Negative Vaccine Information and Adverse Event after COVID-19 Vaccination

Evidence from the Official Recognition of Causality in Korea

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EuHEA Seminar

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Motivation

Information plays a crucial role in shaping vaccine-related behaviors.

1. **MMR-autism link:** Anderberg et al. (2011), Carrieri et al. (2019), Chang (2018), Qian et al. (2020)
   - Wakefield et al. (1998) claimed an MMR–autism link → despite retraction, vaccination rates fell.
   - Highly educated mothers reacted more sensitively.
2. **Influenza vaccine:** Brilli et al. (2020), Yoo et al. (2010)
   - Vaccine news coverage positively linked to uptake.
   - However, reports of deaths following influenza vaccination → a decline in vaccination.
3. **COVID-19 vaccine:** Deiana et al. (2022), Motta and Stecula (2023), Pinna et al. (2022)
   - Temporary suspension, conservative media exposure → decline in COVID-19 vaccination

Motivation

However, vaccine information may affect different margins depending on when it is received.

1. Pre-vaccination
   - Vaccine information affects vaccination decisions by changing perceived benefits and costs.
   - **Existing studies have mainly focused on this stage.**
2. Post-vaccination
   - New information remains meaningful even after vaccination.
   - **Concern about adverse events $\rightarrow$ increased healthcare use.**

Motivation

Why should we focus on post-vaccination behaviors?

- **Less extreme margin:** focusing only on vaccination uptake may underestimate the effect of information (Motta & Stecula, 2021)
  - In some contexts, the vaccination decision may represent a less sensitive margin to information shocks.
    - **(Example)** During COVID-19, under a rapid and mass vaccination program, there was strong social pressure to get vaccinated.
  - **Risk perception may manifest at a less extreme margin.**
- **Capturing vaccine sentiment** (Motta & Stecula, 2023; Motta & Stecula, 2021)
  - Shifts in vaccine sentiment translate into healthcare responses (AE-related)

Gap in the Literature: Prior research mainly focuses on vaccination decisions.

- Exception (Larsen et al., 2021; Motta & Stecula, 2021)
  - Our study identifies the effect of a negative information shock under stable vaccine supply.
  - By linking vaccination and insurance data, we examine how healthcare responses vary across diseases and care settings, offering insights into welfare implications.

Research Question

1. How does negative information about COVID-19 vaccines affect adverse event–related healthcare utilization?

- We exploit the Korean case where the government officially recognized a causal link between COVID-19 vaccines and adverse events.

2. Heterogeneity of responses: disease types, types of care, and healthcare institutions

- By examining how heightened risk perception drives AE-related care, we assess whether such care is of low or high value.

Preliminary Results

1. After recognizing causality for the Pfizer vaccine, AE–related healthcare use among vaccinated individuals **increased by about 1%p** (22% of the pre-period mean)
   - Peaked immediately after the announcement and gradually declined over time
2. The largest rise occurred in **general AE such as headache, fever, and muscle pain.**
   - Severe adverse events (myocarditis/pericarditis, thrombosis) also increased slightly → possibly reflecting marginal case diagnoses
3. No significant increase in ED visits → supports that the rise mainly reflects mild cases.
4. The increase was most pronounced in clinics (in absolute terms).
   - In relative terms (as a share of the pre-period mean), hospitals and general hospitals also showed comparable increases → **potential for inefficient use of healthcare resources.**

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Recognition of Causality for Adverse Events: Pfizer Vaccine

July 26 2021: First Official Recognition of Causality

- A man in his 20s died six days after receiving the Pfizer vaccine → vaccine-induced myocarditis
- Additionally, causality was acknowledged for one case of severe pericarditis.

What type of information shock was triggered by the government's announcement?

- Examining characteristics using the Naver News Platform
  - About 87% of online news consumers use Naver as their main channel.
  - Limitation: due to personalization and recommendation algorithms, the same query can yield different result sets across users.
    - (Solution) collected all news articles from Naver (20 million) → filtered 150,000 articles related to vaccine adverse events
- Supply and Demand of Information
  - **(Supply)** Was information about adverse events supplied to the public?
  - **(Demand)** Did people actually consume the supplied information extensively?

