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Vaccine coverage among children born to immigrant parents in Norway, 2000–2020

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ABSTRACT

Background: The Norwegian Childhood Immunization Program maintains a high national coverage of 95–97% in the most recent years. Whether there are subgroups with lower uptake is less studied. This study examines pertussis and measles vaccination coverage among six immigrant groups in Norway. These vaccines are normally administered as part of different combination vaccines and their coverage rate indicate the national vaccination coverage against a range of additional infections.

Methods: Data from the Norwegian National Population Register were linked at individual level with vaccination data from the Norwegian Immunisation Registry. The final sample consisted of 53,052 children born during 2000–2018 in Norway to parents who were born in Iraq, Lithuania, Pakistan, Poland, Somalia, or Vietnam. Vaccination coverage was measured at 2-years of age. Multivariate linear regression was utilized to estimate the relationship between vaccinations status, year of birth, gender, mother's length of residency in Norway, and area of residence.

Results: At two years of age, the majority of the children were vaccinated. Coverage among the groups varied at, above, and below the national average for the two vaccines. For most of the years examined, children born by parents from Lithuania, Poland, and Somalia had lower coverage for the measles vaccine (range 81–84% in 2020) than the national level (97% in 2020). Children born by parents from the Eastern-European countries also had lower coverage than the national level for the pertussis vaccine (range 87–89% in 2020).

Discussion: This study illustrates how subgroups with lower vaccination coverage may exists within a well-established vaccination program with high national coverages. Differences in coverage were found for both vaccines, but the differences were more pronounced for the measles vaccine. The high vaccination coverage in Norway provides indirect protection through herd immunity for unvaccinated individuals, however, the lower vaccination coverage in some immigrant groups is a concern.

1. Introduction

In Norway, every child has the right to take part in the Childhood Immunization Program. The program is voluntary, free of charge and includes vaccines against twelve infectious diseases. Vaccination rates in Norway have been stable for years and the program maintains a high coverage with a national coverage of 95–97 % for 2-year-olds in 2020 [1]. Furthermore, Norwegian citizens have high confidence in childhood vaccination [2], which is key to sustain high vaccination coverage. However, within a population with a high national coverage there might be subgroups with lower coverage. We have previously shown that the immigrant Somali population has a relatively low uptake of the measles vaccine [3]. Uptake of the HPV vaccine among girls has also been shown to vary by country of origin [4,5].

Immigrant populations in Europe have lower immunization rates compared to individuals born in Europe [6–8] and may be under-

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immunized for vaccine-preventable diseases [9]. Immigration to Norway has increased in recent years and as of 2024, there were more than 900 000 immigrants living in Norway[10,11]. Together, they constitute almost one-fifth of the Norwegian population, with Poland, Lithuania, Ukraine, Syria, and Somalia being the largest non-Nordic groups as of 2023 [10]. Immigrants to Norway may face a range of challenges accessing health care services such as communication and language barriers, cultural differences, and a general lack of knowledge about the health care system in Norway [12–14]. Such challenges may impact on their vaccination uptake.

In Norway, childhood vaccination coverage by country of origin has not been extensively investigated. The objective of the present study is to assess pertussis and measles vaccination coverage in the childhood vaccination program among immigrant groups in Norway. The pertussis and measles vaccines are normally administered as components of hexa- and trivalent combination vaccines, respectively, thus their coverage rates also indicate the national vaccination coverage against a range of additional infections. Moreover, measles and pertussis vaccines have been surrounded by controversy and various degrees of hesitancy [15–17] that also could be relevant in Norway.

2. Methods

2.1. Data

We obtained individual demographic data from the National Population Register, which contains complete and accurate data on all residents in Norway. To define the study-population, we obtained data from the Norwegian National Population Register on all children born in Norway in the years between 2000 and 2018 for whom both parents were born in Iraq, Lithuania, Pakistan, Poland, Somalia, and Vietnam. These countries are all among those with the highest number of children born to immigrant parents in Norway [10]. Eligible children were those who remained resident in Norway until the end of the calendar year in which they turned two years old. Throughout this article, the national vaccine coverage for pertussis and measles vaccination at two years of age is used as a reference (for more information on the Norwegian Childhood Immunisation Programme and vaccine coverage, see [18]).

