

Hospitalization Costs and Disease Burden of *B. Pertussis* in Germany: A Retrospective Analysis of Nationwide Inpatient Data Collected From 2019 to 2023

Krammer M¹, Reinhardt J¹, Wagner J¹, Mahmood A², Waize M¹, Marijic P¹

¹GSK, Munich, BY, Germany; ²GSK, Wavre, Walloon Brabant, Belgium



Hospitalization costs due to *B. pertussis* among adults increase with age. Hence, booster vaccinations are of considerable economic relevance.

Digital poster
Supplementary data



SCAN ME

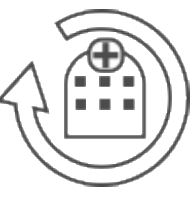
Aims



- The primary objective of this study was to estimate the **mean hospitalization cost** due to *B. pertussis* among children and adults.
- Secondary/exploratory objectives were to describe **characteristics of hospitalized *Bordetella pertussis* (*B. pertussis*) patients**, the utilization of hospital care and costs in inpatients with respiratory complications of interest.



Study design



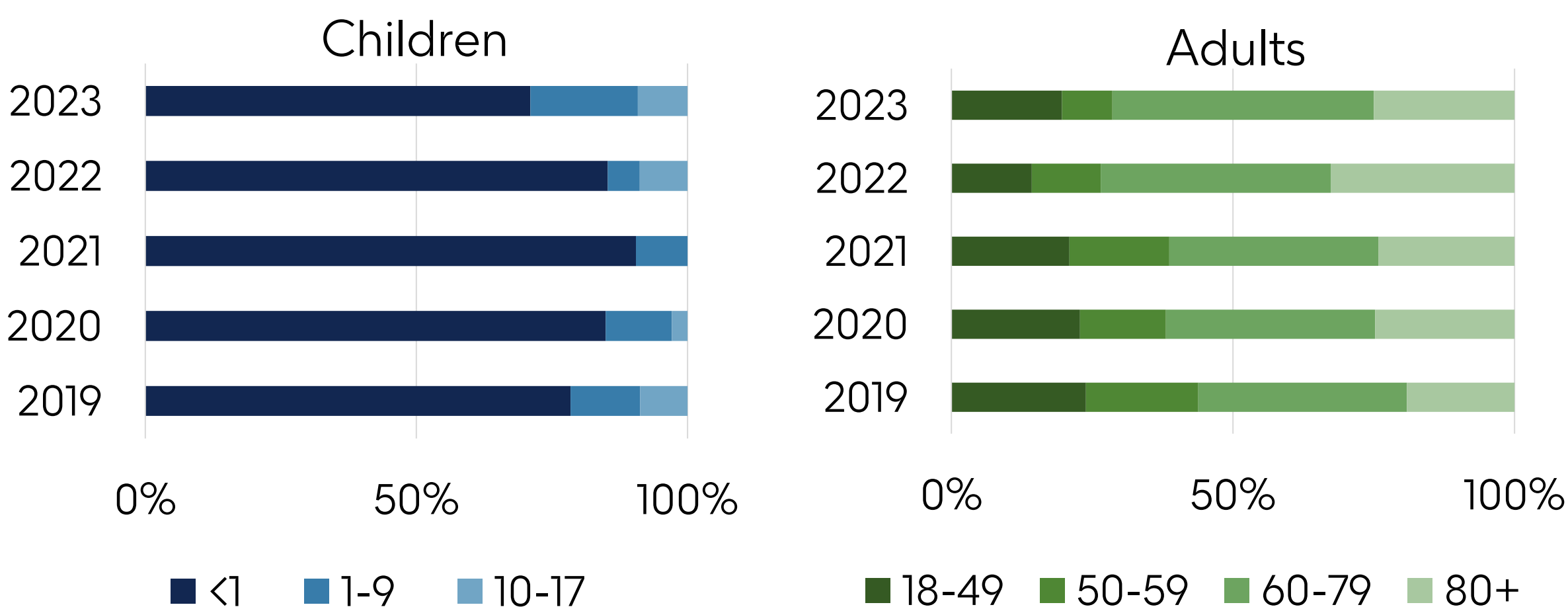
- This **retrospective study** uses aggregated inpatient data from the Institute for the Hospital Remuneration System (InEK).
- B. pertussis* cases** were identified using International Statistical Classification of Diseases and Related Health Problems – German Modification (ICD-10-GM) codes A37.0 and A37.9 as primary diagnoses and hospitalization in a main department in Germany from 2019 to 2023.
- All analyses were performed separately for children (aged 0 to ≤17 years) and adults (aged ≥18 years), and for each year.
- Cost estimates were derived from the **age-group-specific diagnosis-related group** distributions and the respective mean lengths of stay, offset against the year-specific federal base rates (and nursing care revenues from 2020 onwards), and inflation-adjusted to 2023, see supplementary material.



