ROYAL COLLEGE OF PHYSICIANS OF IRELAND

National Immunisation Advisory Committee

RECOMMENDATIONS REGARDING POLIO RE-EMERGENCE

NIAC | 06.10.2022

About NIAC

NIAC membership includes nominees from the RCPI, its Faculties and Institutes, the RCSI, the ICGP, the National Immunisation Office, the Nursing and Midwifery Board of Ireland, the Infectious Diseases Society of Ireland, the Travel Medicine Society, the National Virus Reference Laboratory and lay members. Meetings are attended by representatives from the Department of Health and the HSE. Representatives of the Health Products Regulatory Agency attend to provide regulatory advice in relation to vaccines.

NIAC considers new evidence about vaccines and provides advice to the Chief Medical Officer and the Department of Health. The Department and the Minister for Health make policy decisions on vaccines which are implemented by the HSE.

RECOMMENDATIONS

These recommendations may be updated when more information becomes available.

1. Priority should be given to increasing the uptake of polio containing vaccines in the primary childhood and the school immunisation programmes aiming for vaccination uptake rates of 95% in each.
2. All those who are unvaccinated or incompletely vaccinated are strongly encouraged to receive their polio containing vaccines and to be up to date with all other recommended vaccines.
3. A single, unique, integrated vaccination database is urgently required with timely recording and reporting of all vaccinations. This would assist identification of cohorts and areas with low vaccine uptake to enable targeted interventions.
4. There should be a focus on ease of access and removal of barriers to vaccination, in particular for those with sub-optimal polio vaccine uptake including those from countries with low polio vaccine uptake and those seeking international protection.
5. A media information campaign on polio and polio vaccination should be initiated, informing the population of the need to be up to date with their vaccinations.
6. Those who will be spending more than four weeks in countries or areas with the potential risk of international spread of polio, are recommended to receive an additional dose of poliovirus vaccine between four weeks and 12 months prior to international travel.
7. Healthcare professionals should be reminded of, and comply with, the existing acute flaccid paralysis surveillance system.
8. A wastewater surveillance programme for polio should be considered.

GLOSSARY

AFP acute flaccid paralysis

cVDPV circulating vaccine-derived poliovirus

cVDPV1 circulating vaccine-derived poliovirus type 1

cVDPV2 circulating vaccine-derived poliovirus type 2

cVDPV3 circulating vaccine-derived poliovirus type 3

IPV inactivated polio vaccine

OPV oral polio vaccine

VAPP vaccine associated paralytic polio (polio developing in a OPV recipient or their immediate contact caused by the OPV virus)

VDPP vaccine-derived paralytic polio (polio caused by VDPV)

VDPV vaccine-derived poliovirus (virus arising from OPV strains following prolonged transmission from person to person allowing for the accumulation of mutations that can restore virulence)

WPV wild poliovirus

WPV1 wild poliovirus type 1

WPV2 wild poliovirus type 2

WPV3 wild poliovirus type 3

1. EXECUTIVE SUMMARY

- Poliomyelitis (polio) is a highly infectious vaccine preventable illness. The majority of those who contract the virus have no symptoms or minor symptoms, however in a minority, flaccid paralysis can occur.
- Worldwide, wild type poliovirus (WPV) has almost been eradicated due to vaccination with just a few remaining pockets of transmission in Pakistan and Afghanistan and some imported cases in Mozambique and Malawi.
- The recent upsurge in detection of circulating vaccine-derived polio virus (cVDPV) in areas that had been polio free and reports of two cases of paralytic polio caused by cVDPV is a significant concern and highlights the threat of polio to populations with suboptimal vaccination coverage.
- An increase in case numbers can be expected if cVDPV strains continue to circulate in populations with low vaccine coverage.
- In September 2021, three Member States of the European region of the World Health Organization (WHO), Ukraine, Poland, Romania were considered to be at high risk for a sustained polio outbreak if wild type polio is introduced and for the emergence of cVDPV; 22 were considered to be at intermediate risk, 21 at low risk, and 7 were not assessed. Ireland was deemed at low risk but suboptimal vaccine coverage was noted.
- However in continuation of the recent resurgence, between 16 August 2022 and 23 September 2022, a total of 115 cases of polio have been reported; eight WPV1 from Pakistan, Afghanistan and Mozambique, eight cVDPV1 and 99 cVDPV2.
- There are two types of polio vaccine available which are safe and effective. The inactivated (non-live) polio vaccine (IPV) which is given by injection and the live polio vaccine given orally (OPV).
- IPV offers excellent protection against disease from all strains of wild type and vaccine-derived poliovirus. As a non-live vaccine, there is no replication in the gut and therefore no risk of transmission of vaccine-derived polio from IPV vaccine.
- OPV contains attenuated live viruses that replicate in the gut and are shed in stool. This provides mucosal immunity to the vaccinee. Stool shedding can result in person to person transmission of vaccine strains and spread immunity within a community.
- In rare circumstances if there is ongoing community circulation, the attenuated virus can acquire mutations that result in reversion to neurovirulence i.e., vaccine-derived poliovirus (VDPV), and cause paralytic disease. VDPV is genetically distinct from wild type poliovirus but the clinical outcomes are similar. Communities that use OPV and have low vaccination coverage are at highest risk for the emergence of VDPV.
- The protection afforded by polio vaccination is durable. In Italy, where the polio vaccination schedule is similar to Ireland, protective antibodies were present when students tested at an average of 19 years following vaccination, irrespective of whether IPV or OPV had been

received. In the US, polio antibody seroprevalence in adults aged 40-49 years, was high even after 30 years since vaccination.

