Title: Poor knowledge of vaccination recommendations and negative attitudes towards vaccinations are independently associated with poor vaccination uptake among adults – findings of a population-based panel study in Lower Saxony, Germany

Authors: Manas K. Akmatov[1,2]*, Nicole Rübsamen[1,3]*, Igor V. Deyneko[1,4], André Karch[1,3], Rafael T. Mikolajczyk[1,5,6]

* These authors contributed equally to this work.

Affiliations:

[1] Helmholtz Centre for Infection Research, Inhoffenstr. 7, 38124, Braunschweig, Germany,

[2] TWINCORE, Centre for Experimental and Clinical Infection Research, Feodor-Lynen-Str. 9, 30625, Hanover, Germany

[3] PhD Programme ”Epidemiology” Braunschweig-Hanover, Germany

[4] Institute of Microbiology and Braunschweig Integrated Center of Systems Biology (BRICS), Technical University of Braunschweig, Braunschweig, Germany

[5] Medical School Hanover, Carl-Neuberg-Str. 1, 30625, Hanover, Germany

[6] Institute for Medical Epidemiology, Biometry, and Informatics, Medical Faculty of the Martin Luther University Halle-Wittenberg, Magdeburger Str. 8, 06112, Halle (Saale), Germany

E-mail addresses:

manas.akmatov@helmholtz-hzi.de; nicole_ruebsamen@web.de; igor.deyneko@inbox.ru; andre.karch@helmholtz-hzi.de; rafael.mikolajczyk@uk-halle.de

Corresponding author:

Manas K. Akmatov, MSc (Epi), DrPH

Helmholtz Centre for Infection Research

Inhoffenstr. 7, 38124, Braunschweig, Germany

Phone: +49(0)531-6181-5320

E-Mail: manas.akmatov@helmholtz-hzi.de

HaBIDS, Hygiene and Behaviour Infectious Diseases Survey
KAP, knowledge-attitudes-practice
MCA, multiple correspondence analysis
RKI, Robert Koch Institute
STIKO, Standing Committee on Vaccination

Abstract

Objectives

The aims of this study were to a) assess knowledge of official vaccination recommendations and attitudes towards vaccinations among adults and b) examine their association with vaccination uptake among adults.

Methods

This study was part of the HaBIDS study (Hygiene and Behaviour Infectious Diseases Survey), which is an online panel established in March 2014 in Lower Saxony, Germany with males and females aged between 15 and 69 years (n=2379). Every few months, participants completed questionnaires on different aspects of infectious diseases. In September 2014, knowledge of vaccination recommendations, attitudes towards vaccinations and information on uptake of vaccinations in the last 10 years (practice) were collected using a knowledge-attitude-practice (KAP) questionnaire. Multiple correspondence analysis was applied to identify underlying structures in each KAP domain and fractional polynomial regression analysis to examine the associations of knowledge and attitudes with vaccination uptake.

Results

Of the 2379 panel members, 1698 (71%) completed the KAP questionnaire on vaccinations. The majority of participants (80%) knew that the vaccine against diphtheria and tetanus should be administered every 10 years. Regarding other recommendations, the proportion of correct answers varied between 35% and 60%. 82% of participants agreed that adult vaccinations should be mandatory for selected groups such as health care workers and 40% stated that vaccinations should be mandatory for all adults. For the different vaccines, the odds of being unvaccinated were 1.5- to 5-times higher among participants with poor knowledge of vaccination recommendations compared to participants with good knowledge. Participants with negative attitudes towards vaccinations were also more likely to be unvaccinated.

Conclusions

Efforts should be undertaken to improve knowledge of official vaccination recommendations in the general population and reduce common misconceptions about vaccinations. This information can be provided during general practitioner visits or through media campaigns.

Keywords: knowledge, attitudes, practice, adult vaccinations, vaccination recommendations, Germany

Introduction

Adult vaccinations recommended by the German Standing Committee on Vaccination (STIKO) of the Robert Koch Institute (RKI) can be divided into two broad groups; 1) those for the general population and 2) those for specific risk groups such as individuals with underlying chronic diseases (*e.g.* pneumococcal vaccination for individuals with diabetes mellitus, chronic heart or lung disease or immune compromised individuals), individuals with occupational risks (*e.g.* varicella vaccination for health care workers) or travellers in high endemic regions (*e.g.* vaccination against meningococcal infection for Hajj travellers) [1]. In addition to general recommendations, there are specific recommendations regarding booster vaccination and catch up programs. Regular booster doses against diphtheria and tetanus are recommended every 10 years for adults in the general population [1]. A single booster dose of pertussis vaccination is recommended since 2009 for all adults and should be administered with the next diphtheria and tetanus vaccination. There is a recommendation for measles, mumps and rubella vaccination for individuals born after 1970 and not vaccinated previously. There is also a recommendation for administering inactivated polio vaccine for adults who were previously not vaccinated or vaccinated incompletely. The STIKO recommends annual vaccinations against seasonal influenza infection and vaccination against pneumococcal infection for individuals over 60 years of age.

Available estimates of vaccination coverage among adults show that they are lower than coverage estimates among children in Germany [2;3]; the highest coverage was reported for tetanus vaccination (70-75%) and the lowest for pertussis vaccination (8%). In contrast, the coverage of tetanus and pertussis vaccinations for German children is >90% [4]. It is not well known which factors lead to a poor vaccination status of German adults. Decision to be vaccinated is a complex process influenced by many factors: contextual influences, individual and group influences as well as vaccine/vaccination-specific influences [5]. Understanding these influences may help to develop tailored interventions to improve vaccination coverage in the general adult population. Nichter has differentiated active demand for vaccinations (adherence by an informed public) from passive acceptance of vaccinations (compliance by a public which yields to recommendations and social pressure) [6]. Jarrett et al. reported in a systematic review that the interventions with the largest observed increases (>25%) in vaccine uptake were those that aimed to increase vaccination knowledge and awareness [7]. In studies of parents' choice to get their children vaccinated, this choice was often based on conformity

or following what is recommended [8]. Knowledge of current vaccination recommendations is, thus, important in increasing vaccine uptake. This association has already been shown for influenza vaccination in Austria and the United States [9;10]. Betsch et al. found out that knowledge seems to be an indirect driver of vaccination intentions [11].

