

**SENTINEL LEVEL CLINICAL LABORATORY GUIDELINES**  
**FOR**  
**SUSPECTED AGENTS OF BIOTERRORISM**  
**AND**  
**EMERGING INFECTIOUS DISEASES**

**Novel Influenza Viruses**

American Society for Microbiology (ASM)

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## PREANALYTICAL CONSIDERATIONS

### I. PRINCIPLE

#### A. Introduction

Three viruses in the family *Orthomyxoviridae* cause influenza in humans: influenza virus types A and B, which are responsible for annual seasonal epidemics, and influenza virus C, which is rarely described. Influenza viruses are enveloped, and have a segmented, single-stranded RNA genome. Hemagglutinin (H) and neuraminidase (N) are envelope proteins responsible for the attachment of influenza virus to host cells, and the release of virus from host cells, respectively. The antigenic characteristics of these proteins are used to further characterize influenza A virus subtypes. Influenza A virus subtypes H1N1, H3N2, H2N2 and H1N2 have circulated, or are currently circulating widely, among humans. New strains of influenza A and B viruses emerge as the result of point mutations in the H gene (antigenic drift), or in the case of influenza A virus, after reassortment of H and N sequences from two different subtypes (antigenic shift). These new strains are responsible for annual outbreaks and epidemics of influenza, and the emergence of new influenza A subtypes is often responsible for global pandemics.

Because of reassortment, influenza surveillance programs must monitor for the emergence of any novel strains in humans. The U.S. Department of Health and Human Services has prepared an influenza pandemic plan that outlines testing and biosafety requirements (<http://www.Flu.gov/planning-preparedness/index.html>). Additionally, many state and local public health departments have developed pandemic influenza plans. Most states have also developed influenza surveillance plans and some public health laboratories may have ongoing surveillance programs. Confirm with your state public health laboratory for submission requirements and policies.

Influenza virus is considered a Category C biothreat agent. Agents in this category are emerging, readily available, and easily disseminated. In addition, they are capable of causing high morbidity and mortality rates (<https://emergency.cdc.gov/agent/agentlist-category.asp>)

**Note:** sentinel clinical laboratories do not require registration with the Select Agent Program to conduct diagnostic testing for Select Agents, both Tier I and non-Tier 1. Testing for Select Agents may be performed by laboratories as long as the laboratory destroys any residual specimen and destroys or transfers the confirmed select agent with 7 days of identification. Reporting of all identified Select Agents is still required; laboratories will need to complete Form 4. If the organism is transferred following identification, then the laboratory must also complete Form 2. For further guidance and access to the necessary forms, consult with your

designated LRN Reference Laboratory or refer to the CDC Division of Select Agents and Toxins website at [www.selectagents.gov](http://www.selectagents.gov).

## **B. Geographic distribution**

The classical epidemiologic cycle of influenza A virus includes wild waterfowl and shorebirds, which are naturally infected; domestic waterfowl and poultry, which acquire virus from wild birds; pigs, which serve as “mixing vessels” for both avian and mammalian adapted strains; and humans, who are susceptible to the reassorted viruses. Influenza A virus also infects maritime mammals, including seals and whales, as well as dogs, and horses. Since the beginning of the twentieth century, influenza pandemics have occurred in 1918 (H1N1), 1957 (H2N2), 1968 (H3N2) and 2009 (H1N1). The influenza A viruses causing these pandemics all had some degree of avian origins, and adapted to high transmissibility among humans.

### **Influenza A H5N1**

Influenza A H5N1, causing highly pathogenic influenza in birds, was first identified in 1996 in southern China. The virus has since spread among domestic fowl and a variety of migratory and resident wild bird species in Southeast Asia, the Middle East, Eastern and Western Europe, and Africa. Human infections caused by H5N1 were first identified in 1997 (13).

