International Journal of Infectious Diseases 162 (2026) 108107

Contents lists available at ScienceDirect

International Journal of Infectious Diseases

journal homepage: www.elsevier.com/locate/ijid

Sex differences in adverse event reporting rates following COVID-19 vaccination in South Korea during the pandemic

Jeong Ah Kim[1], Suvin Park[1], Haerin Cho[1], Na-Young Jeong[2], Nam-Kyong Choi[1,3,*]

[1] Department of Health Convergence, College of Science & Industry Convergence, Ewha Womans University, Seoul, Republic of Korea
[2] Health Science Convergence Research Institute, Ewha Womans University, Seoul, Republic of Korea
[3] Graduate School of Industrial Pharmaceutical Science, College of Pharmacy, Ewha Womans University, Seoul, Republic of Korea

ARTICLE INFO

Article history:
Received 24 July 2025
Revised 2 October 2025
Accepted 4 October 2025

Keywords:
Sex
Adverse event
COVID-19 vaccine
Safety
KAERS DB

ABSTRACT

Objectives: Sex differences in adverse event (AE) reporting rates following COVID-19 vaccination were analyzed using data from South Korea's national pharmacovigilance system.

Methods: We analyzed AE reports related to COVID-19 vaccines, as recorded in the Korea Adverse Event Reporting System between February 26, 2021, and December 31, 2022. AEs were classified according to the System Organ Class (SOC) and the Preferred Term (PT), as defined by the Medical Dictionary for Regulatory Activities. Reporting rates were calculated as the number of reported COVID-19 vaccine-AE pairs per 100,000 vaccine doses administered. The female-to-male (F/M) ratios were calculated by dividing the reporting rate for females by that for males, and the corresponding 95% confidence intervals (CIs) were computed.

Results: Among the 887,153 reported COVID-19 vaccine-AE pairs, females showed significantly higher reporting rates in 17 of the 24 SOCs, with the greatest disparity observed in infections and infestations (F/M ratio 3.21 [95% CI 3.05-3.38]). Males exhibited higher rates only for cardiac disorders (0.93 [0.89-0.98]). Among the 340 PTs, 104 exhibited significant sex differences. Females had higher reporting rates in 98 PTs, with injection site pruritus (9.00 [5.34-15.17]) showing the largest difference. Conversely, males had higher rates in six PTs, most notably for myocardial infarction (0.33 [0.18-0.60]) and cardiac arrest (0.33 [0.14-0.78]).

Conclusion: These findings underscore the importance of accounting for sex differences in vaccine development, clinical trials, and postmarketing safety monitoring.

© 2025 The Authors. Published by Elsevier Ltd on behalf of International Society for Infectious Diseases. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)

Introduction

Adverse events (AEs) following coronavirus disease 2019 (COVID-19) vaccination have been widely reported, with sex-specific differences observed. Females have consistently reported higher rates of common AEs, including injection site pain, fever, and paresthesia, following Pfizer-BioNTech vaccination [1]. Conversely, young males have been at increased risk of myocarditis associated with mRNA vaccines [2,3]. Data from the Vaccine Adverse Event Reporting System (VAERS) indicate that serious adverse events (SAEs), including hospitalization and death, are reported more frequently in males [4]. These differences are likely attributable to biological differences between males and females. Sex, defined by biological attributes, influences how the body processes vaccines through variations in absorption, metabolism, and clearance, ultimately affecting the risk and severity of AEs [5–7].

However, research specifically addressing sex differences in AEs remains limited. For instance, a review of 45 COVID-19-related clinical trials published before December 15, 2020, found that only eight reported sex-disaggregated results or conducted subgroup analyses by sex [8]. Similarly, a mini-review of 35 experimental and observational studies on COVID-19 vaccine safety found that just 12 studies presented data disaggregated by sex [9]. In particular, there is limited understanding of which AEs, categorized by anatomical or physiological systems and specific medical conditions, are more frequently reported by females compared to males.

* Corresponding author: Nam-Kyong Choi, Department of Health Convergence, Ewha Womans University, 52 Ewhayeodae-gil, Seodaemun-gu, Seoul 03760, South Korea.
E-mail address: nchoi@ewha.ac.kr (N.-K. Choi).

https://doi.org/10.1016/j.ijid.2025.108107
1201-9712/© 2025 The Authors. Published by Elsevier Ltd on behalf of International Society for Infectious Diseases. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/)

Overlooking sex differences in vaccine research may lead to a loss of important information, delay the detection of critical safety signals, and hinder efforts to ensure equitable vaccine monitoring [10]. Leading experts have underscored the need to investigate sex-specific effects in order to inform the development of prevention and treatment strategies that address both the immediate and long-term consequences of the pandemic on public health [11].

Therefore, we conducted an analysis of sex differences in AE reporting following COVID-19 vaccination in South Korea, using data from the national pharmacovigilance system. By identifying the clinical categories and specific conditions in which these differences are most pronounced, our study aims to inform more precise vaccine safety surveillance, support the development of equitable and evidence-based monitoring strategies, and advance a more comprehensive understanding of the vaccine safety profile.

Methods

Data source

The dataset included AE reports associated with COVID-19 vaccines, recorded in the Korea Adverse Event Reporting System (KAERS) between February 26, 2021, the date of the first COVID-19 vaccination in South Korea, and December 31, 2022 (2307A0006). In accordance with the data use guidelines of the Korea Institute of Drug Safety and Risk Management (KIDS), the dataset is cited as KIDS KAERS DB (2307A0006), where "2307A0006" refers to the official application number issued by KIDS. KAERS provides a comprehensive database of vaccine-related AEs reported across South Korea [12], excluding reports from foreign sources. KAERS is a system developed by the KIDS to facilitate the reporting and management of AE reports. All AE reports have been accumulated in KAERS since 2012 [13].

KIDS, which collects AE reports from a wide range of sources, including regional pharmacovigilance centers (RPVCs), hospitals, pharmacies, patients/consumers, and pharmaceutical companies [14]. Since 2020, the number of RPVCs has expanded to 28 and operated by hospitals and related institutions [15]. These RPVCs play a central role in Korea's pharmacovigilance activity by not only collecting and reporting AEs occurring both in and outside medical institutions, but also by promoting awareness through educational outreach and training activities [16]. Moreover, RPVCs foster close collaborations with local healthcare providers and pharmacies, facilitates more systematic and comprehensive reporting of both serious and non-serious AEs [15]. The activation of pharmacovigilance through RPVCs has facilitated the involvement of healthcare professionals from various disciplines and has contributed to the expansion of the infrastructure for pharmacoepidemiology and pharmacovigilance in Korea [17]. Consequently, the data derived from KAERS appear to more accurately reflect real-world vaccine safety experiences, which may, in turn, enhance the validity and generalizability of research findings based on this system.

