Original Article

The Increase in Invasive Bacterial Infections With Respiratory Transmission in Germany, 2022/2023

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Summary

Background: In late 2022, health care institutions in Germany reported an unusual number of severe, invasive bacterial infections in association with a high incidence of viral respiratory infections.

Methods: We analyzed routine data on invasive infections due to *Haemophilus influenzae, Neisseria meningitidis, Staphylococcus aureus, Streptococcus pneumoniae*, and *Streptococcus pyogenes* (2017–2023) from a voluntary, laboratory-based surveillance system involving continuously participating facilities providing diagnostic routine data that cover approximately one-third of the German population.

Results: In the first quarter (Q1) of 2023, the number of invasive *S. pyogenes* isolates rose by 142% (n = 837 vs. mean Q1/2017–2019 = 346, 95% CI [258; 434]), while the number of *H. influenzae* isolates rose by 90% (n = 209 in Q1/2023 vs. mean Q1/2017–2019 = 110, 95% CI [79; 142]), compared to pre-pandemic seasonal peak values. The number of invasive *S. pneumoniae* isolates was high in two quarters (n = 1732 in Q4/2022 und Q1/2023). Adults aged 55 and older and children younger than 5 years were most affected by invasive *H. influenzae, S. pneumoniae*, and *S. pyogenes* infections. *N. meningitidis* was most commonly found in children under age 5.

Conclusion: The reason for the marked rise in invasive bacterial infections may be an increased circulation of respiratory pathogens and elevated susceptibility in the population after relaxation of the measures taken to prevent COVID-19 infection. Coinfections with respiratory viruses may have reinforced this effect. We recommend continuous surveillance, preventive measures such as raising awareness about invasive bacterial diseases, and vaccination as recommended by the German Standing Committee on Vaccinations (STIKO).

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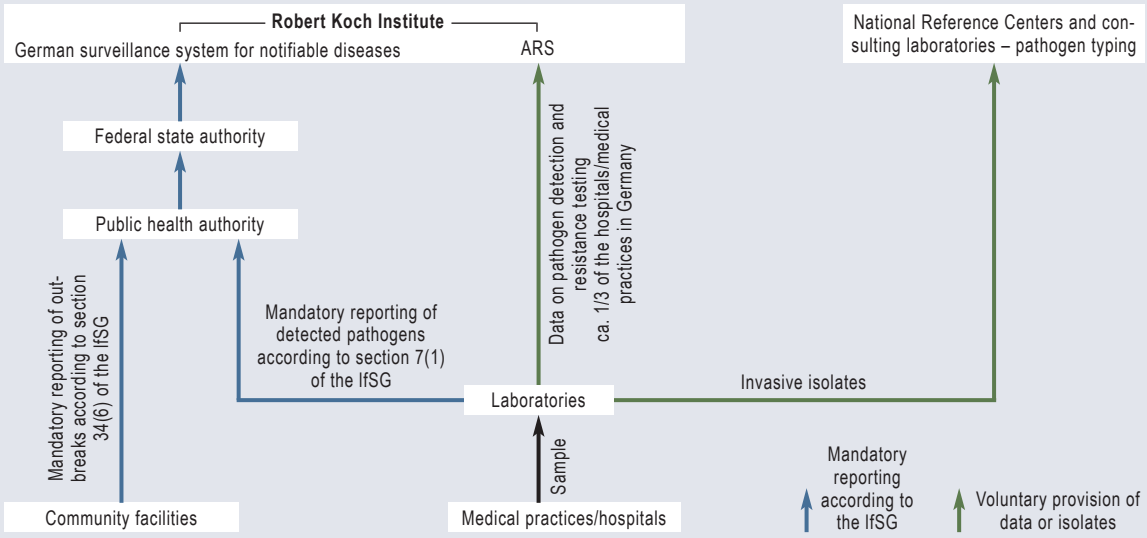
In the fourth quarter (Q) of 2022, pronounced increases in the incidence of acute respiratory infections with fever, cough, or sore throat (ARI) and of influenza-like illness (ILI; defined as ARI with fever) were observed in Germany (1). In calendar weeks (CW) 47–51/2022, the total ARI and total ILI rate was much higher than the reference rate for the same CW of preceding years. ICD-10 code-based hospital surveillance (ICOSARI) showed that the number of severe acute respiratory infections (SARI) increased sharply between CW 47/2022 and CW 51/2022, reaching a level close to the peaks of previous waves of influenza (2).

In light of this increase in SARI cases, in December 2022 the German Interdisciplinary Association for Intensive Care and Emergency Medicine (*Deutsche Interdisziplinäre Vereinigung für Intensiv- und Notfallmedizin*) reported high occupancy of intensive care units, with a high proportion of non-COVID-19 cases requiring respiratory support (3). In CW 52, influenza virus was detected in 28% of hospitalized SARI patients, respiratory syncytial virus (RSV) in 18%, and severe acute respiratory syndrome coronavirus type 2 (SARS-CoV-2) in 11% (4). A sharp increase in influenza infections was discerned (4).

