ORIGINAL ARTICLE

Pneumococcal Vaccination Rates in Adults in Germany

An Analysis of Statutory Health Insurance Data on More Than 850 000 Individuals

Ulrike Theidel, Alexander Kuhlmann, Anja Braem

SUMMARY

Background: The German Standing Committee on Vaccination Recommendations (Ständige Impfkommision, STIKO) recommends standard vaccination against pneumococcal infections for all persons aged 60 or older, and for all persons of any age with an increased health risk. It is not known how many persons in the target group in Germany have actually been vaccinated.

Methods: We used claims data of a German statutory health insurance (Deutsche BKK) to determine pneumococcal vaccination rates, stratified by age and risk, for the one-year period 1 July 2008 to 30 June 2009. The number of influenza vaccinations in the same period was analyzed for comparison. Because pneumococcal vaccination does not need to be performed annually, the calculated rates are an underestimate of the percentage of persons who have been vaccinated. A simulation model was used to correct for persons vaccinated at earlier times. The vaccination rates were estimated on the basis of various scenarios.

Results: Data were obtained on 867 683 persons aged 18 or older. According to an optimistic estimate, the percentage of pneumococcal vaccination in the overall population is 3.75% for persons aged 18–59 and 50.89% for persons aged 60 and above (influenza: 8.80% and 41.15%, respectively). In persons at elevated risk, the rate of vaccination in the presence of at least one risk factor is 12.66% / 54.67% (influenza: 15.66% / 39.96%). In persons with moderate risk, the vaccination rate is 16.02% / 56.75% (influenza: 18.54% / 40.61%); in persons whose elevated risk was high, it is 8.93% / 52.21% (influenza: 7.37% / 37.78%). The limitations of this study are the short study period and the inability to define the population at risk unambiguously.

Conclusion: The rate of pneumococcal vaccination in adults in Germany is too low; at best, it is comparable to that of influenza vaccination. These results should be validated by nationwide monitoring of the pneumococcal vaccination program. For example, questions about pneumococcal vaccination could be included in the GEDA study (German Health Update) that is conducted annually by the Robert Koch Institute.

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Community acquired pneumonia (CAP) is the most common form of pneumococcal disease in adults. About 40% of infections are caused by *Streptococcus pneumoniae* (1). In Germany, the incidence of CAP is some 3 cases per 1000 population for all age groups, and 8/1000 for the group aged 60 or older (2). Bacteremic CAP and sepsis are complications of CAP and range among the group of invasive pneumococcal diseases (IPD) (3). Data from PneumoWeb have shown an annual number of more than 900 cases for IPD in older persons (≥ 60 years), compared with fewer than 100 cases per year in younger age groups (4). Depending on age and number of comorbidities (risk), inpatient mortality due to CAP is between 2% (low risk) and 35% (high risk) (2) in Germany; the proportions reported for IPD are 5–35% (5).

To prevent pneumococcal diseases, the German Standing Committee on Vaccination Recommendations (Ständige Impfkommision, STIKO) (6) recommends standard vaccination for all persons older than 60. Vaccination based on a particular indication, and independent of age, is recommended for persons with an increased health risk. This includes persons with chronic diseases (for example, diabetes, renal failure) and persons with congenital or acquired immunodeficiencies (for example, sickle-cell anemia, HIV infection). Since mortality and morbidity due to pneumococcal diseases are still high, owing to antibiotic resistance in some pneumococcal strains (7, 8), it makes sense to vaccinate especially people in the above groups against pneumococcal infection.

For the groups of persons receiving the vaccine on the basis of an indication there are no confirmed data on incidence and prevalence. The dominant underlying diseases determined by the Community Acquired Pneumonia Network of Excellence (CAPNet) (9) are:

- Respiratory disorders (9.4%),
- Diabetes mellitus (18.0%), and
- Cardiovascular disorders (16.7%).

