An Advisory Committee Statement (ACS) National Advisory Committee on Immunization (NACI)

Canadian Immunization Guide Chapter on Influenza and Statement on Seasonal Influenza Vaccine for 2018–2019

PROTECTING AND EMPOWERING CANADIANS TO IMPROVE THEIR HEALTH

Public Health Agency of Canada
Agence de la santé publique du Canada

Canada

TO PROMOTE AND PROTECT THE HEALTH OF CANADIANS THROUGH LEADERSHIP, PARTNERSHIP, INNOVATION AND ACTION IN PUBLIC HEALTH.
—Public Health Agency of Canada

Également disponible en français sous le titre :
Une déclaration d'un comité consultatif (DCC)
Comité consultatif national de l'immunisation (CCNI)
Chapitre sur la grippe du Guide canadien d'immunisation et Déclaration sur la vaccination antigrippale pour la saison 2018-2019

This publication can be made available in alternative formats upon request.

Publication date: May 2018

Cat.: HP37-25E-PDF
ISBN: 2371-5375
Pub.: 170497

PREAMBLE

The National Advisory Committee on Immunization (NACI) provides the Public Health Agency of Canada (hereafter referred to as PHAC) with ongoing and timely medical, scientific, and public health advice relating to immunization. PHAC acknowledges that the advice and recommendations set out in this statement are based upon the best current available scientific knowledge and is disseminating this document for information purposes. People administering the vaccine should also be aware of the contents of the relevant product monograph(s). Recommendations for use and other information set out herein may differ from that set out in the product monograph(s) of the Canadian manufacturer(s) of the vaccine(s). Manufacturer(s) have sought approval of the vaccine(s) and provided evidence as to its safety and efficacy only when it is used in accordance with the product monographs. NACI members and liaison members conduct themselves within the context of PHAC's Policy on Conflict of Interest, including yearly declaration of potential conflict of interest.

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I. INTRODUCTION

This document, the National Advisory Committee on Immunization (NACI): Canadian Immunization Guide Chapter on Influenza and Statement on Seasonal Influenza Vaccine for 2018–2019, updates NACI's recommendations regarding the use of seasonal influenza vaccines.

NEW OR UPDATED INFORMATION FOR 2018–2019

Individuals with Neurologic or Neurodevelopment Conditions

The findings of an updated review of the literature are consistent with the preliminary evidence indicating that children and adults with neurologic and neurodevelopmental conditions are groups at risk for influenza-related complications and hospitalization. Therefore, based upon current evidence and expert opinion, NACI reaffirms its recommendation that children and adults with neurologic and neurodevelopmental conditions are groups for whom influenza immunization is particularly recommended.

Efficacy and Effectiveness of High-Dose and Adjuvanted Inactivated Influenza Vaccines in Persons 65 Years of Age and Older

Based on updated reviews of the literature on the efficacy and effectiveness of high-dose and adjuvanted inactivated influenza vaccines in persons 65 years of age and older, NACI has concluded there is no substantial change in the conclusions to be drawn from the scientific literature. However, NACI has updated its recommendation on the choice of vaccine product for this age group by creating recommendations for the programmatic level (i.e., provinces and territories making decisions for publicly funded immunization programs) and individual level (i.e., individuals wishing to prevent a vaccine-preventable disease or a clinician wishing to advise individual patients).

At a programmatic level, NACI recommends that any of the four influenza vaccines available for use in adults 65 years of age and older should be used: standard-dose TIV, high-dose TIV, MF59-adjuvanted TIV, and QIV. High-dose TIV is expected to provide superior protection to standard-dose TIV; however, with cost-effectiveness assessments having been outside the scope of the evidence review and without data on the relative efficacy and effectiveness between high-dose TIV, MF59-adjuvanted TIV, and QIV, there is insufficient evidence to make a comparative recommendation on the use of these vaccines at the programmatic level (Grade I). At an individual level, NACI recommends that high-dose TIV should be offered over standard-dose TIV to persons 65 years of age and older. NACI concludes that, given the burden of disease associated with influenza A(H3N2) and the good evidence of better efficacy compared to standard-dose TIV in this age group, high-dose TIV should be offered over standard-dose TIV to persons 65 years of age and older (Grade A). There is insufficient evidence to make comparative recommendations on the use of MF59-adjuvanted TIV and QIV over standard-dose TIV (Grade I).

BACKGROUND

The World Health Organization's (WHO) recommendations on the composition of influenza virus vaccines are typically available in February of each year for the upcoming season. The WHO recommends that, where available, seasonal quadrivalent influenza vaccines contain the recommended three viruses for the trivalent vaccine as well as the influenza B virus lineage that is not included in the trivalent vaccine.

Annual influenza vaccine recommendations for use in Canada are developed by the Influenza Working Group (IWG) for consideration by NACI. Recommendation development includes review of a variety of issues, including: the burden of influenza illness and the target populations for vaccination; safety, immunogenicity, efficacy, and effectiveness of influenza vaccines; vaccine schedules; and other aspects of influenza immunization. Details regarding NACI's evidence-based process for developing a statement are outlined in Evidence-based recommendations for immunization − Methods of the National Advisory Committee on Immunization.

Health care providers in Canada should offer the seasonal vaccine when it becomes available in the fall, since seasonal influenza activity may start as early as November in the northern hemisphere. Decisions regarding the precise timing of vaccination in a given setting or geographic area should be made according to local epidemiologic factors (influenza activity, timing and intensity), opportune moments for vaccination, as well as programmatic considerations. Further advice regarding the timing of influenza vaccination programs may be obtained through consultation with local public health agencies.

Although vaccination before the onset of the influenza season is strongly preferred, vaccine may still be administered up until the end of the season, although its utility may be compromised if exposure to influenza already has occurred. Vaccine providers should use every opportunity to give influenza vaccine to individuals at risk who have not been immunized during the current season, even after influenza activity has been documented in the community.

II. CLINICAL INFORMATION FOR VACCINE PROVIDERS (CANADIAN IMMUNIZATION GUIDE)

The Canadian Immunization Guide, which is written primarily for health care providers (front-line clinicians, public health practitioners) but is also used by policy makers, program planners and the general public, has been a trusted, reader-friendly summary of the vaccine statements provided by NACI for over 40 years.

The information in this section, Clinical Information for Vaccine Providers, replaces the influenza chapter of the Canadian Immunization Guide and is adapted for inclusion in the revised NACI Statement on Seasonal Influenza Vaccine. With a new NACI Statement on Seasonal Influenza required each year, the user will have quick access to the information that he or she requires within one document, whether it is the relevant influenza vaccine information that is written primarily for the frontline vaccine providers as is found in this section, or the more detailed technical information that is found in the rest of this statement, commencing in Section III.

KEY INFORMATION

What	Influenza is a respiratory infection caused primarily by influenza A and B viruses. In Canada, influenza generally occurs each year in the late fall and winter months. Symptoms typically include the sudden onset of high fever, cough and muscle aches. Other common symptoms include headache, chills, loss of appetite, fatigue and sore throat. Nausea, vomiting and diarrhea may also occur, especially in children. Most people will recover within a week or ten days, but some are at greater risk of more severe complications, such as pneumonia. People with chronic diseases may have worsening of their underlying disease. Both inactivated and live attenuated influenza vaccines are authorized for use in Canada; some are trivalent formulations and some are quadrivalent formulations. Influenza vaccine is safe and well-tolerated. Influenza vaccine cannot cause influenza illness because the inactivated influenza vaccines do not contain live virus and the viruses in live attenuated influenza vaccines are weakened so that they cannot cause influenza.
Who	Influenza vaccination is recommended for all individuals aged 6 months and older (noting product-specific age indications and contraindications), with particular focus on people at high risk of influenza-related complications or hospitalization, including all pregnant women, people capable of transmitting influenza to those at high risk, and others listed in **Table 1**.
How	Risks and benefits of influenza vaccine should be discussed prior to vaccination, as well as the risks of not being immunized. **Dose and Schedule** Children who have been previously immunized with seasonal influenza vaccine and adults should receive one dose of influenza vaccine each year. Children 6

months to under 9 years of age receiving seasonal influenza vaccine for the first time in their life should be given two doses, with a minimum interval of four weeks between doses.

The route of administration and dosage varies by product (refer to **Table 3**). The dose for Fluad Pediatric® (available for children 6 to under 24 months of age) is 0.25 mL (milliliter) intramuscular (IM). The dose for all other IM inactivated vaccines is 0.5 mL for all age groups. The dose for live attenuated influenza vaccine (LAIV) is 0.2 mL intranasal (0.1 mL in each nostril) (available for children 2 years of age and older).

Contraindications and Precautions

Persons who have developed an anaphylactic reaction to a previous dose of influenza vaccine or to any of the vaccine's components, with the exception of egg, or who have developed Guillain-Barré Syndrome (GBS) within six weeks of influenza vaccination, should not receive a further dose.

NACI has concluded that egg-allergic individuals without other contraindications may be vaccinated against influenza with any product, without a prior influenza vaccine skin test and with the full dose. The vaccine may be given in any settings where vaccines are routinely administered (see Section IV for details). As with any vaccine product, vaccine providers should be prepared for and have the necessary equipment to respond to a vaccine emergency at all times. LAIV also appears to be well tolerated in individuals with a history of stable asthma or recurrent wheeze; however, it remains contraindicated for individuals with severe asthma (defined as currently on oral or high-dose inhaled glucocorticosteroids or active wheezing) or for those with medically attended wheezing in the 7 days prior to the proposed date of immunization. There are also additional contraindications for LAIV (see Contraindications and Precautions in Section II for details).

Administration of the seasonal influenza vaccine should usually be postponed in persons with serious acute illnesses until their symptoms have abated. Immunization should not be delayed because of minor acute illness, with or without fever. If significant nasal congestion is present that might impede delivery of LAIV to the nasopharyngeal mucosa, inactivated vaccines can be administered or LAIV can be deferred until resolution of the illness.

Co-Administration

All influenza vaccines, including LAIV, may be given at the same time as or at any time before or after administration of other live attenuated or inactivated vaccines (see Vaccine Administration below for details). For concomitant parenteral injections, different injection sites and separate needles and syringes should be used.

Why	Influenza occurs globally with an annual attack rate estimated at 5–10% in adults and 20–30% in children[(1)]. Vaccination is the most effective way to prevent influenza and its complications. Annual vaccination is required because the body's immune response from vaccination diminishes within a year. Also, because influenza viruses change often, the specific strains in the vaccine are reviewed each year by WHO and updated as necessary so that there is the greatest probability of matching circulating viruses.

EPIDEMIOLOGY

Disease Description

Influenza is a respiratory illness caused by the influenza A and B viruses and can cause mild to severe illness. Severe illness can result in hospitalization or death. Certain populations, such as young children and seniors, may be at higher risk for serious influenza complications such as viral pneumonia, secondary bacterial pneumonia and worsening of underlying medical conditions.

Infectious Agent

There are two main types of influenza virus: Types A and B. Influenza A viruses are classified into subtypes based on two surface proteins: haemagglutinin (HA) and neuraminidase (NA). Three subtypes of HA (H1, H2 and H3) and two subtypes of NA (N1 and N2) are recognized among influenza A viruses as having caused widespread human disease over the decades. Immunity to the HA and NA proteins reduces the likelihood of infection and together with immunity to the internal viral proteins, lessens the severity of disease if infection occurs.

Influenza B viruses have evolved into two antigenically distinct lineages since the mid-1980s, represented by B/Yamagata/16/88-like and B/Victoria/2/87-like viruses. Viruses from both the B/Yamagata and B/Victoria lineages contribute variably to influenza illness each year.

Over time, antigenic variation (antigenic drift) of strains occurs within an influenza A subtype or a B lineage. The ever-present possibility of antigenic drift, which may occur in one or more influenza virus strains, requires seasonal influenza vaccines to be reformulated annually.

Transmission

Influenza is primarily transmitted by droplet spread through coughing or sneezing and may also be transmitted through direct or indirect contact with contaminated respiratory secretions. The incubation period of seasonal influenza is usually two days but can range from one to four days. Adults may be able to spread influenza to others from one day before symptom onset to approximately five days after symptoms start. Children and people with weakened immune systems may be infectious longer.

Risk Factors

The people at greatest risk of influenza-related complications are adults and children with underlying health conditions (see **Table 1**), residents of nursing homes and other chronic care

facilities, people 65 years of age and older, children under 60 months of age, pregnant women, and Indigenous peoples.

Seasonal and Temporal Patterns

Influenza activity in Canada usually is low in the spring and summer, begins to rise over the fall and peaks in the winter months. Depending on the year, the peak may occur as early as fall or as late as spring.

Spectrum of Clinical Illness

Symptoms typically include the sudden onset of high fever, cough and muscle aches. Other common symptoms include headache, chills, loss of appetite, fatigue and sore throat. Nausea, vomiting and diarrhea may also occur, especially in children. Most people will recover within a week or ten days, but some, including those 65 years of age and older, young children, and adults and children with chronic conditions, are at greater risk of more severe complications or worsening of their underlying condition.

Disease Distribution: Incidence

Global

Worldwide, annual epidemics result in an approximately one billion cases of influenza, about three to five million cases of severe illness, and about 250,000 to 500,000 deaths. For current international influenza activity information, refer to WHO's FluNet website.

National

Influenza and pneumonia is ranked among the top 10 leading causes of death in Canada[2]. Current influenza activity information can be found on the FluWatch website. The FluWatch program collects data and information from various sources to provide a national picture of influenza activity. An average of 23,000 laboratory-confirmed cases of influenza is reported to the FluWatch program each year. Although the burden of influenza can vary from year to year, it is estimated that, in a given year, an average of 12,200 hospitalizations related to influenza[3] and approximately 3,500 deaths attributable to influenza occur[4].

It should be noted that the incidence of influenza is often underreported since the illness may be confused with other viral illnesses and many people with influenza-like illness (ILI) do not seek medical care or have viral diagnostic testing done.

PREPARATIONS AVAILABLE FOR USE IN CANADA

This section describes the influenza vaccine preparations that are currently available for use in Canada. All influenza vaccines available in Canada have been authorized by Health Canada. However, not all preparations authorized for use are necessarily available in the marketplace. The vaccine manufacturers determine whether they will make any or all of their products available in a given market. Provincial and territorial health authorities then determine which of the available products will be used in the individual jurisdiction's publicly-funded influenza immunization programs.

The antigenic characteristics of circulating influenza virus strains provide the basis for selecting the strains included in each year's vaccine. Vaccine selection by the WHO generally occurs more than six months prior to the start of the influenza season to allow time for the

vaccine manufacturers to produce the required quantity of vaccine. All manufacturers that distribute influenza vaccine products in Canada confirm to Health Canada that the vaccines to be marketed in Canada for the upcoming influenza season contain the WHO-recommended antigenic strains for the Northern Hemisphere. Vaccine producers may use antigenically equivalent strains because of their growth properties.

A summary of the characteristics of influenza vaccines available in Canada can be found in **Appendix A**. For complete prescribing information, readers should consult the product leaflet or information contained within the Health Canada's authorized product monographs available through Health Canada's Drug Product Database.

Inactivated Influenza Vaccines (IIV)

The inactivated influenza vaccines (IIV) currently authorized for use in Canada are a mix of split virus and subunit vaccines. In split virus vaccines, the virus has been disrupted by a detergent. In subunit vaccines, HA and NA have been further purified by removal of other viral components. Refer to Basic Immunology and Vaccinology in Part 1 of the Canadian Immunization Guide for more information about inactivated vaccines.

Both trivalent inactivated influenza vaccines (TIV) and quadrivalent inactivated influenza vaccines (QIV) are authorized for use in Canada.

High-Dose Inactivated Influenza Vaccine

One of the trivalent products, Fluzone® High-Dose influenza vaccine, which has been approved for use in Canada in adults 65 years of age and older, contains 60 µg (micrograms) HA per strain (compared to 15 µg HA per strain in a standard dose) and is administered as a 0.5 mL dose by IM injection.

Adjuvanted Inactivated Influenza Vaccines

Two of the adjuvanted trivalent inactivated influenza vaccine products, Fluad® and Fluad Pediatric®, contain the adjuvant MF59, which is an oil-in-water emulsion composed of squalene as the oil phase, stabilized with the surfactants polysorbate 80 and sorbitan triolate in citrate buffer. The other inactivated products do not contain an adjuvant.

Live Attenuated Influenza Vaccine (LAIV)

FluMist® Quadrivalent is a live attenuated influenza vaccine (LAIV) for administration by intranasal spray and authorized for use for persons 2–59 years of age. The formulation of LAIV licensed for use in Canada contains a low amount of residual ovalbumin (less than 0.24 µg/dose, written communication from AstraZeneca), which is comparable to the amounts in inactivated influenza vaccines available for use in Canada. The influenza strains in FluMist® Quadrivalent are attenuated so that they do not cause influenza and are cold-adapted and temperature sensitive, so that they replicate in the nasal mucosa rather than the lower respiratory tract.

EFFICACY, EFFECTIVENESS AND IMMUNOGENICITY

Efficacy and Effectiveness

Influenza vaccine has been shown to be efficacious, with higher efficacy demonstrated against laboratory-confirmed influenza than clinically defined outcomes. Immunization has been shown to reduce the number of physician visits, hospitalizations and deaths in high-risk adults.

