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Demographics and care of epilepsy in older adults in Germany

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ABSTRACT

Purpose: Epilepsy is one of the most frequent chronic neurological disorders worldwide and is increasingly significant in individuals aged over 65 years due to rising life expectancy and comorbidities. This study aims to improve epilepsy care by examining demographic changes and treatment parameters in patients aged 65 and older in Germany.

Methods: Data from the IQVIA™ LRx and Disease Analyzer (DA) databases (2018–2022) were analyzed for epilepsy patients 65+. The LRx database provided prescription data, while DA offered diagnostic and demographic information. Multivariable logistic regression analysis was conducted to evaluate the association between age, sex, region, physician specialty and pre-defined outcomes, i.e., therapy delay and adherence.

Results: In 2022, the DA database estimated epilepsy prevalence at 0.64 % (65–74: 0.91 %; 75+: 1.32 %), and LRx at 0.67 % (65–74: 0.97 %; 75+: 1.75 %). Regional differences in prevalence, incidence, and treatment were observed, with geographic gradients visualized. Most patients (63 %) received anti-seizure medication (ASM) on diagnosis day, but neurologists prescribed ASMs later than GPs, especially in those over 75. Age 75+ was associated with significantly lower odds of therapy delay (adjusted odds ratio; AOR = 0.79, p 0.004), and male gender with a slightly reduced risk of delay (AOR = 0.91, p 0.003). Treatment by neurologists was associated with a higher adherence (AOR = 1.85, $p < 0.001$) but greater therapy delays (AOR = 1.19, $p < 0.001$) compared with GPs. Third-line therapies improved adherence across all ages (AOR = 2.09, $p < 0.001$).

Conclusion: The study highlights a higher prevalence of epilepsy in older adults than previously estimated and significant differences in treatment timing and adherence between GPs and neurologists. Further research is needed to explore regional treatment disparities and improve care for elderly epilepsy patients.

1. Introduction

Epilepsy is one of the most frequent chronic neurological disorders, ranking third among neurological conditions in older populations (aged 65 and older), following stroke and dementia [1,2]. The incidence of new-onset epilepsy in this age group is notably high [3–5], a trend closely associated with increased longevity and related comorbidities [6]. This rising prevalence, places beside other consequences, an additional burden on healthcare providers in terms of costs, particularly in aging populations such as those in Germany [4,6].

Despite this growing prevalence in older individuals, research on epilepsy in this population is notably limited. Factors making the management of epilepsy in this age group more complicated include atypical disease presentations, the presence of multiple comorbidities, and polypharmacy [3–6]. These factors can obscure the symptoms of epilepsy and make a diagnosis more difficult [4,5]. Additionally, the high incidence of comorbidities not only increases the risk of developing epilepsy, but also introduces further challenges in its management.

Adverse reactions to anti-seizure medications (ASMs) are particularly burdensome for elderly patients [4,5]. Age-related changes in

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pharmacokinetics and pharmacodynamics, combined with polypharmacy, contribute to reduced tolerance and increased risk of adverse effects [4,5,7]. Although there is a shift toward newer ASMs, traditional drugs such as carbamazepine and valproate have been reported to remain commonly prescribed for elderly patients [4,8]. Managing epilepsy in this age group is further complicated by comorbid conditions and the need to coordinate multiple medications, increasing the risk of drug interactions [4,5]. Therefore, tolerance to ASMs and treatment adherence are crucial factors influencing the efficacy of epilepsy management in the elderly [4].

Research focusing on epilepsy in individuals over 65 is notably limited [4,7,9]. Existing studies often concentrate on younger populations, leaving a significant knowledge gap regarding the management of epilepsy in older adults. This scarcity of data and research funding is concerning, given the aging global population and the associated rise in epilepsy incidence among older adults [3–5]. To address this gap, the current study provides updated data on demographics and treatment of epilepsy in patients aged 65 and older in Germany. Key indicators of patient care were examined, including the proportion of patients having tried three or more ASM options, frequency of visits to general practitioners (GPs) and neurologists, timing of initial ASM treatment, and treatment adherence. This analysis focused exclusively on parameters that could be segmented by age, specifically in patients aged 65 and 75 years and older.

2. Methods

To assess the demographics and care of epilepsy patients aged 65 years and older, a four-step methodology utilizing the IQVIA™ LRx and IQVIA™ Disease Analyzer (DA) databases was employed, utilizing data from 2018 to 2022. This combined approach addressed individual database limitations and allowed for a comprehensive analysis of the study's research questions. Both databases provide in-depth information on age and sex at both national and regional levels enabling stratification of the data by these factors.

2.1. Databases used

The LRx database provides anonymized data on medical prescriptions, covering 82 % of statutory health insurance (SHI) prescriptions in Germany. It includes patient data such as age, sex, health insurance status, treatment history, and details of the prescribed medication, including date, strength, dosage, form, and prescriber specialty. Reporting of age, sex, race or ethnicity was based on details as provided through anonymized medical records. It covers drug treatment on an outpatient treatment level and allows precise tracking of interdisciplinary treatments, including primary care products, specialized, niche, and orphan drugs. It also offers regional analysis down to the health insurance district office level. However, the LRx does not include diagnostic information since diagnoses are not recorded on prescriptions.

The DA database contains de-identified electronic medical records from office-based practices, including outpatient data and daily physicians' routines reflecting daily clinical practices in primary and specialty care, including neurology. It includes patient diagnoses, ICD-10 diagnostic codes, prescriptions, physician types, referrals to specialists or hospitals, and the time from diagnosis to ASM initiation. It encompasses over 20 million anonymized electronic medical records collected over >28 years. The data originates from >3200 physicians, including both GPs and specialists. >20 million anonymized records, representing 5 % of office-based doctors in Germany. This extensive dataset is obtained from electronic systems used in clinical practice, providing comprehensive insights into clinical practices and patient histories. The DA database has been found to be representative and valid for the German population with respect to pharmacoeconomic and epidemiologic aspects; data is routinely compared to national population statistics and several publications have used it for population-based studies [10–20].

The database contains solely anonymous data and does not identify any personal information, in compliance with §3 Abs. 6 of the German Federal Data Protection Act (Bundesdatenschutzgesetz). Identification of individual patients was not possible; therefore, informed consent was not required. The DA database has been determined to be both representative and reliable for the German population regarding epidemiologic and pharmacoeconomic features [15,28].

The DA database was used to find out the share of epilepsy patients for each antiepileptic drug (ATC N03A) and based on these findings, a transfer to the LRx database was performed, which represents a basis for subsequent analyses. When a question could not be answered directly using one source, a subset of questions was addressed through supporting analysis from the other database. See Supplementary Table 1 for a detailed description of steps in the identification of epilepsy patients, calculation of incidence and prevalence, profiling of patient care parameters, evaluation of ASM treatment delays, and assessment of treatment adherence based on ASM usage and diagnostic data.

2.2. Statistical analysis

2.2.1. Variables and data sources

We utilized data from the IQVIA™ LRx and IQVIA™ DA databases to conduct our analyses. The LRx database, covering 82 % of SHI prescriptions in Germany, provided insights into ASM treatments, while the DA database provided diagnostic data. Our primary focus was on patients aged 65 years and older, segmented into two age cohorts: 65–74 years and 75 years and older. We analyzed multiple parameters, including treatment adherence, therapy delay, the number of medical visits, and the likelihood of receiving three or more ASM treatment options.

2.2.2. Regression models

2.2.2.1. Therapy delay. A multivariable logistic regression was employed to examine factors associated with a delay in initiating ASM treatment, defined as not receiving therapy on the day of diagnosis, for patients aged 65 years and older. The outcome variable was therapy delay (not receiving therapy on the diagnosis day), and the independent variables included age group (65–74 vs. 75+ years), sex, region (West vs. East Germany), years (2018–2022), and physician specialties (GP vs. neurologist).

2.2.2.2. Number of medical visits. Factors associated with the number of medical visits per year were identified. Due to the large patient samples, p-values were generally significant. Nonetheless, only effects with at least +1 or −1 visit were considered clinically relevant.

