# Epidemiology of Paget's disease of bone in South Korea

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## Abstract

Paget's disease of bone (PDB) is a chronic disorder characterized by abnormal bone remodeling, leading to enlarged and deformed bones, and commonly affecting older adults. The disease frequently involves the pelvis, skull, spine, and long bones. Despite significant geographical variations in PDB prevalence, data from Asian populations remain sparse. This study evaluates the incidence, skeletal distribution, comorbidities, and bisphosphonate use for PDB in South Korea from 2010 to 2020, using a retrospective analysis of the Korean Health Insurance Review and Assessment database. We identified 4252 patients diagnosed with PDB via ICD-10 codes (M880, M888, and M889) over the study period. The primary outcome measured was the incidence of PDB, stratified by sex and age, with secondary outcomes including anatomical site involvement, associated comorbidities, and bisphosphonate use. The mean age of patients was $56.3 \pm 14.8$ yr, with a mean prevalence of 1.20 per 100 000 and an age-adjusted incidence ranging from 0.38 to 1.26 per 100 000 person-years. The incidence of PDB decreased in men but showed a significant increase in women, especially after 2015. The spine (23.5%) and pelvis & femur (17.0%) were the most commonly affected sites. Gastritis and gastroesophageal reflux disease (91.6%), upper respiratory infections (78.9%), and endocrine disorders (69.5%) were frequent comorbidities. Despite the established efficacy of bisphosphonates in managing PDB, only 9.8% of patients received these treatments, predominantly etidronate (3.2%) and alendronate (2.2%). This study is the first comprehensive epidemiologic assessment of PDB in South Korea, highlighting a low but increasing incidence, particularly among women. The findings underscore the need for greater clinical awareness and more proactive management strategies, especially regarding the use of bisphosphonates to improve patient outcomes.

**Keywords:** Paget's disease of bone, epidemiology, antiresorptives, radiology, osteoclasts

## Lay Summary

This study is the first comprehensive analysis of Paget's disease of bone (PDB) in South Korea, covering the period from 2010 to 2020. We discovered that the disease affects roughly 0.8 people per 100 000 each yr, with a notable increase among women. PDB most commonly affected the spine, pelvis, and femur. Common health issues associated with PDB include gastritis and gastroesophageal reflux disease. Despite available treatments, only about 10% of those diagnosed with PDB received bisphosphonates, the primary medication for managing the disease.
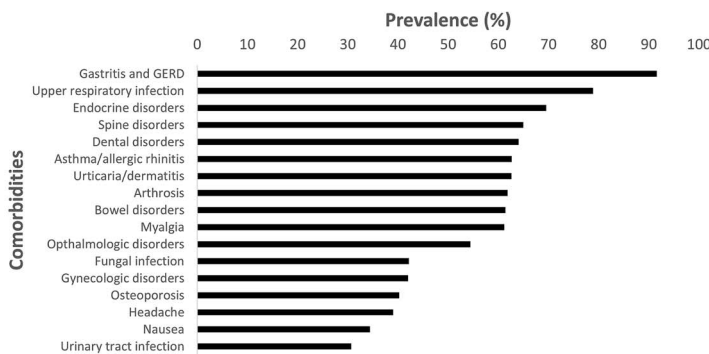
## Graphical Abstract

### Incidence of PDB in South Korea

From 2010 to 2020, overall incidence of Paget's disease of Bone (PDB) → 0.45/100,000 PY in men and 1.15/100,000 PY in women

