Rural-Urban Differences in Caregiver Burden Due to the COVID-19 Pandemic among a National Sample of Informal Caregivers

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Abstract

The objective of this exploratory study was to explore potential associations between changes to caregiver burden (CB) due to the COVID-19 pandemic and rural-urban status using a nationally representative sample of 761 informal caregivers. Tertiles of two measures of rural-urban status were used: Rural-Urban Commuting Areas (RUCAs) and population density. Bivariate and multivariable binary and ordinal logistic regression were used to asses study objectives. Using RUCAs, rural informal caregivers were more than twice as likely as urban informal caregivers to report a substantial increase in CB due to COVID-19 (OR 2.27, 95% CI [1.28–4.02]). Similar results were observed for population density tertiles (OR 2.20, 95% CI [1.22–3.96]). Having a COVID-19 diagnosis was also significantly associated with increased CB. Understanding and addressing the root causes of rural-urban disparities in CB among informal caregivers is critical to improving caregiver health and maintaining this critical component of the healthcare system.

Introduction

There is limited, but growing research on the health impacts of the COVID-19 pandemic on older adults. These impacts include substantially increased mortality (Sharma, 2020) and mental health issues (Fofana et al., 2020; Pfefferbaum & North, 2020; Pierce et al., 2020), as well as impacts to other aspects of health-related quality of life across the lifespan (Adıbelli & Sümen, 2020; Bryson, 2021; Douglas et al., 2020; Xiong, Lipsitz, Nasri et al., 2020), particularly among older adults (Bidzan-Bluma et al., 2020; Shahid et al., 2020).

Informal caregiving, the provision of care to family and friends with long-term illnesses, chronic conditions, or disabilities, is an essential but often overlooked component of the US healthcare system, saving the national economy over $500 billion and allowing care recipients to remain in their homes and avoid costly institutionalization (Chari et al., 2015). Due to the unprecedented and novel nature and scope of COVID-19, there is limited research on the effects of the pandemic to informal caregivers. However, informal caregivers may be especially vulnerable to effects of COVID-19 with respect to changes in caregiving responsibilities (caregiving intensity) and impacts on physical and mental health and health-related quality of life due to the pandemic (Lightfoot & Moone, 2020). Informal caregivers reported that caregiver burden has increased during the pandemic (Altieri & Santangelo, 2021), especially among those who have been diagnosed or are living with someone diagnosed with COVID-19 (Cohen et al., 2021). The social isolation and related indirect effects of caregiving on informal caregivers may be magnified during times of crisis such as during the COVID-19 pandemic (Aledeh &

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Adam, 2020), and protecting the health and wellbeing of informal caregivers is of critical importance.

There are important socioeconomic and demographic differences in who becomes an informal caregiver, and there are differences in caregiver responsibilities and caregiver intensity among informal caregivers based on a number of factors. For example, women (Wolff & Kasper, 2006) and people of color (Rubin & White-Means, 2009) are more likely than other demographic groups to become informal caregivers. Among a sample of informal caregivers to older adults with dementia, females provided more intensive care than their male counterparts (Gallicchio et al., 2002). Similar results were observed among a nationally representative sample of informal caregivers (Lahaie et al., 2013). Although Black caregivers tend to offer higher levels of caregiving intensity compared to their White counterparts (Fuller-Thomson et al., 2009), they report fewer negative health effects of caregiving (Fredman et al., 2008), suggesting that Black caregivers may be more resilient that White caregivers, particularly in the case of caregiving for individuals with severe cognitive decline (Cherry et al., 2013; Scott, 2013).

Disparities in informal caregiving extend beyond individual socioeconomic and demographic factors. Place of residence and geographic factors have been shown to affect aspects of informal caregiving. People living in rural areas (Agree & Glaser, 2009; Bédard et al., 2004) are more likely to be informal caregivers. Among informal caregivers themselves, caregiver burden (CB), defined as the multidimensional toll on caregivers' emotional, social, financial, physical, and spiritual functioning (Adelman et al., 2014; Zarit et al., 1986), varies by socioeconomic and demographic factors, as well. Research also suggest that rural informal caregivers have higher CB and caregiver strain (Crouch et al., 2017) and experience lower social support (Rozario & Simpson, 2018) than their urban counterparts. A Canadian study of rural-urban differences showed that among a sample of primarily rural informal caregivers, degree of rurality was not associated with differences in CB (O'Connell et al., 2013). However, this study did not compare rural and urban caregivers directly. Similar findings were observed among informal caregivers in China (Wang et al., 2020). To date, few studies have directly compared rural and urban caregivers with respect to CB, a critical correlate of health among informal caregivers, nor have there been studies exploring rural-urban differences in potential changes to CB during the COVID-19 pandemic (Liu et al., 2020).