Individual data on vaccination was obtained from the Norwegian Immunization Register (SYSVAK), which is a high-quality nationwide vaccination register [19]. Reporting of vaccination to SYSVAK is mandatory.

Information on date of birth, gender, area of residence, and parents' dates of immigration (including any emigration dates registered at a later date) were linked with data from the SYSVAK on each child's vaccination status (date of vaccination and vaccine-type) for both measles and pertussis, using a unique Norwegian personal identification number provided to all residents in Norway.

The difference between date of vaccination and date of birth was used to calculate a child's age at vaccination. Mother's length of residency prior to birth of the child was calculated using the difference between mother's registered date of immigration and the child's date of birth. If mother's length of residency was missing, father's length of residency was utilized when available (n = 167). Length of residency was categorized into three groups: 1) < 2 years; 2) 3–5 years; or 3) ≥ 6 years.

Area of residence was defined by place of birth, which was categorized as: 1) Oslo county (capital); 2) Akershus county (area surrounding Oslo) and; 3) the rest of Norway. These are the two counties with the highest resident population in Norway and both have a higher share of immigrants compared to the rest of the country. We use Statistics Norway's definition of an immigrant as either a person born outside of Norway to two foreign-born parents or a person born in Norway to immigrant parents [20].

2.2. Population under study

We identified 55 396 children born during 2000–2018 to parents who were born in Iraq, Lithuania, Pakistan, Poland, Somalia, or Vietnam. However, we subsequently excluded 2 002 children due to emigration before they turned two years old. To ensure stable estimates for the analyses, we only included years for which there was at least 100 observations (i.e., 100 children born) for each nationality. Thus, for Iraq, Pakistan, Somalia, and Vietnam, all years between 2000 and 2018 were included. Poland included all years starting at 2006, and Lithuania all years starting at 2008. This resulted in a final study population of 53 052 children (Fig. 1, Table 1). If length of residency were missing for both parents (n = 1 486, the children were included in the study, but not in the regression analysis.

2.3. Vaccination status

To enhance comparability with national vaccination coverage statistics for the years 2002–2020, we used SYSVAK coverage definitions [19]. Coverage was calculated at the end of the calendar year in which the child turned two years of age. Pertussis vaccination is recommended at 3, 5 and 12 months of age. Complete pertussis vaccination at two years of age requires three doses of the pertussis vaccine and accounts for the minimum age at the time of a dose, the minimum time interval between consecutive doses, and the maximum number of days each dose is valid. Measles vaccination is recommended at age 15 months. Complete measles vaccination requires one dose after 12 months of age.

2.4. Statistical methods

Multivariate linear regression [21] was utilized to estimate the relationship (as percentage point differences) between vaccination status and the following four covariates: year of birth, gender, mother's length of residency in Norway, and area of residence. The regression was run separately for pertussis and measles and separately for each country group.

We included the following interaction terms between the yearly vaccination trend for each country of origin and 1) gender; 2) mother's length of residency in Norway; 3) area of residence; 4) gender and mother's length of residency; and 5) gender and area of residence. This was explored by adding interaction terms between the yearly trend and mentioned variables.

All the obtained data was analyzed using StataSE 17 software. We present yearly coverage rates for each vaccine and country of origin.

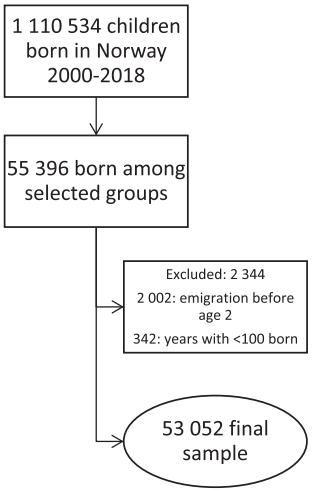

Fig. 1. Flowchart of criterion for the population under study.

Table 1
Characteristics of the population under study (n = 53 052).

