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Research Article

Seroprevalence of measles antibodies in Northwestern Russia population in 2012- 2023

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Abstract

Background: Measles is a highly contagious viral infection that may cause life-threatening disease, especially in children. The main approach for measles prevention and elimination is vaccination and support for strong immunity in 95% of the population. Although the mandatory measles immunisation was introduced in 1972 in Russia, the infection is still widespread in the country. We summarise the data of twelve-year (from 2012 to 2023) surveillance of the IgG levels in the North-Western Russian population.
Methods: The data for anti-measles IgG levels in 28,530 samples from healthy subjects from the Northwestern Russia population which were examined from January 2012 to December 2023 were statistically analysed.
Results: IgG levels and seroprevalence are higher in subjects who were born before 1967 and were not admitted to the massive vaccination programs compared to the younger population. In the adult population covered by the single-dose vaccination program (i.e., born in 1971-1990), the seroprevalence level reaches 69 % (compared to >90% in the subjects born before 1967). The gain of seroprevalence to 61,7%, accompanied by a decline of mean IgG levels, was demonstrated in subjects who were born in 1990 or later and covered by the MCV1+MCV2 vaccination according to the National vaccination schedule.
Conclusion: These results reveal the necessity of vaccination coverage improvement, especially in the adult population. Also, more complex monitoring programs, including T-cell mediated immunity control, maybe more informative to estimate the actual anti-measles herd immunity.

Keywords*:* measles, vaccination, herd immunity, IgG, seroprevalence

Introduction

Measles first emerged when livestock domestication led to the adaptation of cattle rinderpest virus (*Rinderpest morbillivirus*) to humans, and the growth of both human and cattle populations supported the circulation of the virus [1]. The time of divergence is suggested to be in the range from 10,000 [2] years before to VII–XII [3] century, according to the different published evolution models. The etiologic agent of measles named *Measles morbillivirus* belongs to *Paramyxoviridae* [2]. This RNA virus is genetically stable, and a common ancestor of the modern measles strain suggested to have emerged in 1908–1943 year [4].

The most dangerous feature of measles is the high basic reproduction number (R_0), i.e., the average number of secondary infection cases arising from a sick person in a totally susceptible population. In the case of measles, R_0 varies from 12 to 20 [5]. The disease commonly presents with mild symptoms but can proceed in life-threatening form in younger children. Till anti-measles immunisation is initiated, the measles incidence rate reached 120-300 cases per 100,000 population million per year [6, 7]. The progress towards measles elimination is not persistent and the return of the disease in the USA after 2000 when no further measles cases were registered. United Kingdom, Albania, the Czech Republic, and Greece also eliminated measles but lost this status [9].

Currently, new measles cases are registered in all parts of the world, and morbidity increases are periodically reported, for example in 2000 when the measles frequency in the world reached 853,479 confirmed cases (i.e. 145.3 per 100,000 of the population) or in 2019 (873,022 confirmed cases, 119.5 cases per 100,000 of the population) [10].

In Russia, measles is endemic, and in 2012–2014, the outbreak of measles incidence occurred. The morbidity reached 3.3 cases per 100,000 in 2014 [11]. In Northwestern Russia, the epidemiological situation is more prosperous, and the measles incidence in the previous decade fluctuated from 0 cases per 100,000 in 2016 to 1.1 per 100,000 in 2014 and 0.96 per 100,000 in 2019 [12].

Vaccination is the most effective way to control measles incidence [13]. John E. Enders developed the first measles vaccine after the initial isolation of the virus in 1954 [14]. In 1968, Maurice Hilleman produced a more attenuated measles-containing vaccine (MCV) derived from the virus isolated by John Enders in 1962 [15]. In the USSR, the vaccine strain Leningrad-16 (L-16) was isolated in Leningrad Pasteur Institute of Epidemiology and Microbiology. Observation of L-16 vaccinated children demonstrated more than 10-fold risk of disease reduction [16]. With the onset of the COVID-19 pandemic, the management of global measles in epidemiological situations weakened. The global level of MCV immunisation decreased from 86 to 81%, and the global measles burden grew by 67% [10]. Despite the lack of published data, there is reason to believe that the in Russia the same trend occurs.

The published data for the actual anti-measles seroprevalence in North-Western Russia are limited. In the group 386 volunteers of the maternity hospital staff, the seroprevalence reached 87.5% in 2018, but in other groups, like 1,399 employees at the Military Medical Academy clinics, the level of seropositivity was lower and reached only 81.6% [17]. A more massive seroprevalence study was published in 2019 and demonstrated 78.5% seropositivity in 5,303 subjects recruited from North-Western State Medical University named after I.I. Mechnikov students and staff [18]. Meanwhile, all these data were received in narrow groups with high medical competence. At the same time, according to the results of sociologic studies, there is a growing decrease in vaccination compliance in Russia [19].

The main aim of the present study is to analyse the data of twelve-year (from 2012 to 2023) surveillance dynamics of the anti-measles IgG levels in the Northwestern Russia population to fill the missing data for the actual seroprevalence status and retrospectively estimate its dynamic in this long-time period Taking into account, that there was no publicly available data for the immunisation coverage, we could only consider the impact of changes in National vaccination schedule on the studied parameters. So, we also analysed the seroprevalence in groups based on the coverage by the particular vaccination programs.