Compounding this issue is the lack of a unified measure of rural-urban status in population health research. Rurality and urbanicity are multidimensional constructs (Pedersen et al., 2020; Zahnd et al., 2019), yet in caregiving and other population health research, a single unidimensional measurement such as population density

(O'Reilly et al., 2008), population size (Wimo et al., 2017), and/or proximity to a metropolitan area (O'Connell et al., 2013) typically is used. Composite measures such as the Rural-Urban Continuum Code (RUCC) (Chen et al., 2017), Urban Influence Codes (UIC) (Beeber et al., 2008), and Rural-Urban Commuting Area (RUCA) codes (Morrill et al., 1999; U.S. Department of Agriculture, Economic Research Service, 2010) can also be used to examine rural-urban differences but these measures are limited by the geographic level of observation. For instance, RUCCs and UICs are only available at the county level, while RUCA codes are available on both the county and ZIP code levels. The Index of Relative Rurality (Waldorf, 2006) is a promising composite measure that takes into account four dimensions of rural-urban characteristics (population size, population density, percent urban population, and proximity to metropolitan area) and maps them onto a continuous scale which can be adapted for use on any geographic level for which the component data are available (Inagami et al., 2016). Nonetheless, there is no universal consensus as to which of these or other measures is most appropriate and most accurately captures the distinguishing characteristics of rural and urban areas that underlie rural-urban health disparities. Furthermore, utilizing different measures of rural-urban status may influence the associations between rural-urban status and health outcomes (Cohen et al., 2015).

It is unclear as to whether the direct or indirect impacts of the COVID-19 pandemic on aspects of informal caregiving differ by place of residence, specifically rural-urban status. No study to date has examined changes in informal caregiver CB due to the COVID-19 pandemic overall and by rural-urban status. Therefore, the objective of this study was to explore potential associations between changes to CB due to the pandemic and rural-urban status while accounting for baseline CB level using a nationally representative sample of informal caregivers and two measures of rural-urban status.

Methods

Study participants were recruited using Amazon's Mechanical Turk (MTurk) (Simons & Chabris, 2012) between June 4 and 15, 2020. Interested individuals accessed a link to Qualtrics, provided informed consent, and completed questions assessing eligibility. Eligibility was based on being an informal caregiver for an individual 50 years of older with some health condition, disability, or cognitive decline, living in the United States (U.S.), and being able to read English. If the respondent was eligible based on those criteria, the respondent completed a survey assessing health, quality of life, caregiving duties, and caregiver burden (CB), which also included basic demographic and socioeconomic information. Compensation for each MTurk respondent was $1.50.

The main study variable of interest was change in caregiver burden (CB) due to the COVID-19 pandemic. Response categories were "decreased a lot," "decreased a little," "stayed the same," "increased a little," and "increased a lot." The main exposure of interest was rural-urban status. As there is no singular measure of rural-urban status used in health research (Cohen et al., 2018; Isserman, 2005; Prouty Vanderboom & Madigan, 2007; Waldorf & Kim, 2015), this study used two measures: population density (Laditka et al., 2009; Zahnd et al., 2019) and RUCA codes (Morrill et al., 1999; U.S. Department of Agriculture, Economic Research Service, 2010). Each respondent's reported ZIP code was matched to the corresponding population density and RUCA. Each respondent's ZIP code was matched to the corresponding population density of the ZIP code tabulation area (ZCTA) using 2010 US Census data (Krieger et al., 2002).

Several covariates were included in the analysis. CB was assessed through the Caregiver Burden Inventory (CBI) (Novak & Guest, 1989), a multidimensional scale used to estimate the amount of burden caregivers experience as a direct result of caregiving. Other characteristics of interest included respondents' age (years), gender (male or female), race (White, Black, Asian, or Other), relationship to care recipient (child, spouse, or other), whether caregiver has been diagnosed with COVID-19 (yes or no), whether someone in the caregiver's household was diagnosed with COVID-19 (yes or no), whether the caregiver lives with the care recipient, and US Census Region (Northeast, Midwest, South, or West).

Descriptive statistics were obtained for all study variables, including means, standard deviations, maxima, and minima for all continuous variables and frequencies for all categorical and ordinal variables. Bivariate associations between the main outcome of interest (change in CB due to COVID-19) and all continuous and categorical study variables were assessed through ANOVA with Bonferroni corrections, respectively, for multiple comparisons and chi square tests.

Two types of regression models were used to examine potential associations between rural-urban status and changes to CB due to the COVID-19 pandemic. The first set of models were binary logistic regression models with the outcome variable dichotomized to "increased a lot" versus all others ("decreased a lot," "decreased a little," "stayed the same," and "increased a little"). Binary logistic regression models were used in this case to facilitate ease of interpreting the model results. In the second set of models, ordinal regression was used to model the outcome of changes to CB due to the COVID-19 pandemic using a four-level version of the original five-level variable in which the "decreased a lot" and "decreased a little" were combined into one category due to small sample sizes ($n = 28$ and 77, respectively). Ordinal logistic regression models fit the ordinal outcome variable, but the resultant odds ratios may be difficult to interpret relative to binary logistic regression. Briefly, odds ratios from binary logistic regression models suggest the odds of being placed in the increased a lot category compared to all other possible responses (i.e., the reference group). Odds ratios from ordinal logistic regression models are interpreted in a similar fashion, the single odds ratio coefficient applies to the likelihood of each response category on the ordinal scale. In other words, in binary logistic regression, an odds ratio of 2.00 suggests being two times more likely to be placed in the increased a lot group compared to all other groups. In ordinal logistic regression models, an odds ratio of 2.00 suggests being two times more likely to be placed in the decreased a little versus decreased a lot, stayed the same versus decreased a little, increased a little versus stayed the same, and increased a lot versus increased a little.

