Master's Thesis

Submitted in partial fulfilment of the requirements of the
Master of Science in Epidemiology (MSc)

Charité – Universitätsmedizin Berlin
Institute of Public Health/Berlin School of Public Health

A Retrospective Analysis of German Non-Specific Lower Back Pain Patients and their Patient Pathway Before and After Emergency Department Treatment

September 8, 2023

[redacted]

Statutory Declaration

I hereby certify that this thesis has been written by me, **Peter Gray**, and is based on my own work. All quotes, references and verbatim extracts have been cited accordingly. All sources of information, including graphs and data sets, have been specifically acknowledged. No other person's work has been used without due acknowledgement.

Date: 08.09.2023 [redacted]

Declaration of Own Contribution to the Master's Thesis

I, **Peter Gray**, conceived and designed the analysis, performed the statistical analysis, incorporated feedback or observations from my supervisors on the data analysis, prepared all tables and figures, interpreted the results, wrote the first complete draft of the manuscript, and incorporated comments from the supervisors regarding content, style and formatting.

Date: 08.09.2023 [redacted]

Contents

Abbreviation	Definition
ATC	Anatomical Therapeutic Code
AUC	Area Under the Curve
CI	Confidence Interval
ED	Emergency Department
EMS	Emergency Medical Services
GOP	Fee Order System (Gebührenordnungsposition)
ICD-10	International Classification of Diseases - Version 10
INDEED Study	Utilization and Trans-Sectoral Patterns of Care for Patients to the Emergency Departments in Germany [English translation]
IQR	Interquartile Range
LASSO	Least Absolute Shrinkage and Selection Operator
LBP	Lower Back Pain
M2Q	At Least 2 Quarters (Mindestens 2 Quartale)
NRS	Numerical Rating Scale
NSLBP	Non-specific Lower Back Pain
OPC	Outpatient Care
OR	Odds Ratio
ROC	Receiver Operating Curve
p-value	Probability Value
WHO	World Health Organisation

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Abstract

Background and Introduction

Non-specific lower back pain (NSLBP) is a major cause of emergency department (ED) attendance in Germany, adding to the ever increasing burden on the healthcare system. Understanding patient dynamics before, during, and after attending the ED is of interest to mitigate these visits and reduce the burden on healthcare systems.

Methods

This study is a retrospective, descriptive analysis of the INDEED study, which contains information on 16 hospitals' ED visits in 2016 linked to outpatient care (OPC) data from 2014 to 2017. Patient characteristics of those diagnosed with NSLBP who were admitted or discharged from the ED are described, as well as the utilisation of outpatient care services prior to and after the ED visit. A LASSO regression model was developed to identify predictors of admission to the hospital or discharge from the ED.

Results

In 2016, there were 7,250 ED NSLBP patients from a total of 353,926 ED patients in 2016. Of the 7,250 ED patients, 80.21% (n=5,815) patients were discharged whereas 19.79% (n=1,435) of cases were admitted to hospital for further treatment. There was a notable increase in both prescriptions given to patients and the utilization of therapeutic services three months before their ED visit. For the LASSO regression, arriving at the hospital medically accompanied (i.e. by ambulance), being classified as urgent in triage, attending the ED between 7am and 7pm during weekdays, and having multiple co-morbidities were also significantly associated with being admitted to the hospital.

Conclusion

There are indications that healthcare utilisation increases in the OPC setting prior to an ED visit for NSLBP. Further consideration is needed in how to proactively manage NSLBP patients through outpatient interventions to reduce the number of ED visits and the subsequent burden on the German healthcare system.

1 Background

1.1 Lower Back Pain and Associated ED Utilisation

Lower back pain (LBP) is defined as pain originating from below the costal margin and above the inferior gluteal folds (Chou, 2010; Steinmetz, 2022). In 2020, the global prevalence of LBP was estimated to be approximately 619 million people. LBP is a leading cause of disability globally, estimated to cause approximately 7.7% of the total number of years of healthy life lost due to disability annually. Approximately 90% of LBP cases are considered to be non-specific lower back pain (NSLBP), i.e., have no clear pathological cause such as fracture or degenerative disease (Amundsen et al., 2018).

A 2017 survey estimated that 85% of Germans experience LBP in their lifetime (Lippe et al., 2021). In a cross-sectional telephone survey, 52.9% (n=5,009) of participants reported LBP in the last 12 months (Lippe et al., 2021). Women reported LBP more often than men (66% and 56.4%, respectively) (Lippe et al., 2021). LBP reporting did not appear to be significantly differentiated by age (Lippe et al., 2021). In a recent review of the German non-emergency doctor service, LBP was the most common reason for contacting this service (Facharztmagazin, 2021).

It is well documented that the hospital emergency departments (ED) are under increasing pressure and becoming more overcrowded (Morley et al., 2018; Pines and Griffey, 2015; Turner et al., 2020). Increasing utilisation of EDs cannot be explained by population increases alone (Morley et al., 2018; Sartini et al., 2022). A 2016 systematic literature review of "high-income" countries, including Germany, identified the need for limiting "inappropriate ED visits" as a core tenet of reducing ED overcrowding, along with decreasing the number of frequent users (defined as between three and ten visits per year) (Schmiedhofer et al., 2016; Van den Heede and Van de Voorde, 2016).

LBP has been identified, particularly in industrialised countries, as one of the main reasons for ED attendance (Edwards et al., 2017; O'Sullivan et al., 2012). One study estimated LBP to constitute as much as 17.1% of ED admissions, though a systematic review of global healthcare systems reported that LBP ED prevalence lay somewhere between 2-4% of all ED admissions (Edwards et al., 2017). NSLBP is estimated to make up between 85% and 90% of LBP cases, thereby constituting a considerable burden to hospital ED departments (Amundsen et al., 2018; Turner et al., 2020). In addition, while 90% of NSLBP patients recover within 6 weeks, approximately 10% of NSLBP patients become chronic (Tulder et al., 2006). Currently, there is limited information on NSLBP prevalence and characteristics of NSLBP patients in German EDs.