Since 1998, a 23-valent polysaccharide vaccine (10) has been recommended by the STIKO for indication based as well as standard vaccination in adults (11). Regarding the use of the 13-valent conjugate vaccine (12), the current STIKO recommendation makes reference to a statement dated 20 February 2012 (6). According to this, persons in whom repeated vaccination against

Herescon GmbH, Hannover: Theidel, M.Sc.

Centre for Health Economics Research Hannover, Hannover: Kuhlmann, M.Sc.

Department of Health Care Management, Deutsche BKK, Wolfsburg: Dr. rer. nat. Braem

TABLE 1

Documentation codes according to Schutzimpfungsrichtlinie (SI-RL, the guideline on protective vaccinations) 2008

Vaccination	First doses of vaccination cycle or incomplete vaccination series (documentation codes)	Booster vaccination (documentation codes)
Pneumococcal		
Standard vaccination with a polysaccharide vaccine for persons aged 60 and older	89 119	
Indication based vaccination: persons with increased health risk as a result of congenital or acquired immunodeficiencies with residual T- and/or B-cell function, or as a result of a chronic disease	89 120	89 120R
Influenza		
Persons aged 60 and older	89 111	
Other indications	89 112	

pneumococcal infections is indicated because of immunodeficiency or chronic renal disease can be vaccinated with either the 13-valent conjugate vaccine or the 23-valent polysaccharide vaccine. Previously unvaccinated persons should initially be vaccinated with the conjugate vaccine. For a repeat vaccination after five years in persons who have already been vaccinated with the 23-valent polysaccharide vaccine, the 13-valent conjugate vaccine can be used.

There is no recommended vaccination rate for pneumococcal vaccination. Information on vaccination rates of pneumococcal vaccination in adults in Germany are thus far available only from CAPNetz. Of the collected and confirmed cases of pneumococcal CAP included in the database for the time period 07/2002 to 12/2008, 11.4% had been vaccinated against pneumococci (9).

Persons in whom pneumococcal and seasonal influenza vaccination are recommended should receive both vaccines (13). In 2005, a target vaccination rate of 75% for influenza vaccination had already been set by the World Health Organization (WHO) for older persons (14). In Germany, both vaccinations are permitted in persons older than 60 and persons at risk. For this reason it might be expected that the rates of vaccinated persons for both vaccinations are similar.

It was therefore the objective of our study to determine pneumococcal vaccination rates in adults by using claims data. For comparison purposes we determined the vaccination rate of influenza vaccination and the proportion of pneumococcal vaccinations that were administered simultaneously with the influenza vaccine (in the same quarter or on the same day). We did not intend to present any extrapolation of our data.

Methods

In order to determine the size of the at-risk population and the vaccination rates, we conducted a routine data

analysis as a retrospective cohort study without direct patient contact.

A dataset from the Deutsche BKK health insurance for the accounting period (= study period) from 1 July 2008 to 30 June 2009 was available for our study. For this time frame, accounting data were available for the documentation codes (= vaccination codes, billing codes) (Table 1) valid and definite nationwide for vaccination services, since 1 July 2008 (15). These formed the basis for identifying vaccination services (eBox [16–19]).

Results

Study population

In the study period, 86.04% of insured persons in the reported data set were aged 18 or older. The dominant underlying disorders in the age groups 18–59 and 60 and older were cardiovascular disorders (2.93% / 30.03%), diabetes or other metabolic disorders (4.33% / 25.32%), and disorders of the blood-forming organs (5.32% / 10.53%) (Table 2).

24.27% of insured persons in the dataset had at least one predefined risk, 68.21% of these in the age group of 60 and older.

Vaccination rates for the pneumococcal vaccine

16 116 vaccinations were identified for the documentation codes 89 119–89 120R in all insurance members aged 18 or older; 95.06% of all recorded vaccination services for the pneumococcal vaccine. Of these, 12 018 corresponded to the code 89 119. The mean age of adults given the vaccinations was 70 (± 11) years. The Figure shows that older people received 97.99% (11 777 / 12 018) of the standard vaccinations administered (code 89 119) and 60.24% (2471 / 4102) of the administered indication-based vaccinations (codes 89 120–89 120R).

