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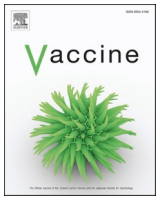

School vaccination programmes to increase HPV vaccination coverage – Experiences from Bremen, Germany

Regina Singer [a,b,c], Imke Hübotter [d], Franziska Hölzner [d], Christine Genedl [e], Lutz Jasker [e], Niels Michalski [f], Christiane Piepel [d], Thorsten Rieck [a], Günter Tempel [d], Ole Wichmann [a], Anja Takla [a,*]

[a] Department of Infectious Disease Epidemiology, Robert Koch Institute, Berlin, Germany
[b] Postgraduate Training for Applied Epidemiology, Robert Koch Institute, Berlin, Germany
[c] ECDC Fellowship Programme, Field Epidemiology path (EPIET), European Centre for Disease Prevention and Control (ECDC), Stockholm, Sweden
[d] Public Health Department, City of Bremen, Germany
[e] Institute for Quality Development in the State of Bremen (IQHB), Germany
[f] Department of Epidemiology and Health Monitoring, Robert Koch Institute, Berlin, Germany

A B S T R A C T

Germany primarily relies on a practice-based, opportunistic immunisation system. Despite the introduction of the Human papillomavirus (HPV) vaccine into the German vaccination schedule in 2007, coverage remains low. International experience suggests that school-based vaccination can increase HPV coverage. Therefore, in 2013/14 Bremen's public health department offered HPV vaccinations within a school programme, targeting all 8th-graders. We aimed to evaluate the programme, with a focus on vulnerable groups. In a retrospective cohort design, we analysed vaccination status and uptake among all 8th-graders from 2015/16 to 2018/19 (girls) and 2022/23 (girls and boys). Sub-analyses were based on the School Social Index (SSI), which ranges from 1 (higher socio-economic position, SEP) to 5 (lower SEP), considering factors like poverty, migration, and living environment. The study included 13,550 students from 1,440 classes in 56 schools. Among previously unvaccinated students, 26–35 % of girls and 39 % of boys annually accepted and received the school-based HPV vaccination. Uptake was higher among students from lower as compared to higher SEP schools (SSI 5: 37 % vs. SSI 1: 30 %, $p = 0.022$). Vaccine uptake among unvaccinated students remained stable over time, with one-third receiving at least one HPV vaccination at school. The remaining two-thirds of unvaccinated did not make use of the vaccination offer at school. It needs to be investigated if this is possibly due to vaccine hesitancy or a preference for practice-based vaccinations. While school vaccination programmes can improve uptake, implementing a nationwide programme in Germany will be challenging and may not address all existing major uptake barriers.

1. Introduction

Infections with human papillomavirus (HPV) are responsible for around 100,000 new cancer cases in Europe every year, foremost cervical cancer [1]. In Germany, around 8,000 women and men are diagnosed with HPV-related cancers every year, primarily affecting the cervix, throat, larynx and anus [2]. The first HPV vaccine was licensed in the European Union (EU) and European Economic Area (EEA) in 2006, and by 2024, all 30 EU/EEA countries offered HPV vaccination (28 for girls and boys, 2 for girls only) [3–5]. In 2007, the Standing Committee on Vaccination (STIKO) recommended HPV vaccination for all girls aged 12–17 years in Germany [6]. In 2014, the recommended age was lowered to 9–14 years [7] and in 2018 the recommendation was extended to boys [8,9].

The World Health Organization (WHO) and the European Commission aim to achieve HPV vaccination coverage of ≥90 % in 15-year-old girls and a significant increase in boys by 2030, due to the vaccine's potential to eliminate cervical cancer as a public health problem and reduce other HPV-related cancers [10,11]. However, HPV vaccination coverage varies widely across Europe, from over 90 % in Norway to less than 10 % in Bulgaria (for 15-year-old girls, full vaccination course, 2021) [12]. In Germany, HPV vaccination coverage in 2021 was 54 % for 15-year-old girls and 27 % for boys, placing it among the EU/EEA countries with low coverage [13]. It remains unclear how vaccinated and unvaccinated individuals in Germany differ in terms of socioeconomic position (SEP) or migration history.

