Measles incidence and reporting trends in Germany, 2007–2011
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Objective We aimed to quantify progress towards measles elimination in Germany from 2007 to 2011 and to estimate any potential underreporting over this period.

Methods We determined the annual incidence of notified cases of measles – for each year – in northern, western, eastern and southern Germany and across the whole country. We then used measles-related health insurance claims to estimate the corresponding incidence.

Findings In each year between 2007 and 2011, there were 6.9–19.6 (mean: 10.8) notified cases of measles per million population. Incidence decreased with age and showed geographical variation, with highest mean incidence – 20.3 cases per million – in southern Germany. Over the study period, incidence decreased by 10% (incidence rate ratio, IRR: 0.90; 95% confidence interval, CI: 0.85–0.95) per year in western Germany but increased by 77% (IRR: 1.77; 95% CI: 1.62–1.93) per year in eastern Germany. Although the estimated incidence of measles based on insurance claims showed similar trends, these estimates were 2.0- to 4.8-fold higher than the incidence of notified cases. Comparisons between the data sets indicated that the underreporting increased with age and was generally less in years when measles incidence was high than in low-incidence years.

Conclusion Germany is still far from achieving measles elimination. There is substantial regional variation in measles epidemiology and, therefore, a need for region-specific interventions. Our analysis indicates underreporting in the routine surveillance system between 2007 and 2011, especially among adults.
tential underreporting represented by the data from the mandatory notification system.

**Methods**

**Definitions**

In our analyses of the mandatory notification data, a measles case was defined as a person reported within the national surveillance system with laboratory-confirmed measles – i.e. positive for measles-specific immunoglobulin (Ig) M, showing a substantial increase in measles-specific IgG or positive for measles RNA (ribonucleic acid) in a polymerase chain reaction – and/or with the clinical symptoms of measles – i.e. a maculo-papular rash and fever for at least three days, plus at least one of the following: cough, catarh, Koplik’s spots and conjunctivitis.

Within the ASHIP data set, a measles case was defined as a person who had been diagnosed by a physician with a measles-related code from the tenth revision of the International Classification of Diseases and Related Health Problems, 10th Revision (ICD-10) – i.e. B05.0, B05.1, B05.2, B05.3, B05.4, B05.8 or B05.9, indicating cases of measles with encephalitis, meningitis, pneumonia, otitis media, intestinal complications, other complications or no complications, respectively.

For some of our analyses, we divided Germany into four areas: northern – comprising the federal states of Bremen, Hamburg, Lower Saxony and Schleswig-Holstein; western – Hesse, North Rhine-Westphalia, Rhineland-Palatinate and Saarland; eastern – Berlin, Brandenburg, Mecklenburg-Western Pomerania, Saxony, Saxony-Anhalt, Schleswig-Holstein and Thuringia; and southern – Bavaria and Baden-Württemberg. In 2011, the northern, western, eastern, and southern areas had populations of approximately 13 million, 29 million, 16 million and 23 million, respectively.18

**Mandatory notification data**

We extracted national data on the measles cases recorded by the mandatory notification system – for the years 2007–2011 – using the SurvNet@RKI software package.19 SurvNet@RKI – or SurvNet@RKI-like softwares – are used by local health authorities in Germany to report anonymized information on inpatient and outpatient cases with notifiable diseases to the relevant state health authorities and on to the national health authority. For each reported case, the data set included the case’s month and year of birth, sex and vaccination status, the week and year of the notification and whether the case was hospitalized. To be able to make comparisons with the ASHIP data, we excluded all hospitalized cases from the notification data, all cases reported from the federal state of Hesse and cases reported in 2007 from the federal state of Baden-Württemberg.

**SHIP data**

In Germany, once every quarter, physicians accredited with statutory health insurances send their reimbursement claims for provided ambulatory medical services to their corresponding regional ASHIP. For each case, the ASHIP data set contained the patient’s unique identifier, month and year of birth, sex, ICD-10 code, quarter and year of diagnosis, reliability of diagnosis – suspected, confirmed, recovered or excluded – and type of diagnosis – current state, previous state, unknown or not provided.

