Analysis of changes and trends in the use of sedatives in dental sedation using data from the National Health Insurance in Korea

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Background: Although dental sedation helps control anxiety and pain, side effects and serious complications related to sedation are gradually increasing. Due to the introduction of new drugs and sedation methods, insurance rates, legal regulations, drugs, and methods used for dental sedation are inevitably changed. In the Republic of Korea, National Health Insurance is applied to all citizens, and this study investigated changes in the use of sedatives using this big data.

Methods: This study used customized health information data provided by the Healthcare Insurance Review & Assessment Service of Korea. Among patients with a record of use of at least one of eight types of sedatives for dental sedation between January 2007 and September 2019 were selected; the data of their overall insurance claims for dental treatment were then analyzed.

Results: The number of patients who received dental sedation was 786,003, and the number of dental sedation cases was 1,649,688. Inhalational sedation using nitrous oxide (N_2O) accounted for 86.8% of all sedatives that could be claimed for drugs and treatment. In particular, it was confirmed that the number of requests for sedation using N_2O sharply increased each year. Midazolam showed an increasing trend, and in the case of chloral hydrate, it gradually decreased.

Conclusion: According to our analysis, the use of N_2O and midazolam gradually increased, while the use of chloral hydrate gradually decreased.

Keywords: Chloral Hydrate; Midazolam; National Health Insurance; Nitrous Oxide; Sedation.

INTRODUCTION

Anxiety and phobia of dental treatment are common and important factors that negatively influence treatment outcomes. In 1987, Weinstein et al. [1] reported that 6–14% of the total US population had dental phobia, and in 1995, Klingberg et al. [2] reported that dental phobia caused a lower frequency of dental visits and consequently worsened oral health problems. In 2016,

Appukuttan et al. [3] reported that avoidance of dental treatment due to dental phobia caused a vicious cycle of oral health problems. This shows the seriousness of the problem of dental phobia from the past to the present.

Dental sedation helps improve treatment outcomes by controlling anxiety and fear [4,5]. As awareness of the importance of satisfaction with dental treatment increases, the number of sedation cases in dental treatment also increases [6].

Sedation was mainly used for children and patients

with disability in the Republic of Korea, but its use has been steadily increasing in recent years due to changes in the medical insurance system, such as the insurance application of nitrous oxide (N_2O) [6]. According to a 2012 survey on dental sedation in the Republic of Korea, chloral hydrate, hydroxyzine, and midazolam were mainly used as oral sedatives, and midazolam and propofol were used as intravenous sedatives. N_2O was used as an inhalational sedative [7].

However, in the Republic of Korea, misuse of propofol and deaths due to deep sedation using chloral hydrate or sevoflurane in children have led to social problems. Therefore, with the enactment of the sedation guidelines by the Korean Dental Association (KDA), the use of this drug in dental sedation has not been recommended [8].

In the Republic of Korea, the National Health Insurance system was implemented as company medical insurance and regional insurance were integrated on July 1, 1989, and most Koreans (97.2%, as of April 2020) were enrolled in the National Health Insurance. Accordingly, all medical institutions providing medical care under the insurance had to fill in the records of medical treatment and medications performed on the medical expense claim statement and submit it to the Korean National Health Insurance Service (NHIS) [9]. The NIHS and the Health Insurance Review & Assessment (HIRA) Service secure data such as the medical history of all patients who received insurance treatment, disease codes, and claim codes. The accumulated insurance treatment information for all citizens is coded and provided by the HIRA in the form of big data, and many researchers are trying to obtain new results by analyzing it in various ways [10].

In this study, using big data for health and medical care, the trends related to the types of drugs used in dental sedation were investigated, and the characteristics of sedation by year and age were analyzed.

The data analyzed in this study reflect the current dental sedation situation and can be used as reference for future KDA and national dental policy establishment, as well as in dental educational institutions.

METHODS

1. Study design and population

This study received approval from the institutional review board of our institution (No. S-D20200006). The analysis data used in the study were customized health information data from the HIRA (approval No. M20191014119).

First, the payment data of patients at dental hospitals and dental clinics of eight types of representative drugs (chloral hydrate, hydroxyzine, midazolam, triazolam, propofol, sevoflurane, N_2O, and dexmedetomidine) that can be used for dental sedation were requested from the Healthcare Bigdata Hub (HBH) of HIRA. In addition, we requested all insurance claims data of patients who underwent dental sedation for additional analysis [11].

HIRA created several customized datasets of all patients included between January 2007 and September 2019 on a remotely accessible server. The datasets contained a general summary information dataset (200 table; pseudonym personal identification number [JID], treatment date, gender, age, pseudonym hospital identification number [YID], region, diagnosis), treatment dataset (300 table; treatment codes, procedure codes, drug codes, and treatment materials code), and diagnosis dataset (400 table; The International Classification of Diseases-10 codes), including unique identification codes for joining tables.

We analyzed customized datasets using the remote analysis system provided by the HBH. The program used for analysis was SAS Enterprise Guide, SAS Visual Analytics (version 9.4.2; SAS Institute Inc., USA). The analyzed and summarized data were exported to PC with HIRA approval.