In Germany, vaccinations are typically administered by physicians in private practices, within an *opportunistic* system where "vaccines are offered (…) at the discretion of the General Practitioners (GPs) through visits motivated by various motives other than vaccination" [3]. For HPV immunisation, targeting 9–14-year-olds, most vaccines are given by paediatricians, with fewer administered by GPs and gynaecologists

* Corresponding author at: Department of Infectious Disease Epidemiology, Robert Koch Institute, Seestraße 10, 13353 Berlin, Germany.
E-mail address: taklaa@rki.de (A. Takla).

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(unpublished results [14]). HPV vaccinations often occur during the free health check-up at ages 12–14 at paediatricians [15]. However, there is no systematic reminder or recall system for either the health check-up or the HPV vaccination.

In contrast to Germany, most other European countries administer the HPV vaccination through a structured vaccination programme "where target groups are systematically offered vaccination" [3]. In many countries, especially in Scandinavia and the Anglo-Saxon region, HPV vaccination is delivered in a school vaccination programme, achieving vaccination coverages often above 80 % [3,5,12]. Therefore, school vaccination programmes are frequently suggested as the key for success to achieve a high HPV vaccination coverage [5,16,17].

To this point, there is knowledge of three local school-based programmes in Germany. Two of them are carried out by private initiatives through physicians with private practices offering HPV vaccinations in school settings in their free time [18,19]. In contrast, the third programme was initiated and carried out by the local public health authority [20]. The public health department of the city of Bremen started an HPV school vaccination programme in the school year of 2013/2014, targeting all girls in the 8th grade (13–14 years of age) in the city. Due to the COVID-19 pandemic, the vaccination programme was suspended in 2019–2022. In 2022/23, the programme was restarted and extended to all male 8th graders, in accordance with the updated STIKO recommendations.

Bremen is a city in the North-West of Germany with 577,000 inhabitants and constitutes together with the city of Bremerhaven the federal state of Bremen [21]. Bremen is characterized by a significant residential segregation based on SEP and ethnicity [22]. To allocate additional funds to schools with students from a lower SEP, the School Social Index (SSI) is calculated for each public school, reflecting the average family SEP as well as migration background of students through various indicators [23].

So far, it is unclear whether a nationwide school vaccination programme would increase HPV vaccination coverage in Germany. Our study aimed to evaluate Bremen's school vaccination programme and its potential to increase HPV coverage. Additionally, we assessed differences in HPV vaccination coverage and uptake among students based on SEP or migration history, to determine if school-based programmes could effectively target vulnerable or underserved groups.

2. Material and methods

2.1. Organization and Processes within the school vaccination programme

Since 2013, class teachers in Bremen have distributed HPV-related information and a questionnaire to 8th graders and their parents at the start of the school year. The materials, created by the public health department, cover HPV, vaccination details, and programme logistics, including a question about the current HPV vaccination status. Parents or guardians are asked to complete the questionnaire and return it to the public health department through the class teacher. The materials remained largely unchanged during the analysis period.

2.2. Study population and included variables

The study population comprised all 8th graders in the city of Bremen in the school years 2015/16–2018/19 (girls), and 2022/23 (girls and boys). Due to the change in the national vaccination recommendation in mid of 2014, data before the school year 2015/16 were excluded to provide consistent data for analysis [8].

The data collected through the questionnaire included the following variables: age, sex, school year, school type, type of health insurance, number of HPV vaccinations received before the offer, acceptance/refusal of the school vaccination offer. Number of received HPV vaccinations within the school vaccination programme were added to the data set by the public health department after the intervention.

For every school year, the Institute for Quality Development in the state of Bremen (IQHB) routinely calculates the SSI for each public school [23]. The SSI is calculated based on indicators shown in Table 1. It has 5 categories (by social levels). Level 1 describes the highest SEP and lower percentage of migration background and level 5 lower SEP and higher proportion of migration background. We matched each student with the respective SSI of their school.