Adverse Event Information – Supply Perspective

A surge in news coverage on adverse events following the announcement of causality recognition Example: news (July 26)

- Peak (July 05): Reports on deaths following Janssen vaccination
- Peak (August): Occupational disease recognition for post-vaccination paralysis / Hair loss after Moderna shot

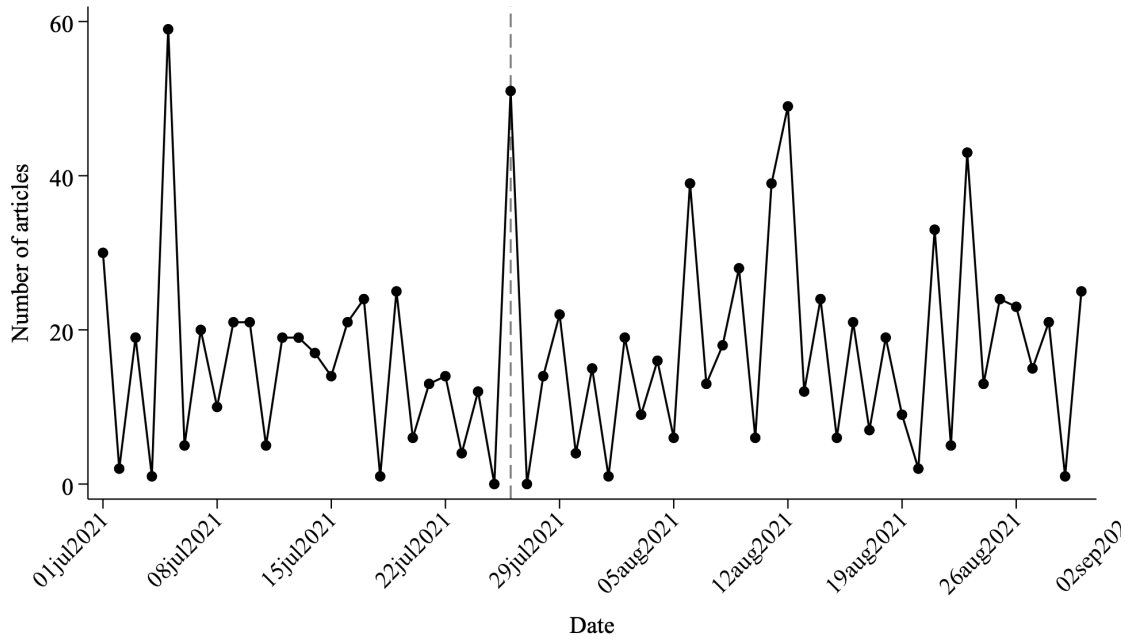

Figure: Adverse Event Article Trend near the Recognition Date

Adverse Event Information – Demand Perspective

Were the supplied articles widely consumed? → Number of adverse event–related articles among Most-Read Articles

- Rise in adverse event news consumption after official recognition

Has public interest in adverse events increased? → Naver search trends (keyword: "adverse event," "side effect," "causality")

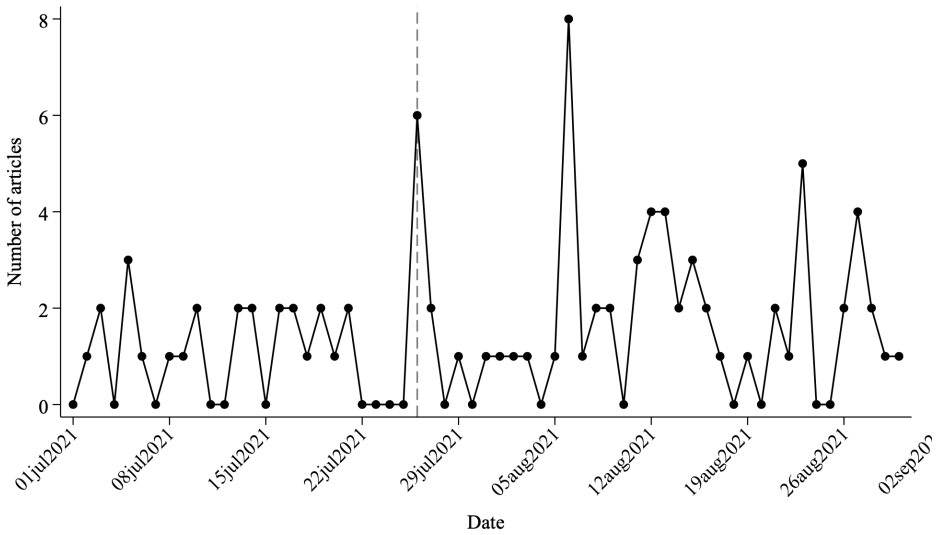

Figure: Most-Read Articles (Adverse Event–Related)

