

**Is Exposure to Epidemic Associated with Older Adults' Health Behavior?**  
**Evidence from China's 2002-2004 SARS Outbreak**

Hong ZOU (Ph.D.) and Sha WEN (MA)

School of Economics

Southwestern University of Finance and Economics (China)

Hongwei XU (corresponding author; Ph.D.)

Department of Sociology

Queens College

Powdermaker Hall 252, 65-30 Kissena Blvd.

Queens, NY 11367, USA

[hongwei.xu@qc.cuny.edu](mailto:hongwei.xu@qc.cuny.edu)

Phone: +1 (718) 997-2809

Fax: +1 (718) 997-2820

**Funding and Acknowledgement:** This research was supported by a grant awarded to Dr. Zhou from the Chinese National Funding of Social Sciences (18VSJ070). An earlier version of the paper was presented at the 2020 Annual Symposium of the Chinese Women Economist Network. We thank the participants for their comments and suggestions. We also thank Robert McLoone and Eric Lindberg for their assistance in copy-editing.

**Author Contributions:** Drs Zou and Xu designed the study and supervised the data analysis. Wen performed the data analysis. Dr. Xu wrote the manuscript. Dr. Zou and Wen edited the manuscript.

### Abstract

**Objectives:** To determine whether exposure to an epidemic is associated with better health behaviors.

**Methods:** Using nationally representative survey data collected in 2011 and 2014, we identified middle-aged and older Chinese adults whose communities experienced an outbreak of the 2002–2004 severe acute respiratory syndrome (SARS). We estimated logistic models of health behaviors in the years after the SARS epidemic.

**Results:** Compared to those who lived in communities not hit by the epidemic, respondents who lived in communities with a SARS outbreak in 2002–2004 were more likely to get a physical examination in 2010–2011 and have their blood pressure checked and participate in regular physical exercise in the years following the SARS epidemic. These associations varied by gender and rural–urban residence.

**Discussion:** Exposure to the SARS epidemic could be positively associated with health behavior among middle-aged and older Chinese adults.

*Keywords:* COVID-19, disaster, exercise, gender, rural–urban

As of April 28, 2020, China reported 84,347 confirmed coronavirus disease 2019 (COVID-19) cases and 4,643 deaths, making it one of the hardest-hit countries (World Health Organization, 2020). Even though China has slowed the spread of COVID-19, one pressing question is: Will COVID-19 have any long-term impact on health behaviors or outcomes for China's aging population? The trauma and loss of life is unmistakable and remains ongoing, but some studies have suggested that public health crises such as epidemics and pandemics may induce positive changes in health behavior among survivors. For example, one recent study found that in Mexico, the 2009 H1N1 pandemic caused positive changes in hygiene practices such as frequent hand washing and increased use of hand sanitizers, which in turn led to fewer diarrhea-related cases among young children in 2010–2012 (Agüero & Beleche, 2017).

It is too early to explore whether the COVID-19 pandemic will induce any health-conscious behavioral changes among Chinese older adults. Therefore, we sought insights from an earlier epidemic—the 2002–2004 severe acute respiratory syndrome (SARS) outbreak. The SARS outbreak started in China in November 2002, with the major part of the outbreak lasting about 8 months and causing more than 8,000 cases and more than 800 deaths in 29 countries and territories (World Health Organization, 2004). There are several similarities between SARS and COVID-19. First, the two diseases are caused by two related coronavirus strains. Hence, they have similar physiological symptoms and are both transmitted through close interpersonal contact or contact with contaminated objects. Second, both diseases were novel when first reported and to date, there have been no specific treatments or vaccines available. Third, during both the 2002–2004 SARS outbreak and the current COVID-19 pandemic, middle-aged and older adults were particularly vulnerable in terms of infection and mortality rates (Epidemiology Working Group, 2020; World Health Organization, 2003).