### Skeletal distribution of PDB in South Korea
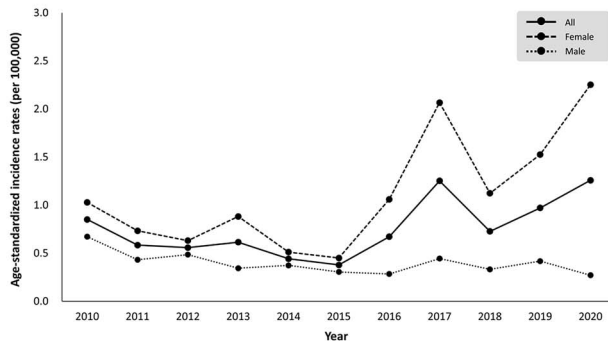


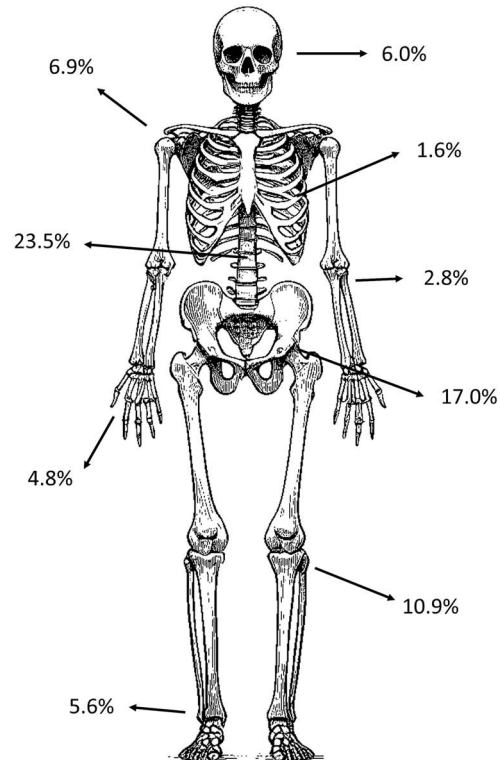### Comorbidities associated with PDB in South Korea



## Introduction

Paget's disease of bone (PDB) is a chronic and often asymptomatic condition primarily affecting older adults, characterized by abnormal bone remodeling, leading to enlarged and deformed bones. The disease can manifest as monostotic, affecting one bone, or polyostotic, involving multiple bones, with common sites including the pelvis, skull, spine, and long bones.[1]

Patients with PDB may experience bone pain, fractures, arthritis, and compression neuropathy symptoms. Diagnosis typically involves radiological tests and biochemical evaluation through alkaline phosphatase levels measurement.[2] Plain radiographs often reveal typical findings of PDB such as osteosclerosis, deformity, cortical thickening, focal osteolysis, and coarse trabeculae.[3,4]

The etiology of Paget's disease involves genetic and environmental factors, with a family history potentially increasing its likelihood.[5] Treatments focus on symptom management and complication prevention, primarily using bisphosphonates such as zoledronic acid.[6] These medications effectively reduce bone pain and turnover and are generally reserved for symptomatic patients.[7] Severe cases may require surgical interventions such as total hip or knee replacements.[8] One severe complication of PDB is the rare potential development of osteosarcoma, occurring in less than 1% of patients. Other complications can include cardiovascular issues and metabolic disturbances in polyostotic disease.[2]

The incidence and prevalence of PDB vary globally. In the United Kingdom, the prevalence of PDB has been reported as high as 5.4%.[9] Conversely, in Japan, the prevalence is strikingly lower, documented at just 0.00028%, showing a remarkable geographical variation in the occurrence of PDB.[10] In spite of the significant discordance of global distribution of PDB, there has been no comprehensive epidemiologic studies in South Korea. Therefore, this study aims (1) to evaluate the incidence and skeletal distribution of PDB, (2) to assess the associated comorbidities, (3) and to report the use of bisphosphonates for PDB from 2010 to 2020 in South Korea. It seeks to deepen our understanding of PDB in South Korean population, enhancing strategies for diagnosis, treatment, and management.

## Materials and methods
### Database

We analyzed data from nationwide claims database, which comprises of medical, and pharmacy claims for all Korean citizens, of the Korean Health Insurance Review Assessment Service (HIRA). In Korea, 97.0% of the population is legally obliged to enroll in the Korea National Health Insurance Program. Patients pay an average of 30% of the total medical costs to clinics or hospitals that manage almost all diseases. All clinics and hospitals then submit claims data for inpatients and outpatients care, including diagnoses (in International

Classification of Diseases, 10th revision (ICD-10)), procedures, prescription records, and demographic information, to the Korean HIRA to obtain 70% reimbursement of the total medical cost from the government. The remaining 3% of the population not insured by the Korean National Health Insurance Program are either covered by a Medical Aid Program or are temporary or illegal residents. The claims data covered by Medical Aid program were also reviewed by the HIRA. Therefore, virtually all information about patients and their medical record is available from the Korean HIRA database, which has been used on several occasions for epidemiological studies.[11,12] All new visits or admissions to Korean hospitals for PDB were recorded prospectively in nationwide cohort by the above-described system using ICD-10 codes and procedures. Each patient has a unique identifier, making it feasible to track a specific patient over time.