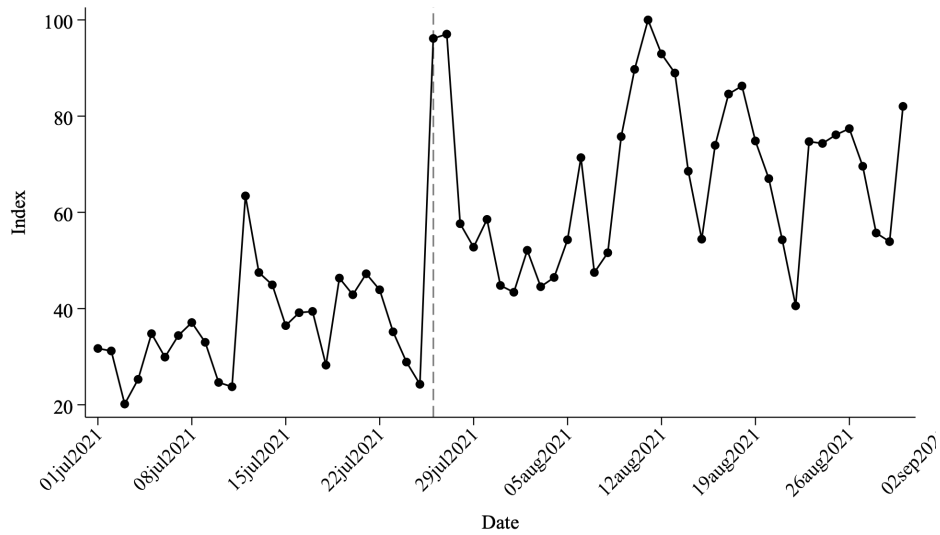

Figure: Naver Search Trend over Time

Adverse Events after COVID-19 Vaccination

Identifying adverse events associated with COVID-19 vaccination

- Identify adverse events in insurance claim data using disease codes (ICD, KCD)

Category	Disease	KCD code	Reference
Special-Interest AE	Anaphylaxis, Brachial neuritis, Vasovagal syncope, Disseminated encephalomyelitis, ...	T78.2, T88.6, M54.1, ...	Huh et al. (2021)
Myocarditis / Pericarditis	Acute myocarditis, Infectious myocarditis, Rheumatic myocarditis, ...	I40.0, I40.1, I40.8, ...	Hwang et al. (2021)
Thrombosis	Deep vein thrombosis, Disseminated intravascular coagulation, ...	I80.1, I80.2, I80.3, ...	Hwang et al. (2021)
General AE	Headache, Myalgia, Limb pain, Chest pain, Dizziness, ...	R51, M791, M796, ...	Jeong (2021), Loosen et al. (2022)

Table: Adverse Event Categories and Corresponding Disease Codes

COVID-19 Vaccination Policy in Korea – Under Age 49

Individuals aged under 49, the target group of analysis, started vaccination on August 26 2021.

- However, occupation-based and leftover vaccination allowed observation of sufficient "early adopters" around the causality recognition period (Pfizer).

Timing	Target group
2021.7.5	Socially essential workers (police, coast guard, firefighters, etc.)
2021.7.13	Preschool, daycare, and elementary school staff
2021.7.19	High school staff
2021.7.28	Elementary and middle school staff
2021.8.26	All individuals aged 18–49

Table: Vaccination Timeline

COVID-19 Vaccination Policy in Korea – Under Age 49

Confirmed sufficient number of vaccinated individuals observed before and after the causality recognition

