ORIGINAL ARTICLE

Immunization Rates at the School Entry in 2012

Nationwide German Data With Regional and Local Breakdown

Martin Weigel, Roswitha Bruns, Kerstin Weitmann, Wolfgang Hoffmann

SUMMARY

Background: The immunization rates for some diseases, including measles, were so low in Germany in recent years that endemic outbreaks occurred. A finely detailed geographic analysis of immunization rates is necessary for the identification of under-immunized areas.

Methods: We addressed this question with the aid of regional and local data from school entrance examinations, which were made available to us by the health departments of the German federal states. These data are represented both in tabular form and with the aid of a geographical information system (GIS).

Results: The immunization rates for tetanus, pertussis, and poliomyelitis were high throughout Germany (96.5%, 95.6%, and 95.2%, respectively). In contrast, major variation across regions was seen in immunization rates for hepatitis B (range: 53.5% to 99.1%) and measles (52.1% to 98.3%), with higher immunization rates in areas of the former East Germany. Low immunization rates were particularly evident in some areas in the states of Bavaria and Baden-Württemberg. In some parts of Saxony (a state in the former East Germany), the official immunization recommendations differ from those of the nationwide Standing Committee on Vaccination (STIKO); as a result, these areas had a mean measles immunization rate of only 66.7% among children entering school.

Conclusion: High immunization rates were found across Germany for tetanus, pertussis, and poliomyelitis, although the rates in some regions were lower than they should be. Stronger informational efforts must be undertaken to improve the public acceptance of immunization against hepatitis B and measles, so that these immunization rates can rise. For measles in particular, uniform nationwide recommendations might help increase the immunization rate.

► Cite this as:

Weigel M, Bruns R, Weitmann K, Hoffmann W: Immunization rates at the school entry in 2012—nationwide German data with regional and local breakdown. *Dtsch Arztebl Int* 2014; 111: 788–94.
DOI: 10.3238/arztebl.2014.0788

Immunizations are an effective measure for preventing infectious diseases, which cause substantial morbidity and whose sequelae, especially in children, can lead to retardation, disability, and even death (1, 2, e1). High rates of immunization in the population are desirable, because in this way, collective protection (“herd immunity”) can be achieved for some vaccine-preventable diseases (3, e2). Herd immunity is reached once a pathogen does not encounter a sufficiently large number of susceptible persons and its spread is therefore interrupted.

For some vaccine-preventable diseases, immunization rates in Germany are too low, so that endemic transmission and outbreaks are possible (4, 5). The applicable and most up to date recommendations on vaccination are published by Germany’s Standing Committee on Vaccination (STIKO), but these are not accepted by all doctors and patients. Common reasons for vaccine-skeptical behavior are the fear of unknown side effects and a lack of trust in the safety of vaccines (6, 7, e3). New vaccines are clinically tested before they receive license approval, and they are subject to continuing postmarketing surveillance afterwards. Because relevant results are published, doubts and fears are usually unsubstantiated in the context of the vaccines in use today (8).

Data on immunization rates in Germany are collected in the context of annual school entrance examinations by the public health offices in the regional and local administrative districts. The data are aggregated at the level of the federal state (*Land; pl., Länder*) and passed on to the Robert Koch Institute (RKI), which publishes immunization rates for the whole of Germany on this basis. For 2012, the RKI reported nationwide immunization rates of 96.1% for tetanus, 95.4 for pertussis, 94.9% for polio, 86.9% for hepatitis B, and 92.4% for measles (9). Regional immunization rates are also collected and evaluated at the international level—for example, in Australia in the Australian Childhood Immunisation Register (ACIR) and in New Zealand in the National Immunisation Register (NIR) (10, 11). An up to date detailed description of nationwide immunization rates in Germany at the level of regional administrative districts does currently not exist. The present study aims to describe

University Medicine Greifswald, Institute for Community Medicine, Section Epidemiology of Health Care and Community Health: Dr. med. Weigel, Weitmann, Prof. Dr. med. Hoffmann, MPH

University Medicine Greifswald, Center for Child and Adolescent Medicine: PD Dr. med. habil Bruns

immunization rates for selected vaccinations in small areas, in order to identify regions with an increased need for information and education about the importance of immunizations and the increased risk of endemic outbreaks.

Including tetanus, pertussis, polio, hepatitis B, and measles, means including only a proportion of the pathogens for which the STIKO recommends childhood immunization. eFigures 1–3 show the data for pertussis, polio, mumps, and rubella (German measles). The tetanus vaccine was introduced as early as in 1927 and is therefore one of the oldest immunizations. It is known to have reached high immunization rates in childhood and is well accepted by doctors and parents (12). In recent years, endemic outbreaks (4, 13) and a rising incidence of pertussis in adults (12, 14) have been increasingly observed. Since 1992, no wild poliovirus has circulated in Germany (e4). The risk of vaccine-associated paralytic poliomyelitis (VAPP)—a possible complication when the live attenuated oral polio vaccine (OPV) is used—has been eliminated as a consequence of using the inactivated (killed) polio vaccine, which has been recommended in Germany since 1998 (16). The World Health Organization is still pursuing the goal of global eradication of polio. Hepatitis B immunization has been available in Germany since 1982 and has been recommended since 1995 in the context of basic childhood immunizations. In spite of a generally positive trend in recent years, immunization rates are still unsatisfactory in some regions (17). The mass media are full of controversial discussions about the measles vaccine, often in connection with the fear of unknown side effects or possible associations with other diseases (18–21, e5, e6).

