Neuroepidemiology

Original Paper

Neuroepidemiology
DOI: 10.1159/000534760

Received: September 23, 2023
Accepted: October 17, 2023
Published online: November 22, 2023

# Diabetes Mellitus and Acute Facial Palsy: A Nationwide Population-Based Study

Hee Won Seo[a] Soorack Ryu[b] Seung Hwan Lee[a] Jae Ho Chung[a]

[a]Department of Otolaryngology-Head and Neck Surgery, College of Medicine, Hanyang University, Seoul, Republic of Korea; [b]Department of Medicine, College of Medicine, Hanyang University, Seoul, Republic of Korea

**Keywords**
Facial palsy · Diabetes mellitus · Korean National Health Insurance · Bell's palsy · Ramsay Hunt syndrome

**Abstract**

***Introduction:*** Acute facial palsy, characterized by sudden hemifacial weakness, significantly impacts an individual's quality of life. Despite several predisposing factors identified for acute facial palsy, the specific relationship between diabetes mellitus (DM) and acute facial palsy has not been comprehensively explored in recent studies. The aim of the study was to assess the risk of acute facial palsy in patients with DM using a nationwide population sample cohort. ***Methods:*** DM cohort and non-DM cohort were built using the Korean National Health Insurance Service-Sample Cohort which represents the entire population of the Republic of Korea from January 2002 to December 2019. The DM cohort comprised 92,872 patients with a record of medication and a diagnosis of DM. Individuals who had facial palsy before the diagnosis of DM were excluded. A comparison cohort comprised 1,012,021 individuals without DM matched sociodemographically in a 1:4 ratio. The incidence of Bell's palsy (BP) and Ramsay Hunt syndrome (RHS) were evaluated in both cohorts. The risk factors for acute facial palsy were also assessed. ***Results:*** Among the 92,868 patients in the DM cohort, the incidence rate (IR) of BP and RHS were 31.42 (confidence interval [CI], 30.24–32.63) and 4.58 per 10,000 person-years (CI, 4.14–5.05), respectively. Among the 371,392 individuals in the non-DM cohort, the IR of BP was 22.11 per 10,000 person-years (CI, 21.62–22.59) and the IR of RHS was 2.85 per 10,000 person-years (CI, 2.68–3.02). IR ratios for BP and RHS were 1.42 (CI, 1.36–1.48) and 1.61 (CI, 1.43–1.80). In multivariate analysis, DM (hazard ratio [HR] 1.428), age (HR 1.008), and high comorbidity score (HR 1.051) were associated with increased risk of BP, and male (HR 0.803) and living in metropolis (HR 0.966) decreased the risk of BP. And DM (HR 1.615), high comorbidity score (HR 1.078), and living in metropolis (HR 1.201) were associated with increased risk for RHS. ***Conclusion:*** This study suggests that patients with DM had an increased risk of acute facial palsy including BP and RHS.



## Introduction

Acute peripheral facial palsy is a neurological disorder characterized by the sudden onset of hemifacial weakness resulting from a lower motor neuron lesion of the facial nerve. Not only does this condition lead to functional impairments, such as an inability to smile, blink, and oral incompetence, but it also causes esthetic problems due to facial asymmetry. In addition, some affected individuals may encounter a decrease in tear flow and changes in taste or salivation. These combined symptoms can have a negative impact on a patient's quality of life [1].

karger@karger.com
www.karger.com/ned



Correspondence to:
Jae Ho Chung, jaeho.chung.md@gmail.com

Acute facial palsy affects approximately 20–30 individuals per one hundred thousand annually [2–4]. There is no difference in incidence between male and female, although some studies suggest that females may be slightly more affected. Also, there is also no difference in incidence between the right and left sides of the face [3, 5, 6]. Acute facial palsy can be attributed to a various underlying medical condition such as infections, cholesteatoma, trauma, acoustic tumors, malignancies, autoimmune disorders, pregnancy, iatrogenic injuries, and congenital abnormalities [5, 7–9]. The most common type of acute facial palsy is idiopathic Bell's palsy (BP). Another condition, the Ramsay Hunt syndrome (RHS), is known to be caused by the varicella-zoster virus and is characterized by facial palsy, auricular vesicles, and vestibulocochlear dysfunction. Notably, RHS is reported to have a poorer prognosis than BP [3, 10].

