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Social and demographic patterns of influenza vaccination coverage in Norway, influenza seasons 2014/15 to 2020/21

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A B S T R A C T

Aims: To examine influenza vaccination coverage among risk groups (RG) and health care workers (HCW), and study social and demographic patterns of vaccination coverage over time.

Methods: Vaccination coverage was estimated by self-report in a nationally representative telephone survey among 14 919 individuals aged 18–79 years over seven influenza seasons from 2014/15 to 2020/21. We explored whether belonging to an influenza RG (being >=65 years of age and/or having >=1 medical risk factor), being a HCW or educational attainment was associated with vaccination status using logistic regression.

Results: Vaccination coverage increased from 27 % to 66 % among individuals 65–79 years, from 13 % to 33 % among individuals 18–64 years with >=1 risk factor, and from 9 % to 51 % among HCWs during the study period. Being older, having a risk factor or being a HCW were significantly associated with higher coverage in all multivariable logistic regression analyses. Higher education was also consistently associated with higher coverage, but the difference did not reach significance in all influenza seasons. Educational attainment was not significantly associated with coverage while coverage was at its lowest (2014/15–2017/18), but as coverage increased, so did the differences. Individuals with intermediate or lower education were less likely to report vaccination than those with higher education in season 2018/19, OR = 0.61 (95 % CI 0.46–0.80) and OR = 0.58 (95 % CI 0.41–0.83), respectively, and in season 2019/20, OR = 0.69 (95 % CI 0.55–0.88) and OR = 0.71 (95 % CI 0.53–0.95), respectively. When the vaccine was funded in the COVID-19 pandemic winter of 2020/21, educational differences diminished again and were no longer significant.

Conclusions: We observed widening educational differences in influenza vaccination coverage as coverage increased from 2014/15 to 2019/20. When influenza vaccination was funded in 2020/21, differences in coverage by educational attainment diminished. These findings indicate that economic barriers influence influenza vaccination decisions among risk groups in Norway.

1. Introduction

Influenza is a seasonal infectious disease with a considerable disease burden, especially among the old and individuals with underlying disease [1–5]. Annual vaccination can reduce the burden of influenza and severe influenza-related disease and mortality [6–9]. Recommendations for annual vaccination include risk groups (RGs) according to the National influenza immunisation programme (NIIP) and health care workers with patient contact (HCWs). The RG is defined as individuals with certain chronic medical conditions and/or age over 65 years ([10]; supplementary Table 1).

The influenza vaccination coverage aim is minimum 75 % in RGs and among HCWs, in accordance with long-standing recommendations from WHO [11] and ECDC [12]. The treshold of 75 % vaccination coverage has proved to be an elusive goal for most European countries [13,14]. However, there has been a positive development in Norway in recent years, coinciding with a period of coordinated vaccination awareness- and information campaigns aimed at RGs

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and HCWs, with a threefold increase in the estimated number of influenza vaccine doses administered during the 7 influenza seasons from 2014/15 to 2020/21 from 436 000 to 1 302 000 doses [15]. The majority of these doses have been administered to HCWs and RGs. The doses administered were all standard dose, egg-based inactivated vaccines, with the exception of 80 000 doses of adjuvanted vaccine for nursing home residents in season 2020/21. HCWs have been entitled to free influenza vaccinations paid by their employer during the entire study period. However, there has not been any similar arrangement for the RGs – with the exception of the first COVID-19 pandemic winter of 2020/21, when the vaccine was free and vaccination was free or nearly free (50 NOK; approximately 5 €) for the RGs. In previous seasons, the RGs were only eligible for vaccine at a reduced price via the municipality or their general practitioner. As there was no price regulation on vaccine administration, the cost of the annual influenza vaccination ranged from 150 to 500 NOK in these years – a considerable sum for a vaccine with an expected effectiveness of 50–60 %, requiring annual revaccination.

We have previously found that about 30 % of the Norwegian population aged 16–79 years belong to the RGs due to either age and/or underlying disease [10]. Results also indicated a socioeconomic patterning of risk of severe influenza, as risk conditions were more prevalent among individuals with lower educational attainment or a weaker connection to the labour market. This overrepresentation of influenza risk among individuals of lower socioeconomic position should be reflected in vaccination coverage rates if we are to reduce social disparities in the influenza-related disease burden [16,17]. However, due to several years of increased information campaigning, a substantial increase in distributed doses in recent years, and the inclusion of the pandemic season 2020/21 in the study – affecting both disease and vaccine awareness, as well as vaccine costs and availability - we hypothesised that the impact of educational attainment on vaccination coverage would vary over time.