Simultaneously with the early and intense influenza A wave, medical professionals and local public health authorities in Germany reported an unusually high increase in cases of invasive (secondary) bacterial infections, especially due to *Streptococcus (S.) pyogenes* (group A streptococci). Other European countries also reported a rise in invasive *S. pyogenes* infections in December 2022, as well as an

Figure 1



Data sources and reporting pathways in the German surveillance system for notifiable diseases, the Antibiotic Resistance Surveillance (ARS) system, and data on pathogen typing
IfSG, German Infection Protection Act

increased number of fatalities, especially in children under 15 years of age (5–7).

Bacterial infections with respiratory transmission due to *Haemophilus (H.) influenzae, Neisseria (N.) meningitidis* (meningococci), *Streptococcus (S.) pneumoniae* (pneumococci), and *S. pyogenes* are seasonally endemic in Europe. These pathogens are typically transmitted via droplets and constitute the principal cause of invasive illness and of secondary infections after viral respiratory disease (8). Invasive infections with *Staphylococcus (S.) aureus* are also associated with viral respiratory tract infections and severe illness (9). Such invasive bacterial infections are observed particularly in association with influenza viruses and occur more frequently in the winter months (10–12).

Our aim was to establish whether Germany was also affected by an unusually high increase in invasive bacterial infections in winter 2022/2023 and to make specific recommendations accordingly.

Methods

Pathogen detection data from the ARS

The primary source of the data analyzed was the Antibiotic Resistance Surveillance (ARS) system of the Robert Koch Institute (RKI). The ARS relies on laboratories' voluntary reporting to the RKI of data on pathogen identification and resistance testing from microbiological routine diagnostics *(Figure 1)*. The data fed into the ARS cover about one third of the outpatient and inpatient care facilities in Germany and include all clinically relevant pathogens from all sample materials.

To avoid duplicates and overestimation, one isolate per patient, per quarter, and per material type was included. To avoid any sampling effects that might arise from fluctuating participation of hospitals and medical practices in the surveillance system over time, data analysis was restricted to facilities whose participation was uninterrupted. These comprised 10 263 medical practices and 470 hospitals that submitted samples to 49 laboratories during the period concerned.