## Patients

From January 2010 to December 2020, patients who were diagnosed with PDB were identified using the ICD-10 code for PDB (M880, M888, and M889). All patients were included regardless of admission or surgery. There was no exclusion according to age or prior fractures. The index date was set as the time of first diagnosis of PDB when the diagnostic codes were first entered.

## Outcomes

The primary outcome of this study was the incidence of PDB from 2010 to 2020. The incidence was stratified with sex and age. The annual population data to calculate the incidence of PDB were obtained from the Korean Statistical Information service.

The secondary outcomes were the anatomical site of involvement of PDB, prevalence of associated comorbidities, and the use of bisphosphonates for PDB. To distinguish the anatomical sites, we used plain radiographs that are routinely used in diagnosis and follow-up of the patients with PDB. Procedural codes of plain radiographs (G****) were identified in all patients with PDB and classified according to the anatomical sites designated in the procedural codes. If the patient is diagnosed with PDB and the radiographs of same site are taken twice within a year period, the patient was assumed to have a PDB at that anatomical site. The anatomical sites were classified into the skull, spine, rib, shoulder and humerus, elbow and ulna/radius, wrist and hand, pelvis and femur, knee and tibia/fibula, and ankle and foot.

For the associated comorbidities, all diagnostic codes that were entered at least twice a year other than PDB after the diagnosis of PDB in all included patients were listed and categorized according to the similar symptoms. For example, unspecified gastritis (K297), functional dyspepsia (K30), gastro-esophageal reflux disease without esophagitis (K219), gastro-esophageal reflux disease with esophagitis (K210), chronic gastritis (K295), and more of the similar diseases were clustered and categorized as gastritis. The number of patients and its prevalence (%) were calculated for each group of associated comorbidities. As the HIRA database did not contain individual patient radiographs or medical charts, comorbidities were defined only using diagnostic codes without confirmation by chart review.

To evaluate the bisphosphonate use in the patients with PDB, all available bisphosphonates in South Korea (alendronate, etidronate, ibandronate, pamidronate, risedronate, and zoledronate) were investigated from 2010 to 2020. The first prescription within 1 year after the index date was evaluated, and compliance was not considered. If the patient was prescribed with bisphosphonate before the index date, the use of bisphosphonate was assumed not to be aimed to treat PDB, and was excluded.

## Statistical analyses

Student t-tests were employed to analyze continuous variables, while chi-square tests were used for comparing categorical variables. The categorization of age groups was done in increments of 10 yr. The total number of men and women in the Korean population was obtained from the web site of the Statistics Korea (http://www.kosis.kr), which is the central government organization for statistics.[13]

The statistical analyses in this research were conducted using R software, version 3.5.3, and a *p*-value threshold of 0.05 was set for statistical significance. The hospital's IRB granted an exemption to this study, as it did not involve any personal information of individuals (IRB number X-2107-696-904).

## Results

### The incidence of PDB

From 2010 to 2020, 4252 patients were diagnosed with PDB in South Korea. There were 1106 (26%) men and 3146 (74%) women with the mean age of $56.3 \pm 14.8$ yr. The mean prevalence of PDB was 1.20 per 100 000. The mean crude incidence and age-adjusted incidence of PDB were 0.79 and 0.80 per 100 000 person-year (PY), respectively (Table 1).