### **Influenza A 2009 H1N1**

In 2009, a novel strain of influenza A H1N1 was identified in Mexico and the U.S. (11). This subtype contained unique gene sequences from swine and avian viruses, as well as human-adapted viruses. Human-to-human transmission was efficient which, in combination with the unique antigenic characteristics, resulted in rapid global spread of the virus.

### **Novel Reassortant Influenza A H3N2v**

In 2011 a novel variant of influenza A, H3N2v, was detected in several U.S. state public health laboratories (3, 10). This strain possesses genes originating from avian, swine, and human H3N2 and 2009 H1N1 viruses. Most cases were linked to direct or indirect exposure to swine at agricultural fairs. Limited person-to-person transmission may also occur (10).

### **Additional novel influenza A subtypes**

Avian subtypes H9N2 and H7N7 were responsible for limited outbreaks among humans in 1999 (12) and 2003 (9) respectively, following close contact with poultry.

## **C. Diseases and Clinical Presentation**

Worldwide, the mortality rate due to H5N1 infection is nearly 60% (4). Morbidity and mortality are severe in previously healthy, young and middle-aged persons. Symptomatic cases are characterized by high fever, cough, and lower respiratory tract symptoms in virtually 100% of patients. Death is primarily due to respiratory

or multi-organ failure. Respiratory infections caused during the 2009 H1N1 pandemic ranged from mild self-limited to severe illness. Most cases were mild, and the overall mortality rate was similar to that observed with seasonal influenza. The majority of deaths occurred in persons under 65 years of age with underlying medical conditions. Influenza due to H3N2v ranged from mild self-limited illness to severe illness requiring hospitalization of persons with underlying illnesses (3). Two H9N2 cases in Hong Kong, China involved young children with mild upper respiratory illness. H7N7 cases in the Netherlands were characterized by conjunctivitis.

#### **D. Clinical case definition**

The CDC clinical case definition of influenza includes clinical criteria (fever  $\geq 100^{\circ}\text{F}$  with cough and/or sore throat) and epidemiologic linkage (strain specific). See the following link for H3N2v case criteria: <http://www.cdc.gov/flu/swineflu/case-definitions.htm>. A confirmed case requires strain-specific laboratory testing.

#### **E. Presumptive diagnosis**

A presumptive diagnosis of influenza caused by a novel strain can be made by the presence of clinical criteria and epidemiologic linkage, along with positive test results that lack a sufficient level of detail to confirm a specific influenza strain (<http://www.cdc.gov/flu/swineflu/case-definitions.htm>).

## **II. SAFETY CONSIDERATIONS**

Viral culture should not be performed if a novel strain of influenza is suspected, and virus pathogenesis and clinical characteristics are unknown. Do NOT perform culture on specimens if influenza A H5N1 is suspected, unless performed using enhanced Biosafety Level 3 (BSL-3) laboratory conditions. Enhancements include use of respirators, decontamination of all waste (solid and liquid), and showering of personnel before exiting. Very few virology laboratories have the capability to operate using enhanced BSL-3 conditions. Further guidance on biosafety for laboratory work involving novel influenza viruses is available at <http://www.cdc.gov/flu/h2n2bsl3.htm>. Molecular and rapid antigen testing can be performed on respiratory specimens using standard BSL-2 conditions in a Class II biological safety cabinet.

Sentinel laboratories may perform rapid antigen tests and direct fluorescent antibody staining on respiratory specimens from suspected avian influenza A H5N1 cases, but only using BSL-2 conditions in a Class II biological safety cabinet. However, influenza A H5N1-specific reverse-transcriptase (RT)-PCR, available at Laboratory Response Network (LRN) reference laboratories, is the preferred method because of its high sensitivity.

Annual influenza vaccination is strongly recommended, and is required in some states, for health care personnel because of their increased risk of contracting and transmitting influenza. Sentinel laboratory personnel are strongly advised to adhere to these

recommendations. Vaccination against seasonal strains of influenza virus may provide some protection against novel influenza strains.