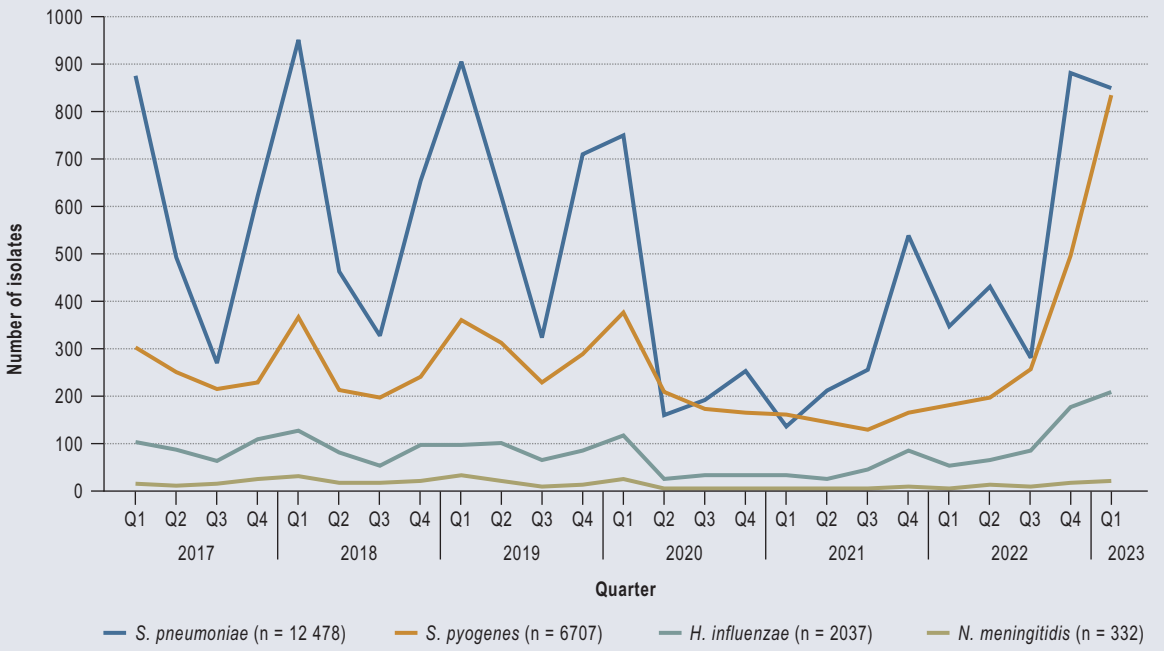
Data on notifiable diseases

In Germany, surveillance of invasive bacterial infections is partly integrated into the nationwide mandatory reporting system as laid down in the German Infection Protection Act (IfSG). The detection of *H. influenzae, N. meningitidis, S. aureus*, and *S. pneumoniae* (since 2020) in blood or cerebrospinal fluid anywhere in Germany has to be reported under section 7(1) of the IfSG (13). Isolated detections of *S. pyogenes* are not subject to nationwide mandatory reporting, but outbreaks of scarlet fever (caused by *S. pyogenes*) in community facilities have to be reported (13, 14). To confirm the epidemiological trend, data on *H. influenzae, N. meningitidis*, and *S. pneumoniae* reported according to the IfSG were also analyzed, together with data on scarlet fever outbreaks.

Pathogen typing data

The Institute for Medical Microbiology at the University Hospital, RWTH Aachen University (appointed as National Reference Center [NRC] for streptococci up to the end of 2022) and the NRC for meningococci and *H. influenzae* receive voluntarily submitted invasive isolates of *H. influenzae, N. meningitidis, S. pneumoniae*, and *S. pyogenes* from all routine laboratories in Germany. The laboratories analyze the serogroups and serotypes/*emm* types of the pathogens as well as their antibiotic resistance.

Figure 2



Invasive isolates (blood culture, sterile aspirate) of *S. pneumoniae* (n = 12 478), *S. pyogenes* (n = 6707), *H. influenzae* (n = 2037), and *N. meningitidis* (n = 332) per quarter (sampling date), 2017–2023, Germany (ARS, as of 11 April 2023)

Case definition

The analysis embraced bacterial pathogens with respiratory transmission that may cause secondary infections in the wake of a viral respiratory tract infection: *H. influenzae, N. meningitidis, S. aureus, S. pneumoniae*, and *S. pyogenes*. Invasive diseases due to *H. influenzae*, *N. meningitidis*, *S. aureus*, and *S. pneumoniae* are defined by detection in blood, cerebrospinal fluid, or, in some cases, other normally sterile substrates; classified by case category; and then reported to the RKI. Invasive bacterial infections caused by these pathogens are defined in the ARS data as detection in a blood culture or another normally sterile aspirate. Non-invasive isolates are defined in the ARS data as swabs, predominantly from the upper respiratory tract and the ear.

Data analysis

A descriptive analysis of the invasive and non-invasive bacterial infections was conducted, and the number of detected cases reported via the ARS in the season 2022/2023 was compared with the reports from the seasons in the period 2017–2019. The years 2020–2021 were excluded from this comparative analysis because of the COVID-19 pandemic and the low case numbers due to the measures adopted to protect against infection. The ARS data were stratified by material, age, sex, and region and evaluated in age-standardized fashion per 100 000 population (not all data shown).

Owing to the low number of cases of *N. meningitidis* detected, and a stable trend for invasive *S. aureus*, not all of these data are presented.

The data were analyzed using Excel Office Professional Plus 2019 and R version 4.1.3.

Results

Pathogen detection data from the ARS

In the period 2017–2020 the numbers of invasive isolates of *H. influenzae, N. meningitidis, S. pneumoniae*, and *S. pyogenes* derived from the ARS system predominantly peaked in the first quarter of the year (Q1) *(Figure 2)*. The numbers of invasive and non-invasive (not shown) bacterial infections decreased sharply in Q2/2020 but increased again gradually up to the end of 2022. Invasive *S. pneumoniae, S. pyogenes*, and *H. influenzae* infections showed an unusually early and steep increase in Q4/2022.

The seasonally highest number of invasive bacterial infections due to *S. pneumoniae* was observed unusually early already in Q4/2022. The numbers reached a level similar to the mean seasonal peaks observed in Q1 of the years 2017–2019 *(Table)*. Notably, compared with the foregoing seasons and the other pathogens analyzed, the number of invasive *S. pneumoniae* isolates stayed high in Q1/2023, so that many more invasive infections occurred in winter 2022/2023 than in the years preceding the pandemic.

There were similarly striking increases in invasive *S. pyogenes* and *H. influenzae* infections in Q1/2023, clearly exceeding the mean peak values in the preceding seasons. The number of invasive *N. meningitidis* isolates also increased, but the value for Q1/2023 was below the peaks in the prepandemic years. The number of *S. aureus* isolates stayed constant over the observation period (data not shown).