Between 2010 and 2020, the incidence rate of PDB in total increased from 0.85 to 1.26 per 100 000 PY. The increase was prominent especially from 2015 and in women. The lowest incidence was 0.38 per 100 000 PY in 2015 and the highest incidence was 1.26 per 100 000 PY in 2020. While the incidence of PDB in men decreased from 0.67 to 0.27 per 100 000 PY from 2010 to 2020, the incidence in women increased from 0.45 to 2.25 per 100 000 PY between 2015 and 2020 (Figure 1A).

The prevalence of PDB mildly decreased from 2010 to 2015 in both men and women. From 2015 to 2020, the prevalence was stable for men but increased in women, resulting in the overall increase (Figure 1B).

The incidence of PDB was the highest in the patients aged 70 to 79 yr followed by those aged 80 yr or more, and those aged 60 to 69 yr. In the younger patients, the incidence increased with aging. Between 2016 and 2017, there was a surge in the incidence of PDB in the patients older than 60 yr but it decreased between 2017 and 2018. While the patients aged over 60 yr were common in 2010, those aged from 40 to 59 yr became more common in 2020 (Figure 2A).

The prevalence rate was the highest in the patients aged from 70 to 79 yr followed by those aged over 80 yr, those aged from 60 to 69 yr. Similar to the incidence of PDB, the prevalence was also higher in those over 60 yr in 2010. Unlike the incidence of PDB, the prevalence was still highest in those aged from 70 to 79 years in 2020 (Figure 2B).

### The skeletal distribution of PDB

The skeletal involvement of PDB was most common in the spine (23.5%) followed by pelvis and femur (17.0%) (Table 2).

**Table 1.** The annual number, prevalence, and incidence of Paget's disease of bone from 2010 to 2020 in South Korea.

| | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Number | 390 | 272 | 263 | 295 | 219 | 193 | 349 | 669 | 392 | 527 | 683 |
| Prevalence (/100 000) | 1.11 | 0.86 | 0.85 | 0.96 | 0.83 | 0.76 | 1.07 | 1.78 | 1.33 | 1.67 | 2.06 |
| Crude incidence (/100 000 PY) | 0.78 | 0.54 | 0.52 | 0.58 | 0.43 | 0.38 | 0.68 | 1.31 | 0.76 | 1.03 | 1.33 |
| Age-adjusted incidence (/100 000 PY) | 0.85 | 0.59 | 0.56 | 0.62 | 0.44 | 0.38 | 0.67 | 1.25 | 0.73 | 0.97 | 1.26 |