### III. MATERIALS

#### A. Commercial influenza test kits

1. RT-PCR
2. Fluorescent antibody staining reagents
3. Rapid antigen

#### B. Reagents for laboratory-developed tests

#### C. Cell culture vials

A future influenza pandemic may result in a dramatic increase in testing orders, shortages of test kits and reagents, and the temporary deterioration of production and distribution systems. As such, laboratorians should plan for shortages of basic laboratory supplies.

### IV. QUALITY CONTROL

Perform quality control of media and reagents according to package inserts and CLIA standards, using positive and negative controls. For frequency of quality control, refer to manufacturer guidelines and state and federal regulations.

### V. SPECIMEN COLLECTION

A. Collection and Transport of Clinical Specimens for Laboratory Rule-Out Testing	
Posterior nasopharyngeal (NP) swab <sup>a, b, c</sup>	<ul style="list-style-type: none"><li>• Place swab in virus transport medium</li><li>• Transport specimen at refrigerated temperature (on ice) as soon as possible to obtain the diagnosis</li></ul>
NP aspirate or wash	<ul style="list-style-type: none"><li>• Collect directly into a sterile container</li><li>• Transport specimen at refrigerated temperature (on ice) as soon as possible to obtain the diagnosis</li></ul>

<sup>a</sup>Consult with your assigned LRN Reference Level laboratory to confirm appropriate specimen collection for emerging viruses.

<sup>b</sup>Detection of influenza virus is more likely from specimens collected within the first three days of illness onset.

<sup>c</sup>Dacron, rayon tipped or flocked swabs should be used for specimen collection, as other materials may inhibit RT-PCR.

**B. Rejection of specimens**

1. Use established laboratory criteria for rejection of orders for culture.
2. Use manufacturer's guidelines for rejection of orders for antigen or molecular tests.

## **ANALYTICAL CONSIDERATIONS**

### **VI. SPECIMEN PROCESSING**

- A. Specimens should be stored at refrigerated temperatures (between 2° - 8°C), unless specified otherwise by test procedures. For viral culture, specimens should be stored at refrigerated temperatures no longer than three days, or frozen at ≤-70°, and shipped on dry ice following current regulations for packaging and shipping hazardous materials. The ASM Sentinel Laboratory Guideline for Packing and Shipping Infectious Substances can be downloaded at <https://www.asm.org/ASM/media/Policy-and-Advocacy/LRN/Sentinel%20Files/PackAndShip.pdf>
- B. Sentinel laboratories should NOT inoculate specimens suspected of containing influenza A H5N1 virus into cell culture. Only laboratories capable of performing culture using BSL-3 conditions with enhancements should perform culture to evaluate a suspected influenza H5N1 case. If these criteria are met, and culture is performed, consultation with CDC and the state public health laboratory is recommended.

### **VII. IDENTIFICATION**

**A. Rapid influenza diagnostic tests (RIDTs)**

The use of rapid influenza diagnostic tests (RIDTs) for diagnosis of influenza is common in laboratories, point of care locations, and in physicians' offices, even though they are among the least reliable of methods. Because influenza RIDTs provide a result in 30 minutes or less, positive results from tests performed during the influenza "season" can significantly impact patient treatment and management. While rapid antigen capture assays may detect novel influenza subtypes, currently available tests are not capable of distinguishing specific influenza A subtypes. The sensitivity of RIDTs varies among influenza virus subtypes (2), and studies showed poor sensitivity for the 2009 H1N1 virus (1, 5, 6, 8) and H5N1 (7). Therefore, the use of RIDTs for detection of suspected novel strains of influenza virus is discouraged until the performance characteristics of such tests are well established. Because the specificity of RIDTs is less than that of viral culture, the positive predictive value is poor when the tests are performed outside of the influenza season. When influenza activity is low or sporadic, positive RIDT results should be

confirmed by additional tests. RIDTs should not be performed when local influenza activity is absent or sporadic.