2.3. Operational definition HPV vaccination

According to the STIKO, an HPV vaccination was considered complete if 2 vaccine doses were administered at the age of 9–14 years or 3 vaccine doses from the age of 15 years (minimum intervals between the doses according to manufactures product information) [6]. The number of required doses was determined by the age at administration of the first vaccine dose.

2.4. Analysis

The data collected by the local health department as part of the school vaccination programme, was cleansed, anonymised and forwarded to the study team at the Robert Koch Institute (RKI).

Students with missing information on the student's sex or school type were excluded ($n = 2$). Due to anonymization, student age was calculated based on the students' date of birth and date of information material distribution (September of the respective school year) to the students resp. parents/guardians. Data on age at first HPV vaccination dose was not collected for those students who had been vaccinated prior to the school vaccination offer. Therefore, students $\geq$15 years of age with two previous HPV vaccination doses were excluded from analysis because the number of doses needed for a complete vaccination status could not be determined ($n = 24$).

In a repeated cohort study design, a descriptive analysis was conducted to assess differences in the response rate of the questionnaire, the utilisation of the vaccination offer, and HPV vaccination coverage before and after the intervention. The response rate was assessed including all students. Differences in the utilisation of the vaccination offer were assessed in the group of unvaccinated students only, representing the group at risk. Differences between groups were assessed and stratified by available variables like age, sex, school year, previous HPV vaccination and SEP. Pearson's chi-squared test was used to assess if the differences between the groups were statistically significant (p-value $\leq$0.05).

Data analysis was performed with R Version 4.2.2.

2.5. Ethics and data protection

Ethical approval was obtained from the Charité Ethics Committee in

Table 1
Definition of the most relevant five (of seven) Indicators of the School Social Index in the city of Bremen.

Indicator	Definition
Living environment	Neighbourhood index to map the social and economic living environment of the students (considers education, income, work)
Poverty	Proportion of students who hold a Bremen Pass*
Learning background	Proportion of students with poor German language skills (self-assessments by schools) over 3 years
Integration	Proportion of students who are non-German native speakers
Immigration	Proportion of students in public schools who have attended a German language preparation course in the last 4 years

* The Bremen Pass is available to recipients of social welfare benefits under the Second Book of the Social Code (SGB II), the Twelfth Book of the Social Code (SGB XII) and the Asylum Seekers Benefits Act (AsylbLG). The Bremen Pass is intended to enable Bremen residents with little money to participate in social and cultural life [24].

Berlin on 19.10.2023 (approval number: EA2/242/23). A declaration of consent from parents/guardians for HPV vaccination and data processing was obtained before the start of the school vaccination programme in Bremen. A data protection approval for analysis of the anonymous secondary data was obtained from the responsible person at state health department of Bremen.

3. Results

After data cleaning, 13,550 students in 1,440 classes from 56 schools were included in the analysis. Median age was 13 years (IQR 13–14 years). Whereas the study population was according to the data collection procedure exclusively female for the first school years, and it consisted of 50 % females in the school year 2022/23. Overall, 82 % of the study population was female. Further demographic details are depicted in Table 2. Most classes were assigned to SSI category 4 and category 1 (23 % and 21 %, respectively), reflecting the strong residential segregation by SEP in Bremen [22]. No information on SSI was available for the 13 % of students that attended private schools and were marked as missing in this category.

3.1. Questionnaire response rate

The overall response rate reflects all returned questionnaires. This rate was 81 % ($n = 6,949$) before the COVID-19 pandemic until school year 2018/2019. It dropped after the pandemic to 56 % ($n = 2,694$; Table 2) and was higher in girls (60 %) than in boys (53 %, p-value <0.001). SSI category 5 (lowest social level) had significantly lower response rates than the other groups (<0.001), also when stratified by school year and sex (data not shown).

3.2. Before and after the intervention: Utilisation of the HPV school vaccination offer by unvaccinated students

Utilisation of the HPV school vaccination offer by unvaccinated students is depicted in Fig. 1.