1.2 The INDEED Study and NSLBP

Studies of German EDs tend to originate from a single hospital and have no cross-linkage to outpatient care (OPC) data prior to, or after the ED visit, potentially limiting the relevance of their conclusions. The INDEED study (the utilization and trans-sectoral patterns of care for patients to the emergency departments in Germany [English translation]) is the largest retrospective study of cross-sectoral patient data in Germany (N=454,747 ED visits and N=353,926 individual patients) (Fischer-Rosinský et al., 2021). The study consists of patient data from those who attended the ED of one of 16 hospitals in 2016. These data are then linked with their health insurance data from

2014 through 2017, providing a comprehensive overview of OPC utilisation before and after their ED visit (Fischer-Rosinský et al., 2021). Further details on the methodology and other aspects of the INDEED Study are described elsewhere (Fischer-Rosinský et al., 2021).

1.2.1 Lower Back Pain in the INDEED Study

In the 16 participating INDEED hospitals, LBP (defined by the International Classification of Diseases version 10 [ICD-10] three-digit code "M54") was ranked as the second in the top primary diagnoses in patients attending the ED (Table 1). Given the pressing requirement for healthcare systems to address ED overcrowding, there is a clear and appropriate need to gain a better understanding of LBP patients, particularly the NSLBP sub-population.

Table 1: Top five three-digit ICD-10 codes recorded in the 16 EDs participating in the INDEED study in 2016

ICD-10 Category	ICD-10 Definition
R10	Abdominal and pelvic pain
M54	Lower back pain
S00	Superficial injury of the head
R07	Pain in throat and chest
I10	Essential (primary) hypertension

Abbreviations: ED: Emergency Department; ICD-10: International Classification of Diseases Version 10; INDEED Study: Utilization and Trans-Sectoral Patterns of Care for Patients to the Emergency Departments in Germany [English translation]

1.2.2 Ethical Approval

All data were processed in line with the ethical approval by the ethics committee of the Charité-Universitätsmedizin Berlin (EA4/086/17) and only aggregated data were reported. The data protection concept was approved by the TMF Working Group of Data Protection on 14.02.2018 as well as by the institutional data protection officer at Charité-Universitätsmedizin Berlin and participating hospitals. Further details are described elsewhere (Fischer-Rosinský et al., 2021)

1.3 Aim and Research Question

The objective of this study is to characterize German NSLBP patients who attended one of the 16 hospital EDs in 2016 that participated in the INDEED study. The characteristics of NSLBP patients who were discharged from the ED and those admitted to hospital for further treatment are described. In addition, this study chronicles the patient journey between the OPC setting (e.g. doctor's visits, treatments received, and pharmacological interventions) between one year before and after the ED visit. Additionally, a regression model to predict the odds of NSLBP patients being admitted to the hospital for further treatment or being discharged from the ED, is developed.

2 Methods

2.1 Study Population

Patients from the INDEED study were included in this analysis if they attended one of the INDEED EDs in 2016 and received an ICD-10 code from the "M54" group as their ED diagnosis. Certain subgroups within the M54 three-digit code group family which are associated with back pain in the thoracic and cervical regions, were excluded from the analysis - as were any ICD-10 codes that referred to a specific cause of LBP (e.g. fracture). Codes containing the word "unspecified" were also excluded to ensure the correct localization of the LBP diagnosis to the anatomical area of interest. The list of excluded codes can be found in the supplementary information (Table S1). To identify chronic NSLBP patients, the German "at least 2 consecutive quarters" (M2Q) criterion was used. This criteria is defined as those patients who receive a repeated NSLBP diagnosis in the OPC setting for two consecutive quarters of the year (Epping et al., 2023).

The identified NSLBP population was stratified by whether they were ambulant (i.e., discharged from the ED) or admitted to the hospital for further treatment.

2.2 Statistical Analysis and Data

2.2.1 Descriptive Analysis of NSLBP Patients

During the ED visit, patient characteristics such as age, gender, time and date of admission, and the type of transport to the ED were recorded. The level of pain experienced by the patient was also recorded using either the numeric rating scale or the visual analogue scale (depending on the ED). To standardize, the scales were recategorised into: "no pain" (level 0), "mild pain" (levels 1-5), and "strong to severe pain" (levels 6-10).

Triage category was recorded either by using the Manchester Triage System and Emergency Severity Index (again depending on the ED). Similar to the method of standardising pain scores as described above, both triage scales were amalgamated into new categories. "Urgent" cases were considered to levels 1-2 on both scales, while levels 3-5 were designated as "Less-Urgent". Each patient was given a unique patient identifier, which was then linked to their health insurance data. Repeated visits by individual patients to the ED in 2016 were also identified by counting the number of "case IDs" per each individual patient number.

Continuous variables are presented as median with interquartile range (IQR). Categorical variables are presented as absolute counts and percentages. 95% confidence intervals (CIs) are provided where relevant.

2.2.2 Outpatient Care Utilisation Analysis

To understand the use of OPC services prior to and after ED visit, the frequency of use of OPC services in relation to the ED visit was analysed. Two time-points of one year and three months before and after ED visit were designated and the frequency in use of doctor's visits, services used, and drugs prescribed at these four time-points was calculated.

Regarding the type of doctor's practices used in the OPC setting by NSLBP patients, the various types of practice were grouped into broader categories for simplification (Table S2).

In Germany, OPC services such as physiotherapy or diagnostics are recorded using the fee order system (Gebührenordnungposition [GOP]). Due to the large number of administrative fees and surcharges that are recorded in an outpatient visit, only GOPs related to the treatment or diagnosis of NSLBP were analysed. The GOPs related to administration, finance, and surcharges for specific patient populations were omitted from the analysis altogether. Procedures were grouped into therapeutic or diagnostic procedures based on expert opinion (Table S3).

Information about pharmacological treatments were analysed to understand what drugs were prescribed to NSLBP patients. To eliminate non-NSLBP related drugs (e.g. treatments for other co-morbidities such as diabetes) only treatments from the anatomical therapeutic code (ATC) beginning with 'M' (Musculoskeletal System) and 'N' (Nervous System) were included in the analysis. Given the large variation in the types of drugs prescribed to patients, only the top 20 prescribed drugs were analysed. Drugs were grouped by their active ingredient (Table S4). Metamizole was kept as a standalone drug due to it being one of the most prescribed drugs (Table 4). Antidepressants and anti-epileptics that are used primarily for other diseases but have analgesic properties were combined into the group "co-analgesics" (Table S4). The proportions and prescriptions of drug types were analysed at specific time points relative to patient's ED visit.

