The Foreign Animal Disease Preparedness and Response Plan (FAD PReP) Standard Operating Procedures (SOPs) provide operational guidance for responding to an animal health emergency in the United States.

These draft SOPs are under ongoing review. This document was last updated in December 2013. Please send questions or comments to:

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# Newcastle Disease (ND)

## Etiology & Ecology Quick Summary

### Disease
Virulent Newcastle disease virus, in domestic poultry, is referred to in the United States as Newcastle Disease (ND).

### Mortality and Morbidity
In domestic poultry, ND consistently causes high mortality and morbidity rates approaching 100% in unvaccinated flocks. Surviving birds may suffer permanent neurological damage such as twisted necks or head tremors.

### Susceptible Species
All avian species have demonstrated some level of susceptibility. Humans are also susceptible to ND.

### Zoonotic Potential?
Yes, but not a significant threat to public health. In humans, conjunctivitis is the most often clinical sign of disease observed.

### Reservoir
Chickens, cormorants, pigeon and other migratory waterfowl are considered natural reservoirs of all pathogenicity levels of ND (domestic poultry populations within the U.S. are considered free of virulent isolates).

### Transmission
Direct exposure to infected birds, excrement, respiratory or other secretions.

### Persistence in the Environment
Viable in ambient environments for longer periods; may survive indefinitely in a frozen environment.

### Animal Products and By-Products
Virus can persist in eggs and poultry meat products.
1.1 Introduction

Newcastle disease (ND) is an infectious viral disease that affects at least 250 species of birds in 27 orders.¹ There are many different clinical signs of ND; signs expressed depend on the virulence of the virus strain, in addition to the susceptibility of the bird species and the immunity of the bird infected. Newcastle disease virus (NDV) is commonly classified according to disease severity with strains being defined as virulent (vNDV) or of low virulence (loNDV). Only infections of NDV (see Section 1.3.5.1) meeting the World Organization for Animal Health (OIE) definitions are reportable to the OIE.

Prior to the ability to easily sequence NDV strains, it was common to define strains by the clinical signs observed in chickens upon infection. The three pathotypes are: lentogenic (low virulence), mesogenic, and velogenic (both virulent). Virulent NDV is further classified as neurotropic and viscerotropic. The neurotropic subtype is commonly associated with neurologic and respiratory symptoms; and the viscerotropic subtype is commonly associated with hemorrhagic lesions in the intestinal tract, but may also cause neurological signs.

Newcastle Disease (ND), as examined here, refers to infections in poultry species with virulent NDV (vNDV). There is currently no evidence of ND circulation in domestic poultry flocks in the United States.

Morbidity and mortality rates vary according to order and species, affecting domestic poultry most acutely. While ND is zoonotic, the transference to humans typically manifests as conjunctivitis, rarely progressing to mild, influenza-like symptoms.

1.1.1 Further Information

This document is intended to be an overview, focusing on vNDV in domestic poultry, which in the United States is referred to as ND. Additional resources on ND are listed in Attachment 1.A. In addition to this document, information can also be found in the ND Response Plan: The Red Book and the NDV Case Definition. These documents are available on the APHIS public website (http://www.aphis.usda.gov/animal_health/emergency_management) or on the Animal and Plant Health Inspection Service (APHIS) Intranet (http://inside.aphis.usda.gov/vs/em/fadprep.shtml), for APHIS employees.

1.1.2 Goals

As a preparedness goal, APHIS will provide etiology and ecology summaries for ND, and update these summaries at regular intervals.

As a response goal, the Unified Command and stakeholders will have a common set of etiology and ecology definitions and descriptions, to ensure proper understanding of ND when establishing or revising goals, objectives, strategies, and procedures.

1.2 Purpose
The purpose of this document is to provide responders and stakeholders with a common understanding of the disease agent.

1.3 Etiology
1.3.1 Name
The virus responsible for causing ND is “a member of the family Paramyxoviridae in the genus Avulavirus.”\(^2\) NDV is also known as avian paramyxovirus, of serotype 1 (APMV-1). Only infections with the virulent APMV-1 (or vNDV) are responsible for ND. Strains of NDV that are of low virulence (loNDV) are often used as vaccines to prevent disease and death from ND.