Methods

Study participants and settings

The study design assumes the retrospective analysis of all samples from patients, who applied in the North-West Centre for Evidence-Based Medicine offices in Sain-Petersburg, Leningrad region, Novgorod region, and Kaliningrad region for the preventive examination of anti-measles IgG levels. Overall, the aggregated data of 28,530 serum sample reports for anti-measles IgG from January 2012 to December 2023.

The sample relevance for the seroprevalence estimation was evaluated by applying the formula:

$$n = \frac{N\frac{z^2 p(1-p)}{e^2}}{\frac{z^2 p(1-p)}{e^2} + N - 1}$$

where:

- n is the sample size,
- N is the population size, which is considered as generalised population of the Sain-Petersburg, Leningrad region, Novgorod region, and Kaliningrad region, which is approximately 10,500,000 people
- z is the confidence level,
- p is the sample proportion (we apply the value 70%),
- e is the margin of error (we apply the value 5%).

The IgG levels were measured in fasting blood samples harvested in vacuum tubes with a coagulation activator and gel. Trained nurses received blood samples in the North-West Centre for Evidence-Based Medicine offices in the Northwestern Federal District of Russia. The samples were collected from people in four regions, including Saint-Petersburg, Leningrad region, Novgorod region, and Kaliningrad region.

Anonymised data were collected in the Laboratory Information System (LIS) of the North-West Centre for Evidence-Based Medicine laboratory as part of the routine diagnostic workflow and analysed as described below in the statistics part of the methods.

All procedures performed in the study were under the ethical standards of the institutional research committee and national standards. For this type of retrospective study, formal consent is not required.

Detection of anti-measles IgG

Enzyme-linked immunoassays (ELISA)

The VectoKor-IgG (Vector-Best, Russia) ELISA test kit was applied for anti-measles IgG estimation in 2012–2019 and 2021–2023. The assay procedure was automated using a HydroFlex microplate washer, Infinite F50 reader, and Magellan software (Tecan Group Ltd, Switzerland). Following the manufacturer's manual, the IgG levels were estimated in international units per ml (IU/mL) in the diapason from 0 to > 5.0 IU/per ml. Samples with anti-measles IgG levels above 0.18 IU/ml were considered seropositive [17, 20]. The IgG levels > 5.0 IU/mL were regarded as 5.1 IU/mL.

Chemiluminescence immunoassay (CLIA)

A CLIA-based assay using the LIAISON® system (LIAISON® Measles IgG assay with LIAISON®XL analyser, DiaSorin, Italy) was applied to estimate anti-measles IgG serum levels in 2019–2022. The detection range for measles IgG with the LIAISON® system was 5.0–300.0 AU/mL. All IgG levels < 5.0 AU/mL and >

300.0 AU/mL were considered as 4.99 AU/mL and 300.1 AU/mL, respectively. Serum samples were classified as positive if the identified IgG levels were > 16.5 AU/mL, which is equivalent to 175 mIU/mL (WHO Third International Standard for Anti-Measles, NIBSC code: 97/648) and specified in the manufacturer's guide [21].

Statistics

To analyse the dynamical changes in IgG levels in the 12 years, we estimated the proportion of seropositive and seronegative tests in each year and calculated mean and SD values of IgG levels to estimate the possible differences between them. The normality of values distribution was examined using the Anderson–Darling test with the nortest R package (version 1.0-4). The test rejects the hypothesis of normality with a *P*-value less than 0.05. Since the hypothesis of normality was rejected, differences between groups were assessed for significance using the Wilcoxon test.

Two proportions Z-test was applied to evaluate the differences in the proportion of anti-measles IgG-positive in different groups. *P*-values were adjusted based on Bonferroni-Holm's method and adjusted $P < 0.05$ was considered statistically significant. Standard Wald confidence interval for proportions was calculated.

Additionally, we estimated the impact of coverage by different vaccination programs in the lifespan on the anti-measles seroprevalence and IgG levels. For this purpose, participants were grouped into the following birth cohorts: (1) born before 1966, i.e., before the first vaccination program was initiated; (2) born in 1966–1971, when the first early implementation of the vaccination program; (3) born 1972–1990, who were covered by MCV1 vaccination, and (4) born after the 1990 and covered by MCV1 and MCV2 vaccination. The between-group differences were estimated in the same way as the differences between subjects studied in different years.

The R (version 4.3.2) package was used to perform all statistical analyses. Diagrams were produced with the R package ggplot2 (version 3.5) [22].

Results

Study population

The data for 28,530 subjects was included in the analysis. The identified year-by-year distribution of cases was not homogeneous (Table 1). As the minimal sample size for the studied population, which was estimated as described above, was 323 participants per year, in every year except 2013, 2014, and 2017, the size of the studied group reached a representative number.