After careful review of the available vaccine effectiveness data over the last several influenza seasons (2010–2016) from various jurisdictions, NACI concludes that the current evidence is consistent with LAIV providing comparable protection against influenza to that afforded by IIV. NACI recognizes the need to continue to monitor LAIV vaccine effectiveness data closely by influenza subtype and the relative effectiveness of LAIV compared to IIV.

Based on expert opinion, the comparative efficacy data for the trivalent formulation of LAIV was applicable to the quadrivalent formulation of LAIV now used in Canada, because the manufacturing processes and immunologic mechanism of the quadrivalent LAIV and the trivalent LAIV products are the same. This expert opinion was supported by the results of the non-inferiority immunogenicity studies comparing trivalent and quadrivalent formulations of LAIV, which were required by regulatory bodies to authorize the use of the quadrivalent LAIV formulation.

An updated literature review found evidence that high-dose TIV provides superior relative protection compared with standard-dose TIV for adults 65 years of age and older.

For a summary of efficacy and effectiveness studies refer to Section IV of this statement.

Immunogenicity

The antibody response after vaccination depends on several factors, including the age of the recipient, prior and subsequent exposure to antigens, and the presence of immune compromising conditions. Humoral antibody levels, which correlate with protection by the vaccine, are generally achieved by two weeks after immunization; however, there may be some protection afforded before that time.

RECOMMENDATIONS FOR USE

Recommended Recipients of Influenza Vaccine

Influenza vaccine is recommended for everyone 6 months of age and older who does not have contraindications to the vaccine. In infants under 6 months of age, influenza vaccine is less immunogenic than in infants and children 6 to 18 months of age and thus does not confer sufficient protection to make it useful before 6 months of age[5]. Therefore, immunization with currently available influenza vaccines is not authorized for use or recommended for infants under 6 months of age.

To reduce the morbidity and mortality associated with influenza, immunization programs should focus on those at high risk of influenza-related complications or hospitalization, including all pregnant women, those capable of transmitting influenza to individuals at high risk of complications and others as identified in **Table 1**. Additional detail regarding the recipients identified in **Table 1** can be found in Section III of this statement.

Table 1: Groups for whom Influenza immunization is particularly recommended

People at high risk of influenza-related complications or hospitalization

- All pregnant women[*].
- Adults and children with the following chronic health conditions:
  - cardiac or pulmonary disorders (including bronchopulmonary dysplasia, cystic fibrosis and asthma);
  - diabetes mellitus and other metabolic diseases;
  - cancer, immune compromising conditions (due to underlying disease, therapy or both);
  - renal disease;
  - anemia or hemoglobinopathy;
  - neurologic or neurodevelopment conditions[**];
  - morbid obesity (body mass index [BMI] of 40 and over);
  - children and adolescents (age 6 months to 18 years) undergoing treatment for long periods with acetylsalicylic acid, because of the potential increase of Reye's syndrome associated with influenza.
- People of any age who are residents of nursing homes and other chronic care facilities.
- People 65 years of age and older.
- All children 6 to 59 months of age.
- Indigenous peoples.

[*] The risk of influenza-related hospitalization increases with length of gestation, i.e., it is higher in the third trimester than in the second.

[**] These neurologic or neurodevelopmental conditions include neuromuscular, neurovascular, neurodegenerative, neurodevelopmental conditions and seizure disorders (and, for children, include febrile seizures and isolated developmental delay), but exclude migraines and psychiatric conditions without neurological conditions.

People capable of transmitting influenza to those at high risk

- Health care and other care providers in facilities and community settings who, through their activities, are capable of transmitting influenza to those at high risk of influenza complications.
- Household contacts (adults and children) of individuals at high risk of influenza-related complications (whether or not the individual at high risk has been immunized):
  - household contacts of individuals at high risk, as listed in the section above;
  - household contacts of infants under 6 months of age as these infants are at high risk of complications from influenza but cannot receive influenza vaccine;
  - members of a household expecting a newborn during the influenza season.
- Those providing regular child care to children 59 months of age and under, whether in or out of the home.
- Those who provide services within closed or relatively closed settings to persons at high risk (e.g., crew on a ship).

Others

- People who provide essential community services.
- People in direct contact during culling operations with poultry infected with avian influenza.

In addition to the recipients identified in **Table 1**, influenza vaccine is also recommended for:

Healthy Individuals 5–64 Years of Age

Literature reviews conducted by NACI have shown that healthy individuals aged 5 to 64 years benefit from influenza vaccination.

Detailed information regarding these reviews can be found in the Statement on Seasonal Influenza Vaccine for 2014–2015 and in each of the relevant literature reviews, available via the NACI website.

Travellers

Influenza occurs year-round in the tropics. In temperate northern and southern countries, influenza activity peaks generally during the winter season (November to March in the Northern Hemisphere and April to October in the Southern Hemisphere). Influenza vaccination is recommended for all individuals, including travellers, aged 6 months and older, with particular focus on the groups indicated in **Table 1**.

Vaccines prepared specifically for use in the Southern Hemisphere are not available in Canada, and the extent to which recommended vaccine components for the Southern Hemisphere may overlap with those in available Canadian formulations will vary. A decision for or against re-vaccination (i.e., boosting) of travellers to the Southern Hemisphere between April and October, if they had already been vaccinated in the preceding fall or winter with the Northern Hemisphere's vaccine, depends on individual risk assessment, the similarity or difference between the Northern and Southern Hemisphere vaccines, the similarity or difference between the Northern Hemisphere vaccine strains and currently circulating strains in the Southern Hemisphere, and the availability of a reliable and safe vaccine at the traveller's destination. Refer to Immunization of Travellers in Part 3 of the Canadian Immunization Guide for additional general information.

CHOICE OF SEASONAL INFLUENZA VACCINE

Table 2 summarizes current recommendations by specific age and risk groups for the choice(s) of influenza vaccine currently available for use in Canada.

The decision to include specific influenza vaccines as part of publicly funded provincial and territorial programs depends on multiple factors, such as cost-benefit evaluation and other programmatic and operational factors, for example implementation strategies. Not all products will be made available in all jurisdictions and availability of some products may be limited; therefore, officials in individual provinces and territories should be consulted regarding the products available in individual jurisdictions.

Table 2: Choice of influenza vaccine for selected age and risk groups (for persons without a contraindication to the vaccine)

Recipient by age group	Vaccine types available for use	Comments
Children 6–23 months of age	• TIV • QIV • Adjuvanted TIV	As TIV, QIV and adjuvanted TIV are authorized for this age group NACI recommends that, given the burden of influenza B disease, QIV should be used. If QIV is not available, either unadjuvanted or adjuvanted TIV should be used.
Children 2–17 years of age	• TIV • QIV • Quadrivalent LAIV	In children without contraindications to the vaccine, any of the following vaccines can be used: LAIV, QIV, or TIV. The current evidence does not support a recommendation for the *preferential* use of LAIV in children and adolescents 2–17 years of age. Given the burden of influenza B disease in children and the potential for lineage mismatch between the predominant circulating strain of influenza B and the strain in a trivalent vaccine, NACI continues to recommend that a quadrivalent formulation of influenza vaccine be used in children and adolescents 2–17 years of age. If a quadrivalent vaccine is not available, TIV should be used. LAIV is contraindicated for children with immune compromising conditions. LAIV, TIV or QIV can be used in children with chronic health conditions and without contraindications (see the *Contraindications and Precautions* (Section II) and *Choice of vaccine product for children 2 to 17 years of age* (Section V) sections below for more details).
Adults 18–59 years of age	• TIV • QIV • Quadrivalent LAIV	TIV and QIV are the recommended products for adults with chronic health conditions. TIV and QIV, instead of LAIV, are recommended for health care workers. LAIV is contraindicated for adults with immune compromising conditions.
Adults 60–64 years of age	• TIV • QIV	TIV and QIV are authorized for use in this age group.
Adults 65 years of age and older	• TIV • QIV • Adjuvanted TIV • High-dose TIV	At the programmatic level, NACI recommends that any of the four influenza vaccines available for use in adults 65 years of age and older should be used: standard-dose TIV, high-dose TIV, MF59-adjuvanted TIV, and QIV. High-dose TIV is expected to provide superior protection compared to standard-dose TIV; however, with cost-effectiveness assessments having been outside the scope of the evidence review and without data on the relative efficacy/effectiveness between high-dose TIV, MF59-adjuvanted TIV, and QIV, there is insufficient evidence to make a comparative recommendation on the use of these vaccines at the programmatic level (Grade I). At the individual level, NACI recommends that high-dose TIV should be offered over standard-dose TIV to persons 65 years of age and older. NACI concludes that, given the burden of disease associated with influenza A(H3N2) and the good

Recipient by age group	Vaccine types available for use	Comments
		evidence of better efficacy compared to standard-dose TIV in this age group, high-dose TIV should be offered over standard-dose TIV to persons 65 years of age and older (Grade A). There is insufficient evidence to make comparative recommendations on the use of MF59-adjuvanted TIV and QIV over standard-dose TIV (Grade I).
Pregnant women	• TIV • QIV	LAIV is not recommended because of the theoretical risk to the fetus from administering a live virus vaccine.

VACCINE ADMINISTRATION

Dose, Route of Administration and Schedule

With the variety of influenza vaccines available for use in Canada, it is important for practitioners to note the specific differences in age indications, route of administration, dosage and schedule for the products that they will be using (**Table 3**). Key relevant details and differences between vaccine products are also highlighted in **Appendix A**.

For influenza vaccines given by the IM route, the deltoid muscle is the recommended site in adults and children 12 months of age and older, and the anterolateral thigh is the recommended site in infants between 6 and 12 months of age. For more information on vaccine administration, please refer to Vaccine Administration Practices in Part 1 of the Canadian Immunization Guide.

Table 3: Recommended influenza vaccine dosage and route, by age, for the 2018–2019 influenza season

Age group	TIV without adjuvant† Intramuscular	QIV without adjuvant# Intramuscular	TIV without adjuvant, high dose (Fluzone® High-Dose) Intramuscular	MF59-adjuvanted TIV (Fluad Pediatric® or Fluad®) Intramuscular	LAIV (FluMist® Quadrivalent) Intranasal	Number of doses required
6–23 months	0.5 mL*	0.5 mL*	-	0.25 mL	-	1 or 2**
2–8 years	0.5 mL	0.5 mL	-	-	0.2 mL (0.1 mL per nostril)	1 or 2**
9–17 years	0.5 mL	0.5 mL	-	-	0.2 mL (0.1 mL per nostril)	1
18–59 years	0.5 mL	0.5 mL	-	-	0.2 mL (0.1 mL per nostril)	1
60–64 years	0.5 mL	0.5 mL	-	-	-	1
65 years and older	0.5 mL	0.5 mL	0.5 mL	0.5 mL	-	1

† Influvac® 3 years and older, Fluviral® 6 months and older, Agriflu® 6 months and older
# Flulaval® Tetra 6 months and older and Fluzone® Quadrivalent 6 months and older

[*] This information may differ from the product monograph. Published and unpublished evidence suggest moderate improvement in antibody response in infants, without an increase in reactogenicity, with the use of full vaccine doses (0.5 mL) for unadjuvanted inactivated influenza vaccines[6, 7]. This moderate improvement in antibody response without an increase in reactogenicity is the basis for the full dose recommendation for unadjuvanted inactivated vaccine for all ages. For more information, refer to Statement on Seasonal Influenza Vaccine for 2011–2012.

[**] Children 6 months to less than 9 years of age who have never received the seasonal influenza vaccine require two doses of influenza vaccine, with a minimum interval of four weeks between doses. Eligible children under 9 years of age who have properly received one or more doses of seasonal influenza vaccine in the past should receive one dose per influenza vaccination season thereafter.

Booster Doses and Re-Immunization

Booster doses are not required within the same influenza season. However, individuals less than 9 years of age who have not previously received the seasonal influenza vaccine require two doses of influenza vaccine, with a minimum of four weeks between doses (see **Table 3**).

Serological Testing

Serologic testing is not necessary before or after receiving seasonal influenza vaccine.

Storage Requirements

Influenza vaccine should be stored at +2°C to +8°C and should not be frozen. Refer to the individual product monographs for further details. Refer to Storage and Handling of Immunizing Agents in Part 1 of the Canadian Immunization Guide for additional information.

Co-Administration with Other Vaccines

In theory, the administration of two live vaccines sequentially within less than 4 weeks could reduce the efficacy of the second vaccine. Studies have been done showing no interference when administering trivalent LAIV concomitantly with: measles, mumps, rubella (MMR); measles, mumps, rubella, varicella (MMRV); or oral polio live vaccines[8-10]. No studies have been done to assess the possibility of interference between LAIV and other live vaccines, or on LAIV given before or after other live vaccines. Additional information regarding co-administration with other vaccines can be found in Section IV of this statement. Given the lack of data for immune interference, and based on expert opinion, NACI recommends that LAIV can be given together with or at any time before or after the administration of any other live attenuated or inactivated vaccine. NACI recognizes that some vaccine providers may choose to give LAIV and other live vaccines simultaneously or separated by at least 4 weeks to avoid any possibility of immune interference. Alternatively, an inactivated influenza vaccine (TIV or QIV) may be given. Note that the timing rules related to two parenteral live vaccines (e.g., MMR and varicella vaccines) still apply. For more information regarding vaccination administration timing rules, please refer to Timing of Vaccine Administration in Part 1 of the Canadian Immunization Guide.

When multiple injections are given at one clinic visit, it is preferable to administer them in different limbs. If it is not possible to do so, injections given in one limb should be separated by a distance of at least 2.5 cm (1 inch). A separate needle and syringe should be used for each injection.

The target groups for influenza and pneumococcal polysaccharide vaccines overlap considerably. Health care providers should take the opportunity to vaccinate eligible persons against pneumococcal disease when influenza vaccine is given.

VACCINE SAFETY AND ADVERSE EVENTS

Data from post marketing surveillance of influenza vaccines in Canada (Canadian Adverse Events Following Immunization Surveillance System [CAEFISS]) have shown seasonal influenza vaccines to have a safe and stable Adverse Events Following Immunization (AEFI) profile with no unexpected events.

All influenza vaccines currently authorized for use in Canada are considered safe for use in persons with latex allergies. The multi-dose formulations of inactivated influenza vaccine that are authorized for use in Canada contain minute quantities of thimerosal, which is used as a preservative[11, 12] to keep the product sterile. Large cohort studies of health databases have demonstrated that there is no association between childhood vaccination with thimerosal-containing vaccines and neurodevelopmental outcomes, including autistic-spectrum disorders[13]. All single dose formulations of inactivated vaccine and LAIV are thimerosal-free. Refer to Vaccine Safety in Part 2 of the Canadian Immunization Guide for additional information.

Common Adverse Events

With IM administered influenza vaccines, injection site reactions are common but are generally classified as mild and transient. Adjuvanted TIV tends to produce more extensive injection site reactions than unadjuvanted TIV, but these reactions are also generally mild and resolve spontaneously within a few days. The high-dose vaccine tends to induce higher rates of systemic reactions post-injection compared to standard-dose TIV, but most of these reactions are mild and short-lived. The most common adverse events experienced by recipients of trivalent LAIV are nasal congestion and runny nose, which are also expected for the quadrivalent formulation. Additional information can be found in the relevant subsections of Section IV of this statement.

Less Common and Serious or Severe Adverse Events

Serious adverse events are rare following immunization with influenza vaccine and in most cases, data are insufficient to determine a causal association. Allergic responses to influenza vaccine are a rare consequence of hypersensitivity to some vaccine components. Refer to Contraindications and Precautions below for additional information.

Other Reported Adverse Events and Conditions

Guillain-Barré Syndrome (GBS)

Studies suggest that the absolute risk of GBS in the period following seasonal and A(H1N1)pdm09 influenza vaccination is about one excess case per 1 million vaccinations and that the risk of GBS associated with influenza illness is larger (about 17 cases per million influenza-coded health care encounters, which are a proxy for influenza illness) than that associated with influenza vaccination. Additional information regarding GBS is found in Section IV. Information regarding vaccinating individuals who have experienced GBS is provided under Contraindications and Precautions below.

Oculo-Respiratory Syndrome (ORS)

Oculo-respiratory syndrome (ORS), which is defined as the presence of bilateral red eyes plus one or more respiratory symptoms (cough, wheeze, chest tightness, difficulty breathing, difficulty swallowing, hoarseness or sore throat) that starts within 24 hours of vaccination, with

or without facial oedema, was found during the 2000–2001 influenza season; few cases have been reported since then. ORS is not considered to be an allergic response.

Persons who have a recurrence of ORS upon revaccination do not necessarily experience further episodes with future vaccinations. Data on clinically significant adverse events do not support the preference of one vaccine product over another when revaccinating those who have previously experienced ORS. Refer to Contraindications and Precautions below for additional information.

Guidance on Reporting Adverse Events Following Immunization (AEFI)

To ensure the ongoing safety of influenza vaccines in Canada, reporting of AEFIs by vaccine providers and other clinicians is critical, and in some jurisdictions, reporting is mandatory under the law.