Abbreviation: PY, person-year.
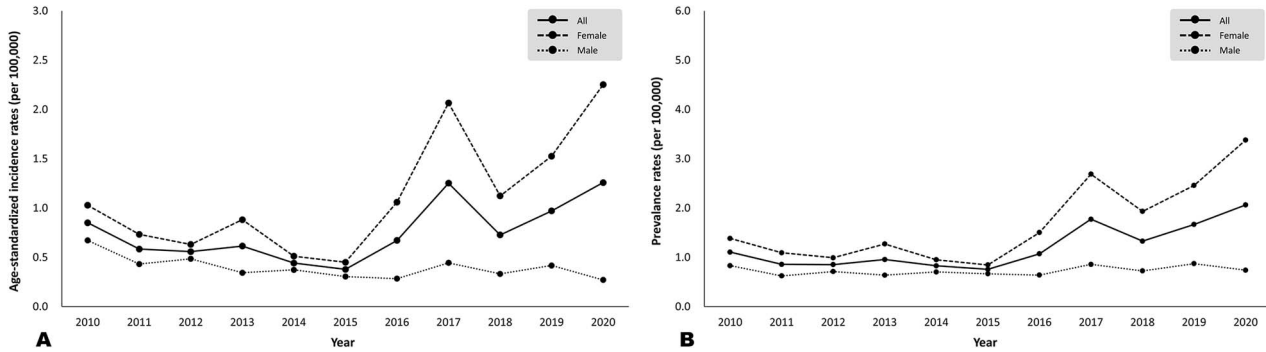


**Figure 1.** (A) The annual incidence of Paget's disease of bone by sex. (B) The annual prevalence of Paget's disease of bone by sex.
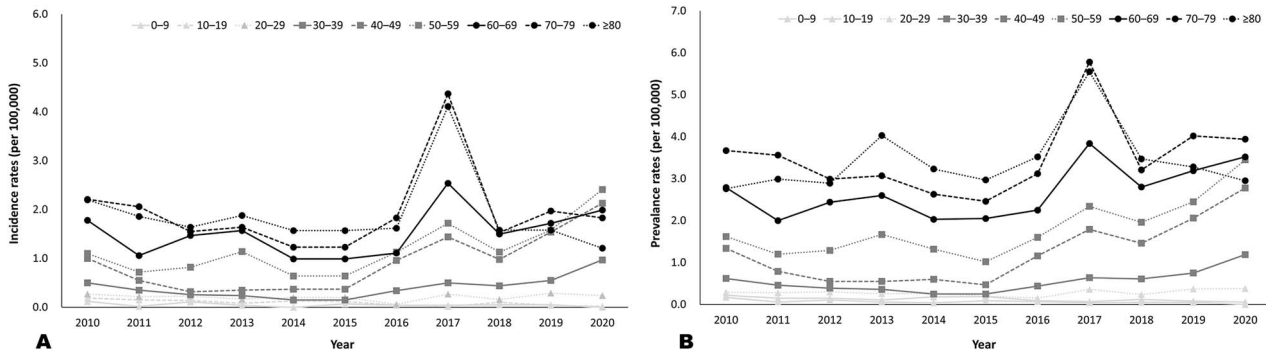


**Figure 2.** (A) The annual incidence of Paget's disease of bone by age. (B) The annual prevalence of Paget's disease of bone by age.

**Table 2.** Skeletal distribution of Paget's disease of bone.

| Anatomical sites | Number of patients | Prevalence (%) |
|---|---|---|
| Skull | 253 | 6.0 |
| Spine | 1001 | 23.5 |
| Rib | 70 | 1.6 |
| Shoulder and humerus | 293 | 6.9 |
| Elbow and ulna/radius | 121 | 2.8 |
| Wrist and hand | 204 | 4.8 |
| Pelvis and femur | 724 | 17.0 |
| Knee and tibia/fibula | 464 | 10.9 |
| Ankle and foot | 240 | 5.6 |

**Table 3.** Comorbidities associated with Paget's disease of bone.

| Diagnostic groups | Number of patients | Prevalence (%) |
|---|---|---|
| Gastritis and GERD | 3894 | 91.6 |
| Upper respiratory infection | 3354 | 78.9 |
| Endocrine disorders | 2956 | 69.5 |
| Spine disorders | 2763 | 65.0 |
| Dental disorders | 2723 | 64.0 |
| Asthma | 2664 | 62.7 |
| Urticaria | 2663 | 62.6 |
| Arthrosis | 2631 | 61.9 |
| Bowel disorders | 2611 | 61.4 |
| Myalgia | 2603 | 61.2 |
| Ophthalmologic disorders | 2314 | 54.4 |
| Fungal infections | 1794 | 42.2 |
| Gynecologic disorders | 1786 | 42.0 |
| Osteoporosis | 1711 | 40.2 |
| Headache | 1660 | 39.0 |
| Nausea | 1465 | 34.5 |
| Urinary tract infection | 1305 | 30.7 |

Abbreviation: GERD, gastroesophageal reflux disease.

## Comorbidities associated with PDB

The most common comorbidities associated with PDB was gastritis and gastroesophageal reflux disease (GERD) (91.6%) followed by upper respiratory infection (78.9%), endocrine disorders (69.5%), and spine disorders (69.5%) (Table 3).

## The use of bisphosphonates in PDB

From 2010 to 2020, among patients diagnosed with PDB, a total of 764 patients (18.0%) received bisphosphonates.

After excluding 349 patients who were prescribed bisphosphonates before their PDB diagnosis, 415 patients (9.8%) were considered to have been treated for PDB.

The most common bisphosphonate used to treat PDB was etidronate (3.2%) followed by alendronate (2.2%), zoledronate (1.6%), risedronate (1.3%), pamidronate (1.2%), and ibandronate (0.4%). Among the bisphosphonates, in 2010, etidronate was most commonly used (63.8%) followed by risedronate (13.8%). In 2020, alendronate was most commonly used (31.8%) followed by pamidronate (27.3%).

