Effect of Social Distancing on Injury Incidence during the COVID-19 Pandemic: An Interrupted Time Series Analysis

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Title Page

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Running title

Social Distancing and Injury during COVID-19 Pandemic

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Data availability

The data of this study were obtained from the National Emergency Medical Center under the Ministry of Health and Welfare in Korea but restrictions apply to the availability of these data and so are not publicly available.

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Keywords: Social distancing; Interrupted time series analysis; Injury; COVID-19

ABSTRACT

Objectives

To evaluate the effects of the social distancing program on the incidence and characteristics of injuries during the COVID-19 pandemic.

Design & setting

A cross-sectional study using the National Emergency Department Information System (NEDIS) database.

Participants

Injured patients who visited all 402 EDs between February 29 and May 29, 2020 (after-distancing) and the corresponding period in 2019 (before-distancing) to control for seasonal influences.

Outcome measures

The study outcome was the incidence of injury. Using the interrupted time series analyses models, we analyzed weekly trends of study outcomes in both periods (before- and after-distancing), the step change (effects of the intervention), and the slope change over two periods (changes in the effect of the intervention over time).

Results

The incidence rates of injury per 100,000 person-days were 11.2 in the before-distancing and 8.6 in the after-distancing periods. In the after-distancing period, the incidence rate of injury decreased (step change -3.23 (-4.34 to -2.12) per 100,000 person-days compared to the before-distancing period, while the slope change (95% CI) increased to 0.10 (0.04 to 0.24). The incidence rate ratios (IRRs) (95% CIs) of all injuries and intentional injury of the after-distancing period were 0.67 (0.60-0.75) and 1.28 (1.18-1.40), compared to the before-distancing period.

Conclusions

The incidence of injuries after the implementation of the social distancing program decrease compared to the same period of one year prior. However, there was a gradual decline in the extent of the incidence decrease after implementing the intervention.

Strengths and Limitations

- Social distancing program to reduce face-to-face contact during the COVID-19 outbreak has dramatically changed people's behavior to life.
- Several studies have reported how implementing the social distancing program in the pandemic indirectly changed the incidence and characteristics of injured patients, however, a few studies have considered time-series changes reflecting the compliance of the policy enforcement at the national level.
- After enforcement of the social distancing program, the incidence rate of injury decreased compared to the same period one year prior.
- However, there was a gradual decline in the extent of the incidence decrease after the implementation of the intervention.
- By characteristics of injury, the proportions of intentional injury and injury in the home increased. In contrast, the proportions of motor vehicle injuries and injuries occurring in the distancing-target area decreased.

INTRODUCTION

The coronavirus disease 2019 (COVID-19) outbreak is a public health crisis worldwide. Several countries have implemented strategies to prevent person-to-person transmission of the virus and reduce the burden of the pandemic, including social or physical distancing, closure of schools and workplaces, transportation restrictions, or lockdown (1, 2). Social and physical distancing programs were among the most effective health policies during the COVID-19 period, particularly useful in environments where community transmission has occurred (3, 4).

The COVID-19 outbreak and the government's policies have changed people's behavior from that before the pandemic. The fear and anxiety of contracting viral infections lead to voluntary changes in people's behavior (5-7), and government policies to control outbreaks have significantly altered citizens' behavior (8, 9). Therefore, the social distancing program has reduced population density in various places (3, 4).

The incidence and characteristics of injury could have been affected by changes in the surrounding environment and people's behavior (10). It is well known that self-harm and interpersonal violence increase in stressful situations such as wars and disasters (11). Over half of all injuries occur at home, and it is the most common place for violence in stressful situations (11, 12). Additionally, the characteristics of injuries are also affected by the population density of the place. Motor vehicle collisions are most affected by vehicle volume on the road (13, 14).

Social distancing program to reduce face-to-face contact during the COVID-19 outbreak has dramatically changed people's behavior to life. Several studies have reported how implementing the social distancing program in the pandemic indirectly changed the incidence and characteristics of injured patients (15-17). However, a few studies have considered time-series changes reflecting the compliance of the policy enforcement at the national level.

We hypothesized that the incidence of injuries after implementing the social distancing program related to the COVID-19 pandemic would decrease compared to before the intervention. The magnitude of the effects of changing injury incidence by reducing interpersonal contact would continue over time after policy enforcement. It was also hypothesized that the effects of the intervention would differ by the characteristics of injury, such as intentionality, mechanism of injury, and place of injury. This study's objective was to evaluate the effects of the social distancing program on the incidence and characteristics of injuries during the COVID-19 pandemic and to test changes in the effects of the intervention over time after the implementation using the time-series analyses.

METHODS

Study design and data source

This is a cross-sectional study using the national emergency medical service (EMS) run-sheets data and the National Emergency Department Information System (NEDIS) database.

The EMS run-sheets are recorded by EMS providers at the scene and collected and operated by EMS headquarters in each province. EMS run-sheets include information about patient demographics and prehospital information for all patients who visited the emergency department (ED) using the EMS.

The NEDIS is a nation-wide database operated by the National Emergency Medical Center under the Ministry of Health and Welfare since 2003. NEDIS includes demographic and clinical information for all patients who have visited ED across the country; demographics (such as gender, age, and insurance), symptoms (chief complaints and reason of visit), prehospital (EMS use and prehospital care), and ED (vital sign, emergency procedures, diagnosis codes based on the International Classification of Disease 10th Edition-based (ICD-10), disposition, and final clinical outcomes) information. All patient-related information is automatically transferred from each hospital to the central government server. The data processing system filters inaccurate data. The health authorities maintain a system of assessment of accuracy and report the results annually to the Ministry of Health and Welfare.

Study setting

The EMS system in Korea is a government-based public system operated by the National Fire Agency. EMS covers approximately 50 million populations and provides prehospital care and ambulance services at approximately 1,400 ambulance stations nationwide in 17 provinces.

The Ministry of Health and Welfare designed three levels of ED, depending on the availability of human resources, facilities, and equipment. Currently, 38 regional EDs (Level I), 125 local EDs (Level II), and 239 emergency facilities (Level III) are providing care across the country. Level I and Level II EDs provide the highest emergency care services.

In Korea, the first COVID-19 case was confirmed on January 20, 2020, and the first community-based infection occurred on February 18, 2020. The national crisis waning level had been raised to the highest level to prevent the spread of COVID-19 infection nationwide on February 23, 2020. The social distancing program was implemented on February 29, when the spread of COVID-19 patients rose rapidly.

Study population

The study population was injured patients who visited all 402 EDs between February 29 and May 29, 2020 (after-distancing period) and the corresponding period in 2019 (between March 2 and May 31, 2019, before-distancing period) to control for seasonal influences on injury incidence. The injured patient was defined as patients who visited ED with injury and had S and T code of ICD-10 code. The study period was 13 weeks from February 29, 2020, when the social distancing program began in Korea. The same period one-year prior was included in the study period for comparison of study outcomes.

Study outcomes and variables

The primary outcome was the incidence of injury. The secondary outcomes were proportions of in-hospital mortality, clinically severe injury, and specified injury (intentionality, mechanism, and place of injury).

The clinically severe injury was defined as a patient with in-hospital mortality, patients admitted to the intensive care unit (ICU), and patients classified as severe in the initial triage.

The following demographic and clinical variables were collected from NEDIS: age, gender, mode of visit (EMS use or not), triage, intentionality, mechanism, diagnoses, and disposition after ED visit. Intentional injury consists of self-harm, suicide, violence, and murder. The injury mechanism was divided into six groups: motor vehicle collision, fall, slip down, blunt, penetrating, and others. The information on intentionality and mechanism of injury were collected only from the Level I and Level II EDs.

The information on the place where the injury occurred was captured on EMS run-sheets. There was no available information on place of injury for patients who visited EDs without EMS use. The places of injury were categorized into five groups: home, traffic area, distancing-target area, non-distancing area, and others. A distancing-target area is where social distancing is possible, such as schools, educational facilities, sports facilities, and entertainment. The non-distancing areas were residential facilities, medical-related facilities, factories, industries, construction facilities, agriculture, primary industrial sites, seas, rivers, mountains, and rice fields.

Statistical analysis

Descriptive statistics for categorical variables are presented as frequency distributions and percentages. For the primary study outcomes, the incidence of injury per 100,000 person-days was calculated using the 2019 mid-year population of Census data. For the secondary study outcomes, the proportions of in-hospital mortality and clinically severe injury were calculated using the number of all injured patients as the denominator. The proportions by intentionality and mechanism of injury were calculated using the number of injured patients who visited Level I and Level II EDs as the denominator, and the proportions by the place of injury were using the number of injured patients with EMS use.