For doctor's visits, GOPs recorded, and prescriptions made, alluvial diagrams were used to visualise the frequency of the respective variables at both three months and one year before and after ED visit.

2.3 LASSO Regression analysis

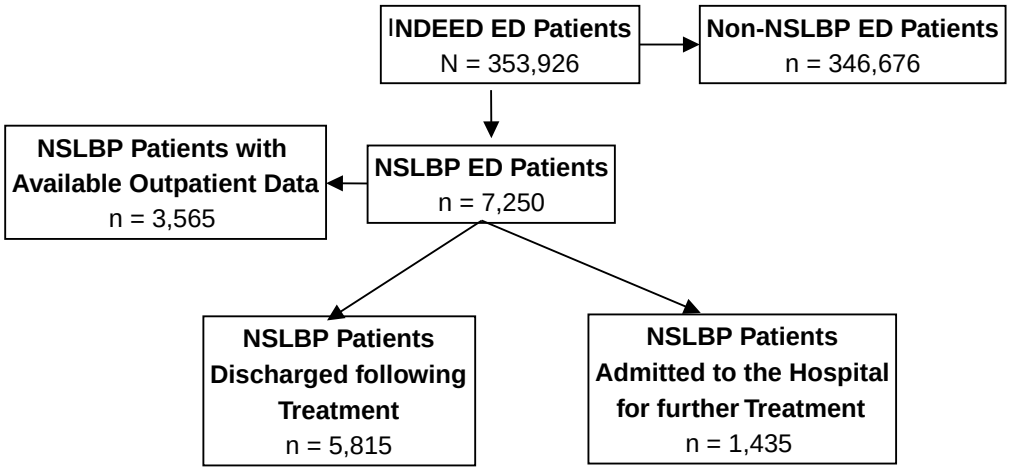
In this study, a predictive regression model was developed using the least absolute shrinkage and selection operator (LASSO) method (Tibshirani, 1996). The outcome variable being whether patients were discharged from or admitted to the hospital. All variables listed in Table 3 were initially included in the LASSO regression model following expert consultation. Due to uncertainties regarding the collection of pain scale data and uncertainty as to whether these data are missing "completely at random", pain was not included as a predictor in the model. The results of this model are reported as odds ratios (OR) along with 95% confidence intervals (CIs). To assess the predictive performance of the model, a receiver operating characteristic (ROC) curve was constructed. Internal validation of the model was carried out using cross-validation. A sensitivity analysis was carried out using multiple imputation to understand the effect of missing data on the LASSO regression model and validate the predictive ability of the model.

All descriptive and statistical analyses described above were conducted using R, version 4.2.2.

3 Results

For the 353,926 individual patients recorded in 2016 of the INDEED study, 7,250 unique patients attended the ED with a NSLBP diagnosis (Figure 1). Approximately 80% (n=5,815) of whom were discharged and 20% (n=1,435) of those were admitted to the hospital for further treatment (Table 5).

Figure 1: Flowchart of selecting the NSLBP subpopulation from the INDEED study



Abbreviations: ED: Emergency Department; INDEED: Utilization and Trans-Sectoral Patterns of Care for Patients to the Emergency Departments in Germany [English translation]; NSLBP; Non-Specific Lower Back Pain

Of all the patients identified, 48% (n=3,481) of patients were given the ICD-10 code of M54.5 (lower back pain), M54.4 (lumboischialgia) was the second most common diagnosis (40.4% [n=2,952]) with the remaining 11.6% being 6 other NSLBP diagnoses (Table 2).

Table 2: NSLBP-relevant ICD-10 codes recorded in the 16 EDs participating in the INDEED study in 2016

ICD-10 Code	ICD-10 Description	n	%
M54.5	Lower back pain	3,481	48.0
M54.4	Lumboischialgia	2,952	40.7
M54.16	Radiculopathy: lumbar region	425	5.9
M54.17	Radiculopathy: lumbosacral area	164	2.3
M54.86	Other back pain: lumbar region	115	1.6
M54.96	Back pain, unspecified: lumbar region	74	1.0
M54.97	Back pain, unspecified: lumbosacral area	24	0.3
M54.87	Other back pain: lumbosacral area	15	0.2

Abbreviations: ED: Emergency Department; ICD-10: International Classification of Diseases Version 10; INDEED Study: Utilization and Trans-Sectoral Patterns of Care for Patients to the Emergency Departments in Germany [English translation]; NSLBP: Non-specific Lower Back Pain

3.1 Characteristics of NSLBP patients

The median age for all NSLBP patients was 49 (IQR 35, 65). For the discharged and admitted patients the median age was 46 (IQR 33, 61) and 62 (IQR 46, 77), respectively (Table 3). 95% (n=6,904) of patients attended the ED only once for NSLBP in 2016 and 4.3% (n=314) attended the ED twice for NSLBP, one person attended the ED for NSLBP five times (Table 3).

A total of 23% (n=1,185) of NSBLP patients were medically accompanied to the ED (i.e., via ambulance or other emergency medical service [EMS]), 67% (n=3,481) arrived by their own means of transport, the remaining 10% (n=536) arrived with their transportation method recorded as "Other". 51% (n=3,565) and 49% (n=3,685) of patients had sought prior OPC for NSLBP or not, respectively (Table 3).

Upon arrival at the ED, 86% (n=6,191) of patients had a documented triage classification. 63% (n=3,901) of these patients were placed into the "Urgent" (triage scale levels 1-3) triage category with 37% (n= 2,290) classified "Less-Urgent" (triage scale levels 4-5) (Table 3).

With regards to pain score, 56% (n=4,103) of NSLBP patients did not have a pain score available. For those who did, 65% (n=2,039) of patients with pain score were recorded as having "Mild-to-Moderate Pain" (numerical rating scale [NRS] levels 1-5), 33% (n=1,027) were recorded as having "Strong to Severe Pain" (NRS levels 6-10). 2% (n=81) of patients attending the ED were recorded as having "No Pain" (NRS level 0). Among those patients admitted, some had a slightly higher number of recorded "Strong and Severe Pain" when compared with "Mild Pain" (35% [n=193] and 32% [n=893], respectively) (Table 3).