- **(Concern)** Changes in the composition of vaccinated individuals over time

Sample characteristics

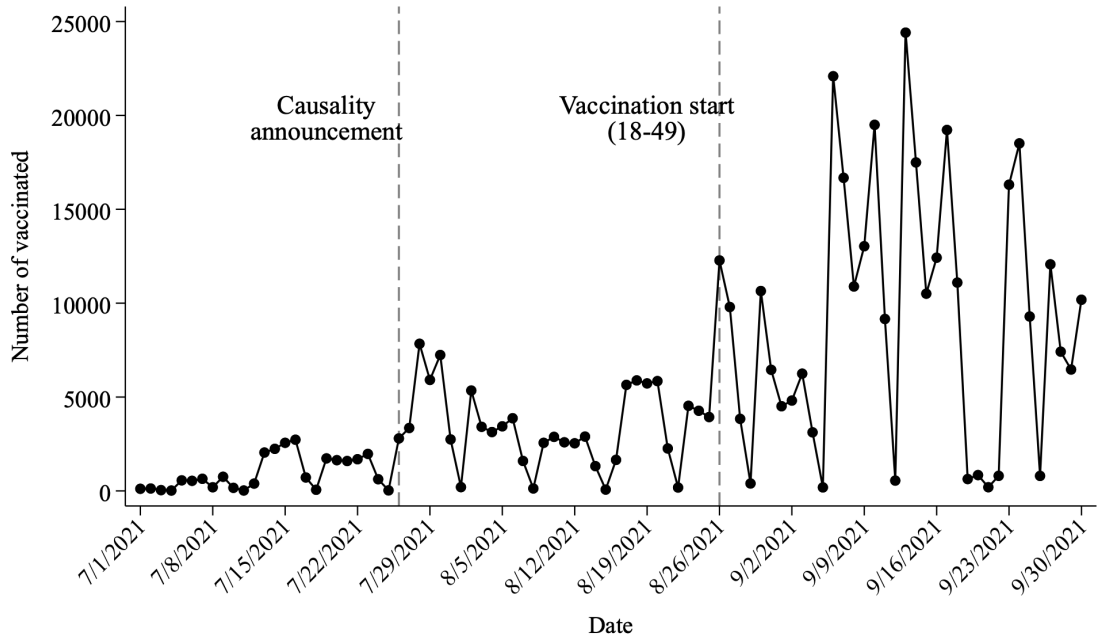

Figure: Daily Number of Vaccinated Individuals

Group definition

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Data

K-COV-N cohort (Korea Disease Control and Prevention Agency-COVID19-National Health Insurance Service cohort)

- Baseline sample: the National Health Information Database from the NHIS
  - Using Korea's universal health insurance data, researchers can flexibly define the study population, sample size, and observation period.
  - **Our sample:** health insurance enrollees who were 20 years of age or older as of 2019
    - 1.44 million unique individuals (about 4% of population)
- Linked with KDCA administrative data
  - Vaccination records (type, date, dose number)
  - COVID-19 infection records

Study sample: from baseline sample,

- Restricted to individuals aged under 49 in 2021

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Trends in Adverse Events

(Outcome) share of vaccinated individuals at each time point who used healthcare services related to adverse events within 14 days after vaccination

- A sharp increase in the rate of adverse events after the recognition $\rightarrow$ followed by a steady decline

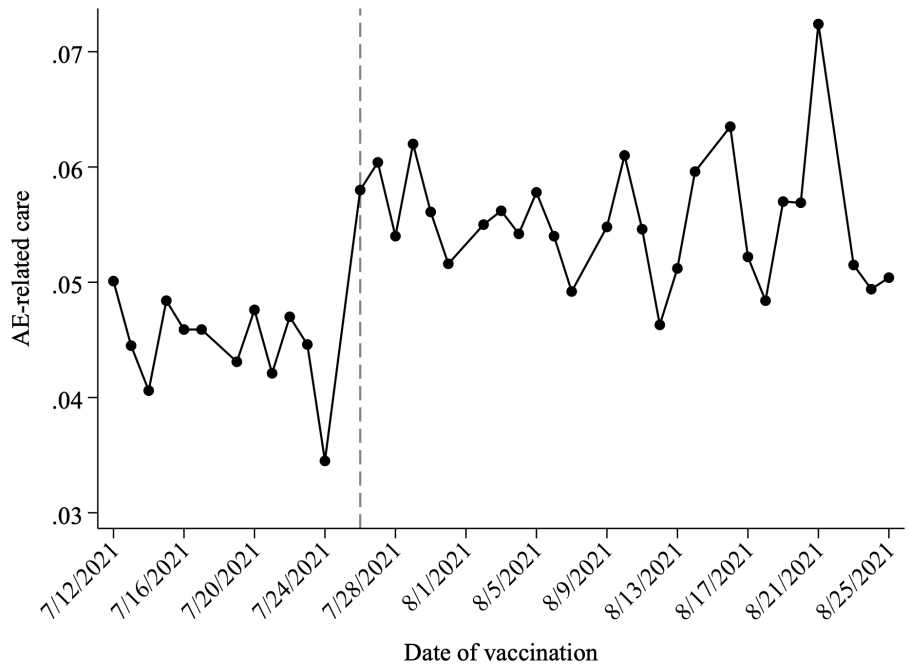

Figure: Healthcare Utilization Rate for Adverse Events (Vaccinated)

Empirical Issue

A simple pre–post comparison fails to disentangle the effect of the causality recognition from temporal trends in healthcare utilization.

- COVID-19 situation, containment policies, and temporal factors → AE–related healthcare utilization
  - This concern is more pronounced because our outcome variable focuses on general AE.
  - **(Comparison)** For severe AE, healthcare utilization might be unaffected by external conditions.
- Interrupted time series or regression discontinuity in time designs are infeasible because the pre-period time window is too short.

What characteristics are required for a valid control group?