This study examined the association between community exposure to the 2002–2004 SARS outbreak and health behaviors in the years up to 2011 in middle-aged and older Chinese adults. Previous research on this topic rarely distinguished between younger and older adults (Agüero & Beleche, 2017; Bennett et al., 2015; Lau et al., 2005). We focused on middle-aged and older adults because they face not only higher risk related to SARS and COVID-19 but are also more likely to have chronic diseases than younger adults (Population Reference Bureau, 2020). A better understanding of changes in health behavior after the SARS outbreak will help inform public health interventions to mitigate disease risks in general and during future epidemics. We examined several outcome variables of physical exercise and utilization of preventive health care that are highly cost-effective behaviors to promote population health and successful aging (Dupas, 2011; Feng et al., 2020) and were behaviors of interest in previous research on SARS (Bennett et al., 2015; Lau et al., 2005).

This study expands the literature in several ways. First, previous research on SARS examined health behaviors when the epidemic was ending or during its immediate aftermath (Bennett et al., 2015; Lau et al., 2005). We extended the time span to 2011 and provided new evidence of long-term differences in health behavior. Second, some researchers relied on aggregate data that were susceptible to potential ecological fallacy (Agüero & Beleche, 2017), whereas others analyzed individual-level data in a single city or province where spatial variation was limited (Bennett et al., 2015; Lau et al., 2005). Using a multilevel design and nationally representative data, we exploited the spatial variation in the SARS outbreak across China, measured exposure at the community level, and examined health behaviors at the individual level. Third, previous research ignored the potential

heterogeneity of populations when examining potential links between health behavior and experiencing an epidemic (Agüero & Beleche, 2017; Bennett et al., 2015; Lau et al., 2005). In China, men, women, and rural and urban residents have different perceptions of health risks (Fan et al., 2013; Whyte & Sun, 2010), which in turn contributes to considerable gender and rural–urban disparities in health behaviors and outcomes (Population Reference Bureau, 2020). Therefore, we formally tested gender and rural–urban differences in the associations between SARS exposure and health behaviors.

## Methods

### Study Participants

The data were drawn from the China Health and Retirement Longitudinal Study (CHARLS), a nationally representative longitudinal survey of adults aged 45 or older and their spouses, if available. CHARLS sampled 17,708 residents from 150 counties across 28 provinces in China at the 2011 baseline, with a response rate of 80.5% (Zhao et al., 2014). The 2011 baseline survey included a community module collecting data from local officials about current socioeconomic conditions and community histories. In 2014, a follow-up survey was conducted to collect data on respondents' retrospective life histories, including health behaviors and health care services prior to the baseline survey.

We constructed the analytic sample in several steps. First, we applied several sample eligibility criteria, including: (a) 50 years old or older at baseline; (b) successful follow-up in 2014; and (c) living in the same community during the 2002–2004 SARS epidemic. These sample restrictions were adopted to ensure validity and reliability in measuring several key variables of interest. Migration is unlikely a serious concern because only 5.0% of the original sample had migrated; nonetheless, these individuals were excluded in our analysis. In the 2011 community survey, local officials were asked to list natural disasters and epidemics that occurred in the past. Using this information, we identified 1,324 eligible respondents living in 60 communities where a SARS outbreak occurred. We considered these respondents as having community exposure to SARS. We defined the unexposed control group as individuals from the same prefectures but different communities where no SARS outbreaks occurred. We identified 1,883 respondents from 71 communities as the control group. Last, we excluded 170 respondents with missing data on any independent variable. To maximize statistical power, we allowed the final sample size to vary depending on the number of valid responses for each health outcome. As a result, the analytic sample ranged from 2,077 (for physical examination) to 3,037 (for regular physical exercise).

### Measures

We examined four health behavior outcomes. Based on self-reports in the 2011 baseline survey, the first outcome was a dichotomous indicator of whether the respondents had a regular physical examination in the past year. Using retrospective recall data from the 2014 follow-up survey, the other three dichotomous outcome variables indicated whether in the years following the 2002–2004 SARS epidemic, respondents ever: (a) had their blood pressure checked; (b) took a blood test (to measure, for example, cholesterol and glucose levels); and (c) participated in regular physical

exercise for at least 1 year. These are the only health behavior variables available in the CHARLS data that are suitable for both men and women. Two other health behaviors—smoking and drinking—were very rare in middle-aged and older Chinese women.