Vaccine providers are asked to report AEFIs through local public health officials and to check for specific AEFI reporting requirements in their province or territory. An AEFI is any untoward medical occurrence that follows immunization and that does not necessarily have a causal relationship with the usage of a vaccine. The adverse event may be any unfavourable or unintended sign, abnormal laboratory finding, symptom or disease. In general, any serious or unexpected adverse event felt to be temporally related to vaccination should be reported. An unexpected AEFI is an event that is not listed in the approved Product Monograph but may be due to the immunization, or a change in the nature, severity, specificity, or outcome of a known AEFI.

For influenza vaccines, the following AEFIs are of particular interest:

- ORS
- GBS within 6 weeks following immunization

For additional information about AEFI reporting, please refer to Reporting Adverse Events Following Immunization (AEFI) in Canada. For general vaccine safety information, refer to Vaccine Safety in Part 2 of the Canadian Immunization Guide.

CONTRAINDICATIONS AND PRECAUTIONS

Contraindications

Influenza vaccine should not be given to:

- People who have had an anaphylactic reaction to a previous dose of influenza vaccine; or
- People who have had an anaphylactic reaction to any of the vaccine components, with the exception of egg (refer to Additional Vaccine Safety Considerations in Section IV).

Refer to Contents of Immunizing Agents Available for Use in Canada in Part 1 of the Canadian Immunization Guide for a list of all vaccines authorized for use in Canada and their contents and to Vaccine Safety in Part 2 of the Canadian Immunization Guide for information regarding the management of adverse events, including anaphylaxis.

Additional LAIV-Specific Contraindications and Precautions

LAIV is contraindicated for:

- Children less than 24 months of age, due to increased risk of wheezing.
- Individuals with severe asthma, as defined as currently on oral or high-dose inhaled glucocorticosteroids or active wheezing, or those with medically attended wheezing in the 7 days prior to the proposed date of immunization.
- Children and adolescents 2 to 17 years of age currently receiving aspirin or aspirin-containing therapy because of the association of Reye's syndrome with aspirin and wild-type influenza infection. It is recommended that aspirin-containing products in children less than 18 years of age be delayed for four weeks after receipt of LAIV.
- Pregnant women, because it is a live attenuated vaccine and there is a lack of safety data at this time. However, it is not contraindicated in breastfeeding mothers.
- Persons with immune compromising conditions, due to underlying disease, therapy, or both, as the vaccine contains live attenuated virus.

As a precautionary measure, LAIV recipients should avoid close association with persons with severe immune compromising conditions (e.g., bone marrow transplant recipients requiring isolation) for at least two weeks following vaccination, because of the theoretical risk for transmitting a vaccine virus and causing infection.

There have been no reported or documented cases, and no theoretical or scientific basis to suggest transmission of vaccine virus would occur to the individual administering LAIV.

Precautions

Allergic Reactions to Previous Vaccine Doses

Expert review of the risks and benefits of vaccination should be sought for those who have previously experienced severe lower respiratory symptoms (wheeze, chest tightness, difficulty breathing) within 24 hours of influenza vaccination, an apparent significant allergic reaction to the vaccine or any other symptoms that could indicate a significant allergic reaction (e.g., throat constriction, difficulty swallowing) that raise concern regarding the safety of re-immunization. This advice may be obtained from local medical officers of health or other experts in infectious disease, allergy and immunology or public health.

In view of the considerable morbidity and mortality associated with influenza, a diagnosis of influenza vaccine allergy should not be made without confirmation, which may involve skin testing by an allergy or immunology expert. If an individual is found to have an allergy to a component in one influenza vaccine, consideration may be given to offering immunization with another influenza vaccine if there is a formulation not containing the implicated component, in consultation with an allergy expert. Individuals who have an allergy to substances that are not components of the influenza vaccine are not at increased risk of allergy to influenza vaccine.

Oculo-Respiratory Syndrome (ORS)

Individuals who have experienced ORS without lower respiratory tract symptoms may be safely re-immunized with influenza vaccine. Persons who experienced ORS with lower respiratory tract symptoms should have an expert review. Health care providers who are unsure whether an individual previously experienced ORS versus an IgE (immunoglobulin E) mediated hypersensitivity immune response should seek advice.

Guillain-Barré Syndrome (GBS)

Although the evidence considering influenza vaccination and GBS is inadequate to accept or reject a causal relation between GBS in adults and seasonal influenza vaccination, avoiding subsequent influenza vaccination of persons known to have had GBS within six weeks of a previous influenza vaccination appears prudent at this time. However, the potential risk of GBS recurrence associated with influenza vaccination must be balanced against the risk of GBS associated with influenza infection itself.

Severe Acute Illness with or without Fever

Administration of seasonal influenza vaccine should usually be postponed in persons with serious acute illness until their symptoms have abated. Immunization should not be delayed because of minor acute illness, with or without fever. If significant nasal congestion is present that might impede delivery of LAIV to the nasopharyngeal mucosa, inactivated vaccines can be administered or LAIV may be deferred until resolution of the illness.

Administration of Influenza Vaccine to Egg-Allergic Persons

All influenza vaccine products authorized for use in Canada are manufactured by a process involving chicken eggs, which may result in the vaccines' containing trace amounts of residual egg protein. Egg-allergic individuals may be vaccinated against influenza using inactivated TIV or QIV, or LAIV without prior influenza vaccine skin test and with the full dose, irrespective of a past severe reaction to egg, and without any extraordinary precautions, but ensuring that, as with all vaccine administration, immunizers be prepared with the necessary equipment, knowledge and skills to respond to a vaccine emergency at all times. For more information regarding vaccination of egg-allergic individuals, please see Section IV of this statement.

Drug Interactions

Although influenza vaccine can inhibit the clearance of warfarin and theophylline, clinical studies have not shown any adverse effects attributable to these drugs in people receiving influenza vaccine. Statins have effects on the immune system in addition to their therapeutic cholesterol-lowering actions. Two published studies have found that adults who are regular statin users (older than 65 years in one study and older than 45 years in the other) had an apparent decreased response to influenza immunization as measured by reduced geometric mean titres (GMT)[14] or reduced vaccine effectiveness against medically attended acute respiratory illness[15]. Statins are widely used in the same adult populations who are also at-risk for influenza-related complications and hospitalizations. Therefore, if these preliminary findings are confirmed in future studies, concomitant statin use in adult populations could have implications for influenza vaccine effectiveness and how this use is assessed in the measurement of vaccine effectiveness. NACI will continue to monitor the literature related to this issue.

It is recommended that LAIV not be administered until 48 hours after antiviral agents active against influenza (oseltamivir and zanamivir) are stopped, and that those antiviral agents, unless medically indicated, not be administered until two weeks after receipt of LAIV so that the antiviral agents do not kill the replicating vaccine virus. If antiviral agents are administered within this time frame (i.e., from 48 hours before to two weeks after LAIV is given), revaccination should take place at least 48 hours after the antivirals are stopped.

This concludes the summary of relevant influenza vaccine information typically found in the Canadian Immunization Guide. The more detailed technical information related to seasonal influenza vaccine can be found in the remainder of this statement.

III. SPECIFICALLY RECOMMENDED RECIPIENTS: ADDITIONAL INFORMATION

Table 1 in Section II lists the groups for which influenza vaccination is particularly recommended. Additional information regarding these specifically recommended recipients is provided below.

PEOPLE AT HIGH RISK OF INFLUENZA-RELATED COMPLICATIONS OR HOSPITALIZATION

Pregnant Women

NACI recommends the inclusion of all pregnant women, at any stage of pregnancy, among the specifically recommended recipients of inactivated influenza vaccine due to the risk of influenza-associated morbidity in pregnant women[16-20], evidence of adverse neonatal outcomes associated with maternal respiratory hospitalization or influenza during pregnancy[21-24], evidence that vaccination of pregnant women protects their newborns from influenza and influenza-related hospitalization[25-28] and evidence that infants born during influenza season to vaccinated women are less likely to be premature, small for gestational age, and low birth weight[29-32].

The safety of inactivated influenza vaccine during pregnancy has been reviewed[33]. Active studies of influenza vaccination during pregnancy have not shown evidence of harm to the mother or fetus associated with influenza immunization[34]. Although the cumulative sample size of active studies of influenza vaccination in pregnant women is relatively small, particularly in the first trimester, passive surveillance has not raised any safety concerns despite widespread use of inactivated influenza vaccine in pregnancy over several decades[18, 19, 33, 35]. Surveillance following the use of both adjuvanted and unadjuvanted 2009 pandemic influenza A(H1N1) vaccines in more than 100,000 pregnant women in Canada and more than 488,000 pregnant women in Europe has not revealed any safety concerns[36, 37].

For further details on influenza immunization in pregnancy and other evidence reviewed to inform this recommendation, see the Statement on Seasonal Influenza Vaccine for 2011–2012 and the Statement on Seasonal Influenza Vaccine for 2012–2013.

Adults and Children with Chronic Health Conditions as Noted in Table 1

A number of chronic health conditions, as noted in **Table 1**, are associated with increased risk of influenza-related complications, and influenza can lead to exacerbation of the chronic disease. Influenza vaccination can induce protective antibody levels in a substantial proportion of adults and children with immune-compromising conditions, including transplant recipients, those with proliferative diseases of the hematopoietic and lymphatic systems, and HIV (human immunodeficiency virus) infected persons. Vaccine efficacy may be lower in persons with immune-compromising conditions than in healthy adults.

Neurologic or Neurodevelopment Conditions

Adults and children with neurologic or neurodevelopment conditions (NNCs) are among the groups for whom influenza immunization is particularly recommended (NACI Evidence Grade B Recommendation). NNCs include neuromuscular, neurovascular, neurodegenerative,

neurodevelopment conditions and seizure disorders (and, for children, include febrile seizures and isolated developmental delay), but exclude migraines and psychiatric conditions without neurological conditions. NACI concludes that there is fair evidence to make this recommendation, based on expert opinion and findings from a recent literature review conducted using a rapid review approach, whereby elements of the full systematic review process have been modified due to time and resource constraints but the modified process remains rigorous and transparent in method. The complete findings from the review can be found in the NACI Literature Review on Individuals with Neurologic or Neurodevelopment Conditions and Risk of Serious Influenza-Related Complications.

The NACI recommendation remains consistent with international bodies, including the USA's Centers for Disease Control and Prevention (CDC)[38], the United Kingdom's (UK) Joint Committee on Vaccination and Immunisation (JCVI)[39] and the Australian Technical Advisory Group on Immunization (ATAGI)[40] who all have listed both children and adults with neurologic conditions as a high-risk group for influenza complications.

Although a large number of studies were identified in the rapid review, the body of evidence related to the risk of serious influenza-related complications in adults and children with NNCs is mostly comprised of descriptive studies (i.e., case series), which are generally considered of lower quality (level III evidence). There was also a lack of clarity in the composition of conditions constituting NNCs in some studies and a lack of consistency across identified studies in the defined lists of specific NNCs investigated. However, the body of evidence appears to suggest consistency in burden and direction of risk of NNCs in both adults and children for pandemic influenza A(H1N1)pdm09 and seasonal influenza.

The body of evidence is suggestive of a relatively high burden of pre-existing NNCs in adults and children who had experienced serious pandemic influenza A(H1N1)pdm09- and seasonal influenza-related complications, such as hospitalization, intensive care unit (ICU) admission and death. Of the individuals with at least one study-defined risk factor for influenza-related complications, 12–17% of adults and 24–26% of children hospitalized for pandemic or seasonal influenza had NNCs as a risk factor. Similarly, of individuals with at least one study-defined risk factor for influenza-related complications, about 18% of adults admitted to the ICU with pandemic influenza and 40% of children admitted to the ICU with pandemic or seasonal influenza had NNCs as a risk factor. Of individuals with at least one study-defined risk factor for influenza-related complications, almost 25% of adults who died from pandemic influenza infection and 58–62% of children who died from pandemic or seasonal influenza infection had NNCs as a risk factor.

Interpreted in consideration of the mostly descriptive nature of the body of evidence, there is also consistent evidence to suggest that pre-existing NNCs increase the risk for these serious influenza-related complications. For example, neurologic conditions and seizure disorder in children and neuromuscular conditions in adults were identified as statistically significant risk factors for influenza-related hospitalization. Among those hospitalized for influenza infection, neurologic, neurodevelopment and neuromuscular conditions in children and neurologic and neurocognitive conditions in adults were identified as statistically significant risk factors for ICU admission. Similarly, among children hospitalized for influenza infection, neurologic conditions were identified as a statistically significant risk factor for death.

Limited evidence was identified for other serious influenza-related complications in this population, such as emergency department presentation, respiratory failure and the need for mechanical ventilation.

A previously identified case series by the Canadian IMPACT surveillance network documented that the burden of influenza infection in hospitalized children with NNCs, even for those conditions that do not obviously compromise respiratory function, is significant[41]. Over five years (2004–2009) of seasonal influenza surveillance, 1991 children were hospitalized with influenza, 293 of whom had NNCs. The pre-existing NNCs included isolated seizure disorders including febrile seizures and isolated developmental delay. These 293 cases were further analyzed to determine if they would have been considered high risk for influenza based on any other vaccine indication. One hundred and fifteen children with NNCs did not have airway compromise or another vaccine indication. This latter group presented with seizures more frequently than those with NNCs and a vaccine indication (41.7% vs. 26.4%; p=0.006), and required ICU admission (20.9% vs. 11.8%; p=0.02) and mechanical ventilation (14.8% vs. 4.5%; p<0.001) more often than children without NNCs but with a vaccine indication.

For further details on the impact of NNCs and risk of serious influenza-related complications, see the Literature Review on Individuals with Neurologic or Neurodevelopment Conditions and Risk of Serious Influenza-Related Complications.

People of Any Age Who Are Residents of Nursing Homes and Other Chronic Care Facilities

Such residents often have one or more chronic medical conditions and live in institutional environments that may facilitate the spread of influenza.

People 65 Years of Age and Older

Admissions attributable to influenza in this age group are estimated at 125 to 228 per 100,000 healthy persons[42], and mortality rates increase with increased age[43].

All Children 6 to 59 Months of Age

On the basis of existing data, NACI recommends the inclusion of all children 6 to 59 months of age among the specifically recommended recipients of influenza vaccine.

For additional details on children 24–59 months of age, please see the Statement on Seasonal Influenza Vaccine for 2012–2013 and for children 6–23 months of age, please see the Statement on Seasonal Influenza Vaccine for 2011–2012.

Indigenous Peoples

Based on the body of evidence indicating a higher rate of influenza-associated hospitalization and death among Indigenous peoples, NACI recommends the inclusion of this population among the specifically recommended recipients of influenza vaccine.

It has been proposed that the increased risk of severe influenza outcomes in the Indigenous populations is a consequence of multiple factors, including high prevalence of chronic health conditions (e.g., diabetes, chronic lung disease, end-stage kidney disease)[44], obesity, delayed access to health care, and increased susceptibility to disease because of poor housing and overcrowding[45-47]. For further details on the evidence reviewed to inform this recommendation, see the Statement on Seasonal Influenza Vaccine for 2011–2012.

PEOPLE CAPABLE OF TRANSMITTING INFLUENZA TO THOSE AT HIGH RISK OF INFLUENZA-RELATED COMPLICATIONS OR HOSPITALIZATION

People who are potentially capable of transmitting influenza to those at high risk should receive annual immunization, regardless of whether the high-risk person has been immunized. Immunization of care providers decreases their own risk of illness[48, 49], as well as the risk of death and other serious outcomes among the patients for whom they provide care[50-53]. Immunization of care providers and residents is associated with decreased risk of ILI outbreaks[54]. Individuals who are more likely to transmit influenza to those at high risk of medical complications or hospitalization due to influenza include the following groups:

Health Care and Other Providers in Facilities and Community Settings

This group includes health care workers (HCWs), regular visitors, emergency response workers, those who have contact with residents of continuing care or long-term care facilities or residences, those who provide home care for persons in high-risk groups and students of related health care services.

For the purposes of this statement, HCWs include any person, paid or unpaid, who provides services, works, volunteers or trains in a health care setting.

Influenza immunization provides benefits to HCWs and to the patients for whom they care. NACI considers the provision of influenza vaccination to be an essential component of the standard of care for all HCWs for the protection of their patients.

Transmission of influenza between infected HCWs and their vulnerable patients results in significant morbidity and mortality. For example, randomized controlled trials (RCTs) conducted in geriatric long-term care settings have demonstrated that vaccination of HCWs is associated with substantial decreases in morbidity[51-53] and all-cause mortality[50-53] in the residents. Therefore, HCWs should consider annual influenza immunization included in their responsibility to provide the highest standard of care. In the absence of contraindications, refusal of HCWs to be immunized against influenza implies failure in their duty of care to patients.

NACI recommends that TIV or QIV, instead of LAIV, should be used for HCWs for two reasons. Firstly and most importantly, most comparative studies in persons 18 to 59 years of age have found that TIV was more efficacious than LAIV[55]. Secondly, as noted in Section II, as a precautionary measure, LAIV recipients should avoid close association with persons with severe immune compromising conditions (e.g., bone marrow transplant recipients requiring isolation) for at least two weeks following vaccination, because of the theoretical risk for transmitting a vaccine virus and causing infection.

