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Original Article

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Trends of clinical trials from 2017 to 2019 in Korea: an integrated analysis based on the Ministry of Food and Drug Safety (MFDS) and the Clinical Research Information Service (CRIS) registries

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ABSTRACT

Public disclosure of approved clinical trials in a reliable registry can provide the transparency of the study. Although the registration of clinical trials has increased remarkably, the integrity of the data is not always satisfactory. In this study, we analyzed public clinical trial databases updated by the Ministry of Food and Drug Safety (MFDS) and Clinical Research Information Service (CRIS) registry to provide an overview of the trends of clinical trials approved between 2017 and 2019 in Korea. Information on clinical trials approved between January 1, 2017 and December 31, 2019 was collected from two databases. Trial information was categorized and summarized by study phase, therapeutic area, and location of the participating centers. A total of 655 to 715 clinical trials were newly approved annually by MFDS during the period from 2017 to 2019. Phase 1 clinical trials accounted for the largest proportion (31.0%), followed by phase 3 (29.5%), investigator-initiated trials (24.1%), phase 2 (14.6%), and phase 4 (0.5%). The number of clinical trials classified as an *Antineoplastic and immunomodulating agent* was the greatest (40.1%) regardless of the study phase. The similar result was obtained from CRIS registry where therapeutic area *Neoplasms* (15.9%) accounted for the largest number. The number of clinical trials performed in Seoul and Gyeonggi-do was approximately 70% of the total trials. In conclusion, our study provided a comprehensive overview of clinical trials in Korea from 2017 to 2019. The discrepancy between clinical trial registries could be resolved by introducing standardized database and guidelines.

Keywords: Clinical trial; Therapeutics; Registries; Geographic Locations

Author Contributions

Conceptualization: Huh KY, Kim H; Data curations: Huh KY, Kim H; Formal analysis: Huh KY, Kim H; Methodology: Huh KY; Investigation: Huh KY, Yu KS, Lim HS, Kim H; Validation: Huh KY, Yu KS, Lim HS; Writing - original draft: Huh KY, Kim H; Writing - review & editing: Yu KS, Lim HS, Kim H.

INTRODUCTION

Prospective registration of clinical trials enables unbiased reporting of the results and ensures transparency [1]. Since 2004, the International Committee of Medical Journal Editors (ICMJE) has required the registration of clinical trials in a public registry as a condition for publication [2]. Since then, prospective registration of clinical trials has increased remarkably [3] and has been accelerated by the legal mandates of registration by regulatory bodies including the United States [4].

Although the number of clinical trials in public registries has increased, the quality of the data in the registries still needs improvement [5]. A worldwide survey of clinical trial registries pointed out that a considerable number of trials missed important information and often was outdated while retrospective registration accounted for a fourth of the total trials [3]. Similar results were reported in a recent study that only 37% of trials were registered in a prospective manner, among which, only 31% of the trials provided study results [6].

In particular, phase 1 clinical trials, which often involve healthy volunteers, have several complicated concerns. Submission of results from phase 1 clinical trials is not mandatory as the trial is not considered as an applicable clinical trial under the Food and Drug Administration Amendments Act [7]. This could make phase 1 clinical trials more vulnerable to biases. Another concern is the overlapping enrollment of healthy volunteers [8] which necessitates sophisticated tracking of phase 1 clinical trials [9].

In Korea, two local databases provide fundamental information on clinical trials. The public database of the Ministry of Food and Drug Safety (MFDS) frequently updates information on the approved clinical trials, and the other is a local clinical trial registry named Clinical Research Information Service (CRIS) [10]. MFDS has provided the approval status of clinical trials, and made registration for the database mandatory since 2019 [11]. CRIS was developed in February 2010 by Korea Centers for Disease Control and Prevention to support registration and report of the study results [10]. Both trial databases are not identical as the former provides all of the information on the clinical trials approved by the regulatory agency whereas the latter is one of the possible public trial registries accepted by ICMJE.

To provide a consistent overview of the approved clinical trials along with its counterpart study for years 2014–2016 [12], we analyzed the characteristics of clinical trials approved in terms of the study phase, therapeutic area, and geographic distribution. The previous study demonstrated an increasing trend of phase 1 clinical trials and a geographic imbalance in Korea. In the current analysis, we set up the study period as 2017–2019, which was prior to the first coronavirus disease 2019 (COVID-19) outbreak in Korea, to avoid the significant impact of COVID-19 on the clinical trial environment [13]. In addition, we newly included CRIS registry into analysis to promote the establishment of a harmonized clinical trial registry in Korea.