A few available studies in Germany examined the effect of socioeconomic factors on selected vaccinations among adults. For example, Bödeker et al. demonstrated age-, sex- and regional differences in coverage of tetanus, pertussis and influenza vaccinations [2]. In addition, Böhmer et al. showed that individuals with a lower socioeconomic status, those with a migration history and those not caring about personal health were less likely to be vaccinated against tetanus and influenza [12]. Recently, Klett-Tammen et al. showed that uptake of influenza vaccination among older German individuals was associated with attitudes towards vaccinations (perceived importance of the influenza vaccination, vaccination due to recommendation by physician or family member), whereas pneumococcal vaccination was associated with the knowledge of vaccination recommendation [13]. In this study, attitudes towards one vaccine did not influence uptake of other vaccines. In contrast to other studies in Germany, which dealt with single or a few vaccinations and included only specific population groups such as the elderly, the present study provides a more complete picture including a broad range of vaccinations recommended for the general adult population. The study focuses on influences arising from personal perception of vaccines, particularly knowledge and attitudes. Thus, the aims of the study were to a) assess knowledge of official vaccination recommendations and attitudes towards vaccinations among adults and b) examine their association with adult's vaccination uptake.

Materials and Methods

Study design and sampling

This study was part of the HaBIDS study (**H**ygiene and **B**ehaviour **I**nfectious **D**iseases **S**urvey), which is a longitudinal online panel aiming to assess hygiene practices and behaviour regarding various infectious diseases in the federal state of Lower Saxony, Germany. The detailed description of the applied methodology is presented elsewhere [14;15]. In brief, around 27,000 males and females between 15 and 69 years of age were invited to participate in the panel. Potential participants were randomly selected from the population registries in urban (Braunschweig, Salzgitter and Wolfenbüttel)

and rural areas (Vechta) and invited to participate in the panel between January and April 2014. Each month, participants complete questionnaires on different aspects of infectious diseases. Individuals were given an opportunity to select between two modes of participation (web- or paper-based) in Braunschweig and Vechta while in Wolfenbüttel and Salzgitter only a web-based participation was offered. The participants who selected web-based approach received monthly a total of nine questionnaires on different topics between March and November 2014. The participants of the paper-based approach received two longer questionnaires covering the themes of the nine online questionnaires. The 2379 individuals who had consented to participate in the panel (8.9% initial response rate) received the questionnaire on adult vaccinations in September 2014. Seventy one percent of the panel members (n = 1698) returned this questionnaire.

KAP questionnaire on adult vaccinations

The questionnaire on adult vaccinations was designed as a knowledge-attitude-practice (KAP) survey. The questions were developed for the study aims or adapted from the literature [16]. Knowledge of official recommendations on adult vaccinations was assessed by six statements (true as well as false statements) with three answer options: ‘true, ‘untrue’ and ‘don’t know’. We used different questions to assess the attitudes towards vaccinations. First we asked about attitudes towards tetanus and influenza vaccination because these two vaccines are known to be perceived differently [17]. The following three questions were used: ‘What is your general attitude towards vaccinations?’, ‘What is your attitude towards vaccination against tetanus?’ and ‘What is your attitude towards vaccination against influenza?’ with five response options: ‘supportive’, ‘slightly supportive’, ‘slightly negative’, ‘negative’ and ‘don’t know’. In addition, eight items were used to assess various attitude aspects with five categories (‘strongly agree’, ‘agree’, ‘disagree’, ‘strongly disagree’, and ‘don’t know’). Uptake of vaccinations (practice domain) was assessed for each of the following vaccinations: diphtheria, tetanus, pertussis, poliomyelitis, hepatitis B and pneumococcus by the question ‘Were you vaccinated against the following infectious diseases in the last 10 years?’ with three answer possibilities for each vaccination (‘yes’, ‘no’ and ‘don’t know’).

Socio-demographic and health-related data

Basic socio-demographic data (*e.g.* sex, age, education level, and country of birth) and health-related data (*e.g.* perceived health status) were collected using a questionnaire applied within the panel on a separate occasion.

Statistical analysis

Initially, we calculated the proportion of correct answers on each knowledge item and proportion of positive attitudes towards vaccinations by 10-year age groups. Next, we estimated the proportion of participants vaccinated in the last 10 years for each of the six vaccines (*i.e.* diphtheria, tetanus, pertussis, poliomyelitis, hepatitis B and pneumococcus) stratified by sex and 10-year age groups. We applied sample weights to obtain state representative estimates for the federal state of Lower Saxony by using the distribution in the federal state with respect to sex, age and education. The latter data were obtained from the Federal Statistical Office [18]. Furthermore, we applied multiple correspondence analysis (MCA) to identify the relationship of qualitative variables in each of the three KAP domains (*i.e.* knowledge about official vaccination recommendations for adults [six items], attitudes towards vaccinations [eight items] and uptake of vaccinations in the last 10 years [six items]). MCA is a statistical technique used to examine the relationship pattern of several nominal variables [19]. We presented biplots of the first two dimensions to graphically assess the relationship across the examined variables; the relative position of the respective categories on the biplots indicates the relationship across the categories. Only a few variables contributed to the second dimensions in the knowledge and attitudes domains (Supplementary Fig. 1A and 1B). We thus used only the first dimensions for further analyses. In the practice domain (vaccination uptake) there was evidence of two-dimensionality, however, all six vaccinations contributed strongly to the first dimension (Supplementary Fig. 1C). We thus used the first dimension for further analysis as an indicator of practice in relation to vaccination. In case of the knowledge and attitude scores, the lower values represent poorer knowledge and less positive attitudes. With respect to the knowledge score, participants were divided into tertiles, *i.e.* ‘poor’, ‘medium’ and ‘good knowledge’. Similarly, based on the attitude score participants were divided into tertiles, *i.e.* ‘negative’, ‘neutral’ and ‘positive attitudes’. With respect to the practice score, participants were divided arbitrarily into three (unequal) groups, ‘poor’, ‘good’ and ‘unknown’ (Supplementary table 1). In the next step, we performed multivariable fractional polynomial regression analysis to examine the associations of knowledge and attitudes with individual’s vaccination uptake. For each of the six vaccinations, a separate regression model was

created, adjusted for sex, age, education level, and country of birth. The dependent variables were vaccinations for diphtheria, tetanus, pertussis, poliomyelitis, hepatitis B and pneumococcus. The category 'don't know' was removed from the analysis because we were interested in differences between those vaccinated and unvaccinated. In addition, a separate logistic regression model was created with the dependent variable 'practice in relation to vaccination' received from MCA. The analysis was conducted with the statistical programmes Stata, version 12 (StataCorp LP, Texas, USA) and the R Foundation for Statistical Computing, version 3.3.2 (https://www.r-project.org). The R package 'FactoMineR' was used for MCA [20].