In KAERS, each AE report includes the date of reporting, demographic information, the administered pharmaceutical product, and the reported AE. The AE report records biological sex but does not capture gender-related information. Accordingly, all analyses in this study are based on binary sex categories (female and male) and do not account for gender-related variables such as gender identity. Pharmaceutical information includes the relationship between the administered product and the AE, classified as suspected, concomitant, or interacting, along with the start and end dates of administration. A single report may contain one or more AEs associated with the administered product. This study was approved by the Institutional Review Board of Ewha Womans University (IRB No.: ewha-202411-0041-01).

Selection of COVID-19 vaccine-AE pair reports

This study included reports for COVID-19 vaccines developed using two viral vector vaccines (Oxford-AstraZeneca, Janssen), two mRNA vaccines (Pfizer-BioNTech, Moderna), and two recombinant protein vaccines (Novavax, SK Bioscience) [18]. To ensure data accuracy, only reports in which a COVID-19 vaccine was classified as the suspected product were included for the analysis, while those classified as concomitant or interacting products were excluded. Additionally, reports were excluded if they lacked information on age or sex, contained internal logical inconsistencies (e.g., an AE onset date preceding the vaccine administration date), or were identified as duplicates.

Outcomes

Initial coding of AEs was conducted using the Lowest Level Term (LLT) from the Medical Dictionary for Regulatory Activities (MedDRA) and subsequently mapped to MedDRA's standardized hierarchical structure [19]. For broader categorization, each AE was assigned to a System Organ Class (SOC) and concurrently mapped to a Preferred Term (PT), which represents a distinct medical concept such as a symptom, sign, disease diagnosis, therapeutic indication, or medical history characteristic. To further classify severity, AEs were designated as SAEs if they resulted in death, a life-threatening condition, prolonged hospitalization, persistent or significant disability, a congenital anomaly, or other unspecified clinical intervention.

Statistical analysis

We identified AE reports associated with COVID-19 vaccines and used a chi-square test to compare demographic characteristics between sexes. Reporting rates were calculated as the number of reported COVID-19 vaccine-AE pair reports per 100,000 vaccine doses administered. Data on vaccine administration were obtained from the Korea Disease Control and Prevention Agency (KDCA), which publicly reported the number of administered doses during the pandemic [20]. During the study period from February 26, 2021, to December 31, 2022, individuals in South Korea were eligible to receive up to four doses of COVID-19 vaccines, in accordance with the national immunization schedule, which included a primary series (first and second doses) and subsequent booster doses [18]. To assess sex differences in AE reporting, female-to-male (F/M) ratios were calculated by dividing the reporting rate among females by that among males, and the corresponding 95% confidence intervals (CIs) were computed. These comparisons were conducted at both the SOC and PT levels, as defined by the MedDRA. SOC categories inherently specific to females, namely "Pregnancy, puerperium and perinatal conditions" and "Reproductive system and breast disorders," were excluded from F/M ratio calculations and instead described narratively. At the PT level, F/M ratios were reported only for AEs with statistically significant differences in reporting rates between females and males. Subgroup analyses were conducted across three age groups: 0-18 years, 19-64 years, and 65 years and older. All statistical procedures were conducted using the SAS Enterprise Guide 8.3 (SAS Institute Inc., Cary, NC, USA) and R 4.2.2 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Baseline characteristics of adverse event reports

During the study period, a total of 887,153 COVID-19 vaccine-AE pair reports were recorded in KAERS, of which 280,566

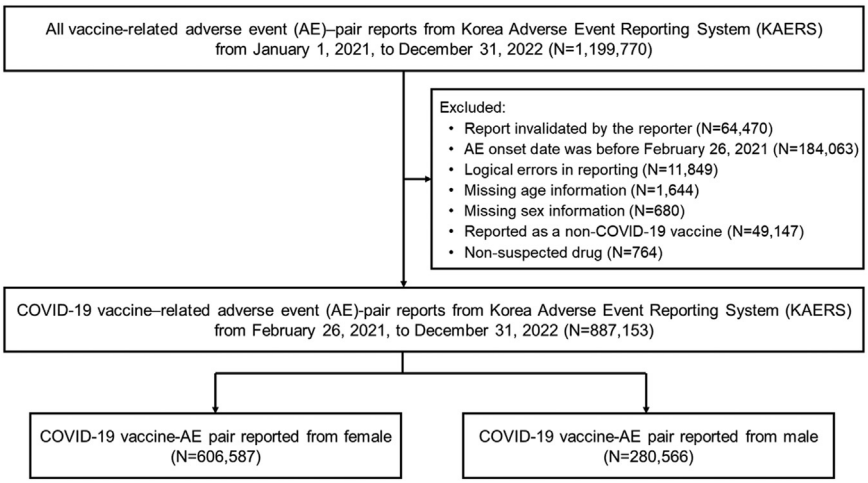


Figure 1. Flow chart of the COVID-19 vaccine-AE pair reports from the KAERS. AE=adverse event. KAERS=Korea Adverse Event Reporting System.

Table 1
Characteristics of AE reports associated with COVID-19 vaccines.

	COVID-19 vaccine-AE pair reports (N = 887,153)		
	Female (N = 606,587)	Male (N = 280,566)	P-value
Age group (years)			
0–18	19,947 (3.3%)	16,794 (6.0%)	<0.0001
19–64	485,449 (80.0%)	213,278 (76.0%)	
≥65	101,191 (16.7%)	50,494 (18.0%)	
Reported year			
2021	513,617 (84.7%)	224,725 (80.1%)	<0.0001
2022	92,970 (15.3%)	55,841 (19.9%)	
Manufacturer			
Pfizer-BioNTech	277,858 (45.8%)	130,811 (46.6%)	<0.0001
Moderna	148,288 (24.4%)	70,327 (25.1%)	
Oxford–AstraZeneca	174,544 (28.8%)	65,186 (23.2%)	
Janssen	4,087 (0.7%)	13,348 (4.8%)	
Novavax	1,809 (0.3%)	892 (0.3%)	
SK Bioscience	1 (0.0%)	2 (0.0%)	
Serious adverse event			
Yes	27,047 (4.5%)	17,813 (6.3%)	<0.0001
No	579,540 (95.5%)	262,753 (93.7%)	

Data are n (%). The P-value was calculated using the chi-square test. AE = adverse event.

(31.6%) were from males and 606,587 (68.4%) were from females (Figure 1). The baseline characteristics of these reports are presented in Table 1. The majority of reports were submitted by individuals aged 19-64 years, representing 76.0% of reports from males and 80.0% from females. Most AEs were reported in 2021, during the first year of the national COVID-19 vaccination campaign. mRNA vaccines were most frequently associated with AE reports, particularly the Pfizer-BioNTech vaccine (46.6% in males and 45.8% in females) and the Moderna vaccine (25.1% in males and 24.4% in females). Reports were predominantly non-serious in both males and females. However, the proportion of SAEs was higher in males than in females (6.3% vs. 4.5%).