METHODS

Data collection

Two local data sources were used for the present analysis. Information on the clinical trials approved between January 1, 2017 and December 31, 2019 was collected from the public database provided by the MFDS (hereafter 'public database') [14]. Local registry data

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were obtained directly from the CRIS (hereafter 'local registry') [15]. The information was analyzed regardless of the current status of the clinical trial.

Categorization of the clinical trial data

The study phase information of the clinical trial data from the public database was categorized based on the investigational product (IP) in the clinical trial. Study phase was categorized similarly to the previous literature as follows: phase 1 (study phase noted as '0,' '1,' '1/2,' '1/2a' and '1/3'), phase 2 ('2,' '2a,' '2b' and '2/3'), phase 3 ('3,' '3a,' '3b' and '3/4'), phase 4, investigator-initiated trials, and 'Others' [12]. Information on the study phase from the local registry data was analyzed without any modifications.

Therapeutic area information of the clinical trial data was categorized based on the main IP and study indication in each clinical trial. When the IP code was not specified, other registry data such as *ClinicalTrial.gov* from the United States National Library of Medicine were consulted [16]. Otherwise, therapeutic area of the trial was coded as 'Others.' Each trial was labeled using the World Health Organization Anatomical Therapeutic Chemical (WHO-ATC) Classification System. Therapeutic area was manually labeled by two investigators in an independent manner. Information on the study phase and therapeutic area from the local registry data was analyzed without any modifications. Therapeutic area in the local registry was coded using the Korean Standard Classification of Diseases (KCD) code [17], which was a local version of the WHO International Classification of Diseases (ICD) code and was analyzed without any modifications.

Study center was grouped by province using clinical trial information from the public database because the local registry did not include all of the participating centers. The study center was counted individually for multicenter trials when counting the total number of clinical trials by province. Otherwise, a multicenter trial was counted as a single trial. Statistical software R version 4.0.3. (R Foundation for Statistical Computing, Vienna, Austria) was used for the analysis.

RESULTS

Summary of clinical trials according to study phase

As shown in **Table 1**, a total of 655 to 715 clinical trials were newly approved annually between 2017 and 2019. In detail, phase 1 clinical trials had the largest number, followed by phase 3, IIT, phase 2, and phase 4. The total number of multicenter clinical trials was relatively similar during the study period whereas single center trials increased in 2018 which was maintained in 2019 (**Table 1** and **Fig. 1**).

On the other hand, each phase of the clinical trials showed different trends. 2018 had the highest number of phase 1 clinical trials while phase 3 trials and IIT were the lowest during the same study period. The number of phase 2 clinical trials increased continuously during the period between 2017 and 2019. The number of phase 4 clinical trials was not more than 10 trials per year. Local registry data on study phase was mostly not specified (63.9%), and phase 2 clinical trials accounted for the largest proportion among the labeled data (12.0%) (**Table 1**).

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Table 1. Summary of clinical trials according to study phase and multicenter status

Study phase	Multi-center			Single center			Total			Total
	2017	2018	2019	2017	2018	2019	2017	2018	2019	
Public database (MFDS)										
1	74 (17.5)	80 (18.8)	69 (16.2)	104 (44.8)	170 (59.4)	149 (51.7)	178 (27.2)	250 (35.1)	218 (30.5)	646 (31.0)
2	80 (18.9)	87 (20.4)	101 (23.7)	9 (3.9)	13 (4.6)	13 (4.5)	89 (13.6)	100 (14.1)	114 (16.0)	303 (14.6)
3	203 (48.0)	185 (43.2)	196 (45.9)	4 (1.7)	13 (4.6)	13 (4.5)	207 (31.6)	198 (27.8)	209 (29.2)	614 (29.5)
4	2 (0.5)	4 (0.9)	1 (0.2)	0 (0.0)	3 (1.0)	0 (0.0)	2 (0.3)	7 (1.0)	1 (0.1)	10 (0.5)
IIT	64 (15.1)	69 (16.2)	54 (12.6)	115 (49.6)	87 (30.4)	113 (39.3)	179 (27.3)	156 (21.9)	167 (23.4)	502 (24.1)
Others	0 (0.0)	1 (0.2)	6 (1.4)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.1)	6 (0.8)	7 (0.3)
Total	423	426	427	232	286	288	655	712	715	2,082
Local registry (CRIS)										
1							32 (9.9)	49 (8.0)	74 (8.2)	155 (8.4)
2							11 (3.4)	73 (12.0)	137 (15.1)	221 (12.0)
3							20 (6.2)	34 (5.6)	55 (6.1)	109 (5.9)
4							27 (8.4)	62 (10.2)	90 (9.9)	179 (9.7)
Not specified							233 (72.1)	392 (64.3)	551 (60.7)	1,176 (63.9)
Total							323	610	907	1,840

Results are displayed as the number of clinical trials (percentage).
MFDS, Ministry of Food and Drug Safety; IIT, Investigator-initiated trials; CRIS, Clinical Research information Service.