2. Selection of each sedative drug case and general anesthesia (GA) exclusion method

After finding the cases in which at least one drug was claimed among the eight sedation drugs, if the patient's claim table (300 table) on the same date contained a GA

Table 1. Number of patients who received sedation, cases and percentage of cases by each sedative drug (from January 1, 2007, to September 30, 2019)

Type of sedative drugs	Number of patients	Number of cases	Percent of cases (%)
N_2O	641,197	1,432,102	86.81
Chloral hydrate	9,198	10,034	0.6
N_2O + chloral hydrate	25,675	27,930	1.69
Hydroxyzine	17,827	21,789	1.32
N_2O + hydroxyzine	12,799	15,970	0.96
Chloral hydrate + hydroxyzine	7,508	8,993	0.54
N_2O + chloral hydrate + hydroxyzine	41,107	48,838	2.96
Midazolam	37,098	41,662	2.52
N_2O + midazolam	13,798	17,246	1.04
Midazolam + chloral hydrate	327	349	0.02
N_2O + midazolam + chloral hydrate	4,787	5,118	0.31
Midazolam + hydroxyzine	89	94	< 0.01
N_2O + midazolam + hydroxyzine	184	202	0.01
Midazolam + hydroxyzine + chloral hydrate	4,075	4,615	0.27
N_2O + midazolam + chloral hydrate + hydroxyzine	7,918	8,723	0.52
Propofol	4,663	4,882	0.29
Propofol + midazolam	185	187	0.01
Sevoflurane	656	739	0.04
Sevoflurane + midazolam	70	73	< 0.01
Propofol + sevoflurane	134	142	< 0.01
Total	786,003	1,649,688	100

N_2O, nitrous oxide.

code (L121), it was separated into a GA case. In the case of sedation in the Republic of Korea, insurance claims for N_2O drug code have been possible since 2014; therefore, N_2O claims records before 2014 could not be found. However, the N_2O behavioral management code (U237) could be claimed, and the N_2O sedation record was searched for the U237 code. For dexmedetomidine, no case could be found because dexmedetomidine is currently treated as a new drug in Korea and insurance claims have not yet been made. Triazolam was excluded from the analysis because there were few cases in which it was used for dental sedation and insurance claims in the Republic of Korea.

In the case of midazolam, the insurance code distinguishes between solution form and oral tablet, but since midazolam tablets have not been sold in the market since 2013 in the Republic of Korea, midazolam solution is often administered orally, so the authors did not separate them for analysis. In addition, since there are many cases of combining multiple drugs, if two or more drugs were included in the insurance claim table (300 table) on the same date, it was classified as a case of combined use.

3. Trends in sedation drug use by date and year

The numbers of claims per day and year for each sedative drug were analyzed. Using the pseudonym personal identification number (JID), we analyzed the number of sedation cases performed on the same patient. The number of medical institutions that performed sedation was also analyzed using the pseudonym hospital identification number (YID). The age and sex of each sedative drug were analyzed.

4. Analysis of the sedation duration and number of trials of sedation in a patient

There are three N_2O behavioral management codes: U2370, U2371, and U2372. U2370 is the basic code for 15 min when first executed, U2371 is a code added every 15 min, and U2372 is the code for 30 min after 1 h. If we count the number of these codes, we can roughly calculate the duration of sedation execution. Calculation of the duration of sedation using this code is only possible with sedation cases that have been executed, including N_2O.

Table 2. Gender ratio and average age of patients by each sedative drug (from January 1, 2007, to September 30, 2019)

Type of sedative drugs	Male	Female	Ratio	Age [year (SD)]
N$_2$O	734,531	697,571	51.3 : 48.7	7.1 (7.3)
Chloral hydrate	5,940	4,094	59.2 : 40.8	3.3 (4.2)
N$_2$O + chloral hydrate	15,125	12,805	54.2 : 45.8	4.3 (2.8)
Hydroxyzine	11,872	9,917	54.5 : 45.5	18.2 (22.8)
N$_2$O + hydroxyzine	8,864	7,106	55.5 : 44.5	4.7 (5.6)
Chloral hydrate + hydroxyzine	4,973	4,020	55.3 : 44.7	3.4 (2.3)
N$_2$O + chloral hydrate + hydroxyzine	26,388	22,450	54.0 : 46.0	4.3 (2.4)
Midazolam	22,708	18,954	54.5 : 45.5	36.2 (22.4)
N$_2$O + midazolam	9,725	7,521	56.4 : 43.6	7.7 (9.0)
Midazolam + chloral hydrate	216	133	61.9 : 38.1	3.6 (2.6)
N$_2$O + midazolam + chloral hydrate	2,809	2,309	54.9 : 45.1	4.2 (2.3)
Midazolam + hydroxyzine	55	39	58.5 : 41.5	21.8 (27.1)
N$_2$O + midazolam + hydroxyzine	120	82	59.4 : 40.6	8.4 (10.5)
Midazolam + hydroxyzine + chloral hydrate	2,571	2,044	55.7 : 44.3	4.0 (3.7)
N$_2$O + midazolam + chloral hydrate + hydroxyzine	4,985	3,738	57.1 : 42.9	4.3 (2.5)
Propofol	2,420	2,462	49.6 : 50.4	38.1 (18.6)
Propofol + midazolam	95	92	50.8 : 49.2	34 (17.2)
Sevoflurane	454	285	61.4 : 38.6	19.8 (15.6)
Sevoflurane + midazolam	43	30	58.9 : 41.1	18.6 (11.3)
Propofol + sevoflurane	106	36	74.6 : 25.4	25.5 (15.1)
Total	854,000	795,688	51.8 : 48.2	7.82 (7.64)

N$_2$O, nitrous oxide.