Methods

The immunization rates at the level of the regional districts were made available by the state public health offices in the *Länder*. We used the data collected at the level of the districts during the school entrance examinations of the examination cohort of 2012. For Saarland, we analyzed data from the 2011 cohort because 2012 data were not available, owing to incomplete evaluations. The school entrance examination collects data on all children entering the school system. To determine immunization rates, only children with an immunization passport (nationwide proportion 92.6%[9]) were included in our analysis. For reasons of legal data protection, declarations of consent had to be obtained from all public health offices in Hesse and Schleswig-Holstein, for the purposes of passing on the data. Data sets from North Rhine–Westphalia, Berlin, Rhineland–Palatinate, and Saarland were extracted via the internet from the websites of the respective supreme state authorities. The school entrance examinations in Baden–Württemberg collect data on a birth cohort that is about 1 year younger than those in the other German *Länder*. In Hesse, the immunization rates for mumps, measles, and rubella (MMR) are collected jointly because of the overwhelming use of the combined vaccine.

Figure 1: Tetanus immunization rate 2012 at district level, complete immunization status after completed basic immunization

Saxony is the only German *Land* to have its own vaccination committee with its own recommendations, the Vaccination Committee of the State of Saxony (SIKO). In contrast to STIKO's rules, the completed immunization status in school entrance examinations according to SIKO requires a booster in tetanus and pertussis. In parallel, the completed basic childhood immunization according to STIKO is also captured in Saxony. For this reason, data are available for these immunizations that are directly comparable with those of the other German *Länder*. The second dose of the measles vaccine, which is required for the complete basic immunization, is recommended in Saxony only after the completed 5th year of life, in contrast to the STIKO recommendations. In spite of these diverging recommendations, a complete immunization status at the time of the school entrance examination requires two vaccine doses, nationwide (22, 23, e7).

The 402 districts (status of 2012) constitute the smallest regional presentation level. The maps were compiled by using the geographical information system (GIS) ESRI ArcGIS™10.0. A consistent color scale was used for all maps; the individual legends comprise only categories that are included in the maps.

Figure 2: Hepatitis B immunization rate 2012 at district level, complete immunization status after completed basic immunization

Results

Tetanus immunization

The tetanus immunization rates (*Figure 1*) are high, at mostly >95% in all of Germany. The standard deviation of immunization rates in the districts from nationwide immunization rates is 1.9% (*eTable 1a, b*). In Baden–Württemberg, Schleswig–Holstein, Hamburg, and North Rhine–Westphalia, various regions have immunization rates <95%. Two districts in Baden–Württemberg had immunization rates <90%.

Pertussis immunization

In spite of higher average immunization rates in the new *Länder* (former East Germany) compared with the old *Länder* (former West Germany), state-wide immunization rates for pertussis of >95% are not reached in any *Land* except Mecklenburg–Western Pomerania and Saxony (*eFigure 1*). Immunization rates of <95% are seen in Berlin, Bremen, and Hamburg, and in all old German states in several districts, with the exception of Rhineland–Palatinate and Saarland. Immunization rates <90% were seen in Bavaria, Baden–Württemberg, and Lower Saxony. The standard deviation of immunization rates for the districts is 2.1% (*eTable 1a, b*).

According to SIKO recommendations, immunization rates for tetanus and pertussis of between 28.5% and 57.4% are documented for Saxony's districts.

Poliomyelitis immunization

The immunization rates for polio are >95% in most rural districts (*eFigure 2*). Immunization rates <95% were observed in Bremen and Hamburg, and, to a larger extent, in Baden–Württemberg, Bavaria, Schleswig–Holstein, and North Rhine–Westphalia. In two rural districts in North Rhine–Westphalia, immunization rates of <85% were documented. An exhaustive coverage >95% was reached only in Mecklenburg–Western Pomerania. The standard deviation of immunization rates in rural districts in the whole of Germany is 2.5% (*eTable 1a, b*).

Hepatitis B immunization

The immunization rates for hepatitis B (*Figure 2*) are mostly <95% and are lower in western states than in eastern ones. A comprehensive immunization rate of >90% was achieved only in Mecklenburg–Western Pomerania and Saxony–Anhalt, as well as in most of in Brandenburg, Rhineland–Palatinate and Saarland. Districts with immunization rates <80% are located mainly in Baden–Württemberg, Bavaria, and North Rhine–Westphalia, as well as in individual cases in Schleswig–Holstein, Lower Saxony, and Hesse. The lowest immunization rates, <65%, were reported for six districts from Baden–Württemberg and Bavaria. The standard deviation for immunization rates of all districts is 7.5% (*eTable 1a, b*).