There are several predisposing factors for acute facial palsy, such as diabetes mellitus (DM), exposure to cold temperatures, hemophilia, hereditary neuropathy, hypertension, leukemia, Melkersson-Rosenthal syndrome, Möbius syndrome, Paget's disease, and sarcoidosis [4, 7]. Among these, DM is known to be related to microangiopathy and macroangiopathy and is believed to have a negative impact on the body's immune system [11]. This can potentially increase the risk of viral infections, which can contribute to the development of acute facial palsy. Previous studies have shown that people with DM or abnormalities in glucose metabolism are more likely to develop BP [12, 13]. In addition, the severity of facial palsy tends to be more severe in these cases [14]. Similarly, other studies have shown that patients with BP have a higher prevalence of DM than those without [15, 16]. In addition, one study found a lower incidence of taste impairment in BP patients with DM, suggesting that BP in DM patients may be thought of as a type of diabetic mononeuropathy that occurs in a more distal part of the fallopian canal [17]. However, most of these studies are considerably dated, and there is a lack of recent research on the relationship between DM and acute facial palsy.

In South Korea, since 1989, all Koreans have been enrolled in the National Health Insurance program. The National Health Insurance Service (NHIS) offers open health data on 1 million individuals, which is about 2% of the National Health Insurance subscribers. This dataset can be considered representative of the healthcare population of South Korea. Therefore, the present study aimed to assess the risk of acute peripheral facial palsy in patients with DM using this nationwide population sample cohort.

## Methods

*Study Population and Design*

This study utilized datasets from the Korean National Health Information Database (NHIS-2023-2-150), provided by the Korean NHIS. The NHIS database includes diagnoses and associated comorbidities classified according to the 10th version of the International Classification of Diseases and Related Health Problems (ICD-10), demographic characteristics, healthcare institution specifics, income level, and urbanization status. We focused on the entire sample cohort population from the period of January 2002 to December 2019. Individuals who were diagnosed with DM (ICD-10 codes E10–E14) at least once during this period were classified into the DM cohort. In contrast, those who had never been diagnosed with DM during the same period were categorized into the non-DM cohort, serving as the control group. Patients diagnosed with acute facial palsy before their DM diagnosis and control individuals diagnosed with acute facial palsy before enrollment were excluded from the study. Individuals with incomplete data regarding gender, age, income status, and urbanization level were also excluded from the study.

To reduce the influence of potential confounders that could affect the onset of acute facial palsy, we employed a 1:4 nearest neighbor matching between the two cohorts. As a result, the final study population consisted of 92,868 individuals in the DM cohort and 371,392 individuals in the non-DM cohort (shown in Fig. 1). Throughout the observational period, occurrences of acute facial palsy were monitored in both cohorts. The onset of acute facial palsy was evaluated based on two conditions: BP (G51.0) and RHS (B02.2).

BP was diagnosed clinically in most cases without specialized tests. It was recognized as a characteristic hemifacial weakness with sudden onset without other neurological findings. On the other hand, RHS was diagnosed when the patient presented with pain and a characteristic vesicular rash on the ipsilateral ear along with facial weakness. In some cases, the presence of varicella-zoster virus was confirmed by a Tzanck smear to confirm the vesicular rash, but in characteristic cases, the diagnosis was made without this specialized test. In clinical practice, these diagnostic decisions were recorded in the NHIS database along with the time of diagnosis using the corresponding ICD-10 code. However, detailed indicators related to the severity of the disease, such as the House-Brackmann grade, are not collected.

*Evaluation of Comorbidities*

For the evaluation of comorbidities, we utilized the Charlson comorbidity index (CCI) score proposed by Charlson et al. [18] in 1987. This index assigns scores to 17 diseases based on their relative risks, using a weighted methodology. For the purpose of this study and to eliminate the impact of DM, we excluded "diabetes without chronic complication" and "diabetes with chronic complication" from the original items, applying an adjusted CCI score for our assessment.

*Statistical Analysis*

Data were analyzed using R Studio, Integrated Development Environment for R Version 1.0.136 (R Studio Inc., Boston, USA, https://www.rstudio.com), and SAS Enterprise Guide software version 7.1 (SAS Institute, Inc., Cary, NC, USA). Comorbidities