The calculated vaccination rate of the pneumococcal vaccine (codes 89 119–89 120R) was 0.34%

TABLE 2

Proportion of insured persons with at least one risk per age and disease group^{*1}

Age group (years)	<18		18–59		≥ 60	
Number of insured persons per age group (N = 1 008 501)	140 818		547 607		320 076	
Disease category	n	%	n	%	n	%
Medium risk (chronic disease)						
Cardiovascular disorders	154	0.11	16 043	2.93	96 127	30.03
Respiratory disorders	563	0.40	5118	0.93	11 723	3.66
Diabetes mellitus or other metabolic disorders	354	0.25	23 733	4.33	81 051	25.32
Chronic renal disease	313	0.22	2187	0.40	4066	1.27
Neurological disorders	181	0.13	4493	0.82	16 672	5.21
High risk						
Neoplastic disease	142	0.10	2157	0.39	5 338	1.67
Status post transplant	34	0.02	609	0.11	441	0.14
Disorders of the blood-forming organs	4 461	3.17	29 159	5.32	33 720	10.53
HIV infection	5	0.004	431	0.08	59	0.02
Total*2	6 030	2.46	71 776	29.33	166 921	68.21

*1 The data in this table follow the narrow risk definition of Fleming et al. (2006) (16)

*2 Reported without duplicates since an insured person may have more than one underlying disorder.

NB: For the purposes of this evaluation and for simplification purposes, we assumed that the documentation codes were used consistently throughout Germany and that the vaccination services and disorders were coded correctly

(1872/547 607) in the age group 18–59 and 4.45% (14 244 / 320 076) in the group aged 60 or older. In the cohort with at least one predefined risk the rates were 1.08% (773 / 71 776) and 4.35% (7267 / 166 921) (Table 3).

We estimated the determined vaccination rates for a period of 12 months by entering the data into a simulation model (17) (Table 4).

The scenario with a rate of 30% for the booster vaccination yielded the best results, independently of how long a person is considered to be vaccinated. According to this scenario, the estimated proportion of vaccinated persons for the total cohort was 3.75% (age group: 18–59) and 50.89% (age group: 60 and older). For the cohort with at least one predefined risk the proportions were 12.66% and 54.67%, respectively.

Vaccination rates for the influenza vaccine

179 905 (96.09%) of the administered and documented influenza vaccinations (documentation codes 89 111–89 112) were given to the group aged 18 and older (mean age of adults 66 [± 15] years).

For the standard vaccination (code 89 111) the proportion of vaccinations given to adults in the group aged 65 to <75 was 44.36%. For the influenza vaccination, we calculated a rate of 8.80% (48 196 / 547 607) for the age group 18–59 and of 41.15% (131 709 / 320 076) for the group aged 60 or older. In the cohort with at least one predefined risk, the rates were 15.66% and 39.96%, respectively. Table 5 provides further information.

In adults in total, 3453 (28.73%) of all pneumococcal vaccinations (code 89 119) were given together with the influenza vaccination (code 89 111) on the same day, and 6091 (50.68%) in the same quarter. With regard to the at-risk population (codes 89 120 and 89 112) the situation is similar: 508 (20.56% of all pneumococcal vaccinations administered were given on the same day as the influenza vaccine and 1117 (45.20%) in the same quarter.

Discussion

The aim of this study was to determine the pneumococcal vaccination rate in adults in Germany within the time period from 1 July 2008 to 30 June 2009. The data on which we based our calculations were claims data from a statutory health insurer with a nationwide membership (Deutsche BKK).

Since the pneumococcal vaccination is not given annually, the exact proportion of persons had to be estimated by using an existing simulation model for this time period. The results (Table 4) obtained from the simulation model show that risk status and the number of booster vaccinations affect the effect size. The aspect of whether a person is still considered vaccinated in the study period also constitutes a crucial factor. The results show that the vaccination was given depending on the predefined risk.

