	− 0.00029*** (0.00007)
Age < 18		− 0.00297*** (0.00006)	− 0.00297*** (0.00006)	− 0.00297*** (0.00006)	− 0.00300*** (0.00006)
Female		− 0.00006* (0.00003)	− 0.00006* (0.00003)	− 0.00006* (0.00003)	− 0.00006* (0.00003)
Rural		− 0.00061*** (0.00003)	− 0.00026 + (0.00015)	− 0.00021 (0.00016)	− 0.00026 (0.00016)
At least one chronic condition		0.00022*** (0.00003)	0.00021*** (0.00003)	0.00021*** (0.00003)	0.00021*** (0.00003)
At least one acute inpatient hospitalization		0.00568*** (0.00011)	0.00564*** (0.00011)	0.00563*** (0.00011)	0.00564*** (0.00011)
%Black or African American			0.00150*** (0.00010)	0.00131*** (0.00011)	0.00123*** (0.00011)
%Asian			0.00240*** (0.00030)	0.00184*** (0.00033)	0.00181*** (0.00033)
%Other race			− 0.00036 (0.00113)	− 0.00135 (0.00116)	− 0.00147 (0.00116)
%Hispanic or Latino of any race in ZIP Code			0.00085 + (0.00051)	0.00108* (0.00053)	0.00098 + (0.00053)
%Below FPL in ZIP code			0.00014 (0.00032)	− 0.00035 (0.00034)	− 0.00029 (0.00034)
Bucks County				− 0.00002 (0.00006)	− 0.00006 (0.00007)
Chester County				0.00001 (0.00007)	0.00004 (0.00007)
Delaware County				0.00006 (0.00006)	0.00004 (0.00007)
Montgomery County				0.00008 (0.00006)	0.00006 (0.00006)
Philadelphia County				0.00031*** (0.00007)	0.00023** (0.00007)
Administration and support and waste management and remediation services					0.00011 (0.00022)
Agriculture, forestry, fishing and hunting					0.00064* (0.00027)
Arts, entertainment, and recreation					− 0.00022 (0.00039)
Construction					0.00016 (0.00021)
Educational services					0.00032 + (0.00019)
Finance and insurance					0.00025 (0.00020)
Health care and social assistance					0.00081*** (0.00020)
Information					0.00025 (0.00020)
Management of companies and enterprises					− 0.00005 (0.00039)

Table 11 (continued)

	(1)	(2)	(3)	(4)	(5)
Manufacturing					0.00064** (0.00020)
Mining, quarrying, and oil and gas extraction					0.00132** (0.00045)
Other services (Except Public Administration)					0.00059** (0.00019)
Professional, scientific, and technical services					0.00050* (0.00020)
Real estate and rental and leasing					0.00035 (0.00022)
Retail trade					0.00026 (0.00021)
Transportation and warehousing					0.00108*** (0.00021)
Utilities					−0.00034 (0.00021)
Wholesale trade					0.00039 + (0.00022)
Week FE	Yes	Yes	Yes	Yes	Yes
Mean of DV	0.00198	0.00198	0.00198	0.00198	0.00198
Observations	176,277	176,277	176,277	176,277	176,277

The table presents results of estimating Eq. (1) using a sample of cohabiting dependents 18 years or older. All columns include week fixed effects. Column (2) adds member-level controls, column (3) adds ZIP Code-level controls, column (4) adds county fixed effects, and column (5) adds industry fixed effects. Robust standard errors are reported in parentheses

$+p<0.10$; $*p<0.05$; $**p<0.01$; $***p<0.001$

Table 12 Effect of cohabiting with essential worker on likelihood of being positive for Covid-19 for cohabiting dependents less than 18 years