The aim of this study was to examine influenza coverage over time, both in the RGs and among HCWs. We also wanted to study whether vaccination coverage varied by educational attainment or by factors such as age, sex, marital status or place of residence. In addition, we wanted to study whether any social or demographic patterns of vaccination coverage changed over time.

2. Methods

2.1. Data source and study sample

This study is based on survey data from Statistics Norway's Travel & Vacation survey (T&V-survey), a quarterly survey of repeated cross-sectional design with the objective to map the travel behaviour of the Norwegian population and collect data for other official statistics [18]. On behalf of the Norwegian Institute of Public Health, questions on influenza RGs, HCWs and vaccination have been included in the survey in the 2nd and 3rd quarter since 2015. The T&V-survey is an interviewer-administered, computer-assisted telephone interview. The sampling frame is the Norwegian National Registry, where every citizen has a unique identifier. The target population is the Norwegian population aged 16–79 years. Statistics Norway draws a new sample of 2000 individuals each quarter by way of stratified random sampling, based on place of residence, sex and 10-year age group - to ensure that the age and sex structure of the sample mirrors the distribution in the target population in each county [18].

We included data from 2015 to 2021 in our analysis, covering 7 influenza seasons from 2014/15 to 2020/21. Of 27 917 eligible individuals, 15 591 responded to the survey. The overall response rate was 55.8 % (Supplementary Table 2). We set a lower cut-off at 18 years. Restricting the sample to adults excluded 578 respondents. After further exclusion of 94 individuals with missing information on vaccination status (n = 72), chronic conditions (n = 74) or HCW (n = 62), the net sample comprised 14 919 respondents.

2.2. Influenza vaccination coverage

Influenza vaccination was measured by self-report. Respondents were asked "*Did you get vaccinated against influenza in the course of the last 12 months?*". The response alternatives were *Yes/No*.

2.3. Explanatory variables

Data on age and sex were obtained from the Norwegian National Registry. Age was categorised as 18–44 years, 45–64 years, and 65–79 years, according to assumed life stages and the vaccine recommendation for individuals $\geq$ 65 years. Two other variables were also linked to vaccine indication. Respondents were coded as belonging to the medical RG for influenza if they answered affirmatively on at least one question on chronic conditions (Supplementary Table 1), and a dichotomous variable on HCWs was established from the question "*Do you work in health care and have contact with patients?*".

Educational attainment was obtained from the National Education Database and categorized as lower (0-10th class level or unspecified, i.e. educational level not recorded in the register), intermediate (11th-14th class level), or higher education [19].

Marital status was obtained from the Norwegian National Registry and categorized as unmarried, married, or formerly married (divorced or widowed). Self-reported population density at place of residence was used as a measure of urbanization. Categories were residing in a sparsely populated area, (<2 000 inhabitants), densely populated area (2 000–100 000), or in a city (>100 000).

2.4. Statistical analysis

Statistics Norway generate weighting variables that adjust for non-response error by age, sex, county and educational level. Such post-survey adjustment gives greater weight to respondents belonging to groups underrepresented in the data set in order to mirror the distribution in the population [18]. We calculated weighted proportions, representative for the population 18–79 years, for vaccination coverage in different groups with 95 % confidence intervals (CIs). Logistic regression analysis was then performed to obtain odds ratios (ORs) with 95 % CIs for the association between vaccination coverage and each of the explanatory variables. The multivariable model included explanatory variables for vaccine indication (older age, medical risk and HCW), socioeconomic position (educational attainment), demographics (age, sex, marital status and place of residence), and influenza season. Although weights were applied in univariable analyses we did not apply weights in multivariable logistic regression analyses as we adjusted for the weighting variables (age, sex and educational level) in the model. The model was first applied to the entire sample (combining all influenza seasons), before it was run season-by-season, in order to assess the overall influence of the various variables as well as variations over time. To assess whether the association between education and vaccination coverage differed over time, we tested for interaction between educational attainment and influenza season with a likelihood ratio test. Lastly, in order to study whether any educational patterns in coverage in the net sample were mirrored in analyses restricted to subgroups with indication for vaccination, we ran separate models restricted to individuals aged 65–79 years, 18–64 years with risk factors, and

HCWs, respectively. Subgroup analyses were not analysed by influenza season due to the restricted sample size. Analyses were performed with STATA SE version 15.