For both the logistic and ordinal models, the primary exposure was rural-urban status. For the analysis, population density was grouped into tertiles. RUCA codes pose a challenge to categorize into rural or urban (Onega et al., 2020), as with many other measures of rural-urban status (Cohen et al., 2015; Zahnd et al., 2019). Therefore, RUCA codes were grouped by original 10-level codes into three groups that attempted to categorize ZIP codes into the general typology based on their RUCA designation (1 = urban, 2–4 = intermediate, 5–10 = rural). For both sets of models, the most urban group (largest population density or RUCA of 1) was used as the reference group. Also, for both the logistic and ordinal models, bivariate associations were assessed, as well as multivariable associations, including the confounders and covariates described above. Collinearity of confounders and covariates were assessed using the variance inflation factor. The two rural-urban status measures (population density tertile and RUCA code group) were assessed in separate multivariable models. IBM SPSS version 26.0 (Armonk, NY) and SAS version 9.4 (Cary, NC) were used for all statistical analyses. Statistical significance was established at $p < .05$. The study was approved by the University of Rhode Island's institutional review board (study # 1606088-2).

Results

A total of 835 MTurk users completed the survey, 761 (91.1%) of whom provided their ZIP code of residence. A state-level map showing the geographic distribution of all survey respondents is shown in Figure 1. California had the most respondents ($n = 110$), followed by Illinois ($n = 66$), Texas ($n = 57$), Washington ($n = 45$), and New York ($n = 40$). No respondents were from Maine, New Mexico, South Dakota, and Vermont. Most of the 761 respondents in the study sample reported their CB had either stayed the same (33.6%) or increased a little (39.0%).
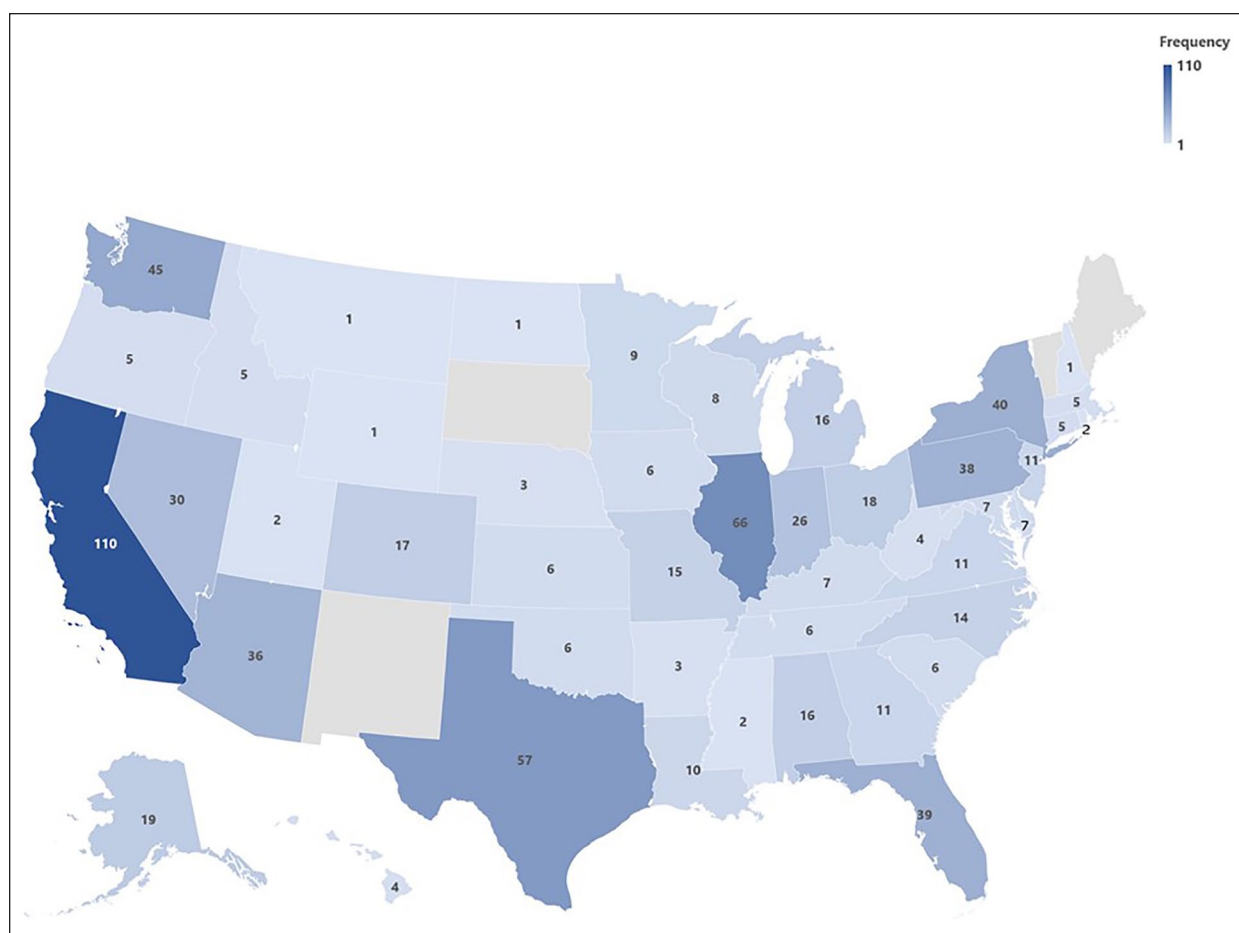
Figure 1. State-level distribution of respondents used in study.