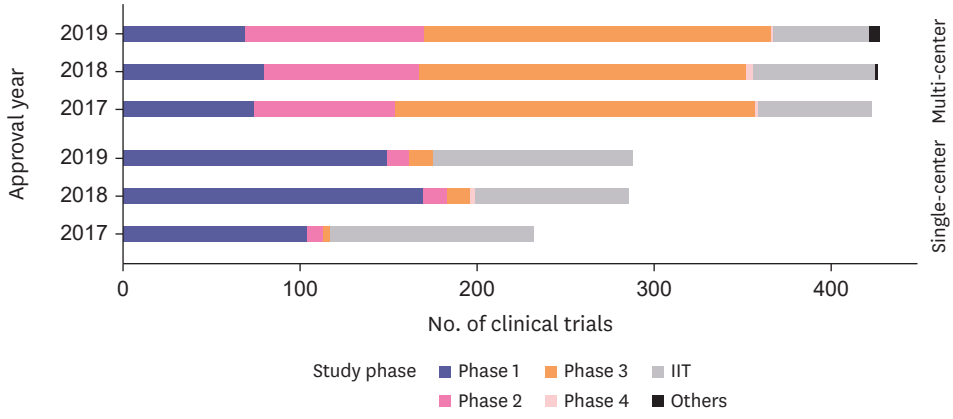

Figure 1. The number of clinical trials according to study phase and approval year (Ministry of Food and Drug Safety). IIT, investigator-initiated trials.

Summary of clinical trials according to therapeutic area

The greatest number of clinical trials was classified as an *Antineoplastic and immunomodulating agent* during the 2017–2019 period regardless of the study phase (**Table 2** and **Supplementary Fig. 1**). The second highest number of clinical trials was classified as *Alimentary tract and metabolism* area during the 2018 to 2019 period while the second highest number of clinical trials classified as *Nervous system* was in 2017. The number of trials in the *Cardiovascular system* area was similar during the 2017–2019 period. The number of clinical trials in the *Antiinfectives for systemic use* area decreased continuously while that of *dermatologicals* increased continuously from 2017 to 2019 (**Fig. 2**).

When the therapeutic area was classified as the KCD code, *Neoplasms* followed by *Diseases of the musculoskeletal system and connective tissue* and *Diseases of the nervous system* accounted for the largest number in the specified data (**Table 3** and **Fig. 3**).

Summary of clinical trials according to location

The number of clinical trials performed in Seoul and Gyeonggi-do occupied approximately 70% of the total number of the trials. The number of clinical trials conducted in Seoul

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Table 2. Summary of clinical trials according to therapeutic area from public database (MFDS)

Therapeutic area (Anatomical Therapeutic Chemical code)	2017	2018	2019	Total
Antineoplastic and immunomodulating agents	283 (43.2)	308 (43.3)	244 (34.1)	835 (40.1)
Alimentary tract and metabolism	55 (8.4)	111 (15.6)	129 (18.0)	295 (14.2)
Nervous system	61 (9.3)	49 (6.9)	68 (9.5)	178 (8.5)
Cardiovascular system	51 (7.8)	51 (7.2)	58 (8.1)	160 (7.7)
Antiinfectives for systemic use	44 (6.7)	39 (5.5)	32 (4.5)	115 (5.5)
Musculo-skeletal system	39 (6.0)	27 (3.8)	38 (5.3)	104 (5.0)
Blood and blood forming organs	38 (5.8)	29 (4.1)	35 (4.9)	102 (4.9)
Respiratory system	17 (2.6)	25 (3.5)	24 (3.4)	66 (3.2)
Genito-urinary system and sex hormones	16 (2.4)	22 (3.1)	17 (2.4)	55 (2.6)
Dermatologicals	9 (1.4)	17 (2.4)	28 (3.9)	54 (2.6)
Sensory organs	12 (1.8)	8 (1.1)	18 (2.5)	38 (1.8)
Various	9 (1.4)	8 (1.1)	17 (2.4)	34 (1.6)
Systemic hormonal preparations, excluding sex hormones	12 (1.8)	6 (0.8)	6 (0.8)	24 (1.2)
Others	9 (1.4)	12 (1.7)	1 (0.1)	22 (1.1)
Total	655	712	715	2,082

Results are displayed as the number of clinical trials (percentage).
MFDS, Ministry of Food and Drug Safety.