We conducted the interrupted time-series analysis to evaluate the effects of the social distancing program on the incidence of study outcomes. Using two models of the generalized least squares model and the segmented Poisson regression model, we analyzed weekly trends of outcomes in both periods (before- and after-distancing), estimated effect size (the step-change over two periods; effects of the intervention) considering the underlying trends, and tested the interaction effects of both periods and weekly trends (the slope change over two periods; changes in the effect of the intervention over time) (18). We applied a corARMA model to correct for autocorrelation for the generalized least squares model (19). Residual autocorrelation can lead to the violation of regression assumption due to the time sequencing of data points used for time series analysis (20). We calculated beta coefficients with 95% confidence intervals (CIs) based on differences of study outcomes between two periods using the generalized least squares model, and the incidence rate ratios (IRRs) with 95% CIs based on ratios of study outcomes of two periods using the segmented Poisson regression model, adjusting for week and with an interaction term (both periods × week).

Data were analyzed using R software (version 4.0.0, R Foundation for Statistical Computing, Vienna, Austria). For statistical significance, a two-sided significance level of 0.05 was used.

Ethics statements

The study protocol was reviewed and approved by the Institutional Review Board of National Medical Center (approval No. NMC-2007-026), and the requirement for informed consent was waived due to the retrospective nature of this study.

Patient and public involvement statement

The National Emergency Medical Center under the Ministry of Health and Welfare was involved in the design and conduct of this research, but it was not possible to involve patients in our research.

RESULTS

Demographic findings

The total number of injured patients was 522,175 in the before-distancing and 402,777 in the after-distancing periods. The incidence rates of injury per 100,000 person-days were 11.2 in the before-distancing and 8.6 in the after-distancing periods. Proportions of in-hospital mortality were 0.3% and 0.4% in the before- and after-distancing periods (p-value 0.10) and clinically severe injury were 3.4% and 3.8%, respectively (p-value <0.01) (Table 1).

Table 1. Characteristics of the study population according to the social distancing intervention

	Total N (%)	Before-distancing N (%)	After-distancing N (%)	p-value
Total, ED visits	924,952	522,175	402,777	
Incidence rate, per 100,000 person-days	9.9	11.2	8.6	
Age, year				<0.01
0~19	225,579 (24.4)	140,377 (26.9)	85,202 (21.2)	
20~39	230,762 (25.0)	126,502 (24.2)	104,260 (25.9)	
40~59	257,957 (27.9)	141,925 (27.2)	116,032 (28.8)	
60~79	164,406 (17.8)	88,643 (17.0)	75,763 (18.8)	
80~120	46,248 (5.0)	24,728 (4.7)	21,520 (5.3)	
Gender, male	544,049 (58.8)	306,379 (58.7)	237,670 (59.0)	<0.01
EMS use	219,741 (23.8)	119,829 (22.9)	99,912 (24.8)	<0.01
Place of injury				<0.01
Home	69,889 (31.8)	35,687 (29.8)	34,202 (34.2)	
Traffic area	82,394 (37.5)	45,807 (38.2)	36,587 (36.6)	
Distancing-target	10,021 (4.6)	7,082 (5.9)	2,939 (2.9)	
Non-distancing	29,179 (13.3)	15,687 (13.1)	13,492 (13.5)	
Others	28,258 (12.9)	15,566 (13.0)	12,692 (12.7)	
Initial triage, severe	23,787 (2.6)	12,812 (2.5)	10,975 (2.7)	0.01
Level of ED, I and II	638,332 (69.0)	368,949 (70.7)	269,383 (66.9)	<0.01
ED disposition				<0.01
Discharge	767,366 (83.0)	436,118 (83.5)	331,248 (82.2)	
Ward admission	122,500 (13.2)	66,676 (12.8)	55,824 (13.9)	
Intensive care units	16,279 (1.8)	8,631 (1.7)	7,648 (1.9)	
Transfer out	14,275 (1.5)	8,265 (1.6)	6,010 (1.5)	
Death	1,384 (0.1)	698 (0.1)	686 (0.2)	
Clinical outcomes				
Clinically severe injury	33,138 (3.6)	17,746 (3.4)	15,392 (3.8)	<0.01
In-hospital mortality	3,448 (0.4)	1,819 (0.3)	1,629 (0.4)	0.10

EMS, emergency medical services; ED, emergency department

Among the patients who visited Level I and Level II EDs, the proportions of intentional injury were 5.4% and 6.0% in the before- and after-distancing periods, respectively (p-value <0.01). By the mechanism of injury, motor vehicle collisions were 17.6% and 17.2% in the before- and after-distancing periods, respectively (p-value <0.01) (Table 2).

Table 2. Characteristics of the study population according to the social distancing intervention among patients visiting Level I and Level II EDs

	Total	Before-distancing	After-distancing	p-value
	N (%)	N (%)	N (%)	
Total, Level I and Level II EDs	638,332	368,949	269,383	
Age, year				<0.01
0~19	172,942 (27.1)	108,252 (29.3)	64,690 (24.0)	
20~39	156,645 (24.5)	87,872 (23.8)	68,773 (25.5)	
40~59	168,144 (26.3)	95,243 (25.8)	72,901 (27.1)	
60~79	108,882 (17.1)	60,232 (16.3)	48,650 (18.1)	
80~120	31,719 (5.0)	17,350 (4.7)	14,369 (5.3)	
Gender, male	373,115 (58.5)	215,929 (58.5)	157,186 (58.4)	0.16
Intentional injury	35,956 (5.7)	19,815 (5.4)	16,141 (6.1)	<0.01
Mechanism of injury				<0.01
Motor vehicle collision	111,295 (17.4)	64,998 (17.6)	46,297 (17.2)	
Fall	50,242 (7.9)	28,349 (7.7)	21,893 (8.1)	
Slip down	129,928 (20.4)	74,177 (20.1)	55,751 (20.7)	
Blunt	125,925 (19.7)	75,863 (20.6)	50,062 (18.6)	
Penetrating	89,762 (14.1)	48,711 (13.2)	41,051 (15.2)	
Others	131,180 (20.6)	76,851 (20.8)	54,329 (20.2)	
EMS use	164,963 (25.9)	91,331 (24.8)	73,632 (27.3)	<0.01
Initial triage, severe	20,863 (3.4)	11,160 (3.2)	9,703 (3.6)	<0.01
ED disposition				<0.01
Discharge	533,324 (83.9)	310,962 (84.6)	222,362 (82.9)	
Ward admission	76,879 (12.1)	42,325 (11.5)	34,554 (12.9)	
Intensive care units	14,648 (2.3)	7,767 (2.1)	6,881 (2.6)	
Transfer out	9,709 (1.5)	5,799 (1.6)	3,910 (1.5)	
Death	1,222 (0.2)	622 (0.2)	600 (0.2)	
Clinical outcomes				
Clinically severe injury	28,717 (29.3)	15318 (29.0)	13,399 (29.6)	0.03
In-hospital mortality	3,026 (3.3)	1,609 (3.2)	1,417 (3.4)	0.08

EMS, emergency medical services; ED, emergency department

The weekly incidence rate of injury and proportions of study outcomes for 13 weeks of the before-distancing (in 2019) and13 weeks of the after-distancing (in 2020) periods are shown in Figure 1.

Effects of the social distancing program on injury

We conducted the interrupted time series analysis to evaluate the effects of the social distancing program on the incidence and characteristics of injuries during the COVID-19 pandemic. In the generalized least squares models, the estimate (95% CI) of step change for the injury incidence rate per 100,000 person-days was -3.23 (-4.34 to -2.12) in the after-distancing period compared to the before-distancing, while the estimate (95% CI) of slope change was positive value as 0.10 (0.04 to 0.24). Regarding the proportion of in-hospital mortality, the step change was 0.13 (0.10 to 0.17), and the slope change was -0.01 (-0.02 to -0.01). For intentional injury, the step change was 1.52 (1.28 to 1.75). By place of injury, the step changes were -2.75 (-2.90 to -2.60) for the distancing-target area and 0.77 (0.50 to 1.04) for the non-distancing area (Table 3).