## Discussion

This was the first comprehensive epidemiologic study on PDB in South Korea. We found that the incidence of PDB was 0.8 per 100 000 PY from 2010 to 2020 with the recent increase especially in women. The skeletal involvement of PDB was prominent in the spine and the pelvis and femur. Gastritis or GERD were the most common comorbidities in the patients with PDB. Only 9.8% of patients with PDB were treated with bisphosphonates, a majority being the etidronate or alendronate.

It is well-known that PDB exhibits substantial variations in incidence and prevalence across different geographical regions. The previous studies have revealed the prevalence as high as 5.4% in the United Kingdom,[14] and the as low as 0.00028% in Japan.[10] When the prevalence was compared between 13 towns in 9 European countries, the prevalence ranged from 2.0% to 2.7% in France, 0.9% to 1.3% in Spain, 1.3% in Germany, 0.5% to 1.0% in Italy, 0.5% in Greece, 0.4% in Sweden.[15] In contrast to European ethnicity, the prevalence of PDB in Asians is reported to be very low.[16] The epidemiologic studies using national registry on the global incidence and prevalence of PDB were listed in Table 4.[17-21] These national registry studies show relatively lower prevalence compared to the previous studies conducted in a single or several centers.[9,14,22] Among the registry studies, the incidence of PDB was highest in Canada[20] and the prevalence was highest in United States.[17] When compared with the similarly recent study in Quebec of Canada, both incidence and prevalence of PDB in current study is relatively lower.[20] Tiegs RD et al. have reported the mean incidence of PDB 9.2/100 000 PY from 1950 to 1994 in the Olmsted County of Minnesota, United States.[23] They suggested that 75% of the PDB patients had lesions in the central bone. Altman et al. showed also similar results that prevalence of 1.3% in the national registry study when assuming that 80% of PDB lesions are pelvis, femur, and lumbar vertebra.[17] The prevalence of 0.0008 to 0.002% in our study is in line with the 0.00028% of prevalence found in Japan, underlining the low prevalence of PDB in East Asia.[10] One of the theories to explain the great disparity of global epidemiology of PDB is that PDB originated in Northwest Europe, namely Britain and disseminated from there.[24] However, recent study in New Zealand reported that the PDB diagnosed in Asian population increased while that in European population decreased, suggesting that Asians are not genetically protected against PDB.[16] This could also support our finding of increasing prevalence over time unlike the decreasing temporal trend in most studies on Europeans (Table 4).[18-21] We were unable to find out the exact reason for the high annual incidence of PDB in 2017, compared to 2016 and 2018. Change of reimbursement guideline and policy might be a possible explanation.

Epidemiologic studies on PDB agree to the substantial increase of PDB with aging.[9,14,17,21,22,25-27] In the present study, the incidence and prevalence of PDB increased greatly in the patients aged over 60 yr, with the highest rate in the patients aged 70 to 79 yr. This is supported by the previous findings that PDB is uncommon in those younger than 50 yr.[21]

The male preponderance of PDB (1.2 to 1.8 times) is found in most studies but with some exceptions.[10,28,29] In the study of Hashimoto J et al., among 169 patient with PDB, 91 patients (54%) were women.[10] In current study, women accounted for 74% of PDB. This might be related to the higher suspicion of PDB in women as they are prone to develop osteoporotic fracture after menopause. In addition, women generally have a longer lifespan than men, and as PDB predominantly affects older adults, the higher proportion of elderly women in the population could lead to a higher incidence of PDB among women observed in specific studies. There might be unknown genetic factor in Asian patients with PDB that is different from the European patients with PDB where the high male prevalence is noted.