Measles immunization

The immunization rates for measles (*Figure 3*) reach >95%—the rate that is comprehensively required for the purposes of eradication—only in Mecklenburg–Western Pomerania. With the exception of Hamburg, Bremen, and Berlin, all other states except Saarland have at least one district with an immunization rate <90%. All districts with an immunization rate <85% are located in Bavaria and Baden–Württemberg. In Saxony, <75% of all children have completed their basic immunizations. The standard deviation of immunization rates in the districts is 5.9% (*eTable 1a, b*; excluding Saxony: 3.5%).

Discussion

This article presents for the first time a geographical analysis by district of the immunization rates for selected immunizations on the basis of school entry examinations. At the present time, this constitutes the only annual population based data collection of immunization rates in one age group of this size in Germany.

Of note was the difference between east and west: the states of former East Germany had higher immunization rates than those of former West Germany. For measles immunization and hepatitis B immunization, this divide is more pronounced than for immunizations for tetanus, pertussis, and polio. One

possible explanation is the fact that immunization was compulsory in the former German Democratic Republic.

In recent decades, the incidence of tetanus in Germany has fallen below 15 cases per year (24). Since the new law on infectious disease control in Germany in 2001 (IfSG) made tetanus a non-notifiable disease, reliable recent data have been lacking. Because of state-specific regulations, tetanus is notifiable only in Mecklenburg–Western Pomerania, Saxony, and Thuringia. Herd immunity is not achievable because the pathogen is ubiquitous and is not transmitted from person to person. For this reason, an increase in the rate should be worked towards, especially in regions with immunization rates <95%.

Conclusions about nationwide case numbers of pertussis are barely possible because pertussis has not been a notifiable disease in Germany for several years. On the basis of state-specific regulations in the new states, for this part of Germany a rising incidence between 2010 and 2012, to 42 cases per 100 000 population, was documented. In terms of the causes of death statistics, between 2002 and 2012 in the new German states, seven deaths were documented, all in persons older than 60. In the old federal states, five deaths occurred, including three in infants (25). The goal of herd immunity is very much at risk because even immunized persons can transmit the pathogen. Furthermore, the age at which persons became infected has risen, because the protection conferred by the vaccine is limited to 10 years. For this reason, adolescents and older persons increasingly contract pertussis (12, 14, 25). The intention is therefore to improve immunization rates, which in some districts can only be described as unsatisfactory, in order to especially protect infants and older persons. After a change to the IfSG, since 29 March 2013, pertussis has become a notifiable disease once again, on a nationwide basis, and the hope is that the data thus collected will enable conclusions about trends in the nationwide incidence of this infection.

The immunization rate that is required to reach comprehensive herd immunity against polio depends on the vaccine, among others. When the inactivated polio vaccine is used, which has been recommended in Germany since 1998, higher immunization rates are required for the effective prophylaxis of endemic polio outbreaks than for the live polio vaccine, since vaccinated persons can still transmit the virus. As multiple factors of influence are at play, independently of the vaccine used, no herd immunity threshold can be defined (26). In Germany, the IfSG stipulates that any suspected case and confirmed case of polio, and each death from the infection, as well as the direct and indirect confirmation of the poliovirus, have to be notified. A suspected case scenario is given in any occurrence of acute flaccid paralysis of an extremity (AFP), unless this is due to trauma (e8). The renewed occurrence of polio in Syria and Somalia in 2013 is a setback for the global eradication that was the goal and underlines the importance of a high immunization rate and careful AFP surveil-

Figure 3: Measles immunization rate 2012 at district level, complete immunization status after completed basic immunization

lance, in order to prevent spread of disease in cases of imported poliovirus.

Immunization rates for hepatitis B are unsatisfactory in many areas of Germany. The recently changed collection of data on basic immunization after using a monovalent vaccine (complete protection after three doses) or a combination vaccine with a pertussis component (complete protection after four doses) has not yet been applied in all German *Länder*, and this may result in deceptively low immunization rates (9). The case numbers in recent years (notified cases 2012: 675; 2013: 687) (27) show, however, in connection with the unsatisfactory immunization rates, that educational measures to ensure better acceptance of the vaccination are urgently required.

Immunization rates for the measles vaccine are also too low in many districts in Germany. The number of notified cases has for many years shown fluctuations and recurring endemic outbreaks (5). After 165 cases in 2012, a total of 1775 cases were registered in 2013, of these 789 in Bavaria and 493 in Berlin (27). An analysis of billing data of the regional Associations of Statutory Health Insurance Physicians regarding measles diagnoses gives rise to the suspicion that data on measles

cases are incompletely captured, although the disease is notifiable (28). The herd immunity threshold can be assumed to be reached when the immunization rates are 94–96% (e2). Skepticism towards the measles vaccine has been supported by negative descriptions in the media and individual wrongful scientific publications (18). In order to achieve the objective of measles eradication by improving immunization rates, educational measures to improve acceptance among doctors and the population are crucial.

The appointment of a national verification commission for measles/rubella by the Federal Ministry of Health in December 2012 constitutes a further step towards improving the epidemiological surveillance of infections (29).