Table 3. Change in the number of sedation drug claim case by year in each sedative drug (from January 1, 2007, to September 30, 2019)

Type of sedative drugs	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019_9	Total
N$_2$O	2,601	3,985	5,657	9,323	15,044	24,450	39,222	106,385	168,647	212,841	257,772	285,114	301,061	1,432,102
Chloral hydrate	991	1,054	1,128	1,065	1,166	1,002	935	947	579	468	265	228	206	10,034
N$_2$O + chloral hydrate	1,531	1,609	1,794	2,308	1,555	1,490	1,649	2,269	3,188	3,573	2,798	2,239	1,927	27,930
Hydroxyzine	1,465	1,699	2,135	2,136	2,282	1,965	1,370	1,381	1,510	1,983	1,547	1,230	1,086	21,789
N$_2$O + hydroxyzine	21	301	546	1,028	1,004	912	1,030	1,524	2,017	2,044	1,962	2,236	1,345	15,970
Chloral hydrate + hydroxyzine	706	616	492	666	632	804	910	980	849	661	676	569	432	8,993
N$_2$O + chloral hydrate + hydroxyzine	1,613	1,654	1,634	1,926	2,127	2,708	3,513	4,572	5,478	6,474	7,501	5,642	3,996	48,838
Midazolam	3,348	3,583	3,807	3,945	3,256	2,986	2,684	2,708	2,756	3,335	3,527	3,218	2,509	41,662
N$_2$O + midazolam	236	266	274	476	665	663	584	1,397	1,889	2,562	2,555	2,809	2,870	17,246
Midazolam + chloral hydrate	55	59	55	40	6	13	5	17	18	61	5	14	1	349
N$_2$O + midazolam + chloral hydrate	147	427	271	350	440	445	279	366	650	628	408	269	438	5,118
Midazolam + hydroxyzine	1	5	3	22	21	14	2	4	2	12	5	3		94
N$_2$O + midazolam + hydroxyzine		1	8	24	15	8	9	5	47	45	19	10	11	202
Midazolam + hydroxyzine + chloral hydrate	328	304	298	374	459	319	421	534	452	329	383	323	91	4,615
N$_2$O + midazolam + chloral hydrate + hydroxyzine	454	372	524	881	1,059	604	576	571	631	567	902	910	672	8,723
Propofol	576	622	668	596	613	215	94	128	209	298	295	321	247	4,882
Propofol + midazolam	23	23	19	16	17	15	8	17	16	21	4	3	5	187
Sevoflurane	20	6	10	7	50	42	51	57	102	138	136	109	11	739
Sevoflurane + midazolam		1			1	6	14	17	23	5	2	4		73
Propofol + sevoflurane	12	7	6	2	4	4	14	26	14	19	13	13	8	142
Total	14,128	16,594	19,329	25,185	30,416	38,665	53,370	123,905	189,077	236,064	280,775	305,264	316,916	1,649,688

N$_2$O, nitrous oxide.

The number of trials of sedation in a patient can be calculated by summing the number of sedative insurance claims per patient per year using a pseudonym personal identification number (JID).
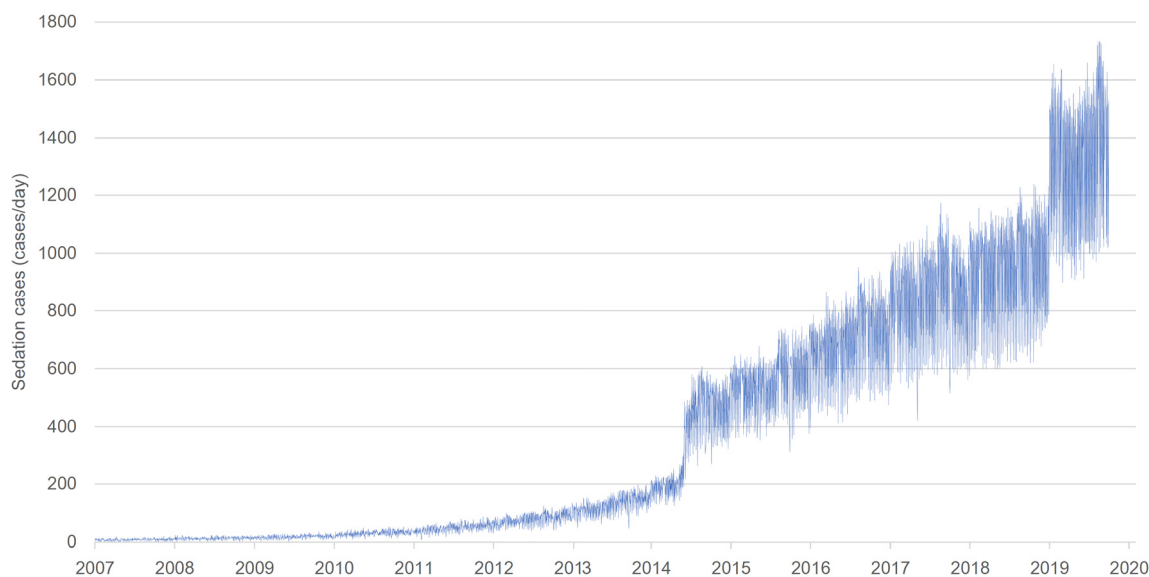
RESULTS