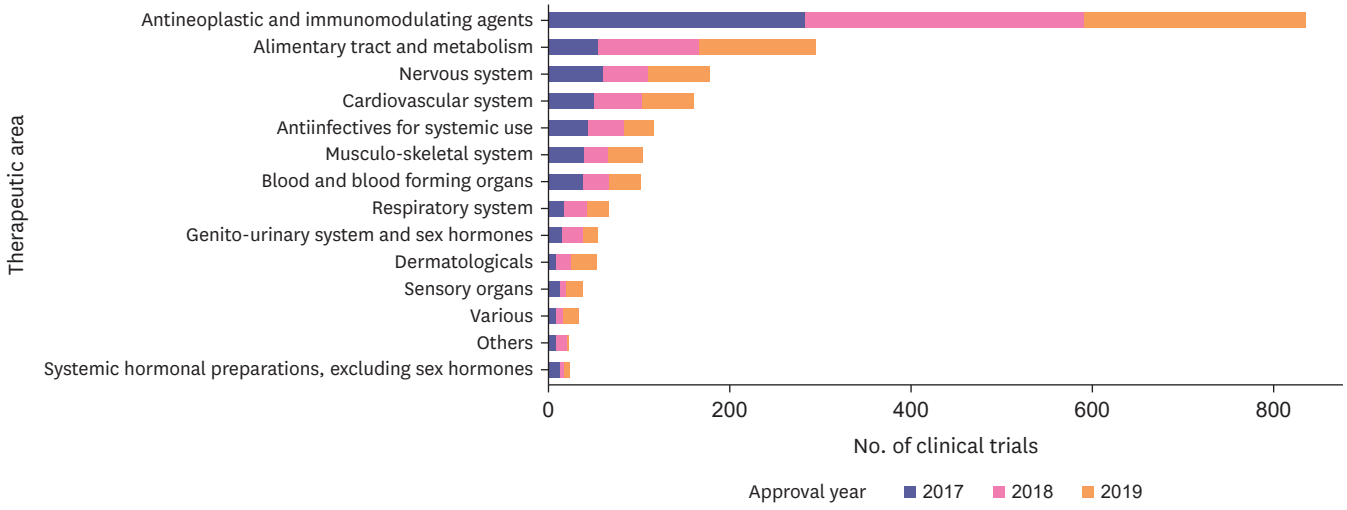

Figure 2. The number of clinical trials according to therapeutic area (Anatomical Therapeutic Chemical code) and approval year (Ministry of Food and Drug Safety).

accounted for more than half (52.6%) and that of Gyeonggi-do accounted for one third of the trials in Seoul (17.1%). The rest of the trials were conducted mostly in metropolitan areas such as Busan, Daegu, Incheon, and Daejeon (**Fig. 4** and **Table 4**).

DISCUSSION

We found that the overall number of clinical trials in Korea from 2017 to 2019 increased by 7.9% compared to previous three-year interval. The increase of phase 1 trials and IIT was another remarkable change, in contrast to the previous predominance of phase 3 trials. In terms of therapeutic area, the number of clinical trials in the *Antineoplastic and immunomodulating agent* area was still the largest as it was in the previous three years [12]. We also found a relative increase of trials in the *Alimentary tract and metabolism* area from 157 (8.0%) to 295 (14.2%).

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Table 3. Summary of clinical trials according to therapeutic area from local registry from local registry (CRIS)