Table 3. Interrupted time series analysis with generalized least squares models for study outcomes of the social distancing intervention

	Step change			Slope change		
	Estimate	95% CI		Estimate	95% CI	
Incidence, per 100,000 person-days						
All injury	-3.23	-4.34	-2.12	0.10	0.04	0.24
Proportions						
In-hospital mortality	0.13	0.10	0.17	-0.01	-0.02	-0.01
Clinically severe injury	1.03	0.81	1.25	-0.08	-0.11	-0.05
Intentional injury	1.52	1.28	1.75	-0.13	-0.16	-0.09
Mechanism						
Motor vehicle collision	-1.39	-1.73	-1.05	0.12	0.08	0.17
Fall	0.89	0.53	1.24	-0.06	-0.10	-0.01
Slip down	0.29	-0.48	1.06	0.04	-0.05	0.14
Blunt	-2.12	-2.31	-1.92	0.03	0.00	0.05
Penetrating	2.70	1.89	3.51	-0.09	-0.19	0.01
Place of injury						
Home	5.56	3.21	7.91	-0.14	-0.44	0.15
Traffic area	-2.14	-3.36	-0.92	0.07	-0.08	0.23
Distancing target	-2.75	-2.90	-2.60	-0.04	-0.06	-0.02
Non-distancing target	0.77	0.50	1.04	-0.06	-0.10	0.03

CI, confidence intervals
Incidence of injury per 100,000 person-days was calculated using the 2019 mid-year population of Census data;
Proportions of in-hospital mortality and clinically severe injury were for all injured patients;
Proportions by intentionality and mechanism of injury were for injured patients who visited Level I and Level II EDs;
Proportions by the place of injury were considered for injured patients with EMS use

In the segmented Poisson regression analyses, the IRR (95% CI) of all injuries of the after-distancing compared to the before-distancing period was 0.67 (0.61-0.74). Compared to before-distancing, the IRRs (95% CIs) of the after-distancing period were 1.38 (1.15-1.65) for the in-hospital mortality and 1.28 (1.18-1.40) for the intentional injury. By place of injury, the IRRs (95% CIs) were 0.44 (0.39-0.49) for the distancing-target area and 1.05 (0.97-1.14) for the non-distancing area (Table 4).

Table 4. Interrupted time series analysis with segmented Poisson regression models for study outcomes of the social distancing intervention

	Incidence rate ratio	95% CI	
Total			
All injury	0.67	0.60	0.75
In-hospital mortality	1.38	1.15	1.65
Clinically severe injury	1.24	1.12	1.38
Level I and Level II EDs			
Intentional injury	1.28	1.18	1.40
Motor vehicle collision	0.92	0.88	0.97
EMS use			
Home	1.18	1.10	1.26
Distancing target area	0.44	0.39	0.49
Non- distancing target	1.05	0.97	1.14

CI, confidence intervals
Incidence of all injury was calculated using the 2019 mid-year population of Census data;
Proportions of in-hospital mortality and clinically severe injury were for all injured patients;
Proportions by intentionality and mechanism of injury were for injured patients who visited Level I and Level II EDs;
Proportions by the place of injury were considered for injured patients with EMS use

DISCUSSION

This study evaluated the effects of the social distancing program on the incidence and characteristics of injuries during the COVID-19 pandemic using a nationwide emergency patient database. After enforcement of the social distancing program, the incidence rate of injury decreased (step change: estimate, -3.23 (-4.34 to -2.12) per 100,000 person-days and IRR, 0.67 (0.61-0.74)) compared to the same period one year prior. However, there was a gradual decline in the extent of the incidence decrease after the implementation of the intervention (slope change: estimate, 0.10 (0.04 to 0.24)). By characteristics of injury, the proportions of intentional injury and injury in the home increased. In contrast, the proportions of motor vehicle injuries and injuries occurring in the distancing-target area decreased. Our study has identified how the social distancing program during the COVID-19 pandemic changes the incidence and characteristics of injured patients secondarily by reducing interpersonal contact, and how the effects of the intervention change over time. These results can be used indirectly in selecting a target population that can highlight the effectiveness of the intervention program considering the decline in compliance over time after policy enforcement, and developing a new evidence-based intervention program promptly.

The social distancing program during the COVID-19 outbreak has dramatically changed people's behavior towards life. The program limits people's outdoor activities, reduces population density in various places, and increases the time spent at home. The incidence of all injured patients decreased significantly during the period of enforcement of the program compared to the same period one year prior. These results were consistent in several studies (15-17). These results might indirectly demonstrate the effects of social distancing policy enforcement. However, the magnitude of the decrease in the incidence of injury declined in this study. In several societies, social distancing inertia has been observed. Stay-at-home broke, and movement began to increase from only two weeks after the declaration of disaster in the United States (21). These quarantine fatigue might be caused by warmer weather, tiredness of staying at home, and unaffordability of living while unemployed. Psychological fatigue with social distancing may be a major challenge for curbing a pandemic.

The proportion of in-hospital mortality and clinically severe injury increased during the period of the social distancing program. During the COVID-19 pandemic, the number of patients visiting EDs with medical illnesses decreased, but mortality rates increased in patients with specific diseases (22, 23). The patients with acute emergency symptoms would be hesitant to visit the ED due to the risk and fear of transmission of COVID-19 (24, 25), which may have decreased the number of patients who visits ED with not severe injuries and increased the proportion of in-hospital mortality and clinically severe injury. By the characteristics of injury, the proportion of intentional injury increased during this study's social distancing periods. In the previous report, domestic violence increased by 25% during the social distancing period in the UK (26), and violence and gunshot injuries increased in Philadelphia (27). In terms of the mechanism of injury, motor vehicle collisions declined in most countries due to reduced traffic during this period. California reported a reduction in traffic by 60%, and motor vehicle injuries have reduced by half (28). In Spain, traffic fell by 62.9%, and motor vehicle collisions decreased by 74.3% (29). In terms of place of injury, as the time spent at home increased, the proportion of injuries occurring in the home increased, and the risk of domestic violence increased due to stress in the family(16, 27, 30). In this study, non-distancing target areas were not affected by social distancing, while the proportion of injury occurring in the distancing target areas reduced to less than half. Additionally, the slope change was significantly decreased with the negative step change. This indirectly demonstrates that social distancing policies would have a powerful effect on changing people's behavior, reducing injuries occurring in target places.

This study has several limitations. First, this study is not a randomized controlled study of the social distancing program. Although we tried to reduce the bias by using a time series analysis, potential biases could have affected our results. Second, the information on the intentionality and mechanism of injury are input only in the Level I and Level II EDs. The information on the place of injury is collected only in patients with EMS use. We calculated the proportions of specific injury using the injured patients with available information as denominators. Therefore, it can act as a potential bias. Third, the population in this study were patients injured between February 29 and May 29, 2019, and 2020. Considering the seasonal variations of the incidence of injury, we analyzed the data from discontinued periods rather than consecutive periods. Using data from January 4, 2019, to May 30, 2020, a plot of the interrupted time-series analyses for the main study outcomes are illustrated in the supplementary figure. Similar results were seen in the data from consecutive periods from 2019 to 2020.

The incidence of injuries after the implementation of the social distancing program decrease compared to before the intervention. However, the extent of the incidence decrease declined over time after implementing the intervention. These results might indirectly demonstrate the effects of social distancing policy enforcement on changes in people's behavior. There is a need to develop tailored intervention programs to reduce the public health burden, including communicable disease and strategies to maintain compliance with policy enforcement.

Figure legend

Figure 1. The weekly incidence rate of injury and proportions of study outcomes for the before-distancing (13 weeks in 2019) and the after-distancing (13 weeks in 2020) periods

Incidence of injury per 100,000 person-days was calculated using the 2019 mid-year population of Census data.

Proportions of in-hospital mortality and clinically severe injury were for all injured patients.

Proportions by intentionality and mechanism of injury were for injured patients who visited Level I and Level II EDs.

Proportions by the place of injury were considered for injured patients with EMS use

The period after social distancing has occurred grayed out.

Supplementary figure. The weekly incidence rate of injury and proportions of study outcomes from January 4, 2019, to May 30, 2020.