2.2.2.3. Likelihood of having tried three or more ASM treatment options. A logistic regression was conducted to determine factors associated with the likelihood of receiving three or more ASM treatment options.

2.2.2.4. Adherence to treatment. To identify factors associated with achieving at least 80 % adherence to ASM treatment for patients aged 65 years and older, a multivariable logistic regression was employed. The outcome variable was adherence of at least 80 % (yes vs. no). Independent variables included age group (65–74 vs. 75+ years), sex, region (West vs. East Germany), therapy line (1st/2nd vs. 3rd+), years (2018–2022), at least once treated by a neurologist (yes/no), and at least once treated in an outpatient center (yes/no).

3. Results

3.1. Key findings

The analysis revealed that patients aged 75 years and older had

lower odds of achieving at least 80 % adherence to ASM treatment and were less likely to experience a therapy delay compared to the 65–74 years age group. Male sex had a slightly positive effect on adherence in the older cohort and was associated with a lower risk of therapy delay. Regional differences had minimal impact on adherence and therapy delay. Patients on their third or higher line of therapy showed better adherence, and those treated by neurologists had higher adherence but also a higher risk of therapy delay compared to those treated by GPs. Recent years, particularly 2022, saw lower odds of adherence and a higher likelihood of therapy delay. The number of medical visits per year was generally lower across older age groups, with no significant sex or regional effects. The probability of receiving three or more ASM treatment options decreased with age, and male sex was linked to a slightly lower chance. Certain regions, like Bremen and Schleswig-Holstein, had a significantly lower chance of patients receiving multiple ASMs, a trend that was more pronounced in elderly groups. The likelihood of receiving multiple ASMs increased in more recent years, with neurologist involvement associated with a higher chance of receiving diverse treatments.

This study focused exclusively on parameters that could be segmented by age, specifically in patients aged 65 years and older.

3.2. Incidence and prevalence in patients with epilepsy aged 65 and older

3.2.1. Incidence

The DA database found a total of 72,811 patients with a first ICD10 G40.0–9 diagnosis of epilepsy in 2022 and no other G40 beforehand. For patients 65–74 (N = 10,729) the incidence was 0.11 % and those over 75 (*n* = 19,888) had a particularly high incidence of 0.21 % with an adjusted rate of 214.8 cases per 100,000 inhabitants. Fig. 1 shows the distribution of epilepsy incidence by age group. In the LRx database, incidence was defined as the first ASM treatment, here for 2022 we assessed a total of 79,806 patients with 13,508 between 65 and 74 and 25,753 patients over 75, representing an incidence rate of 0.14 % for the 65–74 age group and 0.28 % for those over 75 with an adjusted rate of 278.1 cases per 100,000 inhabitants for the highest age group (Fig. 1a).

In 2022, there was significant regional variability in the adjusted incidence rates of epilepsy between the western and eastern regions. In the western region, the adjusted incidence rate for the 65–74 cohort was 109 with a higher rate of 133 in the east. For 75+ patients the difference

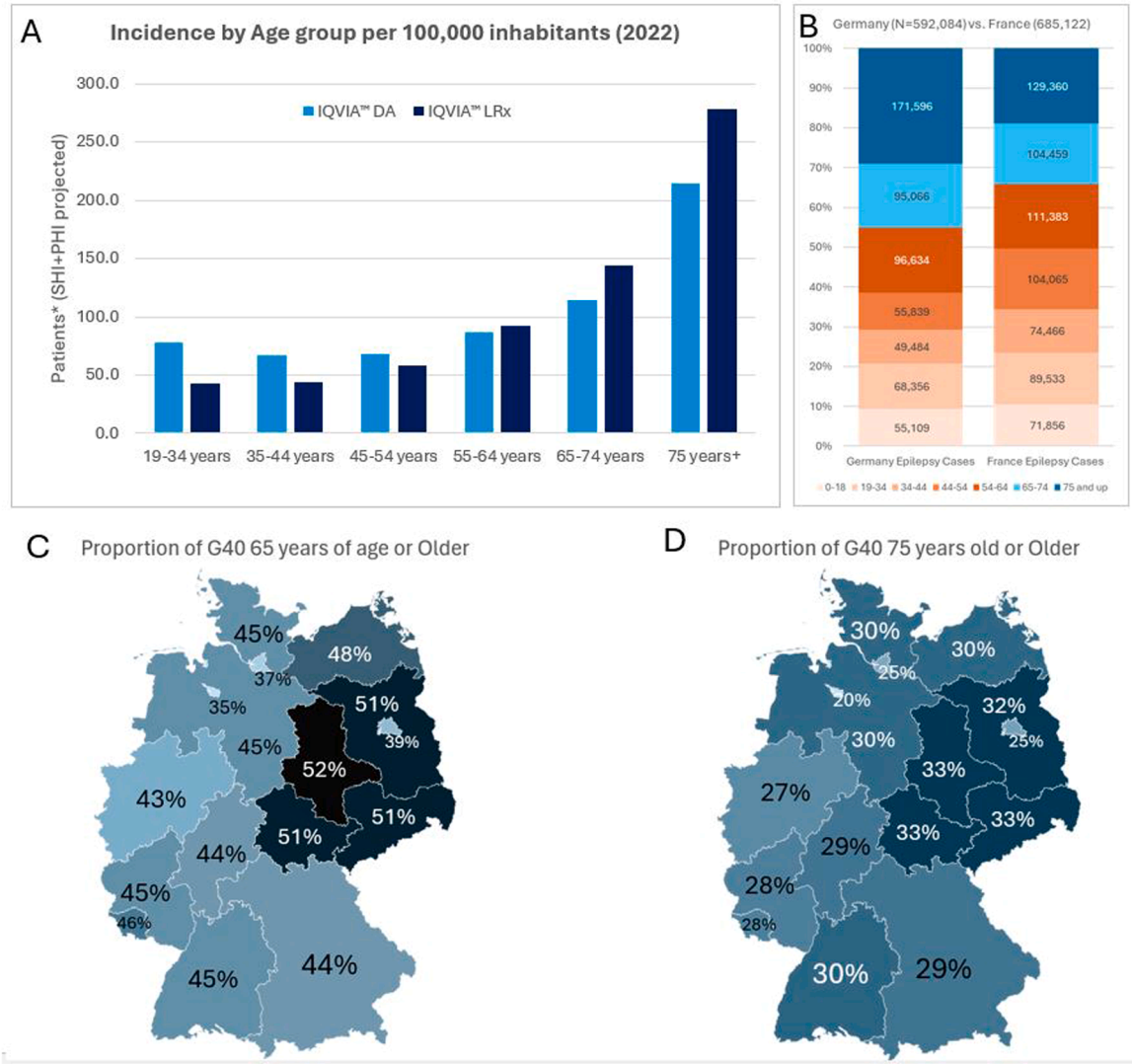

Fig. 1. Incidence of epilepsy in Germany A. Incidence of epilepsy by age group per 100,000 inhabitants in 2022, based on data from the IQVIA™ LRx and IQVIA™ Disease Analyzer (DA) databases. Pediatric patients 0–18 are not displayed. B. Comparison of German G40.0–9 (N = 592,084) age splits with French (N = 685,122) epilepsy cases by age showing the proportion of patients in 65 and older cohorts [12]. C. Proportion of G40 65 years old or older. D. Proportion of G40 75 years of age or Older. (all percentages shown by federal state are statistically significant) Abbreviations: DA=Disease Analyzer; PHI=substitutive private health insurance; SHI=statutory health insurance.

was greater with 202 cases per 100,000 inhabitants in the west but reaching 261 cases per 100,000 inhabitants in the east (Fig. 1d). Nationally, the over-65 demographic represents 45 % of epilepsy patients in Germany. One contributing factor is the proportion of epilepsy patients in older age groups, which we compared with those in France (Fig. 1b), an adjacent European country [12]. Former East Germany has a higher proportion of older adults with epilepsy patients compared to West Germany, with 51 % over the age of 65 and 32 % over the age of 75 (Fig. 1c and 1d). This disparity aligns with the broader demographic trend observed at the end of 2014, where the proportion of individuals aged 65 and older was notably higher in Eastern Germany (24 %) than in Western Germany (just under 21 %). This suggests that regional disparities in the age distribution of epilepsy patients may reflect the overall age distribution differences between these regions [21].