Table 1. The characteristics of samples submitted for anti-measles IgG examination in different years included in the analysis

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
n	528*	61*	152*	433*	357*	298*	6975*	5296*/2698**	3004**	61*/1988**	1210* /769**	4711*
Mean IgG Values	1.6*	1.5*	1.7*	1*	1.3*	1.2*	1.7*	1.5*/123.9**	117.6**	1.5 */ 105.2**	1*/ 110.9**	0.9*
SD	1.79*	1.81*	1.79*	1.3*	1.43*	1.48*	1.76*	1.62*/122.48**	120.92**	1.5*/116.66**	1.5*/116.56**	1.22*
Percent of anti-measles IgG-positive cases (in %)	80*	87*	78*	73*	77*	71*	78*	77*/72**	69**	83*/69**	67*/72**	70*
SE (in %)	3.4*	8.4*	6.6*	4.2*	4.4*	5.1*	1.0*	1.1*/1.7**	1.7*	29.9*/2.4**	2.6*/3.2**	1.3*

** data obtained with ELISA; ** data obtained with CLIA.*

General anti-measles IgG levels and seroprevalence in North-Western Russia.

The mean anti-measles IgG level in participants, whose sera samples were studied with "VectoKor-IgG" (Vector-Best, Russia) ELISA test was 1.39±1.6017 IU/ml. In serum samples studied with the CLIA LIAISON® system, the mean IgG level was 120.248±116.8361 AU/ml. The comparative statistical analysis of these values could not be carried out because of the lack of the conversion coefficient for IU/ml and AU/ml.

Overall, the seroprevalence of anti-measles IgG antibodies was 75.3±0,60% in samples examined by ELISA and 70.3±0.97 % in samples studied by CLIA test ($P < 0.0001$).

Tendency to reduce overall IgG levels and seropositivity in North-Western Russia 2020s.

We compared anti-measles IgG levels and seropositivity evaluated by the ELISA test by year. The identified differences demonstrate that people surveyed in 2012-2017 have higher IgG levels than

people surveyed in 2022-2023 ($P < 0.05$, refer to Table 1 for mean levels and SD, and Supplementary Table S1 for the pair-wise comparison). Figure 1a summarises the data for the dynamic of identified IgG levels in 2012-2023 with the abnormal character of estimated value distribution and tendency to decreasing of mean IgG value in the last two years (i.e. 2022-2023). Furthermore, the study revealed higher IgG mean levels in 2014 and 2018, coinciding with a rise in measles cases in Russia. The identified growth of mean IgG levels in 2018 compared to 2017 reached statistical significance (P < 0.0001, Figure 1a, Supplementary Table S1). For CLIA results, the only significant difference was revealed between the mean IgG serum levels in 2019 and 2021 ($P < 0.01$).

Then we compared the percentages of seropositive cases in subjects who were examined in different years. We also identified the trend for the decline in the frequency of seropositive cases in the population studied with the ELISA in 2022-2023 compared to the previous years (i.e. vs 2012, 2015, 2018, and 2019, $P < 0.05$, refer to Table 1 for seropositivity rates and Supplementary Table S2 for the pair-wise comparison results). The identified tendency is represented in Figure 1c. In subjects examined with the CLIA test in 2019-2022, no differences were identified in the year-by-year comparison (Figure 1 d).

Additionally, we compare IgG levels in participants who applied before the COVID-19 pandemic, i.e. in 2012-2019, and in patients who were examined in 2020-2023. The significant decline of IgG levels was identified both by ELISA (1.56 +/-1.689 IU/ml vs 0.97+/-1.282 IU/ml, $P < 0.0001$) and CLIA (123.89 AU/ml vs 113.53 AU/ml, $P = 0.00083$) tests. We identified the same trend for seroprevalence, as the number of ELISA-positive cases decreased from 77.6±0.69% in 2012-2019 to 69.7±1.16% ($P < 0.0001$) in 2020-2023, and the number of CLIA-positive cases decreased from 72.2±1.69% to 69.5±1.29% ($P = 0.0109$) respectively.