Overall, adults over 55 years of age were most commonly affected by invasive infections by *S. aureus* (14.4/100 000 population), *S. pneumoniae* (2.1/100 000 population), *S. pyogenes* (1.4/100 000 population), and *H. influenzae* (0.6/100 000 population) in Q1/2023, while *N. meningitidis* was most commonly found in children < 5 years. The increase in invasive *S. pyogenes* isolates was apparent in all age groups, the rates being much higher than in the years before *(Figure 3)*. Children < 5 years showed a sudden jump of 300% in numbers of invasive *S. pyogenes* isolates between Q3/2022 and Q4/2022 (from 0.2/100 000 population to 0.8/100 000 population). In winter 2022/2023 the rate of invasive *S. pyogenes* was almost as high in children < 5 years as it was in ≥ 55-year-olds (1.3/100 000 population versus 1.4/100 000 population in Q1/2023).

Invasive *S. pneumoniae* infections were also most prevalent in ≥ 55-year-olds, followed by < 5-year-olds (2.2 and 0.6 isolates/100 000 population in Q4/2022) *(Figure 4)*.

Males were somewhat more often affected by invasive *H. influenzae, N. meningitidis, S. pneumoniae*, and *S. pyogenes* infections than women (59% versus 41%, Q1/2017–Q1/2023).

Analyses of the ARS data with regard to antibiotic resistance showed no increase in resistance (especially to erythromycin and clindamycin) for the pathogens investigated.

Data on notifiable diseases

With regard to invasive *H. influenzae, N. meningitidis*, and *S. pneumoniae* infections, comparison of the IfSG data and the ARS data revealed a very similar time course and a similar age distribution. The number of reported scarlet fever outbreaks in community facilities in Q1/2023 exceeded the average annual total of outbreaks by 210% (n = 1730 versus mean 2017–2019 = 560; 95% CI [–7; –1127]).

Pathogen typing data

More detailed microbiological analyses showed no new clones or variants of *S. pneumoniae* or *S. pyogenes*. During the pandemic there were marked fluctuations in the distribution of serotypes and *emm* types. An increase to prepandemic levels was seen for type *emm* 1 among *S. pyogenes* isolates in winter 2022/2023.

There was an increase in encapsulated strains of invasive *H. influenzae* among the isolates reported in 2022. In the first half of 2022 and in Q4/2022 these strains made up a larger proportion of the total isolates, in contrast to the usual dominance of unencapsulated strains (NTHi). Among the invasive *N. meningitidis* isolates an increased prevalence of serogroup Y was discerned, particularly in Q4/2022.

No changes in antibiotic resistance were seen for the pathogens analyzed during the period 2017–2023.

Table

Numbers of invasive isolates (blood culture, sterile aspirate) of *S. pneumoniae*, *S. pyogenes*, *H. influenzae*, and *N. meningitidis* relative to mean seasonal peak values by quarter, 2017–2019*

Invasive isolates	Mean seasonal peaks by quarter, 2017–2019 number [95% CI]	Q4/2022 (number)	Q1/2023 (number)	Change Q1/2023 vs. mean seasonal peaks 2017–2019 (%)
S. pneumoniae	910 [815; 1005]	881	851	−6%
S. pyogenes	346 [258; 434]	501	837	+142%
H. influenzae	110 [79; 142]	178	209	+90%
N. meningitidis	25 [1.3; 49]	15	22	−12%

* In quarter (Q) 4/2022, Q1/2023 and difference between Q1/2023 and the mean seasonal peak values (by sampling date), Germany (ARS, as of 11 April 2023)
CI, Confidence interval; vs., versus