We analysed measles-related reimbursement claims made between 1 January 2007 and 31 December 2011. We excluded incomplete data from the federal state of Hesse and data on cases diagnosed in 2007 in the federal state of Baden-Württemberg. The final data set covered 68% and 79% of the total population living in Germany in 2007 and 2008–2011, respectively. We only included diagnoses coded as confirmed and current in our incidence estimates. We generally used a four-step algorithm to limit the data set to a single diagnosis for each patient’s unique identifier (Table 1). However, for the data from Bavaria, Rhineland-Palatinate and – for the period 2008–2011 – parts of North Rhine-Westphalia, step 3 had to be omitted because the corresponding data did not contain information on type of diagnosis.

**Statistical analysis**

Incidence, with 95% confidence intervals (CI), was calculated either as the number of notified cases or outpatient cases per million total population – for the mandatory notification data – or as the number of outpatient cases per million residents with statutory health insurance – for the ASHIP data.14,15,20 We calculated incidence ratios by dividing the incidence estimated from the ASHIP data by the incidence derived from the notification data. We used Poisson regression to determine the temporal trends in incidence, as incidence rate ratios (IRR). Statistical analysis was

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**Table 1**

| Cleaning step | Procedure | Bavaria, Rhineland-Palatinate, parts of North Rhine-Westphalia | Other federal states |
|---------------|-----------|---------------------------------------------------------------|----------------------|
| Baseline –    | Exclusion of incompatible or implausible coding combinations for reliability of diagnosis | 23,084               | 46,766               |
| 1             | Exclusion of observations with reliability of diagnosis coded as suspected, excluded or recovered | 22,950               | 46,615               |
| 2             | Exclusion of observations with type of diagnosis coded as previous state, unknown or not provided | 4,696                | 10,396               |
| 3             | Limitation to the most severe ICD-10 diagnostic code assigned to each patient identification numberb | NA                   | 6,869                |
| 4             |                                                   | 3,046                | 5,607                |

ICD-10: International Classification of Diseases and Related Health Problems, 10th revision; NA: not applicable.

b Remaining parts of North Rhine-Westphalia plus the federal states of Baden-Württemberg, Berlin, Brandenburg, Bremen, Hamburg, Lower Saxony, Mecklenburg-Western Pomerania, Saarland, Saxony, Saxony-Anhalt, Schleswig-Holstein and Thuringia.

The diagnoses were measles with – in descending order of severity – encephalitis, meningitis, pneumonia, intestinal complication, otitis media, other complication and no complication.

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14 Remaining parts of North Rhine-Westphalia plus the federal states of Baden-Württemberg, Berlin, Brandenburg, Bremen, Hamburg, Lower Saxony, Mecklenburg-Western Pomerania, Saarland, Saxony, Saxony-Anhalt, Schleswig-Holstein and Thuringia.

15 The diagnoses were measles with – in descending order of severity – encephalitis, meningitis, pneumonia, intestinal complication, otitis media, other complication and no complication.
Results

Notified measles incidence

The demographics of all measles cases notified in Germany between 2007 and 2011 are given in Table 2. The total numbers of cases and corresponding incidence are shown – stratified by year, age group and geographical area – in Table 3. Vaccination status was available for 4142 (93.3%) of the 4440 notified cases: 3730 (90.1%) were unvaccinated and 322 (7.8%), 84 (2.0%) and 6 (0.1%) had received one dose, two doses and at least three doses of measles-virus-containing vaccine, respectively.

Comparison of data

Results of the ASHIP data cleaning are displayed in Table 1. The demographics of outpatient measles cases and ASHIP cases between 2007 and 2011 are given in Table 2. For Germany as a whole, our estimate of the mean annual incidence – based on ASHIP data – was more than threefold higher than the annual incidence of notified measles cases: 27.5 (95% CI: 27.0–28.1) versus 9.1 (95% CI: 8.8–9.4) cases per million population. Fig. 1 depicts the annual incidence estimated using each data set and the corresponding incidence ratios. Over this five-year time period, incidence estimated from the ASHIP data was 2.0- to 4.8-fold higher than incidence based on the notification data. Fig. 2 shows mean annual incidence and incidence ratios for the two outpatient data sets stratified by age group. Although measles incidence decreased with age, the incidence ratios increased with age.