Characteristics of the population under study	N *(%)*
Gender	
Girls	25 861 *(49)*
Boys	27 191 *(51)*
Area of residence	
Oslo county	12 217 *(23)*
Akershus county	10 159 *(19)*
Norway, other	30 676 *(58)*
Mother's length of residency in Norway	
< 2 years	13 733 *(26)*
3–5 years	15 271 *(29)*
≥ 6 years	22 562 *(42)*
Missing	1 486 *(3)*
Country of origin	
Iraq	9 909 *(18.7)*
Lithuania	5 821 (11)
Pakistan	7 623 *(14.4)*
Poland	12 588 *(23.7)*
Somalia	12 684 *(23.9)*
Vietnam	4 427 *(8.3)*

3. Results

3.1. Vaccination coverage

Among the 53 052 children included in this study, 48 742 (92 %) were vaccinated against measles (MMR) and 49 804 (94 %) were vaccinated against pertussis at two years of age. A total of 4 310 (8 %) children were defined as unvaccinated for measles, of which 3 636 had no dose of measles vaccine registered and 193 had received one dose of the measles vaccine before 12 months of age, but no additional dose before turning 2 years of age to ensure sufficient protection. For the pertussis vaccine, 3 248 (6 %) were unvaccinated, of which 866 had no dose of pertussis vaccine registered, while 2 382 had received one or two doses of the pertussis vaccine, but no third and final dose before the age of two. Among the children in the study population, 831 (1.5 %) had not been vaccinated against neither of the vaccines.

Coverage varied by country of origin and birth year, and the overall patterns differed somewhat between measles and pertussis vaccination (Fig. 2). Note that the y-axis does not start at 0.

3.2. Measles vaccine coverage

The Norwegian national coverage for the measles vaccine at 2 years of age has been steadily increasing from an average of 87 % among 2-year-olds in 2000 to 97 % among 2-year-olds in 2020. For children with parents from Iraq, Pakistan and Vietnam, the coverage was higher than the national coverage for more than the first decade explored in this study, and it is only in the most recent years that the national coverage has reached the level of these groups. However, children born by parents from Lithuania, Poland, and Somalia had lower coverage than the national level for most of the calendar years investigated. In 2020, 2-year-olds born with parents from Somalia had the lowest measles vaccination coverage of 81 %, followed by Lithuania (82 %) and Poland (84 %) (Fig. 2).

Mother's length of residency was positively associated with measles vaccine coverage among children with parents from Lithuania, Poland, and Vietnam, and negatively associated among those with parents from Somalia (Table 2). When examining area of residency, there was only a significant association for children born by parents from Somalia and Poland. Children born by Polish parents in Akershus county had a