For almost all immunizations presented in this article, a nationwide, consistent description of immunization rates according to STIKO is possible. Saxony has different recommendations for immunization, and this affects the comparability of the measles immunization. In order to optimize nationwide comparability, the Robert Koch Institute has published data from the examinations of second-year students in Saxony. This examination is not designed to capture the complete data, in contrast to the school entrance examination (30). With a rate of 88.1% (2012), the measles immunization rate in Saxony published by the RKI is clearly higher than the rate at the school entrance examination, of 62.2%, but it is still the lowest immunization rate in all of Germany. As the children grow older, the well-child visits are attended increasingly less (30, 31, e9). Furthermore, completion of the immunization status is hampered by the fact that the numbers of visits to pediatricians in general are falling. An improvement in the measles immunization rate in Saxony could possibly be achieved by making the state's immunization recommendations consistent with those of the STIKO.

Limitations

Although it was possible to note regional differences as a result of the geographical analysis, this did not yield any causal explanation. An analysis published earlier showed an association between doctors' regionally differing attitudes towards vaccination and immunization rates (32). Parents' rejection of immunizations in different regions and parts of the population was confirmed as a risk factor at the national and international levels (33–35). In addition to the absence of compulsory vaccination in Germany, such parental opposition constitutes a further important factor affecting immunization rates.

The fact that the age at which relevant infections are contracted has shifted to adulthood remains a challenge—for example, 64% of all notified cases of pertussis and 39% of cases of measles (5, 25). Regularly collected nationwide data on the immunization status of adults are currently not available. The investigation of a sample of the adult population showed unsatisfactory immunization rates against diverse infections (36). An alternative data collection option is

provided by the surveillance project of the Association of Statutory Health Insurance Physicians, which uses billing data from the association to determine immunization rates at the regional level. One of the advantages of the database is the fact that it includes immunization rates from specific age groups (37, 38). It might even be useful for determining immunization rates against human papillomavirus (HPV) in girls—data that currently cannot be collected nationwide in a standardized manner because of the recommended immunization period from the 9th to the 14th year of life (39). What is clearly a limitation, however, is that only persons who are insured in statutory health insurance funds are included (about 85% of the population), and that the validity of the data is restricted if, for example, an insured person moves to an area that is under the responsibility of a different Association of Statutory Health Insurance Physicians.

Conclusion

Mapping the data at district level makes it possible to identify regions with particularly low immunization rates, where an increased need for education and information exists.

Nationwide, immunization rates for tetanus, pertussis, and polio are high in Germany, but regionally, these should be improved. With regard to hepatitis B and measles, increased measures are required to improve acceptance of these immunizations. In order to be able better to plan future information campaigns, the causes of skepticism and acceptance vis-à-vis immunization need to be studied further. Especially for the measles vaccine, consistent immunization recommendations should be sought, so that comparability is ensured and immunization rates can potentially be improved at the regional level.

Acknowledgment

The present study was supported by funding from the Institute for Community Medicine at Greifswald University Hospital. We thank all participating public health offices and state public health offices for providing data (Baden-Württemberg: State Public Health Service Baden-Württemberg, State Department for Public Health of Baden-Württemberg; Bavaria: Bavarian Health and Food Safety Authority; Berlin: Berlin Senate Department for Health and Social Services Division I A; Brandenburg: State Office of Environment, Health and Consumer Protection; Bremen: The Senator for Health, Department of Health; Hamburg: Office for Health and Consumer Protection, Public Health Office; Hesse: Hessian Ministry of Social Affairs and Integration; Mecklenburg-Western Pomerania: Ministry of Labour, Equality and Social Affairs; Lower Saxony: Governmental Institute of Public Health of Lower Saxony; North Rhine-Westphalia: State Centre for Health North Rhine-Westphalia; Rhineland-Palatinate: State Agency for Consumer and Health Protection; Saarland: Ministry for Justice, Health and Social Affairs; Saxony: State Laboratory for Health and Veterinary Affairs Saxony; Saxony-Anhalt: State Office for Consumer Protection Saxony-Anhalt; Schleswig-Holstein: Public Health Office (Fachdienst Gesundheit); Thuringia: Thuringian State Office of Administration. We also thank the Robert Koch-Institute for the provided contact details for individual health authorities in the states. We also thank Thea Schwaneberg for her help in merging the data, and Ulrike Stenzel for her help in setting out the maps.

Conflict of interest statement

Dr Weigel has received study support (third-party funding) from Wyeth Pharma, Sanofi Pasteur MSD, and Novartis-Behring.

Dr Bruns has received consultancy fees (advisory board) from Pfizer, Astra-Zeneca, and Sanofi Pasteur MSD. She has received conference delegate fees and travel expenses from Pfizer. She has also received honoraria for speaking

from Pfizer, AstraZeneca, Sanofi Pasteur MSD, GlaxoSmith Kline, Novartis, and Abbvie.

Ms Weitmann and Prof Hoffman declare that no conflict of interest exists.

Manuscript received on 19 February 2014, revised version accepted on 18 August 2014.

Translated from the original German by Birte Twisselmann, PhD.

KEY MESSAGES

- Nationwide immunization rates for tetanus, pertussis, and polio are high in Germany but require improvement at the regional level.
- Immunization rates in the former East German states tend to be higher than in the former West.
- With regard to vaccination against hepatitis B and measles, immunization rates in the population in some regions—especially Bavaria and Baden-Württemberg—are unsatisfactory.
- Especially for hepatitis B and measles immunization, educational measures are crucial, in order to improve the general acceptance of the immunizations and the awareness of possible complications of vaccine-preventable diseases, in doctors as well as in the population.
- Nationwide consistent recommendations for immunization might lead to improved immunization rates.