There were differences with respect to changes in CB due to COVID-19 by racial category (*p* = .017) (Table 1). For instance, 22% of those reporting a decrease in CB were Black, compared to less than 15% of those reporting an increase in CB. There also were differences by COVID-19 diagnosis status. Of those reporting that their CB "increased a lot," 69% had a COVID-19 diagnosis, while 43% of those reporting that their CB "decreased a lot" had a COVID-19 diagnosis. There were also significant differences in changes to CB due to COVID-19 with respect to living with someone who had a COVID-19 diagnosis (*p* = .008), living with the care recipient (*p* = .034), relationship to the care recipient (*p* = .027), and initial CB (*p* = .026). No significant associations were observed between CB change and age, sex, Hispanic ethnicity, education, income, caregiving hours, US region, or either measure of rural-urban status.

The sample was 78% urban, 11% intermediate, and 10% rural based on RUCA codes and 74% urban, 16% intermediate, and 10% rural based on population density tertile. Figure 2 shows the change in CB due to COVID-19 by rural-urban status. Of rural respondents, 24% of those in the most rural RUCA categories reported that their CB "increased a lot" due to

COVID-19, compared to 12% of those in the urban and 13% of the intermediate RUCA codes. Similar results were observed when population density tertile was used as the measure of rural-urban status, where 24% of rural respondents reported their CB as increasing a lot due to COVID-19, compared to 13% of urban respondents and 12% of respondents living in an intermediate rural-urban status area.

Table 2 displays the results of the binary logistic regression models for the outcome of CB "increased a lot" due to COVID-19 versus all other categories of change in CB. For both measures of rural-urban status, rural respondents were significantly more likely to report that their CB increased a lot using both RUCA codes (OR 2.27, 95% CI [1.28, 4.02]) and population density (OR 2.20, 95% CI [1.22, 3.96]) as measures of rural-urban status compared to urban respondents. There were no significant associations between those in the intermediate rural-urban categories of either RUCA codes or population density and changes to CB. In the RUCA model, having a COVID-19 diagnosis (OR 2.28, 95% CI [1.37, 3.80] in the RUCA model) and living with the care recipient (OR 2.09, 95% CI [1.36, 3.24] in the RUCA model) were associated with a higher likelihood of reporting that CB "increased a lot," even after

Table 1. Descriptive Statistics (N, %) for Study Variables Overall and by Change in Caregiver Burden Due to COVID-19.