Therapeutic area (Classification of Diseases code)	2017	2018	2019	Total
Neoplasms	27 (6.2)	132 (16.8)	224 (19.0)	383 (15.9)
Not specified	96 (22.1)	101 (12.8)	143 (12.1)	340 (14.1)
Diseases of the musculoskeletal system and connective tissue	76 (17.5)	116 (14.7)	144 (12.2)	336 (14.0)
Diseases of the nervous system	38 (8.7)	71 (9.0)	111 (9.4)	220 (9.2)
Diseases of the digestive system	39 (9.0)	77 (9.8)	97 (8.2)	213 (8.9)
Diseases of the circulatory system	21 (4.8)	73 (9.3)	81 (6.9)	175 (7.3)
Endocrine, nutritional and metabolic diseases	28 (6.4)	41 (5.2)	70 (5.9)	139 (5.8)
Diseases of the genitourinary system	14 (3.2)	37 (4.7)	68 (5.8)	119 (5.0)
Mental and behavioural disorders	22 (5.1)	25 (3.2)	47 (4.0)	94 (3.9)
Diseases of the respiratory system	17 (3.9)	26 (3.3)	37 (3.1)	80 (3.3)
Diseases of the eye and adnexa	14 (3.2)	15 (1.9)	18 (1.5)	47 (2.0)
Diseases of the skin and subcutaneous tissue	7 (1.6)	12 (1.5)	30 (2.5)	49 (2.0)
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	6 (1.4)	10 (1.3)	30 (2.5)	46 (1.9)
Symptoms, signs and abnormal clinical and laboratory findings, NEC	6 (1.4)	15 (1.9)	20 (1.7)	41 (1.7)
Factors influencing health status and contact with health services	6 (1.4)	9 (1.1)	15 (1.3)	30 (1.2)
Pregnancy, childbirth and the puerperium	7 (1.6)	6 (0.8)	10 (0.8)	23 (1.0)
Certain infectious and parasitic diseases	6 (1.4)	3 (0.4)	10 (0.8)	19 (0.8)
Injury, poisoning and certain other consequences of external causes	1 (0.2)	7 (0.9)	9 (0.8)	17 (0.7)
Codes for special purposes	2 (0.5)	3 (0.4)	6 (0.5)	11 (0.5)
Diseases of the ear and mastoid process	1 (0.2)	6 (0.8)	5 (0.4)	12 (0.5)
Certain conditions originating in the perinatal period	1 (0.2)	1 (0.1)	2 (0.2)	4 (0.2)
Congenital malformations, deformations and chromosomal abnormalities	0 (0.0)	1 (0.1)	2 (0.2)	3 (0.1)
External causes of morbidity and mortality	0 (0.0)	1 (0.1)	2 (0.2)	3 (0.1)
Total	435	788	1,181	2,404

Results are displayed as the number of clinical trials (percentage).
CRIS, Clinical Research information Service; NEC, not elsewhere classified.