As noted in the PHAC Guidance: Infection Prevention and Control Measures for Healthcare Workers in Acute Care and Long-term Care Settings, for seasonal influenza, all health care organizations should have a written plan for managing an influenza outbreak in their facilities. Inherent in such plans should be policies and programs to optimize staff's influenza immunization[56]. As part of outbreak management, the above mentioned PHAC guidance suggests consideration of chemoprophylaxis for all unvaccinated HCWs, unless contraindications exist. Guidelines regarding the use of antiviral medications for prophylaxis

can be found on the Association of Medical Microbiology and Infectious Disease Canada (AMMI Canada) website.

Household Contacts, Both Adults and Children, of Individuals at High Risk of Influenza Complications, Whether or Not the Individual at High Risk Has Been Immunized

These individuals include household contacts of individuals at high risk of influenza-related complications or hospitalization, as listed earlier, including: household contacts of those 59 months of age and younger; household contacts of infants under 6 months of age (who are also at high risk of complications from influenza but for whom influenza vaccine is not authorized); and members of a household expecting a newborn during the influenza season.

They also include those who provide regular child care to children 59 months of age and younger, whether in or out of the home, and those who provide services within closed or relatively closed settings to persons at high risk (e.g., crew on a ship).

OTHERS

People Who Provide Essential Community Services

Vaccination for these individuals should be encouraged to minimize the disruption of services and routine activities during annual epidemics. People who provide essential community services, including healthy working adults, should consider yearly influenza immunization, as this intervention has been shown to decrease work absenteeism due to respiratory and related illnesses[48, 49, 57-59].

People in Direct Contact During Culling Operations Involving Poultry Infected with Avian Influenza

NACI recommends immunization against seasonal influenza for people in direct contact with poultry infected with an avian influenza during culling operations, as these individuals may be at increased risk of avian influenza infection because of exposure during the culling operation (see below)[60-63]. However, NACI has concluded that there is insufficient evidence at this time to recommend routine influenza immunization specifically for swine workers. Information informing this recommendation can be found in the Statement on Seasonal Influenza Vaccine for 2013–2014.

Although seasonal influenza immunization will not prevent avian influenza infection, some countries[64] and provinces, have recommended influenza immunization on a yearly basis for poultry workers, based on the rationale that preventing infection with human influenza strains may reduce the theoretical potential for human-avian re-assortment of genes, should such workers become co-infected with human and avian influenza viruses[65].

Direct contact may be defined as sufficient contact with infected poultry to allow transmission of an avian virus to the exposed person. The relevant individuals include those performing the cull, as well as others who may be directly exposed to the avian virus, such as supervising veterinarians and inspectors. It is recommended that biosecurity measures such as personal protective equipment and antivirals be used. Further information regarding recommendations during a domestic avian influenza outbreak can be found in the Agency guidance on Human Health Issues Related to Avian Influenza in Canada.

IV. VACCINE PREPARATIONS AVAILABLE FOR USE IN CANADA

The following sections describe, by vaccine type, relevant information including efficacy and effectiveness, immunogenicity and safety related to influenza vaccines currently available for use.

Key relevant details and differences between vaccine products are highlighted in **Appendix A**.

INACTIVATED INFLUENZA VACCINES

Inactivated seasonal influenza vaccines contain standardized amounts of the HA protein from representative seed strains of the two human influenza A subtypes (H3N2 and H1N1) and either one (for trivalent vaccines) or both (for quadrivalent vaccines) of the two influenza B lineages (Yamagata or Victoria). The amount of NA in the vaccines is not standardized. HA-based serum antibody produced to one influenza A subtype is anticipated to provide little or no protection against strains belonging to the other subtype. The potential for trivalent vaccine to stimulate antibody protection across B lineages requires further evaluation and may be dependent upon factors such as age and prior antigenic experience with the two B lineages[66-71].

Trivalent Inactivated Influenza Vaccine (TIV): Unadjuvanted, IM Administered, Standard Dose

Vaccines currently available for use:

- Agriflu® (Seqirus)
- Fluviral® (GlaxoSmithKline)
- Influvac® (BGP Pharma ULC, operating as Mylan EPD)

Efficacy and Effectiveness

Multiple studies have shown that influenza vaccine is efficacious with higher efficacy demonstrated against laboratory-confirmed influenza than clinically defined outcomes[72]. In healthy children (equal to or younger than 16 or 18 years old, depending on the study), a systematic review and meta-analyses showed that the efficacy of influenza vaccine against laboratory-confirmed influenza ranged from 59% to 82%; similarly, a 2013 literature review looking at influenza vaccine effectiveness (VE), immunogenicity and safety in healthy 5–18 year olds found that VE against laboratory-confirmed influenza was variable but most frequently between 65–85%[73-91]. Efficacy against serologically-confirmed influenza (rise in antibody titres from post-vaccine levels) ranged from 54% to 63% and efficacy against clinical illness ranged between 33% and 36%[92-94]. Vaccine effectiveness against clinical illness was generally not well demonstrated in the studies included in the 2013 literature review in healthy children, although one of the six studies assessing this suggested VE of 68–85% against this outcome[73, 75, 77, 81, 85, 95].

In a systematic review of healthy adults, inactivated influenza VE against laboratory-confirmed influenza was estimated to be 62% (95% confidence interval [CI]: 52 to 69%) and VE against ILI was estimated at 16% (95% CI: 9 to 23%) when the vaccine strain matched the circulating strains[96]. Two other studies found somewhat lower VE at 55% (95% CI: 41 to 65%) against

ILI with laboratory confirmation (real-time polymerase chain reaction) of influenza in the 2006–2007 season[97] and 68% (95% CI: 46 to 81%) in the 2007–2008 season[98]. A VE against laboratory-confirmed influenza of 50% in healthy adults (95% CI: 27 to 65%) has been identified during select seasons of vaccine mismatch, although mismatch is a relative term and the amount of cross-protection is expected to vary[96, 99, 100].

In the elderly, VE is about half of that in healthy adults and varies depending on the outcome measures and the study population[92, 101]. Systematic reviews have demonstrated that influenza vaccine decreases the incidence of pneumonia, hospital admissions and deaths in the elderly[92] and reduces exacerbations in persons with chronic obstructive pulmonary disease[102].

In observational studies, immunization has been shown to reduce the number of physician visits, hospitalizations and deaths in high-risk persons 18 to 64 years of age[103], hospitalizations for cardiac disease and stroke in the elderly[104], and hospitalization and deaths in persons with diabetes mellitus 18 years of age and older[105] during influenza epidemics. Observational studies that use non-specific clinical outcomes and that do not take into account differences in functional status or health-related behaviours should be interpreted with caution[106-110].

The VE may be lower in certain populations (e.g., persons with immune compromising conditions, elderly persons) than in healthy adults. However, the possibility of lower efficacy should not preclude immunization of people at high risk of influenza-associated morbidity, since vaccinated individuals are still more likely to be protected compared to those who are unvaccinated.

In a 2012 systematic review and meta-analysis conducted by Osterholm et al. on influenza vaccine efficacy and effectiveness, efficacy of TIV in adults was found to be lower than was found in other literature[111]. The included studies in 18–64 year olds covered nine influenza seasons and had a random-effects pooled VE of 59% (95% CI: 51 to 67%). The authors found no papers that met their inclusion criteria for TIV efficacy in children or in older adults. These authors found vaccine effectiveness was variable for seasonal influenza with six of 17 analyses in nine studies showing significant protection (lower 95% CI greater than 0%) against medically attended laboratory-confirmed influenza in the outpatient or inpatient setting. The author's conclusions in this review may be subject to interpretation because of the restrictive inclusion criteria that were used to select evidence for this review. The NACI methodology uses broader inclusion criteria for available evidence, and thus, interpretation of evidence may vary from other reviews.

Because of potential changes in the circulating influenza virus from year to year and waning immunity in vaccine recipients, annual influenza immunization is recommended. Although NACI is aware of some recent studies that suggest that vaccine induced protection may be greater in individuals who have no recent vaccine history, optimal protection against influenza season after season is best achieved through annual influenza immunization[112, 113]. NACI will continue to monitor this issue.

NACI continues to encourage high quality research on influenza vaccine efficacy and effectiveness as it constitutes critically important information to make influenza immunization recommendations and data are still lacking on several topics of relevance.

Immunogenicity

Both humoral and cell-mediated responses are thought to play a role in immunity to influenza.

While humoral immunity is thought to play a primary role in protection against infection, cell-mediated immunity, notably cytotoxic T lymphocyte responses to internal viral components, is increasingly invoked as important in protecting against severe outcomes of influenza, particularly those associated with subtype HA variations (shift and drift)[114]. The IM administration of TIV results in the production of circulating IgG (immunoglobulin G) antibodies to the viral HA and NA proteins, as well as a more limited cytotoxic T lymphocyte response.

Considerations Related to Immunogenicity Studies in the Pediatric Population

Some studies have shown that there may be immunogenic differences between influenza vaccine products in young children[6, 115-117]. However, the use of a 0.5 mL vaccine dose of unadjuvanted TIV generated a more comparable immune response than a 0.25 mL dose in children under 24 months of age and in unprimed children.

Overall, the clinical implications of these findings are unclear, as VE was not studied and could be unaffected even where immunogenicity is lower. As well, there are no established licensing criteria for immunogenicity in young children as there is generally insufficient information on immunity in this age group. All four studies that were reviewed with respect to differing immunologic responses between products used licensing criteria for adults, which have not similarly been proven to correlate with 50% efficacy in children. No correlate has ever been identified or clinically validated in the pediatric population, and there remains a need to better define the immunological correlates of protection.

It is important to note that NACI recommends the use of a 0.5 mL dose for all recipients of the unadjuvanted inactivated influenza vaccine, including young children, which is thought to mitigate the reduced immune response observed in the studies with the 0.25 mL dose. Due to insufficient information, there is no change in product recommendations at this time and all products authorized for use in the pediatric population can be used for influenza immunization of children.

Considerations Related to the Elderly and Those with Immune Compromising Conditions

Although the initial antibody response in elderly recipients may be lower to some influenza vaccine components when compared to those in other age groups, a literature review identified no evidence for a subsequent antibody decline that was any more rapid in the elderly than in younger age groups[118].

Influenza immunization can induce protective antibody levels in a substantial proportion of adults and children with immune compromising conditions, including transplant recipients, those with proliferative diseases of the haematopoietic and lymphatic systems, and HIV-infected patients[119-122].

Most studies have shown that administration of a second dose of influenza vaccine in the same season to elderly individuals or other individuals who may have an altered immune response does not result in a clinically significant antibody boost[123-126].

Safety

Healthy adults receiving TIV show no increase in the frequency of fever or other systemic symptoms compared with those receiving placebo. TIV is safe and well tolerated in healthy children. Mild injection site reactions, primarily soreness at the vaccination site, occur in 7% or less of healthy children who are less than 3 years of age[127-129]. Post-vaccination fever may be observed in 12% or less of immunized children 1 to 5 years of age[83, 129].

In adults 60 years of age and older, common local reactions to influenza vaccines without adjuvant that are injected intramuscularly include redness, swelling, pain, and induration. These reactions last 2–3 days and rarely interfere with normal activities. Systemic reactions common to adults 60 years of age and older who receive influenza vaccines include headache, malaise, myalgia, fatigue, arthralgia, and fever.

Trivalent Inactivated Influenza Vaccine (TIV): Unadjuvanted, IM Administered, High Dose

Vaccines currently available for use:

- Fluzone® High-Dose (Sanofi Pasteur)

Efficacy and Effectiveness

Two RCTs and one retrospective cohort study have measured the relative efficacy of Fluzone® High-Dose compared to a standard-dose TIV in adults 65 years of age and older. Relative efficacy of high-dose versus standard-dose vaccine against laboratory-confirmed symptomatic influenza was 12.5% (95% CI: -141 to 66%) in one RCT during the 2009–2010 influenza season, in which the pandemic A(H1N1) influenza virus predominated and represented a vaccine strain mismatch[130]. Canadian authorization of the high-dose vaccine was based on a second, larger RCT conducted over two influenza seasons (2011–2012, 2012–2013) in which the relative efficacy was 24% (95% CI: 10 to 36%) compared to standard-dose vaccine[131-133]. In a retrospective cohort study of Medicare beneficiaries in the USA, conducted using administrative data, Fluzone® High-Dose was estimated to be 22% (95% CI: 15 to 29%) more effective than standard-dose vaccine in preventing probable influenza-related illness, and 22% (95% CI: 16 to 27%) more effective than standard-dose vaccine in preventing hospital admission due to an influenza diagnosis[134].

An updated literature search was conducted from June 2014 (the date cutoff for the previous literature search presented in the NACI Literature Review of High Dose Seasonal Influenza Vaccine for Adults 65 Years and Older) to March 2017 on the efficacy and effectiveness of high-dose influenza vaccine in adults 65 years of age and older. The search identified five studies that assessed the effectiveness of Fluzone® High-Dose in adults 65 years of age and older[135-139], including one study with only interim findings available at time of review[138] (now published[140]). Two studies by DiazGranados et al.[135, 136] conducted supplementary analysis to a previously published DiazGranados et al. RCT[133]. The retrospective cohort study by Shay et al.[139] was a follow up to the study by Izurieta et al.[134], using an expanded dataset (two influenza seasons instead of one season) to investigate mortality as the primary outcome. A multicentre, cluster RCT by Gravenstein et al. investigated all-cause mortality, all-cause hospitalization and functional decline in elderly, long-stay nursing home residents[138]. Finally, a retrospective cohort study by Richardson et al. examined hospitalization for influenza or pneumonia, as well as all-cause hospitalization and all-cause mortality in community-dwelling patients during a single influenza season[137].

The updated review of available evidence continues to support the previous finding suggesting that high-dose TIV provides superior relative protection compared with standard-dose TIV for adults 65 years of age and older. Further details on the studies identified from the updated literature search can be found in the NACI Literature Review Update on the Efficacy and Effectiveness of High-Dose and MF59-Adjuvanted Trivalent Inactivated Influenza Vaccines in Adults 65 Years of Age and Older.

Additional studies are needed to validate whether the high-dose vaccine may provide additional benefit among adults over 75 or 85 years of age. For example, in a supplementary analysis conducted using data from the large efficacy trial mentioned above[131], relative vaccine effectiveness estimates were higher in individuals 75 years of age and older, and in those with two or more high-risk comorbidities[132]. Although the difference in estimates was not statistically significant, this trial was also not powered to address adequately the supplementary analysis. In the study by Izurieta et al., the relative vaccine effectiveness of high-dose vaccine compared to standard-dose TIV was 36% (95% CI: 13 to 54%) in adults 85 years of age and older, although the difference between the overall estimate and the age-stratified estimate was not statistically significant[134]. The study by Richardson et al. identified in the updated review also found a benefit of high-dose vaccine in preventing hospitalization for influenza or pneumonia in persons 85 years of age and older, but not in persons from 65 to 84 years of age[137].

Immunogenicity

Five studies compared the rates of seroconversion for study participants receiving high-dose and standard-dose TIV among those 65 years of age and older[141-146]. Rates of seroconversion were about 19% higher (ranging from 8–39% higher) for those receiving the higher dose vaccine across all three strains in the vaccines and in the studies. Similarly, rates of seroconversion were higher for those receiving the high- compared to standard-dose vaccines for participants 75 years of age and older and for a cohort of participants with underlying cardiopulmonary disease.

Eight studies reported higher rates of seroprotection for older adults receiving high-dose TIV compared to those vaccinated with standard-dose TIV[130, 133, 141-146]. Seroprotection was significantly higher for all three strains in the vaccine in three of five studies assessing significance. There were different results in the remaining studies. In the study by Couch et al., seroprotection was higher only against A(H1N1), possibly attributed to the fact that 78% of participants were vaccinated against the same influenza strains within 6 months prior to the study[142]. In Nace et al., seroprotection was higher against A(H3N2) and B but not A(H1N1); this finding may be attributed to strain circulation during the study that made it difficult to assess seroprotection against this subtype[146].

Geometric mean titre ratios (GMTR) of participants' responses to high- versus standard-dose influenza vaccines were reported in several studies and were calculated for those that provided group-specific, post-vaccination titres for each of the vaccines[130, 133, 141-145]. Seroresponse to the B strains in the vaccines was about 1.5 times greater (1.3–1.7) in the high-dose TIV recipients than the standard-dose TIV recipients. The GMTR of the A strains was about 1.8 times higher for those receiving high-dose TIV compared to the standard-dose TIV; ranging from 1.6–2.3.

Safety

High-dose TIV has been observed to produce a higher rate of some systemic reactions than the comparator standard-dose TIV. Studies have reported higher rates of malaise[141], myalgia[141, 144], and moderate to severe fever[141]. Most systemic reactions were mild and resolved within three days[141]. Serious adverse events were rare, and similar in frequency between the standard-dose and high-dose vaccine[130, 133, 141, 142].