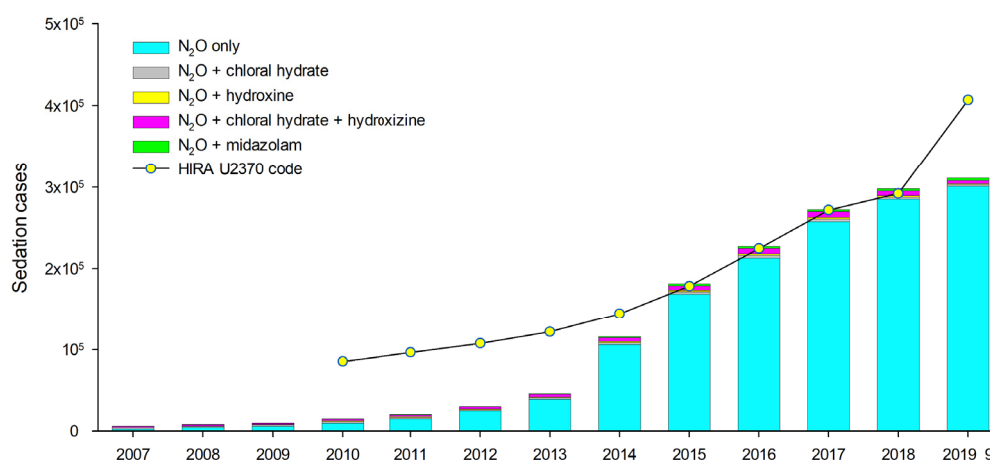Fig. 1. Number of daily cases of the nitrous oxide inhalation sedation method.

Fig. 2. This figure shows the number of U2370 codes by year, which HIRA has provided publicly since 2010 (https://opendata.hira.or.kr/), and the results of comparison with our data. From 2015, the number of cases provided by HIRA and the data we calculated match. HIRA, Health Insurance Review and Assessment; N_2O, nitrous oxide; U2370, N_2O behavioral management basic code for 15 minutes when first executed.

1. Analysis of the number of sedation cases according to sedatives

From January 1, 2007, to September 30, 2019, a total of 1,649,688 sedative use cases and 786,003 patients were identified in the HIRA big data. Table 1 shows the numbers of cases and patients using six sedatives (N_2O, chloral hydrate, hydroxyzine, midazolam, propofol, and sevoflurane), except triazolam and dexmedetomidine. The use of N_2O alone accounted for > 86% of all sedation cases, followed by chloral hydrate, hydroxyzine, and midazolam.

In terms of the number of cases of sedation and sex ratio, 51.8% were men and 48.2% were women. The average age of total sedation was 7.82 years (standard deviation: 7.64). Sedative drugs such as N_2O and chloral hydrate were mainly used in children and adolescents aged < 15 years, and other drugs are mainly used in adults. The average age of the patients for each sedation drug type is shown (Table 2).

2. Rapid increase in N_2O use for dental sedation

Table 3 shows the results of the analysis of each sedative drug use by year. Because N_2O insurance claims have
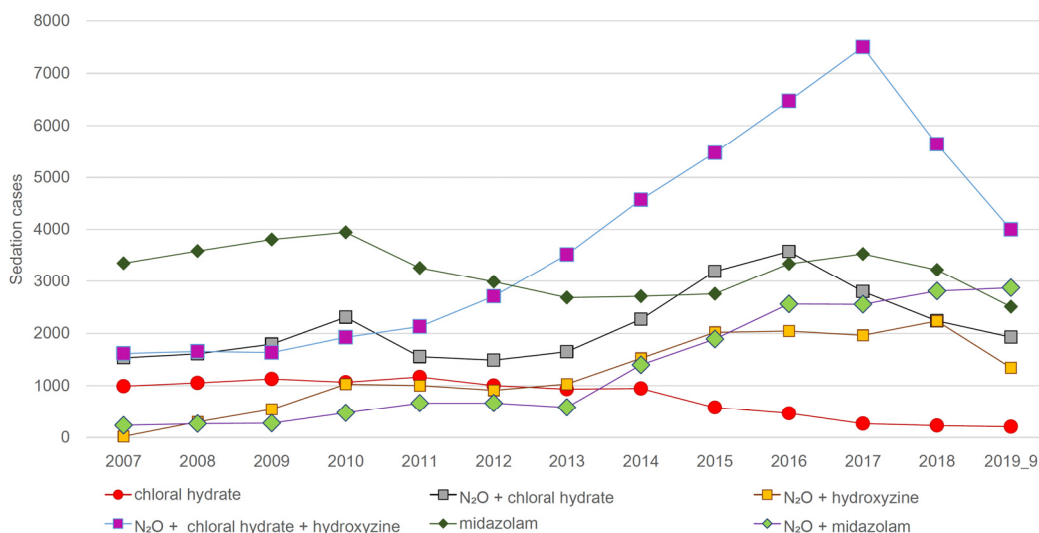
Fig. 3. Annual change of number of cases of several sedatives and combinations. N₂O, nitrous oxide.