RIDTs can be performed on respiratory specimens from suspected novel influenza cases using standard BSL-2 conditions in a Class II biological safety cabinet.

### **B. Fluorescent antibody staining of antigens**

The staining of influenza antigens with fluorescent antibody is an additional rapid test. When performed directly on cells from respiratory specimens, this method can provide results in less than an hour. Availability of fluorescent antibody staining is restricted to laboratories with immunofluorescent microscopes and trained technologists able to accurately interpret fluorescent staining patterns. Fluorescently-labeled antibodies specific for influenza A and B viruses are available. Some commercially available influenza antibodies are provided in pools with antibodies to other common respiratory viruses. Fluorescent antibody staining is generally considered to be slightly more sensitive than rapid antigen tests. Specificity is high, but depends on well trained, experienced technologists.

Fluorescent antibody staining reagents specific for influenza A virus will detect novel subtypes such as H5N1 and 2009 H1N1 (7). When this guideline was written there were no subtype-specific reagents commercially available. Fluorescent antibody staining can be performed on respiratory specimens from suspected avian influenza cases using BSL-2 conditions in a Class II biological safety cabinet.

### **C. Nucleic acid amplification**

Nucleic acid amplification methods such as RT-PCR and nucleic acid sequence-based amplification (NASBA) are becoming more commonly used for detection of influenza virus and other respiratory viruses. Using advances such as real-time, fluorescent detection of amplified product, or fully automated and integrated PCR systems, laboratories are able to complete molecular tests within one hour. These are consistently the most sensitive methods for detection of influenza virus, including novel strains (1, 4, 8). High specificity requires judicious selection of primers and probes, optimization of amplification conditions, and interpretation of results. Continuous adherence to laboratory protocol is essential to avoid false positives due to carry-over contamination. Current commercially available FDA cleared tests are able to identify seasonal influenza A subtypes and 2009 H1N1, but commercial kits marketed in the U.S. do not identify H5N1. A test manufactured by the CDC and cleared by the FDA will detect and identify several subtypes, including H5N1. This test is distributed only to LRN Reference laboratories. In addition to LRN Reference laboratories, some commercial and hospital laboratories may offer “home-brewed” nucleic acid amplification testing for influenza A H5N1. Unlike the FDA cleared tests, these assays are developed and validated in-house by each laboratory. As such, the performance characteristics of the tests may vary between laboratories.

Initial specimen processing, including addition of lysis buffer can be performed in a Class II biological safety cabinet using BSL-2 conditions. Some specimen lysis buffers do not inactivate viruses. If a lysis buffer that is known to inactivate the virus is used, further processing can be performed outside of the biological safety cabinet.

#### **D. Culture**

Culture provides highly specific laboratory diagnosis of influenza, but requires fresh, refrigerated specimens for optimal sensitivity. With proper specimen handling, culture is more sensitive than antigen detection methods. Historically, culture methods have been considered too slow to impact patient management. Incubation for several days is generally required to detect influenza virus in tube cultures. Tubes are generally held for 14 days prior to reporting a negative result. Influenza virus is detected in tube cultures by the presence of cytopathic effect (CPE), adsorption or agglutination of red blood cells, and fluorescently-labeled antibodies specific for influenza A and B viruses. Spin-amplified shell vial cultures have reduced the time to detection to 1 to 3 days. Culture is important for detecting influenza infection missed by rapid testing, confirmation of non-culture results when disease prevalence is low, and to obtain isolates for characterization and surveillance.