1. The control group shows a similar overall trend in healthcare utilization to the vaccinated group.
2. A group whose healthcare utilization is not affected by the causality recognition
   - **(Channel)** Causality recognition → Increased concern about adverse events → Increased healthcare utilization

Not-Yet-Vaccinated as Control Group

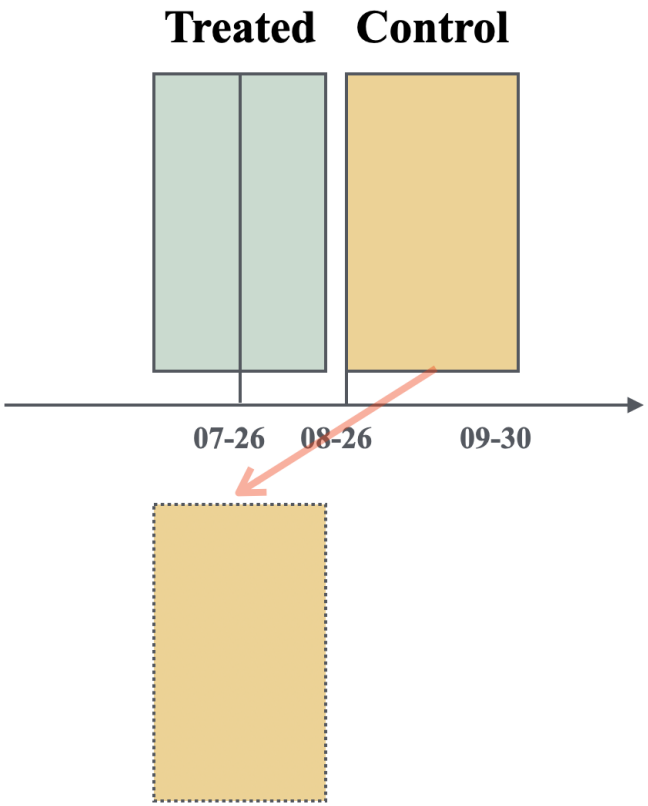

Figure: Control Group

Group definition

- Treated: Individuals who received vaccination within ± 14 days around 26 July
- Control: Unvaccinated around 26 July, later vaccinated after rollout for under-49s
  - General AE–related care is common among the unvaccinated $\rightarrow$ serves as a counterfactual for the vaccinated Types of Adverse Events
  - No vaccination on 26 July, so no vaccine-related healthcare use possible.

Baseline approach

- Randomly assign pseudo vaccination dates around the recognition date and compare with vaccinated individuals

Number of Vaccinated

Empirical Approach

Specification (DID - repeated cross section)

$$Y_i = \beta_0 + \beta_1(Treat_i \times Post_t) + \beta_2 Treat_i + \beta_3 Post_t + \epsilon_i \quad (1)$$

where (i: individual, t: date)

- Y_i: Indicator for healthcare utilization related to adverse events within 14 days after vaccination
- $Treat_i$: Equals 1 if vaccinated within $\pm$14 days around July 26, 0 otherwise
  - Captures baseline differences between treated and control groups: the true risk of vaccination
- $Post_t$: Equals 1 if the vaccination date is after the causality recognition date, 0 otherwise

Identifying assumption: In the absence of the causality recognition, healthcare utilization for the treated and control groups would have evolved similarly.

$$Y_i = \beta_0 + \sum_{k \neq -1} \beta_1^k Treat_i \times 1(\text{Time since announcement} = k)_t + \beta_2 Treat_i + \delta_t + \epsilon_i \quad (2)$$

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Effect of Causality Recognition

Models

- No controls → sequentially add controls for demographics (age, sex, insurance premium quantile), occupation (employment status, industry), and prior COVID-19 infection (up to June)

Magnitude: about 1%p (22% of the pre-period mean)

	(1)	(2)	(3)	(4)	(5)
Treat × *Post*	0.0096***	0.0118***	0.0109***	0.0109***	0.0108***
	(0.0018)	(0.0018)	(0.0018)	(0.0018)	(0.0018)
Controls:					
Demographics		Y	Y	Y	Y
Occupation			Y	Y	Y
COVID infection				Y	Y
Date FE					Y
Pre-treatment mean	.0448	.0448	.0448	.0448	.0448
Adjusted R-squared	.0018	.0037	.0038	.0037	.0038
Observations	397133	397133	397133	397133	397133

Table: Baseline DID Estimation Results

Threats to identification

Threats to Identification

Validity of identifying assumption Event study: raw value | Event study: estimates

- Using Equation 2, compare how the difference between treated and control groups changes before and after the causality recognition.