1.3.2 Virus Characteristics
According to the International Committee on Taxonomy of Viruses (ICTV), this disease has the following characteristics:

- Family: Paramyxoviridae
- Genus: Avulavirus
- Serotypes: One
- Classes: Two
- Genotypes: At least nine identified; classification list is growing
- Isolates/Strains: Hundreds positively identified; classification list is growing
  - Throughout the world, novel strains of the virus are identified as affecting species previously thought to be resistant.\(^3\)

1.3.3 Morphology
According to ICTV, ND virions measure approximately 150–200 nanometers (nm) in diameter, and 1,000–10,000 nm in length. Surface projections on the envelope are spaced widely apart, and haemagglutinin-neuraminidase (HN) and fusion (F) glycoproteins are equally distributed on the surface, embedded in a lipid bilayer. This lipid bilayer is comprised of the HN and the F glycoproteins. The capsid/nucleocapsid is elongated with a helical symmetry; the nucleocapsid is not segmented.\(^4\)

1.3.4 Genus Characteristics
This genus has the following characteristics:

---
Two surface proteins are important to the identification and behavior of the virus: HN and the F protein.

HN is “important in the attachment and release of the virus from the host cells in addition to its serologic identification.”

The F protein is vital to the virulence and pathogenesis of the disease.

1.3.5 ND Virus Types

There are three major pathotypes based on virulence: lentogenic (categorized as low virulence viruses), mesogenic and velogenic (virulent viruses). The virulent viruses are further classified as either neurotropic or viscerotropic. Even under controlled laboratory conditions, these pathotype groupings may not be obvious; low virulence and virulent, based on diagnostics, is a more appropriate way to classify NDV. Only NDV with virulent fusion cleavage sites fit the U.S. definition of ND.

Subtypes are classified into strains, which are described by a number of characteristics, including type, host, place of first isolation, strain number, year of isolation, and antigenic subtype.

1.3.5.1 NDV: OIE Identification

The OIE defines vNDV as the following:

For the purposes of the Terrestrial Code, Newcastle disease (ND) is defined as an infection of poultry caused by a virus (NDV) of avian paramyxovirus serotype 1 (APMV-1) that meets one of the following criteria for virulence:

a. The virus has an intracerebral pathogenicity index (ICPI) in day-old chicks (gallus gallus) of 0.7 or greater; or

b. Multiple basic amino acids have been demonstrated in the virus (either directly or by deduction) at the C-terminus of the F2 protein and phenylalanine at residue 117, which is the N-terminus of the F1 protein. The term ‘multiple basic amino acids’ refers to at least three arginine or lysine residues between residues 113 and 116. Failure to demonstrate the characteristic pattern of amino acid residues as described above would require characterization of the isolated virus by an ICPI test.

In this definition, amino acid residues are numbered from the N-terminus of the amino acid sequence deduced from the nucleotide sequence of the F0 gene, 113–116 corresponds to residues -4 to -1 from the cleavage site.

1.3.5.2 NDV: U.S. Identification

The United States defines ND as the following:

Newcastle disease is an acute, rapidly spreading, and usually fatal viral infection of poultry.

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caused by an avian paramyxovirus serotype 1 that meets one of the following criteria for
virulence: The virus has an intracerebral pathogenicity index (ICPI) in day-old chicks (*Gallus
gallus*) of 0.7 or greater; or multiple basic amino acids have been demonstrated in the virus
(either directly or by deduction) at the C-terminus of the F2 protein and phenylalanine at residue
117, which is the N-terminus of the F1 protein. The term “multiple basic amino acids” refers to at
least three arginine or lysine residues between residues 113 and 116. In this definition, amino acid
residues are numbered from the N-terminus of the amino acid sequence deduced from the
nucleotide sequence of the F0 gene; 113-116 corresponds to residues -4 to -1 from the cleavage
site. Failure to demonstrate the characteristic pattern of amino acid residues as described above
may require characterization of the isolated virus by an ICPI test. A failure to detect a cleavage
site that is consistent with virulent strains does not confirm the absence of a virulent virus.\(^7\)

### 1.4 Ecology

#### 1.4.1 Susceptible Species

Evidence suggests all avian species are susceptible to infection with ND viruses, including:

- Chickens
- Turkeys
- Cormorants
- Migratory waterfowl
- Parrots
- Pigeons
- A wide variety of other birds, including shorebirds and penguins.

ND is particularly threatening to domestic poultry. Under non-experimental conditions, there is
no evidence to suggest ND affects mammalian hosts, with humans being the sole exception.