Discussion

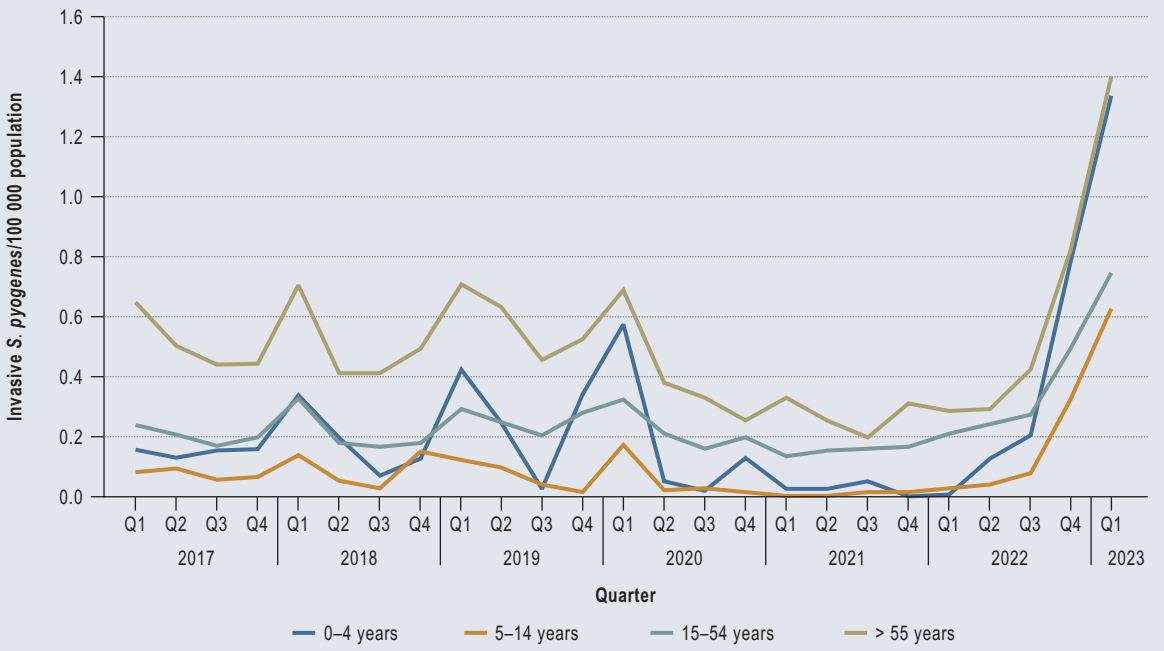
The COVID-19 pandemic prompted expansion of measures to protect against infection from the early months of 2020 onwards. Owing to these actions, and also to increased awareness and correspondingly adjusted behavior on the part of the population, the circulation of pathogens with respiratory transmission was considerably suppressed for a period of almost 2 years (15). Only with the circulation of the SARS-CoV-2 Omicron variant, which had a much lower rate of severe illness, and the simultaneous attainment of high COVID-19 vaccine coverage in the population were the measures relaxed. At the same time, the population's risk perception and behavior changed. Following, a sharp increase in acute viral respiratory tract illnesses was observed in fall 2022. Together with an early and unusually strong influenza A virus (H3N2)-dominated wave and a second wave dominated by influenza B, high RSV activity was seen in Q4/2022 (16). We also found that there was a large increase in bacterial infections due to *H. influenzae, S. pneumoniae*, and *S. pyogenes*. Older persons (> 55 years) and young children (< 5 years) were most likely to be affected by both viral and invasive bacterial infections with respiratory transmission.

The increase in invasive *S. pyogenes* infections was also described in other European countries (7). In contrast to the Netherlands (6) and the UK (5), however, we not only saw a steep increase in children but also observed a very high infection rate in the older population. Denmark reported a similar trend to that in Germany (17).

The early, intense onset of the bacterial infection season that we observed may have been promoted by the simultaneous incidence of viral respiratory tract infections, which can increase the risk of bacterial infections (10–12, 18). Particularly influenza viruses and RSV may increase the risk of severe secondary bacterial infections (12, 19). Bacteria such as *H. influenzae, S. aureus, S. pneumoniae*, and *S. pyogenes* are often the causes of such secondary infections (10, 12, 18). The most frequently occurring combination described to date is that of influenza A and *S. pneumoniae*, as found in winter 2022/2023 (16).

The German Society for Pediatric Infectious Diseases (DGPI) and the RKI were both quick to point out the unusual increase in bacterial infections (20–22). It cannot be excluded that this publicity led to an increase in awareness and to a raised demand for diagnostic tests, particularly those for non-invasive conditions, to detect pathogens with respiratory transmission. However, we

Figure 3



Invasive *S. pyogenes* isolates (blood culture and aspirate, n = 6707) by age group per 100 000 population, per quarter (sampling date), 2017–2023, Germany (ASR, as of 11 April 2023)

worked on the assumption that diagnostic behavior did not change with regard to invasive infections.