The measles incidence based on either data set differed substantially between geographical areas (Fig. 3). In general, the incidence ratios were smaller in the years with high incidence of measles than in low-incidence years (Fig. 3). For the western area, we observed a significant decreasing incidence trend between 2007 and 2011, both in the estimates based on mandatory notification data (–10% per year; IRR: 0.90; 95% CI: 0.85–0.95) and in those based on the ASHIP data (–13% per year; IRR: 0.87; 95% CI: 0.85–0.90). In contrast, the eastern area showed a significant increasing trend in the estimates based on the mandatory notification data (+77% per year; IRR: 1.77; 95% CI: 1.62–1.93) as well as in those based on the ASHIP data (+22% per year; IRR: 1.22; 95% CI: 1.17–1.27). Due to the nonlinear patterns observed in measles incidence in the northern and southern areas – which were caused by several large outbreaks – it was not meaningful to perform trend analysis for these two areas.

Discussion

The annual incidence of notified measles cases in Germany exceeded the WHO progress indicator – of less than one notified case per million – throughout our five-year study period. The highest incidence of notified cases was observed in southern Germany and, generally, among infants, older children and adolescents. It appears that, despite the gradual increase in nationwide coverage with two-dose measles vaccination in

Table 2. Demographics of measles cases, Germany, 2007–2011

| Demographic | Mandatory notification data | ASHIP data on outpatients |
|-------------|----------------------------|--------------------------|
|             | All cases (n = 4440)        | Outpatients (n = 3364)   |
|             |                             |                         |
| Males, no. (%) | 2151 (48) | 1646 (49) | 3828 (44) |
| Age (years) |                             |                         |
| Median       | 14 | 11 | 15 |
| 25th percentile | 6 | 6 | 6 |
| 75th percentile | 20 | 16 | 37 |
| Complications, no. (%) |       |     |
| Pneumonia    | 85 (1.9) | 21 (0.6) | 173 (2.0) |
| Otitis media | 71 (1.6) | 44 (1.3) | 678 (7.8) |
| Encephalitis | 4 (0.1) | NA* | NA* |

ASHIP: Associations of Statutory Health Insurance Physicians; NA: not applicable.

Table 3. Measles incidence according to mandatory notification data, Germany, 2007–2011

| Category | No. of cases | Annual incidence (95% CI) |
|----------|--------------|----------------------------|
| Year     |              |                            |
| 2007     | 566          | 6.9 (6.3–7.5)              |
| 2008     | 915          | 11.2 (10.4–11.9)           |
| 2009     | 571          | 7.0 (6.4–7.6)              |
| 2010     | 780          | 9.5 (8.9–10.2)             |
| 2011     | 1608         | 19.6 (18.7–20.6)           |
| 2007–2011| 4440         | 10.8 (10.5–11.2)           |
| Age (years) |            |                            |
| < 1      | 207          | 61.4 (53.3–70.3)           |
| 0–9      | 1772         | 50.1 (47.8–52.5)           |
| 10–19    | 1557         | 37.5 (35.7–39.4)           |
| 20–29    | 597          | 12.1 (11.1–13.1)           |
| 30–39    | 338          | 6.7 (6.0–7.4)              |
| 40–49    | 140          | 2.0 (1.7–2.4)              |
| ≥ 50     | 36           | 0.2 (1.5–3.0)              |
| Area a   |              |                            |
| Northern | 574          | 8.7 (8.0–9.4)              |
| Western  | 1047         | 7.2 (6.8–7.7)              |
| Eastern  | 455          | 5.5 (5.1–6.1)              |
| Southern | 2361         | 20.3 (19.5–21.1)           |

CI: confidence interval.

a Cases per million population.