Table 3: Characteristics of NSLBP patients in the ED stratified by discharge or admission status

Characteristics	Admitted, N = 1,435	Discharged, N = 5,815	Overall, N = 7,250
Age, Median (IQR)	62 (46, 77)	46 (33, 61)	49 (35, 65)
Sex, n (%)			
Male	648 (45%)	2,934 (50%)	3,582 (49%)
Female	787 (55%)	2,881 (50%)	3,668 (51%)
Transport to ED, n (%)			
Arrived Medically Accompanied	401 (45%)	785 (18%)	1,186 (23%)
Arrived by Own Means	357 (40%)	3,124 (73%)	3,481 (67%)
Other	143 (16%)	393 (9.1%)	536 (10%)
NA	534	1,513	2,047
Triage Category, n (%)			
Urgent	870 (78%)	3,031 (60%)	3,901 (63%)
Less Urgent	247 (22%)	2,043 (40%)	2,290 (37%)
NA	318	741	1,059
Pain Scale Rating, n (%)			
No Pain (0)	32 (5.8%)	49 (1.9%)	81 (2.6%)
Mild Pain (1-5)	329 (59%)	1,710 (66%)	2,039 (65%)
Strong to Severe Pain (6-10)	193 (35%)	834 (32%)	1,027 (33%)
NA	881	3,222	4,103
ED admission within Working Hours*, n (%)			
Out of Hours	537 (37%)	2,856 (49%)	3,393 (47%)
Within Hours	898 (63%)	2,930 (51%)	3,828 (53%)
NA	0	29	29
Time of year of ED admission, n (%)			
Spring	333 (23%)	1,560 (27%)	1,893 (26%)
Summer	426 (30%)	1,590 (27%)	2,016 (28%)
Autumn	362 (25%)	1,329 (23%)	1,691 (23%)
Winter	314 (22%)	1,307 (23%)	1,621 (22%)
NA	0	29	29
Number of visits to the ED in 2016 for NSLBP, n (%)			

Characteristics	Admitted, N = 1,435	Discharged, N = 5,815	Overall, N = 7,250
1	1,354 (94%)	5,550 (95%)	6,904 (95%)
2	72 (5.0%)	242 (4.2%)	314 (4.3%)
3	7 (0.5%)	20 (0.3%)	27 (0.4%)
4	2 (0.1%)	2 (<0.1%)	4 (<0.1%)
5	0 (0%)	1 (<0.1%)	1 (<0.1%)
Chronic Patient prior to ED Visit, n (%)**			
Chronic NSLBP Patient	609 (42%)	1,803 (31%)	2,412 (33%)
Non-Chronic NSLBP Patient	826 (58%)	4,012 (69%)	4,838 (67%)
Prior OPC Interaction for NSLBP, n (%)			
No Prior Outpatient Care for NSLBP	576 (40%)	2,989 (51%)	3,565 (49%)
Prior Outpatient Care for NSLBP	859 (60%)	2,826 (49%)	3,685 (51%)

*Working Hours was defined as attending the ED on a weekday between 0700 and 1900

** Chronic patients were defined using the M2Q criteria

Abbreviations: IQR: Interquartile Range; ED: Emergency Department; NA: Not Available; NSLBP: Non-specific Lower Back Pain; OPC: Outpatient Care

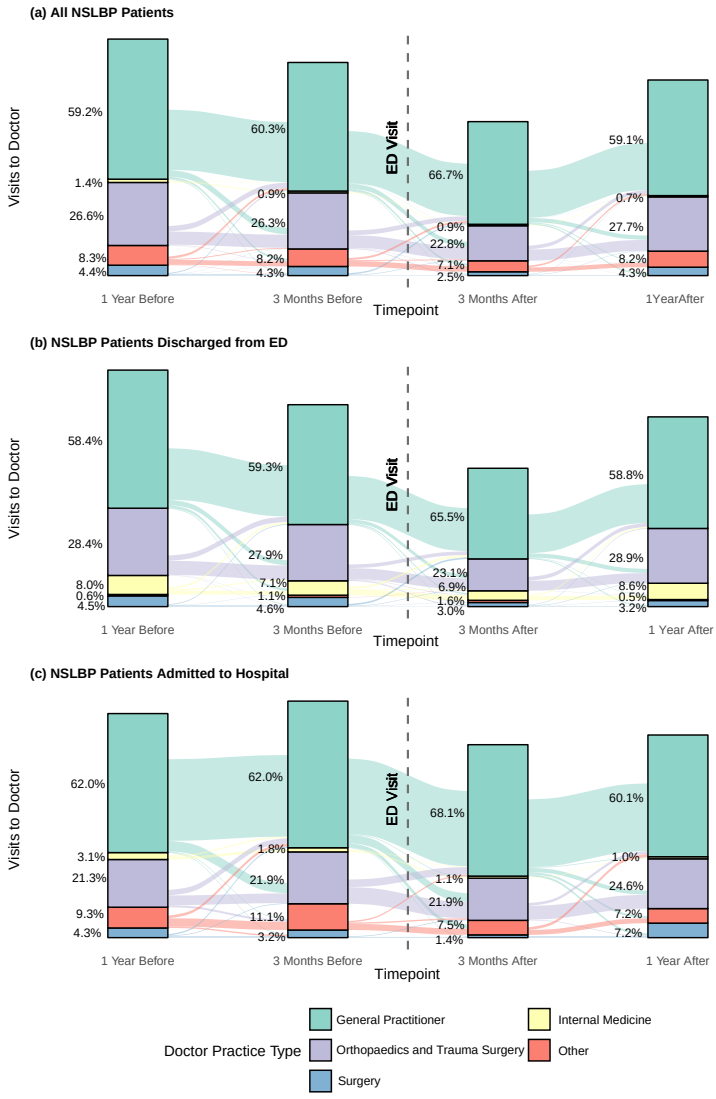
Using the M2Q criteria (two visits to an OPC service for the same ICD-10 code in two consecutive quarters), 33% (n=2,412) of patients were considered chronic prior to the ED visit (Table 4).

3.2 Outpatient Care Utilisation Analysis

3.2.1 Doctors Practices attended by NSLBP Patients

General practitioners were the most frequently visited medical practices by all patients and subgroups, with orthopaedics being the second most frequently visited. Doctor visits appear to decrease post-ED visit (Figure 2 a,b,c). A greater decrease in practice visits is observed for patients who were discharged when compared with those admitted to hospital. General practitioner usage increases after the ED visit, while orthopaedic visits remains relatively constant after ED attendance. Across all subgroups there appears to be indications of rebounding in the number of doctor's visits one year after ED visit (Figure 2).