The proportion of female students vaccinated by their physician (≥1 HPV dose) before school vaccination increased yearly before the pandemic (Fig. 1a, Table 2). This percentage rose further in 2022/2023, though caution is needed due to a lower questionnaire response rate that year compared to 2018/19 (60 % vs. 84 %). Female students had a significantly higher prior vaccination rate than males (46 % vs. 28 %, Table 2).

The proportion of previously unvaccinated female students who accepted the school vaccination offer and received ≥1 HPV vaccination dose remained stable throughout the study period, including before and after the pandemic (Fig. 1a and b). In the post-pandemic school year, a slightly higher proportion of male students received ≥1 dose compared to females, a difference that was statistically significant ($p = 0.002$).

Over the observed years, 8 % ($n = 229$) of respondents who had already started the immunisation process (≥1 dose before school vaccination) chose to complete their HPV vaccination through the school programme.

Regarding the different SSI, students in category 1 were significantly more likely to have received HPV vaccination from their physician before the school offer than those in other categories ($p < 0.001$, Fig. 2). This pattern held across school years and sexes. The proportion of students accepting the school vaccination and receiving ≥1 dose ranged from 30 % to 37 % across the SSI categories, with the highest proportion in category 5 ($p = 0.022$, Table 3).

Table 3 shows the differences in the number of students who accepted the school vaccination, received ≥1 HPV dose, and completed the vaccination programme. Notably, 230 students who accepted the school vaccination dropped out before receiving their first dose.

4. Discussion

In this evaluation of the school vaccination programme in Bremen, about one-third of previously unvaccinated 8th grade girls (and their parents/guardians) accepted the HPV vaccination offer and received at least one dose at school. This proportion remained stable with no significant changes before or after the pandemic. By reaching one-third of unvaccinated students, the programme significantly increased HPV vaccination coverage in the eligible age group. It also effectively reached vulnerable and marginalized groups, who were previously less likely to be vaccinated against HPV as compared to students with the highest SEP.

In our analysis, the questionnaire response rate before the pandemic was 81 % on average for the girls. After the pandemic, the response rate fell to 60 % for girls and was 53 % for boys. There were no drastic changes in the programme structure, the distributed information material or questionnaire, that could explain the drop, suggesting it to be an effect of the COVID-19 pandemic itself. In addition, with the start of the Ukraine war in 2022 there was an influx of refugees in Bremen, and an observed increase particularly of students with language barriers and lower SEP might also have contributed to the lower response rate.

Table 2
Demographics of students contacted within the HPV school vaccination programme in Bremen, school years 2015/16–2018/19 (female) and 2022/23 (female and male), $N = 13,350$.

		Students contacted	Response rate questionnaires, n (% of contacted students)	p-value[1]	Students with at least one previous HPV vaccination, n (% of respondents)	p-value[1]
		13,350 (100 %)	**9,643 (72 %)**		**2,859 (30 %)**	
Female	2015/16	2,101	1,605 (76 %)	<0.001	291 (18 %)	<0.001
	2016/17	2,172	1,801 (83 %)		407 (23 %)	
	2017/18	2,143	1,729 (81 %)		537 (31 %)	
	2018/19	2,162	1,814 (84 %)		616 (34 %)	
	2022/23	2,368	1,418 (60 %)		647 (46 %)	
Male	2022/23	2,404	1,276 (53 %)	<0.001*	361 (28 %)	<0.001*
Age group	≤14	13,078	9,506 (73 %)	<0.001	2,829 (30 %)	0.045
	>14	273	1,37 (50 %)		30 (22 %)	
School social index (assigned to students per school) by social level	Level 1	2,829	2,177 (77 %)	<0.001	865 (40 %)	<0.001
	Level 2	2,033	1,602 (79 %)		411 (26 %)	
	Level 3	2,355	1,635 (69 %)		388 (24 %)	
	Level 4	3,022	2,156 (71 %)		545 (25 %)	
	Level 5	1,380	803 (58 %)		196 (24 %)	
	missing**	1,732	1270		454	

* compared to female in 2022/23.
** private schools without school social index.
[1] Pearson's Chi-squared test.