	(1)	(2)	(3)	(4)	(5)
Essential × post	0.00027*** (0.00005)	0.00027*** (0.00005)	0.00027*** (0.00005)	0.00027*** (0.00005)	0.00027*** (0.00005)
Essential	−0.00003 (0.00004)	−0.00003 (0.00004)	−0.00006 (0.00004)	−0.00005 (0.00004)	−0.00021*** (0.00005)
Female		0.00005* (0.00002)	0.00005* (0.00002)	0.00005* (0.00002)	0.00005* (0.00002)
Rural		−0.00038** (0.00013)	−0.00016 (0.00013)	−0.00007 (0.00013)	−0.00013 (0.00013)
At least one chronic condition		0.0001*** (0.00003)	0.00009** (0.00003)	0.00009** (0.00003)	0.00008** (0.00003)
At least one acute inpatient hospitalization		0.00396*** (0.00011)	0.00391*** (0.00011)	0.0039*** (0.00011)	0.0039*** (0.00011)
% Black or African American			0.00108*** (0.00009)	0.00093*** (0.00009)	0.00087*** (0.00009)
%Asian			0.00069** (0.00025)	0.00018 (0.00027)	0.0002 (0.00028)
%Other race			0.00168 + (0.00094)	0.00103 (0.00096)	0.001 (0.00097)
%Hispanic or Latino of any race in ZIP Code			0.00047 (0.00043)	0.00059 (0.00044)	0.00047 (0.00044)
%Below FPL in ZIP code			−0.00029 (0.00027)	−0.00062* (0.00029)	−0.00056* (0.00029)
Bucks County				0.00005 (0.00005)	0.00003 (0.00005)
Chester County				0.00009 (0.00005)	0.00011 + (0.00006)
Delaware County				0.00008 (0.00005)	0.00006 (0.00006)
Montgomery County				0.00012* (0.00005)	0.00011* (0.00005)
Philadelphia County				0.00029*** (0.00006)	0.00023*** (0.00006)
Administration and support and waste management and remediation services					0.00009 (0.00018)
Agriculture, forestry, fishing and hunting					0.0006** (0.00022)
Arts, entertainment, and recreation					−0.00004 (0.00033)
Construction					0.00012 (0.00017)
Educational services					0.00031 + (0.00016)
Finance and insurance					0.00018 (0.00016)
Health care and social assistance					0.00057*** (0.00016)
Information					0.00023 (0.00016)
Management of companies and enterprises					0.00005 (0.00032)
Manufacturing					0.00053** (0.00017)

Table 12 (continued)

	(1)	(2)	(3)	(4)	(5)
Mining, quarrying, and oil and gas extraction					0.0001 (0.00038)
Other services (Except Public Administration)					0.00051** (0.00016)
Professional, scientific, and technical services					0.00042* (0.00016)
Real estate and rental and leasing					0.00022 (0.00018)
Retail trade					0.00012 (0.00017)
Transportation and warehousing					0.00079*** (0.00017)
Utilities					0.00003 (0.00017)
Wholesale trade					0.00046** (0.00018)
Week FE	Yes	Yes	Yes	Yes	Yes
Mean of DV	0.00146	0.00146	0.00146	0.00146	0.00146
Observations	166,026	166,026	166,026	166,026	166,026

The table presents results of estimating Eq. (1) using a sample of cohabiting dependents less than 18 years. All columns include week fixed effects. Column (2) adds member-level controls, column (3) adds ZIP Code-level controls, column (4) adds county fixed effects, and column (5) adds industry fixed effects. Robust standard errors are reported in parentheses

$+p<0.10$; $*p<0.05$; $**p<0.01$; $***p<0.001$

Table 13 Effect of cohabiting with essential worker on likelihood of being positive for Covid-19 for cohabiting non-essential non-dependents