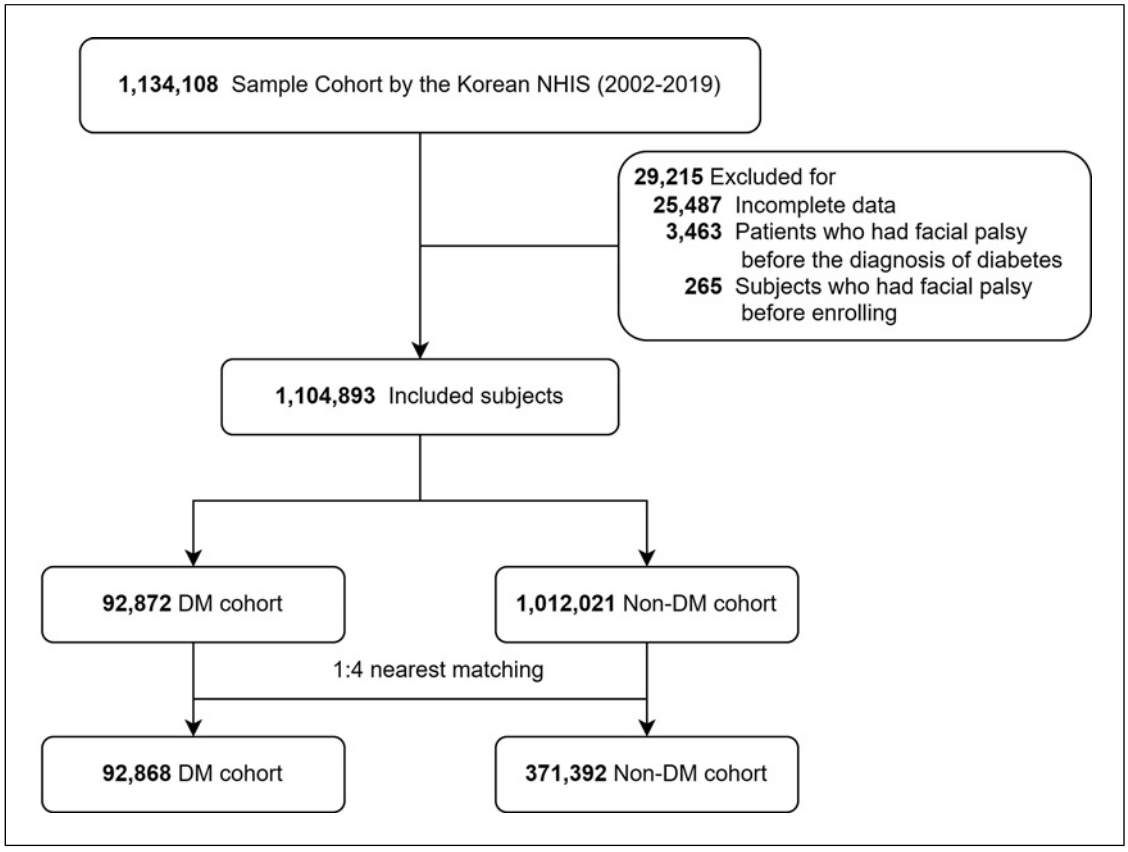


**Fig. 1.** Flow diagram of the study. NHIS, National Health Insurance Service. DM, diabetes mellitus.

and sociodemographic characteristics of the study cohort were represented as percentages for categorical variables and as means with standard deviations for continuous variables. Comparisons between groups were made using independent sample *t* tests for continuous variables and $\chi^2$ tests for categorical variables. For the purpose of unbiasedly estimating the difference in acute facial palsy incidence between the DM and non-DM cohorts, we applied a 1:4 nearest neighbor matching method. This method was chosen because it allows for increased statistical power while maintaining balance and representativeness between cohorts [19]. Propensity score was calculated by a logistic regression analysis with covariates of gender, age, income, urbanization level, and the adjusted CCI score. The caliper was adjusted to 0.01 to ensure a standardized mean difference with an absolute value less than 10% [20]. Person-years were calculated by summing up all the observation years per patient from the enrollment to the endpoint: diagnosis of acute facial palsy, death, or end of the study period. Incidence rates (IRs) per 10,000 person-years were calculated using a 95% confidence interval (CI). The incidence rate ratio (IRR) for acute facial palsy was calculated for the DM cohort in comparison with the non-DM cohort. Both univariate (crude) and multivariate (adjusted) Cox proportional hazard models were utilized to analyze the risk of acute facial palsy (hazard ratio [HR]) for individuals, considering the included covariates.

## Results

*Demographics of the Study Population*

From January 2002 to December 2019, the total sample cohort population comprised 1,134,108 individuals. After applying exclusion criteria, the DM cohort consisted of 92,872 individuals, while the non-DM cohort accounted for 1,012,021. Following a 1:4 nearest neighbor matching, the final study population included 92,868 individuals in the DM cohort and 371,392 in the non-DM cohort (shown in Fig. 1).

Table 1 shows the characteristics of the matched DM and non-DM cohorts. The average age for both cohorts was 57.7 years, with 55.7% being male and 44.3% female. And the mean adjusted CCI score was 0.99. During the study period, BP was diagnosed in 2,701 individuals (2.9%) from the DM cohort and 8,154 (2.2%) from the non-DM cohort. Furthermore, RHS was observed in 401 individuals (0.4%) in the DM cohort and 1,064 (0.3%) in the non-DM cohort.