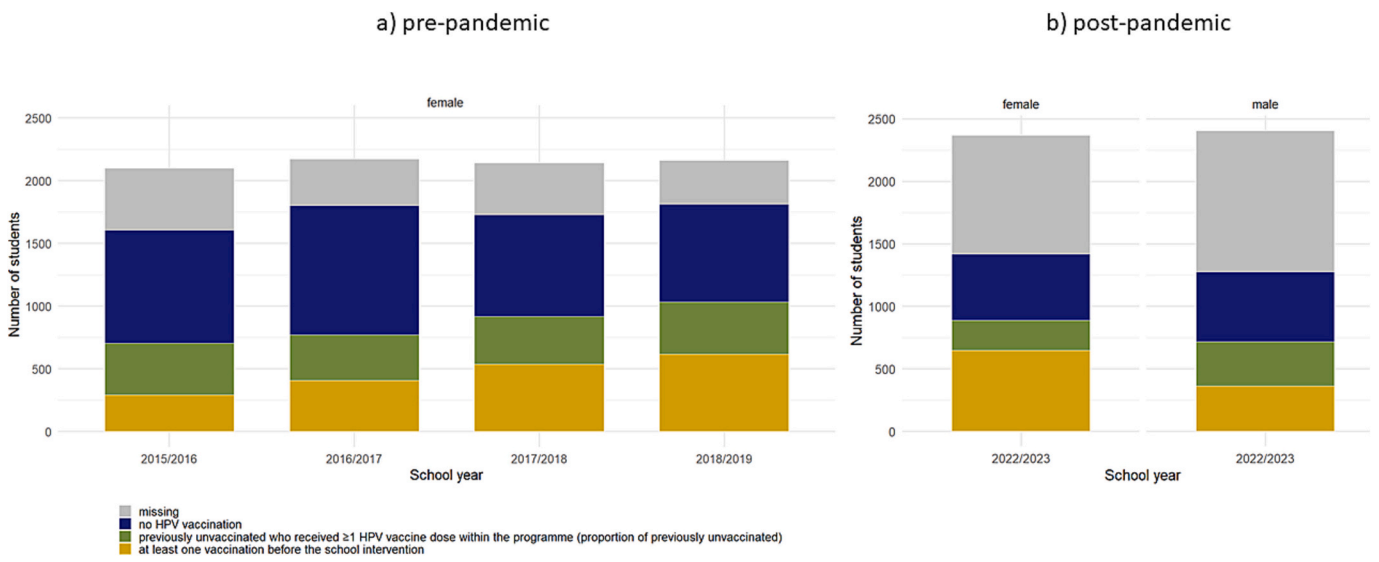

Fig. 1. a) and b): HPV vaccination status of students after the HPV school vaccination programme in absolute numbers, pre- (a) and post- (b) pandemic, by school year and sex, 2015/16–2018/19 (female) and 2022/23 (female and male), N = 13,350.