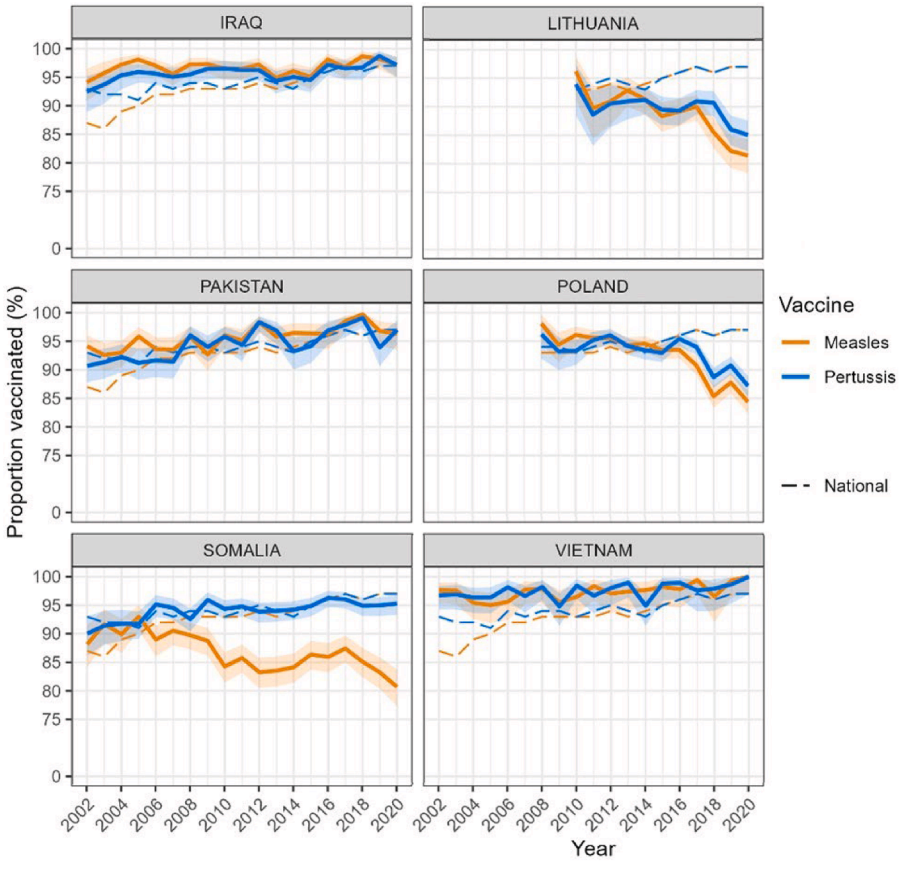

Fig. 2. Vaccination coverage (%) for measles and pertussis at age 2 for children born from immigrant parents, 2002–2020 (n = 53 052). The Norwegian national average is shown as a reference (dashed lines).

Table 2
Multivariate linear regression of measles vaccination coverage at two years of age during 2002–2020, by immigrant group.[1]

Covariates	Iraq		Lithuania		Pakistan		Poland		Somalia[2]		Vietnam	
	Group size (%)	Difference in coverage (95 % CI)	Group size (%)	Difference in coverage (95 % CI)	Group size (%)	Difference in coverage (95 % CI)	Group size (%)	Difference in coverage (95 % CI)	Group size (%)	Difference in coverage (95 % CI)	Group size (%)	Difference in coverage (95 % CI)
Mother's length of residency in Norway												
<2 years	2464 (27)	Reference	2114 (37)		1254 (17)		4573 (37)		2651 (21)		677 (15)	
3–5 years	2602 (28)	0.2 (-0.8 to 1.1)	2250 (39)	4.0 (2.0 to 6.0)***	1328 (18)	−0.2 (-1.8 to 1.4)	4616 (37)	1.2 (0.1 to 2.4)*	3767 (31)	−0.8 (-2.5 to 0.9)	708 (16)	−0.1 (-1.9 to 1.6)
≥6 years	4194 (45)	−0.1 (-1.0 to 0.8)	1365 (24)	4.8 (2.4 to 7.3)***	4891 (65)	−0.3 (-1.6 to 1.0)	3235 (26)	3.1 (1.7 to 4.5)***	5852 (48)	−6.5 (-8.1 to −4.9) ***	3025 (69)	1.6 (0.2 to 2.9)*
Area of residence												
Norway, other	5756 (62)	Reference	4733 (83)		1114 (15)		8823 (71)		6876 (56)		2437 (55)	
Oslo county	1882 (20)	−0.8 (-1.6 to 0.1)	307 (5)	0.3 (-3.4 to 4.1)	3839 (51)	0.3 (-1.1 to 1.7)	1356 (11)	−0.7 (-2.3 to 0.9)	3561 (29)	−6.4 (-7.8 to −4.9) ***	929 (21)	−0.4 (-1.6 to 0.9)
Akershus county	1622 (18)	−0.7 (-1.6 to 0.3)	689 (12)	0.6 (-2.0 to 3.2)	2520 (34)	0.6 (-0.8 to 2.1)	2245 (18)	−1.6 (-2.9 to −0.3) *	1833 (15)	−3.7 (-5.5 to −1.9) ***	1044 (24)	−0.4 (-1.6 to 0.8)
Gender – birth year interaction [3]												
P value	0.674		0.830		0.860		0.349		0.001***		0.694	
Birth year (trend, diff. per year)												
Girls	4540 (49)	0.1 (0.0 to 0.2)	2792 (49)	−1.6 (-2.1 to −1.2) ***	3676 (49)	0.2 (0.1 to 0.4)***	6060 (49)	−1.4 (-1.7 to −1.2) ***	5920 (48)	−0.2 (-0.4 to −0.1) **	2156 (49)	0.1 (0.0 to 0.3)*
Boys	4720 (51)	0.0 (-0.1 to 0.1)	2937 (51)	−1.7 (-2.2 to −1.2) ***	3797 (51)	0.2 (0.1 to 0.3)***	6364 (51)	−1.3 (-1.5 to −1.0) ***	6350 (52)	−0.7 (-0.8 to −0.5) ***	2254 (51)	0.1 (0.0 to 0.2)
Boys vs girls (ref)												
Born in 2000									160 (54)	0.7 (-2.0 to 3.4)		
Born in 2006									362 (54)	−1.7 (-3.3 to −0.2) *		
Born in 2012									396 (49)	−4.1 (-5.4 to −2.9) ***		
Born in 2018	197 (51)	−0.3 (-1.6 to 1.1)	351 (51)	−0.7 (-3.7 to 2.2)	140 (47)	0.3 (-1.6 to 2.2)	699(53)	1.0 (-0.7 to 2.07)	328 (53)	−6.6 (-8.8 to −4.3) ***	57 (49)	−0.1 (-2.3 to 2.0)

*** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$.

[1]Estimates refer to percentage point differences versus the reference level for each variable. All estimates are mutually adjusted. Each immigrant group was modelled separately.

[2] Data on measles vaccination coverage for children born by Somali parents in the years 2000–2016 has been presented in a previous article.[3].

[3] Estimates refer to the birth year 2018. There were no significant interactions for other birth years.

Table 3
Multivariate linear regression of pertussis vaccination coverage at two years of age during 2002–2020, by immigrant group[1].

Covariates	Iraq		Lithuania		Pakistan		Poland		Somalia		Vietnam	
	Group size (%)	Difference in coverage (95 % CI)	Group size (%)	Difference in coverage (95 % CI)	Group size (%)	Difference in coverage (95 % CI)	Group size (%)	Difference in coverage (95 % CI)	Group size (%)	Difference in coverage (95 % CI)	Group size (%)	Difference in coverage (95 % CI)
Mother's length of residency in Norway												
<2 years	2464 (27)	Reference	2114 (37)		1254 (17)		4573 (37)		2651 (21)		677 (15)	
3–5 years	2602 (28)	−0.8 (-1.8 to 0.3)	2250 (39)	3.3 (1.4 to 5.2)***	1328 (18)	−0.2 (-1.9 to 1.6)	4616 (37)	1.6 (0.5 to 2.7)**	3767 (31)	0.5 (-0.6 to 1.6)	708 (16)	0.5 (-1.2 to 2.2)
≥6 years	4194 (45)	−1.4 (-2.4 to −0.3)**	1365 (24)	4.0 (1.7 to 6.4)***	4891 (65)	−0.9 (-2.3 to 0.5)	3235 (26)	3.2 (1.9 to 4.5)***	5852 (48)	−1.9 (-3.0 to −0.8)***	3025 (69)	1.3 (0.0 to 2.7)*
Area of residence												
Norway, other	5756 (62)	Reference	4733 (83)		1114 (15)		8823 (71)		6876 (56)		2437 (55)	
Oslo county	1882 (20)	0.7 (-0.3 to 1.7)	307 (5)	0.6 (-3.0 to 4.1)	3839 (51)	0.1 (-1.5 to 1.6)	1356 (11)	−0.8 (-2.2 to 0.7)	3561 (29)	−2.1 (-3.1 to −1.1)***	929 (21)	−0.2 (-1.4 to 1.0)
Akershus county	1622 (18)	0.4 (-0.7 to 1.4)	689 (12)	0.9 (-1.6 to 3.4)	2520 (34)	0.6 (-1.0 to 2.2)	2245 (18)	−0.7 (-1.9 to 0.5)	1833 (15)	−0.9 (-2.1 to 0.3)	1044 (24)	1.3 (0.1 to 2.4)*
Gender – birth year interaction [2]												
P value	0.787		0.971		0.073		0.349		0.559		0.094	
Birth year (trend, diff. per year)												
Girls	4540 (49)	0.2 (0.1 to 0.3)**	2792 (49)	−0.9 (-1.4 to −0.5)***	3676 (49)	0.2 (0.1 to 0.4)***	6060 (49)	−0.8 (-1.0 to −0.6)***	5920 (48)	0.2 (0.1 to 0.3)***	2156 (49)	0.0 (-0.1 to 0.1)
Boys	4720 (51)	0.2 (0.0 to 0.3)**	2937 (51)	−0.9 (-1.4 to −0.5)***	3797 (51)	0.4 (0.3 to 0.5)***	6364 (51)	−0.9 (-1.1 to −0.7)***	6350 (52)	0.2 (0.1 to 0.3)**	2254 (51)	0.2 (0.0 to 0.3)**
Boys vs girls (ref)												
Born in 2018	197 (51)	0.1 (-1.5 to 1.7)	351 (51)	0.7 (-2.1 to 3.4)	140 (47)	2.0 (-0.1 to 4.2)	699 (53)	0.0 (-1.6 to 1.6)	328 (53)	−0.3 (-1.9 to 1.2)	57 (49)	1.2 (-0.9 to 3.3)