- In Ireland IPV replaced OPV in 2001. IPV containing vaccines are recommended for infants aged 2, 4, and 6 months (6 in 1 vaccine) and at school entry (4 in 1 vaccine). In the first quarter of 2022, the 24-month vaccine uptake rate for the third polio vaccine was 92.5% and in 2020-2021 for the 4 in 1 at school entry, was 86%. Ireland falls short of the 95% uptake recommended for security from polio.
- As recommended by WHO, key responses to this threat include high polio vaccine uptake, consideration of booster doses for those who may be at higher risk, and intensification of surveillance for polio and for cVDPV strains. Target vaccine uptake of 95% is recommended.
- Convenience of access to polio vaccination is critical.
- Complacency with regard to the threat of polio must be overcome through the dissemination of reliable trusted information.
- There is reason for confidence that if high polio vaccine uptake can be achieved and maintained in Ireland, the threat posed here will be averted.

2. INTRODUCTION

Poliomyelitis (polio) is a highly infectious vaccine preventable acute illness that can result from invasion of the gastrointestinal tract by one of three wild types of poliovirus (WPV1, WPV2 or WPV3). The virus enters through the mouth and multiplies in the oropharynx and gastrointestinal tract. The virus is usually present in nasopharyngeal secretions for 1-2 weeks and can be shed in stools for several weeks after infection, even in those with minor symptoms or no illness. On average one case of polio can be expected to infect 4-6 non-immune contacts. Over two-thirds of polio infections in children are asymptomatic and a quarter consist of a minor nonspecific illness with complete recovery in less than a week. Nonparalytic aseptic meningitis occurs in 1-5% of polio infections in children. Typically, symptoms last 2-10 days and are followed by complete recovery. Less than 1% of all polio infections in children result in paralysis.

The risk of severe disease and death following primary infection with poliovirus increases with increasing age. Prior to the development of polio vaccines, widespread viral dissemination among those not protected resulted in large epidemics, including in Ireland in 1955. In 1988, the World Health Assembly adopted a resolution for the worldwide eradication of polio using the two available polio vaccines; inactivated polio vaccine (IPV) and oral polio vaccine (OPV). In 2017, the 99.9% reduction in wild type polio globally was attributed to OPV.

However, civil unrest, war and increase in anti-vaccine sentiment has disrupted the efforts to eradicate polio and resulted in persistence of populations with low immunity, facilitating continued virus transmission by faecal shedding.

Continued person to person transmission of the attenuated vaccine viruses in populations with low vaccine coverage can result in the gradual accumulation of mutations in the virus and reversion to neurovirulence. These strains, genetically distinct from wild type polio, are referred to as vaccine-derived polioviruses (VDPV) and can produce disease clinically indistinguishable from polio.

WPV1 was the main cause of epidemic disease prior to introduction of vaccines. It is now largely confined to areas of Afghanistan and Pakistan. WPV2 and WPV3 have been eradicated. Recent detection of circulating VDPV (cVDPV) in many areas of the world and the report of paralytic polio related to cVDPV2 in an unvaccinated male in New York and to cVDPV3 in an unvaccinated child in Israel highlights the need for concern, even in settings where poliovirus transmission has been previously interrupted and polio eliminated.

As noted by Sutter and colleagues in 2018:

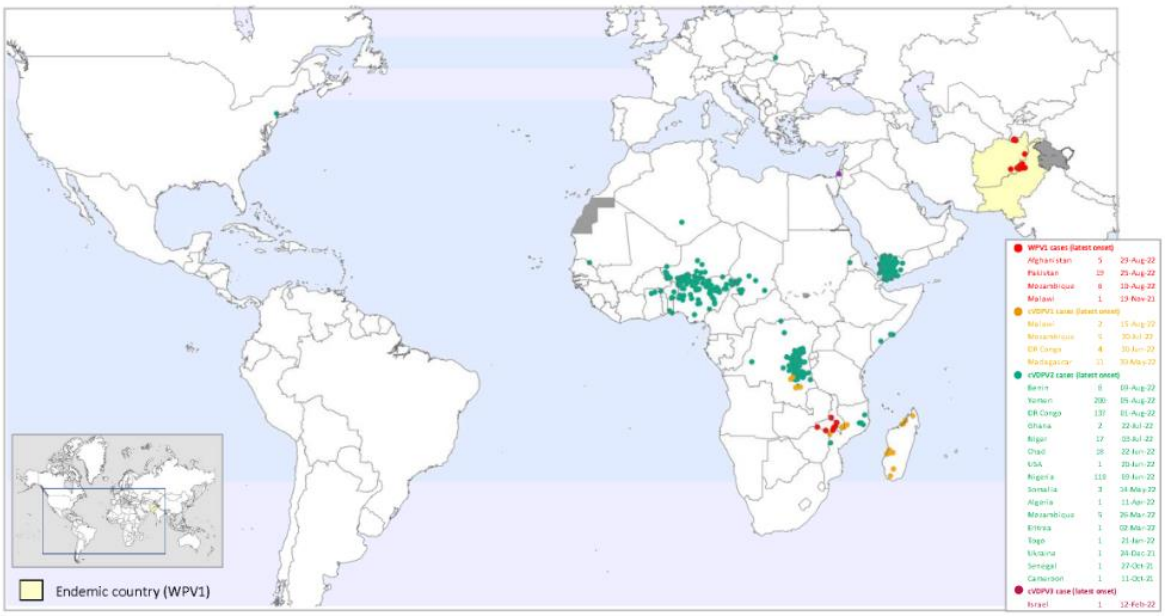
"Circulating VDPVs (cVDPV) pose the same public health threat as wild polioviruses because they have recovered the biological properties of wild polioviruses, have the potential to circulate for years in settings where poliovirus vaccine coverage to prevent the particular type is low, and require the same control measures".[1]

3. EPIDEMIOLOGY

The Global Polio Eradication Initiative had almost achieved its aim of polio eradication with very small numbers of WPV1 occurring in Pakistan and Afghanistan. In 2021, only six cases were reported.[2] The eradication goal is now challenged by spread of cVDPV2 with more than 400 cases reported from 22 countries in 2021. (Figure 1)

Between 16 August 2022 and 23 September 2022, 115 new cases of polio caused by WPV1 or cVDPVs have been reported; five WP1 From Pakistan, one from Afghanistan and two from Mozambique. Eight new polio cases by CVDP1 and 99 cases caused by cVDPV2 were also reported.[3]

Figure 1: Global WPV1 and cVDPV cases 28 September 2021-27 September 2022. Source: WHO.[4]



In 2021/22, cVDPV2 accounted for more than 90% of cVDPV cases globally with reports of its detection in the Ukraine in October 2021, Israel in March 2022, London in June 2022 and New York in July 2022.

Many African and Asian countries are at risk of reintroduction of WPV1 infection and/or spread of cVDPV2 from endemic areas because of low population immunity due to low vaccine coverage.[5]

cVDPV detection in the UK

In June 2022, the U.K. Health Security Agency announced that poliovirus had been detected in several sewage samples collected in the Beckton sewage treatment works between February-June 2022. The plant covers large catchment area in North East and North Central London with a population of four million. Several boroughs were affected indicating widespread community transmission. Identification of the virus as cVDPV2 was confirmed based on the number of mutations present and indicates continued virus circulation over a prolonged period of time.[6] In London, primary vaccination coverage is well below the national average.[7] This shows the real potential for polio re-emergence in settings that had previously interrupted polio if there is suboptimal vaccine uptake.

cVDPV acute flaccid paralysis cases 2022

In July 2022, in New York, cVDPV2 was reported as the cause of paralysis in an unvaccinated immunocompetent adult male. Vaccine coverage in the local area was 60.3% with rates as low as 37.3% in specific zip-code areas. As of September 9, 2022, CDC sequencing analysis confirmed

poliovirus in 57 samples; 50/57 (4 counties) genetically linked the wastewater samples to the virus of the index paralytic case, indicating community transmission.[8]

In March 2022, in Israel, VDPV3 caused paralysis in an unvaccinated child aged 3 years 9 months. This virus was genetically linked to cVDPV3 strains detected from September 2021 to January 2022 in Jerusalem and Bethlehem.[9]

An increase in case numbers can be expected if cVDPV strains continue to circulate in populations with low vaccine coverage.

European countries at risk for cVDPV circulation

In September 2021, three countries in the WHO European region (Ukraine, Poland, Romania) were considered to be at high risk for a sustained polio outbreak if WPV was introduced or the emergence of cVDPV related to suboptimal vaccine uptake; 22 member states were considered to be at intermediate risk, 21 at low risk, and 7 were not assessed. Ireland was deemed at low risk but suboptimal vaccine coverage was noted. Of note, in 2021 the UK was deemed to be at low risk for cVDPV circulation and Israel had not been assessed.[10]

Polio surveillance

A global active surveillance system for acute flaccid paralysis (AFP) has been in operation since 1998. The last case of AFP due to polio in Ireland was reported in 1984. Complacency with regard to the threat of polio and the need for continuing active surveillance needs to be addressed. It is important to strengthen awareness of the existing AFP surveillance system and to ensure that any cases are rapidly detected, reported, and appropriately investigated.