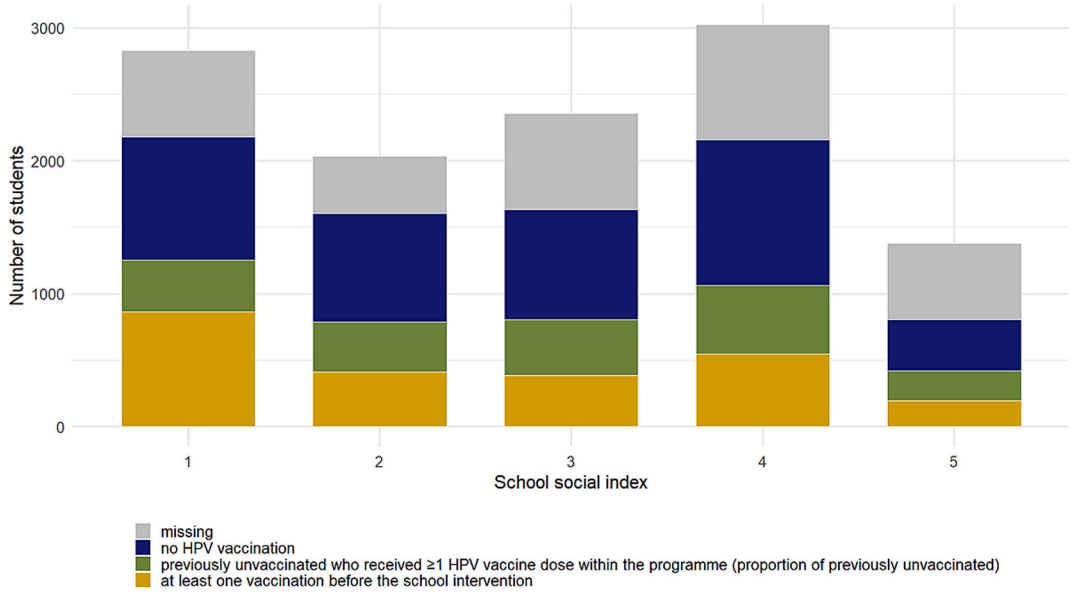

Fig. 2. HPV vaccination status of students after the HPV school vaccination programme in absolute numbers by school social index (SSI) category, 2015/16–18/19 and 2022/23, *N* = 13,350.

Looking at receiving a full vaccination course (2 or 3 vaccinations, respectively) within the school vaccination programme, a quarter of the girls who were not vaccinated before the programme were fully vaccinated afterwards. At the same time, the proportion of girls who had already been vaccinated against HPV by their physician before the school vaccination was offered, has risen steadily over the years. This finding is in line with the increasing vaccination coverage by approximately 3 %-points per year in the state of Bremen as well as overall in Germany [13]. Adding the number of students fully vaccinated in the school programme to the official HPV vaccination coverage data that is based on health insurance claim data [14,25], vaccination coverage rises for the state of Bremen substantially, e.g. in the last pre-pandemic year 2019 by 12.1 %-points to 49.8 % (15 year-old girls, full vaccination series, unpublished data). Regarding boys, only data for one schoolyear were available, hence trends could not be observed. However, the proportion of those who accepted and received at least one vaccination as part of the programme was slightly higher, but overall in the same order of magnitude as for girls.

In the group with lower SEP, fewer returned the completed questionnaires. However, the acceptance of the school vaccination offer was slightly higher than in other groups. This tendency was also observed in another study assessing COVID-19 vaccine uptake capturing the willingness and acceptance of different population groups in Germany [26]. Lower vaccination uptake in groups with a lower SEP could be due to different reasons, like a lack of access to medical practices where vaccinations are carried out in Germany, but also missing outreach offers for groups e.g. with language barriers. Especially for migrants and refugees, groups that constitute a substantial proportion within in the group of lower SEP in Bremen, language barriers and a lack of knowledge about the German health care system and the childhood vaccination schedule could be additional factors. Offering vaccinations at school could facilitate access and increase vaccination coverage if language

Table 3
Previously unvaccinated students who accepted the school vaccination offer and who were fully vaccinated within the HPV school vaccination programme, school years 2015/16–2018/19 (female) and 2022/23 (female and male), respondents of distributed questionnaires (n = 9,643).