Data on COVID-19 vaccination

COVID-19 vaccination data were obtained from the KDCA. Between February 26, 2021, and December 31, 2022, a total of 67,093,500 females and 65,732,676 males received COVID-19 vaccinations in South Korea. When stratified by age group, 3,082,793 females and 3,280,223 males aged 0 to 18 years were vaccinated. Among individuals aged 19 to 64 years, 45,895,314 females and 47,781,864 males underwent vaccinations. In the population aged 65 years and older, COVID-19 vaccines were administered to 18,115,393 females and 14,670,589 males (Supplementary Table 1).

Reporting rates of COVID-19 vaccine adverse events by System Organ Class

Out of the 24 SOC categories classified by MedDRA, 18 demonstrated statistically significant differences in AE reporting rates between sexes (Figure 2). Females showed significantly higher reporting rates in 17 SOC categories. The most pronounced disparities were observed in three SOCs where AE reporting rates were more than three times higher in females than in males: “Infections and infestations” (F/M ratio 3.21 [95% CI 3.05-3.38]), “Psychiatric disorders” (3.20 [2.13-4.80]), and “Metabolism and nutrition disorders” (3.00 [2.34-3.84]). Eight additional SOCs showed reporting rates in females that were at least twice as high as those in males, including “Ear and labyrinth disorders” (2.75 [1.78-4.24]), “Gastrointestinal disorders” (2.58 [2.55-2.61]), “Injury, poisoning and procedural complications” (2.29 [1.88-2.79]), “Nervous system disorders” (2.13 [2.11-2.15]), “General disorders and administration site conditions” (2.13 [2.11-2.15]), “Musculoskeletal and connective tissue disorders” (2.09 [2.07-2.11]), “Blood and lymphatic system disorders” (2.08 [2.00-2.16]), and “Surgical and medical procedures” (2.00 [1.06-

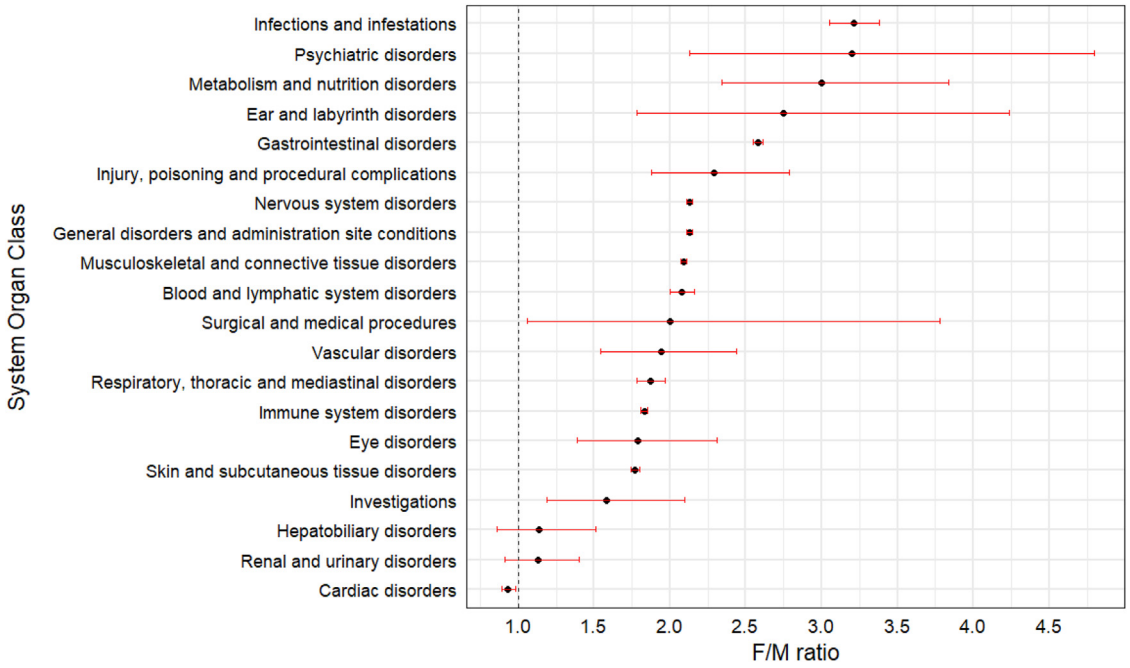


Figure 2. Sex differences in adverse event reporting rates for COVID-19 vaccines by system organ class. F/M ratio= The female-to-male (F/M) ratio were calculated by dividing the reporting rate for females by that for males.

3.78]). Additional SOCs with significantly higher AE reporting rates in females included "Vascular disorders" (1.94 [1.54-2.44]), "Respiratory, thoracic and mediastinal disorders" (1.87 [1.78-1.97]), "Immune system disorders" (1.83 [1.81-1.85]), "Eye disorders" (1.79 [1.39-2.31]), "Skin and subcutaneous tissue disorders" (1.77 [1.74-1.80]), and "Investigations" (1.58 [1.19-2.10]). In contrast, higher AE reporting rates among males were observed only in the "Cardiac disorders" category (0.93 [0.89-0.98]). AEs in the "Pregnancy, puerperium and perinatal conditions" category were reported exclusively by females, with only one case recorded. In the "Reproductive system and breast disorders" category, the vast majority of reports were from females (n = 4,498), compared with just 10 from males (Supplementary Table 2).

Reporting rates of COVID-19 vaccine adverse events by Preferred Term

Among the 340 PTs analyzed, 104 showed statistically significant differences in AE reporting rates between sexes. Of these, 98 PTs had higher reporting rates among females. PTs were ranked by F/M ratio within each SOC, as shown in Table 2. The ten PTs with the highest F/M ratios, among those with significantly elevated reporting rates in females, were predominantly concentrated in three SOCs: "General disorders and administration site conditions," "Respiratory, thoracic and mediastinal disorders," and "Nervous system disorders." Within the "General disorders and administration site conditions" category, the most frequently reported AEs included injection site pruritus (F/M ratio 9.00 [95% CI 5.34-15.17]) and injection site rash (8.00 [2.90-22.09]). For the "Respiratory, thoracic and mediastinal disorders" category, females more frequently reported rhinorrhoea (7.50 [4.21-13.36]) and nasal congestion (5.00 [2.39-10.47]). Within the "Nervous system disorders" category, females exhibited notably higher reporting rates for somnolence (5.13 [3.84-6.85]) and neuropathy peripheral (5.00 [2.31-10.80]). In contrast, males exhibited higher reporting rates in only six PTs. These included paralysis (0.93 [0.88-0.99]) under "Nervous system disorders," and cardiovascular disorder (0.78 [0.73-0.83]), myocarditis (0.75 [0.64-0.88]), myocardial infarction (0.33 [0.18-0.60]), and cardiac arrest (0.33 [0.14-0.78]) within "Cardiac disorders." Additionally, death (0.58 [0.51-0.66]) was more frequently reported by males within the "General disorders and administration site conditions" category.