REFERENCES

- Cortese MM, Baughman AL, Zhang R, Srivastava PU, Wallace GS: Pertussis hospitalizations among infants in the United States, 1993 to 2004. *Pediatrics* 2008; 121: 484–92.
- Schönberger K, Ludwig MS, Wildner M, Weissbrich B: Epidemiology of Subacute Sclerosing Panencephalitis (SSPE) in Germany from 2003 to 2009: A Risk Estimation. *PLoS ONE* 2013; 8: e68909.
- Smith PG: Concepts of herd protection and immunity. *Procedia Vaccinol* 2010; 2: 134–9.
- Robert Koch-Institut (RKI): Pertussis: Management eines Ausbruchs an einer Grundschule. *Epid Bull* 2005; 6: 43–7.
- Robert Koch-Institut (RKI): Aktuelle Epidemiologie und Impfquoten – Wer erkrankt in Deutschland an Masern? *Epid Bull* 2013; 48: 485–91.
- Gust DA, Strine TW, Maurice E, et al.: Underimmunization among children: effects of vaccine safety concerns on immunization status. *Pediatrics* 2004; 114: 16–22.
- Mills E, Jadad AR, Ross C, Wilson K: Systematic review of qualitative studies exploring parental beliefs and attitudes towards childhood vaccination identifies common barriers to vaccination. *J Clin Epidemiol* 2005; 58: 1081–8.
- Schneeweiß B, Pfeleiderer M, Keller-Stanislawski B: Impfsicherheit heute. *Dtsch Arztebl* 2008; 105: 590–5.
- Robert Koch-Institut (RKI): Impfquoten bei der Schuleingangsuntersuchung in Deutschland 2012. *Epid Bull* 2014; 16: 137–41.
- Hull BP: Australian childhood immunisation coverage, 1 January to 31 March cohort assessed as at 30 June 2013. *Commun Dis Intell* 2013; 37: 434–5.
- Mueller S, Exeter DJ, Petousis-Harris H, Turner N, O'Sullivan D, Buck CD: Measuring disparities in immunisation coverage among children in New Zealand. *Health & Place* 2012; 18: 1217–23.
- Robert Koch-Institut (RKI): Zur Situation bei wichtigen Infektionskrankheiten – Impfpräventable Krankheiten in Deutschland bis zum Jahr 2000. *Epid Bull* 2002; 07: 49–57.
- Kalies H, von Kries R: Durchimpfungsraten bei Kindern in Deutschland. *Monatsschr Kinderheilkd* 2005; 153: 854–61.
- Hellenbrand W, Beier D, Jensen E, et al.: The epidemiology of pertussis in Germany: past and present. *BMC Infect Dis* 2009; 9: 22.
- Poliomyelitis prevention in the United States: Introduction of a sequential vaccination schedule of inactivated Poliovirus vaccine followed by oral Poliovirus vaccine; Recommendations of the Advisory Committee on Immunization Practices (ACIP). *Morbidity and Mortality Weekly Report* 1997; 46: 1–25.
- Robert Koch-Institut (RKI): Impfempfehlungen der Ständigen Impfkommission (STIKO) am Robert Koch-Institut/Stand März 1998. *Epid Bull* 1998; 15: 101–12.
- RKI: Zur Situation bei wichtigen Infektionskrankheiten in Deutschland Virushepatitis B und D im Jahr 2012. *Epid Bull* 2013; 29: 259–69.
- Kaulen H: Masern-Mumps-Röteln-Impfung: Wie ein Impfstoff zu Unrecht in Misskredit gebracht wurde. *Dtsch Arztebl* 2007; 104: 166–8.
- Fleck F: MMR controversy raises questions about publication ethics. *Bulletin of the World Health Organisation* 2004; 82: 311–2.
- Duderstadt SK, Rose CE Jr, Real TM, et al.: Vaccination and risk of type 1 diabetes mellitus in active component U.S. Military, 2002–2008. *Vaccine* 2012; 30: 813–9.
- Stowe J, Kafatos G, Andrews N, Miller E: Idiopathic thrombocytopenic purpura and the second dose of MMR. *Arch Dis Child* 2008; 93: 182–3.
- SIKO: Synopsis – Impfkalendar für Kinder, Jugendliche und Erwachsene im Freistaat Sachsen. www.slaek.de/de/03/36impfen/pdf/Synopsis_2014.pdf (last accessed on 5 September 2014).
- Robert Koch-Institut (RKI): Empfehlungen der Ständigen Impfkommission (STIKO) am Robert Koch Institut/Stand: Juli 2012. *Epid Bull* 2012; 30: 283–95.
- Robert Koch-Institut (RKI): Tetanus: Zwei Fallberichte zu Erkrankungen. *Epid Bull* 2008; 24: 193–5.
- Robert Koch-Institut (RKI): Zur Situation bei ausgewählten Infektionskrankheiten in Deutschland, Keuchhusten-Erkrankungen in den neuen Bundesländern, 2002 bis 2012. *Epid Bull* 2014; 01: 1–11.
- Fine P: Herd immunity: History, theory, practice. *Epidemiologic Reviews* 1993; 15: 265–302.
- Robert Koch-Institut (RKI): Infektionsepidemiologisches Jahrbuch meldepflichtiger Krankheiten für 2013. Berlin: Robert Koch-Institut 2014.
- Mette A, Reuss AM, Feig M, et al.: Under-reporting of measles: An evaluation based on data from North Rhine-Westphalia. *Dtsch Arztebl Int* 2011; 108: 191–6.
- Robert Koch-Institut (RKI): Konstituierung der Nationalen Verifizierungskommission Masern/Röteln beim Robert Koch-Institut. *Epid Bull* 2013; 7: 55–7.
- Stadt Leipzig: Daten und Fakten zur Kindergesundheit in der Stadt Leipzig 2011. Kapitel 3 Gesundheitsvorsorge, Angebot und Inanspruchnahme; Stadt Leipzig, Hauptamt – Zentrale Vervielfältigung (eds.): 2011; 9–23.
- Niedersächsisches Landesgesundheitsamt: Gesundheitsberichterstattung Report 6: Evaluation im Rahmen eines niedersächsischen Gesundheitsziels; Entwicklung der Teilnahmeraten an den Krankheitsfrüherkennungsuntersuchungen (U-Untersuchungen U1–U9 und J1); Niedersächsisches Landesgesundheitsamt (eds.) 2008; 7–9.
- Weigel M, Weitmann K, Rautmann C, Schmidt J, Bruns R, Hoffmann W: Impact of physicians' attitude to vaccination on local vaccination coverage for pertussis and measles in Germany. *Eur J Public Health* 2014; [Epub ahead of print]; 1–8; DOI:10.1093/eurpub/cku013.

