The Long-Term Association between Exposure to Epidemic and Later-Life Health Behaviors and Outcomes

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Abstract

Emerging epidemics have devastating impacts on people's lives and livelihoods. However, acting as a severe health shock, exposure to an epidemic may induce positive changes in health behaviors among survivors, thereby leading to long-lasting improvement in population health. This study examined the long-term association between exposure to the 2002–2004 severe acute respiratory syndrome (SARS) outbreak and middle-aged and older Chinese adults' health behaviors and outcomes assessed in 2011–2018. We have compiled numbers of confirmed SARS cases at the prefecture level to constructed contextual measures of exposure to the epidemic. We will match the prefecture-level measures of SARS exposure to individual-level data from the 2011–2018 China Health and Retirement Longitudinal Study. We will then estimate the longitudinal associations of SARS exposure with health-related behaviors (e.g., fitness spending, annual physical examination, and participation in physical exercise). We will conduct mediation analysis to examine whether SARS-induced positive changes in health-related behaviors lead to better physical and mental health outcomes. We will also examine variations in these longitudinal associations by socioeconomic resources.

Keywords: biomarker; epidemic; health behavior; life course

1. Introduction

Despite a continued decrease in the burden of infectious diseases on a global scale, they still account for nearly 20% of deaths and remain the leading cause of years of life lost for certain vulnerable populations (GBD 2017 Causes of Death Collaborators, 2018). Among infectious diseases, lower respiratory infections are a leading cause of mortality worldwide for people of all ages, especially young children and older adults in low- and middle-income countries (Troeger et al., 2018). On the other hand, emerging infectious diseases have increased significantly since 1940 due to changes in socioeconomic, environmental, and ecological conditions (Jones et al., 2008). Emerging infectious diseases cause substantial damage to public health and the global economy. Notable examples during the last two decades include the 2002–2004 severe acute respiratory syndrome (SARS) outbreak, the 2009 swine flu pandemic, the 2012 Middle East respiratory syndrome coronavirus outbreak, and the ongoing coronavirus disease 2019 (COVID-19) pandemic.

SARS and COVID-19 are caused by two related virus strains—SARS-CoV-1 and SARS-CoV-2. The SARS outbreak started in China in November 2002, and the major part of the outbreak lasted about 8 months, leading to more than 8,000 cases and 800 deaths in 29 countries and territories (WHO, 2004). The World Health Organization (WHO) declared the SARS outbreak contained in early July 2003, although a few additional SARS cases were reported until May 2004 (WHO, May 18, 2004). Similar to COVID-19, middle-aged and older people were at a higher risk of SARS infection, partly because they were more likely to have severe underlying medical conditions such as heart conditions, respiratory disease, and diabetes than younger people (CDC, 2020). In China, the median age of people with SARS was 42 years old, and the

case fatality ratios were much higher for those between 45 and 64 (15%) or 65 and older (52%) than those between 25 and 44 (6%) (WHO, 2003).

Despite the devastating impacts of emerging epidemics on public health and the economy, recent research has revealed a silver lining. Acting as a severe health shock, exposure to an epidemic may induce positive changes in health behaviors among survivors, thereby leading to a long-lasting improvement in population health. 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 led to fewer diarrhea-related cases among young children in 2010–2012 (Agüero & Beleche, 2017). In our recent study, we found that among middle-aged and older Chinese adults, those who lived in communities with a SARS outbreak in 2002–2004 were more likely to seek a physical examination, have their blood pressure checked, and participate in regular physical exercise after the SARS epidemic, compared with those who lived in communities not affected by the epidemic (Zou et al., 2020).

However, our prior study has several limitations. First, we relied on reported SARS outbreak by local community officials which may not be reliable because they might have an incentive to underreport to avoid possible political scandals. In addition, focusing on community SARS outbreaks may ignore the potential impact on people living in nearby communities. Second, the measures of physical examination and exercise were only available for a subsample in earlier waves of the CHARLS. Third, we did not examine other health-related behaviors such as spending on fitness, or physical or mental health outcomes. Lastly, we did not formally test health-related behaviors as mediators for the longitudinal association between SARS exposure and health outcomes, or heterogeneity in these associations by socioeconomic resources.

In this study, we will address these limitations using updated data from CHARLS and public archives. We theorize that SARS outbreaks would pose an imminent public health threat to local residents, resulting in a collective trauma. It is possible that survivors of a SARS outbreak might experience such positive psychosocial changes as greater appreciation of health and life, changed priories in life (e.g., valuing health, balancing between work and life), and more intimate relationships with others (Tedeschi & Calhoun, 1996, 2004). These psychosocial changes could further lead to behavioral changes such as increased spending in fitness, participation in regular physical exercise, and social activities, and close intergenerational relationships. In turn, these behavioral changes contribute positively to physical and mental health in middle and older ages.