*** $p < 0.001$ ** $p < 0.01$ * $p < 0.05$.

[1]Estimates refer to percentage point differences versus the reference level for each variable. All estimates are mutually adjusted. Each immigrant group was modelled separately.

[2] Estimates refer to the birth year 2018. There were no significant interactions for other birth years.

significantly lower coverage than those born elsewhere in Norway ($p < 0.05$), while children born by Somali parents in Oslo and Akershus counties had significantly lower coverage than those born elsewhere in Norway ($p < 0.001$).

There was no significant interaction between gender and birth year with the exception of children born by Somali parents (Table 2), which has been discussed previously [3].

When exploring trends in birth year and measles vaccine coverage, a significant trend was found for both girls and boys with parents born in Lithuania, Pakistan, Poland, and Somalia while Vietnam only had a significant trend for girls. For Lithuania, Poland, and Somalia, there was a significant annual percentage point reduction in vaccine coverage for both genders. Thus, boys and girls born in more recent years had lower vaccination coverage than those born in earlier years. Children born by parents from Pakistan had a significant annual percentage point increase in vaccine coverage for both genders, thus those born in more recent years had higher vaccination coverage than those born in earlier years. This was also found for girls born by Vietnamese parents. No other significant trends were found.

3.3. Pertussis vaccine coverage

Compared to the measles vaccine coverage, (Fig. 2), the differences in pertussis vaccine coverage among the immigrant groups was less pronounced. The Norwegian national coverage for the pertussis vaccine at 2 years of age has seen a moderate increase from an average of 93 % among those born in 2000, to 97 % among those born in 2020 [1]. It is not until the most recent years that some groups have dropped below the national coverage. When examining the most recent years, the same four groups are below the national average for the pertussis vaccines as for the measles vaccine. Nevertheless, the gap is less pronounced for pertussis vaccination, especially for children born by parents from Somalia. In 2020, two-year olds born by parents from Lithuania had the lowest vaccination coverage of 87 %, followed by Poland (89 %), and Somalia (95 %).

Mother's length of residency was positively associated with pertussis vaccine coverage among children with parents from Lithuania, Poland, and Vietnam (Table 3), while a negative association was found for those with parents from Iraq, and Somalia. When examining area of residency, a significant association was found for children born by parents from Somalia and Vietnam. Children born by parents from Somalia in Oslo County had significantly lower coverage than those born elsewhere in Norway ($p < 0.001$), while children born by Vietnamese parents in Akershus county had significantly higher coverage than those born elsewhere in Norway ($p < 0.05$).

No significant interaction was found between gender and birth year for any of the immigrant groups investigated. When exploring trends in birth year and pertussis vaccine coverage, a significant trend was found among children with parents from Iraq, Lithuania, Pakistan, Poland, and Somalia, while Vietnam only had a significant trend for boys. For both boys and girls with parents from Lithuania and Poland, there was a significant annual percentage point reduction when comparing trends in birth year. Thus, those born in more recent years had lower coverage than those born in earlier years. For both boys and girls with parents from Iraq, Pakistan, and Somalia, there was a significant annual percentage point increase in vaccine coverage. Thus, those born in more recent years had higher coverage than those born in earlier years. This was also found for boys with parents from Vietnam. No other significant trends were found.