The key independent variable of interest was community exposure to SARS, coded 1 if there was a SARS outbreak in the respondent's community during the 2002–2004 epidemic and coded 0 otherwise. Following recent research on health behaviors among older Chinese adults (Feng et al., 2020), we controlled for respondents' demographic and socioeconomic characteristics, self-reports of chronic conditions and physical functioning, and community socioeconomic conditions and provincial fixed effects (see Table 1).

### Statistical Analysis

We estimated logistic regression models of the dichotomous outcome variables. Statistical significance was based on robust standard errors that adjusted for clustering at the community level. We used two approaches to test gender and rural–urban variations: adding interactions and conducting subsample analysis. The results were similar, and we present subsample analysis for ease of interpretation. We compared regression coefficients across subsamples using the seemingly unrelated regression method.

## Results

### Descriptive Statistics

Table 1 reports descriptive statistics of the dependent and independent variables. Less than 1 in 5 respondents (16.3%) participated in regular physical exercise for at least a year. Participants exposed to the SARS outbreak in their communities were more likely to participate in regular physical exercise (20.4%) than those with no exposure (13.4%). Nearly half of the respondents (46.6%) had a physical examination in the past year. Since the end of the SARS epidemic, 41.2% of the respondents had their blood pressure checked and 36.0% had a blood test. There was little difference in rates of physical examination, blood pressure checks, or blood tests between respondents who were exposed to SARS and those who were not. Again, people who were exposed to the SARS outbreak had slightly higher rates of blood pressure checks (42.5%) and blood tests (35.8%) than those who were not (39.6% and 35.6%, respectively).

[Table 1 here]

### Logistic Regression Estimates

Table 1 reports the estimates of odds ratios from the logistic models in the full sample. Compared with participants whose communities were not affected, the respondents whose communities experienced a SARS outbreak had 40% higher odds of participation in regular physical exercise and 19% higher odds of having their blood pressure checked during recent years. No significant association was found between community exposure to SARS and recent physical examinations or blood tests.

[Table 2 here]

Table 3 shows the estimated odds ratios from separate logistic models with gender and rural–urban subsamples. In terms of gender variations, community exposure to SARS was positively associated with participation in regular physical exercise and blood pressure checks in the male subsample but not in the female subsample. However, these gender differences were not statistically significant. With respect to rural–urban variations, community exposure to SARS was positively associated with blood pressure checks and blood tests in the urban subsample and regular physical exercise in the rural subsample. There were statistically significant rural–urban differences with respect to recent blood pressure checks and blood tests.

[Table 3 here]

As a sensitivity check, we repeated the same regression analyses as in Tables 2 and 3 using multiple imputation by chained equations with five replications for missing data. The results are shown in Appendix Tables A1 and A2. Most results remained qualitatively unchanged except that the association between SARS exposure and blood pressure checks was no longer significant in the full sample.

### Discussion

Using nationally representative survey data, we found long-term positive associations between community exposure to the 2002–2004 SARS epidemic and health behaviors in later years among middle-aged and older Chinese adults. The association was most notable for participation in regular physical exercise, which might be more cost effective and less constrained by access to health resources than the other outcomes, which are more dependent on access to and use of preventive health care. It is possible that people improved their health behavior following direct community experience with SARS (Agüero & Beleche, 2017). However, due to a lack of measures in the pre-SARS period, the internal validity of our regression models is insufficient and we can't conclude that exposure to SARS has causally changed people's health behaviors. Nevertheless, this correlational finding is important because previous research has only shown short-term associations between SARS exposure and health behaviors within several months of the epidemic ending (Bennett et al., 2015; Lau et al., 2005). Furthermore, this finding suggests that although health behaviors are often well established by young adulthood (Smith et al., 2001), they remain open to improvement in midlife and beyond.