Quadrivalent Inactivated Influenza Vaccine (QIV): Unadjuvanted, IM Administered

Vaccines Currently Available for use:

- Flulaval® Tetra (GlaxoSmithKline)
- Fluzone® Quadrivalent (Sanofi Pasteur)

Note: NACI is aware of the potential for a new quadrivalent inactivated influenza vaccine to be available for use during the 2018–2019 season. When any data on the efficacy and effectiveness, immunogenicity or safety of this product become available, NACI will develop a recommendation on its use, available via the NACI website.

Efficacy and Effectiveness

In a Literature Review on Quadrivalent Influenza Vaccines conducted by NACI, to date, only one study has measured QIV efficacy. In that study, VE was estimated at 59% in children 3–8 years of age, in comparison to children who received hepatitis A vaccine[147]. No literature was found on head to head efficacy or effectiveness studies directly comparing trivalent and quadrivalent formulations, for either inactivated or live attenuated formulations.

Immunogenicity

In this same review of the literature, NACI reviewed the immunogenicity data for QIV produced by manufacturers who supplied influenza vaccine in Canada at the time of the literature review: GlaxoSmithKline, AstraZeneca and Sanofi Pasteur. The results of phase II and III trials that compared trivalent formulations to quadrivalent formulations generally showed non-inferiority of the quadrivalent products for the A(H3N2), A(H1N1) and B strain contained in the trivalent formulations. As expected, these studies showed that the immune response to the B strain that was not in the trivalent formulation was better in subjects who received the quadrivalent vaccine, which contained the additional strain. These findings were consistent across age groups and different types of trivalent vaccines (inactivated and LAIV).

In some of the unpublished data from manufacturers that were submitted to NACI, the A(H3N2) or A(H1N1) immune response in QIV recipients was different compared to TIV recipients. For example, in a study in 6–35 month olds by one manufacturer, the seroconversion and seroprotection rates for A(H1N1) and A(H3N2) were much higher in QIV recipients compared to TIV recipients. Of note, the QIV and TIV products in this study were manufactured by different processes. In another study, by a different manufacturer, in adults 65 years of age and older, the A(H1N1) seroconversion rate was statistically inferior in QIV recipients compared to TIV recipients. The A(H1N1) GMTs were also slightly lower in the QIV recipients compared to the TIV recipients; however, this result was statistically non-inferior. These results were not further explained by investigators. The number of patients in these studies is relatively small and the clinical significance of these results is unknown. As previously mentioned, comparative vaccine efficacy and effectiveness data of TIV and QIV are not available.

In the phase III trials, recipients of the trivalent formulations showed, to a lesser degree, some immune response to the B strain not contained in the trivalent formulation. In one study of adults, both the trivalent and quadrivalent vaccines met all the criteria in the Committee for Medicinal Products for Human Use (CHMP) and Centre for Biologics Evaluation and Research (CBER) guidelines, including those for the strain not in the trivalent vaccine. In all other studies, the trivalent vaccine failed at least one of the criteria for seroprotection or seroconversion for the missing B strain. It has been hypothesized that there is some level of cross-reactivity between B strains. This cross protection against infection with one lineage provided by immunization against the other lineage is uncertain, however, and it is expected to be low[148].

Safety

The QIV phase III trials generally showed similar and expected rates of adverse events between the trivalent and quadrivalent formulations. Most of these studies included a limited number of patients. As the quadrivalent formulations have a higher antigenic content than the trivalent vaccine, phase IV trials and post-marketing surveillance will need to monitor whether increased reactogenicity will be a concern for the quadrivalent vaccine.

Trivalent Inactivated Influenza Vaccine (TIV): Adjuvanted, IM Administered

Vaccines currently available for use:

- Fluad® (Seqirus)
- Fluad Pediatric® (Seqirus)

1. Fluad® (Seqirus)

Efficacy and Effectiveness

A phase III, randomized, observer-blinded study comparing the safety and immunogenicity of a MF59-adjuvanted influenza vaccine with unadjuvanted influenza vaccine in adults 65 years of age and older noted no significant difference in the clinical effectiveness between adjuvanted and unadjuvanted TIV in terms of ILI[149]. However, this study was not designed to estimate vaccine effectiveness against laboratory-confirmed outcomes.

A few observational studies suggest that Fluad® may be effective at reducing the risk of hospitalization for influenza and influenza complications in the elderly, compared to unvaccinated individuals and those who received unadjuvanted trivalent inactivated subunit vaccine. However, these studies have significant methodological limitations that make their interpretation difficult[150-155].

A Canadian observational study performed in British Columbia by Van Buynder et al. evaluated the comparative effectiveness of Fluad® to TIV in reducing laboratory-confirmed influenza in the elderly[156]. During the 2011–2012 season, elderly people in three health authorities were included in a community-based case control study. Participants were included if they were 65 or older, had ILI and were swabbed and tested for influenza. The participants included elderly in long-term care, as well as individuals in the community. Influenza testing was carried out as part of routine clinical care. Cases had a positive test for influenza, whereas controls had negative tests. The choice of product was determined by external factors such as geographic location and vaccine availability, and these factors were not controlled. There were a total of 84 cases and 198 controls, which the authors acknowledged was a very small sample size and was attributable to the low level of influenza activity in the

community that year. The results showed that in a variety of multivariate analyses, Fluad® effectiveness was 58% (95% CI: 5 to 82%), with a relative effectiveness of 63% (95% CI: 4 to 86%) when compared to TIV. The study did not evaluate protection against hospitalization. The authors identified a number of limitations to this study, including the small sample size and low influenza activity in the community that year and noted that repeated studies in subsequent years would be necessary to confirm findings and to look for potential strain variation not assessable due to a relatively homogenous strain year.

An updated literature search was conducted from January 2012 to March 2017 on the efficacy and effectiveness of MF59-adjuvanted influenza vaccine in adults 65 years of age and older. The search identified four observational studies that assessed the effectiveness of Fluad® in adults 65 years of age and older[157-160], including one unpublished study from the Canadian Serious Outcomes Surveillance (SOS) Network with interim findings presented to the NACI IWG and at the 2016 Canadian Immunization Conference[159]. Two of four studies investigated VE against laboratory-confirmed influenza[158, 159] while two studies investigated hospitalization for influenza or pneumonia[157, 160]. As with the previously identified observational studies investigating Fluad®, methodological limitations should be considered when interpreting these study findings.

The updated literature review evidence is consistent with the previous review of the literature that suggests MF59-adjuvanted TIV (Fluad®) is effective at reducing the risk of hospitalization for influenza and influenza complications in the elderly compared to unvaccinated individuals. The updated review could not address whether adjuvanted vaccine provided an added benefit over unadjuvanted TIV, owing to lack of such comparative studies, methodological or sample size limitations or both. Further details on the studies identified from the updated literature search can be found in the NACI Literature Review Update on the Efficacy and Effectiveness of High-Dose and MF59-Adjuvanted Trivalent Inactivated Influenza Vaccines in Adults 65 Years of Age and Older.

Immunogenicity

The mechanism of action of MF59 is not fully determined and has primarily been studied using in vitro and mouse models. From these studies, it appears that MF59 may act differently from aluminum-based adjuvants. These studies show that MF59 acts in the muscle fibres to create a local immune-stimulatory environment at the injection site[161]. MF59 allows for an increased influx of phagocytes (e.g., macrophages and monocytes) to the site of injection. The recruited phagocytes are further stimulated by MF59, thereby increasing the production of chemokines to attract more innate immune cells and inducing differentiation of monocytes into dendritic cells[162, 163]. MF59 further facilitates the internalization of antigen by these dendritic cells[162, 164]. The overall higher number of cells available locally increases the likelihood of interaction between an antigen presenting cell and the antigen, leading to more efficient transport of antigen to the lymph nodes, with resulting improved T cell priming[162].

There is evidence from RCTs on the immunogenicity and cross-reactivity of Fluad® in adults 65 years of age and older as compared to the unadjuvanted subunit vaccines. In the Frey et al. RCT, adjuvanted subunit TIV elicited non-inferior immune responses compared to unadjuvanted subunit TIV. Superiority by pre-defined criteria was not formally met[149]. Similar but less consistent results have been shown in terms of improvement in antibody response relative to split-virus vaccine, which is the type of influenza vaccine used most often in Canada. The studies that compare Fluad® to split-virus vaccine generally compared it to a vaccine called Mutagrip® (not available in Canada). The one study that compared Fluad® to

Vaxigrip® (an IM TIV product, not available in Canada) found similar seroprotection and seroconversion rates for A(H3N2) and a higher immune response for A(H1N1) and B for Fluad® recipients less than 75 years of age[165]. For those 75 years of age and older, higher seroprotection and seroconversion rates were noted for all three strains in those receiving Fluad®. In a randomized clinical trial comparing Fluad® to Intanza® (an intradermal [ID] TIV product, not available in Canada) in participants aged 65 years and older, non-inferiority of the ID vaccine compared with the adjuvanted vaccine was demonstrated for the A(H1N1) and B strains, but not the A(H3N2) strain, with the haemagglutination inhibition assay (HAI) method and for all three strains with the single radial haemolysis (SRH) method[166].

A Canadian study conducted by PHAC/Canadian Institutes of Health Research (CIHR) Influenza Research Network (PCIRN) looked at the immunogenicity of Fluad® (adjuvanted TIV), Intanza 15® (TIV-ID) and Agriflu® (subunit TIV) in ambulatory seniors (65 years of age and older) living in the community[167]. This RCT comprised 911 participants. For the B strain (Brisbane), the baseline antibody titres were too high for meaningful response assessments post-immunization. For A(H1N1), seroprotection rates were significantly higher after adjuvanted TIV than after the other vaccines when measured by HAI, but not by SRH. For A(H3N2), seroprotection rates were significantly higher after adjuvanted TIV than after other vaccines by both HAI and SRH, while rates did not differ significantly between TIV-ID and the subunit TIV. In the microneutralization (MN) assay, titres of 1:40 or greater to A(H3N2) were achieved more frequently after adjuvanted TIV than after the other vaccines. GMTs were highest after adjuvanted TIV for both A viruses. When immune responses were compared using criteria for licensing influenza vaccines in seniors, all 3 vaccines met the seroprotection criterion for each virus (both HAI and SRH assays). By HAI, adjuvanted TIV and TIV-ID met the seroconversion and geometric mean (GM) fold increase criteria for the A viruses. TIV did not meet the seroconversion criterion for A(H3N2). By SRH assay, the GM fold increase criterion was not met for any virus after TIV-ID or TIV but it was met for the A viruses after adjuvanted TIV. While statistically significant, the differences in seroprotection rates and GMT ratios after adjuvanted TIV compared to TIV were of modest magnitude. Whether this would result in greater protection against infection is not yet certain.

Six months after vaccination, residual seroprotection rates to the A viruses did not differ significantly among the 3 groups, but only adjuvanted TIV recipients had rates over 60% for each virus, meeting international immunogenicity criteria.

The implication of these immunogenicity findings with regard to clinical efficacy is unknown and requires further study.

Safety

MF59-adjuvanted TIV produces injection site reactions (pain, erythema and induration) significantly more frequently than unadjuvanted vaccines, but they are classified as mild and transient. Systemic reactions (myalgia, headache, fatigue and malaise) are comparable or more frequent with Fluad® compared to unadjuvanted vaccines and are rated as mild to moderate and transient.

2. Fluad Pediatric® (Seqirus)

Efficacy and Effectiveness

In a Literature Review on Pediatric Fluad® Influenza Vaccine Use in Children 6–72 Months of Age conducted by NACI, only a single efficacy trial of adjuvanted TIV in children aged 6 to

less than 72 months was identified[168]. However, there were several considerations regarding the applicability of this trial in the Canadian context. Firstly, the European Medicines Agency (EMA) identified a number of critical issues related to trial management, quality of data, and data handling for this study at some of the trial sites during a Good Clinical Practice inspection conducted as part of the authorization process in Europe, which could impact the estimate of adjuvanted TIV VE[169]. The original study authors conducted a reanalysis of VE excluding data from one of the audited trial sites, and reported no notable change from the original findings[170]. However, the auditors were of the opinion that the deficiencies identified in the audited site were of a nature that could have occurred in other study sites not subject to audit. As a result, despite the company's reanalysis of the data, there remained concerns with the conduct of the study, which could have affected the accuracy of the estimate of VE.

Secondly, the unadjuvanted TIV comparator in this trial was shown, in an unrelated study, to generate a lower immune response compared to another unadjuvanted TIV product during the 2006–2007 season[116, 171]. It is not clear what implication this finding has on clinical protection. Finally, the study administered 0.25 mL doses of the comparator vaccine for children under 36 months, which is lower than the dose of 0.5 mL of unadjuvanted influenza vaccine that is recommended for this age group in Canada.

After reviewing this information, NACI continues to conclude that the concerns with the trial identified above should be taken into account when assessing study results.

Immunogenicity

In children, there is limited but consistent evidence that adjuvanted TIV is more immunogenic than comparable unadjuvanted TIVs against both influenza A and B[168, 172-176]. In particular, a single dose of adjuvanted TIV is more immunogenic than a single dose of unadjuvanted TIV, and has been shown in one study to produce greater GMTs than two doses of unadjuvanted TIV against influenza A[176]. However, similar to unadjuvanted TIV, adjuvanted TIV generally induced a weaker haemagglutination inhibition response against B strains compared to A strains and therefore two doses of adjuvanted TIV are still necessary to achieve a satisfactory immune response against influenza B.

Almost all of the studies included in the NACI Literature Review on Pediatric Fluad® Influenza Vaccine Use in Children 6–72 Months of Age used vaccine formulations of 0.25 mL in children 6–35 months of age, both for the adjuvanted vaccine and the comparator unadjuvanted influenza vaccine. One study employed a dose-ranging factorial design comparing adjuvanted and unadjuvanted versions of both seasonal TIV and QIV administered to children 6–36 months old[174]. Immunogenicity data were presented for 0.25 mL adjuvanted TIV (n=27) and 0.5 mL unadjuvanted TIV or QIV, reported jointly as a single group (n=50). The 0.25 mL adjuvanted TIV generated a better immune response after the first and second dose when compared to the first and second dose of unadjuvanted 0.5 mL TIV or QIV. Additional data provided by the authors separating unadjuvanted TIV (n=22) and QIV (n=28), showed a similar or better immune response for QIV compared to TIV. It should be noted that participants receiving adjuvanted TIV were, on average, older than those in the unadjuvanted TIV and QIV groups, which may lead to an enhanced immune response, and the findings are based on small sample sizes.

NACI recommends 0.5 mL dosage of unadjuvanted inactivated influenza vaccine in all age groups. While there is some indication of how adjuvanted TIV at 0.25 mL dose would compare to unadjuvanted TIV or QIV at 0.5 mL dose immunologically in the 6 to under 24 month age

group, it is unclear whether the stronger humoral immune response induced by adjuvanted TIV in one trial with a very limited number of participants translates into an appreciable advantage in terms of preventing influenza or its complications.

Safety

The safety data in children are consistent with what is known about adjuvanted TIV's safety profile in adults. In the pediatric trials, adjuvanted TIV was more reactogenic than unadjuvanted TIV, with recipients experiencing 10–15% more solicited local and systemic reactions[177]. However, most reactions were mild and resolved quickly.

There are currently no data on the effects of long-term or repeated administration of adjuvanted influenza vaccines in children. The most significant experience with an adjuvanted influenza vaccine in children was the AS03-adjuvanted A(H1N1) pandemic vaccine that has been associated with an increased risk of narcolepsy. A study published in December 2014 comparing two AS03-adjuvanted A(H1N1) vaccine products (Pandemrix and Arepanrix) has suggested that the underlying immune mediated mechanism may not be initiated by the adjuvant, but by another component of the vaccine, specifically the A(H1N1) viral antigen[178]. However, the pandemic vaccine was a single strain adjuvanted vaccine administered only during one season, and it is unknown what effects a multi-strain adjuvanted vaccine or an adjuvanted vaccine administered for more than one season may have in young children.

One study employed a dose-ranging factorial design and included both adjuvanted and unadjuvanted versions of seasonal TIV and QIV administered to children 6–36 months old[174]. Overall, there was no indication of an increasing risk of adverse events associated with increasing MF59 dose, antigen dose, or the addition of a second B strain. However, reactogenicity of 15 µg formulations were slightly higher for both adjuvanted and unadjuvanted vaccines compared to the 7.5 µg formulations.

LIVE ATTENUATED INFLUENZA VACCINE (LAIV)

LAIV contains standardized quantities of fluorescent focus units (FFU) of live attenuated influenza virus reassortants. The virus strains in LAIV are cold-adapted and temperature sensitive, so they replicate in the nasal mucosa rather than the lower respiratory tract, and they are attenuated so they do not produce ILI. As a live replicating whole virus formulation administered intranasally, it elicits mucosal immunity, which may more closely mimic natural infection.

Vaccines currently available for use:

- FluMist® Quadrivalent (AstraZeneca)

Note: Although the evidence supporting the use of live attenuated influenza vaccines was based on the trivalent formulation, based on expert opinion, the comparative efficacy data that supported the recommendations for the trivalent formulation of LAIV are also applicable to the quadrivalent formulation of LAIV because the manufacturing processes and immunologic mechanism of the quadrivalent LAIV and the trivalent LAIV products are the same. This expert opinion is supported by the results of the non-inferiority immunogenicity studies comparing trivalent and quadrivalent formulations of LAIV, which were required by regulatory bodies to authorize the use of the quadrivalent LAIV formulation.