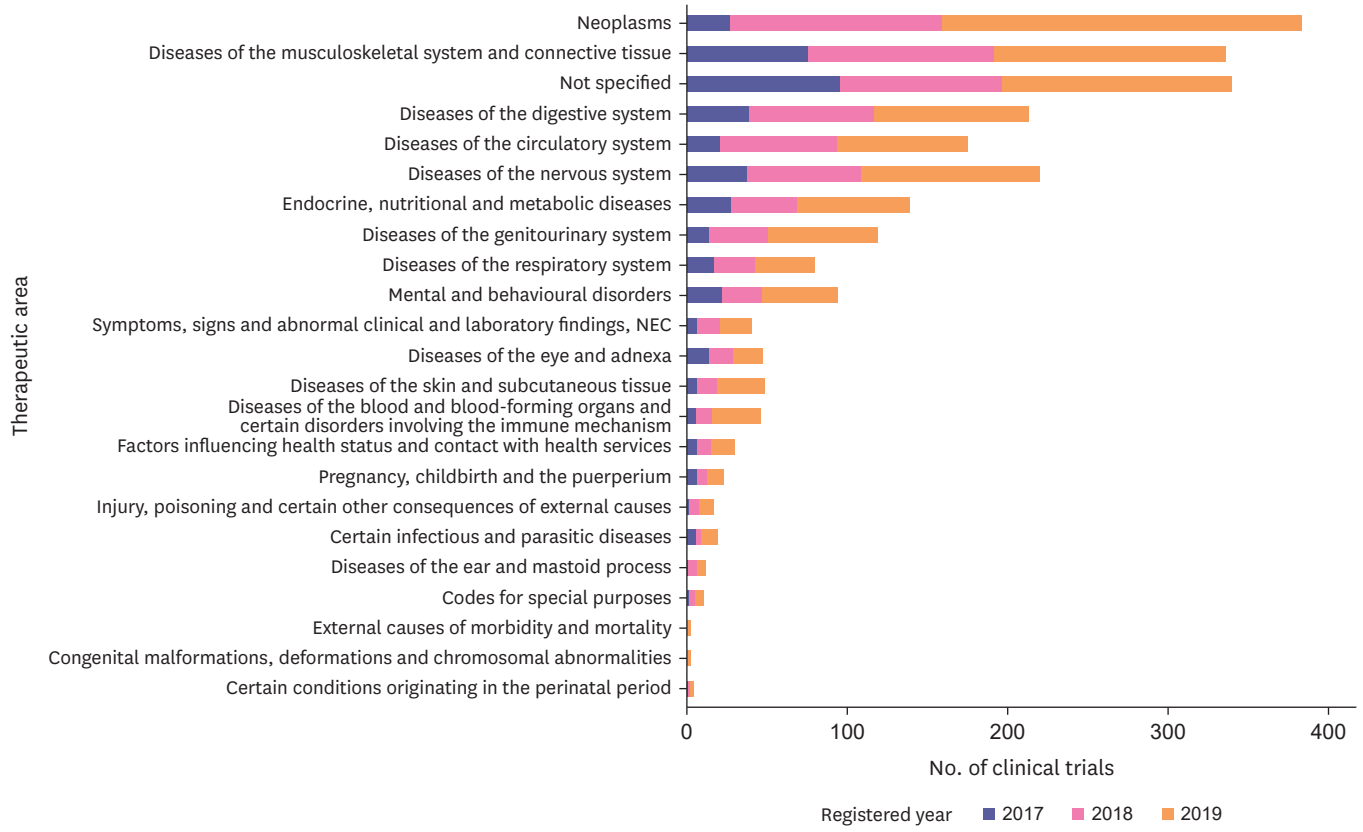

Figure 3. The number of clinical trials according to therapeutic area (Classification of Diseases code) and approval year (Clinical Research information Service).

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Table 4. Summary of clinical trials according to province and multicenter status from public database (MFDS)

Province	2017			2018			2019			Total
	Multi-center	Single center	Yearly total	Multi-center	Single center	Yearly total	Multi-center	Single center	Yearly total	
Seoul	1,860 (52.5)	142 (61.7)	2,002 (63.1)	1,610 (50.7)	189 (66.8)	1,799 (52.0)	1,730 (52.1)	162 (57.7)	1,892 (52.4)	5,693 (52.6)
Gyeonggi-do	626 (17.7)	18 (7.8)	644 (20.3)	556 (17.5)	35 (12.4)	591 (17.1)	590 (17.8)	31 (11.0)	621 (17.3)	1,856 (17.1)
Busan	200 (5.6)	22 (9.6)	222 (7.0)	226 (7.1)	5 (1.8)	231 (6.7)	196 (5.9)	3 (1.1)	199 (5.5)	652 (6.0)
Daegu	197 (5.6)	3 (1.3)	200 (6.3)	193 (6.1)	6 (2.1)	199 (4.6)	195 (5.9)	12 (4.3)	207 (5.7)	606 (5.6)
Incheon	163 (4.6)	12 (5.2)	175 (5.5)	152 (4.8)	6 (2.1)	158 (4.6)	134 (4.0)	15 (5.3)	149 (4.1)	482 (4.5)
Daejeon	105 (3.0)	9 (3.9)	114 (3.6)	65 (2.0)	14 (5.0)	79 (2.3)	75 (2.3)	15 (5.3)	90 (2.5)	283 (2.6)
Gangwon-do	96 (2.7)	3 (1.3)	99 (3.1)	68 (2.1)	2 (0.7)	70 (2.0)	69 (2.1)	1 (0.4)	70 (1.9)	239 (2.2)
Jeollabuk-do	41 (1.2)	13 (5.7)	54 (1.7)	49 (1.5)	17 (6.0)	66 (1.9)	58 (1.7)	13 (4.6)	71 (2.0)	191 (1.8)
Gwangju	59 (1.7)	2 (0.9)	61 (1.9)	47 (1.5)	4 (1.4)	51 (1.5)	63 (1.9)	5 (1.8)	68 (1.9)	180 (1.7)
Gyeongsangnam-do	49 (1.4)	3 (1.3)	52 (1.6)	46 (1.4)	1 (0.4)	47 (1.4)	60 (1.8)	7 (2.5)	67 (1.9)	166 (1.5)
Jeollanam-do	56 (1.6)	1 (0.4)	57 (1.8)	43 (1.4)	0 (0.0)	43 (1.2)	36 (1.1)	3 (1.1)	39 (1.1)	139 (1.3)
Chungcheongbuk-do	34 (1.0)	0 (0.0)	34 (1.1)	47 (1.5)	3 (1.1)	50 (1.4)	38 (1.1)	13 (4.6)	51 (1.4)	135 (1.2)
Ulsan	24 (0.7)	0 (0.0)	24 (0.8)	40 (1.3)	1 (0.4)	41 (1.2)	32 (1.0)	0 (0.0)	32 (0.9)	97 (0.9)
Chungcheongnam-do	27 (0.8)	1 (0.4)	28 (0.9)	24 (0.8)	0 (0.0)	24 (0.7)	32 (1.0)	1 (0.4)	33 (0.9)	85 (0.8)
Jeju-do	6 (0.2)	1 (0.4)	7 (0.2)	7 (0.2)	0 (0.0)	7 (0.2)	8 (0.2)	0 (0.0)	8 (0.2)	22 (0.2)
Gyeongsangbuk-do	2 (0.06)	0 (0.0)	2 (0.06)	1 (0.03)	0 (0.0)	1 (0.03)	3 (0.1)	0 (0.0)	3 (0.1)	6 (0.06)
Sejong	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.03)	0 (0.0)	1 (0.03)	1 (0.03)	0 (0.0)	1 (0.03)	2 (0.02)
Total	3,545	230	3,775	3,175	283	3,458	3,320	281	3,601	10,834