		Respondents, n	Unvaccinated students with no previous HPV vaccination, n (% of respondents)	p-value[1]	Acceptance of school vaccination offer, n (% of unvaccinated)	p-value[1]	Received at least one school-based HPV vaccination, n (% of unvaccinated)	p-value[1]	Fully immunized after school-based HPV vaccinations, n (% of unvaccinated)	p-value[1]
		9,643 (100 %)	**6,784 (70 %)**		**2,400 (35 %)**		**2,170 (32 %)**		**1,714 (25 %)**	
Female	2015/16	1,605	1,314 (82 %)	<0.001	445 (34 %)	<0.001	412 (31 %)	<0.001	362 (28 %)	0.008
	2016/17	1,801	1,394 (77 %)		410 (29 %)		364 (26 %)		322 (23 %)	
	2017/18	1,729	1,192 (69 %)		404 (34 %)		379 (32 %)		295 (25 %)	
	2018/19	1,814	1,198 (66 %)		462 (39 %)		417 (35 %)		321 (27 %)	
	2022/23	1,418	771 (54 %)		292 (38 %)		243 (32 %)		167 (22 %)	
Male	2022/23	1,276	915 (72 %)	<0.001*	387 (42 %)	0.065*	355 (39 %)	0.002*	247 (27 %)	0.011*
Age group	≤14	9,506	6,677 (70 %)	0.045	2,337 (35 %)	<0.001	2,116 (32 %)	<0.001	1,701 (25 %)	0.002
	>14	137	107 (78 %)		63 (59 %)		54 (50 %)		13 (12 %)	
School social index (assigned to students per school) by social level	Level 1	2,177	1,312 (60 %)	<0.001	431 (33 %)	<0.001	388 (30 %)	0.022	304 (23 %)	0.044
	Level 2	1,602	1,191 (74 %)		409 (34 %)		378 (32 %)		302 (25 %)	
	Level 3	1,635	1,247 (76 %)		462 (37 %)		418 (34 %)		345 (28 %)	
	Level 4	2,156	1,611 (75 %)		578 (36 %)		516 (32 %)		387 (24 %)	
	Level 5	803	607 (76 %)		251 (41 %)		224 (37 %)		167 (28 %)	
	Missing**	1,270	816		269		246		209	

* compared to female in 2022/23.
** private schools without school social index.
[1] Pearson's Chi-squared test.

barriers can be overcome, e.g. with adapted information material and targeted community outreach [27].

One of the other two existing school vaccination programmes in Germany, running in the state of Hesse, has been evaluated [28]. Unlike Bremen's programme, Hesse's programme targeted 4th-grade girls (9–10-year-olds) in a rural area and was conducted by volunteer private practice physicians. Based on health insurance claim data, estimated 40 % of eligible girls were fully vaccinated after the school offer, leading to earlier vaccination. Since this programme began at the start of the recommended HPV vaccination age, most 4th-grade girls were likely unvaccinated. In contrast, Bremen's programme targets 8th-graders, where a proportion is already vaccinated by their paediatrician, making it difficult to draw concrete conclusions from comparisons of vaccine uptake (40 % in 9–10-year-olds vs. 25 % in 13–14-year-olds).

The demand to implement nationwide school vaccination programmes in Germany to achieve high HPV vaccination coverage is based on the hypothesis that low coverage is primarily due to access barriers. Schools are seen as ideal locations to reach all children in the relevant age group for vaccination. However, our evaluation found that each year, two-thirds of unvaccinated 13–14-year-olds did not make use of the offer possibly due to higher vaccine hesitancy in Germany. A recent survey found that about 35 % of parents of children aged 9–14 are hesitant about HPV vaccination, with 59 % either having already vaccinated their child or intending to, and 6 % firmly refusing (unpublished results, [29]). Despite the Bremen public health department providing HPV vaccination information and offering phone counselling, hesitant parents may prefer consulting their long-trusted paediatrician for vaccination advice, as surveys consistently show physicians are the most trusted source for vaccination decisions [30]. Analysis of health insurance claim data from Bremen showed a repeated increase in first-time HPV vaccinations among 13–14-year-olds in private practices that correlates with the school vaccination offer (unpublished data, [14]). This increase was not present in the city of Bremerhaven that does not have a school vaccination programme. Furthermore, there are anecdotal reports of paediatricians in Bremen about parents bringing school vaccination information to their practices for advice or vaccinations, indicating that the school-based information serves as a reminder – a strategy commonly used by countries with high HPV vaccination coverage [3,5].