Discussion

The annual incidence of notified measles cases in Germany exceeded the WHO progress indicator – of less than one notified case per million – throughout our five-year study period. The highest incidence of notified cases was observed in southern Germany and, generally, among infants, older children and adolescents. It appears that, despite the gradual increase in nationwide coverage with two-dose measles vaccination in...
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Germany – from 21.1% at school entry in 1998–2001 to 92.1% in 2011 – population immunity has never been sufficient to stop the circulation of measles virus in the country as a whole or in each area of the country. Moreover, analysis of the ASHIP data on reimbursements for measles diagnoses indicates that there are approximately three cases of measles in Germany for every case of the disease that is formally notified.

In our analysis we observed distinct regional differences in measles incidence and trends. These differences can be largely explained by local differences in vaccination coverage and population immunity. Several possible reasons for these differences in vaccine uptake have already been discussed. For example, there is a fairly recent – i.e. pre-1990 – history of mandatory measles vaccination in eastern Germany. Compared with the other areas, individuals who live in southern Germany are more likely to be anthroposophic or vaccine-sceptic or both. The existence of vaccine-sceptic physicians in some districts and general shortages of physicians in certain rural districts may also cause geographical gaps in vaccine coverage. In a review in 1988 of more than 86 000 immunization records of Bavarian children aged 10–12 years, only 54.8% of the children were found to have received one dose of measles vaccine. Due to a lack of concerted catch-up campaigns of measles vaccination, it seems likely that the many children who were unvaccinated when aged 10–12 years in 1988 still are unvaccinated. Low vaccine coverage in southern Germany presumably contributed to several major outbreaks of measles in the area over the previous years. Analysis of notification data indicates that Bavaria was hit by a major measles outbreak every two–three years between 2001 and 2013. The absence of characteristically prolonged interepidemic spacing intervals suggests that Bavaria has probably not yet reached a pre-elimination phase.

In contrast, we found that measles incidence in the western area followed a constantly decreasing trend between 2007 and 2011. This encouraging trend may be associated with concerted programmes of health education and a catch-up campaign of measles vaccination, as well as the efforts to increase vaccination coverage at school entry that followed the large-scale outbreak of measles that occurred in North Rhine-Westphalia in 2006. The proportion of children in North Rhine-Westphalia who had received a second dose of measles vaccine at school entry increased from 74.7% in 2005 to 94.1% in 2011.

Despite having the highest rates of vaccination coverage in Germany, the eastern area experienced ever increasing incidence of measles between 2007 and 2011. Possible explanations could be the influx of new residents from German areas with traditionally lower coverage rates – e.g. into the former East Berlin and the districts surround-
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Fig. 3. Annual incidence of outpatient measles cases in four areas of Germany, 2007–2011

Note: Incidence was estimated using two data sources – the mandatory notification system and the Associations of Statutory Health Insurance Physicians (ASHIP) – and expressed as the number of cases per million population and the number of cases per million residents with statutory health insurance, respectively. Incidence ratios were calculated by dividing the incidence estimated from the ASHIP data by the incidence derived from the notification data.

The northern area comprises the federal states of Bremen, Hamburg, Lower Saxony and Schleswig-Holstein. The western area comprises the federal states of North Rhine-Westphalia, Rhineland-Palatinate and Saarland. The eastern area comprises the federal states of Brandenburg, Mecklenburg-Western Pomerania, Saxony, Saxony-Anhalt and Thuringia. The southern area comprises the federal states of Baden-Württemberg and Bavaria.

The magnitude of underreporting in our analysis increased with the age of the case – as also observed in the potential underreporting of mumps cases in Germany.\(^{17}\) Perhaps paediatricians are more aware of the need to notify – or are more accustomed to notifying – local health authorities of cases of measles – and other infectious diseases that predominantly occur or used to occur in childhood – than physicians who treat adult patients.