Efficacy and Effectiveness

Children and Adolescents (2–17 Years of Age)

There is evidence from randomized controlled studies that trivalent LAIV provides superior efficacy to TIV in young children (younger than 6 years of age) (Grade A), with weaker evidence of superior efficacy in older children (Grade I). Two studies have directly compared the efficacy of LAIV and TIV in younger children (up to age 5 and 6) and one study has compared the efficacy of LAIV and TIV in asthmatic children 6–17 years of age[179-181]. The study by Fleming et al. looked at 2229 asthmatic children 6–17 years of age (mean age: 11 years) and showed superior efficacy of LAIV over TIV in this age group[179]. These results seem to have been mostly driven by influenza B and were not significant for the A(H3N2) strain. Although the study has limitations, such as the fact that the study population was asthmatic and the results may not be generalizable to all children, its strengths include a randomized design and culture confirmed outcome. NACI recognizes that there are differences in levels of evidence for younger and older children. There is more evidence that directly compares TIV and LAIV efficacy and that shows superior efficacy of LAIV in children younger than 6 years of age than in older children. Also, for children under 6 years of age, the evidence for the superiority of LAIV is of higher quality and the estimate of efficacy is higher, compared to the one study performed on children 6–17 years old.

It was anticipated that the superior efficacy of LAIV over TIV extended beyond 6 years of age, but the evidence did not indicate at which specific age the efficacies of LAIV and TIV might have become equivalent nor at which age LAIV efficacy may have become inferior to that of TIV. It is hypothesized that as children get older, they are more likely to have had previous influenza infection or vaccine, which might interfere with the immune response elicited to LAIV. More evidence is needed that directly compares the efficacy and effectiveness of LAIV with TIV or QIV and NACI considers this a research priority.

Data on LAIV vaccine effectiveness have come primarily from American studies[182-195]. Only the United States Influenza Vaccine Effectiveness Network (US Flu VE Network) has consistently reported LAIV vaccine effectiveness over the past several influenza seasons (2010–2016) in children and adolescents 2–17 years of age[182-185]. The Influenza Clinical Investigation for Children (ICICLE) study, conducted by MedImmune as part of its four season (until 2017) post-marketing commitment to the US Food and Drug Administration (FDA), has VE data available for the 2013–2014 through 2015–2016 influenza seasons for children and adolescents 2–17 years of age[187-189]. The US Department of Defense (DoD) has published LAIV vaccine effectiveness data for US Air Force dependants (2–17 years of age) for the 2013–2014 and 2015–2016 influenza seasons[184, 186] and active military personnel for the 2010–2011 through 2013–2014 influenza seasons[190-193]. These American studies used the test-negative design[182-193]. The American Household Influenza Vaccine Effectiveness (HIVE) study, using an alternative household cohort design, investigated LAIV and IIV vaccine effectiveness in children (2–8 years of age) and adolescents (9–17 years of age) for the 2012–2013 and 2013–2014 seasons[194, 195].

Data on LAIV vaccine effectiveness from outside of the USA have come from Canada (the Canadian Sentinel Practitioner Surveillance Network [SPSN] for 2013–2014 and 2015–2016[196, 197], and two studies for the 2013–2014 season[198] and spanning the 2012–2013 to 2014–2015 influenza seasons[199]), Germany for the 2012–2013 season[200], the UK sentinel surveillance network for the 2013–2014 through the 2015–2016 seasons[201-203], and Finland for the 2015–2016 season[204]. These LAIV vaccine effectiveness studies were mostly of test-

negative design[196, 197, 200-203], with one prospective cohort study[204] and two cluster randomized trials[198, 199].

Data from all of these jurisdictions are summarized by season below:

Influenza Seasons 2010–2011, 2011–2012, and 2012–2013

Overall, studies in children and adolescents (2–17 years of age) report moderate and statistically significant (lower bound of the 95% CI does not include zero) trivalent LAIV vaccine effectiveness against any influenza virus, influenza A(H3N2) and influenza B for the 2010–2011 through 2012–2013 influenza seasons[182, 200]. The US Flu VE Network reported that the vaccine effectiveness estimates for LAIV and IIV were comparable (with overlapping confidence intervals) and statistically significant against any influenza, influenza A(H3N2) and influenza B viruses during the 2010–2011 and 2012–2013 influenza seasons, and against any influenza and A(H3N2) in the 2011–2012 season (sample sizes were too small to estimate vaccine effectiveness against influenza B virus in this season)[182]. The German study also reported a high and statistically significant vaccine effectiveness estimate for LAIV against any influenza in the 2012–2013 influenza season[200]. In contrast, the US Flu VE Network observed LAIV to have had a low and statistically non-significant (95% CI includes zero) VE against A(H1N1) compared to a high and statistically significant vaccine effectiveness estimate for IIV against A(H1N1) in the 2010–2011 influenza season (vaccine effectiveness of LAIV and IIV against A(H1N1) was not estimated in the 2011–2012 or 2012–2013 influenza seasons due to limited sample size)[182].

Influenza Season 2013–2014

During the 2013–2014 influenza season in which influenza A(H1N1) was dominant, all three American test-negative studies (US Flu VE Network, DoD and ICICLE) reported low to negative and statistically non-significant vaccine effectiveness estimates for quadrivalent LAIV against any influenza and against A(H1N1)[185, 187]. In contrast, the reported vaccine effectiveness of IIV was moderately high and statistically significant against any influenza and against influenza A(H1N1) (US Flu VE Network and ICICLE). The American HIVE study found moderately high, but statistically non-significant LAIV and IIV VE estimates against influenza A(H1N1) in children (2–8 years of age)[195]. Investigations by the manufacturer concluded that the reduced effectiveness seen in the USA may have been due to the A/California/7/2009(H1N1)pdm09-like LAIV strain's being vulnerable to heat degradation, which may have occurred during distribution[189].

NACI subsequently concluded that heat degradation was unlikely to have been an issue in Canada for the 2013–2014 season due to strict temperature control and monitoring throughout transport[205]. NACI further noted that VE estimates for the trivalent LAIV formulation used in Canada were higher than those seen in the American studies for the 2013–2014 season[196]. Data from the Canadian SPSN reported a high and statistically significant unadjusted VE estimate for LAIV against any influenza, with a high but statistically non-significant unadjusted VE estimate against A(H1N1). Both point estimates were comparable to those of IIV, but based on small sample sizes with wide confidence intervals[196]. In light of these findings, at that time, NACI continued to recommend preferential use of LAIV in children and adolescents, but with a commitment to continue to monitor LAIV VE in future seasons[205, 206].

As a result of the concerns regarding thermostability that followed the investigation into the poor LAIV VE against influenza A(H1N1) in the USA, the manufacturer replaced the

A/California/7/2009(H1N1)pdm09-like strain with an antigenically similar strain (A/Bolivia/559/2013) with improved thermostability for the 2015–2016 season.

Influenza Season 2014–2015

The 2014–2015 influenza season was dominated by antigenically drifted A(H3N2) viruses. Two American studies (US Flu VE Network and ICICLE)[183, 189] and the UK sentinel surveillance network study[202] reported low to negative and statistically non-significant LAIV and IIV VE against any influenza and against influenza A(H3N2) (with the exception of the ICICLE study which reported a low but statistically significant IIV VE estimate against A(H3N2)[188]). No LAIV VE estimates were available for A(H1N1). Predominance of antigenically drifted A(H3N2) viruses was proposed as an explanation for the estimates of reduced VE against A(H3N2) generally; higher VE was observed against less prevalent vaccine-like A(H3N2) viruses in the USA[183] and also with IIV in Canada[207].

Influenza Season 2015–2016

In the 2015–2016 influenza season with predominant circulation of influenza A(H1N1), moderate and statistically significant LAIV VE against any influenza (46–58%) was observed among children and adolescents 2–17 years of age in two American studies (DoD and ICICLE)[184, 188], the UK[203], and a cohort study conducted by the Finland National Institute for Health and Welfare[204]. In unadjusted analysis by the Canadian SPSN, LAIV effectiveness against any influenza (74%) was also statistically significant but with wide confidence intervals[197]. However, in contrast, the US Flu VE Network found a low, non-statistically significant LAIV VE against any influenza (3%)[184]. All four studies with both LAIV and IIV VE data (US Flu VE Network, DoD, ICICLE, and the Finland study) reported lower VE point estimates for LAIV compared to IIV for any influenza, but only the US Flu VE Network showed a statistically significant difference (non-overlapping confidence intervals) between LAIV and IIV[184, 188, 204]. In unadjusted analysis, the Canadian SPSN reported comparable point estimates for LAIV (74%) and IIV (63%) effectiveness against any influenza, but with wide and overlapping confidence intervals[197].

In A(H1N1) specific analysis, two of the five studies that used the test-negative design (ICICLE and Canadian SPSN) found comparable but statistically non-significant LAIV VE estimates of approximately 50%, again with wide confidence intervals[188, 197]. Two other American studies based on the test-negative design (US Flu VE Network, DoD) reported lower LAIV VE estimates (-21%, 15%) with confidence intervals overlapping zero that were more consistent with no vaccine protection[184]. The point estimates of VE against A(H1N1) for LAIV were lower than for IIV in all four studies (ICICLE, DoD, US Flu VE Network, Canadian SPSN), but only the US Flu VE Network reported a significantly lower LAIV estimate (non-overlapping confidence intervals). The UK study VE estimates against influenza A(H1N1) are not currently publicly available. The study from Finland using a prospective cohort design did not generate subtype specific VE estimates.

LAIV VE against A(H3N2) was only reported in one study (DoD), which found a statistically non-significant, moderate vaccine effectiveness estimate[184].

Influenza Season 2016–2017

Sample sizes were insufficient to derive estimates of LAIV vaccine effectiveness for the influenza A(H3N2) dominant 2016–2017 influenza season by either the US Flu VE Network[208] or by the Canadian SPSN[209]. Provisional end-of-season LAIV adjusted VE

estimates for the UK for children 2−17 years of age were high and statistically significant against influenza A and B combined (65.8%, 95% CI: 30.3 to 83.2%) and moderately high and statistically significant against influenza A(H3N2) (57.0%, 95% CI: 7.7 to 80.0%). The adjusted VE point estimate was high against influenza B (78.6%), but it was not significant (95% CI: -86.0 to 97.5%). Based upon these provisional end-of-season estimates, the UK has concluded the findings support the ongoing rollout of its pediatric vaccine program[210]. LAIV VE estimates from Finland for the 2016–2017 influenza season have not yet been published.

The manufacturer of LAIV is conducting an investigation into the reduced VE of LAIV in some studies over recent influenza seasons[211]. The investigation is currently looking into biological characteristics of the vaccine strain components (e.g., cell receptor binding and fusion, replicative fitness). Preliminary findings suggest that the lower LAIV VE against influenza A(H1N1) may have been due to lower replicative fitness of the influenza A(H1N1) component of the vaccine, but the investigation is ongoing.

Relative Vaccine Effectiveness

Data on the relative VE of LAIV versus IIV (the ratio of the risk of influenza in persons vaccinated with LAIV compared to the risk in persons vaccinated with IIV) in children and adolescents 2–17 years of age have come from the US Flu VE Network over the past several influenza seasons (2010–2016)[182-184]. Adjusted estimates of relative VE of LAIV and IIV against any influenza were not statistically significantly different in the 2010–2011, 2011–2012 and 2012–2013 influenza seasons[182]. However, the reported relative VE of IIV was statistically significantly higher than LAIV in both the 2013–2014 (adjusted odds ratio [aOR]: 2.88) and 2015–2016 (aOR: 2.63) influenza seasons[182, 184]. No estimate was available for the 2014–2015 season.

When examining relative VE of LAIV versus IIV by influenza subtype, analysis of data from the US Flu VE Network found IIV to provide statistically significantly higher protection against influenza A(H1N1) in the mixed or A(H1N1) dominant 2010–2011 (aOR: 5.53), 2013–2014 (aOR: 2.65), and 2015–2016 (aOR: 3.67) influenza seasons[182, 184]. In contrast, there was no statistically significant difference in relative VE between LAIV and IIV against influenza A(H3N2) in the mixed or A(H3N2) dominant 2010–2011, 2011–2012 or 2012–2013 influenza seasons[182] or against influenza B in the 2010–2011, 2012–2013 or 2015–2016 influenza seasons[182, 184]. No relative VE estimates by influenza subtype were available for the influenza A(H3N2) vaccine mismatched 2014–2015 season.

Although also limited in sample size, a Canadian cluster randomized clinical trial conducted in children and adolescents in the 2013–2014 influenza season found better performance of LAIV compared to IIV[198]. A Canadian blinded cluster randomized study in Hutterite children compared trivalent LAIV versus IIV over three influenza seasons (2012–2013 to 2014–2015). This study found no significant difference in the protection provided by the two vaccines against any influenza in each of the three seasons, and no significant difference in the protection provided against the predominant circulating influenza strains in each of these seasons[199].

Adults

A literature search conducted in early 2016 identified three studies examining the effectiveness of LAIV in adult populations published since the NACI literature review conducted in 2011[212]. These three studies measured the relative effectiveness of LAIV compared to TIV in adult (17–49 years of age) active duty US military personnel. The 2011

literature review identified four RCTs that examined the relative efficacy of LAIV compared to TIV, and one that compared LAIV and TIV to placebo, in healthy community-based adults (the majority 18–49 years of age, with one study including subjects up to 65 years). Most of these studies have found that LAIV and TIV had similar efficacy and effectiveness or that TIV was more efficacious[212]. Given the small number of studies with adult participants, it is uncertain what factors influence the relative efficacy and effectiveness of LAIV compared to TIV. However, LAIV may be more effective when there has been minimal lifetime exposure to the influenza viruses or vaccine and thus less pre-existing immunity. Further details regarding the recommendation rationale for LAIV are found in Section V.

Conclusions and Recommendations

After careful review of the available VE data over the last several influenza seasons, NACI concludes that the current evidence is consistent with LAIV's providing comparable protection against influenza to that afforded by IIV in various jurisdictions. Previous studies and clinical experience also indicate LAIV to be a safe vaccine. However, the current evidence does not support a recommendation for the *preferential* use of LAIV in children 2–17 years of age. The observational study data reviewed highlight the challenge in interpreting LAIV and IIV VE when point estimates by influenza subtype are derived based on small sample sizes associated with wide confidence intervals.

The reasons for the discordant 2015–2016 VE estimates between studies are currently unknown, but may reflect biological mechanisms, methodological issues or both, such as biases in the design of observational studies, as well as statistical (sample size) considerations limiting the precision of VE estimates. Possible explanations for poor LAIV effectiveness against A(H1N1) in some studies include changes in the serological profile of the population post pandemic A(H1N1), higher population levels of pre-existing antibody interfering with vaccine virus replication, potential competitive interference with viral replication among live viruses in the quadrivalent vaccine, and suboptimal performance of the new A/Bolivia/559/2013(H1N1) LAIV component for reasons that have yet to be identified.

As a consequence of these gaps in scientific knowledge, NACI strongly encourages further, multidisciplinary (e.g., epidemiological, immunological, virological) research in this area. NACI also strongly recommends that sufficient resources be provided to enhance influenza-related research and sentinel surveillance systems in Canada to improve the evaluation of influenza vaccine efficacy and effectiveness to provide the best possible evidence for Canadian influenza vaccination programs and recommendations.

Immunogenicity

LAIV (FluMist® Quadrivalent), which is administered by the intranasal route, is thought to result in an immune response that mimics that induced by natural infection with wild-type viruses, with the development of both mucosal and systemic immunity. Local mucosal antibodies protect the upper respiratory tract and may be more important for protection than serum antibody.

Studies have demonstrated that the presence of an HAI antibody response after the administration of trivalent LAIV is predictive of protection. However, efficacy studies have shown protection in the absence of a significant antibody response as well[212]. In these studies, LAIV has generally been shown to be equally, if not more, immunogenic compared to TIV for all three strains in children, whereas TIV was typically more immunogenic in adults than was LAIV. Greater rates of seroconversion to LAIV occurred in baseline seronegative

individuals compared to baseline seropositive individuals in both child and adult populations, because pre-existing immunity may interfere with response to a live vaccine. For further details regarding immunogenicity of LAIV, consult the NACI Recommendations on the use of live, attenuated influenza vaccine (FluMist®): Supplemental Statement on Seasonal Influenza Vaccine for 2011–2012.

The quadrivalent formulation of LAIV has shown non-inferiority based on immunogenicity compared to the trivalent formulation in both children and adults. The immune response to the B strain found only in the quadrivalent formulation was better in children who received the quadrivalent vaccine[213-215].

Safety

The most common adverse events experienced by recipients of trivalent LAIV are nasal congestion and runny nose, which are expected also for the quadrivalent formulation. In a large efficacy trial, wheezing occurred in recipients of trivalent LAIV vaccine at rates above those in TIV recipients only, in children under 24 months of age[212]. This finding is expected to be the same for recipients of the quadrivalent LAIV.