|		Total	Decreased a lot	Decreased a little	Stayed same	Increased a little	Increased a lot	p-value
	Total N	761	28 (3.7)	77 (10.1)	255 (33.6)	297 (39.0)	103 (13.5)	
Age	(Mean, SD)	34.1 (9.7)	34.8 (11.3)	35.0 (8.8)	34.5 (10.1)	33.4 (9.1)	34.6 (10.5)	.549
Sex								.399
	Male	519 (68.2)	20 (71.4)	50 (64.9)	182 (71.4)	192 (64.6)	74 (71.2)	
	Female	242 (31.8)	8 (28.6)	27 (35.1)	73 (28.6)	105 (35.4)	29 (28.2)	
Race								.017
	White	430 (56.7)	18 (64.3)	49 (62.6)	145 (57.1)	155 (52.4)	62 (60.2)	
	Black	110 (14.5)	6 (21.4)	17 (22.1)	28 (11.0)	46 (15.5)	13 (12.6)	
	Asian	143 (18.8)	3 (10.7)	3 (3.9)	53 (20.9)	68 (23.0)	16 (15.5)	
	Other	76 (10.0)	1 (3.6)	8 (10.4)	28 (11.0)	27 (9.1)	12 (11.7)	
Hispanic ethnicity								.458
	Yes	341 (44.8)	10 (35.7)	33 (42.9)	108 (42.4)	136 (45.8)	53 (51.5)	
	No	420 (55.2)	18 (64.3)	44 (57.1)	147 (57.6)	161 (54.2)	50 (48.5)	
Bachelor's or higher								.877
	Yes	659 (87.2)	24 (85.7)	68 (89.5)	224 (88.2)	252 (85.7)	90 (87.4)	
	No	97 (12.8)	4 (14.3)	8 (10.5)	30 (11.8)	42 (14.3)	13 (12.6)	
Income ($)								.096
	<$25,000	205 (27.1)	4 (14.3)	16 (21.3)	81 (31.9)	67 (22.6)	36 (35.0)	
	$25,000–49,999	251 (33.2)	10 (35.7)	28 (37.3)	82 (32.3)	102 (34.5)	29 (28.2)	
	$50,000+	301 (39.8)	14 (50.0)	31 (41.3)	91 (35.8)	127 (42.9)	38 (36.9)	
COVID diagnosis (self)								<.001
	Yes	400 (52.6)	12 (42.9)	35 (45.5)	115 (45.1)	167 (56.2)	71 (68.9)	
	No	361 (47.4)	16 (57.1)	42 (54.5)	140 (54.9)	130 (43.8)	32 (31.1)	
COVID diagnosis lives with you								.008
	Yes	294 (38.6)	11 (39.3)	24 (31.2)	81 (31.8)	126 (42.4)	51 (49.5)	
	No	467 (61.4)	17 (60.7)	53 (69.8)	174 (68.2)	171 (57.6)	52 (50.5)	
Lives with care recipient								.034
	Yes	304 (39.9)	11 (39.3)	25 (32.5)	95 (37.3)	117 (39.4)	55 (53.4)	
	No	457 (60.1)	17 (60.7)	52 (67.5)	160 (62.7)	180 (60.6)	48 (46.6)	
Relationship to recipient								.027
	Adult-child	509 (66.9)	21 (75.0)	46 (59.7)	172 (67.5)	202 (68.0)	67 (65.0)	
	Spouse or partner	50 (6.6)	1 (3.5)	6 (7.8)	8 (3.1)	21 (7.1)	14 (13.6)	
	Other	202 (26.5)	6 (21.4)	25 (32.5)	75 (29.4)	74 (24.9)	22 (21.4)	
Caregiving hours per week								.356
	20+	172 (22.6)	6 (21.4)	16 (20.8)	48 (18.8)	74 (24.9)	28 (27.2)	
	<20	589 (77.4)	22 (78.6)	61 (79.2)	207 (81.2)	223 (75.1)	75 (72.8)	
Initial Caregiver Burden Inventory	Mean (SD)	38.4 (14.3)	41.3 (19.8)	39.5 (15.0)	36.6 (12.8)	38.3 (12.4)	41.7 (19.2)	.026
RUCA category								.137
	More urban (1)	596 (78.3)	22 (78.6)	60 (77.9)	200 (78.4)	240 (80.8)	73 (70.9)	
	Intermediate (2–4)	86 (11.3)	2 (7.1)	12 (15.6)	32 (12.5)	29 (9.8)	11 (10.7)	
	More rural (5–10)	79 (10.4)	4 (14.3)	5 (6.5)	23 (9.0)	29 (9.4)	19 (18.4)	
Pop dens tertile								.151
	Most urban	533 (73.9)	18 (69.2)	56 (74.7)	175 (72.9)	216 (77.1)	67 (67.7)	
	Intermediate	113 (15.7)	6 (23.1)	14 (18.7)	43 (17.9)	36 (12.9)	14 (14.1)	
	Most rural	75 (10.4)	2 (7.7)	5 (6.7)	22 (9.2)	28 (10.0)	18 (18.2)	
US Census Region								.110
	Northeast	102 (13.4)	2 (7.1)	11 (14.3)	39 (15.3)	37 (12.5)	13 (12.6)	
	Midwest	174 (22.9)	6 (21.4)	19 (24.7)	43 (16.9)	72 (24.2)	34 (33.0)	
	South	210 (27.6)	8 (28.6)	26 (33.8)	73 (28.6)	79 (26.6)	23 (22.3)	
	West	275 (36.1)	12 (42.9)	21 (27.3)	100 (39.2)	109 (36.7)	33 (32.0)	
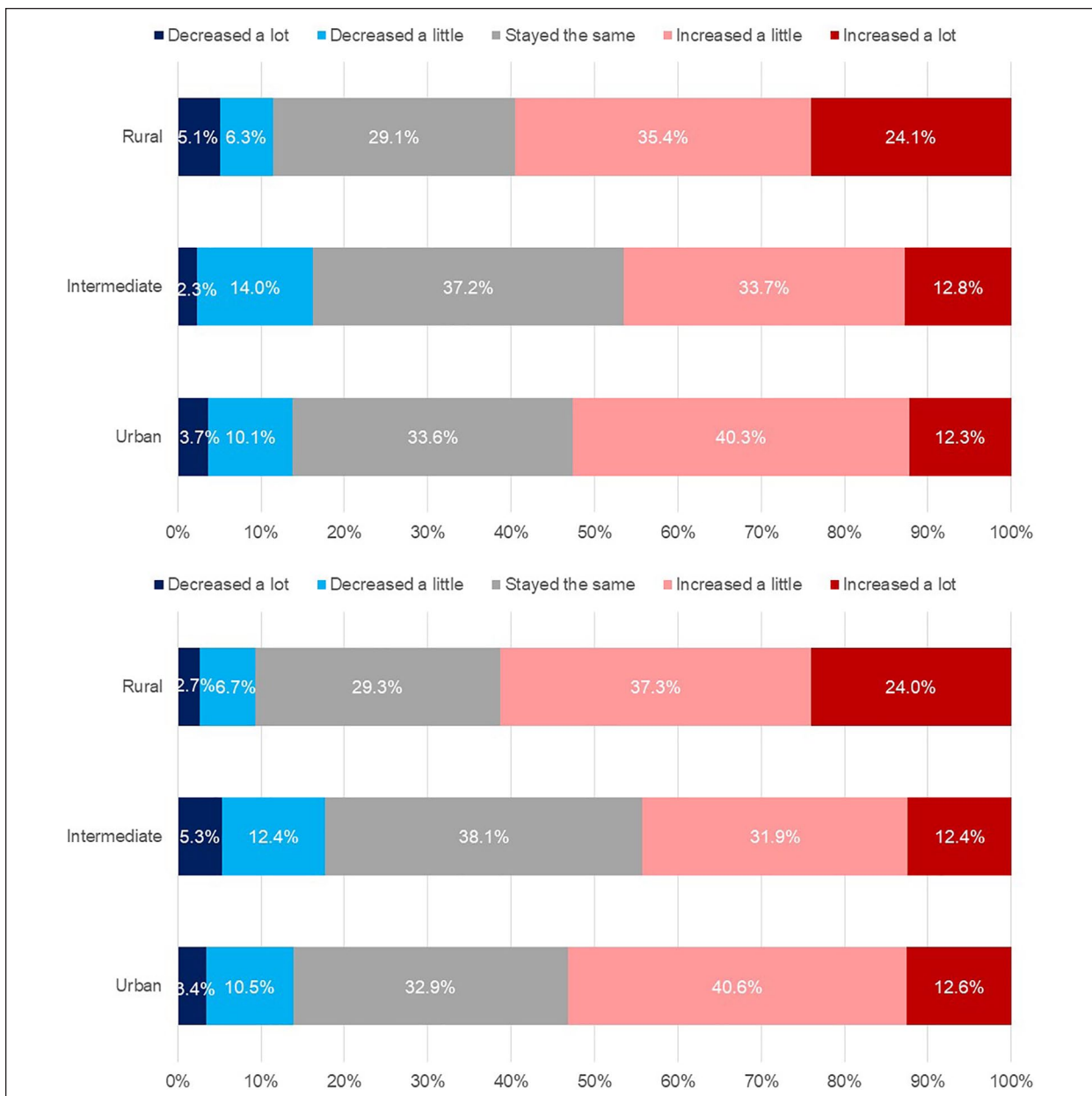
Figure 2. Distribution of changes to caregiver burden due to COVID-19 by rural-urban tertile (top: RUCA tertiles, bottom: population density tertiles).