Demographics

- Across study years, **714 children** (2019-2023: 389, 139, 21, 34, 131; respectively) and **523 adults** (2019-2023: 251, 105, 62, 49, 56; respectively) were hospitalized with *B. pertussis*.
- In adults, more hospitalized patients were female, ranging from 54.3% to 61.2% (no such trend was observed in children) (Table S1 and S2).
- Over the study period, **78.0% of adults were aged ≥50 years**, while **79.0% of children were under 1 year of age (YOA)** (Figure 1).
- Across study years, **7.0% of children and 3.3% of adults required intensive care unit admission**.

Figure 1: Age distribution of hospitalized *B. pertussis* cases



Results



- Hospitalization costs per case ranged from € 2,524 to € 3,078 in children and € 3,022 to € 3,917 in adults (Table 1 and 2).
- Costs among adults increased with age, ranging from € 2,466 to € 3,499 in those 18-49 YOA, € 3,022 to € 3,852 in those 50-59 YOA, € 3,022 to € 3,854 in those 60-79 YOA and € 3,022 to € 4,953 in those ≥80 YOA.
- Patients with pneumonia or acute respiratory distress syndrome (ARDS) showed increased costs, ranging from € 2,745 to € 3,584 in children and from € 3,010 to € 5,099 in adults for pneumonia, and from € 3,022 to € 5,417 in children and from € 3,022 to € 5,446 in adults for ARDS.
- Mean length of hospital stay (standard deviation) increased with age among adults, ranging from 6.6 (3.9) to 7.8 (6.3) days compared to a range from 3.4 (1.5) to 6.0 (6.7) days in children (Figure 2).

Table 1: Mean hospitalization cost per *B. pertussis* case among children

Subgroup	2019	2020	2021	2022	2023
0-17 YOA	€ 2,524	€ 3,078	€ 2,535	€ 2,993	€ 2,676
0-9 YOA	€ 2,569	€ 3,078	€ 2,535	€ 2,989	€ 3,073
10-17 YOA	€ 2,524	-	-	-	€ 2,689
Pneumonia*	€ 2,745	-	-	-	€ 3,584
ARDS*	€ 3,022	€ 4,435	-	€ 5,417	€ 4,446

*- indicates that a cost estimate could not be calculated as less than 5 cases were admitted to hospital in the respective year and therefore no data could be extracted from the InEK database.

* Pneumonia/ARDS costs were derived by case-weighting costs of *B. pertussis* patients aged 0-17 YOA with primary and secondary pneumonia/ARDS diagnosis.

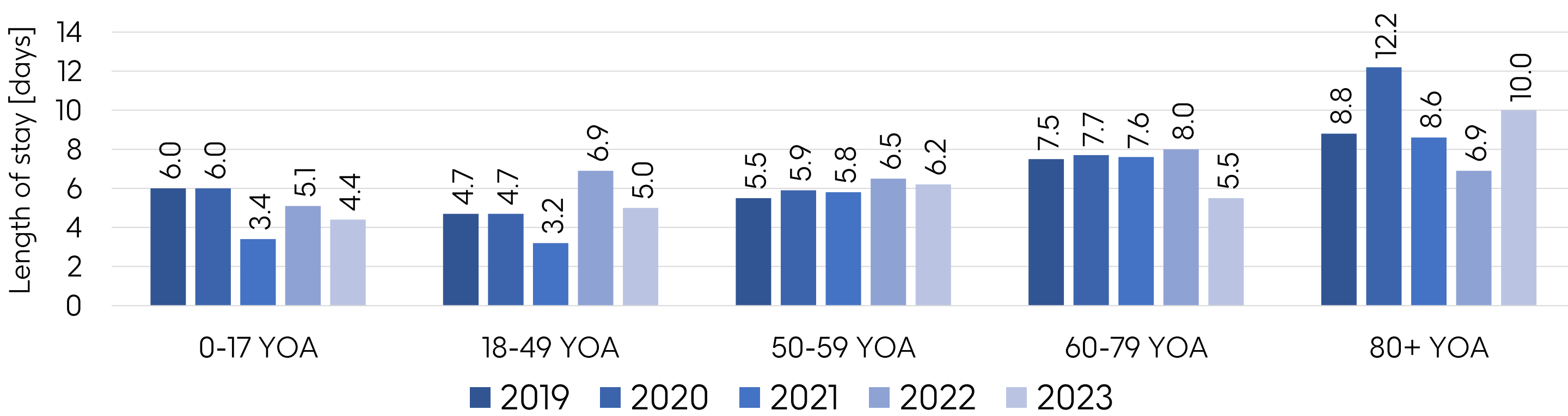
Table 2: Mean hospitalization cost per *B. pertussis* case among adults