The period after social distancing has occurred grayed out. Straight lines indicate the best-fit regression lines for the before and after implementation of the social distancing program

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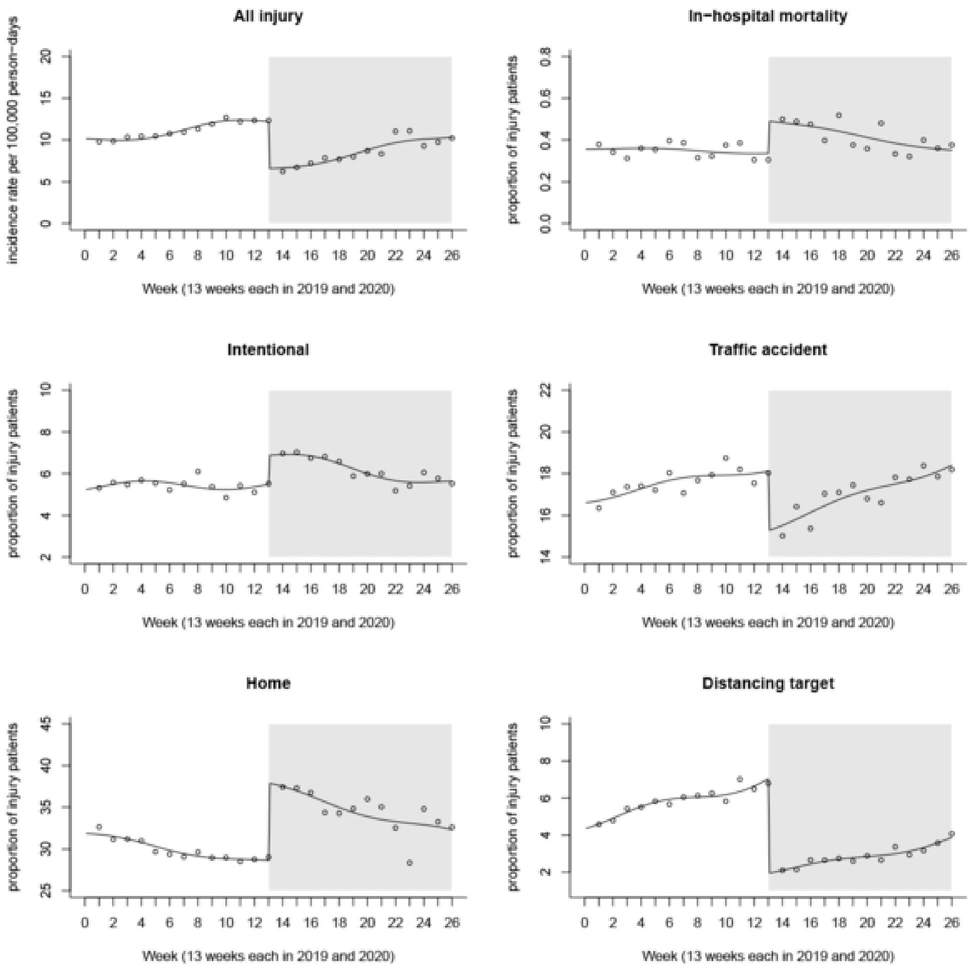

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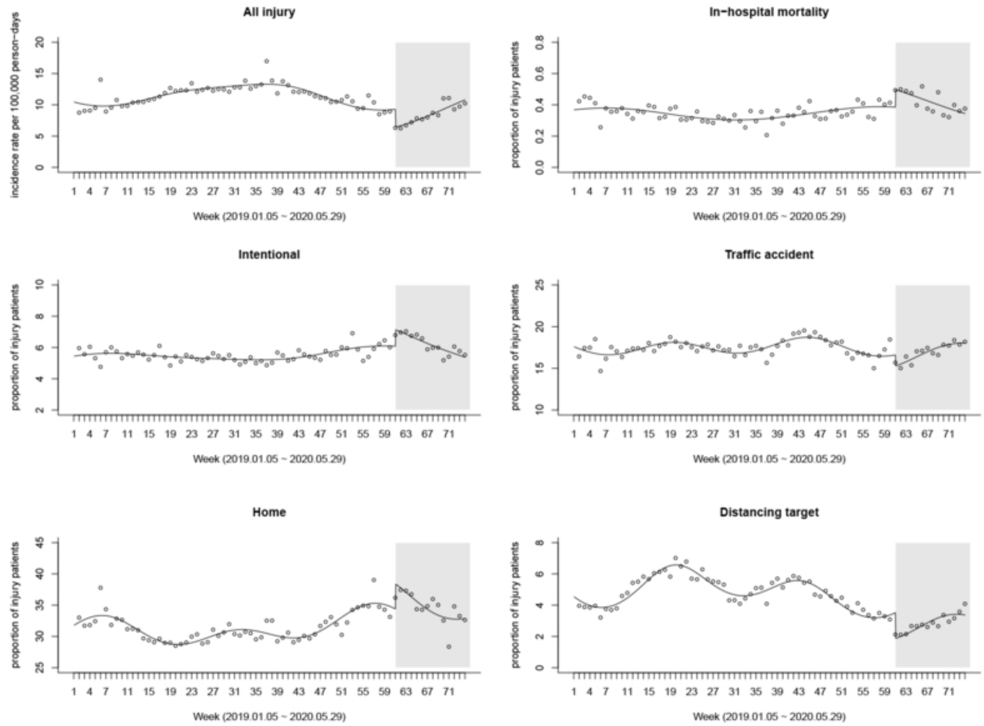

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	4
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	9
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*8-10*
Bias	9	Describe any efforts to address potential sources of bias	10
Study size	10	Explain how the study size was arrived at	10
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9,10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12
		(b) Give reasons for non-participation at each stage	12
		(c) Consider use of a flow diagram	12
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-15

		(*b*) Report category boundaries when continuous variables were categorized	12-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	12-15
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17
Generalisability	21	Discuss the generalisability (external validity) of the study results	17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	N/A

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Effect of Social Distancing on Injury Incidence during the COVID-19 Pandemic: An Interrupted Time Series Analysis

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Title Page

Title

Effect of Social Distancing on Injury Incidence during the COVID-19 Pandemic: An Interrupted Time Series Analysis

Running title

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Data availability

The data of this study were obtained from the National Emergency Medical Center under the Ministry of Health and Welfare in Korea; however, restrictions apply to the availability of these data, and thus, they are not publicly available.

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Keywords: Social distancing; Interrupted time series analysis; Injury; COVID-19

ABSTRACT

Objectives

To evaluate the effects of social distancing on the incidence and characteristics of injuries during the COVID-19 pandemic.

Design & setting

This cross-sectional study used the National Emergency Department Information System (NEDIS) database.

Participants

Injured patients who visited all 402 emergency departments (EDs) between February 29 and May 29, 2020 (after-distancing), and in the corresponding period in 2019 (before-distancing) to control for seasonal influences.

Outcome measures

The study outcome was the incidence of injury. Using the interrupted time series analysis models, we analyzed weekly trends of study outcomes in both periods (before- and after-distancing), the step change (the effect of intervention), and the slope change over two periods (the change in the effect over time).

Results

The incidence rates of injury per 100,000 person-days were 11.2 and 8.6 in the before- and after-distancing periods, respectively. In the after-distancing period, the incidence rate of injury decreased (step change -3.23 (95% confidence interval (CI), -4.34 to -2.12) per 100,000 person-days) compared to the before-distancing period, while the slope change was 0.10 (95% CI, 0.04 to 0.24). The incidence rate ratios of all injuries and intentional injuries for the after-distancing period were 0.67 (95% CI, 0.60 to 0.75) and 1.28 (95% CI, 1.18 to 1.40), respectively, compared to the before-distancing period.

Conclusions

Fewer injuries occurred after the implementation of social distancing program compared to the same period in the previous year. However, this effect gradually decreased post-implementation.

Strengths and Limitations

- Social distancing measures to reduce face-to-face contact during the COVID-19 outbreak have dramatically changed people's behavior toward life.
- Several studies report how implementing social distancing during the pandemic indirectly changed the incidence and characteristics of injuries in patients; however, very few studies have considered time-series changes reflecting compliance with policy enforcement at the national level.
- We find that after social distancing was implemented, the incidence rate of injury decreased compared to the same period in the previous year.
- However, post-implementation, this effect gradually decreased over time.
- Regarding the characteristics of injury, the proportions of intentional injury and injury at home increased. In contrast, there were fewer road traffic injuries and injuries occurring in locations where social distancing was possible.

INTRODUCTION

Globally, the coronavirus disease 2019 (COVID-19) outbreak has been a major public health crisis. Several countries have implemented strategies to prevent person-to-person transmission of the virus and reduce the burden of the pandemic, including social or physical distancing, closure of schools and workplaces, transportation restrictions, and lockdowns (1, 2). Social and physical distancing restrictions were among the most effective health policies during the pandemic, particularly in environments with community transmission (3, 4).