3. Results

Characteristics of the participants are presented in Table 1. 6 224 individuals, or 40.6 % of the sample, had indication for vaccine due to older age (17.3 %) and/or because they reported at least one medical risk factor (19.8 %) or were HCWs (11.8 %). >75 % of the HCWs were women.

3.1. Vaccination coverage over time

Reported coverage increased both in the overall sample and in all subgroups during the study period (Fig. 1; Supplementary Table 3). The group with the largest increase was HCWs, among whom coverage increased more than fivefold, from 9 % to 51 %.

Table 1
Characteristics of the study participants, Statistics Norway's Travel & Vacation-survey Q2 & Q3, 2015–2021. Proportions are weighted.

Variables	Categories	*Sample*	*Men (50.8 %)*	*Women (49.2 %)*
N (%)		**14 919 *(100.0)***	**7 678 *(100.0)***	**7 241 *(100.0)***
Age group	18–44 years	6 660 *(48.1)*	3 444 *(48.7)*	3 216 *(47.5)*
	45–64 years	5 463 *(34.5)*	2 804 *(34.4)*	2 659 *(34.6)*
	65–79 years*	2 796 *(17.3)*	1 430 *(16.8)*	1 366 *(17.8)*
Medical risk factors	≥ 1 medical risk factor*	2 950 *(19.8)*	1 483 *(19.0)*	1 467 *(20.7)*
Risk profile				
18–64 years	*No medical risk factor*	*10 164 (69.0)*	*5 319 (70.7)*	*4 845 (67.3)*
	*≥ 1 medical risk factor**	*1 959 (13.7)*	*929 (12.5)*	*1 030 (14.8)*
65–79 years	*No medical risk factor**	*1 805 (11.1)*	*876 (10.3)*	*929 (12.0)*
	*≥ 1 medical risk factor**	*991 (6.2)*	*554 (6.5)*	*437 (5.8)*
Health care worker	Work in health care with patient contact*	1 798 *(11.8)*	402 *(5.2)*	1 396 *(18.6)*
Educational attainment	Lower education (≥10th class level)	3 056 *(27.0)*	1 668 *(28.1)*	1 388 *(25.8)*
	Intermediate education (11th-14th class level)	5 989 *(40.1)*	3 389 *(43.7)*	2 600 *(36.3)*
	Higher education (14th-20th class level+)	5 874 *(33.0)*	2 621 *(28.2)*	3 253 *(37.9)*
Marital status	Never married	5 773 *(39.8)*	3 163 *(43.0)*	2 610 *(36.4)*
	Married	6 903 *(45.3)*	3 589 *(45.1)*	3 314 *(45.4)*
	Formerly married	2 243 *(15.0)*	926 *(11.9)*	1 317 *(18.2)*
Population density at place of residence	Sparsely populated (<2 000)	2 639 *(17.9)*	1 441 *(19.1)*	1 198 *(16.6)*
	Densely populated (2 000–100 000)	8 713 *(58.6)*	4 453 *(58.3)*	4 260 *(59.0)*
	City (>100 000)	3 567 *(23.5)*	1 784 *(22.6)*	1 783 *(24.4)*

*Categories marked with an asterisk are groups with indication for annual influenza vaccination in the Norwegian national influenza immunisation programme (NIIP). The variable "risk profile" is recoded from the variables "age group" and "medical risk factors" in order to illustrate the age distribution of the risk group. See Supplementary table 1 for details of coding.

Fig. 1. Respondents reporting influenza vaccination last season, by category and study year. Data from Statistics Norway's Travel & Vacation-survey, Q2 & Q3, 2015–2021. Proportions are weighted. Age range: 18–79 years.The lines in this figure should be printed in colour.

Individuals 65–79 years old consistently reported the highest coverage in all seasons. The only group to breach the treshold of 75 % vaccination coverage during the study period was those 65 years or older reporting at least one additional risk factor, who reached 77 % in the 2020/21 influenza season.