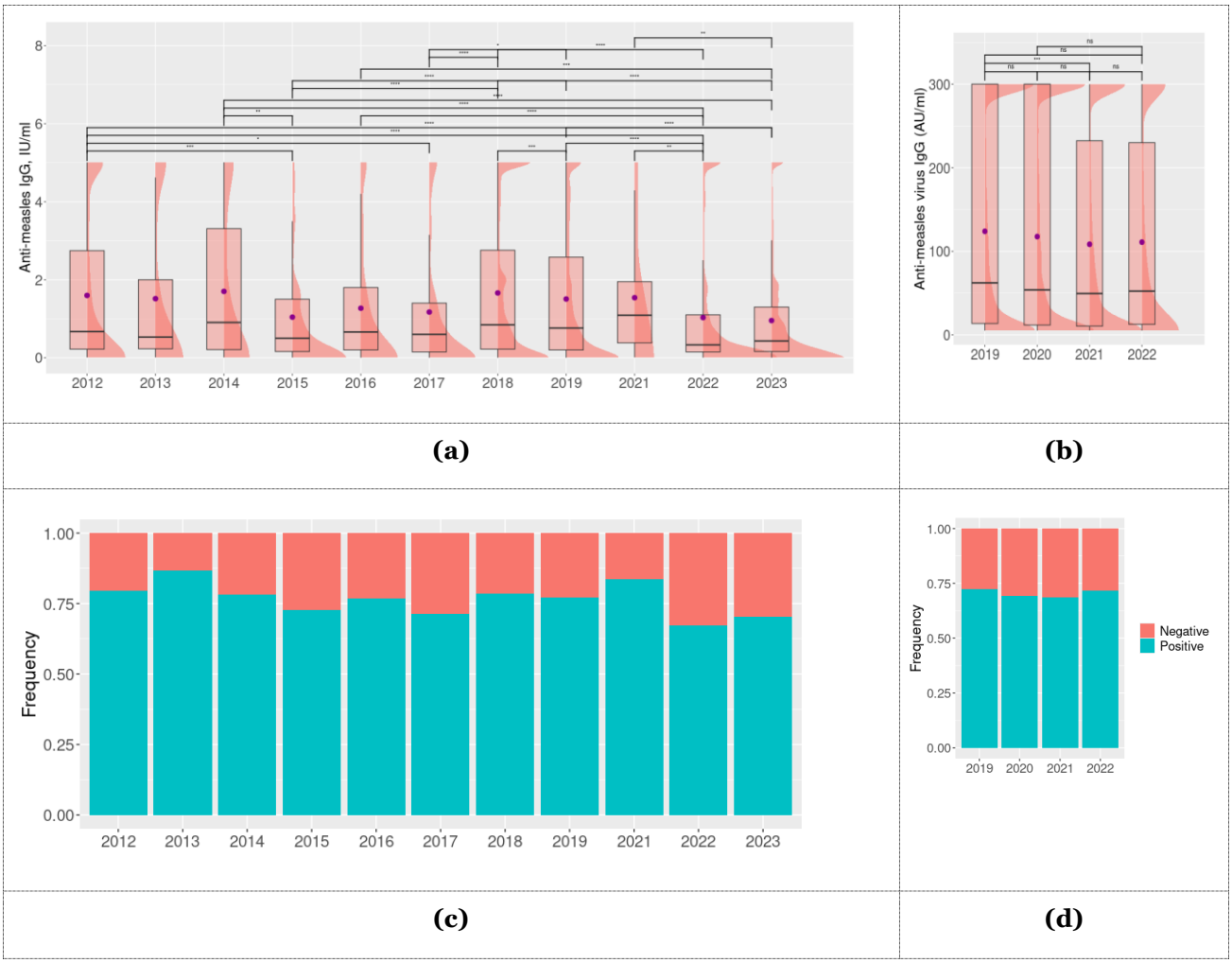


Figure 1. Anti-measles IgG levels and seropositivity depending on the year of surveillance. (a) Mean IgG levels estimated by ELISA; (b) Mean IgG levels estimated by CLIA; (c) the IgG seropositivity estimated by ELISA or (d) CLIA. *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$, ****$P < 0.0001$, ns – not significant.

Anti-measles IgG levels reach a minimum in the population, which was covered by the MCV2 program.

The study population (n = 28,530) was divided into four groups based on the year of birth. Participants included in Group 1 were born before 1966 and were not covered by any anti-measles vaccination program. The first L-16 (MCV1) vaccination program in the USSR had covered 15–18-month-old children, so the participants who were born in 1966–1971 were included in Group 2. Immunisation coverage of 30–50 % is suggested in this group [23]. Group 3 includes subjects who were born in 1972–1990 and were vaccinated with a single dose of MCV at 12 months old following the National Vaccination Schedule. In 1996, the second MCV immunisation in 6-year-old children was included in the National Vaccination Schedule. This vaccination scheme covered participants who were born in 1990 or later, which were included in Group 4. No public data were available for the vaccination coverage in the last two groups.

The details for age and sex distribution in Groups 1–4 are summarised in Table 2. Significant heterogeneity of age and sex was identified between subgroups in which IgG levels were estimated by different methods.

Table 2. Participant characteristics in different age groups

Test	ELISA (VectoKor-IgG)				CLIA (LIAISON ® system)			
Group	#1	#2	#3	#4	#1	#2	#3	#4
Age at the date of serum collection.								
Mean±SD	53.75 ±6.743	50.72 ±3.016	38.01 ±5.785	19.26 ±8.811	64.33 ±7.099 ****	51.25 ±1.879 ****	37.65 ±5.151 ****	20.24 ±8.479 ****
Range	46–95	40–57	22–51	0–32	54–95	47–55	28–50	1-31.26
Gender								
Male	901 (17,6%)	382 (16.6%)	1951 (23.1%)	1414 (37%)	337 (25.2%)* ***	141 (23.9%) **	1325 (31.1%)** **	824 (37%)
Female	4228 (82,4%)	1926 (83.4%)	6866 (76.9%)	2404 (63%)	1001 (74.8%)	448 (76.1%)	2936 (68.9%)	1406 (63%)

*** P< 0.01; **** P< 0.0001 (compared to the equivalent group tested by ELISA)*

As mentioned earlier, we divided the study population into four groups, considering the development of anti-measles immunity in the background of different vaccine schedules. Since we did not collect information on the MCV1 and MCV2 vaccination status during the sampling, we had to estimate the population effect of vaccination instead of the effect of the vaccine on the IgG levels in immunised individuals.

The mean anti-measles IgG levels for participants of a certain year of birth are represented in Figures 2a and 2b for the populations studied by ELISA or CLIA, respectively. The IgG levels demonstrated a downward trend in the population's part that was not introduced in the first vaccination program in 1968 but is close in age to the individuals covered by this first large-scale program of anti-measles vaccination.