While many countries, particularly in Scandinavia and Anglo-Saxon regions, have HPV school vaccination programmes leading to high coverages, our findings might indicate that this model may not work everywhere. Countries with an HPV school vaccination programme may find the programmes success in decades of tradition of administering childhood vaccines at school. In contrast, Germany discontinued school vaccination programmes for diseases like poliomyelitis and German measles decades ago. A recent study on vaccination confidence in Europe highlighted differences in trust in health authorities and commitment to vaccination across countries [31]. For instance, Portugal and Finland, countries with high HPV vaccination coverage, scored highly on trust in health authorities, whereas Germany and France, countries with low HPV vaccination coverage, scored lower. In the 2023/2024 school year, France will implement a nationwide HPV school vaccination programme alongside its existing private practice-based system, aiming to increase coverage [32]. Given France's similarities to Germany in terms of HPV vaccination coverage, trust in health authorities, and an opportunistic vaccination system, France's experience will be crucial in determining whether school vaccination programmes are the effective success strategy for all to increase HPV vaccination coverage and reach coverage goals by 2030 [10,11].

Our study has several limitations. The SSI is only available at the school level, with no individual SEP data due to data protection concerns, which could lead to an ecological fallacy in interpretation [33]. Additionally, classes from special needs and private schools were excluded from SEP analyses due to the lack of SSI information. The lower response rate to the questionnaire after the pandemic also reduces confidence in the reported proportions of acceptance and utilisation of the vaccination offer.

No data was collected within the school vaccination programme on parents' preferences for their child's vaccination location (school vs. private practice vs. no preference) or their degree of HPV vaccine hesitancy. Such data is essential for making an informed, evidence-based decision on implementing a nationwide HPV school vaccination programme in Germany. To address this gap, a survey among parents is planned for the school year 2024/2025 as part of the Bremen school vaccination programme. This analysis will also provide insights into marginalized and vulnerable groups, crucial for targeted interventions. Additionally, a cost-benefit analysis of the programme should be

conducted.

5. Conclusion

The evaluation of the Bremen HPV school vaccination programme suggests mixed results regarding the potential to increase HPV vaccination coverage. It appears to be effective for girls and boys who may not have access to vaccination. Marginalized or vulnerable groups showed slightly higher utilisation of the HPV school vaccination offer than other groups, but lower questionnaire response rates indicate possible language barriers or mistrust which need to be considered in further adjustments of the programme. On the other hand, the striking fact that two-thirds of unvaccinated ≤14-year-olds (4,340 of 6,677 students in the five-year observation period) did not make use of the offer, suggests that there are other reasons for the low HPV vaccination uptake than a lack of access. Reasons for the decline could be specific to the German setting and include a higher level of vaccine hesitancy compared to other countries or a preference for vaccination in a practice-based setting. A possible future school vaccination programme in Germany that does not simultaneously find a way to incorporate these aspects, is unlikely to lead to a significant increase in HPV vaccination coverage.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ChatGPT (Version 3.5) in order to provide code snippets in data analysis using R and to shorten paragraphs of the manuscript. After using this tool/service, the author(s) reviewed and edited the content as needed and take (s) full responsibility for the content of the publication.

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Contribution

AT, CP, GT, NM, OW and RS were involved in the conceptualization of the study. Other authors contributed the following: methodology (AT, NM, RS), project administration (CP, GT, IH), data provision (CG, FH, GT, IH, LJ), data cleaning and data analysis (FH, GT, RS, TR) and visualization (RS), interpretation (AT, IH, OW, RS), supervision (AT). AT and RS prepared the original draft of the manuscript. All co-authors reviewed and edited the manuscript before submission. All authors meet the ICMJE criteria for authorship.

CRediT authorship contribution statement

Regina Singer: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **Imke Hübotter:** Writing – review & editing, Project administration, Investigation, Data curation. **Franziska Hölzner:** Writing – review & editing, Formal analysis, Data curation. **Christine Genedl:** Writing – review & editing, Investigation, Data curation. **Lutz Jasker:** Writing – review & editing, Investigation. **Niels Michalski:** Writing – review & editing, Methodology, Conceptualization. **Christiane Piepel:** Writing – review & editing, Project administration, Investigation, Data curation, Conceptualization. **Thorsten Rieck:** Writing – review & editing, Formal analysis. **Günter Tempel:** Writing – review & editing, Project administration, Formal analysis, Data curation, Conceptualization. **Ole Wichmann:** Writing – review & editing, Conceptualization. **Anja Takla:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

Data will be made available on request.

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