There is no wastewater surveillance for poliovirus in Ireland. The value of wastewater surveillance in predicting emerging disease threats has been evidenced during COVID-19.[11]

4. POLIO VACCINES

Inactivated polio vaccine (IPV) is a trivalent vaccine which protects against all three wild types of paralytic polio. As it is a non-live virus there is no risk of replication or reversion to virulence i.e., no risk of causing vaccine-derived poliovirus (VDPV). It must be given by injection and while very effective in preventing the serious consequences of polio, it does not always stop gastrointestinal infection and is proven ineffective in stopping transmission.

Live oral polio vaccine (OPV) initially contained all three types of poliovirus in an attenuated (weakened) form. In 2015, this was changed to a bivalent vaccine (WPV1 and WPV3). OPV is a very safe, easily administered vaccine that has contributed very significantly to the global near eradication of polio. The attenuated virus replicates in the gut and is shed in stool. Up to 90% of

OPV vaccinated infants excrete poliovirus for some weeks following vaccination. Transmission of the excreted virus to non-immune household contacts is common and can also induce protection. Excretion can be prolonged in those who are immunocompromised although rarely in healthy children.[12 13]

Rarely, vaccine associated paralytic polio (VAPP) may develop in an OPV recipient or their immediate contacts. Vaccine associated paralytic polio (VAPP) is a rare event occurring in one in four million vaccinees or their contacts in countries using trivalent OPV. Since the removal of OPV2 and addition of IPV, the estimated VAPP incidence has fallen below one in 2 per million.[14] While very rare, the risk is highest following the first dose of OPV, in those with immunocompromise, and in non-immune contacts of vaccinees.[15] Vaccine associated paralytic polio (VAPP) is a rare event occurring in one in four million vaccinees or their contacts in countries using trivalent OPV. Since the removal of OPV2 and addition of IPV, the estimated VAPP incidence has fallen below one in 2 per million.[16 17] While very rare, the risk is highest following the first dose of OPV, in those with immunocompromise, and in non-immune contacts of vaccinees.[15]

If, following OPV vaccination, person to person transmission of the vaccine strain continues over long periods of time, mutations may gradually accumulate resulting in a genetically distinct viruses i.e., vaccine-derived polio viruses (VDPVs). This process can result in reversion to neurovirulence and cause disease that is clinically indistinguishable from wild type polio i.e., vaccine-derived paralytic polio (VDPP). VDPV have the capacity for sustained circulation. They may be also associated with increased transmission capacity. The risk is highest where vaccine uptake is low and transmission to unprotected individuals occurs. It is important to note that those who are protected from paralysis by vaccination or past infection can still become infected and contribute to transmission, with a risk of paralysis in the unvaccinated.

Vaccine effectiveness and duration of immunity

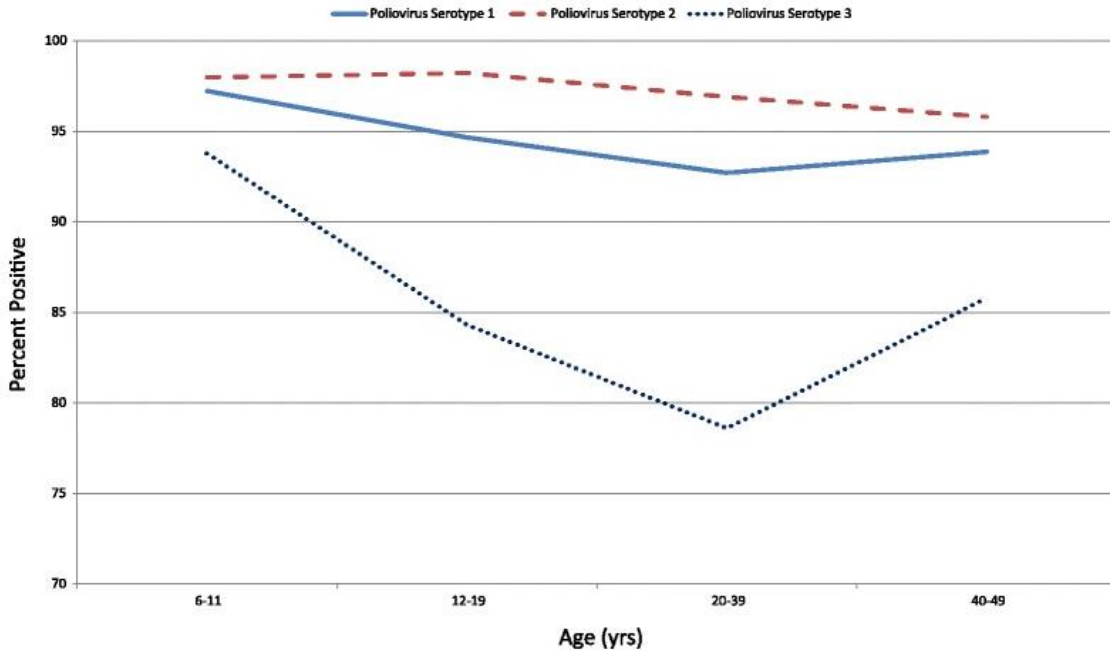
Both IPV and OPV are highly immunogenic and effective at preventing paralytic polio from both wild type and vaccine-derived poliovirus.[15] Detection of neutralising antibodies is accepted as a correlate of protection. Both IPV and OPV are highly immunogenic and effective at preventing paralytic polio from both wild type and vaccine-derived poliovirus.[15] Detection of neutralising antibodies is accepted as a correlate of protection.