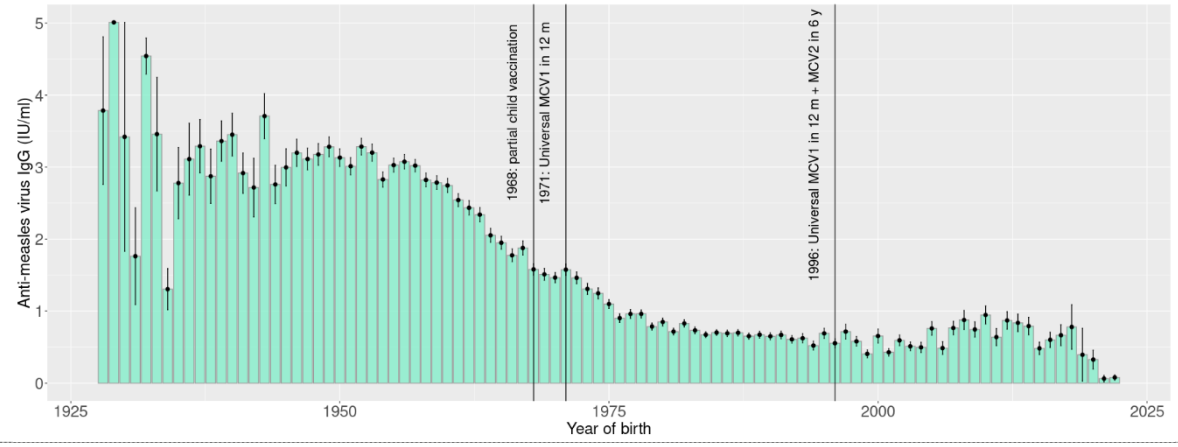
As regards the participants who were born at the end of the XX century, the continuing decline of mean antibody levels was identified. Despite the launch of the MCV2 program in 1996 for children aged 6 years, participants born in the 1990s exhibited a continuing decline in mean antibody levels. In the participants who were born in the first decades of the XXI century, the IgG levels vary and demonstrate the tendency to grow.

The pairwise comparison of Groups 1–4 demonstrates the downward growth trend from Group 1 (participants who were born before the large-scale vaccine programs, 2.8+/-1.71 IU/ml or 233,9+/-109.24 AU/ml) to Group 4 (participants who had access to the MCV2 vaccination, 0.6+/-0.98 IU/ml or 80.2+/-100.39 AU/ml) despite the method of IgG evaluation (i.e., ELISA or CLIA, Figure 2c, d). The differences between all examined age groups were statistically significant ($P < 0.05$).

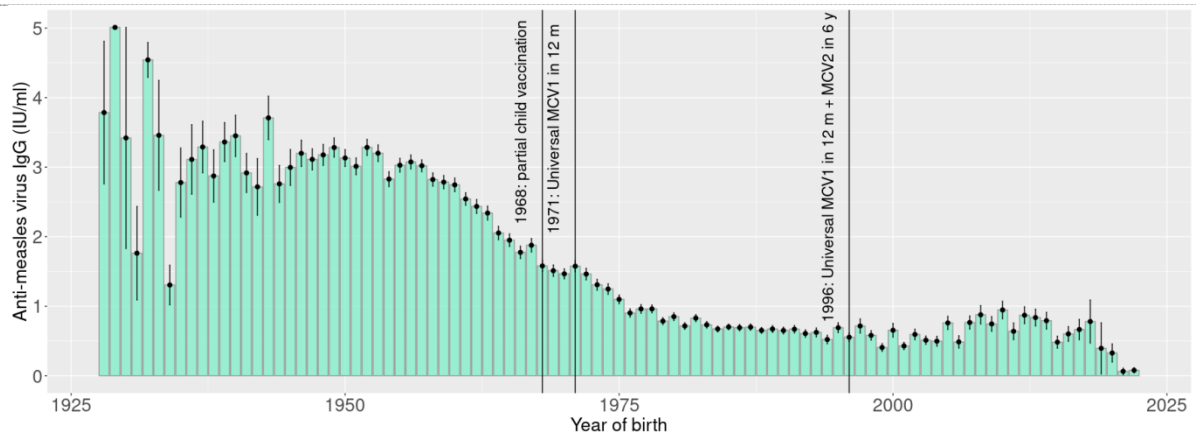
The seroprevalence of antibodies against measles demonstrates the downward trend in the population, which was covered by the MCV1+MCV2 immunisation.

As the mean IgG levels, the seroprevalence also trends to downgrade in younger subjects (Figure 3a, b). Seroprevalence, we compared the anti-measles IgG seroprevalence in groups that were divided based on the vaccination background, as described above. The decline from 94.2±0.64% ELISA-positive cases or 91.6±1.49% CLIA-positive cases in Group 1 to 82.8±1.51% ELISA-positive or 79.2±3.28% CLIA-positive cases in Group 2, 69.0±0.97% ELISA positive or 66.9±1.35% CLIA-positive cases in Group 3 and only 61.7±1.54% ELISA-positive or 59.8±1.87% CLIA-positive cases in Group 4.