Table 4. Change in the number of dental clinic or hospital that applied insurance claims for sedation drugs by year in each sedative drug (from January 1, 2007, to September 30, 2019)

Type of sedative drugs	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019_9
N₂O	168	183	219	248	265	291	314	362	408	441	466	474	510
Chloral hydrate	76	80	72	93	82	83	75	68	69	47	41	33	29
N₂O + chloral hydrate	19	16	18	23	22	21	22	34	40	33	33	37	32
Hydroxyzine	62	74	100	78	81	66	69	93	96	79	102	90	84
N₂O + hydroxyzine	8	17	27	28	20	13	17	29	33	37	37	52	42
Chloral hydrate + hydroxyzine	33	30	35	30	33	39	40	40	36	38	32	29	27
N₂O + chloral hydrate + hydroxyzine	27	19	26	29	33	25	40	44	45	51	51	48	38
Midazolam	84	86	96	97	95	89	80	78	78	88	78	77	74
N₂O + midazolam	20	20	23	23	26	28	22	26	29	36	40	39	51
Midazolam + chloral hydrate	16	11	12	7	6	7	4	8	7	1	3	5	1
N₂O + midazolam + chloral hydrate	6	8	6	9	6	5	5	7	8	8	6	11	14
Midazolam + hydroxyzine	1	5	2	6	7	4	2	3	2	3	4	3	
N₂O + midazolam + hydroxyzine		1	5	5	4	2	3	2	6	5	4	4	4
Midazolam + hydroxyzine + chloral hydrate	11	10	10	13	14	12	12	13	11	12	10	10	11
N₂O + midazolam + chloral hydrate + hydroxyzine	9	7	10	14	11	10	17	18	15	19	21	19	14
Propofol	11	10	6	14	11	11	18	12	14	11	7	11	18
Propofol + midazolam	9	6	9	8	5	4	6	7	8	10	4	3	5
Sevoflurane	4	2	3	3	8	6	4	7	7	9	8	6	5
Sevoflurane + midazolam		1			1	3	2	3	3	1	2	3	
Propofol + sevoflurane	1	1	2	1	1	1	5	5	4	5	4	5	3
Total dental clinic or hospital	302	323	380	406	415	423	436	496	534	564	590	582	613

N₂O, nitrous oxide.

been possible since 2014, the total number of N₂O sedation uses was calculated by the number of N₂O behavioral management code (U237). Figure 1 shows the number of N₂O usage daily. The sharp increase after 2014 was because the N₂O code can be claimed. In the case before 2014, when the same patient received multiple N₂O sedation after 2014 and there was a history of claiming other sedative

drugs, the U237 code was discovered and investigated because all claim records were obtained from that patient since 2007. Figure 2 shows the number of U2370 codes by year, which HIRA has provided publicly since 2010 (https://opendata.hira.or.kr/), and the results of comparison with our data. From 2015, the number of cases provided by the HIRA and the data we calculated matched. It was
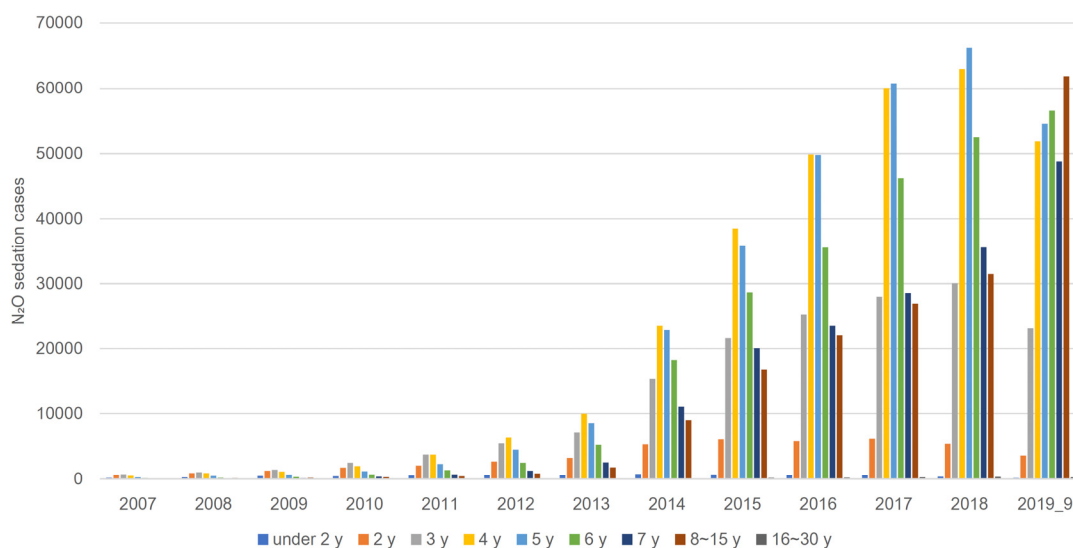
Fig. 4. This figure shows annual change in the age group of patients underwent N$_2$O sedation, the highest age group in 2015 was 4 years, but it increased to 5 years in 2017, and in 2019 (September), the age increased to 8–15. N$_2$O, nitrous oxide; y, years.
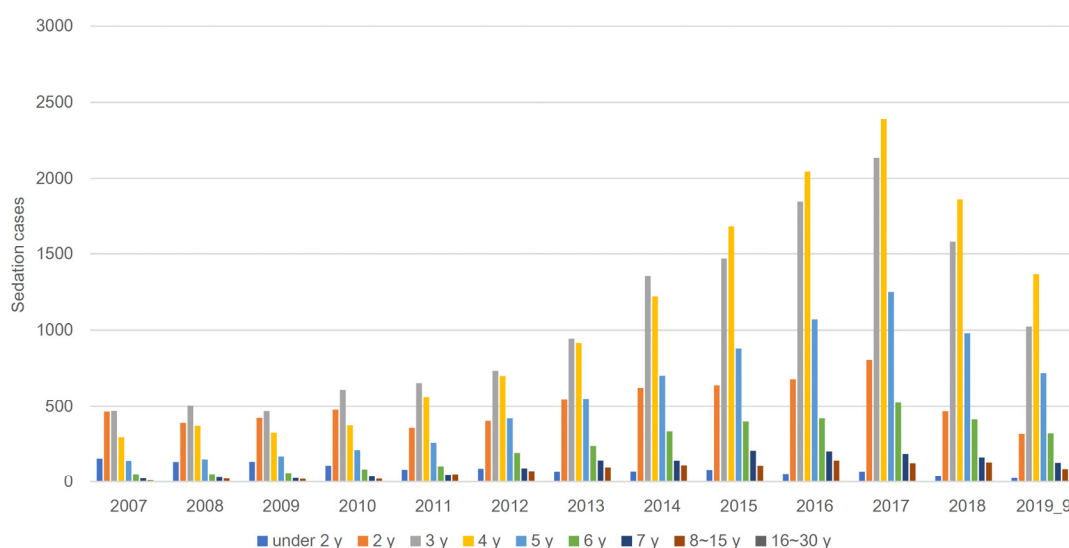

