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Behavioral responses to the 2015 MERS epidemic in Korea

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Understanding behavioral responses to epidemics is important in evaluating the broad health consequences of emerging infectious diseases. Building on the economic epidemiology literature, this study investigates individual behavioral responses to the 2015 Middle East Respiratory Syndrome Coronavirus (MERS-CoV) epidemic in Korea using a panel of individuals in a nationally representative survey. Results show that exposure to the epidemic led to lasting impacts on smoking and drinking behaviors, indicating that emerging infectious disease outbreaks are motivations for behavioral changes and opportunities for public policy interventions. In particular, individuals in the hardest-hit regions or socially connected persons were more likely to change their risky behaviors, suggesting that intensity of exposure and social interactions are potential mechanisms.

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1. Introduction

A growing body of research has reported negative impacts on health and human capital of external shocks such as natural disasters, disease epidemics, or violence/conflicts (Almond, 2006; Di Novi, 2010; Kelly, 2011; Neilsen, Stratmann, 2012; Currie, Vogl, 2013; Karlsson et al., 2014; Acquah et al., 2017; Altindag et al., 2017; Frankenberg, Thomas, 2017; Ogasawara, 2017). These studies provide consistent evidence that health can be affected through changes in wealth, nutritional uptakes, or psychological stress, even without direct contact with the external shock itself.

Recent studies also reported that negative external shocks alter individual risky behaviors and risk preferences (Hanaoka et al., 2015), but the direction and mechanisms of impacts remain unclear. In fact, little is known about what determines and changes health behaviors and health-related investment in general (Fadlon, Nielsen, 2019). Not knowing much about immediate private behavioral responses could lead to poorly targeted policies and biased estimates of the effects of a shock given that behavioral responses are mediators in the association between shocks and health outcomes. Thus, better knowledge of these behavioral responses can direct public policy on how to distribute limited resources to prevent the long-run negative impacts of external shocks.

In contrast to the epidemiology literature, which predicts that hazards associated with a disease outbreak increase in prevalence, an economic approach to epidemics suggests that infectious diseases are self-limiting because of newly created incentives for disease prevention. Based on the findings of an association of condom use with HIV/AIDS epidemic, Philipson (2000) argued that the private demand for prevention against infectious diseases is prevalence-elastic. Recent studies also report positive behavioral changes, in the form of increased vaccination or hand washing rates, in response to outbreaks (Agüero, Beleche, 2017; Oster, 2018).

This study contributes to the literature on behavioral responses by exploring changes in individual risky health behaviors in response to the 2015 Middle East Respiratory Syndrome (MERS) epidemic in Korea. This research focuses on smoking and drinking given the contribution of these behaviors to morbidity and mortality (Rehm et al., 2009; World Health Organization (WHO), 2013).

Leveraging a panel of individuals in a nationally representative survey, this study utilizes a difference-in-differences framework to estimate the behavioral impacts of the MERS. Results show that exposure to the MERS epidemic significantly reduced smoking intensity and increased attempts to stop smoking and drinking, indicating that emerging infectious disease outbreaks provide a motivation for behavioral changes and an opportunity for public policy interventions. This paper also reveals that individuals in the hardest-hit regions or persons who are more socially connected are more likely to change their risky behaviors, suggesting that the
intensity of exposure and social interactions (information-seeking) are potential mechanisms.

2. Methods

This study uses individual-level longitudinal data from the 2011–2017 Korean Labor and Income Panel Study, an annual nationally representative panel survey. The survey has collected a wide range of information on demographic and socioeconomic characteristics, job status, and health-related information including risky healthy behaviors such as cigarette and alcohol consumption. The study sample is restricted to those who participated in every survey and never moved across city lines during the study period. The study sample, a balanced panel, consists of 7120 adults aged 20 or older (49,840 person-year observations). Appendix Table 1 shows that differences in observables between the study sample (non-mover panel) and those excluded due to moving (mover panel, N = 2207 individuals), and differences between the study sample and the whole survey sample (including those not included in the panel, N = 13,087 individuals) are not statistically significant. Note that all the empirical results are weighted by sampling probabilities, thus this result does not reveal evidence that the study sample, despite sample restriction, is deviate from the whole population.

MERS, a respiratory disease that spreads MERS-Coronavirus through close contact between persons, requires about 70% of patients to be hospitalized for mechanical ventilation (Lee, Cho. 2016). The epidemic in Korea originated in the city of Pyeongtaek in May 2015 when the index case became ill after returning from business travel to the Middle East. By the time of the announcement of official end of the epidemic in December 2015, MERS infected 186 and killed 38 Koreans (fatality rate = 19.4%). In addition, about 0.33% of all population (16,993 citizens) had been quarantined for 14 days at some point during the epidemic due to close contacts with infected persons (Oh et al., 2018). Based on information on the government’s official counts of quarantined persons, this study uses the city-level prevalence of the quarantined (per million population, based on the 2015 census) as the exposure measure. Appendix Fig. 1 shows that, in general, cities far from the epidemic origin tended to face lower risks of the disease (sixty four percent of all 226 cities have at least one quarantined person).