Ethical approval

The study was approved by the Ethics Committee of the Hannover Medical School (No. 2021-2013) and by the Federal Commissioner for Data Protection and Freedom of Information, Germany. Each participant provided written informed consent before entering the study.

Results

Description of the sample

Of the 2379 panel members, 1698 (71%) completed the KAP questionnaire on vaccinations. Among these participants, the proportion of females was higher than of males (Table 1). Approx. 95% of participants were born in Germany and approx. 94% reported having a vaccination card. There were some differences in sociodemographic characteristics between males and females; *e.g.* there was a higher proportion of males than females with a university degree (Table 1, X^2=40.369, df=3, p<0.0001).

Table 1. Sociodemographic and health-related characteristics of the study population, by sex, unweighted percentage

Characteristics	Female (n=1023)	Male (n=668)	Total (n=1698)*
Age groups			
15-19 years	4.0	3.2	3.5
20-29 years	12.9	12.8	12.9
30-39 years	13.3	16.1	15.0
40-49 years	20.5	25.0	23.2
50-59 years	25.3	24.5	24.8
60-69 years	24.0	18.3	20.5
Education level			
Lower secondary education or apprenticeship	34.9	22.4	30.0
Still at upper secondary school	1.8	3.2	2.3
University entrance qualification (upper secondary	27.2	25.6	26.6

education or vocational school)			
University degree	36.1	48.9	41.1
Marital status			
Single	27.0	30.9	28.6
Married	59.8	62.0	60.7
Divorced	9.8	6.1	8.4
Widowed	3.3	0.9	2.3
Country of birth			
Germany	95.1	95.1	95.1
Other	4.9	4.9	4.9
Self-perceived health status			
Poor	0.4	0.9	0.6
Fair	8.9	9.3	9.0
Good	51.3	45.2	48.9
Very good	34.2	38.8	36.1
Excellent	5.2	5.8	5.4
Availability of vaccination card			
Yes	94.8	92.5	93.9
No	4.1	5.3	4.6
Don't know	1.1	2.3	1.5
* Information on sex was missing for 7 participants. The proportion of missing values for other variables in the table was <2%.			

Knowledge of vaccination recommendations

Findings on knowledge of official vaccination recommendations are presented in Table 2. The majority of participants (80%) knew that the vaccine against diphtheria and tetanus should be administered every 10 years. Regarding other vaccinations, the proportions of correct answers varied between 35% and 60%. There was an association of knowledge items and participant's age, however, without similar pattern across knowledge items. For example, knowledge regarding diphtheria/tetanus and poliomyelitis vaccination recommendations increased with advancing age, whereas knowledge regarding measles decreased (Table 2). Of note, only 44% of participants in the age group 60-70 years were aware of the recommendation regarding pneumococcal vaccination for those above 60. The first two dimensions obtained from the MCA explained approx. 50% of the variance (Fig. 1A). There was a distinct group of participants with good knowledge regarding vaccination recommendations against diphtheria, poliomyelitis, measles and pneumococcal infection. Knowledge of influenza and rabies vaccinations made the second dimension (Supplementary Fig. 1A). The distribution of the first dimension is presented in Fig. 1B; the majority of the participants had good or moderate knowledge, a small proportion of participants had poor knowledge (represented by the small peak on the left side of the score).

Table 2. Knowledge of official recommendations regarding adult vaccinations by age group, weighted percentage[a]

	15-19 years, n=103	20-29 years, n=232	30-39 years, n=216	40-49 years, n=373	50-59 years, n=310	60-70 years, n=252	Total, N=1485
Knowledge items	**Correct[b] %**	**Correct[b] %**	**Correct[b] %**	**Correct[b] %**	**Correct[b] %**	**Correct[b] %**	**Correct[b] %**
All adults over 18 years should be vaccinated every 10 years against diphtheria and tetanus (true)	65.4 (55.8-73.8)	72.7 (66.6-78.1)	80.9 (75.2-85.6)	83.4 (79.3-86.8)	81.0 (76.2-84.9)	86.6 (81.8-90.2)	80.1 (78.0-82.1)
All adults, who are not protected against measles, should be vaccinated (true)	71.8 (62.5-79.6)	57.6 (51.1-63.8)	41.9 (35.5-48.5)	47.2 (42.2-52.3)	47.9 (42.3-53.5)	40.3 (34.4-46.5)	48.7 (46.2-51.3)
All adults over 18 years should be vaccinated against influenza (false)	64.1 (54.5-72.7)	65.5 (59.2-71.3)	49.1 (42.5-55.7)	62.3 (57.2-67.1)	62.8 (57.2-68.1)	52.6 (46.4-58.7)	59.4 (56.9-61.9)
All adults over 60 years should be vaccinated once against pneumococcal infection (true)	53.4 (43.8-62.7)	36.0 (30.0-42.4)	24.7 (19.4-30.8)	35.0 (30.4-40.0)	27.1 (22.4-32.3)	44.0 (38.0-50.2)	34.8 (32.4-37.3)
All adults over 18 years, who were not vaccinated against poliomyelitis, should be vaccinated (true)	30.0 (21.9-39.6)	36.1 (30.2-42.5)	47.4 (40.8-54.1)	52.6 (47.5-57.6)	49.2 (43.6-54.8)	57.9 (51.7-63.9)	47.9 (45.3-50.4)
All dog owners should be vaccinated against rabies (false)	39.8 (30.9-49.5)	48.3 (41.9-54.7)	34.7 (28.7-41.3)	49.5 (44.4-54.5)	44.0 (38.6-49.7)	26.9 (21.8-32.7)	41.5 (39.0-44.0)

[a] Poststratification weights were applied by using the distribution of the general population of the federal state of Lower Saxony with respect to sex, age and education.
[b] Percentage of correct answers. The proportion of incorrect answers can be subtracted. 'Don't know' answers count as incorrect answers. The proportion of 'Don't know' answers across knowledge items varied between 14% and 55%.