Figure 2: Doctor visits recorded in the OPC sector for the three months and one year prior to and after ED visit



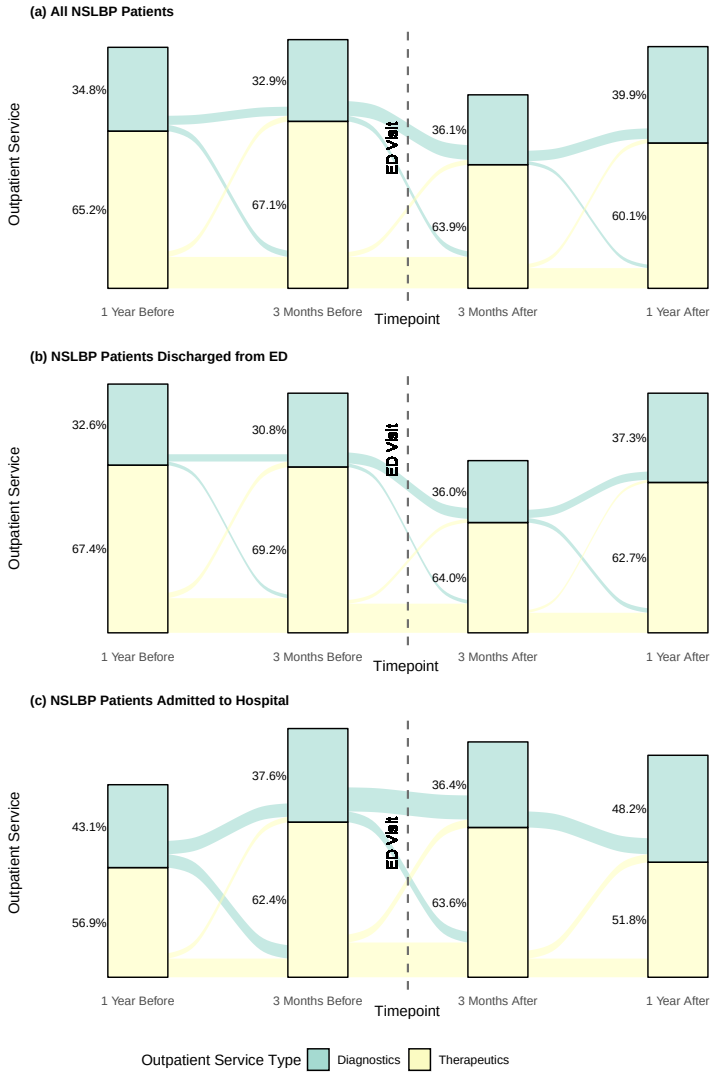
Abbreviations: ED: Emergency Department; NSLBP; Non-Specific Lower Back Pain; OPC: Outpatient Care

3.2.2 Outpatient Care Services Utilised by NSLBP Patients

In terms of OPC services utilized by NSLBP patients, there is a slight increase in the number of therapeutic GOPs observed one quarter before the ED visit compared to one year prior. Specifically, for all patients, there is a small increase in GOPs related to therapy for NSLBP (e.g. physiotherapy and electrotherapy [See Table S3]) from 66.2% before the ED visit to 67.1%. However, the absolute number of diagnostic GOPs recorded after the ED visit shows an approximate 4% decrease after ED visit (Figure 3 a,b,c). For admitted patients, the volume of therapeutic services recorded remains relatively high post ED visit when compared with those

discharged, where there is a substantial decrease in services billed three months post-ED visit (Figure 3 b and c).

Figure 3: Outpatient non-pharmacological treatments used for the three months and one year prior to and after ED visit



Abbreviations: ED: Emergency Department; NSLBP; Non-Specific Lower Back Pain

3.2.3 Medications prescribed to NSLBP Patients

The most common outpatient prescription made for NSLBP patients was metamizole, with no differences between the proportion of prescriptions for admitted versus discharged patients. Ibuprofen was prescribed to more patients who were discharged compared with those admitted (20% and 13%, respectively). Opioids (e.g. tramadol, fentanyl, hydromorphone) were prescribed

at higher frequencies for patients who were admitted when compared with those discharged (Table 4). According to the German clinical guidelines for LBP, antidepressants and antiepileptics (defined in this study as co-analgesics), have been used in the past but are not recommended for LBP (unless the patient also has depression or epilepsy) due to the lack of evidence of efficacy (Chenot et al., 2017). Despite this, pregabalin and amitriptyline, an anti-epileptic and an antidepressant, respectively, are in the top 10 drugs prescribed to patients with an NSBLP ICD-10 code (Table 4).

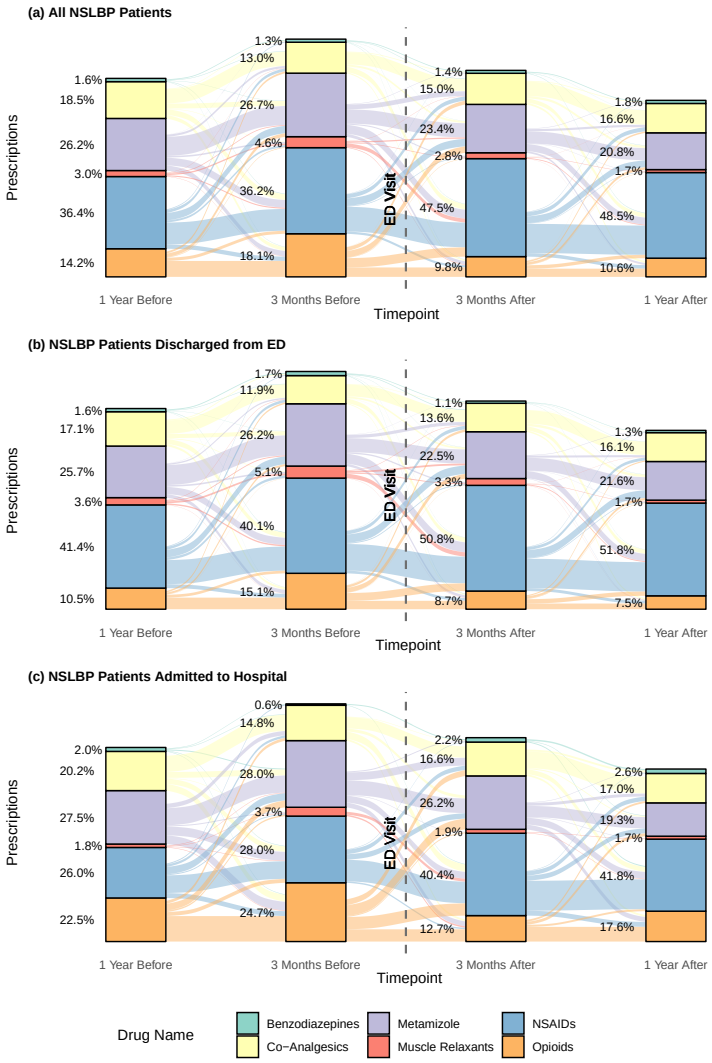
Table 4: Top 10 drugs prescribed to NSLBP patients in the INDEED study stratified by whether they were admitted to the hospital or discharged from the ED