33. Kriwy P: Gesundheitsvorsorge bei Kindern. Eine empirische Untersuchung des Impfverhaltens bei Masern, Mumps und Röteln. Wiesbaden: VS Verlag für Sozialwissenschaften 2007; 139–70.
34. Poethko-Müller C, Kuhnert R, Schlaud M: Durchimpfung und Determinanten des Impfstatus in Deutschland. Bundesgesundheitsbl 2007; 50: 851–62.
35. Feifei W, Mullooly JP, Goodman M, et al.: Identification and characteristics of vaccine refusers. BMC Pediatrics 2009; 9: 18.
36. Poethko-Müller C, Schmitz R: Impfstatus von Erwachsenen in Deutschland: Ergebnisse der Studie zur Gesundheit Erwachsener in Deutschland (DEGS1). Bundesgesundheitsbl 2013; 56: 845–57.
37. Rieck T, Feig M, Eckmanns T, Benzler J, Siedler A, Wichmann O: Vaccination coverage among children in Germany estimated by analysis of health insurance claims data. Hum Vaccin Immunother 2014; 10: 476–84.
38. Reuss A, Feig M, Kappelmayer L, Eckmanns T, Poggensee G: Bestimmung von Impfquoten und Inzidenzen von Erkrankungen anhand von Daten der Kassenärztlichen Vereinigungen. Gesundheitswesen 2010; 72: 340–6.
39. Robert Koch-Institut (RKI): Empfehlungen der Ständigen Impfkommission (STIKO) am Robert Koch-Institut/Stand: August 2014. Epid Bull 2014; 34: 305–321.

Corresponding author

Dr. med. Martin Weigel
 Institut für Community Medicine
 Abteilung Versorgungsepidemiologie und Community Health
 Universitätsmedizin Greifswald
 Ellernholzstraße 1–2, 17487 Greifswald, Germany

For eReferences please refer to:
www.aerzteblatt-international.de/ref4614

eTables, eFigures:
www.aerzteblatt-international.de/14m0788

ORIGINAL ARTICLE

Immunization Rates at the School Entry in 2012

Nationwide German Data With Regional and Local Breakdown

Martin Weigel, Roswitha Bruns, Kerstin Weitmann, Wolfgang Hoffmann

eREFERENCES

- e1. Bellini WJ, Rota JS, Lowe LE, et al.: Subacute sclerosing panencephalitis: more cases of this fatal disease are prevented by Measles immunization than was previously recognized. *JID* 2005; 192: 1686–93.
- e2. Anderson RM, May RM: Directly transmitted infectious diseases, control by vaccination. *Science* 1982; 215: 1053–60.
- e3. Smith PJ, Kennedy AM, Wooten K, Gust DA, Pickering LK: Association between health care providers' influence on parents who have concerns about vaccine safety and vaccination coverage. *Pediatrics* 2006; 118: 1287–92.
- e4. Diedrich S, Schreier E: Kinder- und Jugendgesundheitssurvey (KiGGS): Immunitätslage gegen Poliomyelitis. *Bundesgesundheitsbl – Gesundheitsforsch – Gesundheitsschutz* 2007; 50: 771–4.
- e5. Black C, Kaye JA, Jick H: MMR vaccine and idiopathic thrombocytopenic purpura. *Br J Clin Pharmacol* 2003; 55: 107–111.
- e6. Taylor B, Miller E, Lingam R, Andrews N, Simmons A, Stowe J: Measles, mumps, and rubella vaccination and bowel problems or developmental regression in children with autism: population study. *BMJ* 2002; 324: 393–6.
- e7. Wiese-Posselt M, Tertilt C, Zepp F: Impfempfehlungen für Deutschland. *Dtsch Arztebl Int* 2011; 108: 771–80.
- e8. Robert Koch-Institut (RKI): RKI-Ratgeber Infektionskrankheiten: Merkblätter für Ärzte – Poliomyelitis. *Epid Bull* 2000; 27: 215–218. www.rki.de (last accessed on 3 August 2014).
- e9. Grobe TG, Heller G, Szecsenyi J: Barmer GEK Arztreport 2014. Schriftenreihe zur Gesundheitsanalyse Band 24. Berlin: Asgard-Verlagsservice GmbH 2014: 125–134.