Contrary to our expectations, the rates in the at-risk population for the 18–59 age group were considerably below those in the 60+ age group. Similarly, persons at moderate risk apparently received more vaccinations

Number of
identified
(administered)
pneumococcal
vaccinations
in the dataset

FIGURE

Age group in years

Age group of documented (= administered) vaccinations

than persons at high risk. The higher proportion of vaccinated persons aged 60 or older determined for the at-risk population might be explained with the fact that

- persons without risk develop a risk only during the period with vaccination, and
- at-risk patients in the group aged 60 or older received one previous vaccination before they reach their 60th year of life.

However, it should be noted that non-vaccinated persons who develop a risk during the course of their lives increase the proportion of non-vaccinated people in the at-risk group. If the results are compared with those of influenza vaccination, the estimated rates for the pneumococcal vaccine as seen in their totality (results of all scenarios) can be considered similar.

The vaccinations in the “no risk” group ages 18–59 can probably be explained with a risk definition that was too narrow or irregularities in applying the documentation codes. This may have led to misestimates in the other cohorts too.

Unsatisfactory vaccination rate

From the results of this study it can be deduced that even in the presence of all factors no satisfactory vaccination coverage was achieved for adults in the study period. The influenza vaccination rates we found in our study are not satisfactory either, compared with the

WHO target of 75% vaccination coverage in older persons. The rates for pneumococcal vaccination cannot be compared with the study reported by Pletz et al. (2012) (9), because our study encompasses a larger cohort of persons (not restricted to CAP patients) and a different study period. A comparison for the influenza vaccination from the GEDA study (57% for the 2007/2008 season) (20) is possible to a limited extent only. The GEDA study was a telephone health survey, in which 21 262 randomly selected, exclusively German-speaking persons older than 18 were questioned. The sample for this cross sectional survey was based on a representative random sample from a telephone landline sampling system of the *Arbeitskreis Deutscher Markt- und Sozialforschungsinstitute* (ADM, a business association that represents the interests of private-sector market and social research agencies in Germany) (21).

Vaccination rates in other countries are as follows: According to the Centers for Disease Control and Prevention, the pneumococcal vaccination rate in the US in 2011 was 62.3% (influenza 64.9%) in persons older than 65, in high-risk patients younger than 65, 20.1% (influenza: age 18–49: 28.6%, age 50–64, 42.7%) (22, 23). The Department of Health determined a vaccination rate for the pneumococcal vaccine in the UK for the season 2007/2008 of 69% (24) for persons aged 65

TABLE 3

Overview of billed (= administered) doses for the pneumococcal vaccination

	Empirical results (vaccinated persons [n])					
	Age group 18–59 years			Age group ≥ 60 years		
	n	N	%	n	N	%
Total cohort of insured persons	1872	547 607	0.34	14 244	320 076	4.45
Cohort with no risk	1099	475 831	0.23	6977	153 155	4.55
Cohort with at least one risk	773	71 776	1.08	7267	166 921	4.35
Cohort with medium risk	599	45 410	1.32	6765	153 594	4.40
Cohort with high risk	283	31 585	0.90	1641	37 905	4.33

NB: For the purposes of this evaluation and for simplification purposes, we assumed that the documentation codes were used consistently throughout Germany and that the vaccination services and disorders were coded correctly

TABLE 4

Estimated proportion*¹ of vaccinated persons for the pneumococcal vaccination (simulation)