Drug Name	Discharged	Admitted
Metamizole sodium	40%	41%
Ibuprofen	20%	13%
Diclofenac	12%	9%
Tramadol	9%	9%
Methocarbamol	5%	3%
Fentanyl	3%	6%
Hydromorphone	3%	6%
Oxycodone	3%	7%
Pregabalin	2%	4%
Amitriptyline	2%	2%

Abbreviations: ED: Emergency Department; INDEED Study: Utilization and Trans-Sectoral Patterns of Care for Patients to the Emergency Departments in Germany [English translation;] NSLBP: Non-specific Lower Back Pain

In terms of the relationship between prescriptions and the time prior to and after ED visit, there is an increase in the total number of prescriptions to patients recorded three months prior to ED visit, when compared with the number of prescriptions one year before ED visit. For all ED patients, the proportion of opioid prescriptions increased from 14.2% of all prescriptions one year before to 18.1% three months before ED visit, subsequently decreasing to 9.8% one quarter after ED. Additionally, three months following the ED visit the absolute number of prescriptions are lower than one quarter prior. The amount of non-steroidal anti-inflammatories (NSAIDs) prescribed increased substantially after ED visit (36.2% and 47.5%, respectively) (Figure 4a). Regarding the differences between the admitted and discharged, the proportion of opioids is greater at all time-points in those patients admitted to the hospital when compared with those discharged (Figure 4 b and c).

Figure 4: Prescriptions made to NSLBP patients for the three months and one year prior to and after ED Visit



Abbreviations: ED: Emergency Department; NSLBP; Non-Specific Lower Back Pain

3.3 LASSO Regression

The results of the LASSO regression model are reported in Table 5. Arriving medically accompanied (i.e., by EMS) (OR=2.50, 95% CI 2.05-3.05), being categorized in triage as “Urgent” (OR=2.39, 95% CI 1.90-3.01), arriving at the ED within typical working hours (i.e. on weekdays between 7:00 and 19:00) (OR=1.51, 95% CI 1.25-1.84), and the presence of more than three co-morbidities (OR=14.9, 95% CI 12.1-18.4) were all associated with an increased odds of hospital admission for NSLBP (Table 5).

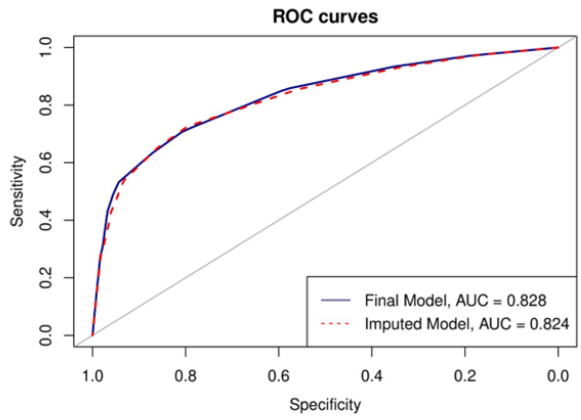
Table 5: Predictive LASSO Regression for the odds of NSLBP patients being admitted to hospital versus those discharged

Characteristic	OR	95% CI	p-value
Transport to ED			
Arrived by Other Means	—	—	
Medically Accompanied	2.50	2.05 to 3.05	**<0.001**
Triage Category			
Less Urgent	—	—	
Urgent	2.39	1.90 to 3.01	**<0.001**
Outside of typical working hours*			
Out of Hours	—	—	
Within Hours	1.51	1.25 to 1.84	**<0.001**
Multimorbidity			
One Diagnosis	—	—	
At least three Different Comorbidities	14.9	12.1 to 18.4	**<0.001**

*Working Hours was defined as attending the ED on a weekday between 07:00 and 19:00
Abbreviations: ED: Emergency Department; LASSO: Least Absolute Shrinkage and Selection Operator; OR: Odds Ratio; NSLBP: Non-specific Lower Back Pain.

As part of a sensitivity analysis, values were imputed using multiple imputation to assess the impact of missing data on the model, ROC curves were generated for two imputed datasets and compared with the original model. The final model demonstrated good discrimination (area under the curve [AUC] = 0.828); the imputed data had a slightly lower AUC score (AUC = 0.824) indicating that the original model has a good ability to discriminate and this ability it is not impacted by missing data (Figure 5).

Figure 5: ROC curves for LASSO model with original and imputed data



Abbreviations: AUC: Area Under the Curve; LASSO; Least Absolute Shrinkage and Selection Operator; ROC: Receiver Operating Curve

3.4 Discussion

This study describes the characteristics of NSLBP patients in German EDs and is one of the first to discuss the cross-sectoral patient journey between the OPC setting and the ED. The median age of an NSLBP patient was 49, the gender balance of patients was broadly 50%. 19.8% of NSLBP patients who attended the ED were admitted to hospital. Other similar studies in Australia and Canada had admission percentages of between 34.1% and 11.0%, suggesting our results are similarly aligned with other studies. (Kawchuk et al., 2022; Luca et al., 2023). Given 2% of patients in the study visited the ED for NSBLP, these results align with the estimated 2%-4% of Edwards et al. 2017 (Edwards et al., 2017). This discrepancy could also be explained by our more stringent definition of NSLBP when compared with the other studies.