The COVID-19 outbreak and the government's policies have changed people's behavior compared to the pre-pandemic period. The fear and anxiety of contracting viral infections led to voluntary changes in people's behavior (5-7). Moreover, government policies to control outbreaks have significantly altered citizens' behavior (8, 9). Importantly, social distancing has reduced the population density in various places (3, 4).

The incidence and characteristics of injury may have been also affected by changes in the surrounding environment and people's behavior (10). Self-harm and interpersonal violence are known to increase in stressful situations, such as wars and disasters (11). Over half of all injuries occur at home; it is also the most common place for violence in stressful situations (11, 12). Additionally, the characteristics of injuries are affected by the population density of the place. Road traffic injuries are most affected by the vehicle volume on the road (13, 14).

Social distancing program to reduce face-to-face contact during the COVID-19 outbreak has dramatically changed people's behavior to life. Several studies report how implementing social distancing during the pandemic indirectly changed the incidence and characteristics of injured patients (15-17). However, to the best of our knowledge, few studies have considered time-series changes reflecting compliance with policy enforcement at the national level.

We hypothesized that after implementing COVID-19-related social distancing, the incidence of injuries decreased compared to that before this intervention. The magnitude of this effect would continue over time post-implementation of this intervention. We also hypothesized that the effects of the social distancing would differ according to the characteristics of the injury, such as intentionality, mechanism of injury, and place of injury.

This study seeks to evaluate the effects of social distancing on the incidence and characteristics of injuries during the COVID-19 pandemic. Furthermore, we seek to test the changes in the effects of the intervention over time post-implementation using time-series analysis.

METHODS

Study design and data source

This cross-sectional study used data from the national emergency medical service (EMS) run-sheets and the National Emergency Department Information System (NEDIS) database.

The EMS run-sheets are recorded by EMS providers at the scene, and collected and operated by the EMS headquarters in each province. EMS run-sheets include information about patient demographics and prehospital information for all patients who visited the emergency department (ED) using the EMS. NEDIS is a nationwide database operated by the National Emergency Medical Center under the Ministry of Health and Welfare since 2003. NEDIS includes demographic and clinical information for all patients who have visited EDs across the country, including demographics (such as age, sex, and insurance), symptoms (chief complaints and reason of visit), prehospital (EMS use and prehospital care), and ED (vital signs, emergency procedures, diagnosis codes based on the International Classification of Disease 10th Edition (ICD-10), disposition, and final clinical outcomes). All patient-related information is automatically transferred from each hospital to the central government server. The data-processing system filters inaccurate data. The health authorities maintain a system of assessment of accuracy and report the results annually to the Ministry of Health and Welfare.

Study setting

The EMS system in Korea is a government-based public system operated by the National Fire Agency. EMS covers approximately 50 million population and provides prehospital care and ambulance services at approximately 1,400 ambulance stations nationwide in 17 provinces.

The Ministry of Health and Welfare designed three levels of ED, depending on the availability of human resources, facilities, and equipment. Currently, 38 regional EDs (Level I), 125 local EDs (Level II), and 239 emergency facilities (Level III) provide care across the country. Level I and Level II EDs provide the highest emergency care services.

In Korea, the first COVID-19 case was confirmed on January 20, 2020, while the first community-based infection occurred on February 18, 2020. To prevent the spread of COVID-19, the national crisis warning level was raised to the highest level on February 23, 2020. However, as the number of COVID-19 patients rose rapidly, social distancing was soon implemented on February 29. The social distancing program to reduce the likelihood of transmitting communicable disease consisted of suspending the operation of indoor crowded places (religious, indoor sports facilities, entertainment facilities, etc.), maintaining physical distance of at least 2 meters between individuals in public places, working from home, and closing of the schools.

Study population

The study population included injured patients who visited all 402 EDs between February 29 and May 29, 2020 (after-distancing period), and the corresponding period in 2019 between March 2 and May 31, 2019 (before-distancing period) to control for seasonal influences on injury incidence. Injured patients were defined as patients who visited the ED with injury, and had S and T codes of the ICD-10 code. The study period was 13 weeks from February 29, 2020, when social distancing was implemented in Korea. The same period in the previous year was used for comparison of outcomes.

Study outcomes and variables

The primary outcome was the incidence of the injury. The secondary outcomes were the proportions of in-hospital mortality, clinically severe injury, and specified injury (intentionality, mechanism, and place of injury).

Clinically severe injury was defined as a patient with in-hospital mortality, patients admitted to the intensive care unit (ICU), and patients classified as severe in the initial triage.

The following demographic and clinical variables were collected from NEDIS: age, sex, mode of visit (EMS use or not), triage, intentionality, mechanism, diagnoses, and disposition after ED visit. Intentional injury consists of self-harm, suicide, violence, and murder. The injury mechanism was divided into six groups: road traffic injury, fall, slip down, blunt, penetrating, and others. Information on intentionality and mechanism of injury was collected only from the Level I and Level II EDs.

Information on the place where the injury occurred was captured on EMS run-sheets. There was no available information on the place of injury for patients who visited EDs without EMS use. The places of injury were categorized into five groups: home, traffic area, distancing-target area, non-distancing area, and others. A distancing-target area is where social distancing is possible, such as schools, educational facilities, sports facilities, and entertainment. The non-distancing areas were residential facilities, medical-related facilities, factories, industries, construction facilities, agriculture, primary industrial sites, seas, rivers, mountains, and rice fields.

Statistical analysis

Descriptive statistics for categorical variables are presented as frequency distributions and percentages. For the primary study outcomes, the incidence of injury per 100,000 person-days was calculated using the 2019 mid-year population from Census data. For the secondary study outcomes, the proportions of in-hospital mortality and clinically severe injury were calculated using the number of all injured patients as the denominator. The proportions by intentionality and mechanism of injury were calculated using the number of injured patients who visited Level I and Level II EDs as the denominator. The proportions by the place of injury were calculated using the number of injured patients with EMS use.

An interrupted time-series analysis was conducted to evaluate the effects of social distancing on study outcomes. Using the generalized least squares and the segmented Poisson regression models, we analyzed weekly trends of outcomes in both periods (before- and after-distancing), estimated effect size (the step-change over two periods; the effect of the intervention) considering the underlying trends, and tested the interaction effects of both periods and weekly trends (the slope change over two periods; the change in the effect of the intervention over time) (18). We applied a corARMA model to correct for autocorrelation for the generalized least squares model (19). Residual autocorrelation can lead to the violation of the regression assumption due to the time sequencing of data points used for time series analysis (20). We calculated beta coefficients with 95% confidence intervals (CIs) based on differences in study outcomes between the two periods using the generalized least squares model. We used the segmented Poisson regression model for computing the incidence rate ratios (IRRs) and the hazard ratios (HRs) with 95% CIs based on the ratios of study outcomes of the two periods, adjusting for week and with an interaction term (both periods × week).

Data were analyzed using R software (version 4.0.0, R Foundation for Statistical Computing, Vienna, Austria). Statistical significance was set at a two-sided significance level of 0.05.

Ethics statements

The study protocol was reviewed and approved by the Institutional Review Board of the National Medical Center (approval no. NMC-2007-026). The requirement for informed consent was waived due to the retrospective nature of this study.

Patient and public involvement statement

The National Emergency Medical Center under the Ministry of Health and Welfare was involved in the design and conduct of this research, but it was not possible to involve patients in our research.

RESULTS

Demographic findings

Among the 2,211,180 ED visits in the before-distancing period and 1,485,590 ED visits in the after-distancing period, the total number of injured patients was 522,175 and 402,777 in the before- and after-distancing periods, respectively. The incidence rates of injury per 100,000 person-days were 11.2 and 8.6 in the before- and after-distancing periods, respectively. The proportion of in-hospital mortality was 0.3% and 0.4% in the before- and after-distancing periods (p-value 0.10), respectively, while that of clinically severe injury was 3.4% and 3.8%, respectively (p-value <0.01) (Table 1).