Results are displayed as the number of clinical trials (percentage).
MFDS, Ministry of Food and Drug Safety.

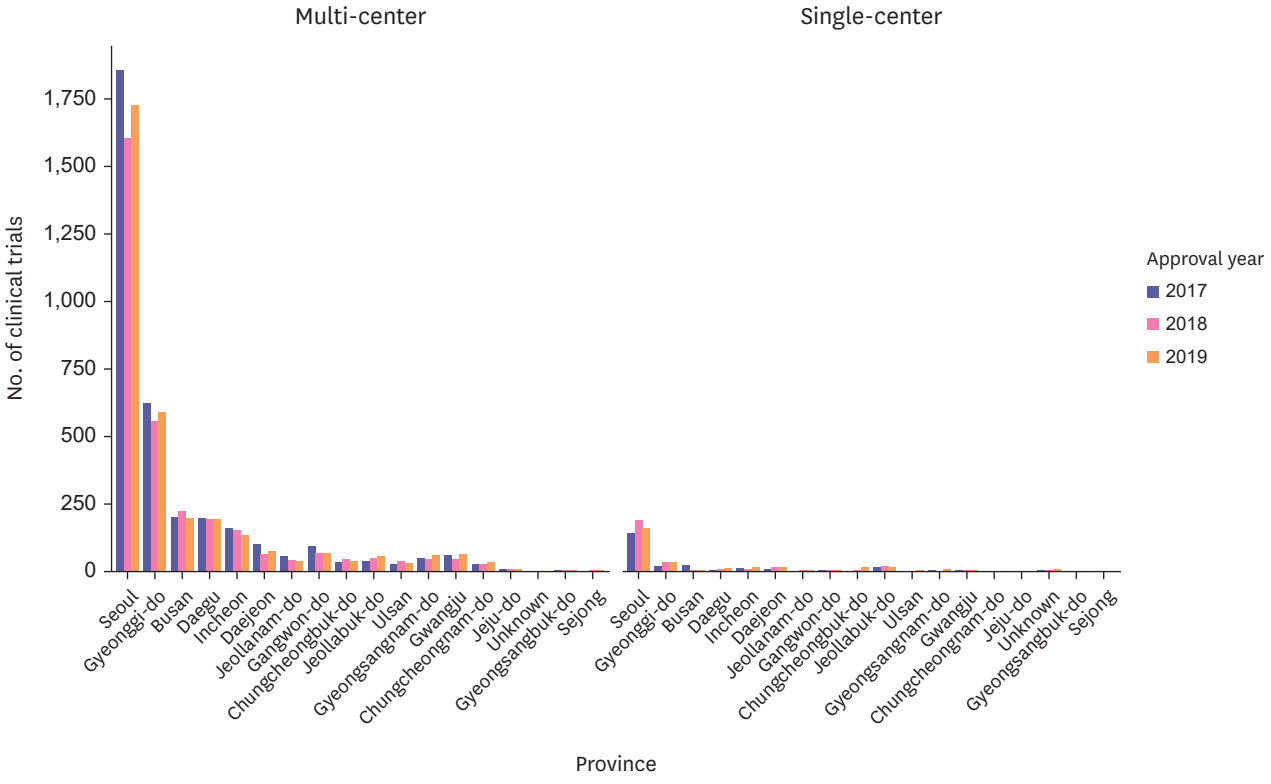

Figure 4. The number of clinical trials according to location of the study centers. The number of clinical trials was calculated separately for each center in multicenter trials (Ministry of Food and Drug Safety).

We noted that relative increase in the *Alimentary tract and metabolism* area was a distinctive trend compared to that in 2014–2016. Despite the increase in phase 1 clinical trials in 2014–2016, the proportion of the *Alimentary tract and metabolism* was constant. In contrast, the proportion of the area, where most trials were at phase 1 (**Supplementary Fig. 1**), almost doubled in

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2017–2019 (**Table 2**). We expected that increased development of several popular drug classes in the area (e.g., proton-pump inhibitors [18]) might contribute to the increase.