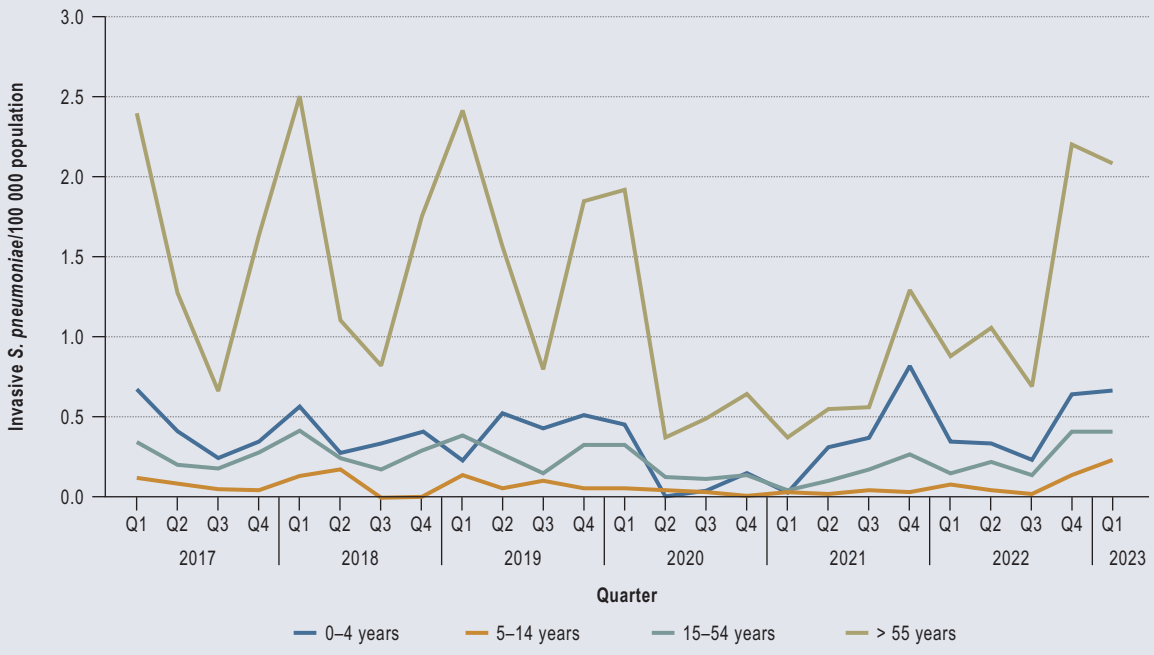
Another possible cause for the increase in bacterial and viral infections with respiratory transmission is a catch-up effect due to elevated susceptibility on the part of the general population. The long period of reduced contact during the COVID-19 pandemic meant that particularly children had less exposure to certain seasonal respiratory pathogens (23). When the COVID-19 measures were rolled back, the circulation of and exposure to endemic pathogens resurged and intensified. Children aged < 15 years were particularly affected, with a sharply increased ARI rate in winter 2022/2023 (1).

Analyses showed no increase in antibiotic resistance, neither were any alterations in serotypes or serogroups observed. To date, therefore, there is no evidence of altered pathogen virulence or of clonal spread.

General measures to prevent infection, combined with restriction of contacts on the appearance of symptoms and the suggestion to consult a physician/pediatrician if needed, can reduce the risk of respiratory infection, slow the spread of the disease, and bring about individual risk reduction (24). Full vaccination against influenza and *S. pneumoniae*, as recommended by the German Standing Committee on Vaccination (STIKO), may also decrease the risk of infection and protect against severe illness. Despite the observed increase in invasive *S. pyogenes* infections, the DGPI continues (as of December 2022) to recommend confining prescription of antibiotics to patients with a sore throat, as stipulated in in the multidisciplinary AWMF clinical practice guideline (25, 26). The impact of chemoprophylaxis for household contacts of patients with invasive *S. pyogenes* infections has not been adequately researched. With regard to the risk that a close household contact person will develop an invasive *S. pyogenes* infection within 30 days following the index case, for example, an Australian study states an incidence rate ratio (IRR) of 2011 [95% confidence interval 413; 5929], while researchers from the UK report an IRR of 1940 [1240; 2880] (27). Studies from different countries vary in their assessment of which household contacts are particularly at risk. For instance, postexposure prophylaxis is recommended for close contact persons in Belgium, Canada, and some states of Australia, but in the UK and Ireland, aside from cluster outbreaks, it is advised above all for mothers and/or their newborn infants (28–30). Other countries (e.g., the USA and France) recommend postexposure prophylaxis especially for those close household contacts who exhibit certain risk factors, such as age ≥ 65 years, HIV infection, diabetes, and cancer (31). In Germany, antibiotic prophylaxis (e.g., rifampicin or clindamycin) for close household contacts—together with meticulous counseling—is recommended only in the case of severe invasive *S. pyogenes* infections (e.g., sepsis, necrotizing fasciitis, toxic shock-like syndrome) (32).

Awareness of invasive (secondary) bacterial infections needs to be reinforced—both in the general population and among physicians. In the event of a leap in the incidence of respiratory tract infections, additional targeted campaigns could sensitize the public. Outbreaks and _epidemic situations may necessitate further action. The ultimately unexpected steep increase in invasive bacterial infections in winter 2022/2023 clearly shows the importance of active surveillance of infectious diseases.

Figure 4



Invasive *S. pneumoniae* isolates (blood culture and aspirate, n = 12 478) by age group per 100 000 population, per quarter (sampling date), 2017–2023, Germany (ARS, as of 11 April 2023)

The surveillance program should have several pillars: laboratory-based systems such as ARS, laboratory testing, reporting of outbreaks as laid down in the Infection Protection Act, detailed typing by specialized reference laboratories, syndromic and virological sentinel surveillance of acute respiratory tract infections, and, when the circumstances require, additional clinical studies and surveys.