#### 1.4.2 Reservoirs

NDV, particularly the loNDV, is frequently isolated from free-living wild birds. Migratory
waterfowl and Charadriiformes (shorebirds) can be infected with loNDV and vNDV. It is
possible for them to be infected with and shed NDV in saliva and feces without showing any
signs of illness. NDV strains are found worldwide and have been isolated from over 250
species.\(^8\) The relative significance of different wild bird reservoirs is unknown, however, some
evidence suggest that some bird species such as cormorants and pigeons may represent a major
potential source of infection for domestic birds, particularly poultry. There is no evidence of ND
generation in a reservoir.

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\(^7\) From 9 CFR 82.1.

\(^8\) Center for Food Security and Public Health (CFSPH), Iowa State University & Institute for International Cooperation in Animal
1.4.3 Distribution

Endemic vNDV is present in much of the world, including Asia, Africa, Central and South America, and regions of Mexico. An outbreak of vNDV in the United States has not occurred since 2003.9, 10

1.4.4 Introduction and Transmission of ND Virus

Contact with infected domestic birds, and occasionally wild birds or wild waterfowl, is the most likely mode of introduction of ND into a poultry population. Many species of migratory waterfowl carry the loNDV sub-clinically, which makes it difficult to track. As many wild birds are migratory, they are able to spread the disease and make containment difficult. In addition, upon transmission to domestic poultry, a loNDV may mutate into a vNDV. However, only two documented outbreaks worldwide have been caused by loNDV that originated from wild birds and mutated into vNDV as the virus circulated in poultry.11,12

Because of the ND reservoir in wild birds and the ability of this virus to mutate, minimizing contact between domestic and wild birds is fundamental to preventing ND infection in the U.S. domestic poultry population. Live-bird markets are considered another method by which sub-clinically infected birds may transmit the virus to susceptible birds, who then act as carriers of NDV; these carriers may then, in turn, return to their originating farms and transmit the virus.

A vNDV is usually transmitted to domestic birds through direct contact with feces, feathers, eggshells, or respiratory secretions from infected domestic birds. Transmission of the virus can also result from contact with birds smuggled from areas that have vNDV endemic in the environment, as is seen in Mexico.13 Also, the movement of contaminated fomites, people, clothing, boxes, equipment, egg trays, and vehicles increases the potential for susceptible birds to be exposed to vNDV.

Vaccination against ND has been used within the U.S. for a number of years.14 There is evidence that immunization may help mitigate infection within contained bird populations; however, this offers no guarantee against infection, morbidity, and mortality within the domestic poultry population at large. Study of the actual benefits and results of herd immunity remains active research.15

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10 USDA-APHIS-VS-CEAH National Surveillance Unit; Draft Case Definition for Virulent Newcastle Disease Virus, 2011.


1.4.5 Incubation and Infectious Periods
Incubation periods for ND are variable depending on the host species. The OIE Terrestrial Animal Health Code (2013) gives the incubation period for ND as 21 days.\textsuperscript{16} ND incubation periods vary depending on the strain of the virus; age, health, and species of infected birds; and other environmental factors. Most commonly, after natural exposure the period can be from two to five days with the average being five to six days.\textsuperscript{17}

It is possible for a bird to shed the virus before and after the appearance of clinical signs. Depending on the species of bird, virus shedding can last anywhere from one week to a year.

1.4.6 Morbidity and Mortality in Birds
ND affects many species of birds, though the rates of morbidity and mortality and the variety and appearance of clinical symptoms vary from species to species. In domestic poultry, ND causes high morbidity and mortality rates, approaching 100 percent in unvaccinated flocks. Raptors are usually somewhat resistant, while ducks, waterfowl, parrots, and geese infected with ND may not show clinical signs. In many cases, the first sign of ND in a flock is abnormal and sudden mortality. In vaccinated populations, such as layers with high antibody titers, a decrease in egg production may be seen three to four weeks after infection, and misshapen and lighter in color than normal eggs may be produced (Figure 1-1).\textsuperscript{18} Lower morbidity and mortality can be seen in vaccinated flocks. Well-vaccinated birds still can be infected with a vNDV, but may not show clinical signs of the disease while shedding the virulent virus in saliva and feces. The rate of death will depend on the immunity of the birds and the virulence of the NDV isolate. Surviving birds often suffer permanent neurological damage, such as twisted necks or head tremors.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{misshapen_eggs.png}
\caption{Misshapen Eggs}
\end{figure}

\textit{Source: Dr. P. Miller}

1.4.6.1 Clinical Signs

Infection in birds can give rise to a wide variety of clinical signs that may vary according to the host, strain of virus, host immune status, presence of any secondary exacerbating organisms, and environmental conditions.