3.2.2. Prevalence

The results of both databases are provided to demonstrate accuracy, and both gave similar results reflecting the robust nature of the data. In 2022 DA database provided a total of 539,255 patients while the LRx database projected 565,481 patients. The difference between these figures is expected due to the projection methodology used to estimate the total population from the LRx data, which covers 82 % of SHI prescriptions in Germany. For the IQVIA™ LRx database, prevalence was defined as any ASM treatment. The LRx database identified 90,911 patients between 65 and 74 and 162,063 patients over 75 years of age. This provides an adjusted rate of 9.7 in the 65–74 age group and 17.5 cases per 1000 inhabitants in the over 75 range. In the IQVIA™ DA database, prevalence was defined as a diagnosis in the same year or the previous year with a medical visit in the current year. Results for 2022 showed a prevalence of 85,937 between 65 and 74 and 122,213 patients over 75 identified, with an adjusted rate of 9.1 and 13.2 cases per 1000 inhabitants respectively. Fig. 2 displays the distribution of epilepsy prevalence by age groups based on data from the IQVIA™ LRx and IQVIA™ DA databases. This data underscores a higher prevalence as individuals age, with both databases demonstrating differences between east and west with higher prevalence in the former East Germany. Fig. 2c provides a graphic representation of prevalence for those 65 and over and Fig. 2d for those 75 and over, using the LRx database.

3.3. Identification and profile of epileptic patients aged 65 years and older

3.3.1. Number of patients receiving three or more anti-seizure medication treatment options

Patients with at least 3 p.m. had significantly more visits per year

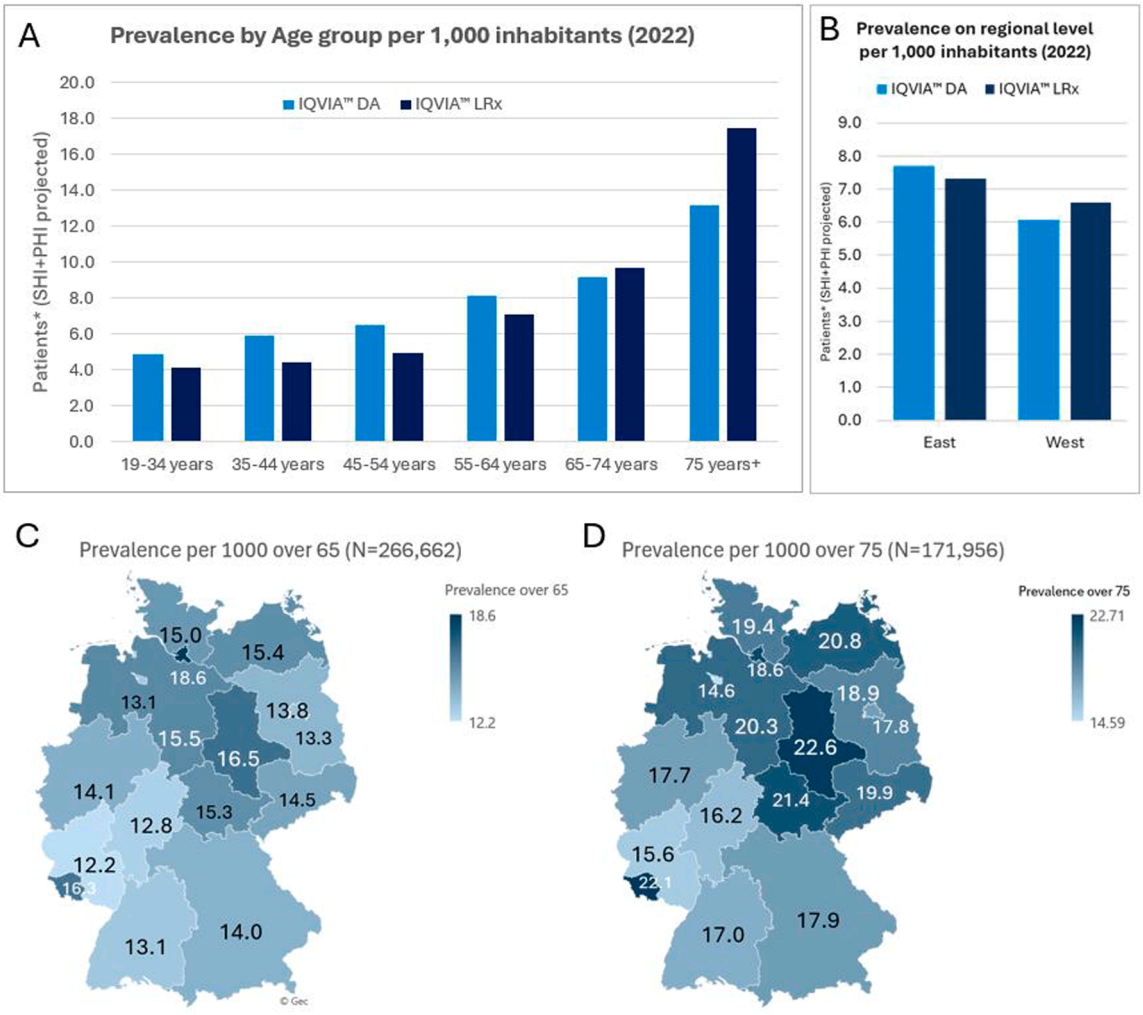

Fig. 2. Prevalence of epilepsy in Germany. A. and B. Prevalence of epilepsy by age group. (A) and by region (B) per 1000 inhabitants in 2022, based on data from the IQVIA™ LRx and IQVIA™ Disease Analyzer (DA) databases. Pediatric patients 0–18 are not displayed. C and D: Prevalence of patients with epilepsy aged 65 or over (C; N = 266,662) and 75 or over (D; N = 171,956) per 1000 inhabitants by federal states in Germany in 2022, based on data from IQVIA™ LRx database. Abbreviations: DA=Disease Analyzer; PHI=substitutive private health insurance; SHI=statutory health insurance. All differences between federal states were statistically significant.

(+1.5 visits) compared to those with 1–2 ASMs. No relevant effect of the year was observed. Compared to patients treated by GPs only, those treated by GPs plus other specialties or neurologists had a significantly higher number of yearly visits. The probability of having at least 3 p.m. strongly decreased with age, with age groups 65–74 and 75+ years showing more than two times lower chances of receiving at least three ASMs. Male sex was associated with a slightly lower chance of receiving at least three ASMs. In the total population, localization in Bremen and Schleswig-Holstein was associated with more than a 30 % lower chance of receiving at least three ASMs. This association became stronger in the age groups 65–74 and 75+ years, with Hamburg and Sachsen-Anhalt also showing a strong negative association with the likelihood of receiving 3 p.m. in elderly patients. There was a strong association between more recent years and a higher chance of receiving at least three ASMs, with the chance being higher in 2022 compared to 2018. Patients treated by GPs plus other specialties or neurologists had a significantly higher chance of receiving at least 3 p.m. compared to those treated by GPs only.

For the national data in 2022, 31.1 % of patients 65–74 and 26.1 % (n = 44,843) of patients with epilepsy aged 75 years and older had received three or more ASM treatment options (adjusted odds ratio AOR = 0.48, $p < 0.001$ for patients aged 65–74 years and AOR = 0.40, $p < 0.001$ for patients aged 75+ years). Fig. 3a illustrates the distribution of line groups by age group in 2022. This indicates a lower proportion of patients having tried three or more ASMs among those aged 75 years and older. Figs. 3b, c and d show the distribution of proportions of all patients who have tried three or more ASM treatment options by federal states. This highlights a notable difference between northern and southern regions. The pattern for patients aged 65 and older and for those aged 75 and older was very similar.