Following previous research studying the impacts of a one-time exposure to natural disasters or policy changes (Hanaoka et al., 2015; Agüero, Beleche, 2017; Bullinger, 2019), this study compares changes in individual risky behaviors for those who lived in exposed localities surveyed before and after the 2015 MERS epidemic to corresponding behavioral responses among control groups never exposed to the epidemic, relying on a difference-in-differences approach as follows:

$$Y_{it} = \beta_0 + \beta_1(EverExposed_{it} \times Post_{it}) + \delta X_{it} + \delta_1 + \theta_1 + \epsilon_{it}$$ (1)

The unit of analysis is person-year. An indicator, EverExposed, equals 1 if the surveyed person lived in a city with any MERS-related quarantined cases in 2015, Post is a binary indicator that equals 1 if the outcome was measured in 2015 or later. $\delta_1$ are individual fixed effects, and $\theta_1$ are year fixed effects. In additional analyses, the exposure indicator (EverExposed) was replaced with indicators of the intensity of exposure using three prevalence brackets (1, 5, 10 per million) to explore if individuals living in hard-hit regions were more likely to change their behaviors.

The dependent variable $Y$ is a measure of risky health behaviors of person $i$ in city $c$ during year $t$. It includes self-reported smoking behavior – indicators for current smoking, for trying to quit, and for smoking intensity (2 or more packs daily, 1–2 packs daily, or fewer than a pack a day) – and drinking behavior (indicators for currently drinking, for trying to get sober, and for drinking at least once a week). The time-varying socioeconomic factor $X$ is household monthly expenditures adjusted by family size to the square root of household members. As individual fixed effects are included in the main specification and the sample is restricted to those who never moved across city lines, city fixed effects are canceled out in the above specification due to perfect multicollinearity. Standard errors are clustered at the individual level.

Identification in the above model requires that persons having lived in cities ever exposed to the epidemic and persons in non-exposed cities would have had similar trends in outcomes without the epidemic in 2015. To examine whether there were differential trends in outcome measures before the epidemic, I additionally report event study coefficients where smoking and drinking measures are regressed on interactions between the exposure group indicator and the full set of year dummies (Hoynes et al., 2015; Willage, 2020). The survey year 2014 is treated as the omitted category, so coefficients on the interactions can be interpreted as changes in outcomes relative to this reference period.

Table 1
Summary statistics of the study sample in survey year 2015 (mean (standard deviation)).

| Ever exposed | Never exposed | Whole sample |
|--------------|---------------|--------------|
| Current smoking | 0.222 | 0.228 | 0.225 |
| Quit attempt | 0.064 | 0.060 | 0.061 |
| Quit attempt | 0.004 | 0.004 | 0.004 |
| Smoking 20–39 cigarettes per day | 0.156 | 0.150 | 0.153 |
| Smoking 20–39 cigarettes per day | 0.337 | 0.335 | 0.336 |
| Drinking | 0.019 | 0.016 | 0.017 |
| Drinking | 0.234 | 0.238 | 0.236 |
| Female | 0.522 | 0.500 | 0.511 |
| Age | 47.723 (14.887) | 45.225 (17.812) | 46.962 (16.305) |
| Education attainment | | | |
| Primary education or less | 0.114 | 0.118 | 0.116 |
| Secondary education or less | 0.417 | 0.405 | 0.415 |
| At least college attendance | 0.469 | 0.477 | 0.469 |
| Married | 0.704 | 0.675 | 0.681 |
| Adjusted household monthly expenditure (10,000 Won) * | 147.884 (63.664) | 150.182 (65.964) | 148.874 (71.109) |
| Wage earner | 0.594 | 0.515 | 0.510 |
| Observations | 5082 | 2038 | 7120 |

# monthly expenditure/√number of household members
US$1=1110 Won.
Means are weighted by sampling probabilities.
null
smoking behaviors. Coefficients on the parameter of interest ("Post * Exposed") are statistically significant and meaningful for quitting attempts and for measures of the intensity of smoking, though smoking rates are not significantly affected. Results indicate that the probability of a quitting attempt increased by 1 percentage point (16.4 % of the mean) after the epidemic among the exposed group. In addition, exposure to the MERS epidemic led to a decline in cigarette consumption among smokers. The probability of consuming 20–39 cigarettes per day decreased significantly by 1.5 percentage points (22.1 % of the mean). At the same time, the propensity to smoke fewer than a pack a day was up 1.7 percentage points (11.1 % of the mean), implying a downward shift in intensity among current smokers.