3.2. Associations between vaccine indication, educational attainment and vaccination coverage

3.2.1. All influenza seasons combined

Multivariable logistic regression showed that indication for vaccine, either by age ≥ 65 years (OR 7.02, 95 % CI 6.08–8.12), ≥1 risk factor (OR 3.00, 95 % CI 2.70–3.34) or being a HCW (OR 3.73, 95 % CI 3.26–4.26) was significantly associated with higher coverage (Table 2). Individuals with intermediate (OR 0.76, 95 % CI 0.68–0.84) and lower (OR 0.80, 95 % CI 0.70–0.92) educational attainment reported significantly lower coverage compared to individuals with higher education. For the demographic variables, higher coverage was observed among females (OR 1.14, 95 % CI 1.04–1.26) and married individuals (OR 1.29, 95 % CI 1.39–1.47), whilst those living in the countryside (OR 0.75, 95 % CI 0.64–0.87) or in smaller towns (OR 0.87, 95 % CI 0.77–0.98) reported significantly lower coverage than city-dwellers. Lastly, compared to 2014/15, the probability of vaccination increased every season onwards from 2015/16, especially in 2018/19 and 2020/21.

3.2.2. Analysis by influenza season, 2014/15–2020/21

Indication for vaccine was associated with higher coverage also in season-by-season analyses (Table 3; cf. Supplementary table 4 for unadjusted analyses). Compared to individuals aged 18–44 years, those aged 65–79 years consistently reported significantly higher coverage in all influenza seasons, with ORs fluctuating between 4.73 (95 % CI 3.03–7.38) and 11.38 (95 % CI 7.99–16.21). The variable on ≥ 1 medical risk factor for influenza produced rather similar ORs for vaccination each season, with ORs ranging between 2.75 (95 % CI 2.09–3.63) and 3.61 (95 % CI 2.68–4.88). For HCWs, estimated ORs gradually increased over time, from 1.81 (95 % CI 1.11–2.94) in 2014/15 to 6.35 (95 % CI 4.59–8.77) in 2020/21.

No significant associations between education and vaccination were observed in the first four (2014/15–2017/18) or in the last (2020/21) influenza seasons, but individuals with intermediate or lower education were less likely to report vaccination than those with higher education in 2018/19, OR = 0.61 (95 % CI 0.46–0.80) and OR = 0.58 (95 % CI 0.41–0.83), respectively, and in 2019/20, OR = 0.69 (95 % CI 0.55–0.88) and OR = 0.71 (95 % CI 0.53–0.95), respectively. However, the likelihood ratio test did not indicate significant interaction between influenza season and education (p = 0.07).

While women reported significantly lower coverage than men in 2014/15, OR 0.71 (95 % CI 0.52–0.98), and significantly higher coverage than men in 2019/20, OR = 1.26 (95 % CI 1.01–1.57) there were no significant differences in vaccination coverage between men and women in any other season. For marital status, being married was associated with higher vaccination coverage in the last two study seasons, in 2019/20 with OR = 1.41 (95 % CI 1.07–1.86) and in 2020/21 with OR = 1.81 (95 % CI 1.35–2.42). And lastly, although individuals living in cities in general reported higher coverage, differences in vaccination coverage by place of residence was significant only in season 2020/21, when those living in the countryside, OR 0.68 (95 % CI 0.48–0.93) and those living in smaller towns, OR 0.70 (95 % CI 0.53–0.92) reported significantly lower vaccination coverage compared to those living in cities.

3.2.3. Educational patterns of vaccination in subsamples with indication for vaccine

Compared to the analysis on the overall sample (Table 2), educational differences in vaccination were stronger in analyses

Table 2
Unadjusted and adjusted logistic regressions on the probability of being vaccinated against influenza, all influenza seasons combined (2014/15 to 2020/21). Data from Statistics Norway's Travel & Vacation-survey, Q2 & Q3, 2015–2021.