adjustment in the multivariable models. A COVID-19 diagnosis was associated with a significant increase in CB in all three models. A COVID-19 diagnosis among someone in the caregiver's household was also associated with increased CB in the bivariable model. An ad hoc analysis, stratifying by COVID-19 diagnosis among someone in the household, found associations between rural-urban status and increases in CB remained among those in the most rural tertiles of both RUCA codes (OR 2.28, 95% CI [1.15, 4.92]) and population density (OR 2.23, 95% CI [1.05, 4.73]). Among those without a household member diagnosed with COVID-19, there were no significant associations between rural-urban status and increased CB.

Associations between rural-urban status and change in CB due to COVID-19 were less common in the

ordinal regression models (Table 3). Although there was an association between rural population density and change in CB due to COVID-19 in the bivariate models (OR = 1.64, 95% CI [1.04, 2.57]), the association was not significant in the multivariable model. Having a COVID-19 diagnosis and living with the care recipient were both associated with a significantly higher likelihood of increased CB due to COVID-19 in the bivariate and multivariable models.

Discussion

The main findings of this study suggest that rural informal caregivers were more likely to report experiencing substantial increases in CB due to the COVID-19 pandemic than urban caregivers, although the evidence is

Table 2. Odds Ratios (and 95% Confidence Intervals) for Binary Logistic Regression Models for the Outcome of CB "Increased a Lot" Due to COVID-19 Versus All Other Categories of Change in CB.

			Adjusted models	
		Bivariate models	With RUCA	With pop density
Zip code RUCA	Rural	**2.27 (1.28, 4.02)**	**1.87 (1.01, 3.48)**	
	Intermediate	1.05 (0.53, 2.07)	1.08 (0.54, 2.16)	
	Urban (ref)	I	I	
Zip code pop density	Rural	**2.20 (1.22, 3.96)**		**2.04 (1.05, 3.97)**
	Intermediate	0.98 (0.53, 1.82)		0.95 (0.50, 1.79)
	Urban (ref)	I		I
Age	Per 1-year inc	1.01 (0.99, 1.03)	1.01 (0.99, 1.03)	1.01 (0.99, 1.03)
Gender	Female	0.82 (0.52, 1.30)	0.88 (0.54, 1.42)	0.88 (0.54, 1.44)
	Male (ref)	I	I	I
Race	Black	0.80 (0.42, 1.51)	0.70 (0.36, 1.36)	0.71 (0.36, 1.37)
	Asian	0.75 (0.42, 1.34)	0.61 (0.32, 1.13)	0.63 (0.33, 1.20)
	Other	1.11 (0.57, 2.18)	0.75 (0.36, 1.59)	0.62 (0.28, 1.38)
	White (ref)	I	I	I
COVID diagnosis (self)	Yes	**2.22 (1.42, 3.46)**	**2.28 (1.37, 3,80)**	**2.21 (1.31, 3.71)**
	No (ref)	I	I	I
COVID diagnosis lives with you	Yes	**1.68 (1.10, 2.54)**	1.17 (0.72, 1.89)	1.16 (0.71, 1.90)
	No (ref)	I	I	I
Lives with care recipient	Yes	**1.88 (1.24, 2.86)**	**2.09 (1.35, 3.24)**	**2.03 (1.30, 3.18)**
	No (ref)	I	I	I
Relationship to recipient	Adult-child	0.91 (0.59, 1.41)	0.70 (0.44, 1.12)	0.70 (0.44, 1.12)
	Other	I	I	I
Initial Caregiver Burden Inventory	Per 10-pt inc	1.20 (1.04, 1.39)	1.09 (0.94, 1.27)	1,09 (0.94, 1.28)

Boldface indicates $p < 0.05$

Table 3. Odds Ratios (and 95% Confidence Intervals) from Ordinal Logistic Regression Models for the Outcome of Change in Caregiver Burden Due to COVID-19*.