	Persons regarded as vaccinated (assumption) for	Proportion for the booster vaccination (assumption)					
		30%		50%		100%	
		Age group 18–59 years	Age group ≥ 60 years	Age group 18–59 years	Age group ≥ 60 years	Age group 18–59 years	Age group ≥ 60 years
Total cohort of insured persons	6 years	1.70%	24.89%	1.70%	24.85%	1.69%	24.85%
	10 years	2.23%	33.99%	2.17%	32.76%	2.10%	31.22%
	infinity	3.75%	50.89%	3.33%	47.46%	2.89%	43.21%
Cohort with no risk	6 years	1.11%	24.07%	1.11%	24.39%	1.11%	24.78%
	10 years	1.56%	34.68%	1.56%	35.44%	1.56%	36.34%
	infinity	2.42%	47.25%	2.42%	48.97%	2.42%	51.10%
Cohort with at least one risk	6 years	5.67%	25.82%	5.66%	25.14%	5.53%	24.98%
	10 years	6.64%	33.26%	6.19%	29.58%	5.55%	25.61%
	infinity	12.66%	54.67%	9.42%	45.37%	5.86%	34.48%
Cohort with medium risk	6 years	7.02%	26.08%	6.99%	26.04%	6.95%	25.41%
	10 years	8.19%	33.95%	7.19%	30.70%	6.97%	26.14%
	infinity	16.02%	56.75%	10.44%	47.97%	7.20%	35.98%
Cohort with high risk	6 years	4.48%	25.44%	4.47%	24.97%	4.37%	24.51%
	10 years	5.27%	32.56%	4.95%	29.10%	4.42%	24.90%
	infinity	8.93%	52.21%	7.16%	42.86%	4.96%	31.31%

*¹ The estimated proportion of vaccinated persons corresponds to the proportion of all persons who were vaccinated in the current period or are still considered as vaccinated in this period

and older (influenza, 73.5% [25]). The rates in Sweden in 2005 were 28% for pneumococcal vaccination and 39% for influenza vaccination (26).

The low vaccination rates for the pneumococcal vaccine may be the result of a lack of awareness of the risks posed by infectious diseases. However, skepticism regarding the effectiveness and/or safety of the pneumococcal polysaccharide vaccine may also play a

part (9, 27, 28). According to a oft-cited meta-analysis, no protection is conferred in cases of non-bacteremic pneumonia and only relative protection in IPD (odds ratio [OR] 0.26) (28). This OR (0.28) was also reported for bacteremic pneumococcal pneumonia in Germany (9). Only one clinical study (27) showed better efficacy. Estimates of the effectiveness in specific pneumococcal diseases may be gleaned from the model of Kuhlmann

TABLE 5

Overview of billed (= administered) doses for the influenza vaccination

	Empirical results(vaccinated persons [n])					
	Age group 18–59 years			Age group ≥ 60 years		
	n	N	%	n	N	%
Total cohort of insured persons	48 196	547 607	8.80	131 709	320 076	41.15
Cohort with no risk	43 193	475 831	9.08	65 011	153 155	42.45
Cohort with at least one risk	11 239	71 776	15.66	66 698	166 921	39.96
Cohort with medium risk	8417	45 410	18.54	62 376	153 594	40.61
Cohort with high risk	2328	31 585	7.37	14 319	37 905	37.78

NB: For the purposes of this evaluation and for simplification purposes, we assumed that the documentation codes were used consistently throughout Germany and that the vaccination services and disorders were coded correctly

et al. (2012 [17]), on which this study is based. Polysaccharide vaccines are regarded as not at all or barely suited to developing an immunological memory by administering booster vaccinations (hyporesponsivity syndrome) (29); for this reason, since 2009 the STIKO has been recommending a booster only in selected indications (30).

Since end-2012, the 13-valent pneumococcal conjugate vaccine has been licensed for the vaccination of adults older than 50 (12). The restricted recommendation from the STIKO regarding the use of the pneumococcal conjugate vaccine in adults is viewed critically by experts (31) as the success of conjugate vaccines is obvious in children (4, 32). The *Schutzimpfungsrichtlinie SI-RL* (the guideline on protective vaccinations) (33) allows for reimbursement for the conjugate vaccine for standard vaccination in adults too.

Further reasons for low vaccination rates may include insufficient take-up of doctor–patient contacts to check up on and boost vaccination protection (6, 34). For this reason it seems sensible to use every contact with patients, to address patients directly with regard to vaccination conferred protection and achieve an increase in vaccination rates. Further possible measures include the introduction of a bonus system for doctors and patients or the certification for vaccination training events, as well as reminders by telephone for insureds from their health insurance company (35, 36).