	Unadjusted (univariable) analyses			Adjusted (multivariable) analysis		
Variables	**OR**	**95 % CI**	***p*-value**	**OR**	**95 % CI**	***p*-value**
Sex (women)	1.34	1.23–1.46	*< 0.001*	1.14	1.04–1.26	0.01
Age group						
18–44	1	–		1	–	
45–64	1.40	1.25–1.56	*<0.001*	1.27	1.11–1.44	*<0.001*
65–79	6.34	5.68–7.07	*<0.001*	7.02	6.08–8.12	*<0.001*
≥ 1 medical risk factor	3.35	3.05–3.67	*<0.001*	3.00	2.70–3.34	*<0.001*
Health care worker	2.09	1.87–2.34	*<0.001*	3.73	3.26–4.26	*<0.001*
Educational attainment						
Lower	0.75	0.67–0.85	*<0.001*	0.80	0.70–0.92	*<0.001*
Intermediate	0.90	0.82–0.99	*0.03*	0.76	0.68–0.84	*<0.001*
Higher	1	–		1	–	
Marital status						
Never married	1	–		1	–	
Married	2.20	1.99–2.44	*<0.001*	1.29	1.39–1.47	*<0.001*
Formerly married	2.20	1.94–2.51	*<0.001*	1.01	0.85–1.19	*0.94*
Place of residence						
Sparsely populated	1.00	0.87–1.14	*0.96*	0.75	0.64–0.87	<0.001
Densely populated	1.02	0.92–1.13	*0.70*	0.87	0.77–0.98	0.02
City	1	–		1	–	
Influenza season						
2014/15	1	–		1	–	
2015/16	1.16	0.95–1.42	*0.13*	1.14	0.93–1.42	*0.21*
2016/17	1.47	1.22–1.78	*<0.001*	1.47	1.20–1.80	*<0.001*
2017/18	1.70	1.41–2.05	*<0.001*	1.81	1.48–2.22	*<0.001*
2018/19	2.59	2.17–3.10	*<0.001*	3.05	2.51–3.71	*<0.001*
2019/20	3.07	2.58–3.65	*<0.001*	3.65	3.03–4.41	*<0.001*
2020/21	3.93	3.31–4.67	*<0.001*	4.86	4.03–5.87	*<0.001*

The multivariable model in the adjusted analysis includes all variables listed in table 2.

Table 3
Adjusted logistic regressions on the probability of being vaccinated against influenza, by influenza season. Data from Statistics Norway's Travel & Vacation-survey Q2 & Q3, 2015–2021.

Influenza season	2014/15			2015/16			2016/17			2017/18			2018/19			2019/20			2020/21		
	N = 2 196			N = 2 169			N = 2 127			N = 2 001			N = 2 013			N = 2 365			N = 2 048		
Variables	OR	95 % CI	p-value	OR	OR	p-value	OR	95 % CI	p-value	OR	95 % CI	p-value	OR	95 % CI	p-value	OR	95 % CI	p-value	OR	95 % CI	p-value
Sex (women)	0.71	0.52–0.98	0.04	1.22	0.90–1.65	0.19	1.06	0.79–1.42	0.70	1.31	0.99–1.73	0.06	1.09	0.85–1.40	0.49	1.26	1.01–1.57	0.04	1.25	0.99–1.57	0.06
Age group 18–44	1	–		1	–		1	–		1	–		1	–		1	–		1	–	
45–64	1.24	0.79–1.95	0.35	1.25	0.82–1.91	0.30	1.26	0.83–1.90	0.27	1.17	0.80–1.69	0.42	1.26	0.92–1.74	0.16	0.98	0.72–1.28	0.92	1.76	1.31–2.36	<0.001
65–79	7.41	4.68–11.73	<0.001	4.73	3.03–7.38	<0.001	10.15	6.57–15.67	<0.001	5.89	3.93–8.82	<0.001	6.84	4.77–9.82	<0.001	4.91	3.58–6.73	<0.001	11.38	7.99–16.21	<0.001
$\geq$ 1 medical risk factor	3.18	2.30–4.39	<0.001	3.61	2.68–4.88	<0.001	3.23	2.41–4.33	<0.001	3.16	2.35–4.25	<0.001	2.75	2.09–3.63	<0.001	2.95	2.32–3.74	<0.001	2.80	2.15–3.64	<0.001
Health care worker	1.81	1.11–2.94	0.017	1.74	1.11–2.72	0.02	3.37	2.24–5.06	<0.001	4.41	3.04–6.38	<0.001	3.68	2.64–5.13	<0.001	4.76	3.56–6.34	<0.001	6.35	4.59–8.77	<0.001
Educational attainment																					
Lower	0.88	0.57–1.37	0.57	1.05	0.70–1.56	0.82	0.96	0.65–1.43	0.86	0.94	0.65–1.37	0.75	0.58	0.41–0.83	0.003	0.71	0.53–0.95	0.02	0.76	0.55–1.08	0.12
Intermediate	0.92	0.64–1.32	0.65	0.77	0.54–1.08	0.13	0.71	0.52–0.99	0.04	0.79	0.58–1.07	0.12	0.61	0.46–0.80	<0.001	0.69	0.55–0.88	0.002	0.88	0.68–1.14	0.33
Higher	1	–		1	–		1	–		1	–		1	–		1	–		1	–	
Marital status																					
Never married	1	–		1	–		1	–		1	–		1	–		1	–		1	–	
Married	0.75	0.50–1.15	0.19	1.31	0.86–1.99	0.20	1.01	0.69–1.50	0.94	1.46	1.01–2.11	0.05	1.19	0.87–1.63	0.27	1.41	1.07–1.86	0.01	1.81	1.35–2.42	<0.001
Formerly married	0.67	0.39–1.14	0.14	1.34	0.81–2.21	0.26	0.84	0.51–1.37	0.48	1.13	0.70–1.83	0.63	1.05	0.70–1.56	0.82	1.05	0.74–1.51	0.78	1.05	0.71–1.56	0.80
Place of residence																					
Sparsely populated	0.63	0.38–1.04	0.07	1.08	0.66–1.79	0.75	0.63	0.40–1.00	0.06	0.61	0.38–0.97	0.04	0.87	0.58–1.27	0.46	0.84	0.61–1.16	0.29	0.68	0.48–0.93	0.03
Densely populated	0.93	0.64–1.36	0.71	1.04	0.71–1.53	0.83	0.73	0.53–1.02	0.07	0.96	0.69–1.33	0.79	0.92	0.68–1.23	0.57	0.95	0.73–1.22	0.67	0.70	0.53–0.92	0.01
City	1	–		1	–		1	–		1	–		1	–		1	–		1	–	