**Table 1.** Comorbidities and sociodemographic characteristics of the study cohort

| | DM ($n$ = 92,868) | Non-DM ($n$ = 371,392) | SMD |
|---|---|---|---|
| | $n$ (%) or M±SD | $n$ (%) or M±SD | |
| Matching parameters | | | |
| Gender | | | |
| Male | 52,564 (56.6) | 206,235 (55.5) | 0.0216 |
| Female | 40,304 (43.4) | 165,157 (44.5) | −0.0216 |
| Age | 57.55±12.73 | 57.72±13.12 | −0.0132 |
| Income | | | |
| Lowest | 20,734 (22.3) | 84,510 (22.8) | −0.0101 |
| Lower mid | 15,502 (16.7) | 60,894 (16.4) | 0.0078 |
| Upper mid | 18,804 (20.3) | 73,156 (19.7) | 0.0138 |
| Highest | 37,828 (40.7) | 152,832 (41.2) | −0.0085 |
| Urbanization level | | | |
| Metropolis | 41,899 (45.1) | 170,881 (46.0) | −0.0179 |
| Rural | 50,969 (54.9) | 200,511 (54.0) | 0.0179 |
| Adjusted CCI score* | 0.97±1.53 | 0.99±1.43 | −0.0172 |
| Myocardial infarction + congestive heart failure | 4,220 (4.5) | 12,111 (3.3) | 0.0662 |
| Peripheral vascular disease | 8,168 (8.8) | 27,816 (7.5) | 0.0479 |
| Cerebrovascular disease | 5,864 (6.3) | 21,707 (5.8) | 0.0197 |
| Outcome (1) | | | |
| BP | | | |
| Incidence | 2,701 (2.9) | 8,154 (2.2) | |
| Follow-up years | 9.26±5.57 | 9.93±5.56 | |
| Outcome (2) | | | |
| RHS | | | |
| Incidence | 401 (0.4) | 1,064 (0.3) | |
| Follow-up years | 9.42±5.58 | 10.06±5.55 | |

DM, diabetes mellitus; M, mean; SD, standard deviation; SMD, standardized mean difference; CCI, Charlson comorbidity index. *Adjusted CCI excludes the categories "diabetes without chronic complication" and "diabetes with chronic complication" from the original CCI.

*Incidence of Acute Facial Palsy*

The IR of BP was 31.42 per 10,000 person-years in the DM cohort and 22.11 in the non-DM cohort, revealing a 1.42-fold higher incidence in the DM cohort (95% CI 1.36–1.48). In both cohorts, the IR of BP was higher in females than in males and greater in individuals aged 50 and above than those below 50. In every category, based on gender and age, the BP incidence was consistently higher in the DM cohort compared to the non-DM cohort (IRR 1.47, 95% CI 1.37–1.56 in male; IRR 1.39, 95% CI 1.30–1.47 in female; IRR 1.51, 95% CI 1.37–1.66 in those below 50 years; IRR 1.40, 95% CI 1.33–1.47 in those 50 years and above) (Table 2).

Regarding RHS, the IR was 4.58 per 10,000 person-years in the DM cohort and 2.85 in the non-DM cohort, indicating a 1.61-fold increase in the DM cohort (95% CI 1.43–1.80). No significant difference in the incidence of RHS based on gender or age was observed. However, the incidence was consistently higher in the DM cohort for both genders (IRR 1.64, 95% CI 1.40–1.91 in male; IRR 1.57, 95% CI 1.32–1.86 in female) and age groups (IRR 1.86, 95% CI 1.50–2.30 in those below 50 years; IRR 1.52, 95% CI 1.32–1.74 in those 50 years and above) (Table 3).

*Risk Factors for Acute Facial Palsy*

When analyzing factors affecting the development of BP in the entire cohort, univariate analysis revealed significant associations with the presence of DM, higher age, female gender, highest income, rural

residence, and the presence of comorbidities. However, multivariate analysis showed presence of DM, increased age, being female, having the highest income, and the presence of comorbidities, especially cerebrovascular disease, as risk factors (Table 4). For the development of RHS, presence of DM, living in a metropolis, a higher adjusted CCI score, and the presence of cerebrovascular disease emerged as significant risk factors (Table 5).

## Discussion

In this nationwide cohort study assessing the association between DM and the risk of acute facial palsy, we found that individuals with DM had an increased risk of both BP and RHS. Furthermore, we also identified that other comorbidities, especially cerebrovascular disease, increased the risk of acute facial palsy. Utilizing data spanning 17 years from the Korean NHIS-Sample Cohort, this research offers a comprehensive overview of the factors associated with acute facial palsy within the South Korean population.

Acute facial palsy significantly affects an individual's quality of life, leading to both functional and esthetic challenges. Therefore, it is necessary to focus not only on treatment of the disease but also on its prevention. Understanding the risk factors underlying the onset and progression of this condition is essential. Previous studies have highlighted that the causes of acute facial palsy can be attributed to various medical conditions and predisposing factors [4, 5, 7]. In particular, DM, which is associated with microangiopathy and immune system dysfunction, is emerging as an important risk factor of acute facial palsy.