	(1)	(2)	(3)	(4)	(5)
Essential × post	0.00349*** (0.00032)	0.00349*** (0.00032)	0.00349*** (0.00032)	0.00349*** (0.00032)	0.00349*** (0.00032)
Essential	0.00018 (0.00025)	0.00029 (0.00025)	−0.00034 (0.00025)	−0.0004 (0.00025)	−0.00039 (0.00025)
Age < 18		−0.00408 (0.00299)	−0.00464 (0.00299)	−0.00458 (0.00299)	−0.00522 + (0.00299)
Age 51–64		0.00006 (0.00008)	0.00031*** (0.00008)	0.00038*** (0.00008)	0.00034*** (0.00008)
Age 65+		−0.00183*** (0.00013)	−0.00161*** (0.00013)	−0.00163*** (0.00013)	−0.00148*** (0.00013)
Female		−0.0006*** (0.00007)	−0.00093*** (0.00007)	−0.00086*** (0.00007)	−0.00016* (0.00008)
Rural		−0.00317*** (0.00039)	−0.00097* (0.0004)	−0.00079 + (0.00041)	−0.00132** (0.00041)
At least one chronic condition		0.00201*** (0.00008)	0.00193*** (0.00008)	0.00191*** (0.00008)	0.00185*** (0.00008)
At least one acute inpatient hospitalization		0.00519*** (0.00017)	0.00505*** (0.00017)	0.00503*** (0.00017)	0.00499*** (0.00017)
%Black or African American			0.00991*** (0.00026)	0.00864*** (0.00027)	0.00855*** (0.00027)
%Asian			0.01127*** (0.00076)	0.00784*** (0.00082)	0.00813*** (0.00082)
%Other race			0.02344*** (0.00292)	0.01445*** (0.003)	0.01166*** (0.00301)
%Hispanic or Latino of any race in ZIP code			0.0007 (0.00134)	0.00333* (0.00138)	0.00285* (0.00138)
%Below FPL in ZIP code			−0.00306*** (0.0008)	−0.00833*** (0.00084)	−0.00761*** (0.00085)
Bucks County				−0.00002 (0.00017)	0.00008 (0.00017)
Chester County				−0.00088*** (0.00017)	−0.00033 + (0.00018)
Delaware County				0.00016 (0.00017)	0.0005** (0.00017)
Montgomery County				−0.00026 (0.00017)	0.00015 (0.00017)
Philadelphia County				0.00217*** (0.00018)	0.00185*** (0.00018)
Administration and support and waste management and remediation services					0.00016 (0.00054)
Agriculture, forestry, fishing and hunting					−0.00268 (0.00574)
Arts, entertainment, and recreation					0.00092 (0.00082)
Construction					−0.00065 (0.0005)
Educational services					−0.00092 + (0.00048)
Finance and insurance					−0.00037 (0.00049)
Health care and social assistance					0.00127 (0.00077)

Table 13 (continued)

	(1)	(2)	(3)	(4)	(5)
Information					−0.0029** (0.0009)
Management of companies and enterprises					−0.00322*** (0.00088)
Manufacturing					0.00025 (0.0005)
Mining, quarrying, and oil and gas extraction					−0.00108 (0.00098)
Other services (Except Public Administration)					0.00252*** (0.00048)
Professional, scientific, and technical services					−0.00073 (0.00049)
Real estate and rental and leasing					0.00143** (0.00053)
Retail trade					−0.00016 (0.0005)
Transportation and warehousing					0.00314 + (0.00177)
Utilities					−0.00119* (0.0005)
Wholesale Trade					−0.0007 (0.00071)
Week FE	Yes	Yes	Yes	Yes	Yes
Mean of DV	0.00926	0.00926	0.00926	0.00926	0.00926
Observations	151,377	151,377	151,377	151,377	151,377

The table presents results of estimating Eq. (1) using a sample of cohabiting non-essential non-dependents. All columns include week fixed effects. Column (2) adds member-level controls, column (3) adds ZIP Code-level controls, column (4) adds county fixed effects, and column (5) adds industry fixed effects. Robust standard errors are reported in parentheses

$+p<0.10$; $*p<0.05$; $**p<0.01$; $***p<0.001$

Table 14 Effect of cohabiting with essential worker on likelihood of being positive for Covid-19 for cohabitants of the first Covid-positive member in the household