Subgroup	2019#	2020	2021	2022	2023
≥18 YOA	€ 3,022	€ 3,406	€ 3,344	€ 3,666	€ 3,917
18-49 YOA	€ 3,022	€ 2,851	€ 2,466	€ 3,499	€ 3,427
50-59 YOA	€ 3,022	€ 3,170	€ 3,155	€ 3,453	€ 3,852
60-79 YOA	€ 3,022	€ 3,406	€ 3,612	€ 3,854	€ 3,618
80+ YOA	€ 3,022	€ 4,219	€ 3,884	€ 3,575	€ 4,953
Pneumonia*	€ 3,010	€ 3,906	€ 3,568	€ 3,995	€ 5,099
ARDS*	€ 3,022	€ 4,120	€ 4,041	€ 3,960	€ 5,446

* Pneumonia/ARDS costs were derived by case-weighting costs of *B. pertussis* patients aged ≥18 YOA with primary and secondary pneumonia/ARDS diagnosis.

In 2019, cost estimates were similar across all groups because only one diagnosis-related group code was used for billing in most cases, nursing care costs had not yet been itemized, and the average length of stay for each group was within boundary limits.

Figure 2: Mean length of hospital stay per *B. pertussis* case



Background

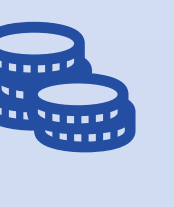


- Whooping cough is usually caused by the bacterium *B. pertussis* and can last for multiple weeks to months.^{1,2}
- Infection-related hospitalizations and complications occur most frequently in infants, followed by older adults.²
- To date, published information on inpatient health economic implications due to *B. pertussis* is limited for Germany

Conclusions



Both infants and adults are at risk of *B. pertussis* hospitalizations.



Hospitalization costs in adults increase with age.



Booster vaccinations are of considerable economic relevance.

Abbreviations

ARDS: acute respiratory distress syndrome; *B. pertussis*: *Bordetella pertussis*; ICD-10-GM: International Statistical Classification of Diseases and Related Health Problems – German Modification; InEK: Institute for the Hospital Remuneration System; YOA: years of age.

References

- Mattoo S, Cherry JD. Molecular pathogenesis, epidemiology, and clinical manifestations of respiratory infections due to *Bordetella pertussis* and other *Bordetella* subspecies. Clin Microbiol Rev. 2005 Apr;18(2):326-82. doi: 10.1128/CMR.18.2.326-382.2005. PMID: 15831828; PMCID: PMC1082800.
- Liese J, et al. Pertussis. In: Berner R, Bialek R, Forster J, Härtel C, Heininger U, Huppertz H, et al, editors. Deutsche Gesellschaft für Pädiatrische Infektiologie: DGPI Handbuch Infektionen bei Kindern und Jugendlichen. 7. Stuttgart: Thieme; 2018. p. 669-75.

Acknowledgements

Business & Decision Life Sciences Medical Communication Service Center provided editorial assistance and publication coordination, on behalf of GSK.

Disclosures

Conflicts of Interest: MK, JR, JW, AM, MW and PV are employed by GSK. On a voluntary basis, AM also sits on the Board of Trustees for mental health charity "Beyond Conflict" (registered UK charity number: 1176499) and works as distance learning tutor for MSc in Clinical Trials (London School of Hygiene and Tropical Medicine). The authors declare no other financial and non-financial relationships and activities. Funding: GSK (study identifier: VEO-001006).