The economic consequences of low vaccination rates

The economic consequences of non-vaccination are made up of the savings made from vaccination costs (the vaccines and its administration) and the expenses incurred by pneumococcal diseases caused by non-vaccination (visits to doctors, inpatients' hospital stays, medication, nursing costs). The extent of these effects depends primarily on the effectiveness of the vaccine under real-world conditions, the vaccination rate, and the costs of the vaccine and those of the avoided cases of pneumococcal disease.

Limitations

Routine data can be accessed more rapidly and cost-effectively than primary data. However, there are some limitations that we will explain.

The diagnoses for determining the at-risk population could not be clearly determined from the STIKO's definition of risk. This may have resulted in a misestimation of the results in the at-risk groups. Relative to the entire cohort of insurance members, however, it can be assumed that vaccination rates vary only very slightly. This is because the overall number of doses administered does not change and the different vaccination schemes in the at-risk groups (rate of booster vaccinations) will lead to notable differences in the results only in case of the unrealistic assumption that the protection conferred does not fall over time. Furthermore, the calculated proportion of the at-risk population corresponds roughly with the data from the European Centre for Disease Prevention and Control. According to those data, the proportion of the population in Germany with at least one risk amounts to 28.1%, of which 19.8% is in the age group of those aged 65 or older and 8.3% in the age group <65 years (37).

Compared with the total of German statutory health insurers, the age distribution in our data set is average and no variations are known (personal communication, Braem A: distribution of insurance members compared with other statutory health insurers; 15 February 2012). Relative to the proportions in the available age groups, the age distribution in our cohort of insureds was comparable to that of the total population of Germany (*eFigure*). Therefore it appears probable that the results presented correspond to general vaccination practice in Germany. We did not intend to conduct any testing or extrapolations in this respect. For this reason, extreme caution is indicated when drawing conclusions about whether needs are met or not.

Since 1 July 2008 documentation numbers are valid (15) that are consistent nationwide, subsequent to the §20d SGB V (the part of the social code that relates to

health insurance) (38), which came into force on 1 April 2007. In the dataset under investigation, we still observed the use of different documentation code for the billing of vaccinations in Germany. This may on the one hand be the result of a latency period for the use of the new documentation codes, and on the other hand, an indication of incorrect use (in the sense of coding errors) (39, e1–e3).

A particularly limiting factor, however, is the short study period of a total of four quarters. The vaccination rates observed during this period provide only a small out-take of the pneumococcal vaccination status in adults.

Because of the limitations, our results on vaccination rates should be validated in further studies. Investigations regarding the effectiveness of the vaccination in routine medical care should also be conducted. Furthermore, qualitative studies of vaccination behavior may provide an insight into why vaccination rates are so low.

Conclusion

In the best case scenario, vaccination rates of pneumococcal vaccination are as high as those of influenza vaccination. Compared with the WHO target for influenza vaccination in older persons, both vaccination rates are lower. Contrary to expectations, our study shows that the pneumococcal vaccination in the age group 18–59 among the at-risk population was taken up less than in the 60 and over age group. Possible measures to improve vaccination rates include, for example, a bonus system for patients and doctors, an active approach to patients, using suitable opportunities for vaccination counseling, or certification of doctors by means of vaccination training.

KEY MESSAGES

- The rates for the pneumococcal vaccination we found for the billing period in our study are in the best-case scenario comparable to those of influenza vaccination.
- Both rates are lower than the WHO's target for influenza vaccination.
- Compared to the population without any risk factors, the at-risk population is more often vaccinated, but the vaccination rate in the age group 18–59 is much lower, at 12.66%, than that in the age group of 60 and older (54.67%), for whom the pneumococcal vaccination is generally recommended.
- The overall low rates may be the result of a lack of awareness of the risks of infectious diseases or insufficiently used contact opportunities between patients and doctors.
- Measures to improve vaccination rates may include a system of bonuses for doctors and patients, certification offered to doctors for participation in further professional training in vaccination, or use of available opportunities by the family doctor, who actively prompts patients for their vaccination status.