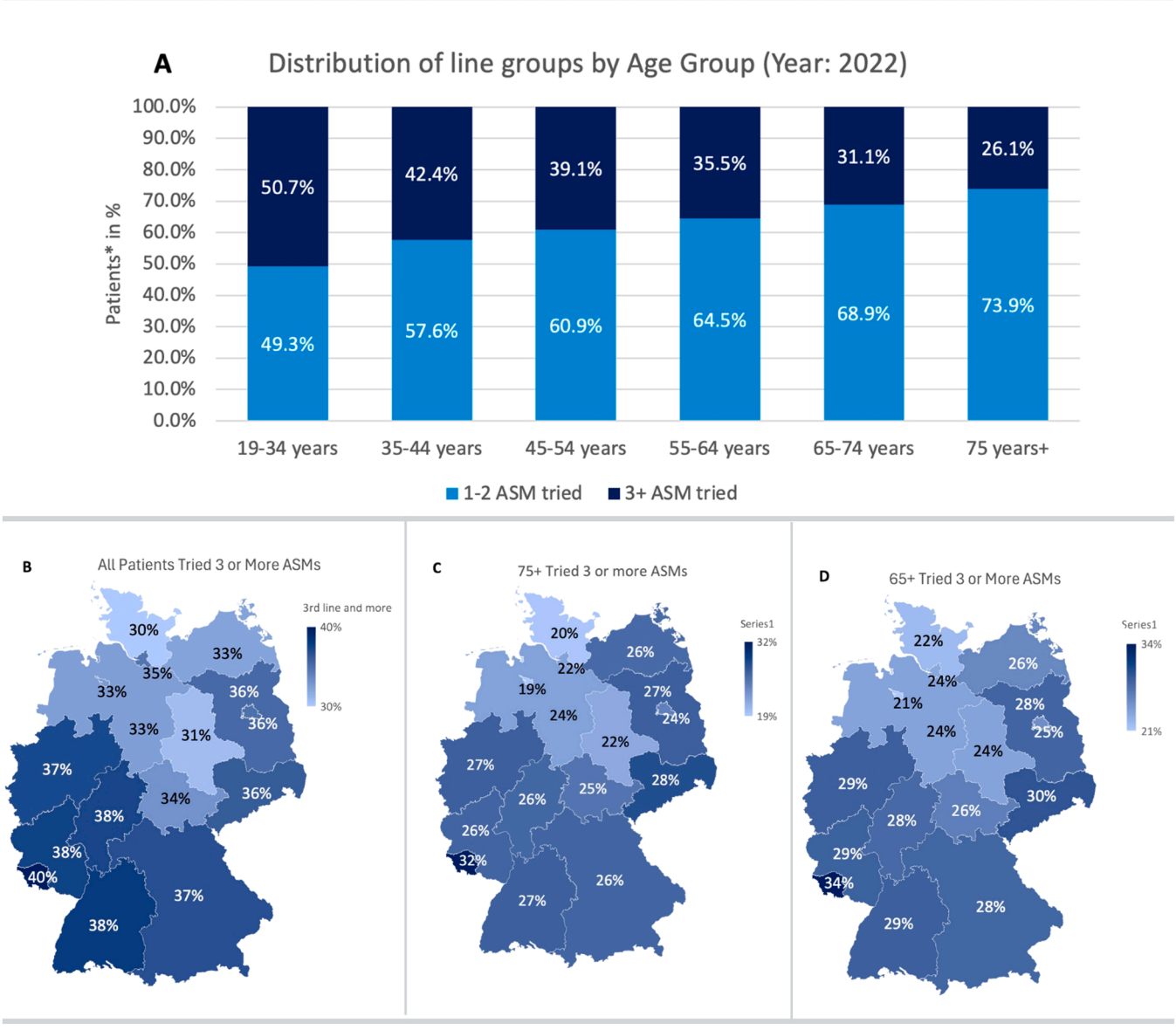

Fig. 3. Percentage of patients receiving three or more ASM treatment options A. Proportion of patients in Germany who have received three or more ASM treatment options (N = 216,029) by age groups in 2022, based on IQVIA™. LRx Database (of total N = 592,084). B, C and D shows the distribution of proportions of all patients, patients aged 65 and older and patients aged 75 and older, who have tried three or more ASM treatment options by federal states. Distribution of proportions of all patients (B; N = 592,084) and those aged ≥75 (C) and ≥65 (D) (N = 171,596) who have received three or more ASM treatment options in 2022 by federal states. The split between neurologist and GP was approximately 30 % to 70 % respectively. Abbreviations: ASM=anti-seizure medication, GP=General Practitioners.

3.3.2. Number of medical visits in a year

Compared to the youngest age group (<18 years), all other age groups had approximately 1 less visit per year, with no special effect observed for elderly groups. There were no significant sex effects on the number of visits or relevant effects of region.

Epilepsy patients in general are seeing their physicians on average 5.2 times a year which is more than the German standard reimbursable 4 times per year, pointing to a health economic issue for physicians treating epilepsy patients. Furthermore, in 2022, older patient cohorts received fewer visits than younger ones. Overall, the treatment patterns of neurologists differed from that of GPs in that for patients who had tried more than 3 p.m. the GPs saw their patients more often (6.7 vs. 6.2 annual visits). Patients 65–74 had an overall average of 5.0 visits per year for both GPs and neurologists when looking at all patients, while for the presumably more refractory patients who have tried three or more ASMs, GPs saw their patients more often than neurologists. (6.5 vs. 6.0) (Fig. 4a). Patients who had tried three or more ASMs had notably higher average levels of visits than the group of all patients (Fig. 4b). Figs. 4c and d show that although average visits increased throughout Germany for patients who have tried three or more ASMs, the average difference between the former East and West states is higher for the more refractory cohort, with patients in former East states having curiously comparatively fewer visits than in the West. When looking at the distribution of visits, there is a clear east/west gradient which overshadows the previous north/south gradients as patients become more refractory. Fig. 4 shows the distribution of the average number of medical visits by treatment options and federal states; we found a nearly identical pattern in the 65 and up (data not shown).