Supplementary material for “Hospitalization Costs and Disease Burden of *B. Pertussis* in Germany: A Retrospective Analysis of Nationwide Inpatient Data Collected From 2019 to 2023”

Krammer M¹, Reinhardt J¹, Wagner J¹, Mahmood A², Waize M¹, Marijic P¹

¹GSK, Munich, BY, Germany; ²GSK, Wavre, Walloon Brabant, Belgium

Cost calculation methodology

The case-weighted calculation of the average hospitalization cost per year and case was conducted as follows:

1. Calculation of the average cost per diagnosis-related group (DRG) using the year-specific federal base rates and the DRG-specific flat rate case weights
2. For the calculation of the additional nursing cost which were introduced in Germany in 2020 (thus, only applicable for the years 2020-2023), the average length of stay per DRG was offset against a DRG-specific nursing charge value to obtain the average nursing cost per DRG (which is then added to the flat rate calculated in step 1)
3. Calculation of an average cost value by weighting the individual DRG costs based on the number of cases billed with the respective DRGs
4. Correction of average costs per year based on the health-specific consumer price index of the Federal Statistical Office of Germany to the price level of 2023

Table S1: Patient characteristics of hospitalized children (0-17 YOA)

Characteristic, n (%)	2019	2020	2021	2022	2023
Number of patients	389	139	21	34	131
Age groups					
<1 YOA	305 (78.4%)	118 (84.9 %)	19 (90.5%)	29 (85.3%)	93 (71.0%)
1-9 YOA	50 (12.9%)	17 (12.2%)	2 (9.5%)	2 (5.9%)	26 (19.8%)
10-17 YOA	34 (8.7%)	4 (2.9%)	0 (0.0%)	3 (8.8%)	12 (9.2%)
Sex					
- Male	204 (52.4%)	68 (48.9%)	10 (47.6%)	22 (64.7%)	58 (44.3%)
- Female	185 (47.6%)	71 (51.1%)	11 (52.4%)	12 (35.3%)	73 (55.7%)
ICU admission	23 (5.9%)	12 (8.6%)	0 (0.0%)	5 (14.7%)	10 (7.6%)
In-hospital death	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)

Considering primary diagnoses for pertussis only.

Table S2: Patient characteristics of hospitalized adults (18+ YOA)

Characteristic, n (%)	2019	2020	2021	2022	2023
Number of patients	251	105	62	49	56
Age groups					
18-49 YOA	60 (23.9%)	24 (22.9%)	13 (21.0%)	7 (14.3%)	11 (19.6%)
50-59 YOA	50 (19.9%)	16 (15.2%)	11 (17.7%)	6 (12.2%)	5 (8.9%)
60-79 YOA	93 (37.1%)	39 (37.1%)	23 (37.1%)	20 (40.8%)	26 (46.4%)
80+ YOA	48 (19.1%)	26 (24.8%)	15 (24.2%)	16 (32.7%)	14 (25.0%)
Sex					
- Male	100 (39.8%)	48 (45.7%)	27 (43.5%)	19 (38.8%)	22 (39.3%)
- Female	151 (60.2%)	57 (54.3%)	35 (56.5%)	30 (61.2%)	34 (60.7%)
ICU admission	10 (4.0%)	4 (3.8%)	1 (1.6%)	1 (2.0%)	1 (1.8%)
In-hospital death	0 (0.0%)	1 (1.0%)	0 (0.0%)	2 (4.1%)	0 (0.0%)

Considering primary diagnoses for pertussis only.

Table S3: Proportion of patients with pneumonia or ARDS among children (0-17 YOA) and adults (18+ YOA)

Characteristic, n (%)	2019	2020	2021	2022	2023
Number of patients 0-17 YOA	454	171	35	43	158
- Pneumonia ⁺	36 (7.9%)	10 (5.8%)	3 (8.6%)	3 (7.0%)	18 (11.4%)
- ARDS ⁺	49 (10.8%)	22 (12.9%)	1 (2.9%)	5 (11.6%)	10 (6.3%)
Number of patients 18+ YOA	393	232	198	106	108
- Pneumonia ⁺	51 (13.0%)	31 (13.4%)	44 (22.2%)	21 (19.8%)	7 (6.5%)
- ARDS ⁺	30 (7.6%)	22 (9.5%)	10 (5.1%)	9 (8.5%)	10 (9.3%)

Considering primary and secondary diagnoses for pertussis. ⁺ARDS and pneumonia cases were identified via primary or secondary diagnoses for ARDS/pneumonia.

Abbreviations

ARDS: acute respiratory distress syndrome; DRG: diagnosis-related group; ICU: intensive care unit; YOA: years of age.