Conflict of interest statement

Ulrike Theidel MSc has received honoraria for consulting from Pfizer in the context of her work for Herescon. Furthermore she has received study support (third party funding), honoraria for speaking and authorship, and reimbursement for conference participation fees from Pfizer.

Alexander Kuhlmann MSc has received honoraria for authorship and has been reimbursed for conference participation fees and travel expenses from Pfizer. Furthermore he has received study support (third party funding) from Pfizer.

Dr Braem declares that no conflict of interest exists.

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Corresponding author

Ulrike Theidel, M.Sc.
Herescon GmbH
Königsworther Str. 2
30167 Hannover, Germany
theidel@herescon.com

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ORIGINAL ARTICLE

Pneumococcal Vaccination Rates in Adults in Germany

An Analysis of Statutory Health Insurance Data on More Than 850 000 Individuals

Ulrike Theidel, Alexander Kuhlmann, Anja Braem

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eTABLE

Risk definition based on ICD-10 categories

ICD-10 category	Risk definition*	Description
Medium risk (chronic disorder)		
I00–I99	I05–I09, I11–I13, I15, I20–I28, I42, I50	Cardiovascular disorders
J00–J99	J41–J44, J47, J80–J84, J60–J70	Respiratory disorders
E00–E90	E10–E16, E20–E22, E25–E27, E31–E32	Diabetes mellitus or other metabolic disorders
N00–N18	N01–N08, N11–N18	Chronic renal disease
G00–G99	G10–G32, G35–G37	Neurological disorders
High risk		
D50–D90	D50–D90	Diseases of the blood-forming organs
C00–C99	C30–C39, C81–C99	Neoplastic disease
B20–B24	B20–B24	HIV infection
Z94	Z94	Status post transplant

* The definition of the risk categories was done according to Fleming et al. (2006) (16)

eBOX

Dataset and conditions of the model simulation

All datasets were passed on in total and were available in an anonymized format including the age (month and year) and treatment dates of insured persons as well as documented diagnoses (ICD-10 codes). The analysis was restricted to persons continuously insured with the Deutsche BKK insurance company. The vaccination services were assigned to the risk groups according to their documentation codes by day and the insured persons according to predefined disease categories (*eTable*).

The vaccination rate is the quotient of the performed vaccinations in each quarter and the total numbers of insured persons by age group and risk group. For simplicity's sake we assumed that the documentation codes were used consistently all over Germany and that the vaccination services and disorders were coded correctly. Identified vaccination services were considered to have been administered. The disease categories were determined according to the underlying diseases named in the STIKO vaccination recommendation and matched to those of Fleming et al. (2006) (16).

The pneumococcal vaccination is not an annual vaccination. In order to determine the exact proportion of vaccinated persons for this period we needed to include persons who had received the vaccine in periods preceding the study period. To this end, we used in a second step an existing simulation model (17), which illustrates in a simplified format the age structure of persons insured with the Deutsche BKK.

In our model, the number of persons vaccinated before the study period is affected by, 1. how long a person is considered vaccinated, and 2. The number of booster vaccinations. Because of the uncertain data we calculated different scenarios for both these factors:

Ad 1: The total cohort is considered vaccinated for (a) 6 years (according to [18]), (b) 10 years (assumption based on [17, 19]), and (c) infinity (assumed).

Ad 2: 30%, 50%, and 100% of persons with at least one predefined risk receive the booster vaccination (rates below 30% were excluded as our empirical results showed that 39.76% of adults had received a booster [all age groups: 34.76%]).

Because of the six-yearly booster cycle imposed by the STIKO, the proportion of risk populations in the model receives a booster in any scenario. We determined the vaccination rates and the proportions of vaccinated persons iteratively in our model.

We were able to determine the vaccination rate for influenza without any problems from the dataset as the influenza vaccine is given annually.

We stratified the results by age group (18–59 years, 60 or older) and risk group (total cohort, no risk, at least one risk, medium risk, high risk).

Age group
distribution in the
dataset compared
with the population
of Germany

eFIGURE

Age group in years