Fig. 5. Annual changes in the number of cases of sedation using combination of nitrous oxide, chloral hydrate, and hydroxyzine by age. y, years.

difficult to re-analyze the U2370 data from the HIRA data hub again because of various limitations.

3. Changes in the number of sedatives used by year

In the case of sedation with chloral hydrate alone and sedation with chloral hydrate (except midazolam mixed), the number of cases has been gradually decreasing since the mid-2010s (Fig. 3, Table 3). Other drugs also showed an increasing trend and then gradually decreased, but the cases of N$_2$O alone and mixed use of N$_2$O and midazolam continuously increased (Fig. 3).

The proportion of propofol used is very low compared to other drugs, because insurance claims are often impossible in the Republic of Korea for propofol sedation, and it is thought that a large proportion of dental sedation cases with propofol in adults are prescribed without insurance.

Table 4 shows the number of dental clinics or dental hospitals that make insurance claims for dental sedative drugs, which is increasing every year.

4. Analysis of sedation use by age

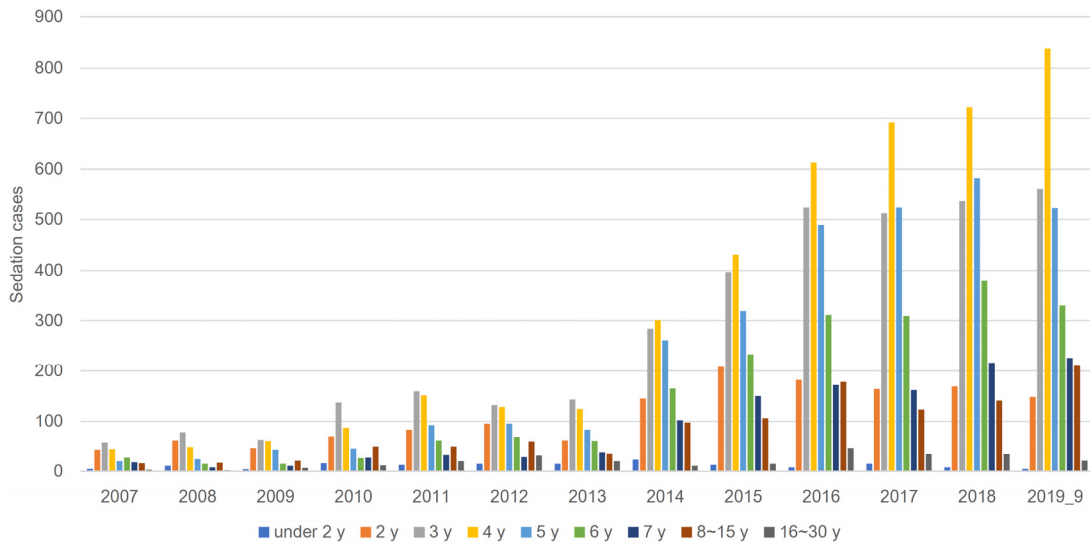According to the annual change in the average age of