Unlike the geographic variation, anatomical sites of PDB involvement are known to be similar among reports from different countries.[30-33] In 1932, Schmorl G. autopsied 138 patients with PDB and first reported that sacrum (57%), spine (50%), and femur (46%) were the most common sites of involvement.[34] In 2011, Seton M et al. used X-ray to report that the most common sites of skeletal involvement were spine (43%) and hip (38%) in 285 patients with PDB.[33] The authors also evaluated the bone lesions using bone scintigraphy and the PDB was still prevalent in spine (58%) and hip (41%).[33] In a registry study using the General Practice Research Database, van Staa TP. et al. reported similar results that prevalent location of PDB was pelvis (47.5%), femur (25.8%), tibia/fibula (21.7%), and lumbar spine (19%).[21] The primary involvement of axial skeleton, pelvis, and femur stems from their abundant proportion of cancellous bone.[30] In the long bones, the metaphysis is usually the first portion for the PDB to start for the same reason.[30] In current study, we found high prevalence of PDB in spine (23.5%), pelvis and femur (17.0%), and knee and tibia/fibular (10.9%) as in previous studies.

Complications and comorbidities of PDB are known to aggravate the quality of life in patients with PDB.[33,35,36] While Gold et al. suggested that psychosocial aspect of PDB was a major factor,[35] Langston et al. reported conspicuous impairment in physical scores in patients with PDB.[36] van Staa TP et al. reported high rate of back pain (10.2%), osteoarthritis (5.6%), and dizziness (5.0%) in patients with PDB.[21] Seton et al. reported that 89% of patients had complications of PDB; arthritis (50.2%), deformity (35.9%), back pain (28.1%), and hearing loss (18.9%) were common complications.[33] Wermers et al. reported that osteoarthritis was observed in 73% of patients, hip or knee replacement in 11%, significant hypercalcemia in 5.2%, and congestive heart failure in 3.0%.[37] They also emphasized the high prevalence of hearing loss (61%).[37] However, the whether the cause of these comorbidities is PDB or the aging is quite unclear. Notably, the hearing loss has been previously considered as one of the unique complications of PDB.[21,35] Nevertheless, the hearing disorders are also common problems in the elderly, suggesting it cannot be a surrogate marker for PDB.[33] In current study, we reported that common comorbidities of PDB were gastritis or GERD (91.6%), upper respiratory infection (78.9%), endocrine disorders (69.5%), spine disorders (65.0%), dental

**Table 4.** Global epidemiologic studies on Paget's disease of bone using national registry data.

| First author | Study period | Country | Registry | Number of patients | Mean age (yr) | Incidence (/100000PY) | Prevalence (%) | Temporal trend |
|---|---|---|---|---|---|---|---|---|
| **Altman RD.**[17] | 1971-1975 | USA | NHANES-1 | 31 | N/A | N/A | 1.00-1.16 | N/A |
| van Staa TP.[21] | 1988-1998 | UK | GPRD | 2465 | 75 | 7-11 | 0.30 | Decrease |
| Cook MJ.[18] | 1999-2015 | UK | CPRD | 3592 | N/A | 2-7.5 | N/A | Decrease |
| Kanecki K.[19] | 2008-2014 | Poland | NIPHD | 225 | 56.8 | 0.08 | N/A | Decrease |
| Michou L.[20] | 2000-2020 | Canada (Quebec) | QICDSS | 13 165 | 72.5 | 28-77 | 0.43-0.55 | Decrease |
| **Current study** | 2010-2020 | South Korea | HIRA | 4252 | 56.3 | 0.38-1.26 | 0.0008-0.002 | Increase |

Abbreviations: CPRD, Clinical Practice Research Datalink; GPRD, General Practice Research Database; HIRA, Health Insurance Review and Assessment; N/A, not accessible; NHANES-1, National Health and Nutrition Examination Survey; NIPHD, National Institute of Public Health data; PY, person-year; QICDSS, Quebec Integrated Chronic Disease Surveillance System; UK, United Kingdoms; USA, United States of America.

disorders (64.0%), and ophthalmologic disorders (54.4%). The findings in our study share the same problem in which the presented comorbidities could derive from either the elderly cohort or PDB itself. Unlike previous studies where only the musculoskeletal, hearing, and dental symptoms were investigated,[21,33,35] the entire diagnostic codes in patients with PDB were reviewed and classified in this study. The high prevalence of gastritis or GERD could be related to the use of bisphosphonates or NSAIDs in those with PDB.[38,39] Despite the ambiguous causative relationship between PDB and these conditions, our findings could aid patients with PDB to understand and prepare for the potential comorbidities in advance.