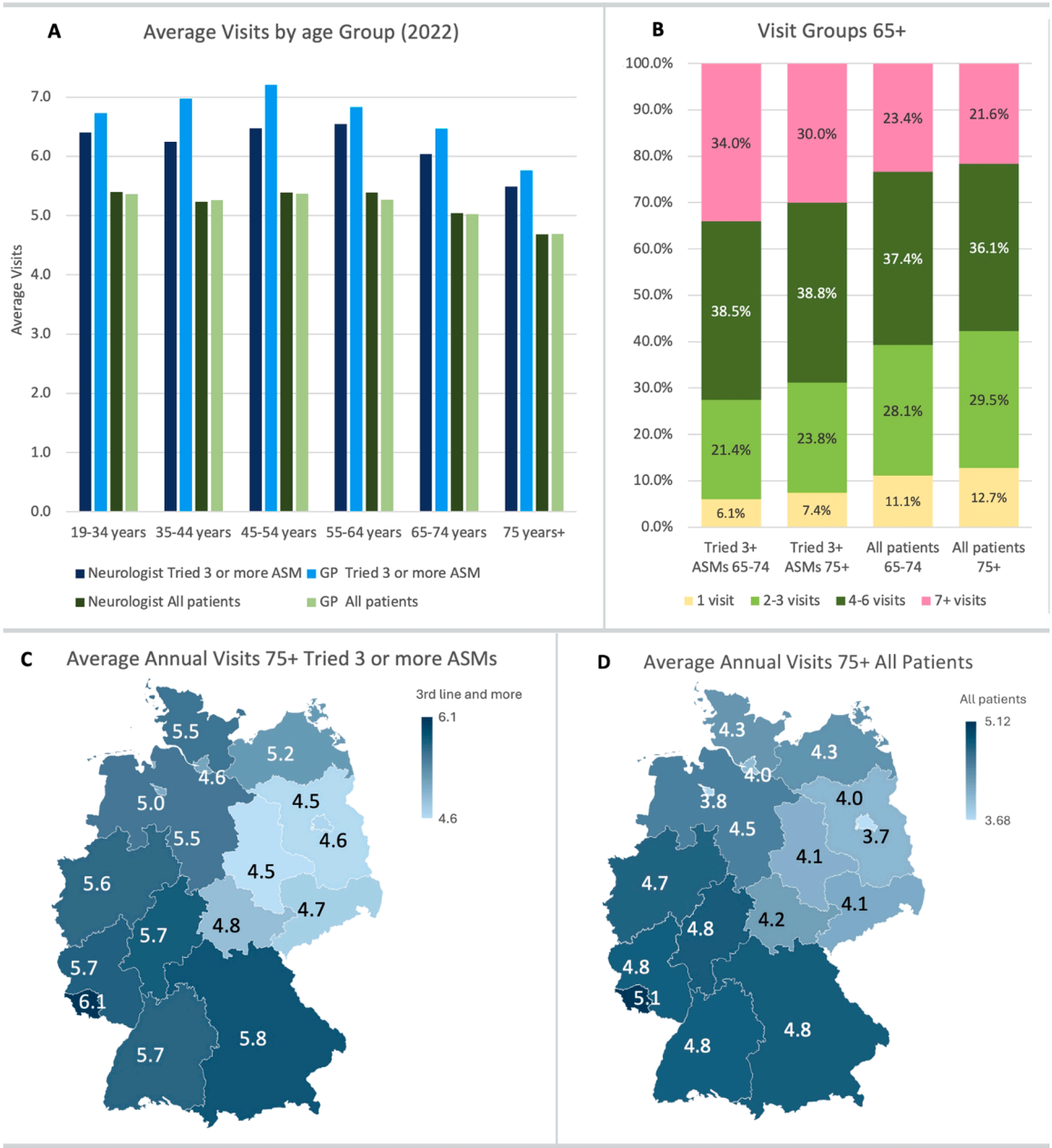

Fig. 4. Average visits to a GP. A. Distribution of the average number of visits to a GP (N = 188,222 patients) and to a neurologist (N = 187,637 patients) by the number of ASM treatment options received and age groups. B. Distribution of visits of older patients with epilepsy to their healthcare professional demonstrating a higher proportion of those that tried 3 or more ASMs needed more visits per year (red vs. green shaded sections of bars). C and D. Distribution of the average number of medical visits of patients who have tried 3 or more ASMs (C) and of the total number of patients aged 75 or older (D; N = 135,729) by the number of ASM treatment options received and federal states. Abbreviations: ASM=anti-seizure medication, GP=general practitioners.

3.3.3. Time to receive the first ASM

The findings indicated that, compared to the youngest age group (<18 years), each other age group was associated with less risk of therapy delay, for 75+ (AOR = 0.79, 95 % CI: 0.67–0.93). Male sex was associated with slightly lower odds of therapy delay (AOR =0.91, 95 % CI: 0.86–0.97). There was no relevant effect of region (AOR = 0.98, 95 % CI: 0.98–1.05). Therapy delay was more common in recent years compared to 2018, with the year 2022 showing the lowest odds of therapy delay (AOR = 0.66, 95 % CI: 0.66–0.73). Compared to patients who were treated by GPs, those treated by neurologists had a higher risk of therapy delay (AOR = 1.19, 95 % CI: 1.12–1.27).

Our analysis showed that a significant portion of patients received timely treatment, with 64 % of those diagnosed by GPs and 61 % by neurologists receiving their first ASM on the same day as their diagnosis. (Fig. 5). This prompt initiation by GPs may include cases of acute symptomatic seizures, particularly post-stroke, highlighting the need for careful assessment before prescribing ASMs to avoid unnecessary treatment. However, among those (36 %−39 % of patients) who experienced delays, the average time to ASM initiation was 245 days for patients under GPs and 226 days for those under neurologists. Notably, 7

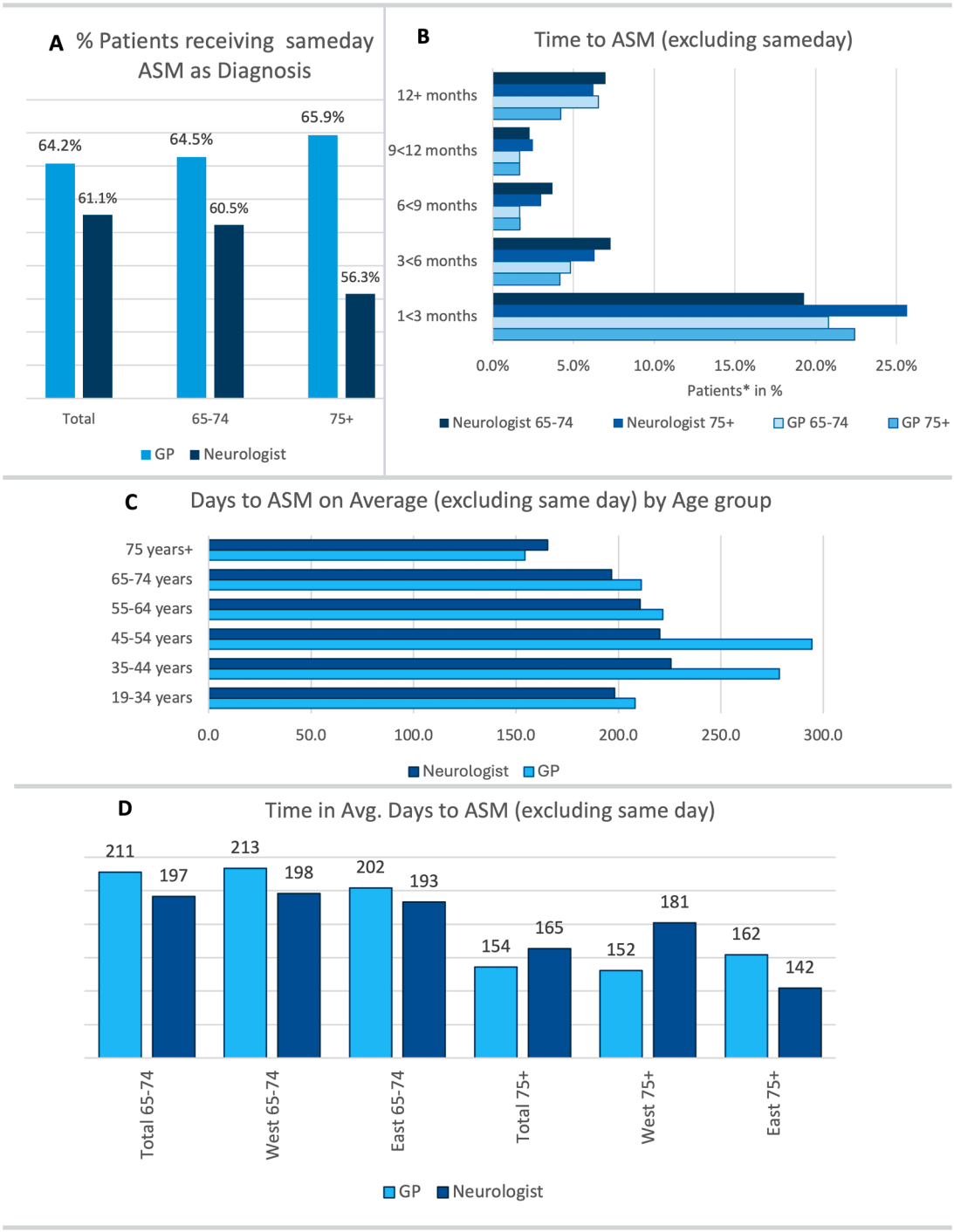

Fig. 5. Delay to first treatment. A and B: Proportion of patients with epilepsy receiving treatment with ASMs at diagnosis (B) and at different time points, C. Average time in days (2018–2022) for patients with epilepsy to receive the first ASM after diagnosis at the national, regional, age group, and medical specialty levels. D. Average time (days) to ASM. Abbreviations: ASM=anti-seizure medication.

% of patients began treatment >365 days after their diagnosis, indicating a substantial delay for a minority.