Attitudes towards adult vaccinations

In general, approx. 88% of the study participants reported positive attitudes towards adult vaccinations (Fig. 2). However, attitudes differed by specific vaccinations; for example, the majority of participants (95%) showed positive attitudes towards tetanus vaccination whereas less than half of participants (43%) had positive attitudes towards influenza vaccination. Responses to the attitude items by age are presented in Table 3. Approx. 95% of the study participants agreed with the statement 'Vaccinations are effective means to protect against severe infectious diseases'. 82% and 40% of the study participants supported mandatory vaccinations for specific population groups such as health care workers and for all adults, respectively. However, every third participant agreed with the statement 'I am concerned that my immune system could become weakened as a result of too many vaccinations'. Approx. 30% of the variance was explained by the first two dimensions of attitude items obtained from the MCA (Fig. 1C). There was a distinct group of participants who tended to have positive attitudes towards various items (represented by green colour in the Fig. 1C). All attitudes items, except "fear of injections", contributed to the first dimension (Supplementary Fig. 1B). The distribution of the first dimension is presented in Fig. 1D; the majority of participants had positive attitudes (seen at the right side of the score) and only a small proportion of participants had negative attitudes (represented by the left tail of the score).

Table 3. Attitudes towards adult vaccinations by age group, weighted percentage[a]

	Age groups						
	15-19 years, n=113	**20-29 years, n=231**	**30-39 years, n=221**	**40-49 years, n=373**	**50-59 years, n=310**	**60-70 years, n=253**	**Total, N=1501**
Attitudes items	**Strongly agree/ agree[b], %**	**Strongly agree /agree[b], %**	**Strongly agree/ agree[b], %**	**Strongly agree/ agree[b], %**	**Strongly agree/ agree[b], %**	**Strongly agree/ agree[b], %**	**Strongly agree/ agree[b], %**
Vaccinations are effective means to protect against severe infectious diseases	100 (96.5-100)	91.8 (87.4-94.8)	95.6 (91.8-97.7)	94.9 (92.1-96.8)	90.5 (86.7-93.4)	97.5 (94.7-98.9)	94.4 (93.1-95.5)
Vaccinations are getting better and safer	85.9 (77.3-91.6)	77.7 (71.3-83.0)	82.9 (76.7-87.7)	82.5 (78.0-86.3)	83.1 (78.1-87.1)	89.7 (84.8-93.2)	83.4 (81.2-85.3)
I am for mandatory vaccinations for all adults	39.2 (30.1-49.1)	33.4 (27.6-39.9)	48.5 (41.7-55.4)	40.4 (35.3-45.8)	29.6 (24.5-35.2)	40.4 (34.4-46.7)	38.2 (35.7-40.8)
I am for mandatory vaccinations for some individuals such as health care workers	86.4 (78.5-91.7)	75.6 (69.4-80.8)	85.7 (80.2-89.9)	82.9 (78.6-86.5)	80.5 (75.6-84.7)	84.7 (79.6-88.7)	82.3 (80.2-84.2)
I am concerned that my immune system could become weakened as a result of too many vaccinations	23.3 (16.2-32.3)	33.8 (27.9-40.2)	35.2 (29.1-41.9)	31.3 (26.6-36.4)	31.2 (25.9-37.0)	32.1 (26.3-38.6)	31.8 (29.4-34.3)
I will not get vaccinations because of fear of injections	1.9 (0.5-6.7)	6.5 (4.0-10.4)	7.0 (4.3-11.2)	1.7 (0.8-3.7)	3.4 (1.9-6.1)	1.2 (0.4-3.5)	3.5 (2.7-4.6)
I will not get vaccinations because of fear of side effects	7.6 (3.9-14.3)	20.4 (15.7-26.1)	20.9 (16.0-26.9)	16.2 (12.8-20.4)	20.5 (16.3-25.6)	14.0 (10.2-18.9)	17.5 (15.6-19.5)
I will not get vaccinations because of fear of long-term consequences	0.9 (0.2-5.2)	16.4 (12.1-21.9)	15.0 (10.8-20.3)	9.4 (6.8-12.9)	14.3 (10.7-18.8)	8.7 (5.7-12.9)	11.6 (10.0-13.3)

[a] Poststratification weights were applied by using the distribution of the general population of the federal state of Lower Saxony with respect to sex, age and education.
[b] The proportion of participants who answered 'strongly disagree/disagree' can be subtracted.

Vaccination uptake

The proportion of participants who reported having been vaccinated in the last 10 years varied between 16% (pneumococcal vaccination) and 78% (tetanus vaccination) (Table 4). For all vaccinations, the proportion of vaccinated participants was higher among females than males (Table 4). Overall, the proportion of vaccinated participants was higher among younger age groups, in particular, in the age youngest group '15-19 years'. Of note, only every third participant in the age group '60-70 years' reported vaccination against pneumococcal infection (the target group according to official vaccination recommendations). The MCA identified distinct patterns regarding practice in relation to vaccination (Fig. 3A); participants who reported having received several vaccinations in the last 10 years clustered together whereas participants who did not receive vaccinations made another cluster. We arbitrarily divided participants into three groups, i.e. 'poor' (20%), 'good' (70%) and 'unknown' (10%) (Fig. 3B). Participants in the 'poor' group were not vaccinated against diphtheria and pertussis at all and nearly all of them missed vaccinations against poliomyelitis, pneumococcus and hepatitis B (Supplementary table 1). The proportion of vaccinated participants varied between 23% (pneumococcus) and 97% (tetanus) in the group with 'good' vaccination practice (Supplementary table 1). Figures 3C and 3D shows exemplary individual object scores of the first two dimensions by three categories of diphtheria and tetanus vaccinations, *i.e.* a) reported being vaccinated against diphtheria and tetanus vaccinations in the last 10 years, b) reported being not vaccinated and c) reported 'don't know'.