eFigure 1: Pertussis immunization rate 2012 at district level, complete immunization status after completed basic immunization

eFigure 2: Polio immunization rate 2012 at district level, complete immunization status after completed basic immunization

eFigure 3: Mumps and rubella immunization rate 2012 at district level (presentation is identical for both immunizations), complete immunization status after completed basic immunization

eTABLE 1a
Immunization rates (in %) on the basis of school entrance examinations at district level in 2012

Federal state (Land)	Districts (n)	Tetanus (%)		Polio (%)		Pertussis (%)		Hepatitis B (%)		Measles (%)	
		Min/ Max	Mean (STD)	Min/ Max	Mean (STD)	Min/ Max	Mean (STD)	Min/ Max	Mean (STD)	Min/ Max	Mean (STD)
Baden–Württemberg	44	89.0/ 98.4	94.2 (2.2)	87.1/ 98.4	93.2 (2.5)	88.2/ 98.2	93.9 (2.3)	55.3/ 92.9	82.2 (9.2)	77.8/ 96.4	89.5 (4.0)
Bavaria	96	93.9/ 99.8	97.1 (1.4)	87.1/ 98.3	95.3 (2.5)	87.0/ 98.9	95.1 (2.3)	53.5/ 98.2	87.5 (8.8)	77.5/ 97.4	90.7 (4.2)
Berlin	1	96.6	96.6 (-)	95.7	95.7 (-)	94.7	94.7 (-)	87.6	87.6 (-)	90.9	90.9 (-)
Brandenburg	18	95.5/ 99.1	98.2 (0.8)	94.0/ 98.8	97.3 (1.0)	94.5/ 99.0	97.8 (1.0)	82.1/ 98.3	93.8 (4.1)	89.1/ 98.3	95.1 (2.1)
Bremen	2	95.3/ 96.1	95.7 (0.6)	94.0/ 96.0	95.0 (1.4)	94.7/ 95.7	95.2 (0.7)	84.5/ 84.9	84.7 (0.3)	92.0/ 95.3	93.7 (2.3)
Hamburg	1	94.6	94.6 (-)	93.4	93.4 (-)	94.3	94.3 (-)	83.7	83.7 (-)	92.3	92.3 (-)
Hesse* ¹	26	94.3/ 97.4	96 (0.9)	93.4/ 96.7	95.2 (0.8)	94.0/ 97.3	95.8 (0.8)	76.3/ 91.9	86.8 (3.9)	86.6/ 95.8	93.1 (1.9)
Mecklenburg–Western Pomerania	8	96.6/ 98.7	98.1 (0.8)	96.3/ 98.4	97.7 (0.7)	96.7/ 98.4	97.6 (0.7)	94.1/ 97.6	96.3 (1.3)	95.1/ 97.5	96.1 (0.8)
Lower Saxony	46	90.3/ 99.8	96.3 (1.9)	90.4/ 99.8	96.1 (1.8)	89.0/ 99.8	95.4 (2.2)	71.6/ 99.1	91.7 (5.2)	87.3/ 97.5	92.9 (2.5)
Nord Rhine–Westphalia* ²	53	90.7/ 97.9	95.5 (1.6)	81.2/ 97.8	93.6 (3.0)	90.1/ 97.8	95.1 (1.7)	70.2/ 96.8	84.1 (6.1)	88.1/ 98.3	94.3 (2.1)
Rhineland–Palatinate	36	96.3/ 99.7	98.4 (0.9)	94.5/ 99.6	97.9 (1.1)	94.3/ 99.6	97.3 (1.3)	89.8/ 98.9	94.5 (2.3)	87.2/ 97.8	93.7 (2.3)
Saarland* ³	6	95.4/ 97.1	96.6 (0.6)	94.4/ 96.4	95.7 (0.8)	94.5/ 96.4	95.6 (0.7)	91.0/ 94.6	93.3 (1.3)	90.9/ 95.6	93.6 (1.6)
Saxony	13	96.4/ 98.9	97.3 (0.8)	92.7/ 98.3	95.9 (1.7)	94.9/ 98.3	96.9 (1.0)	83.5/ 96.6	90.7 (3.8)	52.1/ 74.6	66.7 (7.5)
Saxony–Anhalt	14	93.8/ 98.5	96.7 (1.4)	91.7/ 98.1	95.4 (2.0)	93.3/ 98.5	96.5 (1.5)	90.5/ 97.5	94.9 (2.2)	88.0/ 97.9	93.4 (2.9)
Schleswig–Holstein	15	93.7/ 97.3	95.0 (1.2)	92.0/ 96.1	93.9 (1.2)	93.1/ 96.1	94.4 (1.1)	77.2/ 92.3	86.4 (4.1)	85.2/ 96.1	93.1 (2.5)
Thuringia	23	93.6/ 98.6	96.9 (1.3)	92.5/ 97.9	95.7 (1.5)	92.9/ 98.4	96.7 (1.4)	83.4/ 94.3	90.0 (2.9)	89.9/ 97.4	94.7 (1.8)
Germany	402	89.0/ 99.8	96.5 (1.9)	81.2/ 99.8	95.3 (2.5)	87.0/ 99.8	95.6 (2.1)	53.5/ 99.1	88.5 (7.5)	52.1/ 98.3	91.7 (5.9)