The multivariable model in the adjusted analysis for each season includes all variables listed in table 3.

among individuals $\geq$ 65 years (Supplementary table 5) and among HCWs (Supplementary table 6). In both subsamples, individuals with lower and intermediate education reported significantly lower coverage compared to individuals with higher education: OR 0.60, 95 % CI 0.47–0.77 and OR 0.70, 95 % CI 0.58–0.84, respectively, among those 65–79 years, and OR 0.59, 95 % CI 0.41–0.85 and OR 0.51, 95 % CI 0.39–0.66, respectively, among HCWs. Although the same tendency was present among younger individuals (18–64 years) in the RGs, educational attainment was not significantly associated with vaccination in this subsample (Supplementary table 7).

4. Discussion

As expected, based on existing vaccine recommendations and previous studies [13,20–22], we found that being of older age, belonging to the RG for severe influenza and/or being a HCW was strongly associated with higher influenza vaccination coverage. Higher education was also significantly associated with higher coverage in combined analysis on the entire sample, among those 65–79 years and among the HCWs - but not in the younger RG, and not in all influenza seasons. Other factors associated with higher coverage in combined analysis included being female, being married, and living in a city.

4.1. Trust and misconceptions

Although coverage more than doubled in all RGs over the study period, coverage rates were still suboptimal among younger individuals in the RGs (33 %), individuals $\geq$ 65 years without additional risk factors (59 %), as well as among HCWs (51 %) in the last study season. We surmise that this is in part related to the attitudinal heritage of the last influenza pandemic of 2009. While demand for the inactivated adjuvanted vaccine (Pandemrix) was relatively high in Norway during the influenza A(H1N1)-pandemic and 40 % of the Norwegian population got the pandemic vaccine, seasonal vaccination coverage declined from low to very low in the following years. As the pandemic itself had a relatively modest impact in Norway, whereas several reports were published regarding adverse events following the 2009 vaccinations, public opinion on vaccines and trust in the National influenza immunisation programme (NIIP) took a turn for the worse in the post-pandemic period. As misconceptions about the influenza disease (low susceptibility and severity; preference for "natural" immunity) and of influenza vaccines (low effectiveness and safety) grew more frequent among both HCWs and the public, coverage for seasonal influenza vaccines dropped. A similar increase in vaccine hesitancy and -refusal also correspond with previous research [23–27].