Positive associations between community exposure to SARS and health behaviors were statistically significant in the male subsample but not in the female subsample. Previous analysis of the CHARLS data showed that men had worse perceptions of chronic disease risk and poorer health-seeking behaviors than women (Lei et al., 2014). It is possible that, on average, middle-aged and older Chinese women already adopted healthier behaviors and lifestyles and are thus less susceptible to health shocks.

Last, we found statistically significant rural–urban differences in the associations between community exposure to SARS and health behaviors such as blood pressure checks and blood tests. Community exposure to SARS was associated with utilization of preventive health services for urban residents but not for rural residents and alternatively, with participation in regular physical exercise for rural residents. This again may reflect rural–urban disparities in access to health care resources

(Li et al., 2016). Due to lack of access to clinics and hospitals, rural Chinese adults may perceive physical exercise as one of the few feasible preventive strategies to maintain health in older ages.

Taken together, these findings help identify positive directions for future social efforts and policy decisions to steer the global recovery from the devastating COVID-19 pandemic, which has already caused greater loss of life and socioeconomic damage across communities than the 2002–2004 SARS epidemic. If the trends following the SARS epidemic are any indication of what we can expect among middle-aged and older adults exposed to COVID-19 at the community level, the pandemic may result in lasting, heightened awareness of the importance of preventive medicine and positive health behavior. Although such trends offer a glimmer of hope, concerted efforts must be made to encourage these positive changes through targeted messaging and information campaigns, resource allocation, and clinical practice.

### References

- Agüero, J. M., & Beleche, T. (2017). Health shocks and their long-lasting impact on health behaviors: Evidence from the 2009 H1N1 pandemic in Mexico. *Journal of Health Economics*, 54, 40–55. <https://doi.org/10.1016/j.jhealeco.2017.03.008>
- Bennett, D., Chiang, C.-F., & Malani, A. (2015). Learning during a crisis: The SARS epidemic in Taiwan. *Journal of Development Economics*, 112, 1–18. <https://doi.org/10.1016/j.jdeveco.2014.09.006>
- Dupas, P. (2011). Health behavior in developing countries. *Annual Review of Economics*, 3, 425–449. <https://doi.org/10.1146/annurev-economics-111809-125029>
- Epidemiology Working Group for NCIP Epidemic Response. (2020). The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19) in China. *Chinese Journal of Epidemiology*, 41(2), 145–151. <https://doi.org/10.3760/cma.j.issn.0254-6450.2020.02.003>
- Fan, J. X., Wen, M., Jin, L., & Wang, G. (2013). Disparities in healthcare utilization in China: Do gender and migration status matter? *Journal of Family and Economic Issues*, 34(1), 52–63. <https://doi.org/10.1007/s10834-012-9296-1>
- Feng, J., Li, Q., & Smith, J. P. (2020). Retirement effect on health status and health behaviors in urban China. *World Development*, 126, 104702. <https://doi.org/10.1016/j.worlddev.2019.104702>
- Lau, J. T. F., Yang, X., Tsui, H. Y., & Kim, J. H. (2005). Impacts of SARS on health-seeking behaviors in general population in Hong Kong. *Preventive Medicine*, 41(2), 454–462. <https://doi.org/10.1016/j.ypmed.2004.11.023>
- Lei, X., Sun, X., Strauss, J., Zhao, Y., Yang, G., Hu, P., Hu, Y., & Yin, X. (2014). Reprint of: Health outcomes and socio-economic status among the mid-aged and elderly in