From 2018 to 2021, the timing of ASM initiation varied by age, region, and medical specialty. Nationally, older patients showed a trend toward faster treatment initiation, with those aged 75 years and older experiencing fewer days from diagnosis to ASM initiation compared to the 65–74 age group. Among patients aged 65–74 and 75+ treated by GPs, 64.5 % and 65.9 % respectively, received their first ASM on the day of diagnosis, 28.9 % and 29.9 % within the first year, and 6.5 % and 4.2 % after the first year, with an average initiation time of 211 and 154 days. This trend was more pronounced among GPs, who were better at administering ASM on the same day as diagnosis compared to neurologists, particularly in the oldest age group. Specifically, 64.5 % (65–74) and 66 % (75+) of GPs gave a same-day diagnosis and treatment for patients compared to 60.5 % (65–74) and 56.3 % (75+) by neurologists.

Regional differences were also observed. In the western regions, 65.5 % of older patients treated by GPs received their first ASM on the day of diagnosis, 30.5 % within the first year, and 4 % after the first year, with an average initiation time of 152 days. For those under neurologists, 56.0 % began treatment on the same day, 37.5 % within the first year, and 6.5 % after the first year, with an average of 181 days. In the eastern regions, the figures were similar: 67.3 % of patients under GPs received ASM on the same day, 27.9 % within the first year, and 4.9 % after the first year, with an average of 162 days to initiation. Neurologist-treated patients in the east had a slightly faster initiation time, with 56.7 % starting on the same day, 37.5 % within the first year, and 5.8 % after the first year, averaging 142 days of treatment.

Fig. 5 provides a visual comparison of these findings, highlighting the average time to receive the first ASM across national, regional, and specialty-specific data.

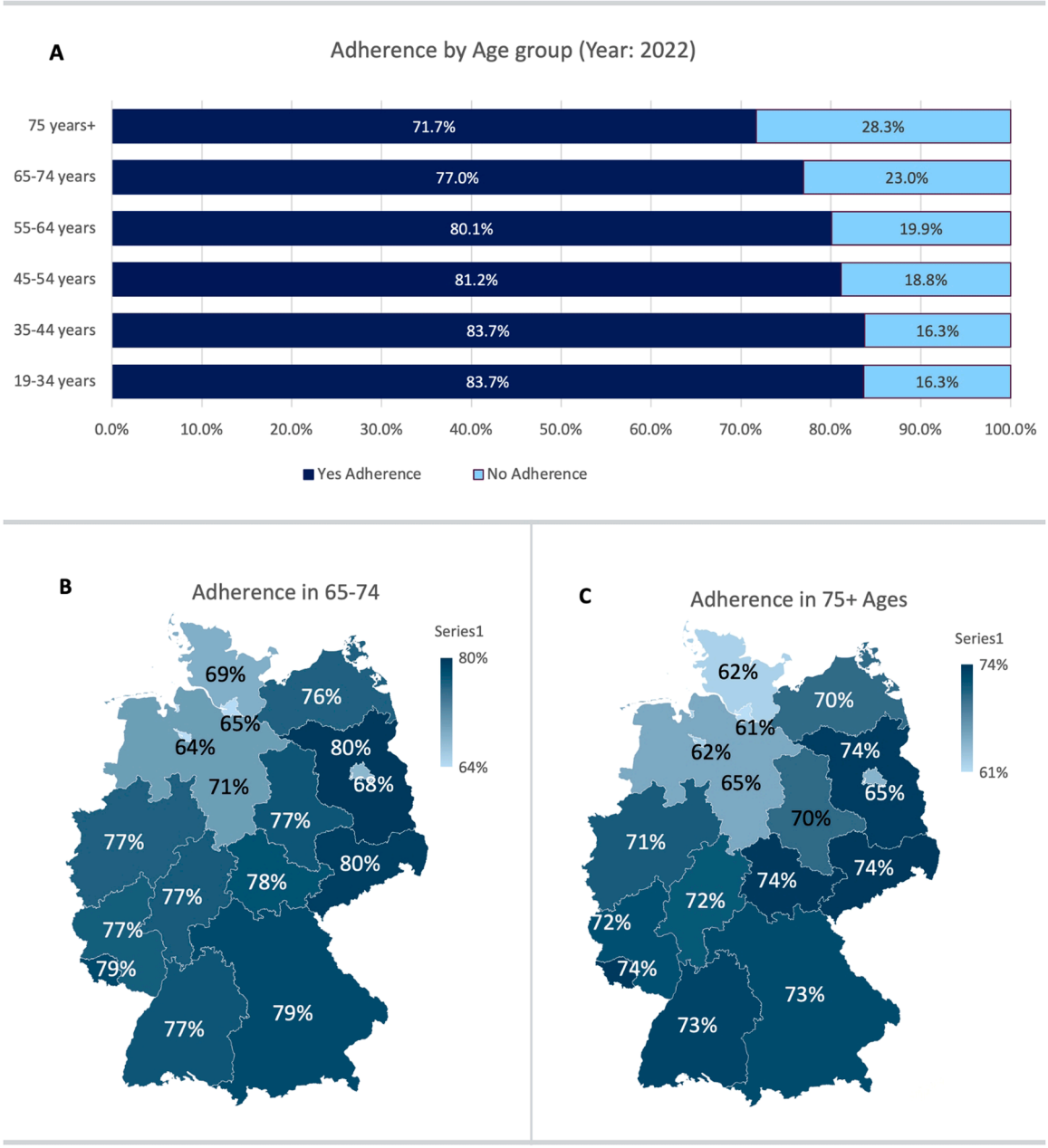

Fig. 6. Treatment adherence. A. Distribution of treatment adherence (N = 565,481) in patients with epilepsy by age groups from the IQVIA™ LRx database. B and C. Distribution of adherence in patients aged 65–74 (B; N = 90,911) and 75 years and older (C; N = 162,063) by federal states. Northern federal states have lower adherence than those in the south and east and differences increase with age.

3.3.4. Treatment adherence

The results indicated that, compared to the 65–74 years age group, the 75+ years age group had significantly lower odds of achieving at least 80 % adherence (AOR = 1.06, 95 % CI: 1.05–1.08). Male sex did not significantly affect adherence for the 65–74 years cohort (AOR = 1.01, 95 % CI: 0.99–1.02), but it did show a slight significant effect for the 75+ years cohort (AOR = 1.04, 95 % CI: 1.03–1.05). No significant effect was observed regionally in the 75+ years cohort (AOR = 0.99, 95 % CI: 0.98–1.01), whereas the East had a slight positive effect in the 65–74 cohort (AOR = 1.04, 95 % CI: 1.02–1.06). Patients on their 3rd line or higher of therapy had significantly higher odds of adherence compared to those on 1st or 2nd line therapy in both age groups (65–74 years: AOR = 1.78, 95 % CI: 1.74–1.82; 75+ years: AOR = 1.46, 95 % CI: 1.44–1.49). The year 2022 was associated with slightly lower odds of adherence compared to 2018 in both age groups (65–74 years: AOR = 0.94, 95 % CI: 0.91–0.97,; 75+ years: AOR = 0.95, 95 % CI: 0.93–0.97). Patients treated by a neurologist had significantly higher odds of adherence (65–74 years: AOR = 2.10, 95 % CI: 2.06–2.14; 75+ years: AOR = 1.85, 95 % CI: 1.82–1.87), while those treated in outpatient centers had slightly lower odds of adherence in both age groups (65–74 years: AOR = 0.75, 95 % CI: 0.73–0.77; 75+ years: AOR = 0.80, 95 % CI: 0.79–0.81).