4.2. Turning the tide

In this environment both the health authorities and HCWs involved in the NIIP at different levels of health care found it hard to advocate for the vaccine, and influenza vaccination campaigns were restricted to a bare minimum for some years with the intent to avoid aggravating the situation. A severe season dominated by influenza A(H3N2) in 2012/13 led to a renewed effort, but the negative trend in coverage did not turn until a couple of years later, after reaching a low point in season 2014/15. As the NIIP had a very restricted budget campaign options were limited, especially in the first seasons covered in this study. In an effort to gradually increase vaccine demand, the focus changed to a strategy of "ripples in a pond", starting with the HCWs. Behind this strategy was the recognition that capacity building and attitudinal change takes time, and that vaccinated role models are important [27]. HCWs are also a target group that can facilitate vaccination in others [28–30], and a personal recommendation from a HCW is significant for a patient's vaccine decisions [25,31]. The main target of the campaigns was therefore to educate HCWs in general, and HCWs working with infection control and vaccines in particular, in order to increase their knowledge and strengthen their advocacy skills for the influenza vaccine among their peers and their patients [25,28–30,32]. For this purpose a knowledge base for the NIIP, addressing major questions regarding influenza disease burden, severity, vaccine safety and effectiveness, as well as the rationale for the vaccine recommendations for different groups, was made publicly available and extensively promoted in 2017. This was complemented by annual campaigns in all subsequent seasons, focusing on short, evidence-based statements on influenza, the influenza vaccine and common misconceptions towards influenza vaccination directed at HCWs. For the RGs the NIIP mainly targeted individuals $\geq$ 65 years, focusing on disease awareness and vaccine effectiveness against severe influenza. It was also an important part of the strategy to be visible and present via email and in social media throughout the influenza season, posting timely responses to all questions and comments from both the general public and HCWs. Seen in retrospect, a more direct approach to vaccine promotion probably played an important part in turning the tide on vaccination coverage. Information campaigns focusing on influenza-specific educational measures do seem to have resulted in increased awareness of the influenza vaccine in the targeted groups in general. However, they also seem related to the observed increase in socioeconomic differences in coverage. It must be noted that the evidence-base and the information material in general was more accessible to HCWs and RGs with higher education during the study period, as resources were too scarce to adapt and promote information material towards a more diverse audience until the last study season.

4.3. Access is key

Practical measures to increase access to vaccination services was probably equally important for the observed increase. During this period more municipal vaccine providers started using patient reminders for vaccine appointments, and also became increasingly aware of the significance of a personal recommendation for patients' vaccine decisions [33,34]. As reported, however, while we observed a gradual increase in RG coverage over the study period, we also observed additional boosts in coverage in seasons 2018/19 and 2020/21. The increase in coverage in RGs in season 2018/19 came after a severe season in 2017/18, and we therefore interpret this as a result of increased awareness of influenza risk [25]. Unfortunately, this increase in coverage also resulted in greater educational differences, probably in part because the cost of vaccination resulted in unequal access in different population groups. This view is strengthened by the fact that the opposite happened in season 2020/21, when disease- and vaccine awareness once more was heightened in the population – this time because of the COVID-19 pandemic. When the government funded both the vaccine and the vaccine administration fees in 2020/21, they also removed the economical barrier to vaccination for individuals with less financial resources. This may have enabled new groups to get vaccinated, resulting in reduced educational differences in influenza vaccination coverage [25,31].

Analysis on the HCW subsample highlighted an interesting difference in temporal vaccination patterns between RGs and HCWs. While we observed two major increases in coverage for the RGs, vaccination coverage among HCWs rose more steadily. As HCW vaccination is funded by employers, costs are less relevant. Instead, we have indications that the most important drivers of this development were better access and organization, such as more widespread use of decentralized vaccination in combination with educational and promotional measures putting influenza vaccination on the agenda. HCW vaccination is voluntary in Norway, but it seems that a clear expectation of vaccination as norm from the health authorities is important for coverage - not least because it promotes employer involvement and facilitation in vaccination campaigns, which is necessary to ensure good vaccination policies in the organisation and easy access to free vaccines administered during work hours [27,35,36]. Nonetheless, while access has become a lot better over the years, especially in larger health care institutions, low accessibility is still an issue in many health care institutions today, and especially among practical nurses, unskilled workers and part-time employees.

Coverage varied systematically with educational attainment also among HCWs; HCWs with university or college degrees were more likely to be vaccinated. While the HCW-variable in this study is unable to differentiate between health care levels, we are aware that coverage in general is higher in hospitals than in primary care in Norway [37]. As the educational pattern of employees differ between institutions on different health care levels, the observed vaccination pattern might therefore partly be related to differences in vaccine access or resources available to advocate vaccination in different workplaces/health care institutions. It might also be related to place of residence, as HCWs in cities are more likely to be vaccinated in this study, and the hospitals in Norway mostly are situated in urban areas. Besides differences in access and resources, it is therefore likely that the observed pattern is related to differences in cultural or social expectations of vaccination and attitudes toward the influenza vaccine, whether it stems from the workplace, from professional identity, or the wider sociodemographic context of the HCWs [25,38]. Karlsson et al. 2019 [28] recently reported increasing confidence in vaccine benefit and safety with increasing educational level among HCWs, indicating that vaccine confidence is related to the amount of medical training - and that lack of influenza-specific knowledge may pose a barrier for vaccination decisions also among HCWs [38].