BP is commonly regarded as an entrapment neuropathy resulting from processes of inflammation, edema, and strangulation [14]. The well-documented microangiopathy in DM patients can lead to impaired blood supply to nerves, resulting in hypoxia-induced neuropathy [21]. In one study, a decrease in total capillary basement membrane area, indicative of decreased nerve conduction, was observed in DM patients, and a significant increase in peripheral neuropathy was found [22]. This supports the hypothesis that microvascular pathology in DM underlies the development of peripheral neuropathy. Another study found that in BP patients with DM, nerve conduction studies revealed that they had asymptomatic polyneuropathy, not just mononeuropathy of the facial nerve. This suggested that BP, an entrapment neuropathy, may be more likely to occur if the reserve capacity of the distal peripheral nerve has already been

**Table 2.** IR and IRR of BP development in the study cohort

| | DM ($n$ = 92,868) | | | | | Non-DM ($n$ = 371,392) | | | | | IRR | 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $N$ | BP | person-year | IR (/10,000 person-year) | 95% CI | $N$ | BP | person-year | IR (/10,000 person-year) | 95% CI | | |
| Overall | 92,868 | 2,701 | 859,560 | 31.42 | 30.24–32.63 | 371,392 | 8,154 | 3,688,475 | 22.11 | 21.62–22.59 | 1.42 | 1.36–1.48 |
| Gender | | | | | | | | | | | | |
| Male | 52,564 | 1,328 | 474,204 | 28.00 | 26.51–29.55 | 206,235 | 3,810 | 1,994,526 | 19.10 | 18.50–19.71 | 1.47 | 1.37–1.56 |
| Female | 40,304 | 1,373 | 385,355 | 35.63 | 33.76–37.56 | 165,157 | 4,344 | 1,693,949 | 25.64 | 24.88–26.41 | 1.39 | 1.30–1.47 |
| Age | | | | | | | | | | | | |
| <50 | 24,341 | 609 | 240,990 | 25.27 | 23.30–27.35 | 96,034 | 1,667 | 998,802 | 16.69 | 15.89–17.51 | 1.51 | 1.37–1.66 |
| ≥50 | 68,527 | 2,092 | 618,570 | 33.82 | 32.38–35.30 | 275,358 | 6,487 | 2,689,673 | 24.12 | 23.53–24.71 | 1.40 | 1.33–1.47 |

DM, diabetes mellitus; BP, Bell's palsy; IR, incidence rate; IRR, incidence rate ratio; CI, confidence interval.

**Table 3.** IR and IRR of RHS development in the study cohort

| | DM ($n$ = 92,868) | | | | | Non-DM ($n$ = 371,392) | | | | | IRR | 95% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $N$ | RHS | person-year | IR (/10,000 person-year) | 95% CI | $N$ | RHS | person-year | IR (/10,000 person-year) | 95% CI | | |
| Overall | 92,868 | 401 | 874,801 | 4.58 | 4.14–5.05 | 371,392 | 1,064 | 3,734,800 | 2.85 | 2.68–3.02 | 1.61 | 1.43–1.80 |
| Gender | | | | | | | | | | | | |
| Male | 52,564 | 224 | 481,356 | 4.65 | 4.06–5.30 | 206,235 | 572 | 2,014,778 | 2.84 | 2.61–3.08 | 1.64 | 1.40–1.91 |
| Female | 40,304 | 177 | 393,445 | 4.50 | 3.86–5.21 | 165,157 | 492 | 1,720,022 | 2.86 | 2.61–3.12 | 1.57 | 1.32–1.86 |
| Age | | | | | | | | | | | | |
| <50 | 24,341 | 120 | 244,137 | 4.92 | 4.07–5.87 | 96,034 | 266 | 1,007,557 | 2.64 | 2.33–2.97 | 1.86 | 1.50–2.30 |
| ≥50 | 68,527 | 281 | 630,664 | 4.46 | 3.94–5.00 | 275,358 | 798 | 2,727,243 | 2.93 | 2.72–3.13 | 1.52 | 1.32–1.74 |

DM, diabetes mellitus; RHS, Ramsay Hunt syndrome; IR, incidence rate; IRR, incidence rate ratio; CI, confidence interval.

reduced by DM [12]. Consequently, in the present study, the high susceptibility of DM patients to peripheral facial neuropathy may have contributed to the development of acute facial palsy.

Moreover, DM is recognized to influence the immune system, leading to an increased vulnerability to viral infections. Insulin itself has been identified as a molecule capable of directly regulating the function of immune cells, particularly T cells. However, in DM, T cell insulin receptor expression diminishes, resulting in impaired proliferation of antiviral T cells and cytokine production, rendering individuals more susceptible to infections [11]. Indeed, during the era of coronavirus disease 2019 (COVID-19), DM emerged as one of the most commonly reported comorbidities among severe patients, further highlighting the susceptibility of diabetes patients to infections [23]. The fact that the incidence of BP, known to be susceptible to various infections, and RHS, known to be primarily caused by varicella-zoster virus infection, were increased in the DM cohort in the present study may also be explained by the preceding explanations.