4. Discussion

This study illustrates that subgroup differences in vaccination coverage may exist within a well-established vaccination program that achieves very high national coverage. The six immigrant backgrounds investigated in this study have coverage at, above, and below the national average, which highlights the importance of viewing immigrant groups as heterogenous. Differences in coverage by immigrant background were observed both for the pertussis and for the measles vaccine, but the differences were more pronounced for the measles vaccine. Although the current high vaccination coverage in Norway provides unvaccinated individuals with indirect protection through herd immunity [22] the lower vaccine coverage in some immigrant groups is a concern. Those who are unvaccinated as children often remain unvaccinated, and thus remain susceptible to disease for many years. Europe has over the last decade experienced an increase in measles outbreaks due to a decline in vaccine coverage [23]. Although most larger outbreaks occurred in countries with low vaccination-coverage, outbreaks may also occur in settings with high coverage if unvaccinated subgroups share common community, age, or religious affiliation. In 2011 Norway experienced a large measles outbreak among unvaccinated Somali children living in the same community, and then subsequently spreading the disease to unvaccinated children elsewhere [24], some of them too young to have reached age of vaccination. Thus, it is important to achieve high vaccination coverage in all subgroups. The most recent data indicates that four of the immigrant groups are still below the national coverage and the recommended measles coverage (95 %) for herd immunity [25]. Maintaining high coverage rates are essential to ensure herd immunity.

Children born by parents from the Eastern European countries examined in this study had lower coverage for both vaccines examined, indicating that their parents might be more skeptical to vaccines in general. Indeed, this is consistent with patterns seen over the past years in Poland [26] where a growing number of parents don't vaccinate their children [27], increasing from less than 4,000 in 2010 to more than 50,000 children not receiving their mandatory childhood vaccinations in 2020 according to the Polish National Institute of Public Health [28]. A decline in childhood vaccination is also seen in Lithuania [29].

Furthermore, vaccination coverage in Poland is lower than in Norway and studies of Polish migrants in Scotland have illustrated how norms, beliefs and behaviors influence utilization of the health care system and impact their vaccination coverage [30]. Moreover, Poland has used a whole cell pertussis vaccine in their vaccination program. The whole cell vaccine is associated with more local and systemic reactions compared with the acellular vaccine which is offered in Norway. This has led to an unfavorable reputation of the pertussis vaccine and may partly explain the hesitancy towards pertussis vaccination [31].

In addition, immigrants from Poland have previously reported a range of barriers when accessing health services in Norway, such as lower trust in the Norwegian health care system [32], more trust in Polish health care personnel, and a preference for traveling to Poland to utilize health services [12]. Studies of vaccine hesitancy among immigrants during the COVID-19 pandemic in Norway, have highlighted lack on information and fear of side-effects as important barriers to vaccination among immigrants from Somalia and Poland [33,34]. Similar explanations may also apply to other vaccines and some of the other immigrant groups investigated in the present study.

We have previously shown that the measles vaccination coverage is suboptimal among children born to parents from Somalia [3]. We confirm this finding here with follow-up data from a longer time-period. Furthermore, we show that the discrepancy between boys and girls was highest for the youngest birth cohort investigated, which was born in 2020, further strengthening the indication that hesitancy towards the measles vaccine in the Somali community is partly gender-specific. Furthermore, the pertussis coverage in the Somali group was similar to the national average for almost all years examined in this study. This indicates that the parents have access to health care services, as well as the vaccines that are part of the Childhood Immunisation Programme, and accessibility does not explain the suboptimal measles vaccination coverage seen among this subgroup of children.