The predominance of phase 1 clinical trials was aligned with early-stage-focused development led by the domestic biopharmaceutical companies. In a review conducted by Korea National Enterprise for Clinical Trials (KoNECT), industry-sponsored domestic trials were mostly at phase 1; the ratio of phase 1, 2, and 3 trials was 6.7: 1.0: 1.3, respectively [19]. As more than half of the phase 1 trials were associated with fixed combination drugs or new formulations of marketed drugs in Korea [19], the trends of clinical trials could be influenced by several popular drug classes. Similarly, bioequivalence trials highly focused in several therapeutic areas were reported in another study [20].

The concentration of clinical trials in urban areas (e.g., Seoul metropolitan area) was a definite trend in Korea. Seoul occupied more than half of the entire trials (52.6%), similar to 53.5% in the previous report. Another study of oncology clinical trial conducted in Korea between 2007 and 2013 also reported that six large volume hospitals each conducted more than 50 clinical trials while 45% of study centers conducted less than 10 trials [21]. A study on the approved oncology trials in 2019 also revealed that 92% trials were available in Seoul while only 33% in provincial areas [22].

Similar phenomena have been addressed in the United States [23,24]. Volunteers in rural areas tended to participate in clinical trials significantly less than urban counterparts (odds ratio, 0.30–0.46) [24]. Furthermore, proximity to clinical sites were related to patient recruitment and retention. Thus, the geography of clinical trials needs to be taken into account when interpreting and generalizing the results of clinical trials [25].

We also found several discrepancies in the results by the clinical trial registries. For instance, the therapeutic area in *Musculo-skeletal system* ranked the 6th in the MFDS public database whereas it was 2nd (excluding 'not specified') in the CRIS registry. Discrepancies in other therapeutic areas and study phases were also noted, despite the differences in the coding systems (**Tables 2** and **3**). Especially, as shown in **Table 1**, most of the study phases (63.9%) were not specified in the CRIS registry.

The discrepancies and errors in the clinical trial registries have been continuously addressed. A cross-sectional study of registered trials in *ClinicalTrials.gov* and European Union Clinical Trials Register revealed that 16.2% of trials were discrepant on the completion status [26]. Another study regarding pediatric trials in a peer-reviewed journal found that 19 out 20 randomized-controlled trials had medium or high combined discrepancy scores [27]. Similar results were reported in other literature [28,29].

The results of this study indicate that a harmonized clinical trial registry with a regulatory database is necessary for proper evaluation of the clinical trial landscape. Since 2019, all applicants are required to register clinical trial information to the MFDS database [11]. Thus, all clinical trials approved by MFDS could be identifiable. The applicants are recommended to register the information to other public registries including CRIS and *ClinicalTrials.gov*. However, as there have been no mandates and guidelines for which public registry to choose, each trial could be filed to any registry even in a duplicated manner.

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Although the importance of clinical trial registries has been emphasized in a systemic review and meta-analysis [30], registry data have not been properly aligned with publications [31]. Furthermore, data are not often standardized. For example, a bioequivalence trial was previously classified as a separate entity in Korea; however, recently, bioequivalence trials are classified as phase 1 studies since October 2017 [32,33]. Similarly, therapeutic area can be coded with various systems including the WHO-ATC and ICD-11. Duplicate registration of clinical trials (e.g., CRIS and ClinicalTrials.gov) should also be avoided [34]. Without such efforts, an appropriate evaluation for the trends of clinical studies would be seriously hampered.

Overall, the results of our study could help to facilitate standardization and harmonization of the clinical trial registries. In this study, we revealed that evaluation of multiple registries was necessary due to discrepancies for overview of the clinical trials in Korea. Solutions for the discrepancy would comprise standardized database coupled with streamlined regulations. Technical integration with other global registries (e.g., *ClinicalTrials.gov*) could also be a possible solution.

Our study has some limitations. As several IPs under the early stage of drug development were yet assigned ATC codes, the therapeutic area should be assigned by subjective judgment of the investigators. The missing information in the registries limited precise analysis of the trends. Further investigations on the study design (e.g., blinding and randomization) need to be performed in future research.

In conclusion, our study provided a comprehensive overview of clinical trials in Korea between 2017 and 2019. The discrepancy between clinical trial registries could be resolved by introducing standardized database and guidelines.

SUPPLEMENTARY MATERIAL

Supplementary Figure 1

The number of clinical trials according to therapeutic area and study phase (Ministry of Food and Drug Safety).

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