Immune response to IPV depends on the amount of antigen, number of doses, interval between doses, age at first dose and level of maternal antibodies present at time of vaccination. Neutralising antibody titres above a 1:8 threshold or a four-fold rise in neutralising antibodies following vaccination is protective.[18] Immune response to IPV depends on the amount of antigen, number of doses, interval between doses, age at first dose and level of maternal antibodies present at time of vaccination. Neutralising antibody titres above a 1:8 threshold or a four-fold rise in neutralising antibodies following vaccination is protective.[18]

The enhanced potency IPV formulations, currently in use globally result in seroconversion rates of 95-100% following three doses at 2, 4 and 6 months of age. Schedules at 2, 3, and 4 months also give good seroconversion rates.[1 17] After two or three doses in the first six months of life antibody levels fall, although they generally remain above the protective level. Studies have shown persistence of antibodies following a three dose schedule in infancy for at least 4-5 years at which stage a fourth dose is given.[1 17 19] After two or three doses in the first six months of life antibody levels fall, although they generally remain above the protective level. Studies have shown persistence of antibodies following a three dose schedule in infancy for at least 4-5 years at which stage a fourth dose is given.[19]

It is not known how long IPV protection lasts, but likely for many years after a complete series of IPV. A US national seroprevalence study of those aged 6 to 49 years, some 30 years following the last indigenous case of polio, showed high seroprevalence of polio OPV vaccination induced mucosal and humoral immunity of 94%, 97% and 83% for types 1, 2, and 3 respectively. In those aged 6-11 years seroprevalence was 97%, 98% and 94%, for types 1, 2, and 3 respectively.[20] As OPV was discontinued in the US in 2000, children under 10 years of age would have received IPV, thus seroprevalence rates in this cohort are largely due to IPV vaccination. (Figure 2)

Figure 2. Seroprevalence of poliovirus antibodies in the US, 2009-2010. Source: Wallace et al.[20]

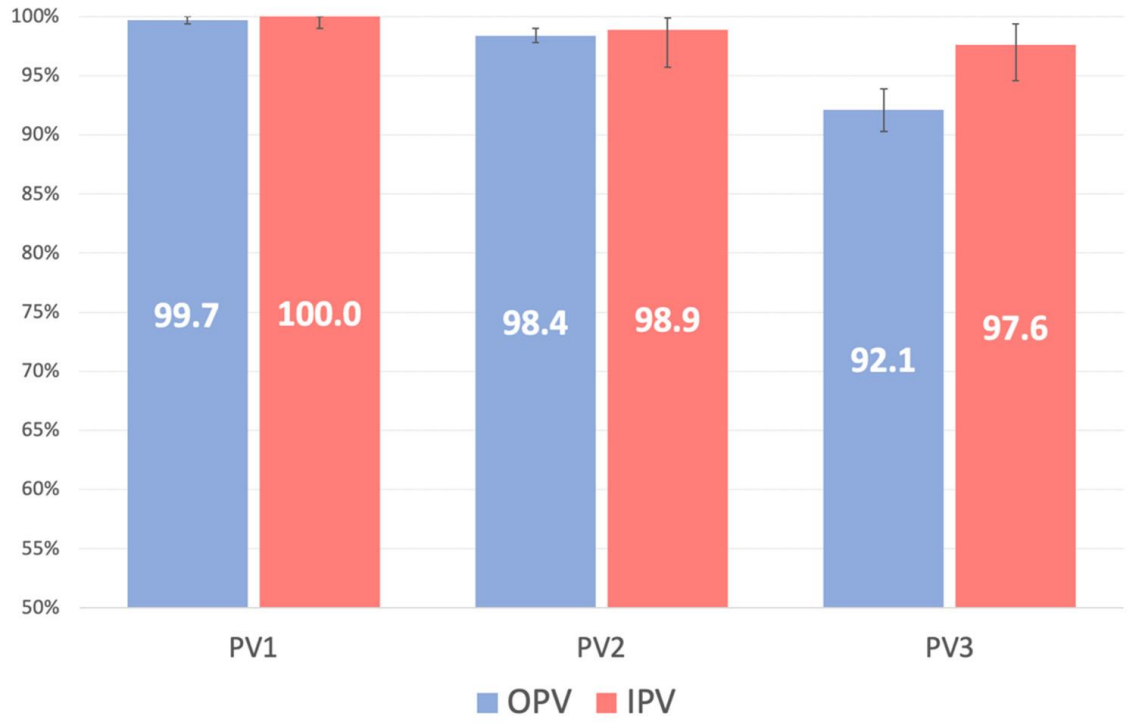


Intestinal immunity is more short lived following IPV than OPV, enabling asymptomatic infection, and thus can contribute to the continued circulation of VDPVs.

As evidenced by the global decline in incident paralytic polio, OPV is highly effective.