Table 4. Estimated proportions of individuals vaccinated in the last 10 years by sex and age group, weighted percentage[a]

Vaccination	Sex	15-19 years	20-29 years	30-39 years	40-49 years	50-59 years	60-70 years	Total
Diphtheria	Female	88.6 (76.0-95.0)	55.4 (46.5-63.9)	57.9 (48.5-66.9)	64.9 (57.6-71.6)	51.7 (43.6-59.8)	54.3 (45.3-63.1)	59.3 (55.6-62.9)
	Male	37.5 (26.0-50.6)	29.9 (22.1-39.2)	62.4 (52.6-71.2)	55.4 (48.0-62.6)	29.1 (22.3-36.8)	39.0 (30.3-48.6)	42.9 (39.3-46.6)
	Total	60.0 (50.2-69.1)	43.4 (37.1-49.9)	60.1 (53.3-66.5)	60.2 (55.0-65.2)	40.2 (34.7-45.9)	47.1 (40.6-53.6)	51.2 (48.6-53.8)
Tetanus	Female	100.0 (92.9-100)	73.4 (65.0-80.4)	70.6 (61.5-78.4)	83.3 (77.2-88.1)	79.5 (72.5-85.1)	81.8 (74.4-87.5)	79.9 (76.9-82.6)
	Male	73.2 (60.4-83.0)	57.9 (48.5-66.9)	86.4 (78.7-91.6)	87.5 (81.9-91.5)	71.4 (63.8-78.0)	74.6 (66.0-81.6)	76.4 (73.2-79.3)
	Total	85.8 (78.0-91.2)	66.2 (59.9-72.0)	78.5 (72.5-83.5)	85.4 (81.4-88.7)	75.5 (70.4-79.9)	78.4 (72.9-83.1)	78.2 (76.0-80.2)
Pertussis	Female	81.8 (68.0-90.5)	39.2 (30.9-48.1)	39.0 (30.3-48.6)	41.0 (33.7-48.7)	23.6 (17.1-31.7)	22.7 (15.5-32.0)	37.0 (33.4-40.8)
	Male	50.9 (37.9-63.9)	34.0 (25.6-43.6)	15.3 (9.5-23.7)	28.8 (22.6-35.9)	12.9 (8.4-19.5)	21.4 (14.5-30.5)	25.0 (21.9-28.4)
	Total	64.9 (55.0-73.7)	36.8 (30.7-43.3)	27.6 (21.9-34.1)	34.6 (29.7-39.8)	18.0 (13.9-23.1)	22.1 (16.8-28.4)	30.9 (28.5-33.5)
Poliomyelitis	Female	91.5 (80.1-96.6)	37.0 (28.8-45.9)	40.2 (31.2-49.9)	51.2 (43.7-58.6)	40.3 (32.5-48.6)	44.0 (35.1-53.4)	46.5 (42.8-50.2)
	Male	62.5 (49.4-74.0)	30.8 (22.9-40.1)	36.4 (27.6-46.2)	45.4 (38.2-52.8)	20.7 (14.9-28.0)	29.7 (21.7-39.2)	35.6 (32.1-39.3)
	Total	75.7 (67.4-83.6)	34.1 (28.3-40.6)	38.3 (32.2-45.5)	48.2 (43.0-53.5)	30.3 (25.2-35.9)	37.1 (31.3-44.3)	41.1 (38.7-43.9)
Hepatitis B	Female	80.4 (66.8-89.3)	58.2 (49.3-66.6)	45.7 (36.5-55.2)	42.8 (35.5-50.4)	34.4 (26.8-42.8)	26.9 (19.4-35.9)	44.4 (40.7-48.2)
	Male	38.9 (27.0-52.2)	50.5 (41.1-59.8)	59.4 (49.7-68.5)	37.8 (30.9-45.2)	19.1 (13.5-26.4)	29.3 (21.1-38.9)	38.0 (34.4-41.7)
	Total	58.0 (48.2-67.2)	54.6 (48.1-60.9)	52.4 (45.6-59.1)	40.2 (35.1-45.5)	26.5 (21.3-31.7)	28.0 (22.2-34.3)	41.2 (38.5-43.8)
Pneumococcus	Female	51.2 (36.8-65.4)	16.1 (10.6-23.8)	12.7 (7.6-20.6)	15.7 (10.8-22.3)	5.1 (2.4-10.7)	29.7 (21.7-39.2)	18.0 (15.2-21.2)
	Male	37.7 (25.9-51.2)	14.2 (8.8-22.0)	5.1 (2.2-11.4)	10.5 (6.7-16.2)	6.6 (3.5-12.0)	28.7 (20.8-38.2)	14.5 (12.0-17.4)
	Total	43.8 (33.9-53.2)	15.2 (11.4-20.9)	9.0 (5.4-13.3)	13.0 (9.8-17.2)	5.9 (3.6-9.5)	29.2 (23.4-35.8)	16.2 (14.3-18.3)

[a] Poststratification weights were applied by using the distribution of the general population of the federal state of Lower Saxony with respect to sex, age and education.

Association of knowledge and attitudes and vaccination uptake

The results of the multivariable fractional polynomial regression models are presented in Table 5. For the different vaccines, the odds of being unvaccinated was 1.5- to 5-times higher among participants with poor knowledge of vaccination recommendations compared to participants with good knowledge. Participants with negative attitudes towards vaccinations were also more likely to be unvaccinated (with odds ratios ranging between 2 and 4). Similar results were obtained for the overall vaccination uptake (Table 5, 8th column). Males were more likely to be unvaccinated against diphtheria, pertussis and poliomyelitis. Vaccination uptake decreased with advancing age for almost all vaccinations, however, with different patterns of associations (Fig. 4). Diphtheria, tetanus and hepatitis B vaccinations decreased linearly with advancing age. A nonlinear association was observed for pertussis, poliomyelitis and pneumococcus. Uptake of pertussis and poliomyelitis vaccination decreased up to the age of 40 years and continued decreasing slightly in older age groups. Pneumococcal vaccination uptake decreased up to the age of 50 years and increased afterwards (Fig. 4).