Table 1. Characteristics of the study population according to the social distancing intervention

	Total		Before-distancing		After-distancing		p-value
	Incidence rate	N (%)	Incidence rate	N (%)	Incidence rate	N (%)	
Total injured, ED visits	9.90	924,952	11.18	522,175	8.62	402,777	
Age, year							<0.01
0~19	13.38	225,579 (24.4)	16.65	140,377 (26.9)	10.10	85,202 (21.2)	
20~39	9.12	230,762 (25.0)	10.00	126,502 (24.2)	8.24	104,260 (25.9)	
40~59	8.41	257,957 (27.9)	9.25	141,925 (27.2)	7.57	116,032 (28.8)	
60~79	9.46	164,406 (17.8)	10.20	88,643 (17.0)	8.72	75,763 (18.8)	
80~120	14.36	46,248 (5.0)	15.36	24,728 (4.7)	13.37	21,520 (5.3)	
Sex							<0.01
Male	11.67	544,049 (58.8)	13.15	306,379 (58.7)	10.20	237,670 (59.0)	
Female	8.13	380,903 (51.2)	9.22	215,796 (41.3)	7.05	165,107 (41.0)	
Place of injury							<0.01
Home	0.75	69,889 (31.8)	0.76	35,687 (29.8)	0.73	34,202 (34.2)	
Traffic area	0.88	82,394 (37.5)	0.98	45,807 (38.2)	0.78	36,587 (36.6)	
Distancing-target	0.11	10,021 (4.6)	0.15	7,082 (5.9)	0.06	2,939 (2.9)	
Non-distancing	0.31	29,179 (13.3)	0.34	15,687 (13.1)	0.29	13,492 (13.5)	
Others	0.30	28,258 (12.9)	0.33	15,566 (13.0)	0.27	12,692 (12.7)	
EMS use	2.35	219,741 (23.8)	2.56	119,829 (22.9)	2.14	99,912 (24.8)	<0.01
Initial triage, severe	0.25	23,787 (2.6)	0.27	12,812 (2.5)	0.23	10,975 (2.7)	0.01
Level of ED, I and II	6.83	638,332 (69.0)	7.89	368,949 (70.7)	5.77	269,383 (66.9)	<0.01
ED disposition							<0.01
Discharge	8.21	767,366 (83.0)	9.34	436,118 (83.5)	7.09	331,248 (82.2)	
Ward admission	1.31	122,500 (13.2)	1.43	66,676 (12.8)	1.19	55,824 (13.9)	
Intensive care units	0.17	16,279 (1.8)	0.18	8,631 (1.7)	0.16	7,648 (1.9)	
Transfer out	0.15	14,275 (1.5)	0.18	8,265 (1.6)	0.13	6,010 (1.5)	
Death	0.01	1,384 (0.1)	0.01	698 (0.1)	0.01	686 (0.2)	
Clinical outcomes							
Clinically severe injury	0.35	33,138 (3.6)	0.38	17,746 (3.4)	0.33	15,392 (3.8)	<0.01
In-hospital mortality	0.04	3,448 (0.4)	0.04	1,819 (0.3)	0.03	1,629 (0.4)	0.10

EMS, emergency medical services; ED, emergency department

Incidence rate per 100,000 person-days was calculated using the 2019 mid-year population of Census data

Among the patients who visited Level I and Level II EDs, the proportion of intentional injury was 5.4% and 6.0% in the before- and after-distancing periods, respectively (p-value <0.01). By the mechanism of injury, road traffic injuries were 17.6% and 17.2% in the before- and after-distancing periods, respectively (p-value <0.01) (Table 2 and Supplementary table for patients who visited Level III EDs).

190 Table 2. Characteristics of the study population according to the social distancing intervention among patients visiting Level I and Level II EDs

	Total		Before-distancing		After-distancing		p-value
	Incidence rate	N (%)	Incidence rate	N (%)	Incidence rate	N (%)	
Total, Level I and II EDs	6.83	638,332	7.90	368,949	5.77	269,383	
Age, year							<0.01
0~19	10.25	172,942 (27.1)	12.84	108,252 (29.3)	7.67	64,690 (24.0)	
20~39	6.19	156,645 (24.5)	6.95	87,872 (23.8)	5.44	68,773 (25.5)	
40~59	5.48	168,144 (26.3)	6.21	95,243 (25.8)	4.75	72,901 (27.1)	
60~79	6.26	108,882 (17.1)	6.93	60,232 (16.3)	5.60	48,650 (18.1)	
80~120	9.85	31,719 (5.0)	10.78	17,350 (4.7)	8.92	14,369 (5.3)	
Sex							0.16
Male	8.01	373,115 (58.5)	9.27	215,929 (58.5)	6.74	157,186 (58.4)	
Female	5.66	265,217 (41.5)	6.54	153,020 (41.5)	4.79	112,197 (41.6)	
Intentional injury	0.38	35,956 (5.7)	0.42	19,815 (5.4)	0.35	16,141 (6.1)	<0.01
Mechanism of injury							<0.01
Road traffic injury	1.19	111,295 (17.4)	1.39	64,998 (17.6)	0.99	46,297 (17.2)	
Fall	0.54	50,242 (7.9)	0.61	28,349 (7.7)	0.47	21,893 (8.1)	
Slip down	1.39	129,928 (20.4)	1.59	74,177 (20.1)	1.19	55,751 (20.7)	
Blunt	1.35	125,925 (19.7)	1.62	75,863 (20.6)	1.07	50,062 (18.6)	
Penetrating	0.96	89,762 (14.1)	1.04	48,711 (13.2)	0.88	41,051 (15.2)	
Others	1.40	131,180 (20.6)	1.65	76,851 (20.8)	1.16	54,329 (20.2)	
EMS use	1.77	164,963 (25.9)	1.95	91,331 (24.8)	1.58	73,632 (27.3)	<0.01
Initial triage, severe	0.22	20,863 (3.4)	0.24	11,160 (3.2)	0.21	9,703 (3.6)	<0.01
ED disposition							<0.01
Discharge	5.71	533,324 (83.9)	6.66	310,962 (84.6)	4.76	222,362 (82.9)	
Ward admission	0.82	76,879 (12.1)	0.91	42,325 (11.5)	0.74	34,554 (12.9)	
Intensive care units	0.16	14,648 (2.3)	0.17	7,767 (2.1)	0.15	6,881 (2.6)	
Transfer out	0.10	9,709 (1.5)	0.12	5,799 (1.6)	0.08	3,910 (1.5)	
Death	0.01	1,222 (0.2)	0.01	622 (0.2)	0.01	600 (0.2)	
Clinical outcomes							
Clinically severe injury	0.31	28,717 (29.3)	0.33	15318 (29.0)	0.29	13,399 (29.6)	0.03
In-hospital mortality	0.03	3,026 (3.3)	0.03	1,609 (3.2)	0.03	1,417 (3.4)	0.08

191 EMS, emergency medical services; ED, emergency department

Incidence rate per 100,000 person-days was calculated using the 2019 mid-year population of Census data

The weekly incidence rate of injury and proportions of study outcomes for 13 weeks of the before-distancing (in 2019) and the after-distancing (in 2020) periods are shown in Figure 1.

Effects of the social distancing program on injury

We conducted an interrupted time series analysis to evaluate the effects of social distancing on the incidence and characteristics of injuries during the COVID-19 pandemic. In the generalized least squares models, the estimate of step change for the injury incidence rate per 100,000 person-days was -3.23 (95% CI, -4.34 to -2.12) in the after-distancing period compared to the before-distancing period, while the estimate of slope change was 0.10 (95% CI, 0.04 to 0.24). Regarding the proportion of in-hospital mortality, the step change was 0.13 (95% CI, 0.10 to 0.17), and the slope change was -0.01 (95% CI, -0.02 to -0.01). For intentional injury, the step change was 1.52 (95% CI, 1.28 to 1.75). By place of injury, the step changes were -2.75 (95% CIs, -2.90 to -2.60) for the distancing-target area and 0.77 (95% CI, 0.50 to 1.04) for the non-distancing area (Table 3).