Diabetes stands as a growing global health concern. According to data from the IDF (International Diabetes Foundation) in 2021, the global diabetic population stands at approximately 537 million, with projections indicating a rise to 783 million by 2045 [24]. The prevalence of DM in South Korea has been steadily increasing; as of 2020, it was reported at 13.6%, higher than the average of OECD (Organization for Economic Co-operation and Development) countries. Despite the high prevalence of DM and its association with acute facial palsy, the clinical significance of DM in the context of acute facial palsy is often overlooked. Given that diabetes can lead to numerous complications, it warrants increased attention in both clinical and public health strategies.

Based on these observations, there are notable clinical implications when considering the management and treatment of acute facial paralysis in patients with DM. The standard treatment for both BP and RHS is known to be high-dose systemic steroids and/or antiviral therapy [4]. High-dose steroids have the potential to elevate blood glucose levels, so caution is required when administered to DM patients. The increased incidence of BP and RHS within our DM cohort signifies a notable association. Tight glycemic control is just as important as steroid treatment in managing these conditions. Therefore, strict DM management alongside steroid treatment is essential. In some cases, clinicians might consider early intratympanic steroid injections as an alternative therapy.

Our study not only examined DM but also comprehensively investigated other factors that could influence

**Table 4.** Multivariate analysis of risk factors for the development of BP during the follow-up period in the whole cohort

| | Overall development of BP ($n$ = 464,260) | | | |
|---|---|---|---|---|
| | crude HR | 95% CI | adjusted HR | 95% CI |
| DM | | | | |
| Yes | 1.423 | 1.362–1.486 | 1.428 | 1.368–1.492 |
| No | Ref | | ref | |
| Age | 1.013 | 1.011–1.014 | 1.008 | 1.007–1.010 |
| Gender | | | | |
| Male | 0.758 | 0.730–0.787 | 0.803 | 0.773–0.835 |
| Female | ref | | ref | |
| Income | | | | |
| Lowest | 0.926 | 0.881–0.973 | 0.927 | 0.882–0.974 |
| Lower mid | 0.889 | 0.841–0.940 | 0.912 | 0.863–0.964 |
| Upper mid | 0.912 | 0.867–0.961 | 0.928 | 0.881–0.977 |
| Highest | ref | | ref | |
| Urbanization level | | | | |
| Metropolis | 0.946 | 0.911–0.982 | 0.966 | 0.930–1.004 |
| Rural | Ref | | ref | |
| Adjusted CCI score* | 1.087 | 1.073–1.101 | 1.051 | 1.034–1.068 |
| Myocardial infarction + congestive heart failure | | | | |
| Yes | 1.344 | 1.212–1.490 | 1.009 | 0.904–1.127 |
| No | ref | | ref | |
| Peripheral vascular disease | | | | |
| Yes | 1.352 | 1.254–1.457 | 1.059 | 0.976–1.150 |
| No | ref | | ref | |
| Cerebrovascular disease | | | | |
| Yes | 1.437 | 1.328–1.556 | 1.126 | 1.032–1.228 |
| No | ref | | ref | |

"ref" denotes the "reference group." This is the baseline category against which the other categories are compared during the analysis. DM, diabetes mellitus; CCI, Charlson comorbidity index; HR, hazard ratio; CI, confidence interval. *Adjusted CCI excludes the categories "diabetes without chronic complication" and "diabetes with chronic complication" from the original CCI.

the onset of acute facial palsy. Our results suggest that beyond DM, factors like age, female gender, higher income, a higher adjusted CCI score, and cerebrovascular disease elevated the risk of BP. Moreover, residing in a metropolis, having a high adjusted CCI score, and concurrent cerebrovascular disease were associated with an increased risk of RHS. In both BP and RHS, the presence of comorbidities, especially cerebrovascular disease, was a significant risk factor for disease development. Previous studies have reported a higher incidence of ischemic stroke in patients with BP [25, 26]. It is believed that viral infections, one of the suspected causes of BP, can induce vasculitis, which in turn increases such risks.

Age was also a significant risk factor for BP. As shown in Table 2, both in the DM and non-DM cohorts, those aged over 50 showed a higher IR of BP compared to those under 50, which is consistent with previous findings that the incidence increases with age [27]. The prevalence of comorbidities increases with age, which may explain the effect of age on the results of this study. In this study, the IR of BP was also found to be higher in females than in males. While some studies suggested that gender does not play a role in BP's occurrence, considering pregnancy as a known predisposing factor for BP, it is reasonable to assume that the higher incidence among females could be influenced by such effects [4].