The mainstream pharmacological treatment of PDB involves the reduction of bone resorption by the osteoclasts using bisphosphonates.[40] Inducing apoptosis in osteoclasts occurs through the interruption of the mevalonate cascade and intracellular prenylation.[41] Recently, studies comparing the efficacy of bisphosphonates to treat PDB favored the intravenous zoledronate due to its high potency.[7,40,42] Although not as potent as zoledronate, literatures have established the efficacy of etidronate,[43] risedronate,[44] alendronate,[45] pamidronate,[46] and ibandronate.[47] Etidronate was the most commonly used bisphosphonate for PDB in this study. Although etidronate had been used historically, it has some limitations including transient effects on bone turnover, potential induction of osteomalacia, and associated risk of fracture.[48,49] Given these concerns and the availability of more potent bisphosphonates like zoledronate, the etidronate should be no longer be considered as the treatment for PDB. The previous studies reported that prescription rates of bisphosphonate were around 27% among patients with PDB.[10,21] It was only 9.8% in our study. We did not know the exact reasons of much lower prescription rate in our study. Many patients with PDB are asymptomatic at the time of diagnosis and found incidentally through other labs or imaging for other purposes. Even after diagnosis of PDB, prescription of bisphosphonate would vary according to the disease activity and physicians' treatment thresholds. Milder disease activity and difference in physicians' practice in South Korea could be the possible reason of our lower prescription rate. Moreover, the use of zoledronate was only 1.6%, which was third commonly used during the study period. In case of PDB diagnosis, physicians in South Korea should more actively consider the use of zoledronate to alleviate the bone pain from PDB.

There are some limitations to this study. First, we could not evaluate radiographs, BMD, and biochemistry, because HIRA database did not include radiographic findings and results of BMD and biochemistry. However, we established the operational definition for diagnosis and the site of involvement. It should be considered before generalization of our findings. Second, if the patient did not take the radiographs of a specific anatomical region, it would not be reflected upon the skeletal distribution of PDB. Nevertheless, corresponding plain radiographs are probably the most fundamental exam to locate the skeletal distribution of PDB, which minimizes the false negativity. In contrast, there also would be false positive patients who took the radiograph but did not, in fact, have the PDB at that site. To minimize this, we only counted when the same radiograph was taken twice within a year period. Third, our operational definition could make an ascertainment bias via less frequent case detection through radiographs or alkaline phosphatase. Practical differences between South Korean and Western countries may lead to lower incidence of PDB in South Korea. Fourth, we could not evaluate more classical complications associated with PDB such as fractures, joint replacements, nerve impairments, hypercalcemia, hearing loss, osteosarcoma, congestive heart failure, etc. However, our purpose was to provide basic epidemiological perspectives rather than focus on complications. Further research should be needed to evaluate PDB associated with complications in future. Fifth, we could not evaluate the extent of disease (monostotic vs. polyostotic), because ICD-10 code system did not distinguish between monostotic and polyostotic. Sixth, we did not evaluate the compliance of bisphosphonates or other medications including proton pump inhibitors, nonsteroidal antiinflammatory drugs (NSAIDs), paracetamol, and opioids.

In conclusion, between 2010 and 2020, incidence of PDB decreased in men but increased in women with the elderly patients over 70 yr being most affected. The spine and pelvis and femur were most commonly involved and the GERD was the most common comorbidity in these patients. Bisphosphonate treatment was less than 10% in these patients, warranting more active prescription from physicians treating PDB.

## Author contributions

Jung-Wee Park (Writing—original draft, Funding acquisition), Dong-Hoon Lee (Data curation, Investigation), Ki-Tae Park (Data curation, Validation), Sung Hwa Kim (Formal analysis, Visualization), Young-Kyun Lee (Writing—review & editing, Conceptualization, methodology).

## Funding

## Conflicts of interest

The authors declare no conflicts of interest.

## Data availability

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

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