208 Table 3. Interrupted time series analysis with generalized least squares models for study outcomes of
209 the social distancing intervention

	Step change			Slope change		
	Estimate	95% CI		Estimate	95% CI	
Incidence, per 100,000 person-days						
Total population						
All injury	-3.23	-4.34	-2.12	0.10	0.04	0.24
In-hospital mortality	-0.00	-0.01	0.00	-0.00	-0.00	0.00
Clinically severe injury	-0.07	-0.07	-0.06	0.00	-0.00	0.00
Proportions						
All injury						
In-hospital mortality	0.13	0.10	0.17	-0.01	-0.02	-0.01
Clinically severe injury	1.03	0.81	1.25	-0.08	-0.11	-0.05
Level I and Level II EDs						
Intentional injury	1.52	1.28	1.75	-0.13	-0.16	-0.09
Mechanism						
Road traffic injury	-1.39	-1.73	-1.05	0.12	0.08	0.17
Fall	0.89	0.53	1.24	-0.06	-0.10	-0.01
Slip down	0.29	-0.48	1.06	0.04	-0.05	0.14
Blunt	-2.12	-2.31	-1.92	0.03	0.00	0.05
Penetrating	2.70	1.89	3.51	-0.09	-0.19	0.01
EMS use						
Place of injury						
Home	5.56	3.21	7.91	-0.14	-0.44	0.15
Traffic area	-2.14	-3.36	-0.92	0.07	-0.08	0.23
Distancing target	-2.75	-2.90	-2.60	-0.04	-0.06	-0.02
Non-distancing target	0.77	0.50	1.04	-0.06	-0.10	0.03

210 CI, confidence intervals
211 Incidence rate per 100,000 person-days was calculated using the 2019 mid-year population of Census
212 data
213

In the segmented Poisson regression analyses, the IRRs of all injuries and clinically severe injury of the after-distancing compared to the before-distancing period were 0.67 (95% CI, 0.61 to 0.74) and 0.82 (95% CI, 0.78 to 0.87). Compared to before-distancing, the HRs of the after-distancing period were 1.38 (95% CI, 1.15 to 1.65) for the in-hospital mortality and 1.28 (95% CI, 1.18 to 1.40) for the intentional injury. By place of injury, the HRs were 0.44 (95% CI, 0.39 to 0.49) for the distancing-target area and 1.05 (95% CI, 0.97 to 1.14) for the non-distancing area (Table 4).

Table 4. Interrupted time series analysis with segmented Poisson regression models for study outcomes of the social distancing intervention

	Incidence rate ratio	95% CI	
Total population			
All injury	0.67	0.60	0.75
In-hospital mortality	0.91	0.77	1.07
Clinically severe injury	0.82	0.78	0.87
	Hazard ratio	95% CI	
All injury			
In-hospital mortality	1.38	1.15	1.65
Clinically severe injury	1.24	1.12	1.38
Level I and Level II EDs			
Intentional injury	1.28	1.18	1.40
Road traffic injury	0.92	0.88	0.97
EMS use			
Home	1.18	1.10	1.26
Distancing target area	0.44	0.39	0.49
Non- distancing target	1.05	0.97	1.14

CI, confidence intervals
Incidence rate per 100,000 person-days was calculated using the 2019 mid-year population of Census data

DISCUSSION

This study evaluated the effects of social distancing on the incidence and characteristics of injuries during the COVID-19 pandemic using a nationwide emergency patient database. After social distancing was implemented, the incidence rate of injury decreased (step change: estimate, -3.23 (95% CI, -4.34 to -2.12) per 100,000 person-days, and IRR, 0.67 (95% CI, 0.61 to 0.74) compared to the same period in the previous year. However, this effect gradually decreased over time post-implementation (slope change: estimate, 0.10 (95% CI, 0.04 to 0.24)). Regarding the characteristics of the injury, the proportions of intentional injury and injury at home increased. In contrast, there were fewer road traffic injuries and injuries occurring in locations where social distancing is possible. Our study shows how social distancing during the COVID-19 pandemic changed the incidence and characteristics of injured patients secondarily by reducing interpersonal contact, and how the effects of the intervention changed over time. These results can be used indirectly in selecting a target population that can highlight the effectiveness of the intervention, considering the decline in policy compliance over time, and developing a new evidence-based intervention.

Social distancing during the COVID-19 outbreak has dramatically changed people's behavior towards life. It has limited people's outdoor activities, reduced population density in various places, and increased the time spent at home. We found that after the implementation of social distancing, the incidence of all injured patients decreased significantly compared to the same period in the previous year. These results are consistent with several studies (15-17). Notably, our results may indirectly demonstrate the effects of enforcing social distancing. However, the magnitude of the decrease in the incidence of injury was lower in this study. In several societies, social distancing inertia has been observed. For example, in the US, stay-at-home orders were violated and movement began increasing only two weeks after the declaration of disaster (21). This quarantine fatigue may be caused by warmer weather, tiredness from staying at home, and unaffordability of living while unemployed. Importantly, psychological fatigue with social distancing may be a major challenge in curbing pandemics.

Meanwhile, the proportions of in-hospital mortality and clinically severe injury increased in the after-distancing period. During the COVID-19 pandemic, the number of patients visiting EDs with medical illnesses decreased, but mortality rates increased for patients with specific diseases (22, 23). Patients with acute emergency symptoms would hesitate from visiting the ED due to the risk and fear of transmission of COVID-19 (24, 25). This may have decreased the number of patients who visited the ED without severe injuries, and increased the proportions of in-hospital mortality and clinically severe injury.

Regarding the characteristics of injury, the proportion of intentional injury increased in the after-distancing period. Similar trends are observed in other geographies: domestic violence increased by 25% during the social distancing period in the UK (26), while violence and gunshot injuries increased in Philadelphia (27). A high proportion of intentional injuries, such as violence-related injuries, during the period of the social distancing program may lead to increase the in-hospital mortality rate and clinically serious injuries. In terms of the mechanism of injury, road traffic injuries declined in most countries due to reduced traffic after social distancing was implemented. California reported a 60% reduction in traffic, and road traffic injuries were reduced by half (28). In Spain, traffic fell by 62.9%, while road traffic injuries decreased by 74.3% (29). In terms of place of injury, as the time spent at home increased, the proportion of injuries occurring at home increased; moreover, the risk of domestic violence increased due to stress in the family (16, 27, 30). In this study, non-distancing target areas remained unaffected by social distancing, while the proportion of injury occurring in locations where social distancing could be observed was reduced to less than half. Furthermore, the slope change significantly decreased with a negative step change. This indirectly demonstrates that social distancing had a powerful effect on changing people's behavior, reducing injuries.

This study has several limitations. First, this study was not a randomized controlled study of social distancing interventions. Although we tried to reduce the bias by using a time-series analysis, potential biases could have affected our results. Second, information on the intentionality and mechanism of injury is available only at Level I and Level II EDs. Furthermore, information on the location of injury is collected only in patients with EMS use. We calculated the proportions of specific injuries using injured patients with available information as denominators. Therefore, it can act as a potential bias. Third, the population in this study was injured between February 29 and May 29 in both 2019 and 2020. Considering the seasonal variations in the incidence of injury, we analyzed data from discontinued periods rather than consecutive periods. Using data from January 4, 2019, to May 30, 2020, a plot of the interrupted time-series analysis for the main study outcomes is illustrated in the supplementary figure. Similar results were observed in the data from the consecutive periods from 2019 to 2020.

In summary, the incidence of injuries after the implementation of social distancing decreased compared to that before the intervention. However, this effect decreased over time post-implementation. These results may indirectly demonstrate the effects of enforcing social distancing on changes in people's behavior. Importantly, tailored intervention programs are needed to reduce the public health burden, including communicable diseases and strategies to maintain policy compliance.

Figure legend

Figure 1. The weekly incidence rate of injury and proportions of study outcomes for the before-distancing (13 weeks in 2019) and after-distancing (13 weeks in 2020) periods

The incidence of injury per 100,000 person-days was calculated using the 2019 mid-year population from census data.

The proportions of in-hospital mortality and clinically severe injury were for all injured patients.

Proportions by intentionality and mechanism of injury were for injured patients who visited Level I and Level II EDs.

Proportions by the place of injury were considered for injured patients with EMS use.

The period after social distancing is grayed out.

Supplementary figure. The weekly incidence rate of injury and proportions of study outcomes from January 4, 2019, to May 30, 2020.

The period after social distancing is grayed out. Straight lines indicate the best-fit regression lines before and after implementation of social distancing.