Fig. 6. Annual changes in the number of cases of sedation using a combination of nitrous oxide and midazolam by age. y, years.
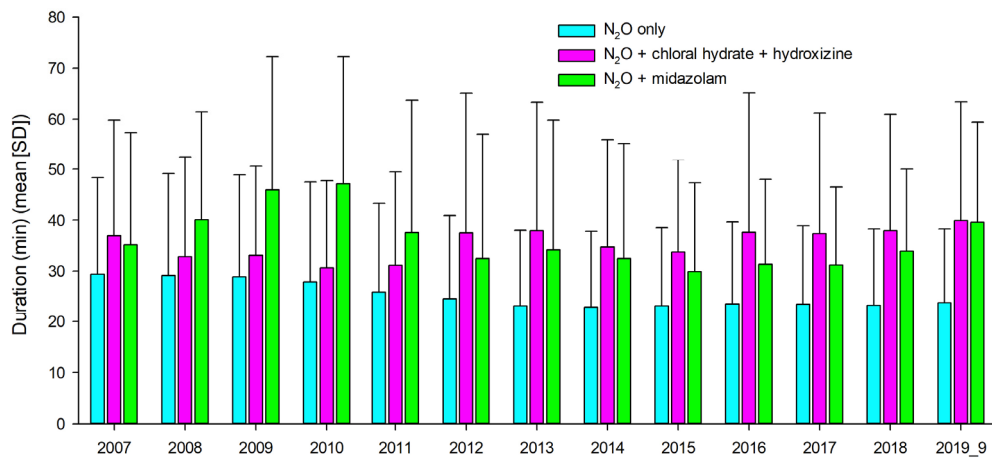

Fig. 7. Annual changes in sedation duration by drug type. N_2O, nitrous oxide.

patients who underwent sedation, there was no significant change in other drugs, but an increase was observed in the case of N_2O inhalation sedation. In the case of N_2O, the highest age ratio in 2015 was 4 years, but it increased to 5 years in 2017, and in 2019, according to the statistics up to September, the age increased to 8–15 (Fig. 4). On the other hand, in the case of combined use of N_2O, chloral hydrate, and hydroxyzine, the proportion of those aged 3 and 4 did not change and occupied a high proportion regardless of the change in year (Fig. 5). In the case of the combination of N_2O and midazolam, drugs with increased use, a high proportion was observed in ages 3–5 years old (Fig. 6).

5. Analysis of the sedation duration and number of sedation trials in a patient

Analysis of the administration duration of sedatives mainly used in children showed that in the case of N_2O inhalation sedation, the average in 2007 decreased from approximately 30 min to approximately 20 min. However, when N_2O, chloral hydrate, and hydroxyzine were combined, and when N_2O and midazolam were used, the duration increased to nearly 40 min (Fig. 7).

If we analyze the number of times a patient undergoes sedation by year, it can be seen that the number of cases that are administered more than twice increases (Fig. 8).
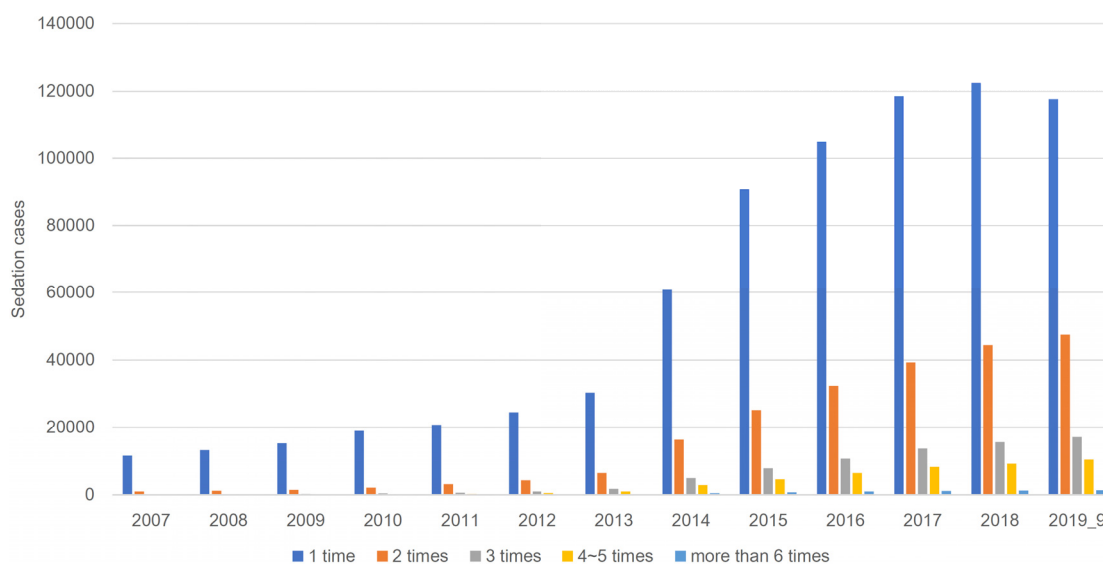
Fig. 8. This figure shows the number of times a patient underwent sedation by year. The proportion of patients taking sedatives more than twice a year is increasing.

DISCUSSION

According to data from the HIRA Service of Korea, the total number of dental treatments they received per year increased from 54 million in 2009 to 81 million in 2019. The number of outpatients undergoing dental treatment per day was approximately 345,000 in 2016 (http://opendata.hira.or.kr/). As the total number of sedations in 2018 was 305,264 (Table 3), sedatives were administered in < 0.5% of all insured dental cases. The health and medical big data used in this study are the most extensive data in the Republic of Korea in terms of claimable treatment. Data from the National Health Insurance, to which > 97% of Koreans are enrolled, are highly reliable [12]. However, in the Republic of Korea, many dental treatments are performed without insurance claims, and a database has not been established to date to check sedative use data that are not covered by insurance. There is no way to check the number of sedation parts not covered by insurance.