			Adjusted models	
		Bivariate models	With RUCA	With pop density
ZIP code RUCA	Rural	1.54 (0.99, 2.41)	1.26 (0.80, 1.99)	
	Intermediate	0.82 (0.54, 1.25)	0.83 (0.54, 1.27)	
	Urban (ref)	I	I	
Zip code pop density	Rural	**1.64 (1.04, 2.57)**		1.33 (0.83, 2.13)
	Intermediate	0.76 (0.52, 1.10)		0.78 (0.53, 1.14)
	Urban (ref)	I		I
Age	Per 1-year inc	0.99 (0.98, 1.01)	1.00 (0.98, 1.01)	1.00 (0.98, 1.01)
Gender	Female	1.06 (0.79, 1.41)	1.16 (0.86, 1.56)	1.15 (0.86, 1.55)
	Male (ref)	I	I	I
Race	Black	0.94 (0.63, 1.39)	0.87 (0.58, 1.31)	0.86 (0.58, 1.29)
	Asian	**1.45 (1.02, 2.07)**	1.24 (0.85, 1.79)	1.17 (0.80, 1.71)
	Other	1.11 (0.69, 1.75)	0.84 (0.51, 1.37)	0.82 (0.50, 1.35)
	White (ref)	I	I	I
COVID diagnosis (self)	Yes	**1.79 (1.37, 2.35)**	**1.66 (1.21, 2.27)**	**1.69 (1.23, 2.31)**
	No (ref)	I	I	I
COVID diagnosis lives with you	Yes	**1.62 (1.23, 2.15)**	1.32 (0.97, 1.81)	1.32 (0.96, 1.80)
	No (ref)	I	I	I
Lives with care recipient	Yes	**1.42 (1.08, 1.87)**	**1.60 (1.20, 2.13)**	**1.59 (1.20, 2.12)**
	No (ref)	I	I	I
Relationship to recipient	Adult-child	1.01 (0.76, 1.34)	0.90 (0.67, 1.21)	0.90 (0.67, 1.21)
	Other	I	I	I
Initial Caregiver Burden Inventory	Per 10-pt inc	1.08 (0.98, 1.19)	1.03 (0.93, 1.14)	1.02 (0.92, 1.13)

*Outcome was change in caregiver burden due to COVID-19 ("increased a lot," "increased a little," "no change," and "decreased").
Boldface indicates $p < 0.05$

mixed. There are few studies that have examined overall changes to CB as a result of an external event such as the COVID-19 pandemic (Anand et al., 2020; Park, 2020; Penteado et al., 2020), nor have there been many studies that have examined such changes by rural-urban status or other socioeconomic and demographic characteristics (Liu et al., 2020). Therefore, the findings of this study advance the understanding of informal caregiving experience in two related ways. First, regardless of rural-urban status or other aspects of socioeconomic status, more informal caregivers have experienced an increase in CB due to COVID-19 than experienced a decrease in CB due to COVID-19. Second, suggestive evidence from this study shows that such changes in CB may be more pronounced among rural caregivers compared to urban caregivers. The potential explanations for these findings merit additional research.

The potential for CB to increase during the COVID-19 pandemic has been suggested in current research on the pandemic. The COVID-19 pandemic poses logistical challenges for many community-dwelling informal caregivers. Restrictions enacted, such as travel restrictions, business closures, and general lockdowns may pose substantial challenges for informal caregivers to older adults, including inability to be physically present to provide care, disrupted routines, reduced access to respite care, and increased or changes to basic hygiene routines (Greenberg et al., 2020). Some of the restrictions imposed to reduce the spread of COVID-19 may have had negative consequences on the potential for receiving social support (Altieri & Santangelo, 2021), and reduced social support is associated with higher CB and rates of depression in caregivers irrespective of the pandemic (Thielemann & Conner, 2009). A study of informal caregivers to dementia patients in Argentina found that when the care recipient had more severe cases of dementia, the added CB due to the pandemic was higher and was attributed to reduced access to paid caregiving and a general fear of spreading COVID-19 (Cohen et al., 2020). While overall mental and physical health and health-related quality of life have generally declined, regardless of caregiving status, a U.S. study that compared the pandemic's effects on informal caregivers versus non-caregivers, informal caregivers, especially long-term caregivers, were more likely than non-caregivers to report physical health issues and impacts on health-related quality of life (Park, 2020).

To the best of our knowledge, the finding that rural informal caregivers were more likely than their urban counterparts to experience substantial increases in CB due to the COVID-19 pandemic has not been previously reported. One study of overall caregiver burden, conducted in the U.S. before the COVID-19 pandemic, found that rural caregivers reported better health than their urban counterparts, although no differences in overall caregiver burden by rural-urban status (Crouch et al., 2017). In contrast, findings from the present study suggest that CB, as assessed through the CBI, was higher among rural caregivers than urban caregivers ($p = .030$ from Bonferroni-corrected ANOVA models), and that informal caregivers in rural areas were more likely to report an increase in CB than urban caregivers as a result of the pandemic.