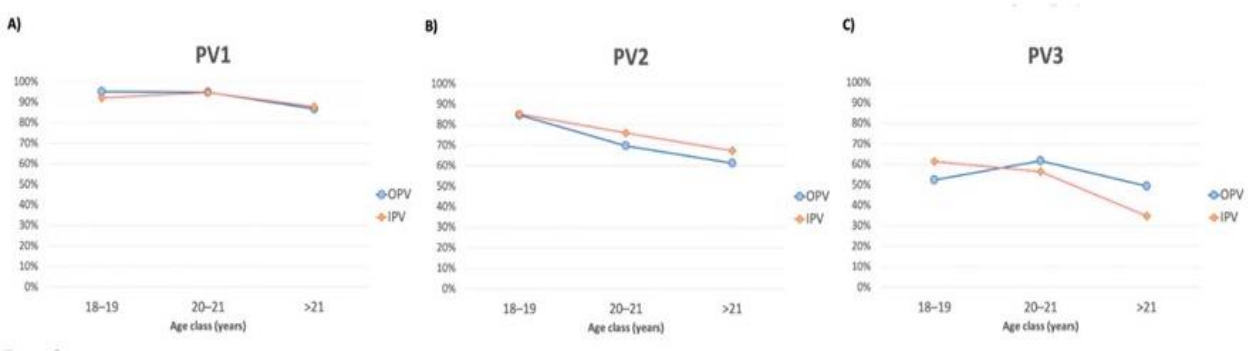
As noted above in the US national study the seroprevalence of polio antibodies was very high in those aged 12 years and older, most likely due to OPV.[20] In Italy with a primary vaccination schedule similar to Ireland, poliovirus antibody seroprevalence was high in young adults tested on average 19 years (range 9-31) following vaccination irrespective of whether IPV or OPV was used. (Figure 3)[21 22]

Figure 3. Prevalence (%) of neutralising antibodies by poliovirus (PV) type among study participants in Italy. Source Larocca et al.[22]



In this, as in the US seroprevalence study, some reduction in neutralising antibodies by age was observed. (Figure 4)[22]

Figure 4. Type specific poliovirus antibody levels by age. Source: Larocca et al.[22]



5. POLIO VACCINATION IN IRELAND

IPV was introduced to Ireland in 1957 so individuals born before 1958 may not have been immunised. OPV replaced IPV in the early 1960s. In 2001, as wild type paralytic polio had been effectively eliminated in Ireland the risk of VAPP was greater than that of wild polio thus IPV was reintroduced into the primary immunisation schedule.

Four polio containing vaccines are recommended for infants at 2, 4, and 6 months of age, as part of the 6 in 1 vaccine, and again at school entry as part of the 4 in 1 vaccine. (Table 1)

Table 1: Polio containing vaccines.

Name	Recommended Age	Components	Schedule
High dose Diphtheria/Tetanus/Pertussis			
Infanrix Hexa (6in1)	2 months-9 years	DTaP/IPV/HiB/HepB	2, 4, 6 months
Tetravac (4in1)	2 months-13 years	DTaP/IPV	4-5 years
IPV-Infanrix (4in1)	16 months–13 years	DTaP/IPV	4-5 years
Low dose Diphtheria/Lower dose Tetanus & Pertussis			
Revaxis	4 years-adult	Td/IPV	Used for travel, patient specific use
Repevax	3 years-adult	Tdap/IPV	EU authorised but not currently marketed in Ireland
IPV-Boostrix	3 years-adult	Tdap/IPV	

ap: low dose acellular pertussis, aP: high dose acellular pertussis, d: low dose diphtheria, D: high dose diphtheria, HepB: hepatitis B, HiB: haemophilus influenzae type b, IPV: inactivated polio vaccine, T: tetanus.

Vaccine uptake at 24 months for DT3/aP3/Hib3/Polio3 was 92.5% in the first quarter of 2022 (range 86%-96%), with lowest uptake levels in Waterford, Carlow, Wicklow and Dublin West.[23] Between 2019/2020 and 2020/2021 DTaP/IPV uptake decreased in HSE vaccine administered areas from 91.5% to 85.5%. Uptake in exclusively GP vaccine administered areas (Donegal and Sligo/Leitrim) decreased from 88.5% to 86.3%.[24]

For a variety of reasons including the COVID-19 pandemic disruption to services, the uptake of the primary childhood and school polio containing vaccines is less than the recommended 95% uptake. In addition, there is no recording of whether those receiving the polio containing booster in school have previously received the three recommended polio containing vaccines.

Ireland falls short of the 95% uptake recommended for the childhood schedules needed for security from polio outbreaks in the event of poliovirus introduction.