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Conflict of interest statement
RB has received consultancy and lecture fees from InfectoPharm, med update GmbH, and Streamed up GmbH.

HC and TTL have received funds for the National Reference Center for Meningococci and H. influenzae from the German Federal Ministry of Health. Moreover, TTL is an honorary board member of the Microbial Systematics, Population Genetics, and Infectious Disease Epidemiology Focus Group, the German Society for Hygiene and Microbiology (DGHM) and the European Meningococcal and Haemophilus influenzae Disease Society

ML has received funds to support the surveillance of pneumococci from Pfizer and MSD; consultancy fees and presentation expenses from Pfizer, Merck, and GSK; and financial assistance with travel costs or funds to cover congress attendance fees from Pfizer and MSD. Moreover, he serves on the advisory boards of Pfizer, MSD, and GSK.

TT has received financial support from Abbott for a study related to the topic of this article (study on group A streptococcal infections). In addition, he has received consultancy and lecture fees from Abbott, Biomerieux, GSK, MSD, Pfizer, Sanofi, and Shionogi.

NT has received fees for lectures, presentations, and training events from the German Federation of Pediatricians (BVKJ), the German Society of Pediatrics and Adolescent Medicine (DGKJ), and the German Society for Pediatric Infectious Diseases (DGPI), as well as reimbursement of travel costs or funds to cover congress attendance fees from the DGPI and the DGKJ. She serves on the boards of the DGPI and the Young Infectious Disease Medicine Network (jUNITE e.V.).

The remaining authors declare that no conflict of interest exists.

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References

1. Buchholz U, Buda S, Loenenbach A, et al.: GrippeWeb-Wochenbericht KW 04. Robert Koch-Institut 2023; 4.
2. Buchholz U, Buda S, Loenenbach A, et al.: GrippeWeb-Wochenbericht KW 50. Robert Koch-Institut 2022; 4.
3. DIVI-Intensivregister: Zeitreihen www.intensivregister.de/#/aktuelle-lage/zeitreihen (last accessed on 7 February 2023).
4. Buda S, Dürrwald R, Biere B, et al.: ARE-Wochenbericht KW 50. www.influenza.rki.de/Wochenberichte.aspx (last accessed on 9 December 2023).
5. Guy R, Henderson KL, Coelho J, et al.: Increase in invasive group A streptococcal infection notifications, England, 2022. Euro Surveill 2023; 28: 2200942.
6. de Gier B, Marchal N, de Beer-Schuurman I, et al.: Increase in invasive group A streptococcal (Streptococcus pyogenes) infections (iGAS) in young children in the Netherlands, 2022. Euro Surveill 2023; 28: 2200941.
7. WHO: Disease Outbreak News; Increased incidence of scarlet fever and invasive Group A Streptococcus infection—multi-country. www.who.int/emergencies/disease-outbreak-news/item/2022-DON429: (last accessed on 9 December 2023).
8. Brueggemann AB, Jansen van Rensburg MJ, Shaw D, et al.: Changes in the incidence of invasive disease due to Streptococcus pneumoniae, Haemophilus influenzae, and Neisseria meningitidis during the

COVID-19 pandemic in 26 countries and territories in the Invasive Respiratory Infection Surveillance Initiative: a prospective analysis of surveillance data. Lancet Digit Health 2021; 3: e360–e70.