Reporting rates of serious adverse events following COVID-19 vaccination

As shown in Table 3, four out of the six SAEs showed statistically significant differences in AE reporting rates between sexes. Females reported higher rates of prolonged hospitalization (F/M ratio 1.63 [95% CI 1.60-1.66]) and other unspecified clinical interventions (1.40 [1.27-1.55]). Conversely, males exhibited higher reporting rates of life-threatening conditions (0.76 [0.64-0.90]) and death (0.53 [0.49-0.57]).

Reporting rates of COVID-19 vaccine adverse events by age category

Age-stratified analyses revealed statistically significant differences in AE reporting rates between females and males across all three age groups, based on MedDRA PTs. Among individuals aged 0-18 years, higher AE reporting rates were observed in females for 17 PTs, and in males for 4 PTs (Supplementary Table 3). While the overall results aligned with the main analysis, several age-specific differences emerged. Notably, chest pain, which was not statistically significant in the main analysis, was more frequently reported by males in this age group. Similarly, although pericarditis was more commonly reported by females in the main analysis, it was more frequently reported among younger males. In the 19-64-year age group, females reported higher AE rates in 105 PTs, while males exhibited higher rates in 3 PTs (Supplementary Table 4). While most findings aligned with the main analysis, 14 PTs showed notable differences, even though they did not achieve statistical significance in the main analysis. These included feeling hot, chest pain, throat irritation, sputum increased, purpura, cold sweat, acute disseminated encephalomyelitis, acute aseptic arthritis, tinnitus, liver injury, chillblains, decreased appetite, anxiety, and eye pain, all of which were more frequently reported in females than in males. Among individuals aged 65 years and older,

Table 2
Sex differences in AE reporting rates for COVID-19 vaccines by preferred term.

Preferred Term (PT)	Female		Male		F/M ratio (95% CI)[a]
	COVID-19 vaccine-AE pair reports	Reporting rate	COVID-19 vaccine-AE pair reports	Reporting rate	
General disorders and administration site conditions (n = 27)					
Injection site pruritus	119	0.18	16	0.02	9.00 (5.34–15.17)
Injection site rash	54	0.08	4	0.01	8.00 (2.90–22.09)
Injection site oedema	90	0.13	16	0.02	6.50 (3.82–11.06)
Injection site warmth	448	0.67	76	0.12	5.58 (4.38–7.12)
Localised oedema	32	0.05	8	0.01	5.00 (2.30–10.85)
Injection site induration	331	0.49	69	0.10	4.90 (3.78–6.35)
Malaise	25	0.04	8	0.01	4.00 (1.80–8.87)
Discomfort	26	0.04	5	0.01	4.00 (1.54–10.42)
Vaccination site rash	28	0.04	4	0.01	4.00 (1.40–11.40)
Fatigue	1,750	2.61	435	0.66	3.95 (3.56–4.39)
Axillary pain	50	0.07	10	0.02	3.50 (1.77–6.90)
Vaccination site pain	80	0.12	24	0.04	3.00 (1.90–4.73)
Oedema	59	0.09	18	0.03	3.00 (1.77–5.09)
Vaccination site oedema	22	0.03	6	0.01	3.00 (1.22–7.40)
Injection site reaction	2,836	4.23	932	1.42	2.98 (2.77–3.21)
Injection site pain	25,575	38.12	8,880	13.51	2.82 (2.75–2.89)
Injection site erythema	21,341	31.81	7,442	11.32	2.81 (2.74–2.89)
Injection site swelling	21,256	31.68	7,452	11.34	2.79 (2.72–2.86)
Pain	163	0.24	57	0.09	2.67 (1.97–3.61)
Generalised oedema	3,805	5.67	1,501	2.28	2.49 (2.35–2.64)
Face oedema	3,840	5.72	1,518	2.31	2.48 (2.34–2.63)
Asthenia	387	0.58	156	0.24	2.42 (2.01–2.91)
Chills	30,045	44.78	13,496	20.53	2.18 (2.14–2.22)
Pyrexia	34,086	50.80	16,330	24.84	2.05 (2.01–2.09)
Vaccination failure	230	0.34	127	0.19	1.79 (1.44–2.22)
Chest discomfort	1,094	1.63	730	1.11	1.47 (1.34–1.61)
Death	399	0.59	663	1.01	0.58 (0.51–0.66)
Nervous system disorders (n = 13)					
Somnolence	272	0.41	55	0.08	5.13 (3.84–6.85)
Neuropathy peripheral	34	0.05	8	0.01	5.00 (2.31–10.80)
Head discomfort	24	0.04	8	0.01	4.00 (1.80–8.90)
Depressed level of consciousness	18	0.03	8	0.01	3.00 (1.30–6.90)
Dysarthria	17	0.03	8	0.01	3.00 (1.29–6.95)
Tremor	47	0.07	20	0.03	2.33 (1.38–3.93)
Dizziness	50,191	74.81	22,088	33.60	2.23 (2.19–2.27)
Headache	82,328	122.71	36,386	55.35	2.22 (2.19–2.25)
Paraesthesia	238	0.35	109	0.17	2.06 (1.64–2.58)
Syncope	53	0.08	32	0.05	1.60 (1.03–2.48)
Hypoaesthesia	144	0.21	94	0.14	1.50 (1.16–1.95)
Seizure	447	0.67	384	0.58	1.16 (1.01–1.33)
Paralysis	2,180	3.25	2,290	3.48	0.93 (0.88–0.99)
Respiratory, thoracic and mediastinal disorders (n = 11)					
Rhinorrhoea	101	0.15	13	0.02	7.50 (4.21–13.36)
Nasal congestion	32	0.05	9	0.01	5.00 (2.39–10.47)
Oropharyngeal pain	181	0.27	37	0.06	4.50 (3.16–6.41)
Hyperventilation	29	0.04	5	0.01	4.00 (1.55–10.33)
Bronchospasm	532	0.79	162	0.25	3.16 (2.65–3.77)
Laryngospasm	347	0.52	109	0.17	3.06 (2.47–3.79)
Laryngeal oedema	23	0.03	4	0.01	3.00 (1.04–8.67)
Cough	163	0.24	60	0.09	2.67 (1.99–3.59)
Wheezing	649	0.97	301	0.46	2.11 (1.84–2.42)
Dyspnoea	1,592	2.37	1,092	1.66	1.43 (1.32–1.54)
Acute respiratory distress syndrome	538	0.80	413	0.63	1.27 (1.12–1.44)
Skin and subcutaneous tissue disorders (n = 9)					
Skin disorder	389	0.58	136	0.21	2.76 (2.27–3.36)
Angioedema	110	0.16	38	0.06	2.67 (1.85–3.86)
Cutaneous vasculitis	86	0.13	34	0.05	2.60 (1.75–3.87)
Hyperhidrosis	48	0.07	23	0.03	2.33 (1.42–3.83)
Erythema	70	0.10	36	0.05	2.00 (1.34–2.99)
Rash	15,163	22.60	8,051	12.25	1.84 (1.79–1.89)
Urticaria	17,922	26.71	10,254	15.60	1.71 (1.67–1.75)
Pruritus	1,106	1.65	689	1.05	1.57 (1.43–1.73)
Erythema multiforme	136	0.20	99	0.15	1.33 (1.03–1.72)
Gastrointestinal disorders (n = 8)					
Dyspepsia	106	0.16	34	0.05	3.20 (2.17–4.71)
Vomiting	18,803	28.03	6,147	9.35	3.00 (2.91–3.09)
Epigastric discomfort	18	0.03	9	0.01	3.00 (1.35–6.68)
Nausea	42,221	62.93	14,354	21.84	2.88 (2.83–2.94)
Abdominal discomfort	64	0.10	28	0.04	2.50 (1.60–3.90)