**Table 3** reports that exposure to the MERS epidemic also led to changes in drinking behaviors. Exposure to the epidemic resulted in an increased probability of trying to get sober by 0.9 percentage points. This figure, equivalent to 52.9 % of the mean, is substantial, but there was no association of exposure to the epidemic with drinking rates or frequency, indicating that the behavioral responses to the external health shock generated by the MERS epidemic were not strong enough to decrease the overall demand for alcohol.

Event study estimates in **Fig. 1**, Appendix Table 2–3 provide evidence that the impacts on risky healthy behaviors (attempting to try quit smoking, the intensity of smoking, and attempting to get sober) appear immediately after the country was hit by the epidemic and last for at least 3 years with similar effect sizes. Another finding of particular interest is that coefficients on leads are statistically insignificant and not meaningful, providing evidence that there were no pre-existing differential trends in outcomes between the two groups.

**Table 4** shows that impacts on behavioral responses vary by the intensity of exposure measured as prevalence rates at the city level. Individuals living in the hardest-hit areas, compared to peers in cities not affected by the epidemic, were significantly more likely to attempt to quit smoking, to reduce smoking intensity, and to try to stop drinking. In particular, coefficients were not statistically significant and meaningful for persons in the least-hit regions, indicating that individuals respond to the risk of contracting the disease.

Appendix Figure 2 presents Google trends data showing that the share of search terms related to "MERS" in Korea hit almost 100 % in early June when the epidemic climbed toward a peak. This indicates an unprecedented level of information-seeking behavior among the public. In **Table 5**, I consider the possible role of social connectedness in mediating behavioral responses to the epidemic. Results from triple differences specification show that, compared to recent arrivals who ever moved across city lines during the last five years, longtime residents are significantly more likely to change their adverse health behaviors if exposed to the epidemic (Panel A). Conditional on living in affected areas, exposure to the MERS epidemic led to an additional increase in the propensity to attempt to quit smoking (+1.7 percentage points) and the propensity to try to stop drinking (1.1 percentage points) among non-movers. Put differently, exposure to the epidemic led to a statistically

**Table 4** The intensity of exposure and behavioral responses to the 2015 MERS epidemic: Difference-in-differences estimation.

| Independent variable of interest (Omitted category = zero cases) | Smoking behavior | Drunk behavior |
|---|---|---|
| | Current smoking | Attempt to quit smoking | Smoking >2 packs daily | Smoking 1–2 packs daily | Smoking <1 pack daily | Current drinking | Attempt to stop drinking | Drinking at least once a week |
| Post * Low-Intensity Area | –0.001 (0.011) | –0.007 (0.02) | 0.002 (0.02) | –0.006 (0.012) | 0.0007 (0.013) | –0.024 (0.018) | 0.008 (0.005) | 0.012 (0.009) |
| (Prevalence <5 per million) | | | | | | | | |
| Post * Middle-Intensity Area | –0.001 (0.010) | 0.006 (0.006) | –0.0001 (0.02) | –0.012 (0.006) | 0.013 (0.010) | –0.014 (0.015) | 0.016 (0.007) | 0.007 (0.016) |
| (Prevalence 5–10 per million) | | | | | | | | |
| Post * High-Intensity Area | 0.006 (0.008) | 0.018*** (0.002) | 0.0004 (0.002) | –0.016** (0.008) | 0.021** (0.007) | 0.009 (0.01) | 0.022*** (0.01) | –0.004 (0.016) |
| (Prevalence >10 per million) | | | | | | | | |
| Pre-exposure period outcome means | 0.225 (0.007) | 0.061 (0.002) | 0.004 (0.002) | 0.068 (0.008) | 0.153 (0.007) | 0.536 (0.011) | 0.017 (0.007) | 0.236 (0.010) |

N = 7120 persons (49,840 observations).
* p < 0.1, " p < 0.05, and *** p < 0.001.
Each column represents separate regressions. Regressions include individual fixed effects, year fixed effects, and adjusted household monthly expenditure. Standard errors, in parentheses, are clustered at the individual level.