6. INTERNATIONAL RESPONSE

	Response
UK August 2022[7]	Ensure all eligible individuals are up to date with their polio vaccinations to increase coverage of routine childhood vaccination programme nationally.
	An extra polio booster vaccine dose recommended for children aged 1-9 years living in London. • Booster IPV vaccination to be given at least 4 weeks after most recent polio vaccine • For those who have had the preschool booster, extra dose only given if more than 12 months since the booster. Children under 10 years of age targeted due to 'lower personal hygiene' and potentially lower antibody levels. In the UK, Tdap/IPV is given in pregnancy thus potentially interfering with infant polio vaccine response by higher maternal antibody levels. Of note pregnant women in Ireland do not routinely receive an IPV containing vaccine.
	A sooner replacement of the 12/13 month Hib vaccine with a DTaP/IPV/HiB/HepB (6in1) vaccine in the routine immunisation schedule once the IPV campaign has ended, thus children would receive an extra dose of polio containing vaccine before the two years of age.
New York, US July 2022[8]	State Disaster Emergency declared.
	New York residents aged 2 months and over who are unvaccinated or incompletely vaccinated should come forward for vaccination.
	Those fully vaccinated should receive one booster dose if • they will or might come in contact with person/s known or suspected to be infected, or with a household member or close contact of such a person • they are a healthcare worker in areas where poliovirus has been detected, or who might handle samples or care for infected patients.
	Individuals with occupational exposure to wastewater can consider booster.

WHO June 2022[5]	All those unvaccinated or incompletely vaccinated should receive/complete their vaccinations. All countries should aim for high vaccination rates.
	All long-term visitors (>4weeks) to countries with WPV1, cVDP1 or cVDPV3 (Afghanistan, Malawi, Mozambique, Pakistan, Madagascar, Israel) should receive IPV between 4 weeks and 12 months prior to departure, or at least at the time of departure. (WHO suggests need for vaccination certificates for exit from these countries).
	Residents and long term visitors in countries with local transmission of cVDPV2 should be encouraged to have a dose of IPV 4 weeks to 12 months prior to international travel.
	Intensify surveillance.
EU August 2022[25]	The EU/ECDC has endorsed the WHO approach as outlined above.

7. DISCUSSION

Receiving four polio containing vaccines in infancy and early childhood confers durable protection for at least 10 to 19 years. While there may be some gradual decline in antibody levels with age, it is unlikely that protection will be rapidly compromised.

As vaccination uptake rates for the fourth dose of polio vaccine in Ireland are as low as 85%, up to 15% of children may not be protected so there is a significant population who would not be adequately protected in the event of poliovirus introduction to Ireland. Given the level of social and commercial travel between Ireland, London, New York and globally, cVDPV in any jurisdiction represents a serious risk.

The immediate necessity is to achieve a national vaccination uptake of 95% for the primary childhood immunisation schedule and for the school programme. Significant efforts will be required to increase uptake. There should be a focus on ease of access and removal of barriers to vaccination (e.g., ensuring no parental costs), in particular for those with sub-optimal polio vaccine uptake including those from countries with low polio vaccine uptake and those seeking international protection. Similar measures will likely be required to ensure access to catch-up vaccinations for older children and adults to ensure protection against polio and as well as other vaccine preventable diseases.

Paradoxically, the success of vaccination has permitted complacency regarding the need for polio vaccination, as societal memories of paralytic polio fade.

Targeted information from trusted sources in multiple languages will be needed to explain the real threat presented by the current situation and protection afforded by vaccination.

In the event that VDPV circulation is detected in Ireland, consideration will then be given to what additional measures will be required. Future options include the addition of a 6 in 1 vaccine in the second year of life, the substitution of a polio containing vaccine for the adolescent Tdap and, depending on the urgency of the threat, the rollout of a targeted or mass polio booster vaccination programme.

There are two components that inform the urgency of response and the extent of measures necessary to counter the poliovirus threat; surveillance and vaccination coverage data. Intensifying surveillance at the clinical level and from wastewater surveillance can provide epidemiological data on both the presence and circulation of cVDPV within the community. Up to date vaccination uptake data indicate the level of protection in the community and can spotlight areas for specific interventions. Together these components are key to informing any further recommendations.

In summary the current global situation represents a real threat to our health security.

Convenience of access to polio vaccination is critical and efforts should be made to identify and overcome any potential barriers. Complacency with regard to the threat of polio can only be overcome with reliable trusted information reaching even the most marginalised and vulnerable. There is however reason for confidence that if excellent vaccine uptake with currently recommended vaccines can be achieved, the threat posed might be averted. The vaccines are excellent and protection from them is durable. They are very safe. The need for additional polio booster vaccines at a future date depending on the evolution of the epidemiology cannot at this time be excluded.

REFERENCES

1. Vidor E. Plotkin's Vaccines. 7th edition ed: Elsevier:841-865.

2. World Health Organization. Poliomyelitis Fact Sheet 2022 [Available from: https://www.who.int/news-room/fact-sheets/detail/poliomyelitis accessed 30/09/2022 2022.

3. European Centre for Disease Prevention and Control. Communicable disease threats report, 18-24 September 2022, week 38, 2022.

4. Global Polio Eradication Initiative. Map of Global WPV1 & cVDPV Cases, Previous 12 Months 2022 [A map showing the latest number of WPV1 and cVDPV cases in each affected country]. Available from: Polio Now – GPEI (polioeradication.org) accessed 30/09/2022 2022.