4.4. Socioeconomic patterns in vaccination coverage

This study indicates that influenza vaccination coverage is linked to socioeconomic position (SEP) in Norway, as individuals with higher educational attainment had a higher likelihood of vaccination, especially among those aged 65–79 years and HCWs. Although the direction of the association consistently favoured higher education, it did not reach significance among the younger risk groups (who in general had a lower vaccination coverage) or in all study years. While earlier studies have reported varied results for the associations between various measures of SEP/health determinants and coverage, the tendency that higher education is related to higher coverage is common [20,39,40].

Mitigating the effect of SEP is an important step towards equal vaccine access. While information campaigning seemed to result in larger inequalities in risk group vaccination during the first study seasons, funding had a levelling effect on the educational distribution in 2020/21. This highlights that economic barriers dampen demand for the vaccine. Inconsistencies between vaccination recommendations and reimbursement practices for RGs may also lead to unequal access to influenza vaccination [41,42]. Conversely, offering free vaccination or providing reimbursement for vaccination tend to increase coverage rates and reduce coverage disparities [22,31,39,43], not least because reimbursement or funding may strengthen the recommendation in public opinion.

Nonetheless, our observations suggest the simultaneous presence of other barriers structuring people's vaccination choices, given that we also observed an educational patterning among HCWs, which have been entitled to free influenza vaccine throughout the study period. Furthermore, while funding reduced the educational differences in vaccination coverage, it did not result in a coverage pattern mirroring the fact that risk conditions are more prevalent among individuals with lower educational attainment in Norway [10]. Taken together this implies that indicators of SEP such as income and education are important when explaining vaccine coverage, but that social, economic and cultural capital, as well as power relations and the individual's social environment, is likely to be equally important in explaining social inequalities in vaccination coverage – as in health [44].

4.5. Strengths and limitations

The primary strength of this study is the high-quality survey data from Statistics Norway, with a large sample, a high response rate and register variables for age, sex, educational level and marital status. The main limitation is that the cross-sectional nature of the data prevent a discussion on causality – we can merely observe the vaccination patterns and discuss these in relation to earlier research and metadata such as programme strategy, historical events and funding. In addition, the sample is restricted by an upper age limit of 79 years, while both medical risk factors and vaccination coverage become more prevalent with advancing age.

This study is based on self-reported vaccination coverage, which is susceptible to recall- and response bias (adherence to vaccine recommendations) and therefore might introduce misclassification, primarily through overreporting [45,46]. Self-reported vaccination is nonetheless widely used, both in coverage surveys and effectiveness studies, and several studies have concluded that it is generally in good agreement with register-based estimates [47–49]. Furthermore, while self-reported data has a tendency for overreporting, register data might be more susceptible to underreporting, through incomplete data capture [48,49]. The NIIP has not had access to reliable registry data for influenza vaccine coverage during the study period for exactly this reason. Firstly, while it has been mandatory to register all administered influenza vaccines in the Norwegian immunisation registry (SYSVAK) since 2009, register entries required consent from the vaccinee until 01.01.2020. This, in combination with challenges pertaining to software and registration practices, led to substantial underreporting. A similar problem existed pertaining to the ascertainment of medical risk for RGs or patient-centred work for HCWs. It would be preferable to triangulate self-reported estimates of vaccination status by medical risk and HCW-status patient-centred work to registry data. However, as the success of the immunisation programme is contingent on the individual's recognition of their vaccine indication, self-reports furthermore offer an important perspective in the management of the programme - by virtue of being a measure of vaccine acceptance that offer an opportunity to gauge attitudes to influenza vaccination in different population groups.

5. Conclusion

We observed widening educational differences as coverage increased during the first 6 of the 7 study seasons (from 2014/15 to 2019/20) - until the importance of educational attainment once again diminished as influenza vaccination was temporarily funded in 2020/21. This shift indicates that economic barriers directly affect demand for the influenza vaccine among RGs in Norway. Considering that medical risk factors for severe influenza is more prevalent among individuals of lower SEP, this implies that affordable - or preferably free - influenza vaccinations will lessen socioeconomic differences in the NIIP and thereby increase its impact.

Data availability

The authors do not have permission to share data.

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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Appendix A. Supplementary material

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