Table 5. Associations between vaccination uptake and knowledge of official vaccination recommendations and attitudes towards vaccinations (results of the multivariable logistic regression analyses)

	Adjusted odds ratios[a] and 95% confidence intervals for being unvaccinated in the last 10 years						
	diphtheria	**tetanus**	**pertussis**	**poliomyelitis**	**hepatitis B**	**pneumococcus**	**poor vs. good vaccination uptake[b]**
Knowledge about official recommendations[b]							
Poor	3.66 (2.68-5.00)	2.17 (1.51-3.10)	3.40 (2.43-4.75)	5.11 (3.72-7.02)	1.66 (1.24-2.22)	2.00 (1.32-3.02)	3.35 (2.41-4.63)
Medium	1.24 (0.91-1.68)	1.07 (0.73-1.56)	1.49 (1.10-2.01)	1.46 (1.10-1.94)	1.07 (0.81-1.42)	1.44 (0.98-2.10)	1.34 (0.96-1.88)
Good	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Attitudes towards vaccinations[b]							
Negative	3.89 (2.84-5.32)	4.10 (2.73-6.16)	3.59 (2.58-4.99)	2.84 (2.09-3.85)	2.17 (1.62-2.89)	2.91 (1.89-4.47)	3.73 (2.66-5.25)
Neutral	1.60 (1.16-2.20)	2.03 (1.32-3.12)	1.38 (1.02-1.87)	1.33 (0.99-1.80)	1.46 (1.10-1.94)	1.20 (0.83-1.74)	1.82 (1.27-2.59)
Positive	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Sex							
Male	2.06 (1.60-2.65)	1.10 (0.83-1.47)	2.12 (1.61-2.79)	2.03 (1.58-2.61)	1.03 (0.81-1.30)	1.33 (0.94-1.87)	1.64 (1.27-2.12)
Female	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Education level							
Lower secondary education or apprenticeship or still at upper secondary school	1.12 (0.84-1.50)	0.96 (0.70-1.32)	1.10 (0.81-1.50)	1.04 (0.78-1.39)	1.13 (0.86-1.49)	0.68 (0.46-1.00)	1.08 (0.81-1.45)
University entrance qualification (upper secondary education or vocational school)	0.90 (0.66-1.22)	0.61 (0.42-0.88)	1.06 (0.77-1.45)	0.90 (0.66-1.22)	0.98 (0.74-1.29)	0.69 (0.46-1.04)	0.87 (0.63-1.20)
University degree	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Country of birth							
Germany	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Other	1.42 (0.81-2.48)	1.46 (0.84-2.54)	1.55 (0.79-3.04)	1.35 (0.73-2.47)	1.02 (0.60-1.72)	1.36 (0.57-3.25)	1.64 (0.94-2.86)

[a] Adjusted for age (see Fig. 4) and all other variables in the table
[b] Derived from the multiple correspondence analysis (see Methods section).

Discussion

Using data from a population-based panel study we assessed the knowledge of official vaccination recommendations, attitudes towards vaccinations and examined their associations with vaccination uptake among adults in Lower Saxony, Germany. To the best of our knowledge, this is the first study that conducted a full vaccination-related KAP survey in the general adult German population. Previous research in Germany has focused on a) specific population subgroups (*e.g.* children [21], pregnant women [22], elderly individuals [23] or physicians [24]), b) examined various risk factors of poor vaccination uptake not related to KAP (*e.g.* sociodemographic factors) [2;12] and c) examined only single [21;23] or a few vaccinations [13;25]. In contrast to these studies we included a broad range of adult vaccinations which have not been examined previously and a broader age range (15-70 years). In addition, our panel study was specifically designed to examine KAP-related research questions for various infection/vaccination-related topics [15].

Knowledge of official recommendations varied by specific vaccinations. The highest proportion of correct answers was observed for diphtheria and tetanus vaccination recommendations. This is in line with findings from other studies that showed that tetanus vaccination is the best accepted vaccination in the general population, also reflected in relatively high vaccination coverage reported (70-75%) [2;3]. In agreement with these results, tetanus vaccination coverage was the highest among the vaccinations in our study (78%). Good knowledge of and positive attitudes towards tetanus vaccination may at least partly be associated with treatment of wounds [17]. Regarding other vaccinations, we observed considerable deficits in participants' knowledge. In particular, a considerable proportion of individuals in the age group of '60-70' years demonstrated poor knowledge regarding influenza and pneumococcal vaccination recommendation. Not surprisingly, only 30% of the participants of our study above 60 years reported having obtained pneumococcal vaccination. Whereas the diphtheria and tetanus vaccination recommendation did not change over a long period of time, there were multiple changes for other vaccination recommendations in recent years, which may partly explain poor knowledge. For instance, a measles vaccination recommendation was extended in 2010 to all adults born after 1970 who were previously not vaccinated or were vaccinated not completely. There were multiple changes for pneumococcal vaccination recommendation; the last change took place in 2009. In general, the majority of participants had positive attitudes towards vaccinations, however, the attitudes varied by specific vaccinations. For example, more than half of participants had negative

attitudes towards a seasonal influenza vaccination whereas tetanus vaccination was well accepted. Consistently with above reported results, attitudes towards tetanus vaccination were even better than attitudes towards vaccinations in general. Although the majority of participants (94%) agreed with the statement that vaccines are effective against infectious diseases, up to 17% stated that they will not obtain vaccinations because of side effects or long-term consequences. Obviously, these participants may have supportive attitudes towards vaccinations, but at the same time they possess common misconceptions regarding vaccinations. These individuals can be classified as 'hesitant' or 'late or selective vaccinators' [26]. Hesitant individuals may have significant concerns about vaccinations, but may still get vaccinations. Both groups may benefit from vaccine-related educational programs, as they do not refuse vaccinations in principle and are not fixed in their less positive attitudes. Providing specific vaccine-related knowledge may help to change their attitudes toward vaccinations. It is more difficult to deal with individuals who refuse all vaccinations, the so-called 'refusers' [26]. This group is convinced about negative effects of vaccinations due to vaccine safety concerns, religious beliefs or mistrust in traditional medicine. Fortunately, only a small proportion of individuals (1.5%) reported negative attitudes towards vaccinations in general, however, 8.9% reported "slightly negative attitudes" (Fig. 2), which is also in agreement with findings form other studies [21]. The association between level of knowledge about vaccination and vaccine acceptance is not straightforward [8]. Vaccination campaigns need to address both the active and the passive demanders [6]. Active demanders are more likely to benefit from increased knowledge and education, and educational campaigns addressing knowledge deficits are reported to be effective [7]. However, the most effective interventions employed multiple strategies, i.e. increasing knowledge alone is not sufficient to increase vaccine uptake.

The multiple correspondence analysis revealed distinct groups of participants in each KAP domain. We found individuals who tended to have poor knowledge, negative attitudes and poor vaccination uptake. Males and those born outside Germany were significantly more likely to have poor knowledge (data not shown). Of note, participants' education level was not associated with knowledge and attitudes. Further research is needed to identify these population groups and implement tailored intervention programs.