Interestingly, socioeconomic aspects, like income and residence, also appeared to influence the incidence of acute facial palsy. These observations are likely attributable to the characteristics of claim data, which captures only those treated. In other words, residing in metropolises and

**Table 5.** Multivariate analysis of risk factors for the development of RHS during the follow-up period in the whole cohort

| | Overall development of RHS ($n$ = 464,260) | | | |
|---|---|---|---|---|
| | crude HR | 95% CI | adjusted HR | 95% CI |
| DM | | | | |
| Yes | 1.617 | 1.442–1.814 | 1.615 | 1.440–1.812 |
| No | ref | | ref | |
| Age | 1.000 | 0.996–1.004 | | |
| Gender | | | | |
| Male | 1.014 | 0.915–1.124 | | |
| Female | ref | | ref | |
| Income | | | | |
| Lowest | 0.927 | 0.809–1.062 | | |
| Lower mid | 0.952 | 0.821–1.104 | | |
| Upper mid | 0.911 | 0.791–1.048 | | |
| Highest | ref | | ref | |
| Urbanization level | | | | |
| Metropolis | 1.186 | 1.071–1.314 | 1.201 | 1.084–1.330 |
| Rural | ref | | ref | |
| Adjusted CCI score* | 1.097 | 1.059–1.137 | 1.078 | 1.034–1.123 |
| Myocardial infarction + congestive heart failure | | | | |
| Yes | 1.176 | 0.868–1.593 | | |
| No | ref | | ref | |
| Peripheral vascular disease | | | | |
| Yes | 1.300 | 1.051–1.608 | 1.043 | 0.828–1.314 |
| No | ref | | ref | |
| Cerebrovascular disease | | | | |
| Yes | 1.553 | 1.257–1.920 | 1.295 | 1.026–1.634 |
| No | ref | | ref | |

"ref" denotes the "reference group." This is the baseline category against which the other categories are compared during the analysis. DM, diabetes mellitus; CCI, Charlson comorbidity index; HR, hazard ratio; CI, confidence interval. *Adjusted CCI excludes the categories "diabetes without chronic complication" and "diabetes with chronic complication" from the original CCI.

having higher income might increase access to medical care, subsequently leading to an increased diagnosis rate. These results highlight the significance of healthcare strategies aimed at enhancing medical accessibility.

A major strength of our study lies in its utilization of a nationwide population dataset. To our knowledge, this is the first formal study using a nationwide population database to assess the impact of DM on the onset of acute facial palsy. Our findings emphasize the potential neurological implications of comorbidities such as DM. Additionally, the consistent increase in the IRs of BP and RHS across various genders and age groups within the DM cohort demonstrates the successful identification of a potential association between DM and these conditions.

However, our study has several limitations. The primary concern stems from the nature of claim data, resulting in the exclusion of data from patients who did not visit hospitals and the absence of detailed information regarding patients' actual health status and treatment processes. In addition, this study did not investigate the incidence of distal symmetrical neuropathy, which could explain the higher incidence of BP in patients with DM. Thus, while the important finding that DM increases the incidence of acute facial palsy, it is important to note that BP in DM patients cannot definitively be classified as part of diabetic mononeuropathy. Further studies to investigate the association with distal symmetrical neuropathy are required. Another limitation is that, given the specialized nature of

our South Korean sample population, our findings may not be easily generalized to populations of other races and ethnicities beyond South Korea. Furthermore, data regarding the severity or prognosis of the facial palsy and the severity or glycemic control of DM were also not provided. Future research could potentially address these limitations by integrating vast medical data repositories.

In light of our findings, clinicians should be alert to the potential increased risk of acute facial palsy in patients with DM and be more attentive in their management. Timely control and management of DM can potentially alleviate the associated risks, highlighting the significance of early diagnosis and intervention for DM patients.

## Statement of Ethics

The study was exempted from the requirement for informed consent by the Institutional Review Board of Hanyang University (HYUIRB-202209-022, date of approval: 2022.09.27) because of the use of publicly available data of the Korean National Health Information Database. The study was performed in accordance with the Declaration of Helsinki and good clinical practice guidelines.

## Conflict of Interest Statement

The author (J.H.C.) has reported no conflict of interest.


## Funding Sources

This research was supported by a grant from the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health and Welfare, Republic of Korea (Grant No.: HI21C1574).


## Author Contributions

J.H.C. had full access to all of the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis. Concept and design: J.H.C.; data curation: H.W.S., S.R., and J.H.C.; drafting of the manuscript: J.H.C.; critical revision of the manuscript for important intellectual content: S.H.L. and J.H.C.; statistical analysis: S.R.; validation and visualization: J.H.C. and H.W.S.; and supervision: J.H.C. and S.H.L.

## Data Availability Statement

The Korean NHIS database was used with permission. The data that support the findings of the study are available from the corresponding author upon reasonable request.