Although analysis of both the notification data and the ASHIP data indicated that measles incidence in Germany decreased with age, our estimates based on ASHIP data of measles incidence among adults aged at least 40 years were still surprisingly high. The German Standing Committee on Vaccination does not recommend measles vaccination for any individuals born before 1970 – i.e. the year when measles vaccination was introduced into any part of Germany – because such individuals are assumed to have acquired natural immunity to measles when nobody in Germany was vaccinated.\(^{30,31}\) The American Advisory Committee on Immunization Practices set the corresponding cut-off at 1957 – i.e. six years before measles vaccine was introduced in the United States of America.\(^{32}\) In a measles outbreak that occurred in Germany in 2013 and involved more than 1600 notified cases, approximately 9% of the cases were aged at least 40 years.\(^{33}\) In addition to our findings, the analysis of recent epidemiological data and population-based surveys of serological immunity against measles will inform future discussions within the German Standing Committee on Vaccination when any re-evaluation of the current vaccination strategy is considered.

Our study had several limitations. The assessment of measles incidence from cases of the disease reported to
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A routine notification or surveillance system is prone to underreporting. However, as a passive surveillance system, the German system for disease notification is not designed to detect every single case – and therefore has limitations when being used for the verification and documentation of measles elimination. Due to its structure, the use of ASHIP data for estimating potential underreporting of measles in Germany also has some limitations. First of all, ASHIP data are not collected for surveillance purposes but to ensure that physicians are reimbursed for provided medical services. We only included cases coded as confirmed in our analysis of the ASHIP data and therefore the resultant estimates of measles incidence are probably conservative – although a case coded as confirmed does not require laboratory confirmation. Moreover, there are no standardized guidelines for a physician faced with coding a case as confirmed or suspected. ASHIP data have only recently become available for studies of vaccine-preventable diseases in Germany and their use in such studies has still to be systematically validated. In our analysis at regional level, the variations and trends in measles incidence seen in the notification data were similar to those seen in the ASHIP data. The ASHIP data therefore appear to be useful at least in monitoring trends. As the ASHIP data only cover ambulatory cases of measles, incidence of measles may be higher than those indicated by the data. In Germany, however, 76% of measles cases notified between 2007 and 2011 were treated as outpatients and other cases might have been seen as ambulatory cases before being hospitalized. When we assessed underreporting in the routine surveillance system, we had to restrict our analysis to outpatient cases; the degree of underreporting of hospitalized measles cases therefore remains unknown.

Without concerted efforts to close immunity gaps, Germany will not achieve the goal of measles elimination by 2015. Regional data on measles-related knowledge and attitudes to measles and measles vaccination in the general population and among physicians – as well as on other potential barriers – would be helpful for understanding the regional differences seen in measles incidence and for tailoring elimination measures to the target area. ASHIP records appear to be a valuable source of complementary data, especially for estimating the level of underreporting in the routine notification system. Enhanced efforts to remind physicians of all specialties about their duty to report suspected and confirmed measles cases – both during outbreaks and, especially, during non-outbreak periods – will be crucial in documenting Germany’s future progress towards measles elimination.

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Incidence of the mumps and trends in the notifications in Germany between 2007 and 2011

Objective To evaluate the progress realized in the elimination of mumps in Germany between 2007 and 2011, and estimate the under-notification potential over the duration of this period.

Methods We have determined the annual incidence of reported cases of mumps (for each year) in the north, west, east, and south of Germany and in the whole country. We have also used the reported incidence to estimate the under-notification corresponding.

Results Each year between 2007 and 2011, there were between 6.9 and 19.6 (average: 10.8) reported mumps cases per million inhabitants. The incidence diminished with age and presented a geographical variation, with the highest incidence rate (20.3 cases per million inhabitants) in the south of Germany. During the study period, the incidence decreased by 10% (incidence ratio, IRR: 0.90; 95% confidence interval, CI: 0.85–0.95) every year in western Germany, but increased by 77% (IRR: 1.77; 95% CI: 1.62–1.93) per year in eastern Germany. Despite the annual variation in mumps incidence, these estimates were 2.0 to 4.8 times higher than the incidence of reported cases. The comparisons between the different years have indicated that the under-notification increased with age and was generally more evident in the years where the mumps incidence was lower, whereas it decreased during the years with incidence underreporting.