Novel influenza A subtypes will grow in cell lines commonly used for isolation of human-adapted influenza virus, including primary monkey kidney, Madin Darby canine kidney, A549, and others. Sentinel laboratories must be cognizant that highly pathogenic novel subtypes may be cultivated unknowingly from unrecognized human cases of avian influenza. **Do NOT perform culture on specimens if avian influenza A H5N1 is suspected, unless performed using enhanced BSL-3 laboratory conditions. Contact the LRN Reference laboratory for instructions on handling and shipping of specimens from suspected avian influenza cases.**

Instructions for sentinel laboratories that set up viral cultures using BSL-2 conditions on a specimen or patient later determined to be positive for a highly pathogenic strain of influenza A:

- Consult with the local or state public health laboratory or CDC. These laboratories may request specimens or cultures.
- Isolate cell culture vessels and supplies potentially contaminated with the novel influenza virus. Sterilize by autoclaving, and discard.
- Disinfect work area.
- Report all potential exposures immediately to both the facility management, following in house policies, and to the local public health agency.
- As guided by public health or medical consultation, monitor potentially exposed staff for symptoms. Public health or medical experts may recommend quarantine and prophylactic antiviral treatment.
- Highly pathogenic avian influenza viruses, including H5N1 are select agents regulated by the Animal and Plant Health Inspection Service (APHIS) of the

U.S. Department of Agriculture (USDA). If live H5N1 virus is isolated from a clinical specimen, CDC or APHIS must be notified, and the agent must be transferred or destroyed (<http://www.selectagents.gov/Forms.html>). Documentation of transfer or destruction must be maintained for three years.

## **POSTANALYTICAL CONSIDERATIONS**

### **VIII. REPORTING, NOTIFICATION, AND TRANSFER**

- A. Report suspected novel strains of influenza to your designated LRN Reference Laboratory in accordance with local and state reporting requirements.
- B. Specimens from suspected novel influenza cases should be referred to your designated LRN Reference Laboratory, or to the local or state public health laboratory. Contact the LRN Reference laboratory for instructions on handling and shipping of specimens from suspected novel influenza cases.
- C. Positive test results for novel influenza strains should be confirmed at the CDC. Follow current regulations for packaging and shipping hazardous materials. (<https://www.asm.org/ASM/media/Policy-and-Advocacy/LRN/Sentinel%20Files/PackAndShip.pdf>).
- D. Thoroughly document the referral of specimens to your designated LRN Reference Laboratory, as well the results reported by the laboratory. Follow institutional protocols for reporting positive test results obtained by an outside referral laboratory.

### **IX. SUMMARY/SPECIAL CONSIDERATIONS**

#### **A. Select agent reporting and compliance**

1. Reporting of all identified Select Agents is still required, even if a laboratory has not been previously registered.
2. If the organism is transferred following presumptive identification, the laboratory must complete Form 2. For further guidance and access to the necessary forms, consult with your designated LRN Reference Laboratory or refer to the CDC Division of Select Agents and Toxins website at <http://www.selectagents.gov>
3. Reporting all identified Select Agents is required by completing Form 4 A within 7 days of identification. If the isolate is from a Proficiency test sample, Form 4 B is to be completed within 90 days of receipt of the sample.
4. Your designated LRN Reference Laboratory will advise you with completion of required forms (e.g., Forms 2, 3, and 4). Always refer to [www.selectagents.gov](http://www.selectagents.gov) for the latest guidance and versions of these forms

#### **B. Destruction**

1. Once the identification of the isolate is confirmed, the Sentinel Laboratory Select Agent regulations require that the residual specimen and cultures of the isolate be destroyed or transferred to an approved Select Agent entity within 7 days of confirmed identification. Your designated LRN Reference Laboratory

- must advise you on destruction or transfer of isolates.
2. Generally, all clinical material that contain the organism should be autoclaved, incinerated on-site or submitted to the designated LRN Reference Laboratory for disposal.
  3. Alternatively, contaminated items should be soaked in 10% bleach or 10% formalin for 24 h.

### **C. Packing and shipping**

1. Refer to the ASM Packing and Shipping Sentinel Guidelines.
2. All materials sent to your designated LRN Reference Laboratory must be shipped in compliance with IATA and DOT regulations

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