The important point that could be confirmed through this study is the changing trend in the use of N$_2$O inhalation sedation. In 2014, Yang et al. [13] published a survey on the use of sedation by pediatric dentists, and

Choi et al. [14] in 1999 reported that 29% of pediatric dentists use sedation. In 2005, An et al. [15] reported that 66% of pediatric dentists use sedation, and in 2021, Tak et al. reported [16] that 89.5% of pediatric patients received sedation in dental treatment. An increase in the use of sedation compared to the past can be inferred, which can be directly confirmed statistically.

According to a survey on changes in the sedation environment in pediatric dental care in the United States for 25 years published by Houpt in 2010, the number of dentists who reported that the frequency of sedation used increased over the past 5 years increased, and 22% and 70% of dentists stated that the reason for the increased use of sedation was a change in the perception that more patients needed sedation [17].

It can be seen that the number of N$_2$O-only sedation cases increased by 40,000 every year from 2015 to 2017. The sedative method of using N$_2$O and midazolam in combination shows an increase in use along with the insurance coverage of N$_2$O inhalation sedation. N$_2$O and midazolam are both recommended for use by dentists for sedation in the "Summary of Evidence-Based Recommendations for Clinical Practice Guidelines for Dental Sedation for Clinicians" published by the KDA in 2015 [18].

Another factor that is increasing the use of N_2O inhaled sedatives is increased emissions by pediatric dentists. Unlike other subject matter experts, pediatric dentists receive specialized training in N_2O inhalation sedation. This is because N_2O inhalation sedation is more likely to be used than other sedation methods when opening the hospital after training (Table 4).

Contrary to the case of N_2O inhalation sedation, chloral hydrate showed a marked decrease starting from 2014. Chloral hydrate is an oral sedative clinically used since 1890, but has been used without approval from the US Food and Drug Administration and has consistently presented safety issues such as cardiotoxicity issues caused by overuse [19,20].

Since 2012, pharmaceutical companies in the United States have stopped producing chloral hydrate. Accordingly, Han et al. [21] argued that chloral hydrate, which does not exist as an antagonist and cannot titrate the depth of oral sedation, needs to be considered as an alternative to other safer drugs for patient safety. As for the trend of decreasing chloral hydrate through this big data analysis, Lee et al. [22] reported that the rate of N_2O inhalation sedation increased in 2018 and that the use of benzodiazepines such as midazolam was preferred over chloral hydrate. The combined use of N_2O and chloral hydrate and hydroxyzine, which accounted for the second-largest share after N_2O and chloral hydrate, began to decline sharply from 2017. Through this, a change in the trend toward favoring drugs for high safety can be confirmed. In addition, it can be inferred that the choice of sedative drug pattern is changing, with the use of chloral hydrate-based drugs being replaced by N_2O inhalation sedation alone or combined with N_2O and midazolam.

Although it is not a direct factor, such as insurance coverage for sedatives, as a treatment for children and adolescents, insurance coverage for sealants started in 2009 and resin coverage in 2019. Among them, in the case of resin treatment, which started to be covered by insurance in January 2019, it is believed that this has had affected the surge in the number of N_2O inhalation sedation cases from 2019 (Fig. 1).

Conversely, the incidence of death due to sedation can be considered a factor in reducing the inflow of dental patients. A typical accident is the death of a 30-month-old girl in Cheonan, Chungcheongnam-do, on October 20, 2017, during dental sedation (SBS, 2017.10.23, https://news.sbs.co.kr/news). The frequency of use of inhalation sedation with sevoflurane, which had shown an increase in use before, rapidly decreased from 2017 (Table 3).

Changes in the age of patients receiving sedation are also noteworthy. In the case of N_2O inhalation sedation, it was confirmed that the age of patients receiving sedation increased from 4 to 8−15 years old. Sedation should be applied with caution as the age of the child and poor systemic condition such as low body weight increase the onset of drug response faster, last longer, and increase the risk of deep sedation [20].

According to the age distribution of sedative drugs, N_2O inhalation sedation and the use of various mixed drugs of N_2O, chloral hydrate, midazolam, and hydroxyzine were mainly used in patients with an average age of ≤ 15 years. This tends to coincide with the drugs used in pediatric dentistry [15].

The duration of inhalational sedation by N_2O alone is decreasing, and dental treatment does not end with one sedation, but increases to two or three times. Given the shortened sedation duration, compared to the past, when many dental treatments were performed with one sedation, the amount of dental treatment performed at one time has been reduced, the sedation duration is shortened, and dental treatment is performed by dividing it into several sedation sessions.

Despite the growing demand for dental sedation, the number of dental clinics offering sedation is not increasing rapidly, so the number of cases of sedation performed by one dental clinic is increasing. The reasons for the slow increase in the number of dental clinics performing sedation compared to the increase in the number of sedatives are the limited opportunities to learn dental sedation methods, the burden of purchasing equipment and drugs, and the heavy burden of bearing

in case of a medical accident.

In conclusion, N$_2$O and midazolam, which are sedative drugs that show an increasing pattern of use, are characterized by rapid onset, short recovery time, and low risk of complications such as respiratory problems [23].

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