	(1)	(2)	(3)	(4)	(5)
Essential × post	0.00453** (0.00169)	0.00453** (0.00168)	0.00453** (0.00168)	0.00453** (0.00168)	0.00453** (0.00167)
Essential	−0.00014 (0.00129)	0.00046 (0.00129)	0.00033 (0.00129)	0.00072 (0.00129)	−0.00888*** (0.00171)
Age < 18		−0.01894*** (0.00097)	−0.01895*** (0.00097)	−0.01897*** (0.00097)	-0.01912*** (0.00097)
Age 51–64		0.01877*** (0.00117)	0.01884*** (0.00117)	0.01894*** (0.00118)	0.01933*** (0.00118)
Age 65+		0.01036*** (0.00176)	0.01009*** (0.00177)	0.01035*** (0.00177)	0.01027*** (0.00181)
Female		0.00243** (0.00082)	0.00236** (0.00082)	0.0023** (0.00083)	0.00242** (0.00083)
Rural		0.01148 (0.01238)	0.0126 (0.01242)	0.01776 (0.01261)	0.01441 (0.01262)
At least one chronic condition		0.01106*** (0.00089)	0.01113*** (0.00089)	0.01121*** (0.00089)	0.01114*** (0.0009)
At least one acute inpatient hospitalization		0.02816*** (0.00206)	0.02781*** (0.00206)	0.02732*** (0.00207)	0.02719*** (0.00207)
%Black or African American			−0.00187 (0.00235)	−0.00593* (0.00245)	−0.00756** (0.00248)
%Asian			0.04768*** (0.00823)	0.02867** (0.00876)	0.02981*** (0.00881)
%Other race			0.10396*** (0.03095)	0.072* (0.03179)	0.06123 + (0.03204)
%Hispanic or Latino of any race in ZIP code			−0.05809*** (0.01516)	−0.04651** (0.0156)	−0.04437** (0.01577)
%Below FPL in ZIP code			0.02627*** (0.00781)	0.01668* (0.00815)	0.02178** (0.0082)
Bucks County				0.00169 (0.00265)	0.00337 (0.00267)
Chester County				0.00071 (0.00279)	0.00369 (0.00283)
Delaware County				0.00549* (0.0026)	0.00684** (0.00263)
Montgomery County				0.00666** (0.00254)	0.00831** (0.00257)
Philadelphia County				0.01042*** (0.00251)	0.01177*** (0.00254)
Administration and support and waste management and remediation services					−0.02034** (0.00727)
Agriculture, forestry, fishing and hunting					−0.01441 (0.00887)
Arts, entertainment, and recreation					−0.03335** (0.01144)
Construction					−0.01019 (0.00733)
Educational services					−0.01813** (0.00644)
Finance and insurance					−0.01495* (0.00668)
Health care and social assistance					−0.00617 (0.00644)

Table 14 (continued)

	(1)	(2)	(3)	(4)	(5)
Information					−0.00531 (0.007)
Management of companies and enterprises					−0.0442 (0.02838)
Manufacturing					−0.00588 (0.00678)
mining, quarrying, and oil and gas extraction					0.00579 (0.0172)
Other services (Except Public Administration)					−0.01722** (0.00642)
Professional, scientific, and technical services					−0.02324*** (0.00674)
Real estate and rental and leasing					−0.03055*** (0.00707)
Retail trade					−0.01901** (0.0071)
Transportation and warehousing					−0.00346 (0.00657)
Utilities					−0.02573*** (0.00704)
Wholesale trade					−0.01952** (0.00735)
Week FE	Yes	Yes	Yes	Yes	Yes
Mean of DV	0.0739	0.0739	0.0739	0.0739	0.0739
Observations	10,117	10,117	10,117	10,117	10,117

The table presents results of estimating Eq. (1) using a sample of cohabitants of the first Covid-positive member in the household. All columns include week fixed effects. Column (2) adds member-level controls, column (3) adds ZIP Code-level controls, column (4) adds county fixed effects, and column (5) adds industry fixed effects. Robust standard errors are reported in parentheses

$+p<0.10$; $*p<0.05$; $**p<0.01$; $***p<0.001$

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