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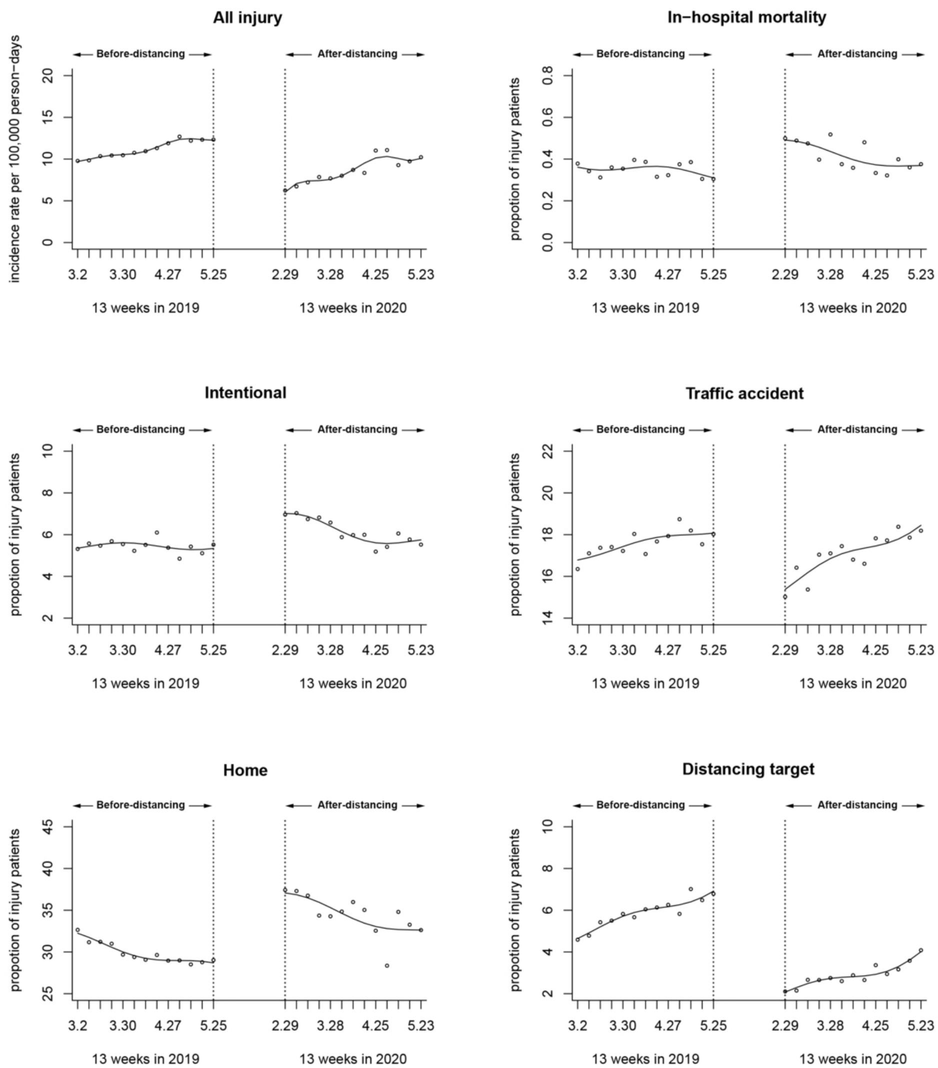

Figure 1

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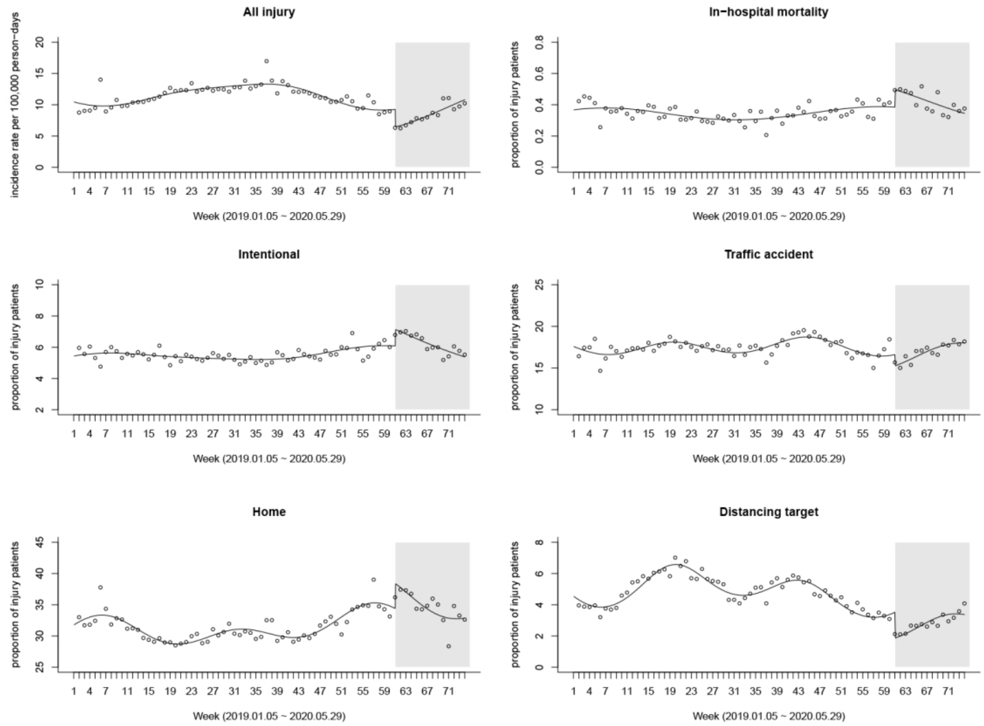
All injury
incidence rate per 100,000 person−days
In−hospital mortality
proportion of injury patients
Intentional
Traffic accident
Home
Distancing target
Week (2019.01.05 ~ 2020.05.29)

Supplementary table. Characteristics of the study population according to the social distancing intervention among patients visiting Level III EDs

	Total		Before-distancing		After-distancing		p-value
	Incidence rate	N (%)	Incidence rate	N (%)	Incidence rate	N (%)	
Total, Level I and II EDs	3.07	286,620	3.28	153,226	2.86	133,394	
Age, year							<0.01
0~19	3.12	52,637 (18.4)	3.81	32,125 (21.0)	2.43	20,512 (15.4)	
20~39	2.93	74,117 (25.9)	3.05	38,630 (25.2)	2.81	35,487 (26.6)	
40~59	2.93	89,813 (31.3)	3.04	46,682 (30.5)	2.81	43,131 (32.3)	
60~79	3.19	55,524 (19.4)	3.27	28,411 (18.5)	3.12	27,113 (20.3)	
80~120	4.51	14,529 (5.1)	4.58	7,378 (4.8)	4.44	7,151 (5.4)	
Sex							<0.01
Male	3.67	170,934 (59.6)	3.88	90,450 (59.0)	3.45	80,484 (60.3)	
Female	2.47	115,616 (40.4)	2.68	62,776 (41.0)	2.26	52,910 (39.7)	
EMS use	0.59	54,778 (19.2)	0.61	28,498 (18.6)	0.56	26,280 (19.8)	<0.01
Initial triage, severe	0.22	20,863 (3.4)	0.24	11,160 (3.2)	0.21	9,703 (3.6)	<0.01
ED disposition							
Discharge	2.50	234,042 (81.8)	2.68	125,156 (81.8)	2.33	108,886 (81.8)	0.70
Ward admission	0.49	45,621 (15.9)	0.52	24,351 (15.9)	0.46	21,270 (16.0)	0.71
Intensive care units	0.02	1,631 (0.6)	0.02	864 (0.6)	0.02	767 (0.6)	0.71
Transfer out	0.05	4,566 (1.6)	0.05	2,466 (1.6)	0.04	2,100 (1.6)	0.46
Death	0.00	162 (0.1)	0.00	76 (0.1)	0.00	86 (0.1)	0.11
Clinical outcomes							
Clinically severe injury	0.05	4,421 (13.5)	0.05	2,428 (15.4)	0.04	1,993 (11.7)	<0.01
In-hospital mortality	0.00	422 (1.0)	0.00	210 (0.9)	0.00	212 (1.0)	0.22

EMS, emergency medical services; ED, emergency department

Incidence rate per 100,000 person-days was calculated using the 2019 mid-year population of Census data

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	4
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	4
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	9
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*8-10*
Bias	9	Describe any efforts to address potential sources of bias	10
Study size	10	Explain how the study size was arrived at	10
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9,10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10
		(*b*) Describe any methods used to examine subgroups and interactions	10
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	N/A
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	12
		(b) Give reasons for non-participation at each stage	12
		(c) Consider use of a flow diagram	12
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	12
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-15

		(*b*) Report category boundaries when continuous variables were categorized	12-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	12-15
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17
Generalisability	21	Discuss the generalisability (external validity) of the study results	17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	N/A

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.