## References


1 Hasmat S, Low TH, Dusseldorp JR, Mukherjee P, Clark JR. Facial nerve palsy: narrative review on the importance of the eye and its assessment. Head Neck. 2022;44(11):2600–7.
2 Stamatiou I, Papachristou S, Papanas N. Diabetes mellitus and bell's palsy. Curr Diabetes Rev. 2023;19(1):e080322201913.
3 Pereira LM, Obara K, Dias JM, Menacho MO, Lavado EL, Cardoso JR. Facial exercise therapy for facial palsy: systematic review and meta-analysis. Clin Rehabil. 2011;25(7):649–58.
4 Baugh RF, Basura GJ, Ishii LE, Schwartz SR, Drumheller CM, Burkholder R, et al. Clinical practice guideline: bell's palsy. Otolaryngol Head Neck Surg. 2013;149(3 Suppl):S1–27.
5 Hohman MH, Hadlock TA. Etiology, diagnosis, and management of facial palsy: 2,000 patients at a facial nerve center. Laryngoscope. 2014;124(7):E283–293.
6 Lorch M, Teach SJ. Facial nerve palsy: etiology and approach to diagnosis and treatment. Pediatr Emerg Care. 2010;26(10):763–9; quiz 770-3.
7 Kim SJ, Lee HY. Acute peripheral facial palsy: recent guidelines and a systematic review of the literature. J Korean Med Sci. 2020;35(30):e245.
8 Batinović F, Martinić MK, Durdov MG, Sunara D. A case of unilateral otologic symptoms as initial manifestations of granulomatosis with polyangiitis. J Audiol Otol. 2023;27(3):161–7.
9 Park MJ, Ahn JH, Park HJ, Chung JW, Kang WS. Diagnostic validity of auditory brainstem response for the initial screening of vestibular schwannoma. J Audiol Otol. 2022;26(1):36–42.
10 Chung SH, Kim JM, Rim HS, Yeo SG, Kim SH. Association between serum varicella-zoster virus igm and igg and prognosis of ramsay hunt syndrome. J Clin Med. 2023;12(15):5164.
11 Turk Wensveen T, Gašparini D, Rahelić D, Wensveen FM. Type 2 diabetes and viral infection; cause and effect of disease. Diabetes Res Clin Pract. 2021;172:108637.
12 Lundgren A, Odkvist LM, Hendriksson KG, Larsson LE, Karlberg BE, Jerlvall L. Facial palsy in diabetes mellitus: not only a mononeuropathy? Adv Otorhinolaryngol. 1977;22:182–9.
13 Bosco D, Plastino M, Bosco F, Consoli A, Labate A, Pirritano D, et al. Bell's palsy: a manifestation of prediabetes? Acta Neurol Scand. 2011;123(1):68–72.
14 Riga M, Kefalidis G, Danielides V. The role of diabetes mellitus in the clinical presentation and prognosis of bell palsy. J Am Board Fam Med. 2012;25(6):819–26.
15 Korczyn AD. Bell's palsy and diabetes mellitus. Lancet. 1971;1(7690):108–9.
16 Adour K, Wingerd J, Doty HE. Prevalence of concurrent diabetes mellitus and idiopathic facial paralysis (bell's palsy). Diabetes. 1975;24(5):449–51.
17 Pecket P, Schattner A. Concurrent bell's palsy and diabetes mellitus: a diabetic mononeuropathy? J Neurol Neurosurg Psychiatry. 1982;45(7):652–5.
18 Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis. 1987;40(5):373–83.
19 Austin PC. The performance of different propensity-score methods for estimating relative risks. J Clin Epidemiol. 2008;61(6):537–45.
20 Morgan CJ. Reducing bias using propensity score matching. J Nucl Cardiol. 2018;25(2):404–6.
21 Papanas N, Vinik AI, Ziegler D. Neuropathy in prediabetes: does the clock start ticking early? Nat Rev Endocrinol. 2011;7(11):682–90.

22 Thrainsdottir S, Malik RA, Dahlin LB, Wiksell P, Eriksson KF, Rosén I, et al. Endoneurial capillary abnormalities presage deterioration of glucose tolerance and accompany peripheral neuropathy in man. Diabetes. 2003;52(10):2615–22.
23 Erener S. Diabetes, infection risk and covid-19. Mol Metab. 2020;39:101044.
24 Sun H, Saeedi P, Karuranga S, Pinkepank M, Ogurtsova K, Duncan BB, et al. Idf diabetes atlas: global, regional and country-level diabetes prevalence estimates for 2021 and projections for 2045. Diabetes Res Clin Pract. 2022;183:109119.
25 Lee CC, Su YC, Chien SH, Ho HC, Hung SK, Lee MS, et al. Increased stroke risk in bell's palsy patients without steroid treatment. Eur J Neurol. 2013;20(4):616–22.
26 Kim JY, Kim MS, Kim MH, Kim DK, Yu MS. Bell palsy and the risk of cardio-cerebrovascular disease: a population-based follow-up study. Laryngoscope. 2019;129(10):2371–7.
27 Singh A, Deshmukh P. Bell's palsy: a review. Cureus. 2022;14(10):e30186.