Whilst there is a substantial numerical difference in the median age between those admitted to hospital for further treatment and those discharged (62 [IQR: 46 to 77] and 46 [IQR 33 to 61]), age was not considered a significant predictor of hospital admission. In two other similar studies in Canada and Australia, increasing age was identified as a significant predictor of hospital admission (Kawchuk et al., 2022; Luca et al., 2023). However, in both of these studies OR ratios were relatively close to 1 (OR=1.03 [95% CI 1.01-1.05], OR=1.05 [95% CI 1.02-1.08]) suggesting that this significance is only small (Kawchuk et al., 2022; Luca et al., 2023). Additionally, in a survey of German LBP patients, Lippe et al. found no significant differentiation of LBP incidence by age - suggesting the relationship between age and NSLBP hospital admission may not be as certain as one may expect (Lippe et al., 2021). Similar to our study, triage and ED arrival by ambulance were both identified as statistically significant predictors of hospital admission in two other studies - reinforcing the strength and generalisability of our model (Kawchuk et al., 2022; Luca et al., 2023).

The proportion of patients with no prior OPC visit for NSLBP and those who had sought treatment prior to their ED visit was broadly equal. Increased prescriptions specifically in typical pain medication prior to ED visit (e.g., opioids and NSAIDs) are potentially an indicator that patients tried to get pain relief prior to the ED visit. Based on this finding, we could infer that there is an opportunity for re-orientating care to try and proactively manage these patients, perhaps through re-evaluation of the patient's care such as coupling pharmacotherapy with more intensive physiotherapy. Additionally, we demonstrate the continued prescription of co-analgesics that are not being recommended in the current treatment guidelines for LBP are still being used (Chenot et al., 2017). This could mean that patients are receiving the sub-optimal treatment for their NSLBP, potentially resulting in poorer outcomes or need for further treatment.

Treatment of NSLBP is pivoting away from "intensive" treatments such as surgery, injections, or opioid therapy towards more passive therapies such as exercise and psychotherapy (Steinmetz, 2022). The analysis of drugs and therapies prescribed in the OPC setting would suggest that this transition in Germany is not yet complete, with opioids and injections of painkillers still being used for patients (Figure 4 and Table S3, respectively).

In the LASSO regression model, it was found that ED admission during typical working hours (i.e. on a weekday between 07:00 and 19:00) was considered a predictor of admission to the ED and could indicate that differences in staff availability during a weekday could mean that hospitals are more willing to admit patients when compared with weekends, where there is less personnel. These findings could indicate a discrepancy in the equality of care depending on the time or day of the week they attend the ED. Further investigations would be needed to better elucidate the reasons for this result. However, this could offer an opportunity to review ED care and ensure

better outcomes regardless of the time of ED visit.

However, as this is a descriptive analysis, further investigation would be needed to validate these findings. This could take the form of more detailed patient/physician surveys, or perhaps an observational study. Additionally, the absence of changes in therapeutic outpatient service utilisation after an ED visit for hospitalised patients compared with before a visit could potentially be of interest. As multimodal therapy is recommended for NSLBP there could be a potential to improve or increase the use of this therapy post ED visit (Steinmetz, 2022).

3.4.1 Strengths and Limitations

There are inherent strengths to the INDEED study. This the only cross-sectoral study of its kind in Germany encompassing data from 16 EDs in Germany linked to their outpatient care data before and after ED treatment. Furthermore, these data are comprehensive for all patients who visited the ED and not limited to specific disease types (i.e., only lung cancer). It is understood it that the INDEED study is the only German study that has been able to cross-link data from ED visits with OPC data, providing a novel insight into the German healthcare system.

However, due its size, the study is susceptible to systematic errors from inaccurate data inputs from the hospital or health insurances. To counteract the impact of different hospitals using different triage systems to categorise patients, scores were amalgamated (see “Methods”), which may mean loss of subtleties in the triage data. In addition, assignations by the ED staff of pain may be susceptible to variations in the patient’s/physician’s perception of the level of pain being experienced. Furthermore, a considerable proportion of NSLBP patients did not have pain scale data available. These two limitations could introduce uncertainties around the conclusions of this study.

Moreover, the OPC data originates from public healthcare insurance companies with none from private health insurers. German public health insurance populations tend to be in poorer health when compared with those enrolled in private insurances - this could bias the results of this study when considering the broader applicability to the German population (Stauder and Kossow, 2016). Another limitation is that, due to the study design, we do not have a population who did not attend the ED for NSLBP with whom we can compare the data (i.e., experienced NSLBP in the OPC sector and did not attend ED in 2016).

4 Conclusion

NSLBP contributes significantly to ED attendance in Germany, leading to substantial stress on the healthcare system. The observed increase in outpatient service utilization in the period leading up to ED visits highlights the need for more effective outpatient interventions aimed at reducing the need for ED visits and improving outcomes for patients in general. Furthermore, this study successfully identified major predictors of hospital admission compared to discharge after the ED visit, offering opportunities for improved ED management and alleviating overcrowding. The findings emphasize the need for focused and targeted investigations to enhance NSLBP care in Germany, ultimately leading to more efficient healthcare, reduced ED burden, and better patient outcomes.

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6 Supplementary Material

Table S1: Table of the omitted ICD-10 codes of the three-digit M54 (back pain) subgroup

Omitted ICD-10 codes	ICD-10 Code Definition
M54	Dorsalgia
M54.3	Sciatica
M54.2	Cervicalgia
M54.6	Pain in thoracic spine
M54.10	Radiculopathy Multiple Sites in Spine
M54.12	Radiculopathy Cervical Region
M54.13	Radiculopathy Cervicothoracic Region
M54.14	Radiculopathy Thoracic Region
M54.15	Radiculopathy Thoracolumbar Region
M54.18	Radiculopathy Sacral and Sacrococcygeal Region
M54.19	Radiculopathy Site unspecified
M54.80	Other Dorsalgia
M54.82	Other Dorsalgia Cervical Region
M54.83	Other Dorsalgia Cervicothoracic Region.
M54.84	Other Dorsalgia Thoracic Region
M54.85	Other Dorsalgia Thoracolumbar Region
M54.89	Other Dorsalgia Site Unspecified
M54.9	Dorsalgia, Unspecified Multiple Sites in Spine
M54.92	Dorsalgia, Unspecified Cervical Region
M54.94	Dorsalgia, Unspecified Thoracic Region
M54.95	Dorsalgia, Unspecified Thoracolumbar Region
M54.99	Dorsalgia, Unspecified Thoracolumbar Region