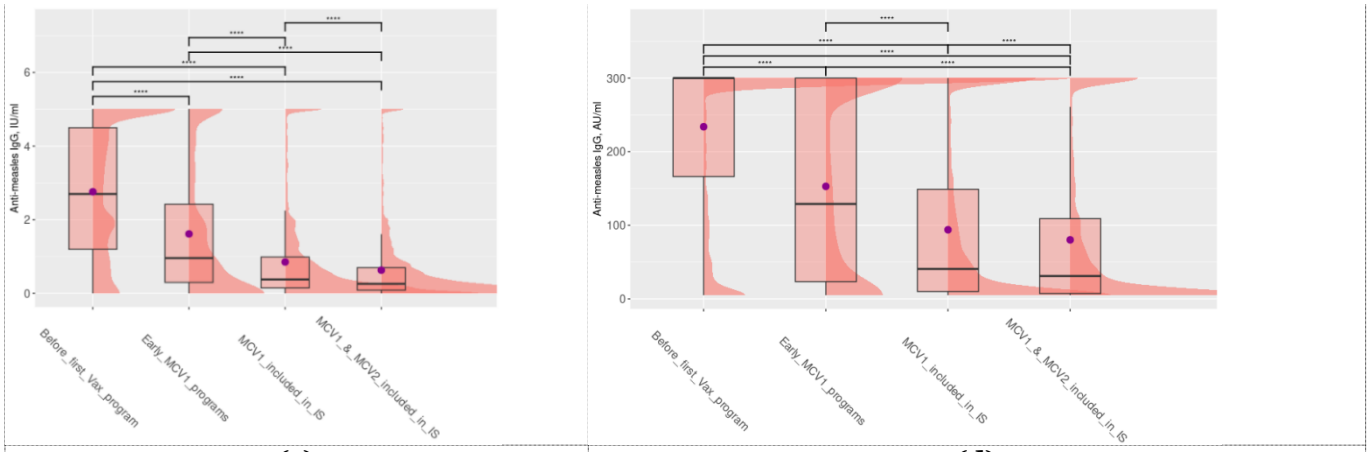
The pairwise comparison showed that the population, covered by MCV1 immunisation only, had significantly fewer IgG seroprevalence compared with the older age group (all $P < 0.05$, Figure 3c, d). The seroprevalence loss in subjects from a population that received two doses of anti-measles vaccine also was significant (all $P < 0.05$, Figure 3c, d).



(a)

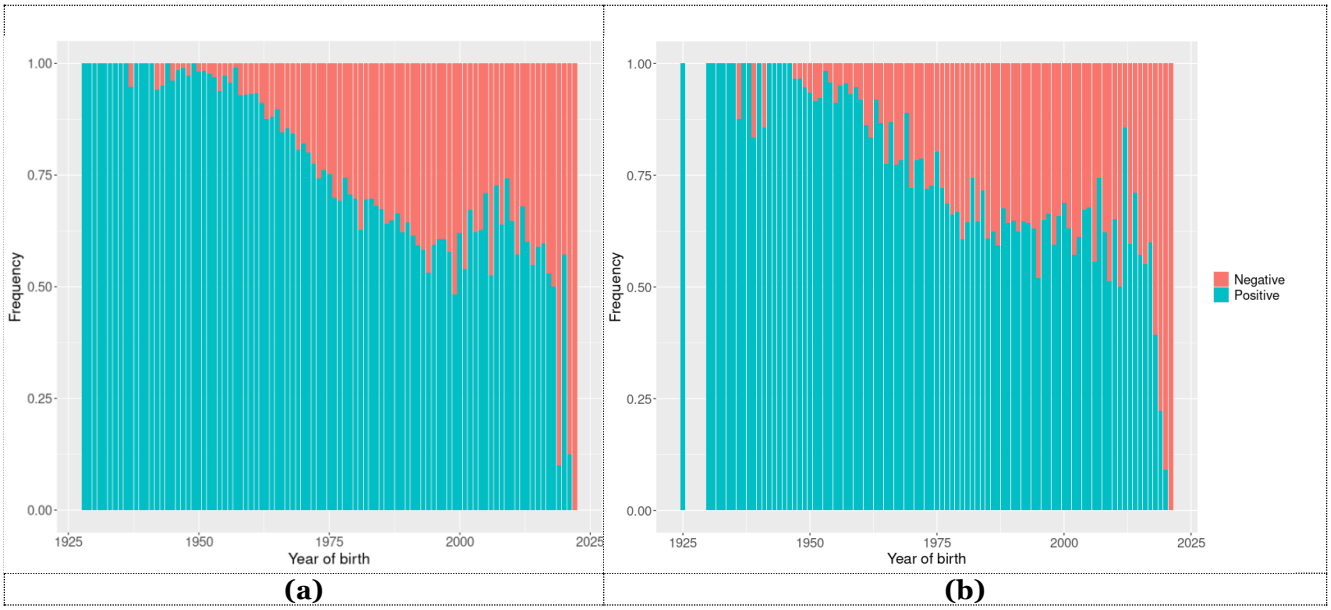


(b)



(c) **(d)**

Figure 2. Anti-measles IgG levels depending on the participants' year of birth. (a) Mean IgG levels estimated by ELISA; (b) Mean IgG levels estimated by CLIA; (c) the IgG level in age groups 1–4 estimated by ELISA or (d) CLIA. ****P < 0.0001.
MCV1 – measles-containing vaccine, first vaccination, MCV1 – measles-containing vaccine, second vaccination, IS – immunisation schedule.