(*continued on next page*)

Table 2 (*continued*)

Preferred Term (PT)	Female		Male		F/M ratio (95% CI)[a]
	COVID-19 vaccine-AE pair reports	Reporting rate	COVID-19 vaccine-AE pair reports	Reporting rate	
Abdominal pain	13,455	20.05	6,254	9.51	2.11 (2.05–2.17)
Abdominal pain upper	43	0.06	19	0.03	2.00 (1.17–3.43)
Diarrhoea	9,552	14.24	5,153	7.84	1.82 (1.76–1.88)
Cardiac disorders ($n = 7$)					
Tachycardia	55	0.08	18	0.03	2.67 (1.57–4.55)
Palpitations	582	0.87	287	0.44	1.98 (1.72–2.28)
Pericarditis	394	0.59	317	0.48	1.23 (1.06–1.43)
Cardiovascular disorder	1,760	2.62	2,202	3.35	0.78 (0.73–0.83)
Myocarditis	281	0.42	371	0.56	0.75 (0.64–0.88)
Myocardial infarction	14	0.02	42	0.06	0.33 (0.18–0.60)
Cardiac arrest	7	0.01	21	0.03	0.33 (0.14–0.78)
Musculoskeletal and connective tissue disorders ($n = 7$)					
Musculoskeletal chest pain	18	0.03	7	0.01	3.00 (1.25–7.18)
Arthralgia	4,375	6.52	1,901	2.89	2.26 (2.14–2.39)
Myalgia	78,902	117.60	36,838	56.04	2.10 (2.07–2.13)
Muscular weakness	51	0.08	26	0.04	2.00 (1.25–3.21)
Arthritis	4,778	7.12	2,382	3.62	1.97 (1.88–2.07)
Back pain	51	0.08	34	0.05	1.60 (1.04–2.47)
Pain in extremity	74	0.11	46	0.07	1.57 (1.09–2.27)
Immune system disorders ($n = 5$)					
Anaphylactoid reaction	2,268	3.38	745	1.13	2.99 (2.75–3.25)
Immunisation reaction	74	0.11	34	0.05	2.20 (1.47–3.30)
Hypersensitivity	64,903	96.74	34,854	53.02	1.82 (1.80–1.84)
Anaphylactic reaction	499	0.74	319	0.49	1.51 (1.31–1.74)
Vaccine associated enhanced disease	1,420	2.12	1,003	1.53	1.39 (1.28–1.51)
Blood and lymphatic system disorders ($n = 4$)					
Lymphadenitis	5,689	8.48	2,360	3.59	2.36 (2.25–2.48)
Lymphadenopathy	38	0.06	22	0.03	2.00 (1.18–3.38)
Thrombocytopenic purpura	1,168	1.74	631	0.96	1.81 (1.64–1.99)
Coagulopathy	299	0.45	220	0.33	1.36 (1.14–1.62)
Vascular disorders ($n = 4$)					
Lymphoedema	19	0.03	4	0.01	3.00 (1.02–8.82)
Capillary leak syndrome	53	0.08	20	0.03	2.67 (1.60–4.47)
Hypotension	31	0.05	12	0.02	2.50 (1.28–4.87)
Hypertension	49	0.07	27	0.04	1.75 (1.09–2.80)
Infections and infestations ($n = 3$)					
Injection site abscess	619	0.92	168	0.26	3.54 (2.99–4.20)
Cellulitis	5,416	8.07	1,525	2.32	3.48 (3.29–3.68)
COVID-19	314	0.47	197	0.30	1.57 (1.31–1.88)
Psychiatric disorders ($n = 2$)					
Mood swings	25	0.04	5	0.01	4.00 (1.53–10.45)
Listless	18	0.03	9	0.01	3.00 (1.35–6.68)
Investigations ($n = 1$)					
Blood pressure increased	42	0.06	10	0.02	3.00 (1.51–5.98)
Injury, poisoning and procedural complications ($n = 1$)					
Contusion	253	0.38	96	0.15	2.53 (2.00–3.20)
Metabolism and nutrition disorders ($n = 1$)					
Cachexia	215	0.32	60	0.09	3.56 (2.67–4.74)
Eye disorders ($n = 1$)					
Visual impairment	27	0.04	14	0.02	2.00 (1.05–3.81)

Reporting rates were calculated as the number of reported COVID-19 vaccine-AE pairs per 100,000 vaccine doses administered. COVID-19 vaccination data were obtained from the Korea Disease Control and Prevention Agency. Between February 26, 2021, and December 31, 2022, a total of 67,093,500 females and 65,732,676 males received COVID-19 vaccinations.

[a] The female-to-male (F/M) ratio were calculated by dividing the reporting rate for females by that for males. AE=adverse event. CI=confidence interval.

higher AE reporting rates were observed in 36 PTs for females and in 8 PTs for males (Supplementary Table 5). Most findings were consistent with the main analysis; however, several exceptions were observed. For instance, encephalopathy, which was not statistically significant in the main analysis, was reported more frequently by older males. Additionally, although dyspnoea, acute respiratory distress syndrome, and COVID-19 were more commonly reported by females in the main analysis, they were reported more frequently by males in this age group.

Discussion

This study offers a comprehensive analysis of sex differences in AE reporting following COVID-19 vaccination in South Korea, using data from the national pharmacovigilance system. Females reported significantly higher rates of AEs across nearly all anatomical or physiological systems, as well as specific medical conditions. Conversely, males were more likely to report SAEs, including life-threatening conditions and death. These findings were consistent across all age groups, underscoring the need for more granular vaccine safety surveillance that considers sex differences.

Females reported AEs at significantly higher rates than males across 17 SOCs, suggesting that biological sex differences may contribute to these disparities. Sex-based factors such as hormonal variations, immune responses, and genetic expression are known to play a critical role in vaccine-related AEs [21,22]. Estrogen, which is more prevalent in females, is known to enhance immune responses and may increase the likelihood of experienc-

Table 3
Sex differences in serious AE reporting rates for COVID-19 vaccines.