Building upon our previous research, we seek to answer three research questions: (1) Was exposure to SARS outbreaks at the prefecture level in 2002–2004 associated with better health-related behaviors and outcomes in 2011–2018 among middle-aged and older Chinese adults? (2) Did health-related behaviors play the role of mediators in the long-term association between SARS exposure and physical and mental health outcomes? (3) Did these associations vary by socioeconomic status?

Research Plan

Data Sources and Key Measures

The data will be 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 17,705 residents from 150 counties across 28 provinces in China. The national baseline survey of CHARLS was conducted in 2011, with a response rate of 80.5%

(Zhao et al., 2014). Follow-up surveys have been carried out in 2013, 2014, 2015, and 2018. We will draw on data mainly from the 2011, 2013, 2015, and 2018 waves for their consistent questionnaire design. We discard the 2014 wave which mainly collected data on retrospective life histories of the respondents.

To measure exposure to SARS outbreaks, we have compiled numbers of confirmed cases at the prefecture-level from historical archives and health statistical yearbooks published by local governments and public health agencies during and after the 2002-2004 epidemic. We will explore different measures of SARS exposure. For example, we can calculate the number of confirmed SARS cases per 100,000 population in each prefecture based on China's 2000 Population Census. We will then match the contextual measure of SARS exposure to CHARLS respondents based on their places of residence at the prefecture-level which were publicly released in the CHARLS data. Geographic locational information below the prefecture-level remains confidential in CHARLS.

The dependent variables (including health-related behaviors as mediators) will be drawn from different waves of CHARLS due to changes in data collection over time. We will examine several health-related behaviors based on respondents' self-reports. A dichotomous variable will be created to indicate whether respondents took physical examination at the baseline or between any two consecutive follow-up surveys. A continuous variable will be created to measure annual household expenditure in fitness (including purchasing fitness equipment and supplementary nutrients). Questions about physical activities (including exercises) were only asked among a random subsample of the CHARLS respondents in 2011-2015. Starting in 2018, all the respondents were asked to list any physical activities they participate in regularly for at least 10 minutes every time in a week. For every reported physical activity, respondents were asked about

whether the participation was for work, leisure, or exercise and how much time they spent doing. We will use the 2018 data alone to measure respondents' participation in regularly physical exercise.

Turning to health outcomes, the CHARLS baseline and follow-up surveys (except the 2014 retrospective life history survey) collected physical-performance measures from the respondents. The baseline and 2015 waves also collected fasting blood samples. These biomarker data were collected by trained medical students with assistance from local nurses (Chen et al., 2019). For blood-based biomarkers, respondents were asked to fast overnight and visit a local blood collection site in the morning. Cardiovascular disease risks will be captured by hypertension status and resting pulse rate. Physical mobility and strength will be captured by gait speed and grip strength. Metabolic disease risks will be captured by body mass index (based on measured body weight and height), waist circumference, and diabetes status (based on levels of fasting glucose and HbA1c). Mental health outcomes will be measured by life satisfaction on a 5-point Likert scale and depressive symptoms based on the 10-item shortened version of the Center for Epidemiologic Studies Depression Scale (CES-D).

Statistical methods

To answer the first research question, we will estimate the following regression model:

$$Y_{ijt} = \alpha + \beta \times SARS_j + \gamma X_{ijt} + \theta_i + \delta_j + \varepsilon_{ijt} \qquad (1)$$

where Y_{ijt} denotes the health-related behavior or outcome variable for *i*th respondent living in *j*th prefecture at time *t*; $SARS_j$ is the key independent variable indicating the number of confirmed SARS cases in *j*th prefecture in 2002–2004; and X_{ijt} represents all individual- and household-level control variables. We will model the correlation among repeated measurements of the same

individuals via an individual-level random effects θ_i. We will control for prefecture fixed effects, denoted by δ_j. Robust standard errors will be calculated to adjust for sample clustering at the community level.

To answer the second research question, we will carry out longitudinal mediation analysis in which health-related behavioral variables served as mediators. We will calculate bootstrap standard errors for statistical inference (Preacher & Hayes, 2008). To answer the third research question, we will add interactions between prefecture-level SARS exposure and individual/household-level socioeconomic variables in Model (1) and the mediation analysis. We will focus on three socioeconomic variables that are salient in the Chinese context: educational attainment, rural-urban household registration status, and annual household income per capita.

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