Changes in sample composition Adding controls

- As the eligible population for vaccination changes over time, healthcare utilization related to adverse events may also vary.
  - **(Comparison)** Control group remains balanced across time (random assignment).
- **Coefficient robust to controls for vaccination-related factors.**

Remaining concerns: sources of time-varying confounders

1. Change in vaccination sites: from mass vaccination centers to contracted clinics
   - Some individuals were already vaccinated at clinics before 26 July $\rightarrow$ vaccination sites did not change drastically.
2. Stronger adverse event monitoring: if management was tightened alongside the causality recognition, a sharp increase in healthcare utilization could occur.
   - This reflects supply-side changes, not an information shock.
   - No evidence of actual change

Heterogeneity Analysis by Disease Types

Objective

- If mild adverse events drove the increase, it supports: negative info → risk perception → healthcare use
- "naive" examination of whether the increased utilization reflects high-value or low-value care.

	(1) Special-Interest AE	(2) Myocarditis / Pericarditis	(3) Thrombosis	(4) General AE
Treat × *Post*	0.0002	0.0004**	0.0014***	0.0116***
	(0.0004)	(0.0002)	(0.0003)	(0.0019)
Controls	Y	Y	Y	Y
Pre-treatment mean	.0015	.0001	.0014	.0432
Adjusted R-squared	.0003	.0005	.0009	.0039
Observations	397133	397133	397133	397133

Table: Results by Adverse Event Type

Heterogeneity Analysis by Disease Types

Why did some severe adverse events increase?

- Vaccinated individuals tended to suspect specific conditions such as myocarditis or thrombosis, as seen in exclusion-diagnosis rates.
  - However, most of these initially suspected cases were later ruled out as unrelated.
- Suggests that **marginal cases may have been diagnosed as these conditions due to more frequent checks.**

	Control		Treated	
Types	N	Mean	N	Mean
Special-Interest AE	352	0.0568	182	0.0385
Myocarditis / Pericarditis	13	0.2308	92	0.4891
Thrombosis	132	0.5000	274	0.7555
General AE	9730	0.0080	5580	0.0048

Table: Exclusion Diagnosis Rates

Heterogeneity Analysis by Type of Care

Objective

- Since ED vitis by patients with adverse events have placed a considerable burden on the emergency care system,
  - Important to distinguish healthcare utilization types to examine differences by type of care.
- This also provides a basis for interpreting whether the increased care following the causality recognition primarily reflects relatively mild cases.

	(1) Baseline	(2) Non-ED Visits	(3) ED visits
Treat × *Post*	0.0119*** (0.0019)	0.0113*** (0.0018)	0.0006 (0.0005)
Controls	Y	Y	Y
Pre-treatment mean	.0448	.0412	.0036
Adjusted R-squared	.0041	.0038	.0009
Observations	397133	397133	397133

Table: Results by Type of Care

Heterogeneity Analysis by Type of Medical Institution

Objective

- Where within the healthcare system is the increased utilization, driven by risk perception of adverse events, being absorbed?
  - Mainly absorbed by primary care clinics where vaccinations were administered as intended.
  - Some demand spilled over into higher-level institutions.

	(1) Baseline	(2) General Hospital	(3) Hospital	(4) Clinic
Treat × *Post*	0.0119***	0.0021**	0.0011*	0.0086***
	(0.0019)	(0.0009)	(0.0006)	(0.0016)
Controls	Y	Y	Y	Y
Pre-treatment mean	.0448	.0093	.0049	.0302
Adjusted R-squared	.0041	.001	.0004	.0029
Observations	397133	397133	397133	397133

Table: Results by Type of Medical Institution

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Summary of Findings

1. After recognizing causality for the Pfizer vaccine, adverse event–related healthcare utilization among vaccinated individuals increased.
2. The largest rise occurred in general AE such as headache, fever, and muscle pain.
3. No significant increase in emergency department visits $\rightarrow$ supports that the rise mainly reflects mild cases
4. The increase was most pronounced in clinics (in absolute terms).
   - In relative terms (as a share of the pre-period mean), hospitals and general hospitals also showed comparable increases $\rightarrow$ potential for inefficient use of healthcare resources.

Policy Implication

Negative information about vaccine can increase healthcare utilization after vaccination through changes in risk perception.

- Vaccine risk communication should consider not only the **uptake margin (whether to vaccinate)** but also **the potential post-vaccination costs** arising from AE–related care.

Thank You

Questions and Comments are Welcome!