5. World Health Organization. Statement of the Thirty-second Polio IHR Emergency Committee, 2022.

6. UK Health Security Agency. Immediate actions in response to detection of vaccine derived polio virus type 2 (VDPV2) in London sewage samples. www.gov.uk, 2022.

7. JCVI. Joint Committee on Vaccination and Immunisation statement on vaccination strategy for the ongoing polio incident, 2022.

8. Centers for Disease Control and Prevention. Public Health Response to a Case of Paralytic Poliomyelitis in an Unvaccinated Person and Detection of Poliovirus in Wastewater — New York, June–August 2022 2022 [71(33);1065-1068:[Available from: Public Health Response to a Case of Paralytic Poliomyelitis in an Unvaccinated Person and Detection of Poliovirus in Wastewater — New York, June–August 2022 MMWR (cdc.gov) accessed 30/09/2022 2022.

9. World Health Organization. Circulating vaccine-derived poliovirus confirmed in Israel 2022 [Available from: Circulating vaccine-derived poliovirus confirmed in Israel (who.int) accessed 30/09/2022 2022.

10. World Health Organization Regional office for Europe. 35th meeting of the European Regional Certification Commission for Poliomyelitis Eradication held virtually on 6-7 September 2021. WHO/EURO:2022-5197-44961-64000 ed. www.who.int, 2021.

11. Izquierdo-Lara R, Elsinga G, Heijnen L, et al. Monitoring SARS-CoV-2 Circulation and Diversity through Community Wastewater Sequencing, the Netherlands and Belgium. *Emerg Infect Dis* 2021;27(5):1405-15. doi: 10.3201/eid2705.204410

12. Macklin G, Liao Y, Takane M, et al. Prolonged Excretion of Poliovirus among Individuals with Primary Immunodeficiency Disorder: An Analysis of the World Health Organization Registry. *Front Immunol* 2017;8:1103. doi: 10.3389/fimmu.2017.01103 [published Online First: 20170925]

13. Martín J, Odoom K, Tuite G, et al. Long-term excretion of vaccine-derived poliovirus by a healthy child. *J Virol* 2004;78(24):13839-47. doi: 10.1128/JVI.78.24.13839-13847.2004

14. European Centre for Disease Prevention and Control. Disease factsheet about poliomyelitis 2022 [Available from: https://www.ecdc.europa.eu/en/poliomyelitis/facts.

15. World Health Organization. Polio vaccines: WHO position paper, January 2014, 2014.

16. Andrus JK, Strebel PM, de Quadros CA, et al. Risk of vaccine-associated paralytic poliomyelitis in Latin America, 1989-91. *Bull World Health Organ* 1995;73(1):33-40.

17. Modlin JF, Bandyopadhyay AS, Sutter R. Immunization Against Poliomyelitis and the Challenges to Worldwide Poliomyelitis Eradication. *J Infect Dis* 2021;224(12 Suppl 2):S398-S404. doi: 10.1093/infdis/jiaa622

18. Grassly NC. Immunogenicity and effectiveness of routine immunization with 1 or 2 doses of inactivated poliovirus vaccine: systematic review and meta-analysis. *J Infect Dis* 2014;210 Suppl 1:S439-46. doi: 10.1093/infdis/jit601 [published Online First: 20140314]

19. Vidor E, Meschievitz C, Plotkin S. Fifteen years of experience with Vero-produced enhanced potency inactivated poliovirus vaccine. *Pediatr Infect Dis J* 1997;16(3):312-22. doi: 10.1097/00006454-199703000-00011

20. Wallace GS, Curns AT, Weldon WC, et al. Seroprevalence of Poliovirus Antibodies in the United States Population, 2009-2010. *BMC Public Health* 2016;16:721. doi: 10.1186/s12889-016-3386-1 [published Online First: 20160805]

21. Bianchi FP, Larocca AMV, Bozzi A, et al. Long-term persistence of poliovirus neutralizing antibodies in the era of polio elimination: An Italian retrospective cohort study. *Vaccine* 2021;39(22):2989-94. doi: 10.1016/j.vaccine.2021.04.005 [published Online First: 20210428]

22. Larocca A, Bianchi F, A B, et al. Long-Term Immunogenicity of Inactivated and Oral Polio Vaccines: An Italian Retrospective Cohort Study. *Vaccines* 2022;10(8) doi: 10.3390/vaccines10081329

23. Health Protection Surveillance Centre. Immunisation uptake statistics at 12 and 24 months of age, Quarter 1, 2022. www.hpsc.ie: HPSC, 2022.

24. Health Protection Surveillance Centre. Annual 2020/2021 report on DTaP-IPV & MMR vaccine uptake in Junior Infants. www.hpsc.ie.

25. European Centre for Disease Prevention and Control. Update on the polio situation in the EU/EEA and the world 2022. Available from: Update on the polio situation in the EU/EEA and the world (europa.eu) accessed 30/09/2022 2022.

ACKNOWLEDGEMENTS

NIAC would like to thank all the individuals and organisations who provided data, time, advice and information in support of this work.