9. Rynda-Apple A, Robinson KM, Alcorn JF: Influenza and bacterial superinfection: illuminating the immunologic mechanisms of disease. Infect Immun 2015; 83: 3764–70.
10. Smith AM, Adler FR, Ribeiro RM, et al.: Kinetics of coinfection with influenza A virus and Streptococcus pneumoniae. PLoS Pathog 2013; 9: e1003238.
11. Choe YJ, Park S, Michelow IC: Co-seasonality and co-detection of respiratory viruses and bacteraemia in children: a retrospective analysis. Clin Microbiol Infect 2020; 26: 1690.e5–e8.
12. McCullers JA: Insights into the interaction between influenza virus and pneumococcus. Clin Microbiol Rev 2006; 19: 571–82.
13. Gesetz zur Verhütung und Bekämpfung von Infektionskrankheiten beim Menschen-IfSG. 2021, www.rki.de/DE/Content/Infekt/IfSG/ifsg_node.html (last accessed on 9 December 2023).
14. Robert Koch-Institut: Krankheiten, für die gemäß LVO eine erweiterte Meldepflicht zusätzlich zum IfSG besteht (Stand 2009). Epidemiologisches Bulletin. www.rki.de/DE/Content/Infekt/EpidBull/Archiv/2009/05/Art_01.html (last accessed on 9 December 2023).
15. Oh DY, Buda S, Biere B, et al.: Trends in respiratory virus circulation following COVID-19-targeted nonpharmaceutical interventions in Germany, January–September 2020: Analysis of national surveillance data. Lancet Reg Health Eur 2021; 6: 100112.
16. Buda S, Dürrwald R, Biere B, et al.: ARE-Wochenbericht KW 8. www.influenza.rki.de/Wochenberichte.aspx:(last accessed on 9 December 2023).
17. Johannesen TB, Munkstrup C, Edslev SM, et al.: Increase in invasive group A streptococcal infections and emergence of novel, rapidly expanding sub-lineage of the virulent Streptococcus pyogenes M1 clone, Denmark, 2023. Eurosurveillance 2023; 28: 2300291.
18. McCullers JA, Rehg JE: Lethal synergism between influenza virus and Streptococcus pneumoniae: characterization of a mouse model and the role of platelet-activating factor receptor. J Infect Dis 2002; 186: 341–50.
19. Dagan R, van der Beek BA, Ben-Shimol S, et al.: The COVID-19 pandemic as an opportunity for unravelling the causative association between respiratory viruses and pneumococcus-associated disease in young children: a prospective study. eBioMedicine 2023; 90: 104493.
20. Robert Koch-Institut: Inzidenzanstieg von Gruppe-A-Streptokokken-Infektionen (z.B. Scharlach). Epidemiologisches Bulletin. www.rki.de/DE/Content/Infekt/EpidBull/Archiv/2023/Ausgaben/01_23.html sowie www.rki.de/DE/Content/InfAZ/S/Scharlach/invasive_Gruppe-A-Streptokokken-Infektionen.html Robert Koch-Institut (last accessed on 9 December 2023).
21. Deutsche Gesellschaft für Pädiatrische Infektiologie e.V. (DGPI): Aktuelle DGPI-Stellungnahme zu vermehrten invasiven Infektionen durch Gruppe A-Streptokokken (S. pyogenes) (Stand 19.12.2022). www.dgpi.de/vermehrten-invasiven-infektionen-a-streptokokken-2022–12–19/: (last accessed on 19 December 2022).
22. Robert Koch-Institut: Update: Anstieg bakterieller Infektionen durch Gruppe-A-Streptokokken, Pneumokokken und Haemophilus influenzae in Deutschland seit Ende 2022. Epidemiologisches Bulletin. www.rki.de/DE/Content/Infekt/EpidBull/Archiv/2023/Ausgaben/08_23.html (last accessed on 9 December 2023).
23. Buchholz U, Lehfeld AS, Tolksdorf K, et al.: Respiratory infections in children and adolescents in Germany during the COVID-19 pandemic. J Health Monit 2023; 8: 20–38.
24. Robert Koch-Institut: Surveillance akuter Atemwegserkrankungen. www.rki.de/SharedDocs/FAQ/ARE-Surveillance/ARE_gesamt.html#FAQId16765454 (last accessed on 9 December 2023).
25. Krüger K, Töpfner N, Berner R, Windfuhr J, Oltrogge JH: Clinical practice guideline: Sore throat. Dtsch Arztebl Int 2021; 118: 188–94.
26. Deutsche Gesellschaft für Pädiatrische Infektiologie e.V. (DGPI): Aktuelle DGPI-Stellungnahme zu vermehrten invasiven Infektionen durch Gruppe-A-Streptokokken (S. pyognes) (Stand 19.12.2022). www.dgpi.de/vermehrten-invasiven-infektionen-a-streptokokken-2022–12–19 (last accessed on 9 December 2023).
27. Thomson TN, Campbell PT, Gibney KB: The epidemiology of invasive group A streptococcal disease in Victoria, 2007–2017: an analysis of linked datasets. Aust N Z J Public Health 2022; 46: 878–83.
28. Khan F, Bai Z, Kelly S, et al.: Effectiveness and safety of antibiotic prophylaxis for persons exposed to cases of invasive group A streptococcal disease: a systematic review. Open Forum Infect Dis 2022; 9: ofac244.
29. Update on invasive group A streptococcal disease In: Department of Health, (ed.). www.health.vic.gov.au/health-advisories/update-on-invasive-group-a-streptococcal-disease (last accessed on 9 December 2023).
30. Streptococcal Infections (invasive group A strep, GAS). In: Department of Health, (ed.). www.health.ny.gov/diseases/communicable/streptococcal/group_a/fact_sheet.htm: (last accessed on 9 December 2023).
31. Laho D, Blumental S, Botteaux A, Smeesters PR: Invasive group A streptococcal infections: benefit of clindamycin, intravenous immunoglobulins and secondary prophylaxis. Front Pediatr 2021; 9: 697938.
32. Deutsche Gesellschaft für Pädiatrische Infektiologie e.V. (DGPI), Berner R, Bialek R, et al.: DGPI Handbuch; Infektionen bei Kindern und Jugendlichen. 2018; 751ff.

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