Abbreviations: ICD-10: International Classification of Diseases - Version 10

Table S2: Categorisation of doctor practice types visited by NSLBP patients in the INDEED Study

Practice Type	Category
General Practitioner/Doctor Without Specialist Training	GP Care
Family Medicine Internal Medicine	GP Care
Anaesthesiology	Other
Ophthalmology	Other
Surgery	Surgery
Vascular Surgery	Surgery
Visceral Surgery	Surgery
Paediatric Surgery	Surgery
Orthopaedics (And Accident Surgery)	Orthopaedics And Trauma Surgery
Trauma Surgery	Orthopaedics And Trauma Surgery
Rheumatology (Formerly Orthopaedics)	Orthopaedics And Trauma Surgery
Plastic Surgery	Surgery
Thoracic Surgery	Surgery
Gynaecology	Gynaecology And Obstetrics
Gynaecological Endocrinology And Reproductive Medicine	Gynaecology And Obstetrics
Gynaecological Oncology	Gynaecology And Obstetrics
Special Obstetrics And Perinatal Medicine	Gynaecology And Obstetrics
Otorhinolaryngology	ENT
Phoniatrics/Paediatric Audiology	ENT
Skin-And Venereal Diseases	Dermatology
Human Genetics	Other
Specialist Internal Medicine	Internal Medicine, Specialist
Angiology	Internal Medicine, Specialist
Endocrinology/Diabetology	Internal Medicine, Specialist
Gastroenterology	Internal Medicine, Specialist
Haematology/Oncology	Internal Medicine, Specialist
Cardiology	Internal Medicine, Specialist
Nephrology	Internal Medicine, Specialist
Pneumology	Internal Medicine, Specialist
Rheumatology (Internal Medicine)	Internal Medicine, Specialist
Geriatrics	Internal Medicine, Specialist
Infectiology	Internal Medicine, Specialist
Family Medicine For Children And Adolescents	GP Care
General Practitioner Children's Haematology	GP Care
General Practitioner Paediatric Cardiology	GP Care
General Practitioner Neonatology	GP Care
General Practitioner Neuropaediatric/Child Neuropsychiatry	GP Care
Family Medicine Children's Pneumology	GP Care
Paediatric And Adolescent Medicine With A Focus And Participation In HA/FA Care	GP Care
Child And Adolescent Psychiatry And Psychotherapy	Psychiatry/Psychosomatics/Medical Psychotherapy
Laboratory Medicine	Laboratory
Microbiology, Virology And Infection Epidemiology	Other
Neurosurgery	Surgery
Neurology	Neurology

Practice Type	Category
Nuclear Medicine	Other
Neuropathology	Other
Pathology	Other
Physical And Rehabilitative Medicine/Physiotherapi8e	Other
Psychiatry/Psychiatry And Psychotherapy	Psychiatry/Psychosomatics/Medical Psychotherapy
Forensic Psychiatry	Psychiatry/Psychosomatics/Medical Psychotherapy
Psychosomatic Medicine And Psychotherapy	Psychiatry/Psychosomatics/Medical Psychotherapy
Psychotherapeutic Doctor	Psychiatry/Psychosomatics/Medical Psychotherapy
Radiology	Radiology
Paediatric Radiology	Radiology
Neuroradiology	Radiology
Radiotherapy	Other
Transfusion Medicine	Other
Urology	Urology
Psychological Psychotherapist	Psychological Psychotherapists
Child and adolescent psychotherapist	Psychological Psychotherapists

Abbreviations: NSLBP: Non-Specific Lower Back Pain; INDEED Study: Utilization and Trans-Sectoral Patterns of Care for Patients to the Emergency Departments in Germany [English translation]

Table S3: Included GOP codes used to analyse the outpatient service utilisation of NSLBP patients in the INDEED study

Included GOP codes (Top 20)	GOP Code Definition* (English Translation)	GOP Classification
30791	Implementation of a body acupuncture	Therapeutic
30791	Physiotherapy of the back	Therapeutic
30724	Spinal nerve analgesia	Therapeutic
2510	Heat Therapy	Therapeutic
35100	Differential diagnostic clarification of psychosomatic disease states	Diagnostic
30708	Pain Therapy Consultation	Therapeutic
35100	Physiotherapy (General)	Therapeutic
34221	X-Ray of parts of the spine	Diagnostic
30702	Pain Therapy (General)	Therapeutic
1950	Substitution of pain therapy	Therapeutic
30702	Electrotherapy	Therapeutic
1950	Substitution of pain therapy	Therapeutic
30790	Initial acupuncture therapy	Therapeutic
16215	Primary neurological care	Therapeutic
33042	Abdominal ultrasound	Diagnostic
30721	Blockade injection in the cervical spine	Therapeutic
30400	Massage therapy	Therapeutic
34234	X-Ray of the pelvis	Diagnostic
30731	Analgesia	Therapeutic
16232	Diagnosis and/or treatment of diseases of the spine in adolescents and adults	Diagnostic
30731	Performance of body acupuncture	Therapeutic

Abbreviations: GOP: Fee Order System (Gebührenordnungposition); INDEED Study: Utilization and Trans-Sectoral Patterns of Care for Patients to the Emergency Departments in Germany [English translation]; NSLBP: Non-Specific Lower Back Pain

* Source of GOP code definitions: https://www.kbv.de/html/ebm.php

Table S4: The Categorisation of different drugs by their WHO designated ”active ingredient”

Included Drugs (Top 20)	Drug Classification
Amitriptyline	Co-Analgesics
Buprenorphine	Opioids
Citalopram	Co-Analgesics
Diazepam	Benzodiazepines
Diclofenac	NSAIDs
Etoricoxib	NSAIDs
Fentanyl	Opioids
Gabapentin	Co-Analgesics
Hydromorphone	Opioids
Ibuprofen	NSAIDs
Lorazepam	Benzodiazepines
Metamizole Sodium	Metamizole
Methocarbamol	Muscle Relaxants
Mirtazapine	Co-Analgesics
Morphine	Opioids
Oxycodone	Opioids
Pregabalin	Co-Analgesics
Tramadol	Opioids
Trimipramine	Co-Analgesics
Venlafaxine	Co-Analgesics

Abbreviations: NSAIDs: Non-Steroidal Anti-Inflammatories; WHO: World Health Organisation