The six groups examined in this study vary in reason for migration and length of residency. For the majority of the groups examined, longer

parental duration of residence was associates with higher vaccination coverage, indicating that their vaccination coverage becomes more similar to the national average as duration of residency increases. Furthermore, coverage does not differ by area of residence for most of the children examined (with the exception of children born to Somali parents). Norway has a well-established and strong tradition for free of charge preventive and health promotion services for all families through decentralized and accessible well child clinics. The Norwegian Childhood vaccination program is an integral part of these services. The centers are easily accessible for the majority of the population regardless of area of residence, which is likely to reduce differences in vaccination coverage due to area of residence.

This study illustrates that the Norwegian immunization programme continues to have a very high national coverage. Yet, there are subgroups within the population with lower coverage which requires more tailored interventions for improving vaccination coverage. Whereas strategies to improve vaccination coverage among children born to Somali immigrants needs to target the MMR-vaccine specifically, improving vaccination coverage among children born to parents from Eastern-Europe needs a broader approach and included childhood vaccines in general. However, additional studies are also needed in order to uncover specific reasons for vaccine refusal. There has been some qualitative research on vaccination behavior in Norway in recent years [33,34], but these have focused on COVID-19 vaccines and future qualitative research on reasons for vaccination refusal in Norway should also include childhood vaccines.

5. Strengths and limitations

One of the main strengths of this study is the utilization of individual data from complete national registries that enable us to assess coverage on an individual level and link this to other demographic variables. We limited the study-population to children born in Norway, knowing that these families have been in contact with health care services in Norway and that they have been invited to routine check-ups where the vaccines in the Childhood immunization program is administered. Furthermore, reporting of childhood vaccines to SYSVAK for vaccines administered in Norway is high, providing more valid data. Norway has a long history of tracking vaccine coverage through its national registries which enables us to examine how coverage changes over time and any potential declines in coverage for individual vaccines. Despite the high-quality register data used, there is some uncertainty regarding length of residency among some of the parents in this study. We are unable to control for any underestimation of coverage due to children being vaccinated in their parents' home country without subsequent registration in SYSVAK, but we assume this number to be small among children born in Norway. Vaccines administered abroad can be retrospectively registered in SYSVAK, a study of COVID-19 vaccination among foreign born indicates that only a small number received their vaccinations abroad and approximately half of those had reported the vaccines to the Norwegian healthcare system [35].

6. Conclusion

This study highlights important gaps in understanding vaccination coverage among people with different immigrant backgrounds, as well as the need to distinguish between immigrant groups as there are important differences in coverage. Although the coverage in Norway is among the highest in the world, this study has revealed that variations in coverage exists within immigrant subgroups, with more pronounced differences for measles vaccination than for pertussis vaccination. Furthermore, it is also evident that for children born by Somali parents, there is something unique about the measles vaccine that negatively impacts the vaccine coverage among these children, especially for boys. When looking at the years examined, some of the groups have coverage rates that continue to decline in the most recent years. This is problematic and an indication that we need to continue surveilling coverage rates among these groups, including booster doses at older age as well as vaccines not included in the combination-vaccines. A high national vaccine coverage might mask lower coverage within subgroups of the population and more knowledge is needed in order to more effectively deliver vaccination services to diverse groups within Norway. We have the ability to utilize high quality register data to examine coverage, but we can only speculate about the reasons for lower rates of coverage among the groups in this study. However, we are currently exploring reasons for lower coverage among some of these subgroups in qualitative studies, aiming to more fully understand the complexity behind the numbers.

CRediT authorship contribution statement

Rebecca Nybru Gleditsch: Conceptualization, Formal analysis, Methodology, Project administration, Visualization, Writing – original draft, Writing – review & editing. **Trine Skogset Ofitserova:** Conceptualization, Formal analysis, Writing – original draft. **Richard Aubrey White:** Conceptualization, Formal analysis, Methodology, Software, Validation, Writing – original draft. **Marte Karoline Råberg Kjøllesdal:** Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Evy Dvergsdal:** Formal analysis, Methodology, Writing – original draft. **Bo T. Hansen:** Formal analysis, Methodology, Validation, Writing – original draft, Writing – review & editing. **Brita Askeland Winje:** Conceptualization, Data curation, Formal analysis, Methodology, Supervision, Writing – original draft, Writing – review & editing.

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.

Data availability

The authors do not have permission to share data.

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