Serious adverse event	Female		Male		F/M ratio (95% CI)[a]
	COVID-19 vaccine-AE pair reports	Reporting rate	COVID-19 vaccine-AE pair reports	Reporting rate	
Prolonged hospitalization	24,724	36.85	14,876	22.63	1.63 (1.60–1.66)
Other unspecified clinical intervention	918	1.37	642	0.98	1.40 (1.27–1.55)
Persistent or significant disability	211	0.31	195	0.30	1.03 (0.88–1.25)
Life-threatening condition	226	0.34	295	0.45	0.76 (0.64–0.90)
Death	1,088	1.62	1,989	3.03	0.53 (0.49–0.57)
Congenital anomaly	0	0	1	0	–

Reporting rates were calculated as the number of reported COVID-19 vaccine-AE pairs per 100,000 vaccine doses administered. COVID-19 vaccination data were obtained from the Korea Disease Control and Prevention Agency. Between February 26, 2021, and December 31, 2022, a total of 67,093,500 females and 65,732,676 males received COVID-19 vaccinations.

[a] The female-to-male (F/M) ratio were calculated by dividing the reporting rate for females by that for males. AE=adverse event. CI=confidence interval.

ing and reporting mild to moderate AEs. In contrast, testosterone, predominant in males, has immunosuppressive effects, potentially leading to weaker vaccine responses but greater susceptibility to severe outcomes from both infections and vaccine-related reactions [5]. Moreover, females are often more aware of faint or diffuse bodily stimuli that might go unnoticed by males [23]. This heightened symptom sensitivity may partly stem from life experiences unique to females—such as menstruation, pregnancy, menopause, and lactation—that routinely draw attention to physiological changes [24].

While this study was limited to biological sex as recorded in KAERS, the observed disparities may, at least in part, be shaped by gender-related factors. Gender, shaped by social roles and identities associated with being categorized as a woman or a man, plays a critical role in influencing individuals' symptom perception, healthcare-seeking behavior, and side effect reporting [7,25]. Previous research suggests that women tend to report a broader range of somatic symptoms with greater frequency, intensity, and quantity compared to men [25]. Women generally report AEs more frequently than men, as they are often more health-conscious, more likely to share health concerns with their acquaintances and have more frequent interaction with healthcare providers. Conversely, men's lower healthcare utilization may contribute to underreporting of AEs [26,27]. Furthermore, the interaction between sex and gender influences health outcomes by shaping environmental and occupational risks, risk-taking behaviors, and access to and use of healthcare [28]. A sex- and gender-informed approach to research has already proven effective in improving patient outcomes in fields such as cardiovascular disease [29]. Understanding how both sex and gender influence vaccine safety is essential for developing more responsive public health strategies and ensuring equitable safety monitoring.

Genetic and cultural factors specific to the Korean population may contribute to the observed sex differences in AE reporting following COVID-19 vaccination. Previous studies have demonstrated that human leukocyte antigen (HLA) alleles are associated with AEs after mRNA-based COVID-19 vaccination [30–32]. In the Korean population, HLA-A and HLA-DRB1 alleles are widely distributed, with HLA-A*24:02 and HLA-DRB1*09:01 showing especially high frequencies [33]. These findings suggest that an underlying genetic background may influence individual susceptibility to AEs following COVID-19 vaccination. In addition to genetic factors, cultural influences may also play a significant role in shaping sex-specific reporting rates. In many Asian cultural contexts, the concept of "face" significantly shapes individual behaviors and decisions, particularly in relation to emotional expression and health-related disclosures [34]. In Korea, this notion is embodied in chemyon, a culturally embedded construct that reflects an individual's social self-image and moral standing as perceived by others [35,36]. Chemyon is a relational construct that is deeply embedded in Confucian values emphasizing harmony, hierarchy, and group-oriented behavior [35,36]. Disclosing distress or adverse symptoms may be perceived as a loss of face, potentially seen not only as a personal weakness but also as bringing shame to one's family [37]. As a result, Korean men's willingness to report symptoms or seek help may be limited by various sociocultural factors, including concerns about losing face and conformity to traditional masculine norms. These factors suggest that Korea's sociocultural context may intensify sex-specific differences in AE reporting.

Our findings suggest additional sex-specific patterns of AE reporting that may be specific to the Korean population. A review of experimental and observational studies on COVID-19 vaccine safety identified seven studies that reported sex-specific risks, generally indicating higher risks among females. In particular, typical local and systemic reactions—such as redness, swelling, and fever—as well as non-anaphylaxis allergic reactions were reported more frequently in females [9]. Likewise, prior international studies have consistently reported higher AE reporting rates among females, particularly in the categories of "General disorders and administration site conditions" (e.g., injection site pain, swelling) and "Skin and subcutaneous tissue disorders" (e.g., redness, dermatologic reactions) [38,39]. By contrast, our analysis showed that females reported AEs at approximately threefold the rate of males in the SOCs "Infections and infestations," "Psychiatric disorders," and "Metabolism and nutrition disorders." This pattern has not been consistently reported in international datasets. Such differences may reflect population-specific characteristics, potentially driven by genetic, cultural, or healthcare system factors.

This study provides key information to inform Korean vaccine policy, highlighting the importance of implementing sex-stratified safety monitoring systems, risk communication strategies, and clinical guidelines tailored to the specific needs of the Korean population. The consistently higher rates of AE reporting among females, particularly in categories such as infections and infestations, psychiatric disorders, and metabolism and nutrition disorders, indicate a need for more focused post-vaccination monitoring and follow-up in female populations. Conversely, the higher reporting rates of cardiac disorders among males underscore the importance

of targeted surveillance for serious AEs in male recipients. Collectively, these findings support the development of more precise, equitable, and population-responsive vaccine safety strategies in Korea.

Although our analysis focused exclusively on COVID-19 vaccines, the observed sex differences in AE reporting may not be unique to this vaccine type. Previous studies using the KAERS database have shown a consistent pattern of female predominance in AE reporting across various drug classes. For example, Park et al. (2021) examined AEs related to cardiovascular drugs and found that females had a significantly higher overall reporting rate than males [40]. Similarly, Joung et al. (2020) analyzed AE reports associated with antidiabetic drugs and reported higher reporting rates among females in the majority of SOCs [41]. These findings suggest that the higher frequency of AE reporting among females is not specific to COVID-19 vaccines, but rather reflects a consistent trend observed across spontaneous pharmacovigilance data involving various therapeutic areas.

This study is among the first to provide a comprehensive analysis of sex differences in AE reporting rates following COVID-19 vaccination in South Korea during the pandemic. A major methodological strength is the use of national vaccine administration data from the KDCA, which enabled the calculation of AE reporting rates per 100,000 administered doses. This approach addresses a fundamental limitation of passive surveillance systems such as KAERS, namely the absence of denominator data, and enables more accurate comparisons of AE reporting rates between sexes. Furthermore, by disaggregating AEs at both the SOC and PT levels, the study provides a more granular understanding of sex differences in vaccine safety reporting. This analytical framework integrates national vaccine administration data with pharmacovigilance reports and applies sex-specific analyses of vaccine-related AEs at both broad and detailed levels, based on MedDRA classifications. In doing so, it offers a practical basis for supporting more equitable vaccine safety policies and informing sex-responsive public health interventions. Moreover, these findings are particularly relevant for enhancing targeted safety surveillance and refining evidence-based monitoring strategies that account for sex-related disparities.