^{*1}Mumps–measles–rubella only captured in combination

^{*2}One district without data

^{*3}Data from 2011

Min, minimum; Max, maximum; STD, standard deviation

eTABLE 1b

Immunization rates (in %) on the basis of school entrance examinations at district level in 2012

Federal state (<i>Land</i>)	Districts (n)	Diphtheria (%)		Haemophilus influenzae B (%)		Mumps (%)		Rubella(%)	
		Min/Max	Mean (STD)	Min/Max	Mean (STD)	Min/Max	Mean (STD)	Min/Max	Mean (STD)
Baden–Württemberg	44	88.8/98.3	94.2 (2.2)	86.2/97.9	92.7 (2.6)	78.0/96.4	89.4 (4.0)	77.6/96.4	89.3 (4.1)
Bavaria	96	87.8/99.8	96.0 (2.0)	85.4/98.0	93.9 (2.9)	77.5/97.4	90.4 (4.2)	77.3/97.4	90.4 (4.2)
Berlin	1	96.2	96.2 (-)	93.4	93.4 (-)	90.5	90.5 (-)	90.6	90.6 (-)
Brandenburg	18	94.9/99.1	98.0 (0.9)	92.7/98.7	96.7 (1.5)	89.0/98.3	95.0 (2.1)	89.0/98.3	94.9 (2.1)
Bremen	2	95.1/96.0	95.6 (0.6)	93.4/94.7	94.1 (0.9)	91.7/95.0	93.4 (2.3)	91.5/94.8	93.2 (2.3)
Hamburg	1	94.4	94.4 (-)	91.7	91.7 (-)	91.9	91.9 (-)	91.9	91.9 (-)
Hesse* ¹	26	93.3/97.4	95.9 (1.0)	91.8/95.6	94.1 (1.1)	86.6/95.8	93.1 (1.9)	86.6/95.8	93.1 (1.9)
Mecklenburg–Western Pomerania	8	96.4/98.5	97.9 (0.8)	95.4/97.8	96.7 (1.0)	94.9/97.2	96.0 (0.7)	94.9/97.3	96.0 (0.8)
Lower Saxony	46	89.7/99.8	95.8 (2.1)	89.2/99.7	95.0 (2.1)	87.0/97.3	92.7 (2.5)	87.0/97.3	92.7 (2.6)
Nord Rhine–Westphalia* ²	53	90.6/97.9	95.4 (1.6)	82.0/97.8	92.6 (2.8)	88.0/98.0	94.1 (2.1)	87.8/98.0	94.1 (2.1)
Rhineland–Palatinate	36	95.2/99.6	98.1 (1.0)	92.2/99.6	96.6 (1.7)	86.9/97.8	93.5 (2.3)	86.9/97.8	93.5 (2.3)
Saarland* ³	6	95.3/96.7	96.3 (0.5)	92.9/95.5	94.6 (1.0)	90.8/95.5	93.4 (1.6)	90.7/95.4	93.3 (1.6)
Saxony	13	95.6/98.4	97.0 (0.9)	93.3/98.4	95.8 (1.9)	52.0/74.6	66.6 (7.5)	52.0/74.6	66.6 (7.5)
Saxony–Anhalt	14	93.6/98.5	96.6 (1.4)	89.3/97.4	94.6 (2.4)	87.9/97.6	93.3 (2.9)	87.9/97.6	93.3 (2.9)
Schleswig–Holstein	15	93.3/97.3	94.9 (1.2)	85.4/94.9	92.3 (2.3)	85.1/96.0	93.0 (2.5)	85.1/96.0	93.0 (2.5)
Thuringia	23	93.4/98.4	96.8 (1.3)	90.4/97.5	94.2 (1.9)	89.7/97.4	94.5 (1.9)	89.7/97.2	94.5 (1.9)
Germany	402	87.8/99.8	96.1 (2.0)	82.0/99.7	94.2 (2.7)	52.0/98.3	91.6 (5.9)	52.0/98.3	91.5 (5.9)

*¹Mumps–measles–rubella captured only in combination

*²One district without data

*³Data from 2011

Min, minimum; Max, maximum; STD, standard deviation