Incidence Rates by Adverse Event

Category	Disease	Control	Treated
		Mean	
Special-Interest AE	Anaphylaxis	0.00002	0.00005
	Brachial Neuritis	0.00066	0.00049
	Vasovagal Syncope	0.00017	0.00019
	Acute Disseminated Encephalomyelitis	0.00000	0.00000
	Bell's Palsy	0.00007	0.00005
	Guillain–Barré Syndrome	0.00000	0.00000
	Encephalopathy	0.00003	0.00000
	Immune Thrombocytopenic Purpura	0.00001	0.00000
	Optic Neuritis	0.00002	0.00000
	Systemic Lupus Erythematosus	0.00016	0.00029
	Transverse Myelitis	0.00001	0.00000
Myocarditis / Pericarditis	Acute Myocarditis	0.00000	0.00029
	Infectious Myocarditis	0.00000	0.00000
	Rheumatic Myocarditis	0.00000	0.00005
	Acute Pericarditis	0.00000	0.00000
	Rheumatic Pericarditis	0.00000	0.00000

Table: Summary Statistics (Pre-Period)

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Incidence Rates by Adverse Event

Category	Disease	Control	Treated
		Mean	
Thrombosis	Deep Vein Thrombosis	0.00008	0.00010
	Disseminated Intravascular Coagulation	0.00002	0.00015
	Intracranial Thrombophlebitis	0.00000	0.00000
	Intracranial Venous Thrombosis	0.00000	0.00000
	Pulmonary Embolism	0.00006	0.00019
	Other Venous Embolism and Thrombosis	0.00009	0.00029
General AE	Herpes Zoster	0.00087	0.00102
	Headache	0.00193	0.00390
	Muscle Pain	0.00822	0.00877
	Limb Pain	0.00097	0.00127
	Chest Pain	0.00158	0.00575
	Dizziness	0.00162	0.00278
	Fever	0.00109	0.00234
	Fatigue	0.00020	0.00029
	Joint Pain	0.00473	0.00541
	Nausea and Vomiting	0.00350	0.00599
	Localized Swelling of the Arm	0.00007	0.00005
	Abdominal Pain	0.00638	0.00755
	Cellulitis	0.00072	0.00054
	Arthritis	0.00432	0.00419
	Acute Lymphadenitis	0.00064	0.00161

Table: Summary Statistics (Pre-Period)

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Example News

Title	"First Official Recognition of Causality in Korea: Man in His 20s Dies of Myocarditis Following Pfizer Vaccination"
Contents	The COVID-19 Vaccination Response Task Force announced on the 25th that, after evaluating 106 reported cases of death or severe illness following vaccination (42 deaths and 64 severe cases), as well as 11 suspected cases of anaphylaxis, it officially recognized causality in three cases, including a death caused by myocarditis. A man in his 20s, a soldier who died of myocarditis (inflammation of the heart muscle), had received the Pfizer vaccine on July 7 and complained of chest pain and physical discomfort six days later, around 1 a.m. on July 13. He was found in cardiac arrest around 8 a.m. despite resuscitation efforts and was later pronounced dead. This was the first recognized case of death from myocarditis following COVID-19 vaccination in Korea...

Table: News Related to Causality Recognition

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Sample Composition: Early Adopters

	Pre		Post	
	N	Mean	N	Mean
Age	20023	37.922	53583	36.477
Female	20023	0.703	53583	0.585
Type of subscriber:				
individually enrolled (head of household)	20023	0.081	53583	0.08
individually enrolled (household member)	20023	0.088	53583	0.1
Employee-insured (head of household)	20023	0.676	53583	0.608
Employee-insured (household member)	20023	0.148	53583	0.202
Recipient of medical aid (head of household)	20023	0.003	53583	0.007
Recipient of medical aid (household member)	20023	0.003	53583	0.004
Health insurance premium (20-quantiles)	19621	10.51	52255	11.912

Table: Sample Characteristics of Vaccinated Individuals

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Incidence Rate of Adverse Events