We observed a systematic pattern of associations between knowledge and attitudes and adult's vaccination uptake; the risk of being unvaccinated with all six vaccines was higher among participants

with poor knowledge and negative attitudes. A similar finding was observed for the overall vaccination uptake. The effects for the attitude score across all vaccinations ranged between two and four and for the knowledge score between two and five. In contrast to these findings, Klett-Tammen et al. showed various patterns of associations for three vaccinations (tetanus, influenza and pneumococcus); *e.g.* the strongest determinant of tetanus and influenza vaccinations was attitude-related, whereas pneumococcal vaccination was knowledge-associated [13]. Their findings indicate the need for vaccine type-specific intervention programs. Our findings regarding knowledge and attitudes are consistent for all vaccinations that facilitate the development of common intervention programs for all six examined vaccinations.

The associations between participants' age and all vaccinations, except pneumococcal vaccination had a similar pattern; the risk of being unvaccinated increased with advancing age. In case of pneumococcal vaccination we observed an increase at the age of 60 years, which is explained by the recommendation to receive this vaccination. However, overall, the proportion of vaccinated individuals in this age group was low (30%). The risk of being unvaccinated with diphtheria, pertussis and poliomyelitis vaccinations was 2-times higher among males than females. These findings are important as knowing specific population subgroups at higher risk of being unvaccinated or specific factors associated with poor vaccination uptake may be used in tailored intervention programs. Health care professionals may play a pivotal role in providing vaccine-related information to patients and in reducing common misconceptions by addressing specific vaccine concerns. A framework for communicating with parents regarding childhood vaccinations has already been developed for health professionals and can be adapted for adult populations [26]. In addition, vaccine-related knowledge can be distributed in mass media campaigns [27].

Strengths and limitations

One of the main strengths of the study is a population-based sampling with poststratification weighting which may allow providing state representative estimates of knowledge of vaccination recommendations, attitudes towards vaccinations and vaccination uptake. Poststratification weighting was performed with regard to sex, age and education level. However, it remains unclear whether the study population represents the general population of the federal state Lower Saxony with regard to other factors such as health status, or health-seeking behaviour. Another strength of the study is the

application of multivariate techniques to examine underlying structures in all three KAP domains. This analysis allows examination of the relationship of several nominal variables and identification of group of individuals with similar knowledge, attitudes or vaccination behaviour. A few limitations of the study should be mentioned: i) Due to the cross-sectional nature of the study design, we cannot rule out the possibility that uptake of vaccinations itself might result in better knowledge of vaccination recommendations or more positive attitudes towards vaccinations. Both, knowledge and attitudes might be different before vaccination and might change after vaccination; ii) The initial response rate was low, which may result in selection or nonresponse bias; however, all age-sex-education strata that exist in the target population were also occupied in HaBIDS [14], which provides the possibility of generating generalizable estimates via poststratification; iii) History of vaccination uptake in the last 10 years was based on participants' self-reported information, which may be prone to recall bias. We thus cannot rule out the possibility of false vaccination reports. However, the participants had an opportunity to select the category "don't know" for each vaccination. The proportion of "don't know" responses varied between 3.5% (tetanus vaccination) and 23.3% (pneumococcal vaccination). Although 94% of the study participants reported possessing a vaccination card, we are not aware of whether they used it for reporting vaccination uptake. Moreover, the feasibility of extracting information from a vaccination chart by laypersons has not been examined yet.

Conclusions

We observed considerable deficits in participants' knowledge of vaccination recommendations. The majority of participants had positive attitudes towards vaccinations; however, some participants had common misconceptions. Vaccination uptake was suboptimal; the only high coverage was observed for tetanus vaccination, for remaining vaccines the proportions of persons reporting vaccination in the last 10 years was lower than 50%. In addition, we identified distinct group of individuals with poor knowledge, poor attitudes and poor/incomplete vaccination uptake. Both, knowledge and attitudes were strongly associated with vaccination uptake. Efforts should be undertaken to improve knowledge of vaccination recommendations in the general population, which may lead to better attitudes and better vaccination uptake. Particular attention should be drawn to specific population groups such as the elderly in case of pneumococcal vaccination. Improving knowledge and addressing specific vaccine concerns can be done during general practitioner visits or through media campaigns. Health care workers may play a crucial role in distributing vaccine-related knowledge as they are the only

group involved in the patient-physician interactions. We examined the effect of knowledge of vaccination recommendations and attitudes towards vaccinations. As stated above, individual's decision to get vaccinated is a complex and multifactorial process. Numerous other factors associated with vaccination have been identified such as lack of a provider recommendation for vaccination, health care personnel's attitudes towards vaccinations, type of health insurance, and beliefs regarding the efficacy and benefit of vaccinations.

Conflict of interest

The authors declare no conflict of interest related to this study.

Funding

This work was supported with intramural funds from the Helmholtz Association.

Availability of data and materials

The dataset used in the study is available from the corresponding author.

Authors' contributions

MKA designed the study, performed statistical analysis, and wrote the manuscript. NR designed the study, managed the survey and critically reviewed the manuscript. IVD participated in data analysis. AK and RTM designed the study and critically reviewed the manuscript. All authors read and approved the final version of the manuscript.

References

[1] STIKO. Recommendations of the Standing Committee on Vaccinations (STIKO) of the Robert Koch Institute - 2016/2017, Epi Bull 34 https://www.rki.de/DE/Content/Infekt/EpidBull/Archiv/2016/Ausgaben/34_16.pdf?__blob=publicationFile/; 2016 [accessed 20 June 2017].

[2] Bodeker B, Remschmidt C, Muters S, Wichmann O. [Influenza, tetanus, and pertussis vaccination coverage among adults in Germany]. Bundesgesundheitsbl 2015;58(2):174-81.

[3] Poethko-Muller C, Schmitz R. [Vaccination coverage in German adults: results of the German Health Interview and Examination Survey for Adults (DEGS1)]. Bundesgesundheitsbl 2013;56(5-6):845-57.

[4] Poethko-Muller C, Kuhnert R, Schlaud M. [Vaccination coverage and predictors for vaccination level. Results of the German Health Interview and Examination Survey for Children and Adolescents (KiGGS)]. Bundesgesundheitsbl 2007;50(5-6):851-62.

[5] MacDonald NE. Vaccine hesitancy: Definition, scope and determinants.(1873-2518 (Electronic)).

[6] Nichter M. Vaccinations in the Third World: a consideration of community demand.(0277-9536 (Print)).