Caregiver support provides resources that allow caregivers to better cope with the demands of providing care (Rozario & Simpson, 2018). Rural-urban differences in caregiver support may influence potential rural-urban differences in CB. With respect to social support for informal caregivers, rural caregivers face unique challenges for accessing and maintaining a support system due to migration from rural to urban areas (O'Connell et al., 2013). This can be particularly problematic for rural caregivers since formal care services are more limited in rural areas than urban areas (Bédard et al., 2004). Specific aspects of rural life contributing to these overarching rural-urban differences remains unclear. Addressing the root causes of rural-urban differences in CB is essential for mitigating the deleterious impacts of informal caregiving on rural caregivers, a population facing higher levels of CB irrespective of the COVID-19 pandemic. Additional research is essential to identify those root causes of rural-urban differences and address them through targeted interventions and policies to reduce rural-urban disparities in CB.

Research has identified rural-urban differences in other aspects of caregiver support as well. Among employed informal caregivers, rural caregivers were less likely to have access to telecommuting, employee assistance programs, and paid leave than their urban counterparts (Henning-Smith et al., 2019; Henning-Smith & Lahr, 2019). Financial strain as a direct consequence of the pandemic may also play a role in rural-urban differences in CB by potentially magnifying the stress of caregiving, which may lead to poorer health outcomes and reduced quality of life (Gilligan et al., 2020). The findings of the present study highlight both rural-urban differences in overall CB and rural-urban differences in the changes to CB as a result of the pandemic. The causes and mechanisms behind these observations remain unknown. Further research is needed to understand if and how these mechanisms involving caregiver support possibly exacerbated rural-urban differences in CB due to the pandemic.

This study has several important limitations to consider. First, this study is cross-sectional, so causality cannot be inferred. Second, as described previously, rurality and urbanicity are multidimensional constructs (Jensen et al., 2020; Waldorf & Kim, 2015), and the measures used (population density and RUCA codes) incorporate limited aspects of the concepts of what makes a location rural or urban. Specific elements of rural-urban status (e.g., geographic isolation, socioeconomic status, culture) could be explored in future studies to better understand the specific root causes of rural-urban disparities more fully in CB. Third, the analyses were conducted at the ZIP code level. ZIP codes were

created by the U.S. Postal Service and were not explicitly designed to be units of observation in population-based studies. However, the use of small geographic units of observation such as ZIP codes in population-based and gerontological research to understand critical small-scale geographic patterns of health and disease has become much more common over the recent decades (Holmes et al., 2018; Jerrett et al., 2010; Spring, 2018; Zahnd et al., 2010). Future studies could examine other geographic units, such as counties and census tracts, to determine if associations are consistent across different geographic units of analyses. Next, the survey was conducted in June 2020, approximately 3 months into the COVID-19 pandemic. Findings may have differed if the survey had been conducted during other time points during the pandemic, as the magnitude and severity of the pandemic has evolved. It is also important to note that the sample was a convenience sample and limited to people with internet access and all responses were self-reported. Research suggests that MTurk samples may actually be advantageous compared to traditional in-person convenience samples such as college undergraduate students because they are more representative of the U.S. population (Behrend et al., 2011). Online convenience samples such as these can provide valid results for exploratory research (Berinsky et al., 2012; Weinberg et al., 2014). However, the survey respondents were not necessarily representative of the population of informal caregivers in the U.S. with respect to sociodemographic characteristics. Most of the respondents were male, younger than most informal caregivers to older adults, and from more urban areas than rural, which may not accurately represent the demographic distribution of informal caregivers across the U.S. (Trivedi et al., 2014). Future studies of CB changes during the pandemic could conduct random population sampling to obtain a sample size of informal caregivers.

The study has a number of notable strengths, as well. This is the first study to date to investigate changes to CB due to the COVID-19 pandemic by rural-urban status. Although the sociodemographic structure of the sample may not reflect the sociodemographic makeup of all informal caregivers, the sample used was nationally representative, and representative of caregivers living in all parts of the rural-urban continuum based on RUCA code and population density. Two types of analyses were utilized: (1) binary logistic regression to model substantial increases in CB versus all other changes and to facilitate interpretation of results and (2) ordinal logistic regression to explore the potential for monotonic associations between the odds of CB change due to the pandemic and rural-urban status. Furthermore, rural-urban status was examined using three levels for RUCA codes and population density, which allowed for potential non-linearity in the associations between rural-urban status and study outcomes.

Obtaining a more complete understanding of how CB has changed due to the COVID-19 pandemic is of critical importance to develop and deliver effective policies and programs to reduce CB effectively across all geographic locations. Tools such as the Caregiver COVID-19 Limitations Scale (CCLS-9) hold promise to effectively measure the impacts of the pandemic on CB and other aspects of informal caregiving (Sheth et al., 2021). The pandemic has increased isolation in terms of social, emotional, informational, and peer support (Koh et al., 2020).

Protecting the health and wellbeing of all informal caregivers, regardless of place of residence, is critical to maintaining this critical component of the healthcare system (Donelan et al., 2002). However, the conditions that lead to rural-urban differences in health (e.g., geographic isolation, income, education, culture, and other factors) are complex and interrelated, making the determination of root causes of those differences more challenging (Hartley, 2004). Understanding and addressing the root causes of rural-urban disparities in CB and other consequences of informal caregiving through the pandemic is critical to protecting caregiver health and in preparation for future pandemics and other societal disruptions and crises.

IRB Protocol/Human Subjects Approval Numbers

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