**Table 5** Social interactions and behavioral responses to the 2015 MERS epidemic: Triple differences estimation.

| Social interaction | Smoking behavior | Drinking behavior |
|---|---|---|
| | Current smoking | Attempt to quit smoking | Smoking >2 packs daily | Smoking 1–2 packs daily | Smoking <1 pack daily | Current drinking | Attempt to stop drinking | Drinking at least once a week |
| **Panel A. Movers vs. non-movers** | | | | | | | | |
| Exposed?’Post | 0.003 (0.005) | 0.006** (0.004) | 0.0002 (0.001) | –0.015*** (0.005) | 0.017*** (0.006) | –0.001 (0.007) | 0.007*** (0.002) | 0.002 (0.007) |
| Exposed’Post & Longtime residents (≥5 years) | –0.007 (0.014) | 0.017** (0.008) | 0.0001 (0.001) | –0.005** (0.002) | 0.004** (0.002) | 0.003 (0.006) | 0.011** (0.005) | 0.001 (0.002) |
| **Panel B. Satisfaction of social relationships** | | | | | | | | |
| Exposed’Post | 0.003 (0.005) | 0.007* (0.004) | 0.0005 (0.001) | –0.010 (0.006) | 0.013** (0.006) | –0.001 (0.006) | 0.004** (0.002) | –0.002 (0.007) |
| Exposed’Post & Satisfied | 0.002 (0.008) | 0.016** (0.007) | 0.0002 (0.001) | –0.004* (0.002) | 0.003 (0.002) | –0.017* (0.010) | 0.010** (0.004) | 0.002 (0.002) |
| Pre-exposure period outcome means | 0.225 (0.008) | 0.061 (0.007) | 0.004 (0.001) | 0.068 (0.002) | 0.153 (0.002) | 0.536 (0.009) | 0.017 (0.004) | 0.236 (0.002) |

N = 9327 persons (65,289 observations).
* p < 0.1, " p < 0.05, and *** p < 0.001.
Each column represents separate regressions. Regressions include individual fixed effects, year fixed effects, and adjusted household monthly expenditure. Standard errors, in parentheses, are clustered at the individual level.
significantly higher increase in a quitting attempt among longtime residents (+2.6 percentage points) than movers (+0.9 percentage point). Exposure to the epidemic among non-movers also led to a shift of current smokers from consuming more than a pack (-0.5 percentage point) toward less than a pack a day (0.4 percentage point). In addition, persons who reported having satisfactory social relationships were significantly more likely to attempt to stop smoking or drinking (Panel B). These results imply that more socialized persons tend to have better opportunities to learn from peers about reliable information on local risks of the epidemic.

4. Discussion and conclusions

This study uses individual longitudinal data and finds sizable protective effects of exposure to the 2015 MERS epidemic in Korea on risky behaviors. Results provide evidence that individuals facing higher infection risks invest more in health capital by reducing consumption of harmful products such as tobacco and alcohol. In particular, the effect size (an increase in trying to quit smoking by 4.4 percentage points) was meaningful given the result of a recent study of banning smoking at outdoor spaces that the policy led to a 5- percentage point increase in quitting attempts (Ko, 2020). This result is broadly in line with Di Novi’s (2010) finding that pollution affects individual health-improving lifestyle choices. In addition, the results of this study add evidence to literature finding anecdotal evidence that individuals actively react to external shocks in the short run to mitigate the long-term negative impacts (Frankenberg, Thomas, 2017). Behavioral responses found in this study, however, may not be generalized to other external shocks. For instance, Hanaoka et al.’s (2015) study on the Japanese earthquake, which caused substantial psychosocial stress due to massive casualties (around 16,000 deaths) and loss of property and social capital, found that individuals living in the worst-hit regions were more likely to engage in risky behaviors, suggesting that the nature of the shocks and the extent of devastated impacts on social networks are keys to understanding the differential behavioral responses.

Results of this study indicating a potential role of social connectedness in differential behavioral responses are consistent with literature. A study of the negative impacts on healthcare utilization of the SARS epidemic in Taiwan found that social interactions magnify the personal responses to the shock (Bennet et al., 2015). A review of evidence of socioeconomic disparities in risky behavior pointed out that less-educated persons are less likely to be motivated to adopt healthy behavior because they are exposed less often to information on harms of risky behaviors (Pampel et al., 2010). In addition, peer influence is often cited as a source of disparities in engaging in healthy behavior (Pampel et al., 2010). Given that the scarcity of information about the shocks would keep individuals from optimally deciding how much and which kind of protective actions (avoidance or investing in healthy behaviors) will be taken when external shocks occur (Bennet et al., 2015), findings of this study lend support to the government’s active role in effective risk communication.

Future studies on the consequences on essential health services utilization, health status, and morbidity are warranted. As other factors, such as time preferences, risk aversion, or expected lifetime utility, may also affect risky behaviors (Bennet et al., 2015; Hanaoka et al., 2015), the underlying mechanism of the findings of this study should be further investigated.

Author Statement

There are no funding sources and conflicts of interest to declare. This study was exempted from ethical review of the institutional review board at the University of Illinois at Chicago given that the deidentified secondary data are publicly available online (https://www.kli.re.kr/klips_eng/index.do). I am grateful to Anthony Lo Sasso, Darren Lubotsky, Nicholas Tilipman, Lisa Powell, Emily Steidl, Sherry Glied, and Hye Myung Lee for valuable comments.

Appendix A. Supplementary data

Supplementary material related to this article, in the online version, at doi:https://doi.org/10.1016/j.ehbe.2020.100965.

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