- China: Evidence from the CHARLS national baseline data. *The Journal of the Economics of Ageing*, 4, 59–73. <https://doi.org/10.1016/j.jeoa.2014.10.001>
- Li, L. W., Liu, J., Xu, H., & Zhang, Z. (2016). Understanding rural–urban differences in depressive symptoms among older adults in China. *Journal of Aging and Health*, 28(2), 341–362. <https://doi.org/10.1177/0898264315591003>
- Population Reference Bureau. (2020). *Aging and health in China*. <https://www.prb.org/wp-content/uploads/2020/01/tra39-health-aging-china-2020.pdf>
- Smith, V. K., Taylor, D. H., Sloan, F. A., Johnson, F. R., & Desvousges, W. H. (2001). Do smokers respond to health shocks? *The Review of Economics and Statistics*, 83(4), 675–687. <https://doi.org/10.1162/003465301753237759>
- Whyte, M. K., & Sun, Z. (2010). The impact of China's market reforms on the health of Chinese citizens: Examining two puzzles. *China: An International Journal*, 8(1), 1–32. <https://doi.org/10.1142/S0219747210000038>
- World Health Organization. (2003). *Consensus document on the epidemiology of severe acute respiratory syndrome (SARS)*. <https://www.who.int/csr/sars/guidelines/en/>
- World Health Organization. (2004). *Summary of probable SARS cases with onset of illness from 1 November 2002 to 31 July 2003*. [https://www.who.int/csr/sars/country/table2004\\_04\\_21/en/](https://www.who.int/csr/sars/country/table2004_04_21/en/)
- World Health Organization. (2020). *Coronavirus disease (COVID-19) outbreak situation*. <https://covid19.who.int/>
- Zhao, Y., Hu, Y., Smith, J. P., Strauss, J., & Yang, G. (2014). Cohort profile: The China Health and Retirement Longitudinal Study (CHARLS). *International Journal of Epidemiology*, 43(1), 61–68. <https://doi.org/10.1093/ije/dys203>

Table 1

*Descriptive Statistics of Dependent and Independent Variables*

Variable	Exposed to SARS		Not Exposed		<i>M</i> diff.
	% or <i>M</i> ( <i>SD</i> )	<i>n</i>	% or <i>M</i> ( <i>SD</i> )	<i>n</i>	
Regular physical exercise	20.4	1,256	13.4	1,781	7.0**
Physical examination	48.6	834	45.3	1,243	3.3
Blood pressure check	42.5	1,129	40.3	1,531	2.2
Blood test	35.8	1,172	36.2	1,670	-0.3
Age					
50–59	43.0	540	49.1	874	-6.1**
60–69	37.2	467	34.7	618	2.5
70–79	16.9	212	12.9	229	4.0**
80+	3.0	37	3.4	60	-0.4
Gender (1 = woman; 0 = man)	50.9	1,256	50.4	1,781	0.5
Married (1 = yes; 0 = no)	85.3	1,256	89.1	1,781	-3.8**
Primary school or above (1 = yes; 0 = no)	54.9	1,256	50.4	1,781	4.5*
Number of living adult children	2.8 (1.4)	1,256	2.8 (1.3)	1,781	0.1
Household consumption per capita (1,000 yuan)	9.4 (19.5)	1,256	7.2 (7.8)	1,781	2.2**
Chronic conditions (range: 0–14)	1.5 (1.5)	1,256	1.4 (1.5)	1,781	0.1*
IADL limitations (range: 0–8)	1.1 (1.7)	1,256	1.0 (1.6)	1,781	0.1*
Residence (1 = urban; 0 = rural)	45.1	1,256	25.6	1,781	19.5**
Community social economic condition					
Poor	23.3	14	36.6	26	-13.3
Average	40.0	24	39.4	28	0.6
Rich	36.7	22	23.9	17	12.7

Note. IADLs = instrumental activities of daily living.

Table 2

*Estimates of Odds Ratios from Logistical Models of Health Behaviors in the Full Sample*