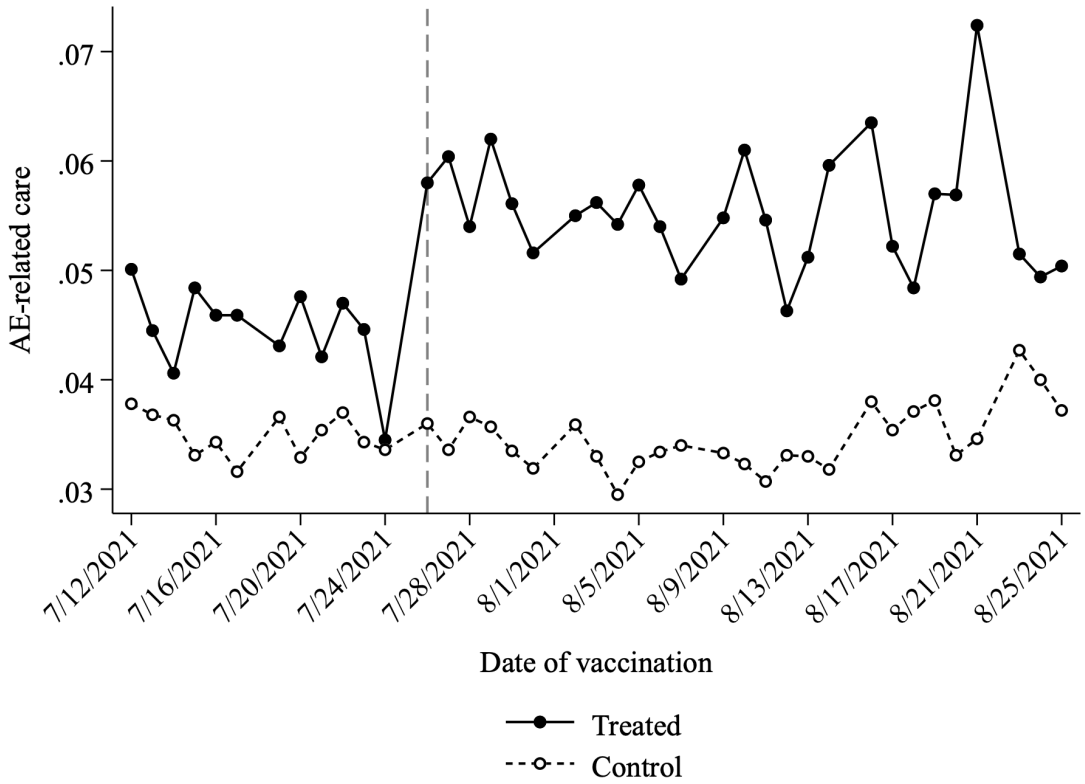

Figure: Adverse Event–Related Healthcare Use within Two Weeks (Treated vs. Control)

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Dynamic DID (Event Study)

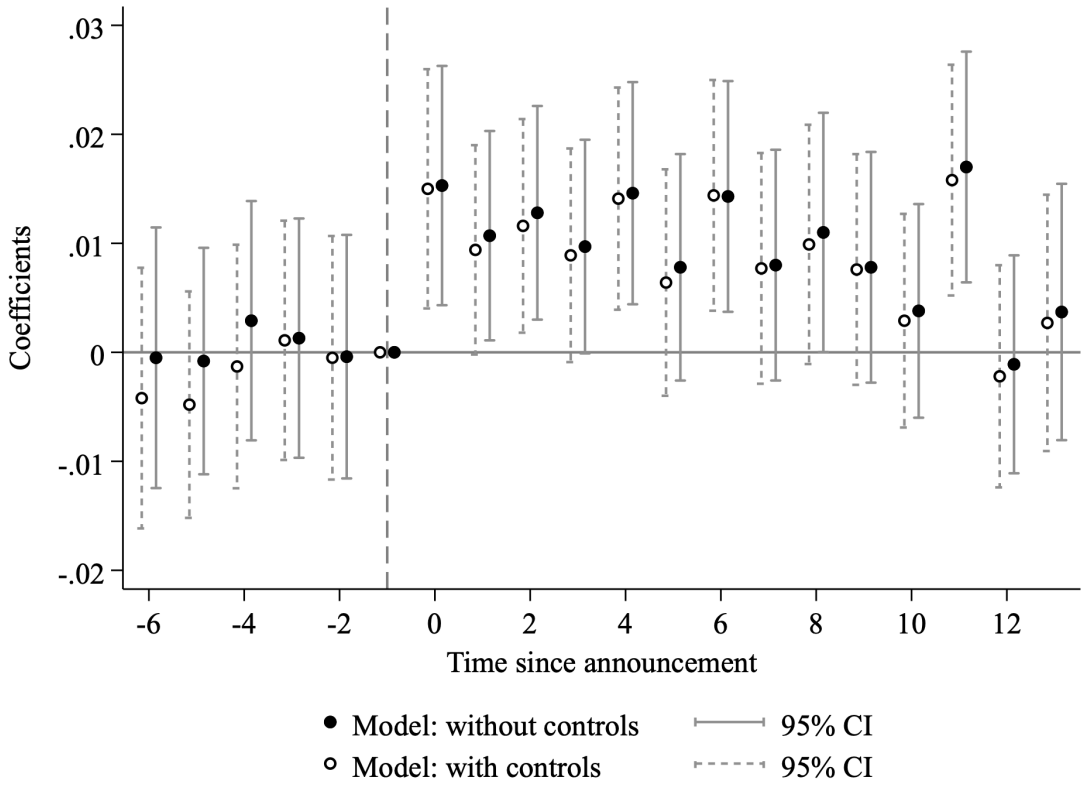

Figure: Estimation Results

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