However, several limitations should be acknowledged. First, as a voluntary reporting system, KAERS is subject to reporting bias, as individuals with more severe symptoms or better access to healthcare may be more likely to report AEs. Second, this study did not include data from the COVID-19 Vaccination Management System (CVMS), a web-based passive vaccine safety surveillance system operated by the KDCA. Under the Infectious Disease Control and Prevention Act, physicians and forensic pathologists are required to report all AEs following immunization to the CVMS [42]. The absence of CVMS data may have led to an underrepresentation of clinically confirmed or severe events. Integrating data from both systems in future studies would provide a more complete assessment of vaccine safety. Third, because the study population consisted exclusively of South Koreans, the findings may not be generalizable to other populations, due to potential differences in genetic, behavioral, and sociocultural factors. Fourth, the dataset lacked gender-related information, as it included only binary sex classifications. This limitation hindered the analysis of the effects of gender-related factors on AE reporting. To enable such analyses in the future, health data systems should include variables that capture both sex- and gender-related constructs. For example, distinguishing between sex (as a biological characteristic) and gender (as an identity), and collecting data on both sex assigned at birth and current gender identity, can facilitate more accurate and comparable analyses. In practice, this also requires vaccine developers, regulatory agencies, and public health authorities to systematically disaggregate safety data by sex and gender to support more inclusive, equitable, and evidence-informed monitoring. Fifth, like all passive surveillance systems, KAERS cannot establish causality. The frequencies reported here do not represent the actual incidence or risk of AEs. To strengthen causal inference and complement these findings, further studies using prospective cohort designs are needed. Finally, the KAERS database lacks information on the number of COVID-19 vaccine doses each individual received. As a result, stratifying AE reports by vaccine dose number was not feasible in this study. To address this limitation, future research could leverage linked datasets that integrate individual-level vaccination records with pharmacovigilance data, thereby enabling more detailed and dose-specific safety assessments. Such analyses could provide insights into dose-dependent sex differences, temporal patterns, and risk stratification.

In conclusion, females consistently demonstrated higher AE reporting rates following COVID-19 vaccination across most clinical categories, particularly for infections and infestations, psychiatric disorders, and metabolism and nutrition disorders. In contrast, males showed higher reporting rates only in the cardiac disorders category and for SAEs. These sex differences were observed across all age groups, highlighting biological factors that influence vaccine safety outcomes. Recognizing and accounting for these disparities may help clinicians provide better counseling and managing vaccine-related AEs more effectively. Moreover, it is essential to consider sex differences throughout the entire vaccine lifecycle, including development, clinical trial design, and post-marketing surveillance, to enhance vaccine safety, foster public trust, and promote transparency.

Author contributions

J.A.K. conceptualized the study, conducted the data analysis, produced the figures and tables, and drafted the initial manuscript. J.A.K., S.P., and H.C. obtained resources. J.A.K. and H.C. had primary responsibility for the integrity and accuracy of the data. All authors contributed to the investigation and participated in manuscript writing, including review and editing. All authors were involved in data interpretation. N.K.C. reviewed the manuscript and obtained the funding. All authors had full access to the data and had final responsibility for the decision to submit for publication.

Data sharing

The data underlying this study cannot be shared publicly due to the ethical and privacy policies of the Korea Institute of Drug Safety and Risk Management. The data will be shared upon reasonable request to the corresponding author.

Ethical approval

This study was approved by the Institutional Review Board of Ewha Womans University (IRB No.: ewha-202411-0041-01).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This work was supported by a grant [22183MFDS433 and RS2024-00332011] from Ministry of Food and Drug Safety, as well as by Korea Center for Gendered Innovations for Science and Technology research [WISET202503GI01]. We acknowledge Korea Institute of Drug Safety and Risk Management for providing access to the Korea Adverse Event Reporting System Database (KAERS-DB) for this study.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijid.2025.108107.

References

[1] Green MS, Peer V, Magid A, Hagani N, Anis E, Nitzan D. Gender differences in adverse events following the Pfizer-BioNTech COVID-19 vaccine. *Vaccines (Basel)* 2022;**10**(2):233. doi:10.3390/vaccines10020233.

[2] Mevorach D, Anis E, Cedar N, Bromberg M, Haas EJ, Nadir E, et al. Myocarditis after BNT162b2 mRNA vaccine against covid-19 in Israel. *N Engl J Med* 2021;**385**(23):2140–9. doi:10.1056/NEJMoa2109730.

[3] Bozkurt B, Kamat I, Hotez PJ. Myocarditis with COVID-19 mRNA vaccines. *Circulation* 2021;**144**(6):471–84. doi:10.1161/CIRCULATIONAHA.121.056135.

[4] Xiong X, Yuan J, Li M, Jiang B, Lu ZK. Age and gender disparities in adverse events following COVID-19 vaccination: real-world evidence based on big data for risk management. *Front Med* 2021;**8**:700014. doi:10.3389/fmed.2021.700014.

[5] Klein SL, Flanagan KL. Sex differences in immune responses. *Nat Rev Immunol* 2016;**16**(10):626–38. doi:10.1038/nri.2016.90.

[6] Klein SL, Jedlicka A, Pekosz A. The Xs and Y of immune responses to viral vaccines. *Lancet Infect Dis* 2010;**10**(5):338–49. doi:10.1016/S1473-3099(10)70049-9.

[7] Flanagan KL, Fink AL, Plebanski M, Klein SL. Sex and gender differences in the outcomes of vaccination over the life course. *Annu Rev Cell Dev Biol* 2017;**33**:577–99. doi:10.1146/annurev-cellbio-100616-060718.

[8] Brady E, Nielsen MW, Andersen JP, Oertelt-Prigione S. Lack of consideration of sex and gender in COVID-19 clinical studies. *Nat Commun* 2021;**12**(1):4015. doi:10.1038/s41467-021-24265-8.

[9] Vassallo A, Shajahan S, Harris K, Hallam L, Hockham C, Womersley K, et al. Sex and gender in COVID-19 vaccine research: substantial evidence gaps remain. *Front glob women's health* 2021;**2**:761511. doi:10.3389/fgwh.2021.761511.

[10] Harper A, Flanagan KL. Effect of sex on vaccination outcomes: important but frequently overlooked. *Curr Opin Pharmacol* 2018;**41**:122–7. doi:10.1016/j.coph.2018.05.009.

[11] Spagnolo PA, Manson JE, Joffe H. Sex and gender differences in health: what the COVID-19 pandemic can teach Us. *Ann Intern Med* 2020;**173**(5):385–6. doi:10.7326/M20-1941.

[12] Choi NK, Park BJ. Adverse drug reaction surveillance system in Korea. *J Prev Med Public Health* 2007;**40**(4):278–84. doi:10.3961/jpmph.2007.40.4.278.