Studies on the trivalent formulation of FluMist® have shown that vaccine virus can be recovered by nasal swab in children and adults following immunization (i.e., “shedding”). The frequency of shedding decreases with increasing age and time since vaccination. Shedding is generally below the levels needed to transmit infection, although in rare instances, shed vaccine viruses can be transmitted from vaccine recipients to unvaccinated persons. For more detailed information on LAIV and viral shedding, consult the NACI Recommendations on the use of live, attenuated influenza vaccine (FluMist®): Supplemental Statement on Seasonal Influenza Vaccine for 2011–2012.

CO-ADMINISTRATION WITH OTHER VACCINES

NACI has reviewed the potential for immune interference when live vaccines are administered sequentially within a short time period (less than 4 weeks). In general, NACI recommends that two live parenteral vaccines be administered either on the same day or at least four weeks apart[216]. This is based largely on a single study from 1965 that demonstrated immune interference between smallpox vaccine and measles vaccine administered 9 to 15 days apart. Subsequent studies have revealed conflicting results on immune interference between live vaccines[217-220].

A literature search was conducted for clinical data on immune interference between LAIV and other live attenuated vaccines (oral or parenteral) administered within 4 weeks. No studies were found. Three studies included data on concomitant administration of LAIV with MMR, varicella and oral polio vaccines[8-10]. Although the impact on VE was not evaluated, none found evidence of clinically significant immune interference. One study reported a statistically significant but not clinically meaningful decrease in seroresponse rates to rubella antigen.

In theory, the administration of two live vaccines sequentially within less than 4 weeks could reduce the efficacy of the second vaccine. Possible immune mechanisms include (i) the inhibitory and immunomodulatory effects of systemic and locally produced cytokines on B- and T-cell response and viral replication, (ii) immunosuppression induced by certain viruses (such as measles), and (iii) direct viral interference as a result of competition for a common niche. Mucosal vaccines may have less impact on a parenteral vaccine and vice versa. The immune

response with a mucosal vaccine may be compartmentalized to the mucosa while that to a parenteral vaccine is systemic. It is likely that there is some interaction between the systemic and mucosal compartments; however, the extent to which this interaction occurs is not known.

Given the lack of data for immune interference, based on expert opinion, NACI recommends that LAIV can be given together with or at any time before or after the administration of any other live attenuated or inactivated vaccine. NACI recognizes that some vaccine providers may choose to give LAIV and other live vaccines simultaneously or separated by at least 4 weeks to avoid any possibility of immune interference. Alternatively, an inactivated influenza vaccine (TIV or QIV) may be given.

Research on immunogenicity and efficacy following concomitant and non-concomitant administration of LAIV and parenteral live vaccines is encouraged, to determine the optimal timing for vaccine administration.

ADDITIONAL VACCINE SAFETY CONSIDERATIONS

Influenza vaccine is safe and well tolerated. Contraindications, precautions and common adverse events are described in Section II. Additional information regarding egg-allergic individuals and GBS is provided below.

Egg-Allergic Individuals

After careful review, NACI has concluded that egg-allergic individuals may be vaccinated against influenza using any appropriate product without prior influenza vaccine skin test and with the full dose, irrespective of a past severe reaction to egg and without any particular consideration, including immunization setting. NACI first made a recommendation that egg allergy was no longer a contraindication to influenza immunization in 2011 in response to studies of TIV. Based on expert opinion, informed by the understanding that QIV manufacturing processes are similar to those of TIV and by information regarding the egg albumin content of the current vaccines, similar recommendations have been made for QIV and LAIV. The waiting period post immunization is as recommended in the Canadian Immunization Guide. As with all vaccine administration, immunizers should be prepared with the necessary equipment, knowledge and skills to respond to a vaccine emergency at all times.

Supporting the recommendation for TIV is work done by DesRoches et al.[221] and Greenhawt et al.[222]. DesRoches et al. conducted two studies, a prospective cohort study (2010–2011 and 2011–2012 influenza seasons) in 5 Canadian hospitals, and a retrospective cohort study (2007–2008, 2008–2009 and 2009–2010 influenza seasons) based out of one Canadian hospital. Recruitment included patients with egg allergy, including severe allergy defined as the occurrence of anaphylaxis or cardiorespiratory symptoms upon egg ingestion. For both studies, patients were examined immediately before vaccination with Fluviral® and remained under observation for 60 minutes post-vaccination before being re-examined. Over the 5 influenza seasons, 457 doses of the seasonal TIV were administered to 367 egg-allergic patients, among whom 132 (153 doses) had a history of severe egg allergy. Four patients reported mild allergic-like symptoms after previous influenza vaccination (1 urticaria, 2 vomiting, and 1 eczema), but none experienced an adverse event when given the current vaccine. While 13 patients developed mild allergic-like symptoms in the 24 hours following vaccination, none of the 367 patients developed anaphylaxis.

DesRoches et al. also conducted a literature review on egg-allergic patients who had been vaccinated with TIV. A total of 26 studies were found, representing 4729 doses of influenza vaccine administered to 4172 patients with egg allergy, of which 513 patients had been identified as having severe egg allergy. None of the 4172 patients experienced anaphylaxis post influenza immunization. For the 597 doses administered to the 513 patients with a history of severe allergic reaction to egg, the 95% CI of the risk of anaphylaxis was 0% to 0.62%[221]. Greenhawt et al., using inclusion criteria of a history of a severe reaction, including anaphylaxis, to the ingestion of egg and a positive skin test result or evidence of serum specific IgE antibody to egg, conducted a 2-phase multicentre study. Phase I consisted of a randomized, prospective, double-blind, placebo control trial in which TIV was given to egg-allergic children, using a 2-step approach: group A received 0.1 mL of influenza vaccine, followed in 30 minutes if there was no reaction, with the remainder of an age-appropriate dose. Group B, by contrast, received an injection of normal saline followed in 30 minutes if there was no reaction with the full 100% of the age-appropriate dose. Phase II was a retrospective analysis of single dose versus divided doses administration of TIV in eligible study participants who declined participation in the RCT. All participants in both phases received TIV without developing an allergic reaction[222].

The safety of LAIV in egg-allergic individuals has now been studied in more than 1100 children and adolescents (2–18 years of age) in the UK and Canada. Two prospective cohort studies conducted by Turner et al.[223, 224] in the UK recruited individuals with egg allergy, including those with a history of anaphylaxis to egg or a history of severe but stable asthma, from multiple hospital-based allergy centres. In both studies, a previous history of requiring invasive ventilation for an anaphylactic reaction to egg was an exclusion criterion; however, no children were excluded based on this criterion. A history of severe, unstable asthma was also an exclusion criterion. One study (n=779) used quadrivalent LAIV with a detectable level of residual ovalbumin (greater than 0.3 ng/mL), and the other (n=282) used a trivalent LAIV with an undetectable level of residual ovalbumin (less than 0.3 ng/mL). In both studies, no systemic reactions were reported within one hour or within 72 hours post-immunization. Less than 10 participants in each study experienced AEFI of possible allergic cause during the one hour post-immunization observation period; the reactions were mild and self-limiting, and occurred within 30 minutes of immunization. When looking at delayed symptoms, 221 participants who received quadrivalent LAIV reported events potentially related to the vaccine. Sixty-two of these individuals reported lower respiratory tract symptoms, of which 29 reported wheeze. Of those who received trivalent LAIV, 91 children reported a delayed event; 26 experienced lower respiratory tract symptoms of which 13 reported wheeze. No serious adverse events attributable to LAIV were reported.

In the Canadian study by Des Roches et al.[225], individuals with and without egg allergy (n=68 and n=55, respectively) were recruited to receive trivalent LAIV (less than 0.24 µg of ovalbumin/dose) to evaluate the incidence of anaphylaxis at one hour and 24 hours after immunization. Of the 68 participants with egg allergy, 40 had mild asthma, and 52 had previously received TIV. No allergic reactions were reported after one hour, and seven patients reported non-specific AEFI after 24 hours, but none were suggestive of an allergic reaction.

Post-licensure safety data are available in Canada from two sources: reports by manufacturers and others to Health Canada, and spontaneous reporting through local and provincial and territorial public health authorities to PHAC[226, 227]. Reports received by PHAC are recorded in the CAEFISS. These reports describe adverse events occurring following

vaccination, and while the system is not designed to determine whether immunization caused the event, it may identify signals or trends that require further investigation.

A total of 131 reports of adverse events in influenza vaccine recipients who describe a history of allergy to eggs have been reported in CAEFISS between January 1997 and January 2016.

Analysis of the CAEFISS data shows that overall, case series of individuals with and without a medical history of confirmed or possible egg allergy demonstrated similar proportions (approximately 30%) of spontaneous reports of anaphylaxis, allergic or allergic type reactions (including ORS) after receipt of any influenza vaccine. Thus, a reported medical history of egg allergy does not appear to be associated with a greater proportion of spontaneous reports of anaphylaxis, allergic, or allergic-type adverse events following influenza vaccination. There has been no significant change in the number of these reports since the change in NACI recommendation for immunization with inactivated influenza vaccine in egg-allergic individuals in 2011.

After careful review of these recently published studies, and the fact that the formulation of LAIV licensed for use in Canada contains a low amount of residual ovalbumin (less than 0.24 µg/dose) (communication from AstraZeneca), which is comparable to the amounts in inactivated influenza vaccines available for use in Canada, NACI concludes that egg-allergic individuals may also be vaccinated against influenza using the full dose of LAIV without prior vaccine skin test and in any settings where vaccines are routinely administered. LAIV also appears to be well tolerated in individuals with a history of stable asthma or recurrent wheeze; however, it remains contraindicated for individuals with severe asthma (defined as currently on oral or high-dose inhaled glucocorticosteroids or active wheezing) or for those with medically attended wheezing in the 7 days prior to the proposed date of immunization (see Contraindications and Precautions in Section II for details).

Guillain-Barré Syndrome (GBS)

In a review of studies conducted between 1976 and 2005, the United States Institute of Medicine concluded that the 1976 swine flu vaccine was associated with an elevated risk of GBS. However, evidence was inadequate to accept or reject a causal relation between GBS in adults and seasonal influenza vaccination[228].

Recent studies suggest that the absolute risk of GBS in the period following seasonal and A(H1N1)pdm09 influenza vaccination is about one excess case per 1 million vaccinations[229, 230], which is consistent with a 2013 study by Kwong et al.[231]. This self-controlled study, which explored the risk of GBS after seasonal influenza vaccination and after influenza health-care encounters (a proxy for influenza illness), found the attributable risks were 1.03 GBS admissions per million vaccinations, compared with 17.2 GBS admissions per million influenza-coded health-care encounters. These observations demonstrate that both influenza vaccines and influenza illness are associated with small attributable risks of GBS, although the risk associated with influenza infection is larger than that associated with vaccination. Kwong found that the risk of GBS after vaccination was highest during weeks 2–4, whereas for influenza illness, the risk was greatest within the first week after a health-care encounter and decreased thereafter, but remained significantly elevated for up to four weeks. The risk of GBS associated with influenza vaccination must be balanced against the risk of GBS associated with influenza infection itself and all the other benefits of influenza vaccination[232-235].

Refer to Contraindications and Precautions in Section II for additional information.

V. CHOICE OF PRODUCT

With the recent availability of a number of new vaccines, some of which are designed to enhance immunogenicity in specific age groups, the choice of product is no longer straightforward. **Table 2** in Section II summarizes NACI's recommendations for the choice(s) of currently available influenza vaccines in specific age and risk groups. More details along with brief supporting rationale are outlined here. Further detail for the trivalent formulation of FluMist®, Fluzone® High-Dose, Fluad® and Fluad Pediatric® can be found in supplementary NACI statements for each product[150, 212, 236, 237]. Further detail regarding quadrivalent influenza vaccines can be found in the Statement on Seasonal Influenza Vaccine for 2014–2015 and in the Literature Review on Quadrivalent Influenza Vaccines.

PEDIATRIC CONSIDERATIONS

The first time that children under 9 years of age receive seasonal influenza immunization, a two-dose schedule is required to achieve protection[238-240]. Several studies have looked at whether these two initial doses need to be given in the same season[68, 69, 241]. Englund et al. reported similar immunogenicity in children 6–23 months of age whether two doses were given in the same or separate seasons when there was no change, or only minor vaccine strain change, in vaccine formulation between seasons[68, 69]. However, seroprotection rates to the B component were considerably reduced in the subsequent season when there was a major B lineage change, suggesting that the major change in B virus lineage reduced the priming benefit of previous vaccination[67, 69]. Issues related to effective prime-boost when there is a major change in influenza B lineage across sequential seasons requires further evaluation[242]. Because children 6–23 months of age are less likely to have had prior priming exposure to an influenza virus, special effort is warranted to ensure that a two-dose schedule is followed for previously unvaccinated children in this age group.

Published and unpublished evidence suggests moderate improvement in antibody response in infants, without an increase in reactogenicity, with the use of full vaccine doses (0.5 mL) for unadjuvanted inactivated influenza vaccines[6, 7]. This moderate improvement in antibody response without an increase in reactogenicity is the basis for the full dose recommendation for unadjuvanted inactivated vaccine for all ages. For more information, refer to Statement on Seasonal Influenza Vaccine for 2011–2012.

In choosing a vaccine product for the pediatric age group, it is important to consider the following:

- The burden of influenza B disease in the pediatric population being cared for;
- The potential for mismatch between the predominant circulating strain of influenza B and the vaccine strain given historical trends; and
- The efficacy, immunogenicity and safety profile of the vaccine.

With the availability of QIV, it is important to evaluate the burden of influenza B to consider the impact of protection from having both B lineage strains in the vaccine. Canadian surveillance data from 2001–2002 to 2012–2013 has shown that influenza B strains accounted for 17% of laboratory-confirmed tests for influenza. Previously, in anticipation of QIV's entrance to the Canadian market, NACI had assessed that the burden of influenza B is highest in people less than 20 years of age. Children under 24 months of age make up approximately 2% of the Canadian population[243]. Using case-based laboratory data from 2001–2012, children 0–23

months of age averaged (excluding 2009) 10.8% of reported influenza B cases (range: 8.3–13.7%). With respect to severe outcomes (e.g., hospitalization, ICU admission and death), influenza B was confirmed in 15.1% to 58.2% of pediatric influenza-associated hospitalizations (children 16 years of age and younger) reported by IMPACT between 2004–2005 and 2012–2013 (excluding the 2009–2010 pandemic season). The proportion of hospitalizations due to influenza B relative to all influenza hospitalizations has been generally similar to the proportion of influenza B detections relative to all influenza infections in the general population during the same time period. Additional information can be found in the Statement on Seasonal Influenza Vaccine for 2014–2015.

In the NACI Literature Review on Quadrivalent Influenza Vaccines, a review of B lineage antigens included in the Canadian influenza vaccines and the circulating strains each season indicates a match in 5 of the 12 seasons from 2001–2002 through to 2012–2013, a moderate match (about 50% from each lineage) in 1 season, and a mismatch in remaining 6 influenza seasons (70% or more of the characterized B strains were of the opposite lineage to the antigen in that season's vaccine). It is important to note that QIV provides protection against two, rather than only one, of the strains of influenza B that may circulate.

Children 6 to 23 Months of Age

There are three types of vaccine authorized for use in this age group: TIV, QIV and adjuvanted TIV.

Choice of Vaccine Product for Children 6 to 23 Months of Age

For children 6–23 months, NACI recommends that given the burden of influenza B disease, QIV should be used. If QIV is not available, either unadjuvanted or adjuvanted TIV should be used.

NACI has reviewed the available evidence on Fluad Pediatric® and has concluded that Fluad Pediatric® may be used in children 6–23 months of age if a QIV product is unavailable (NACI Recommendation Grade B). There is currently insufficient efficacy data on adjuvanted TIV compared to unadjuvanted TIV or QIV to determine the relative clinical benefit of adjuvanted TIV.

See Vaccine Preparations Available for Use in Canada in Section IV for more information on adjuvanted TIV.

Children 2 to 17 Years of Age

There are three types of vaccine authorized for use in this age group: TIV, QIV and LAIV.

Choice of Vaccine Product for Children 2 to 17 Years of Age

In children without contraindications to the vaccine, any of the following vaccines can be used: quadrivalent LAIV, QIV, or TIV. The current evidence does not support a recommendation for the *preferential* use of LAIV in children and adolescents 2–17 years of age.

Given the burden of influenza B disease in children and the potential for lineage mismatch between the predominant circulating strain of influenza B and the strain in a trivalent vaccine, NACI continues to recommend that a quadrivalent formulation of influenza vaccine be used in children and adolescents 2–17 years of age. If a quadrivalent vaccine is not available, TIV should be used.

Children with Immune Compromising Conditions

Given the burden of influenza B disease in children, QIV should be used. If QIV is not available, TIV should be used.

NACI recommends against LAIV for individuals with immune compromising conditions. (NACI Recommendation Grade D). Live vaccines are generally contraindicated in people with immune compromising conditions, with some exceptions. NACI concludes that there is insufficient evidence supporting the use of LAIV in those with immune compromising conditions, in terms of both safety and effectiveness. The trivalent formulation of LAIV has been administered to approximately 170 children and adults with mild to moderate immune suppression due to HIV infections and 10 children with mild to moderate immune suppression due to cancer[212]. Although these small studies demonstrated a similar safety profile to healthy individuals, based on expert opinion, NACI concludes that the use of LAIV in this population is contraindicated.