(a) **(b)**

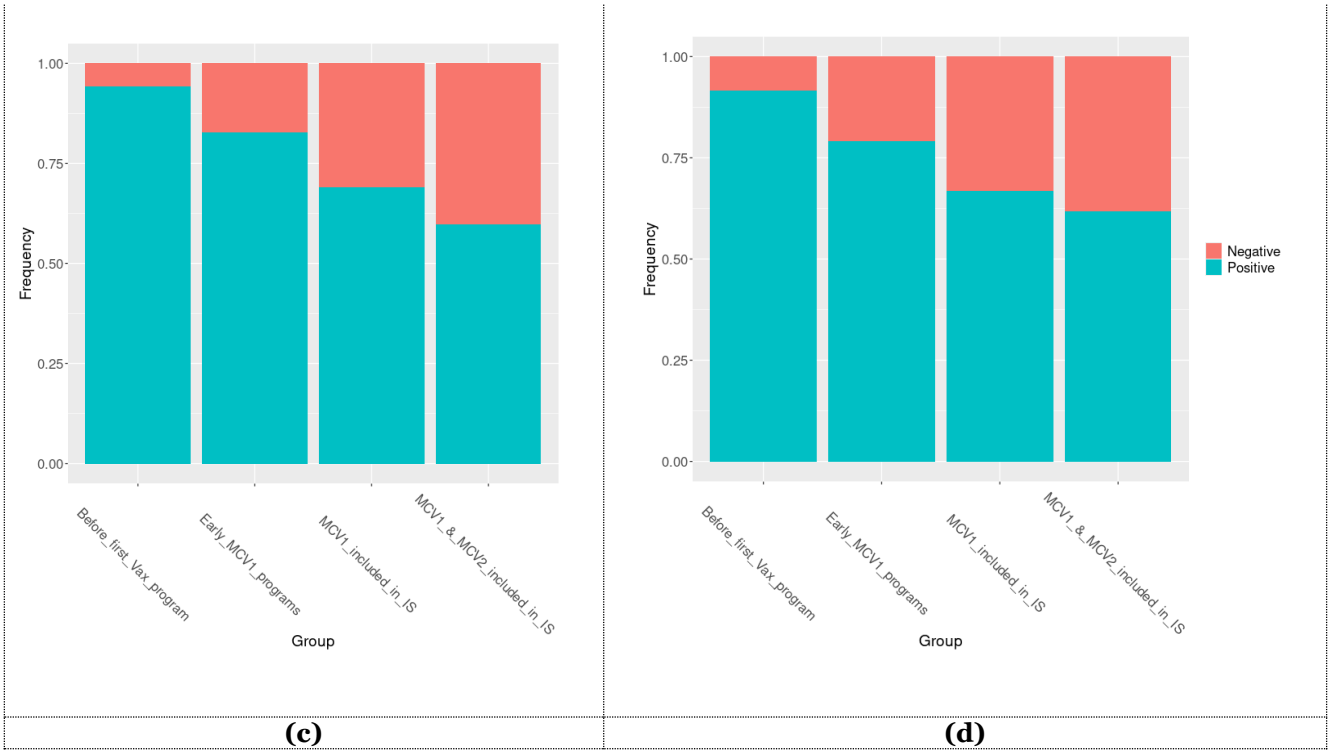


Figure 3. Anti-measles IgG seroprevalence depending on participants' year of birth. (a) Mean IgG levels estimated by ELISA; (b) Mean IgG levels estimated by CLIA; (c) the IgG level in age groups 1–4 estimated by ELISA or (d) CLIA. *MCV1 – measles-containing vaccine, first vaccination, MCV1 – measles-containing vaccine, second vaccination, IS – immunisation schedule.*

Discussion

Herd immunity means that not every member of a population must be immune to prevent large-scale outbreaks [24]. Suggested, that the seroprevalence level, which is necessary to prevent the measles spread, is 93–95% [2, 13]. In our study, we reveal that actual seroprevalence in Northwestern Russia is near 75%. The seroprevalence levels observed in the present study could not protect the population from outbreaks, which registered in Russia in the past decade [12]. Measles incidence in Northwestern Russia is lower than the national average. Nevertheless, Saint Petersburg, Leningrad region, and Kaliningrad region, which were studied in the present surveillance, are the most affected regions in this territory [24]. In 2012–2014 and 2018–2020, the increase in measles incidence from 0.02 cases per 100,000 to 0.9–1.1 cases per 100,000 was recognised [12, 24]. Our data covers the period from 2012 to 2023, so we compare the mean IgG levels and seroprevalence in the population in different years. As the study's aim is to estimate the dynamics of immune protection, we identified significant growth of mean IgG levels in 2014 and 2018–2021 years and a decrease in 2022–2023. The possible reasons are the decline of an immune layer in the population because [25] the natural reduction of the number of people who were born before vaccination initiation and had high-level post-infection immunity, accompanied by reducing vaccine coverage [26] that was worsened by the COVID-19 pandemic [20]. The last factor seems to be less significant because of vast majority of studied subjects were adults and were vaccinated before the COVID-19 pandemic. However, both of these processes do not explain the abrupt decrease of seroprevalence in the post-COVID period and some hidden causes may be input in the identified tendency.