In 2022, nationally, 77 % (N = 69,969) of the 65–74 cohort and 71.7 % (N = 116,159) of patients aged 75 years and older with epilepsy demonstrated a treatment adherence of at least 80 % of the days in a year. Conversely, 23 % (N = 20,942) of 65–74-year-olds and 28.3 % (N = 45,904) of 75+ patients did not achieve this level of adherence. Fig. 6 illustrates the distribution of treatment adherence across different age groups, showing that as patients aged adherence levels dropped. Our data shows that patients who had not seen a neurologist had an overall adherence rate of 70.3 %, compared to 84.5 % for those who had. Additionally, more elderly patients are treated by GPs than by neurologists. Specifically, 24 % of patients over 75 and 16 % of those aged 65–74 are treated by GPs, compared to 19 % and 15 %, respectively, for neurologist-treated patients. This higher proportion of older patients being managed by GPs, combined with lower adherence in those who do not see a neurologist, may partly explain the drop in adherence in this age group.

Lower adherence rates in the northern regions were again observed in a north/south gradient pattern with the discrepancy becoming more pronounced in the oldest cohort (Fig. 6,b and c). In 2022, Sachsen, Saarland, Thüringen, and Brandenburg reported treatment adherence rates exceeding the national average, with 74.3 % (n = 7311), 74.1 % (n = 1851), 74.0 % (n = 3965), and 73.8 % (n = 4055), respectively. In contrast, Hamburg, Schleswig-Holstein, Bremen, and Berlin had adherence rates below the national average, with 60.9 % (n = 2367), 62.1 % (n = 3996), 62.2 % (n = 654), and 64.6 % (n = 4024), respectively.

4. Discussion

This study evaluated the treatment situation of patients aged 65 years and older with epilepsy in Germany using data from the LRx and DA databases and provides for several parameters, a new geo-spatial assessment on the level of federal states.

We determined an annual crude prevalence rate in adults between 0.95 % and 1.09 % and incidence rates of at least 156 per 100,000. The DA database estimated the epilepsy prevalence at 0.64 % (539,255 patients), while the LRx database estimated 0.67 % (565,481 patients) across all ages.

4.1. Prevalence and incidence

We found a prevalence of 565,481 cases of epilepsy (6.7 per 1000 LRx in 2022), significantly higher than the 429,396 patients reported in the 2019 GBD Lancet study [16], where rates were calculated based on over 300 previously published studies. Additionally, depending on the state, one-third to one-half of these patients are over 65 (9.7 per 1000 LRx for ages 65–75, and 17.5 per 1000 for 75+).

When comparing Germany with France, an adjacent European country, France shows an even higher overall epilepsy prevalence (n = 685,122) of (1.02 %) 10.2 per 1000, which is closer to the crude adult rates of between 0.95 % and 1.09 % calculated in a German study from 2016 using insurance data [22]. However, regarding older patients in France, 50 % of epilepsy patients are over 55, and 34 % are over 65. The proportion of patients aged 65–74 is similar in both countries (15 % in Germany, 16 % in France). The key difference lies in the 75+ age group, where Germany has a higher proportion of epilepsy patients (29 % vs. 19 % in France), which is although not completely explained by Germany's larger elderly population (11.4 % vs. 9.4 %) clarifies the trend.

The high incidence of older individuals is comparable and within the range of an analysis of the incidence of epilepsy in older individuals from 2019 [17] which used the same DA database and found an incidence that started at 92 per 100,000 persons in the 60–65 year old cohort and reached 311 per 100,000 in the 90 + cohort. The higher proportion of epilepsy patients in the over-75 demographic in Germany may be attributed to increased identification and treatment, particularly in the 75+ age group [32] [31]. For example, we found shorter time to ASM initiation in Germany for the 75+ cohort suggesting a potential advantage in identifying epilepsy in older adults and likely explaining at least in part the larger proportion of 75+ epilepsy patients in Germany.

The findings furthermore reveal several insights into the current state of epilepsy management in this demographic. Two studies, in 2020 and another in 2023 identified clusters of lower accessibility for epilepsy care (G40.0–9) in central and eastern Germany, suggesting that patients in these regions are less frequently accessing specialized epilepsy centers [19,20]. We also observed north/south and east/west gradients and city-state countervailing trends for various indicators of patient care which spatially echo part of these findings. First, we observed overall incidence and prevalence rates higher in the north than in the south averaged over all ages. For patients aged 65 and older however, we found the highest adjusted rates of epilepsy incidence and prevalence [3–5], both nationally and regionally with rates notably higher in the eastern states of Germany compared with the western regions, regardless of the database used for calculations.

4.2. Patients having tried three or more ASMs per year

Our data reveals that overall, more patients are treated with only the first or second ASM options, with fewer patients having tried three or more ASMs than would be expected according to population demographics and historical literature [23]. It is therefore possible to interpret these findings to mean that states with fewer than a third of patients trying three or more ASMs may not be "finding" these patients, rather than treatment not being necessary.

In our data, we found that as patients age, a decreasing proportion were shown to have received three or more ASM treatment options; the proportion steadily drops from 50.7 % in the 19–34 ages group to 26.1 % in those 75 and older. The low rate of those who have tried three or more ASMs might indicate that some older adult patients have not been given the opportunity to try more effective combination therapies. Another possible explanation for the low share of older adults who have tried three or more ASMs is that older patients appear to be less refractory, requiring fewer ASMs to become seizure free [10,11]. However, both these reasons may also occur in tandem; further research is required to better understand this finding.

4.3. Time to ASM

A study on early prescription of ASMs found that as patients get older, the likelihood of receiving ASM treatment also changes [24]. This study found that those aged 31–40 years are more likely to receive treatment within 30 days of diagnosis. However, for patients aged 41–60

years, the odds of receiving treatment decrease within 6 to 12 months after diagnosis. For those over 80 years old, the likelihood of receiving treatment decreases within 12 months. Our results, which are more granular, find that a significant portion of patients 65–74 (60–64 %) received their first ASM on the same day as diagnosis. However, 19–25 % wait 1–3 months to receive an ASM, while 15–20 % experience delays of 6 months or more. Although patients over 75 have fewer days to treatment than those 65–74, it is unclear why so many patients have delays between diagnosis and medications, which can have negative or positive repercussions, and therefore this trend requires more research [33,34].

We furthermore found unexpected differences in how neurologists and GPs (patients seeing GPs access ASMs faster following diagnosis) treat their elderly patients which may be associated with older individuals possibly having a higher level of familiarity with their local GPs than with neurologists [29,30]. Our data indicates that a significant proportion of patients diagnosed by GPs receive their first ASM on the same day as their diagnosis. This trend, particularly notable in older patients, may include cases of acute symptomatic seizures, such as those occurring shortly after a stroke. Acute symptomatic seizures do not require long-term ASM treatment, suggesting that some of these early prescriptions by GPs might be unnecessary. This underscores the importance of distinguishing between acute symptomatic and epilepsy-related seizures to avoid overtreatment. We recommend enhancing guidelines and training for GPs to improve differentiation and ensure appropriate management.

The study revealed variability in the time to initiate treatment with the first ASM, influenced by whether a GP or a neurologist was consulted. Nationally, 65.9 % of patients who consulted GPs and 56.3 % of those who consulted neurologists received their first ASM on the same day as their diagnosis. Curiously, a notable difference was observed in patient cohorts over 75 with a reversal where we observed neurologists in the West as opposed to the East taking longer to provide ASMs in this oldest of cohorts. Our data shows the average delay in treatment initiation excluding same day diagnosis, was 154 days (about 5 months) for GP consultations and 165 days (about 5 and a half months) for neurologist consultations. The few differences we found in treatment initiation times between eastern and western regions were most pronounced in the oldest cohorts.

4.4. Epilepsy patients visits

The analysis of the visit data suggests that managing epilepsy patients is often financially challenging for physicians in Germany. Under the current public insurance system, office-based physicians are reimbursed for up to four visits per year (one per quarter). Any additional visits are not covered, forcing physicians to absorb the costs. This reimbursement structure significantly influences how we interpret the visit data. On average, epilepsy patients visit their physician five times annually, while patients who have tried three or more ASMs visit even more frequently, averaging over six visits per year, which increases the financial burden on physicians. Critically, GPs see their epilepsy patients as frequently as neurologists, except notably in cases of refractory epilepsy. For patients who have tried three or more ASMs, GPs tend to see them more often than neurologists, further intensifying the financial strain on these practices. Regarding elderly epilepsy patients, they are being seen less often than younger cohorts with lower average visits per year in 2022.