Children with Asthma

NACI recommends that LAIV, QIV or TIV can be used in children 24 months and older with stable, non-severe asthma. (NACI Recommendation Grade B).

LAIV should not be used in those with severe asthma (as defined as currently on oral or high-dose inhaled glucocorticosteroids or active wheezing) and those with medically attended wheezing in the 7 days prior to the proposed date of vaccination.

A study of trivalent LAIV found increased rates of wheezing in children 6–23 months of age when compared to TIV[244]. Children 2 years of age and older and adolescents with asthma who received LAIV in clinical trials showed that there was no significant difference between LAIV and TIV in the exacerbation of asthma post-vaccination. Several studies demonstrated that the trivalent LAIV is well tolerated in asthmatics, and it has been demonstrated to have a higher relative efficacy compared to TIV with matched and mismatched strains[179]. NACI's review of current evidence on the use of LAIV in children 2 years of age and over with asthma and wheezing supports the use of LAIV in stable, non-severe asthmatics; however, NACI recommends against LAIV in those with severe asthma or medically attended wheezing in the previous seven days or current wheezing. In such situations, given the burden of influenza B disease in children, QIV should be used. If QIV is not available, TIV should be used.

Children with Chronic Health Conditions

NACI recommends that LAIV, QIV or TIV can be used in children 24 months and older with chronic health conditions. (NACI Recommendation Grade B).

LAIV should not be used in those with immune compromising conditions or severe asthma (as defined as currently on oral or high-dose inhaled glucocorticosteroids or active wheezing) and those with medically attended wheezing in the 7 days prior to vaccination.

If inactivated vaccine is being used, given the burden of influenza B disease in children, QIV should be used. If QIV is not available, TIV should be used.

A limited number of immunogenicity and efficacy studies have been conducted in this population. Based on expert review, it is expected that LAIV should be as immunogenic,

efficacious in immune competent children with chronic health conditions as it is in healthy children.

A Canadian study conducted by Boikos et al. during the 2012–2013 season followed a cohort of 168 participants, 2–18 years of age with cystic fibrosis for 56 days following administration of trivalent LAIV to evaluate the safety of LAIV in this population [245]. Individuals were excluded if they were using systemic corticosteroids, considered immunosuppressed, or had nasal polyps or rhinorrhea considered significant enough (by vaccinator) to prevent LAIV from reaching the nasal mucosa. Overall, LAIV was found to be well-tolerated by the study participants. When comparing the at-risk period (0–28 days post receipt of LAIV) to the not-at-risk period (29–56 days post LAIV), there was no significant increase in the rate of incident respiratory deteriorations (incident rate ratio [IRR]: 0.72, 95% CI: 0.11 to 4.27) or all-cause hospitalizations was observed (IRR: 1.16, 95% CI: 0.30 to 4.81). At least one solicited adverse event was reported in the first week following vaccination by 64% of participants. The most frequent symptoms reported included fever, runny nose, nasal congestion, headaches, and tiredness. Thirteen cases of wheezing were reported (IRR: 4.33, 95% CI: 1.26 to 14.93), with the greatest incidence occurring during the day of vaccination. Of 15 participants who reported redness in both eyes, 13 were reported during the first three days post-vaccination, and all reports of facial swelling (n=10) also occurred during the same time period. Most of these symptoms occurred within 24 hours of vaccination and were compatible with ORS.

Cystic fibrosis is a considered a hyper-inflammatory disorder, and unless treated with immunosuppressive drugs, such as prolonged systemic corticosteroids, children with cystic fibrosis are not considered immunosuppressed, and may receive LAIV. The findings in the study by Boikos et al. provide reassurance that LAIV is safe for use in this population [245].

Additional detail regarding these recommendations can be found in the NACI Recommendations on the use of live, attenuated influenza vaccine (FluMist®): Supplemental Statement on Seasonal Influenza Vaccine for 2011–2012.

ADULTS

Adults 18 to 59 Years of Age

There are three types of vaccine available for use in adults 18–59 years of age: TIV, QIV and LAIV. For healthy adults in this age group, NACI considers all three types of vaccine to be acceptable choices, unless contraindicated.

For adults in this age group with chronic health conditions, TIV or QIV may be used. Additional information on LAIV in adults can be found in the NACI Recommendations on the use of live, attenuated influenza vaccine (FluMist®): Supplemental Statement on Seasonal Influenza Vaccine for 2011–2012.

Adults 60 to 64 Years of Age

The vaccines available for use in adults 60–64 years of age, with or without chronic health conditions, are TIV and QIV.

Adults 65 Years of Age and Older

Four types of vaccine are available for use in adults 65 years of age and older: standard-dose TIV, high-dose TIV, MF59-adjuvanted TIV, and QIV.

Choice of Vaccine Product for Adults 65 Years of Age and Older

In choosing a vaccine product, it is important to consider the relative burden of influenza disease caused by the various influenza subtypes (i.e., influenza A(H1N1), influenza A(H3N2) and influenza B) in this age group, as well as the efficacy, immunogenicity and safety profile of the available vaccines.

A study focusing on estimates of deaths associated with influenza in the USA has established that the average annual rate of influenza-associated deaths for adults aged 65 years of age and older was 17.0 deaths per 100,000 (range: 2.4–36.7)[246]. The study also states that deaths among persons 65 years of age and older accounted for 87.9% of the overall estimated average annual influenza-associated deaths with underlying pneumonia and influenza causes. When influenza-related deaths were estimated using underlying respiratory and circulatory causes, these estimates increased to 66.1 deaths per 100,000 (range: 8.0–121.1) and 89.4%, respectively. This study described a wide variation in the estimated number of deaths from season to season, which was closely related to the particular influenza virus types and subtypes in circulation. Estimates presented in the study of yearly influenza-associated deaths with underlying pneumonia and influenza causes (1976–2007) reveal a large difference between influenza type A and B with a calculated median of greater than 6,000 deaths associated with influenza type A and half of that number for influenza type B (approximately 3,360) for persons 65 years of age and older. During the 22 seasons in which influenza A(H3N2) was the prominent strain, the average influenza-associated mortality rates were 2.7 times higher than for the nine seasons that it was not (all age groups combined) and on average, there were about 37% more annual influenza-associated deaths, regardless of the underlying medical cause. A higher risk of hospitalization and death was also reported by Cromer et al. in their assessment of the burden of influenza in England by age and clinical risk group[247].

Canadian surveillance data show that hospitalization rates among individuals 65 years of age and older were higher during the 2014–2015 season, a season in which A(H3N2) circulation predominated and in which there was a vaccine mismatch with the circulating A(H3N2) strain, compared to the previous five influenza seasons and also compared to the 2012–2013 season when A(H3N2) also predominated. Similar to the hospitalization rates, death rates among seniors were highest in the 2014–2015 season compared to the previous five seasons and compared to the previous A(H3N2) season in 2012–2013. Death rates among other age groups were similar to or lower than the previous five influenza seasons. Laboratory detections over this same time period showed that influenza seasons in which influenza subtype A(H3N2) predominated, disproportionally affected adults 65 years of age and older while seasons with greater A(H1N1) detections resulted in a higher prevalence of positive cases in younger age groups.

VE, immunogenicity and safety are discussed in Section IV.

Available relative efficacy estimates from RCTs against laboratory-confirmed symptomatic influenza were 12.5–24% in favour of high-dose TIV compared with standard-dose TIV for adults 65 years of age and older. Although some observational studies suggest that Fluad® may be effective at reducing the risk of hospitalization for influenza and influenza complications in the elderly compared to unvaccinated individuals and those who received unadjuvanted trivalent inactivated subunit vaccine, these studies have significant methodological limitations that make their interpretation difficult[150-155]. As noted in Section IV (immunogenicity of Fluad®), adjuvanted TIV has been shown in clinical trials to induce higher

immunogenicity and broader cross-reactivity compared to unadjuvanted, standard-dose TIV. However, it is not yet known how immunogenicity and the vaccine's efficacy and effectiveness compare between adjuvanted TIV and high-dose TIV, as there have been no studies directly comparing high-dose and adjuvanted influenza vaccines in elderly populations. There are also currently no data on the comparative efficacy or effectiveness of QIV and high-dose TIV or adjuvanted TIV.

Based on updated reviews of the literature on the efficacy and effectiveness of high-dose and adjuvanted inactivated influenza vaccines in persons 65 years of age and older, NACI has concluded that there is no substantial change in the conclusions to be drawn from the scientific literature. However, NACI has updated its recommendation on the choice of vaccine product for this age group by creating programmatic-level (i.e., provinces and territories making decisions for publicly funded immunization programs) and individual-level (i.e., individuals wishing to prevent vaccine-preventable disease or a clinician wishing to advise individual patients) recommendations.

At a programmatic level, NACI recommends that any of the four influenza vaccines available for use in adults 65 years of age and older should be used: standard-dose TIV, high-dose TIV, MF59-adjuvanted TIV, and QIV. High-dose TIV is expected to provide superior protection compared to standard-dose TIV; however, with cost-effectiveness assessments having been outside the scope of the evidence review and without data on the relative efficacy and effectiveness between high-dose TIV, MF59-adjuvanted TIV, and QIV, there is insufficient evidence to make a comparative recommendation on the use of these vaccines at the programmatic level (Grade I).

At an individual level, NACI recommends that high-dose TIV should be offered over standard-dose TIV to persons 65 years of age and older. NACI concludes that, given the burden of disease associated with influenza A(H3N2) and the good evidence of better efficacy compared to standard-dose TIV in this age group, high-dose TIV should be offered over standard-dose TIV to persons 65 years of age and older (Grade A). There is insufficient evidence to make comparative recommendations on the use of MF59-adjuvanted TIV and QIV over standard-dose TIV (Grade I).

Pregnant Women

TIV and QIV are available for use in pregnant women. Due to a lack of safety data at this time, LAIV, which is a live attenuated vaccine, should not be administered to pregnant women, but it can be administered to breastfeeding women.

LIST OF ABBREVIATIONS

Abbreviation	Term
ACIP	Advisory Committee on Immunization Practices (USA)
AEFI	Adverse event following immunization
AMMI	Association of Medical Microbiology and Infectious Disease
aOR	Adjusted odds ratio
ATAGI	Australian Technical Advisory Group on Immunization
BMI	Body mass index
CAEFISS	Canadian Adverse Events Following Immunization Surveillance System
CBER	Centre for Biologics Evaluation and Research (USA)
CCDR	Canada Communicable Disease Report
CDC	Centers for Disease Control and Prevention (USA)
CHMP	Committee for Medicinal Products for Human Use
CI	Confidence interval
CIHR	Canadian Institutes of Health Research
CIRID	Centre for Immunization and Respiratory Infectious Diseases
DoD	Department of Defense (USA)
EMA	European Medicines Agency
FFU	Fluorescent focus units
GBS	Guillain-Barré syndrome
GM	Geometric mean
GMT	Geometric mean titre
GMTR	Geometric mean titre ratio
HA	Haemagglutinin
HAI	Haemagglutination inhibition assay
HCW	Health care worker
HIV	Human immunodeficiency virus
HIVE	Household Influenza Vaccine Effectiveness
ICD	International Classification of Diseases
ICICLE	Influenza Clinical Investigation for Children
ICU	Intensive care unit
ID	Intradermal
IgE	Immunoglobulin E
IgG	Immunoglobulin G
IIV	Inactivated influenza vaccine
ILI	Influenza-like illness
IM	Intramuscular
IMPACT	Immunization Monitoring Program Active
IRR	Incident rate ratio
IWG	Influenza Working Group
LAIV	Live attenuated influenza vaccine
mL	Millilitre
MMR	Measles, mumps and rubella
MMRV	Measles, mumps, rubella, varicella
MN	Microneutralization
NA	Neuraminidase
NACI	National Advisory Committee on Immunization
NML	National Microbiology Laboratory

ORS	Oculo-respiratory syndrome
PCIRN	PHAC/CIHR Influenza Research Network
PHAC	Public Health Agency of Canada
QIV	Quadrivalent inactivated influenza vaccine
SOS	Serious Outcomes Surveillance
SPSN	Sentinel Practitioner Surveillance Network
SRH	Single radial haemolysis
RCT	Randomized controlled trial
rVE	Relative vaccine effectiveness
TIV	Trivalent inactivated influenza vaccine
TIV-ID	Trivalent inactivated influenza vaccine administered intradermally
µg	Microgram
UK	United Kingdom
USA	United States of America
VAERS	Vaccine Adverse Event Reporting System (USA)
VE	Vaccine effectiveness
WHO	World Health Organization

ACKNOWLEDGMENTS

This statement was prepared by: Dr. R. Stirling (Centre for Immunization and Respiratory Infectious Diseases [CIRID], Public Health Agency of Canada [PHAC]), Dr. L. Zhao (CIRID, PHAC), Dr. W. Vaudry (NACI) and approved by NACI.

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APPENDIX A: CHARACTERISTICS OF INFLUENZA VACCINES AVAILABLE FOR USE IN CANADA, 2018–2019*

Manufacturer and Product Name	BGP Pharma ULC (Mylan) Influvac®	GlaxoSmithKline Fluviral®	Seqirus Agriflu®	Seqirus Fluad Pediatric® *and* Fluad®	Sanofi Pasteur Fluzone® High-Dose	AstraZeneca FluMist® Quadrivalent	GlaxoSmithKline Flulaval® Tetra	Sanofi Pasteur Fluzone® Quadrivalent
Vaccine Preparation	TIV	TIV	TIV	TIV	TIV	LAIV	QIV	QIV
Vaccine Type	Inactivated (Surface antigen subunit)	Inactivated (Split virus)	Inactivated (Subunit)	Inactivated (Subunit)	Inactivated (Split virus)	Live attenuated	Inactivated (Split virus)	Inactivated (Split virus)
Route of Administration	IM	IM	IM	IM	IM	Intranasal spray	IM	IM
Authorized Ages for Use	3 years and older	6 months and older	6 months and older	Pediatric: 6–23 months Adult: 65 years and older	65 years and older	2–59 years	6 months and older	6 months and older
Antigen Content (Each of Strains)	15 µg HA /0.5 mL dose	15 µg HA /0.5 mL dose	15 µg HA /0.5 mL dose	Pediatric: 7 µg HA /0.25 mL dose Adult: 15 µg HA /0.5 mL dose	60 µg HA /0.5 mL dose	$10^{6.5-7.5}$ FFU of live attenuated reassortants /0.2 mL dose (Given as 0.1 mL in each nostril)	15 µg HA /0.5 mL dose	15 µg HA /0.5 mL dose
Adjuvant	No	No	No	MF59 (Oil-in-water emulsion)	No	No	No	No
Formats Available	Single dose pre-filled syringes with luer tip	5 mL multi-dose vial	5 mL multi-dose vial, single dose pre-filled syringes without a needle	Single dose pre-filled syringes without a needle	Single dose pre-filled syringes	Prefilled single use glass sprayer	5 mL multi-dose vial	5 mL multi-dose vial, single dose vials, single-dose pre-filled syringes without attached needle

Manufacturer and Product Name	**BGP Pharma ULC (Mylan)** **Influvac®**	**GlaxoSmithKline** **Fluviral®**	**Seqirus** **Agriflu®**	**Seqirus** **Fluad Pediatric®** *and* **Fluad®**	**Sanofi Pasteur** **Fluzone® High-Dose**	**AstraZeneca** **FluMist® Quadrivalent**	**GlaxoSmithKline** **Flulaval® Tetra**	**Sanofi Pasteur** **Fluzone® Quadrivalent**
Post-Puncture Shelf Life for Multi-Dose Vials	Not applicable	28 days	28 days	Not applicable	Not applicable	Not applicable	28 days	Up to expiry date indicated on vial label
Thimerosal	No	Yes	Yes (Multi-dose vials only)	No	No	No	Yes	Yes (Multi-dose vials only)
Antibiotics (Traces)	Gentamicin	None	Kanamycin Neomycin	Kanamycin Neomycin	None	Gentamicin	None	None
Other Clinically Relevant Non-Medicinal Ingredients*	Egg protein Chicken protein Formaldehyde CTAB Polysorbate 80	Egg protein α-tocopheryl hydrogen succinate Polysorbate 80 Formaldehyde Ethanol Sodium deoxycholate Sucrose	Egg protein Formaldehyde Polysorbate 80 CTAB	Egg protein Formaldehyde Polysorbate 80 CTAB	Formaldehyde Egg protein Triton X-100	Egg protein Gelatin hydrosylate Sucrose Arginine Monosodium glutamate	Egg protein α-tocopheryl hydrogen succinate Polysorbate 80 Formaldehyde Ethanol Sodium deoxycholate Sucrose	Egg protein Formaldehyde Triton X-100 Sucrose

* Full details of the composition of each vaccine authorized for use in Canada and a brief description of its manufacturing process can be found in the product monograph.

** Refer to product monograph for alternate route(s) of administration.

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