In the present study, in the youngest subjects, the IgG levels are the lowest in the population, despite the method of IgG evaluation (i.e., ELISA or CLIA). Previous literature reported a similar trend for the general population [11, 12, 27] or specific groups like medical staff [28, 29]. The oldest group of patients (i.e. those born before 1967) had a higher number of subjects who had previously suffered the measles, which resulted in the tendency for the growth of anti-measles IgG antibody levels. Considering that measles had affected up to 90% of the population until 15 years old [30], the percentage of subjects who suffered the natural infection in the patients born before 1967 is substantial. Also, previous studies have identified lower antibody levels in late post-vaccination serum samples compared to serum from subjects who previously had a natural infection [31]. Meanwhile, we demonstrate IgG levels decreasing not only in people born in 1966-1990 (Groups 2 and 3), which were covered by the first vaccination programs in 1960–1970s but also in younger participants from Group 1 (i.e. subjects who were born at the beginning of

1960s). This trend may reflect the protective effect achieved by beginning immune interlayer formation in younger children.

When seroprevalence in different groups was compared, the downward trend was identified in younger participants. In subjects, who were born before the initiation of vaccination, over 90% are seropositive for measles, but in the age group partially covered by immunisation seroprevalence level is only 79.17–82.76% (depending on immunologic test). In the population that received only MCV1 in childhood, the seroprevalence is only 66,88%. Similarly, in countries in other parts of the world, including Guinea, where over 28,5% of the population aged 19–40 years was seronegative [27]. Also, in Thailand and Columbia, in adult subjects who received only MCV1 in childhood only 70% [32] and 64.7% [33] have protective level of anti-measles IgG, respectively.

Then we compare the youngest group of participants, that suggested to be mandatory vaccinated by MCV1 and MCV2, with other age groups. Despite the indefinite vaccination status, this group demonstrated a near 10% gain in seroprevalence loss compared to subjects covered by mandatory MCV1 vaccination. On the other hand, the previous study of measles epidemiology features in Saint Petersburg demonstrated, that the mean age of infected subjects in 2017–2019 was 33.4 years old [12], i.e. they correspond to Group 3 rather the Group 4 in our study. This supports the idea that the two-times-vaccinated younger group is better protected than the population that received only a single MCV immunisation. The decreased seroprevalence was identified in adolescents in several studies, for example in Canada [34] or South Korea [35], where the declined IgG positivity in younger age may reflect the failure of vaccination [34] or lack of boosting by the natural virus [35]. Altogether, the current data for the IgG levels and seroprevalence in the contingent that received MCV2 seems to be controversial. In some populations, a higher seroprevalence in children and adolescents compared to young adults or middle-aged adults was identified. For example, this trend was represented in Poland [36].

There were some limitations to the present study. First, we have no access neither to the information about the actual participants' vaccination status nor to the data for the vaccination coverage in the region. Despite this limitation, the obtained data is in line with the trends described in the literature. Second, the analysed data were acquired retrospectively, and the seroprevalence was estimated by different methods in unmatched groups, which are difficult to compare with another one. Meanwhile, the comparable trends in groups examined by the CLIA or ELISA additionally support the validity of identified population serological characteristics. Additionally, we identified a significant gender imbalance between age groups and insufficient data for several years at the beginning of surveillance. These limitations are insuperable, but despite these constraints, our results seem to be in common trend with published data, as discussed above.

Also, the protective immunity against measles is not determined solely by IgG levels. Strong T-cell-mediated immunity also may protect the subject against the measles infection despite the low activity of humoral immunity. So, screening T-cell immunity, for example, by the ELISPOT assay, may improve understanding actual herd immunity status [37]. The study aggregates the data for the population of several districts, but all these regions are characterised by similar social tendencies in common and possible differences are not the aims of the study.

Conclusion

The present study identified certain tendencies in anti-measles IgG levels and seroprevalence dynamics in the Northwestern Russian population in the past decade. We have revealed a significant decrease in anti-measles IgG levels in the Northwestern Russian population in the past decade, accompanied by a trend of seropositivity decline. The mandatory MCV1 vaccination, which was started in the USSR in 1972 year, decreased the measles incidence and provided the immune layer in the population. It appears that there is controversy surrounding the effect of including MCV2 in the National Vaccination Schedule. There was no increase in seroprevalence observed in the population that received MCV2 according to this schedule. Measles outbreaks are still being registered in schoolchildren and students in Northwestern Russia, in line with this trend. The possible reason is the low population compliance with preventive measures and refusal of vaccination. The COVID-19 pandemic disrupted the preventive medicine work, which also affected herd immunity, especially in younger subjects, who did not receive vaccination in time. However, this effect can only be evaluated in the future. Currently, a debate is being held about what will be the next global pandemic after COVID-19. The present data demonstrates that the success achieved by measles immunisation is not resistant. So, for now measles is on the one line with new influenza, coronaviruses, or “Disease X”. The lack of commitment to the control of this disease may cause measles to re-emerge with a massive infection spread.

Author Contributions

Conceptualisation, AVI and ANV; methodology, ANV; software, ANV; validation, AVI; formal analysis, ANV; investigation, ANV and AVI; resources, AVI; data curation, ANV; writing—original draft preparation, ANV; writing—review and editing, AVI and ANV; visualisation, ANV; supervision, AVI; project administration, AVI; funding acquisition, ANV. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest disclosure

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Data accessibility statement

All data underlying the results are available as part of the article and no additional source data are required.

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