This data might suggest that neurologists are more cost-effective, managing patients within the limited reimbursed visits. Alternatively, it could imply that GPs, despite the financial burden, are less efficient in managing complex cases or rather more attentive to patient needs. Importantly a greater proportion of patients over 75 see a GP rather than a neurologist and these GPs may have longer term and closer emotional and geographic relationships with their patients., Moreover, these patients often visit their GP for additional comorbidities beyond their neurological issues [29,30]. Our data shows conversely that 85 % of neurologist patients are under 75 (vs. 76 % for GPs). This may mean that the neurologist perspective of which patients have epilepsy may be skewed, pointing to another possibility, that neurologists might adhere strictly to the reimbursed visits, potentially at the expense of additional necessary follow-up, while GPs take on a more proactive, albeit costly, role in managing refractory cases. This raises questions about whether the current reimbursement model appropriately supports the level of care required for older epilepsy patients.

Regional visit patterns also revealed differences, with western regions reporting higher visit numbers compared to the national average, while eastern regions had fewer visits. These discrepancies appear to be at least partially driven by cost considerations. Interestingly, there is a north-south gradient in visit frequency across all patients, but this trend becomes more pronounced along an east-west axis as the cost of treatment increases—specifically when patients have tried three or more ASMs. This regional variation highlights the potential impact of economic factors on the provision of care for more complex cases. However, these patterns require further study to assess how patients in these areas are receiving follow-up care and therapeutic adjustments and how this affects treatment outcomes particularly for older patients, more of whom are being seen by a GP rather than a neurologist.

4.5. Adherence

The study also evaluated the treatment adherence of patients with epilepsy showing a decrease in adherence levels as patients aged. Here we also found spatial differences in a gradient across quadrants of Germany. Adherence to ASMs has been assessed in a 2016 publication [13]. Based on an analysis of 31,317 patients from the same DA database from 2010 to 2013, overall patients were found to be less compliant than in our data, with 64.7 % having greater than 80 % “medication possession ratio” (percentage of days covered by supply for a specific drug over the observation period defined by the time from the dispense date until the first observed ASM refill). A small decrease in compliance is seen in the 14,064 patients they assessed who were over 60 years of age (64.6 %) compared with the 41–60-year-old age group (65 %). Their data found an East (61.8 %) vs West (65.8 %) gradient. Our data reports a large overall improvement (15–20 %) in adherence since 2013 across all age groups. However, our analysis also has a larger sample size, and cohorts are more granular which also may explain why we see a gradient from young to old. The comparatively lower adherence rates observed in the older patient population, while partially explained by the higher proportion of patients over 75 being treated by GPs rather than neurologists, still warrant further investigation. These findings highlight the importance of developing strategies to improve treatment adherence in this group.

4.6. Gradients in treatment parameters

The observed geographic gradients, characterized by higher prevalence and incidence rates, lower adherence, and fewer visits in specific sectors of Germany across all age groups, has similarities with previous spatial studies and suggests that there may be a need for increased attention to ASM therapy for some patients in these regions [19,20]. City-states were also observed to be geographical islands regarding some parameters likely reflecting their comparatively younger populations. That some patients have tried fewer ASMs than expected based on published rates [23], coupled with these indicators, is a sign that further research is needed to determine the outcomes on treatment of epilepsy patients in this region.

4.7. Need for personalized care in epilepsy for the elderly

Epilepsy is the third most common neurological disorder affecting older adults after stroke and dementia, and recent data on

hospitalization in this field provides insights into patient care [2]. In Germany, according to a survey including 30,000 patients, a surprisingly high proportion of patients who present in the ER are elderly with 25 % percent of patients older than 75 years of age [25]. Recently, a retrospective analysis in a German neurological ER (N = 2791) demonstrated that seizures are the 3rd most common neurological emergency [26]. A second study, however, highlights the issue that elderly patients in Germany are often relying on these emergency medical services (EMS) for hospital admissions [27]. The high proportion of elderly patients using EMS emphasizes a lack of utilization of outpatient structures for elderly patients in the country. This was found to be particularly important because over 30 % of emergency hospital cases were classified as "low or moderate" severity, suggesting that many of these patients could have been treated outside of a hospital setting. Notably, epilepsy (G40) came up repeatedly as ICD3 top reasons for hospitalization in the low to moderate severity class [27].

Both studies point to the need for improvement in ambulant care for epilepsy in elderly patients. Possible reasons given in the papers as factors likely to result in persistent misuse of neurological ER resources included: difficulty seeing outpatient-based neurologists in obtaining timely appointments, and limited access to outpatient care. The additional finding that, on average treating epilepsy patients results in uncompensated costs may make it even more difficult for an epilepsy patient to find a physician willing to treat them. Furthermore, one of the studies found that although seizures are among the most common diagnoses in neurological ERs, they remain underexplored in contrast to stroke, in particular with an underuse of EEG diagnostics [26].

The data from these studies support ours, which also implies that although most older patients with epilepsy are receiving medications at an adequate rate following diagnosis, a smaller proportion of patients are left behind. Additionally, many older patients may not be obtaining adequate personalized care in the form of annual visits. This is exemplified by the low levels of visits for older patients, particularly for those who have tried three or more ASMs, (i.e., likely refractory patients) with annual average visit levels decreasing with age. Consequently, some issues around the treatment of elderly patients with epilepsy in office-based settings seems to result in a spilling over into the emergency departments across Germany.

5. Limitations

Due to the extent of the data not all results for all parameters could be included in this paper.

- **Lack of Diagnostic Data in LRx Database**: The IQVIA™ LRx database, while comprehensive in terms of prescription data, does not include diagnostic information. This limitation necessitated the use of proxy measures, such as ASM prescriptions, to estimate epilepsy prevalence and incidence.
- **Hospital Prescriptions**: If the patient received their initial ASM prescription in a hospital, then it would not be captured in this data.
- **Adherence data** assumes that medication collected by the patient is actually consumed as per the instructions, however this information is not available.
- **Projection Methodology**: The LRx database covers 82 % of statutory health insurance (SHI) prescriptions in Germany with projections to estimate the total population.
- **Therapy Success**: Although we can assess if patients have tried three or more ASMs, we can only infer if treatments were successful.
- **Mortality**: Mortality data is not available.
- **Treatment Switching Analysis**: The data required to analyze treatment switching behavior by neurologists for specific ASMs is currently not available and would require a new, lengthy analysis. This analysis is planned for a follow-up publication.

6. Conclusions

Research on epilepsy in individuals aged 65 years and older is notably limited [4,7,9], with existing literature predominantly focused on younger populations. This lack of data is concerning, given the ongoing global aging trend and the proportional increase in older patients with epilepsy [3–5]. The current study addresses this gap by providing specific and up-to-date data on the treatment of epilepsy in individuals aged 65 years and older in Germany while providing new information which serves as a basis for future studies in this area. The parameters we have collected represent a first important step in understanding the age stratified care of epilepsy in Germany.

The findings of this study furthermore underscore the necessity for improved education and training for both GPs and neurologists in managing epilepsy among older patients with epilepsy, particularly in recognizing atypical presentations and optimizing treatment strategies [3–5]. Following the new treatment guidelines for older individuals is essential, considering comorbidities and polypharmacy [18]. Future research should address the underlying causes of regional disparities in epilepsy treatment. Geographic disparities may be associated with the lack of a specialized center in the region, and this should be a subject for follow-up studies.

Disclaimer

The data used in this study was collected and evaluated at patient level; nevertheless, this had previously been satisfactorily anonymized in line with German data privacy legislation. Throughout this document, whenever terms such as “patient, doctor, medical practice, prescriber or pharmacy” are used, these therefore do not refer to any personal data but exclusively to anonymous information (in accordance with § 3 Sect. 6 “Bundesdatenschutzgesetz” – German Federal Data Protection Act). Angelini Pharma financed the collection of the data and supported the medical writing.

Declaration of competing interest

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Supplementary materials

Supplementary material associated with this article can be found, in

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