	Regular Physical Exercise	Physical Examination	Blood Pressure Check	Blood Test
Exposed to SARS in community (ref: no)	1.40* (1.06, 1.84)	1.17 (0.78, 1.74)	1.19† (1.00, 1.43)	1.07 (0.88, 1.31)
Age (ref: 50–59)				
60–69	2.02** (1.58, 2.57)	1.05 (0.85, 1.30)	1.03 (0.85, 1.25)	1.06 (0.88, 1.28)
70–79	1.79** (1.20, 2.66)	0.98 (0.69, 1.39)	0.84 (0.63, 1.11)	1.21 (0.92, 1.59)
80+	1.54 (0.62, 3.84)	2.49* (1.24, 5.01)	0.82 (0.49, 1.40)	0.82 (0.45, 1.49)
Women (ref: men)	0.93 (0.75, 1.16)	1.00 (0.82, 1.21)	1.50** (1.29, 1.75)	1.40** (1.20, 1.63)
Primary school or above (ref: no)	1.57** (1.21, 2.03)	1.10 (0.86, 1.40)	0.96 (0.79, 1.16)	0.96 (0.79, 1.18)
Married (ref: no)	0.97 (0.67, 1.41)	1.02 (0.80, 1.32)	0.87 (0.68, 1.10)	0.90 (0.68, 1.20)
Household consumption per capita (log)	1.72** (1.43, 2.07)	0.89 (0.76, 1.05)	0.83** (0.73, 0.94)	1.04 (0.91, 1.18]
Number of living children	0.89* (0.80, 0.99)	1.07 (0.96, 1.18)	1.07† (1.00, 1.15)	1.07* (1.00, 1.15)
IADL limitations	0.92† (0.84, 1.01)	0.97 (0.91, 1.04)	1.02 (0.97,1.08)	1.00 (0.95, 1.06)
Number of chronic conditions	1.08* (1.00, 1.12)	1.06† (0.99, 1.14)	1.03 (0.97, 1.08)	1.12** (1.06, 1.19)
Urban residence (ref: rural)	2.18** (1.52, 3.11)	1.02 (0.63, 1.66)	0.90 (0.74, 1.10)	0.85 (0.67, 1.08)
Community socioeconomic condition (ref: poor)				
Average	0.94 (0.68, 1.30)	1.30 (0.75, 2.24)	0.84† (0.69, 1.03)	0.97 (0.79, 1.19)

	1.29)	2.25)	1.03)	1.20)
Rich	0.69 (0.45, 1.08)	0.82 (0.46, 1.46)	0.87 (0.69, 1.11)	1.11 (0.85, 1.46)
Provincial fixed effects	Yes	Yes	Yes	Yes
<i>N</i> (observations)	3,037	2,077	2,660	2,842

*Note.* IADLs = instrumental activities of daily living; 95% confidence intervals shown in the parentheses.  
Significance based on clustered standard errors at the community-level.

† $p < .10$ . \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ .

Accepted Manuscript

Table 3.

Estimates of odds ratios from logistical models of health behaviors in gender and rural-urban subsamples.

	Regular Physical Exercise		Physical Examination		Blood Pressure Check		Blood Test	
	Women	Men	Women	Men	Women	Men	Women	Men
Exposed to SARS (ref: no)	1.36 (0.93, 1.99)	1.47* (1.06, 2.02)	1.16 (0.75, 1.79)	1.16 (0.73, 1.84)	1.11 (0.86, 1.42)	1.28* (1.02, 1.60)	0.98 (0.74, 1.31)	1.17 (0.94, 1.44)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	1,537	1,500	1,052	1,025	1,347	1,295	1,431	1,393
SUR test <i>p</i> -value	.731		.991		.377		.285	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Exposed to SARS (ref: no)	1.06 (0.66, 1.69)	1.59** (1.13, 2.24)	0.98 (0.66, 1.45)	1.28 (0.70, 2.35)	1.79** (1.16, 2.76)	1.10 (0.90, 1.35)	1.70* (1.09, 2.66)	0.95 (0.77, 1.18)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Provincial fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
<i>N</i>	1,016	1,996	759	1,309	888	1,766	940	1,896

SUR test $p$ - value	.163	.469	.047	.021
-------------------------	------	------	------	------

---

*Note.* SUR = seemingly unrelated regression; 95% confidence intervals show in parentheses; significance based on clustered standard errors at the community-level.

† $p < .10$ . \* $p < .05$ . \*\* $p < .01$ . \*\*\* $p < .001$ .

Accepted Manuscript