[13] Shin JY, Jung SY, Ahn SH, Lee SH, Kim SJ, Seong JM, et al. New initiatives for pharmacovigilance in South Korea: introducing the Korea Institute of Drug Safety and Risk Management (KIDS). *Pharmacoepidemiol Drug Saf* 2014;**23**(11):1115–22. doi:10.1002/pds.3715.

[14] Ahn SH, Chung S, SY Jung, Shin JY, Park BJ. Awareness of adverse drug reaction reporting system in general population. *Health Policy Manag* 2014;**24**(2):164–71. doi:10.4332/KJHPA.2014.24.2.164.

[15] Korea Institute of Drug Safety & Risk Management (KIDS). Regional PV Center. Introduction of RPVC. https://www.drugsafe.or.kr/iwt/ds/ko/community/EgovCenterGuide.do [accessed 30 May 2025].

[16] Park BJ. Current status and improvement plans for the patient safety management system related to pharmaceuticals. *Health Insur Rev Assess Serv Res* 2014;**8**(5):16–26.

[17] Park JW. Past, Present, and future of korean regional drug safety center. *Pharmacoepidemiol Risk Manag* 2018;**10**:43–8.

[18] Kim JA, Lee HE, Kim J, Jang D, Choi NK. vaccination and social distancing policy during the COVID-19 Pandemic in South Korea. *Regul Res Food Drug Cosmet* 2023;**18**(2):123–34. doi:10.23049/FDCRS.2023.18.2.00123.

[19] Fescharek R, Kübler J, Elsasser U, Frank M, Güthlein P. Medical dictionary for regulatory activities (MedDRA): data retrieval and presentation. *Int J Pharm Med* 2004;**18**:259–69. doi:10.2165/00124363-200418050-00001.

[20] Korea Disease Control and Prevention Agency (KDCA). Adverse event trends in Korea. Immunizations. https://dportal.kdca.go.kr//pot/bbs/BD_selectBbsList.do?q_bbsSn=1018 [accessed 30 May 2025].

[21] Soldin OP, Mattison DR. Sex differences in pharmacokinetics and pharmacodynamics. *Clin Pharmacokinet* 2009;**48**(3):143–57. doi:10.2165/00003088-200948030-00001.

[22] Schwartz JB. The influence of sex on pharmacokinetics. *Clin Pharmacokinet* 2003;**42**(2):107–21. doi:10.2165/00003088-200342020-00001.

[23] Verbrugge LM. Sex differences in complaints and diagnoses. *J Behav Med* 1980;**3**(4):327–55. doi:10.1007/BF00845289.

[24] Verbrugge LM. Sex differentials in health. *Public Health Rep* 1982;**97**(5):417–37.

[25] Barsky AJ, Peekna HM, Borus JF. Somatic symptom reporting in women and men. *J Gen Intern Med* 2001;**16**(4):266–75. doi:10.1046/j.1525-1497.2001.00229.x.

[26] Al Meslamani AZ. Adverse drug event reporting among women: uncovering disparities in underserved communities. *Expert Opin Drug Saf* 2024;**23**(5):543–5. doi:10.1080/14740338.2024.2337745.

[27] Bertakis KD, Azari R, Helms LJ, Callahan EJ, Robbins JA. Gender differences in the utilization of health care services. *J Fam Pr* 2000;**49**(2):147–52.

[28] Heidari S, Babor TF, De Castro P, Tort S, Curno M. Sex and Gender Equity in Research: rationale for the SAGER guidelines and recommended use. *Res Integr Peer Rev 1* 2016;**1**:2. doi:10.1186/s41073-016-0007-6.

[29] Bartz D, Chitnis T, Kaiser UB, Rich-Edwards JW, Rexrode KM, Pennell PB, et al. Clinical advances in sex- and gender-informed medicine to improve the health of all: a review. *JAMA Intern Med* 2020;**180**(4):574–83. doi:10.1001/jamainternmed.2019.7194.

[30] Zheng K, Chong AY, Mentzer AJ. How could our genetics impact COVID-19 vaccine response? *Expert Rev Clin Immunol* 2024;**20**(9):1027–39.

[31] Bolze A, Neveux I, Barrett KMS, White S, Isaksson M, Dabe S, et al. HLA-A∗03: 01 is associated with increased risk of fever, chills, and stronger side effects from Pfizer-BioNTech COVID-19 vaccination. *Hum Genet Genom Adv* 2022;**3**(2).

[32] Nogawa S, Kanamori H, Tokuda K, Kawafune K, Chijiiwa M, Saito K, et al. A web-based genome-wide association study reveals the susceptibility loci of common adverse events following COVID-19 vaccination in the Japanese population. *Sci Rep* 2023;**13**(1):20820.

[33] Han HK, Kim MH, JEONG SS, KIM DK, KIM Y, HWANG JY, et al. A comprehensive analysis of HLA-A and HLA-DR allele frequencies and haplotype associations in a Korean population of 790 individuals. *Korean J Clin Lab Sci* 2024;**56**(3):236–47.

[34] Shea M, Yeh CJ. Asian American students' cultural values, stigma, and relational self-construal: correlates of attitudes toward professional help seeking. *J Ment Health Couns* 2008;**30**(2):157–72.

[35] Markus HR, Kitayama S. Culture and the self: implications for cognition, emotion, and motivation. *Psychol Rev* 1991;**98**(2):224–53.

[36] Choi SC, Lee SJ. Two-component model of chemyon-oriented behaviors in Korea: constructive and defensive chemyon. *J Cross Cult Psychol* 2002;**33**(3):332–45.

[37] Kim S, Kim D. Mental health help-seeking among Korean men: the influence of stigma, masculine norms, and face. *BMC Psychol* 2025;**13**(1):1–12.

[38] Laurini GS, Montanaro N, Broccoli M, Bonaldo G, Motola D. Real-life safety profile of mRNA vaccines for COVID-19: an analysis of VAERS database. *Vaccine* 2023;**41**(18):2879–86.

[39] Al-Qazaz HK, Al-Obaidy LM, Attash HM. COVID-19 vaccination, do women suffer from more side effects than men? A retrospective cross-sectional study. *Pharm Pr* 2022;**20**(2):2678. doi:10.18549/PharmPract.2022.2.2678.

[40] Park HH, Kim JH, Yoon D, Lee H, Shin JY. Gender differences in the adverse events associated with cardiovascular drugs in a spontaneous reporting system in South Korea. *Int J Clin Pharm* 2021;**43**(4):1036–44.

[41] Joung KI, Jung GW, Park HH, Lee H, Park SH, Shin JY. Gender differences in adverse event reports associated with antidiabetic drugs. *Sci Rep* 2020;**10**(1):17545.

[42] Korea Disease Control and Prevention Agency (KDCA). Adverse event management guidelines following COVID-19 vaccination. 2-2th ed. https://www.kdca.go.kr/board/boardApi.es?mid=a20507050000&bid=0080 [accessed 23 June 2025].