Conclusion Germany is still far from achieving the goal of eliminating mumps. There are substantial regional variations in mumps epidemiology and, consequently, a need for specific interventions in the regions. Our analysis indicates that under-notification in the surveillance system of routine between 2007 and 2011, particularly in the adults.

Заболеваемость корью и тенденции отчетности в Германии в 2007—2011 годах

Цель Нашей целью является измерение прогресса в деле ликвидации кори в Германии за период 2007—2011 гг. и оценить возможное потенциальное занижение данных об заболеваемости за этот период.

Методы Мы определили ежегодные уровни заболеваемости на основе числа зарегистрированных случаев кори для каждого года по регионам: в северной, западной, восточной и южной Германии и по всей стране. Затем мы сравнили эти данные с числом случаев в медицинской системе, зарегистрированных в немецкой системе медицинского страхования, а также с целью оценить соответствующие уровни заболеваемости.

Результаты В течение каждого года за период 2007—2011 гг. было зарегистрировано 6.9—19.6 (в среднем: 10.8) случаев кори на один миллион человек. Заболеваемость снижалась с возрастом и показала географическую изменчивость, при этом самая высокая среднегодовая заболеваемость — 20.3 случая на миллион человек — была зарегистрирована в южной Германии. За период исследования заболеваемость снизилась на 10% (показатель роста заболеваемости, IRR: 0.90; 95% доверительный интервал, DI: 0.85–0.95) за год в западной Германии, но возросла на 77% (IRR: 1.77; 95% DI: 1.62–1.93) за год в восточной Германии. Хотя уровень заболеваемости корью на основе страховых случаев показал аналогичные тенденции, число случаев, по данным страховых компаний, было в 2.0—4.8 раз выше, чем число зарегистрированных случаев в системе медицинского страхования. Сравнение между наборами данных показало, что занижение увеличивалось с возрастом и в целом было меньше в годы, когда заболеваемость корью была высокой, по сравнению с годами с низким уровнем заболеваемости.

Вывод Германия по-прежнему далека от достижения полной ликвидации кори. Существует немало региональных различий в эпидемиологии кори и, следовательно, необходимо принимать меры в соответствии со спецификой региона. Наш анализ показывает снижение данных о заболеваемости в системе текущего эпиднадзора за период 2007—2011 гг., особенно среди взрослых.

Resumen

Incidencia del sarampión y tendencias en las notificaciones en Alemania 2007-2011

Objetivo Pretendemos cuantificar las pérdidas de la eliminación del sarampión en Alemania de 2007-2011 y estimar cualquier falta de notificación en el periodo.

Métodos Se determinó la incidencia anual de casos notificados de sarampión para cada año en el norte, el oeste, el este y el sur de Alemania, así como en todo el país. A continuación, se emplearon las reclamaciones de seguros médicos relacionadas con el sarampión para estimar la incidencia correspondiente.

Resultados Cada año entre 2007 y 2011, hubo entre 6,9 y 19,6 (media: 10,8) casos notificados de sarampión por millón de habitantes. La incidencia disminuyó con la edad y mostró variación geográfica, con mayor incidencia media (20,3 casos por millón) en el sur de Alemania. Durante el periodo del estudio, la incidencia se redujo en un 10% (razón de tasas de incidencia, IRR: 0,90; Intervalo de confianza del 95%, IC: 0,85-0,95) al año en el oeste de Alemania, pero aumentó en un 77% (IRR: 1,77; IC del 95%: 1,62-1,93) al año en el este de Alemania. Si bien la incidencia estimada del sarampión basada en las reclamaciones de seguros mostró tendencias similares, estas estimaciones eran de
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Conclusión Alemania sigue lejos de lograr la erradicación del sarampión. Existe una variación regional considerable en la epidemiología del sarampión y, por lo tanto, se requieren intervenciones específicas en cada región. Nuestro análisis señala una falta de notificación en el sistema de vigilancia sistemática entre 2007 y 2011, sobre todo entre los adultos.