[7] Jarrett C, Wilson R, O'Leary M, Eckersberger E, Larson HJ. Strategies for addressing vaccine hesitancy - A systematic review.(1873-2518 (Electronic)).

[8] Dube E, Laberge CF, Guay MF, Bramadat PF, Roy RF, Bettinger J. Vaccine hesitancy: an overview.(2164-554X (Electronic)).

[9] Harrison N, Brand A, Forstner C, Tobudic S, Burgmann K, Burgmann H. Knowledge, risk perception and attitudes toward vaccination among Austrian health care workers: A cross-sectional study.(2164-554X (Electronic)).

[10] Lu PJ, Srivastav A, Santibanez TA, Christopher SM, Bostwick M, Dever JA, et al. Knowledge of influenza vaccination recommendation and early vaccination uptake during the 2015-16 season among adults aged >/=18years - United States.(1873-2518 (Electronic)).

[11] Betsch C, Wicker S. E-health use, vaccination knowledge and perception of own risk: drivers of vaccination uptake in medical students.(1873-2518 (Electronic)).

[12] Böhmer M, Walter D, Krause G, Müters S, Gößwald A, Wichmann O. Determinants of tetanus and seasonal influenza vaccine uptake in adults living in Germany. Hum Vaccin Immunother 2011;7(12):1317-25.

[13] Klett-Tammen CJ, Krause G, Seefeld L, Ott JJ. Determinants of tetanus, pneumococcal and influenza vaccination in the elderly: a representative cross-sectional study on knowledge, attitude and practice (KAP). BMC Public Health 2016;16:121.

[14] Rubsamen N, Akmatov MK, Castell S, Karch A, Mikolajczyk RT. Factors associated with attrition in a longitudinal online study: results from the HaBIDS panel. BMC Med Res Methodol 2017;17(1):132.

[15] Rübsamen N, Akmatov MK, Castell S, Karch A, Mikolajczyk RT. Comparison of response patterns in different survey designs: a longitudinal panel with mixed-mode and online-only design. Emerg Themes Epidemiol 2017;14:4.

[16] Gellin BG, Maibach EW, Marcuse EK. Do Parents Understand Immunizations? A National Telephone Survey. Pediatrics 2000;106(5):1097-102.

[17] Wheelock A, Parand A, Rigole B, Thomson A, Miraldo M, Vincent C, et al. Socio-psychological factros driving adult vaccination: a qualitative study. PLoS One 2014;9(12):e113503.

[18] Destatis. [Individuals by age (five-year age group), highest vocational degree, and further characteristics for Lower Saxony (federal state). Census 2011], Federal Statistical Office https://ergebnisse.zensus2011.de/#dynTable:statUnit=PERSON/; 2011 [accessed 27 January 2015].

[19] Greenacre M. Correspondence analysis in medical research. Stat Methods Med Res 1992;1(1):97-117.

[20] Lê S, Josse J, Husson F. FactoMineR: An R package for multivariate analysis. J Stat Soft 2008;25(1):1-18.

[21] Gaczkowska A, Mertens B, Reckendrees B, Wortberg S, Pott E. [Knowledge, attitude, and practice concerning measles vaccination. Approaches for national vaccination education]. Bundesgesundheitsbl 2013;56(9):1270-1278.

[22] Bodeker B, Betsch C, Wichmann O. Skewed risk perceptions in pregnant women: the case of influenza vaccination. BMC Public Health 2015;16:1308.

[23] Bodeker B, Remschmidt C, Schmich P, Wichmann O. Why are older adults and individuals with underlying chronic diseases in Germany not vaccinated against flu? A population-based study. BMC Public Health 2015;15:618.

[24] Betsch C, Wicker S. Personal attitudes and misconceptions, not official recommendations guide occupational physicians' vaccination decisions. Vaccine 2014;32:4478-84.

[25] Bodeker B, Walter D, Reiter S, Wichmann O. Cross-sectional study on factors associated with influenza vaccine uptake and pertussis vaccination status among pregnant women in Germany. Vaccine 2014;32(33):4131-39.

[26] Leask J, Kinnersley P, Jackson C, Cheater F, Bedford H, Rowles G. Communicating with parents about vaccination: a framework for health professionals. BMC Pediatr 2012;12:154.

[27] Goldstein S, MacDonald NE, Guirguis S. Health communication and vaccine hesitancy. Vaccine 2015;33(34):4212-14.

Figures

Figure 1. Knowledge of official vaccination recommendations (A,B) and attitudes towards vaccinations (C,D) assessed by multiple correspondence analysis.

Knowledge domain: biplot of the first two dimensions depicting the relationship across examined variables and their respective categories (A); incorrect answers in panel A consist of false and 'don't know' answers and density plot for the first dimension obtained from MCA (B). Attitudes domain; biplot of the first two dimensions depicting the relationship across examined variables and their respective categories (C) and density plot for the first dimension obtained from MCA (D). Both scores were reversed so that low values of the scores indicate poorer knowledge and less positive attitudes. Two vertical dashed lines on panels B and D divide the scores into three equal groups, *i.e.* tertiles.

Figure 2. Attitudes towards vaccinations, weighted percentage[a,b]

[a] The following questions were used: 'What is your attitude towards vaccinations in general?', 'What is your attitude towards tetanus vaccination?' and 'What is your attitude towards influenza vaccination?'.

[b] Poststratification weights were applied by using the distribution of sex, age and education of the general population of the federal state of Lower Saxony.

Figure 3. Practice in relation to vaccinations assessed by multiple correspondence analysis*

* Vaccination uptake was assessed by the question 'Were you vaccinated against the following infectious diseases in the last 10 years?': diphtheria, tetanus, pertussis, poliomyelitis, hepatitis B and pneumococcus. Biplot of the first two dimensions depicting the relationship across examined variables and their respective categories (A), density plot of the first dimension obtained from MCA (B), individual object scores by vaccination status for diphtheria (C) and tetanus (D) vaccinations.

Figure 4. The associations between uptake of vaccinations and participants' age*

* Estimated in fractional polynomial models, adjusted for all variables in Table 4.

Supplementary figure 1. Biplots of the first two dimensions depicting the relationship across examined variables obtained from multiple correspondence analysis for each KAP domain, *i.e.* knowledge of official vaccination recommendations (A), attitudes towards vaccinations (B) and vaccination uptake (C).