Table 1-1 gives a description of some of the most basic clinical symptoms; visuals are supplied where applicable.

**Table 1-1. Physical Symptoms of Poultry with ND**

<table>
<thead>
<tr>
<th>Subtype</th>
<th>Symptom description</th>
<th>Visual</th>
</tr>
</thead>
<tbody>
<tr>
<td>General, regardless of diagnosed subtype</td>
<td>- apathy, depression (at right)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- lack of movement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- lack of appetite</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- reduced egg production</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- green or watery stool</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- respiratory difficulty (i.e. coughing and gasping)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- conjunctivitis (at right)</td>
<td></td>
</tr>
<tr>
<td>Viscerotropic</td>
<td>- internal and external hemorrhages (seen on comb at right)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- swelling of the head and neck</td>
<td></td>
</tr>
<tr>
<td>Neurotropic</td>
<td>- partial wing paralysis (may also see with mesogenic strains)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- involuntary muscle tremors (at right)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- stiff or twisted head or neck</td>
<td></td>
</tr>
</tbody>
</table>

1.4.7 ND in Humans

ND is a zoonotic disease, though not one that poses a significant threat to public health. Human infection via exposure to infected birds can cause mild conjunctivitis and influenza-like

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symptoms, and in severe cases, can lead to some lasting impairment of vision. Individuals most likely to become infected are those working in the poultry industry or in laboratories; evidence has linked past human ND infection with lack of correct eyewear while working with commercial poultry. Although there is no evidence to indicate that the virus is contagious from one human to another, responder groups and vaccination crews should comply with the appropriate biosecurity and safety measures, including the use of personal protective equipment (PPE). Transmission of ND through the consumption of properly cooked poultry products has not been reported. Immuno-suppressed individuals are urged to take extra care to avoid exposure.

1.5 Environmental Persistence of ND Viruses

While the “epidemiology of APMV-1 is incompletely understood,” substantive information exists regarding its environmental persistence. ND can survive “for several weeks in a warm and humid environment... [and] indefinitely in frozen material.” When using agents to inactivate virus, it is critical that the manufacturer’s directions for the correct concentration of the solution, and the time needed for complete inactivation to occur, be followed. In addition, appropriate PPE (goggles, glove, and respirator) should be used.

- **Temperature**: ND is “inactivated by being heated at 56°C (132.8°F) for 3 hours, or 60°C (140°F) for 30 minutes.”
- **pH**: Inactivated by acidic pH of ≤ 2.
- **Chemicals**: “Ether sensitive; inactivated by formalin, phenolics and oxidising agents (e.g. Virkon®); chlorhexidine, sodium hypochlorite (6%).”
- **Disinfectants**: Multi-purpose disinfectants, such as Virkon®, ether, or formalin will inactivate ND virus particulate.
- **Survival**: Survival of the aerosolized virus and long distance transmission are still subject to further study; aerosolized survival is likely dependent on humidity and a number of other environmental factors. Other reports indicate that the virus is destroyed by dehydration and exposure to ultraviolet rays.

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26 USDA-APHIS-VS-CEAH National Surveillance Unit; Draft Case Definition for Virulent Newcastle Disease Virus, 2011.
28 USDA-APHIS-VS-CEAH National Surveillance Unit; Draft Case Definition for Virulent Newcastle Disease Virus, 2011.
29 USDA-APHIS-VS-CEAH National Surveillance Unit; Draft Case Definition for Virulent Newcastle Disease Virus, 2011.
31 USDA-APHIS-VS-CEAH National Surveillance Unit; Draft Case Definition for Virulent Newcastle Disease Virus, 2011.
1.5.1 In Eggs and Egg Products

The OIE recommends the following times and temperatures for the inactivation of ND virus in eggs and egg products (Table 1-2).32

Table 1-2. Inactivation of ND in Eggs and Egg Products

<table>
<thead>
<tr>
<th>Type of product</th>
<th>Core temperature (°C)</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whole egg</td>
<td>55.0</td>
<td>2,521 seconds</td>
</tr>
<tr>
<td>Whole egg</td>
<td>57.0</td>
<td>1,596 seconds</td>
</tr>
<tr>
<td>Whole egg</td>
<td>59.0</td>
<td>674 seconds</td>
</tr>
<tr>
<td>Liquid egg white</td>
<td>55.0</td>
<td>2,278 seconds</td>
</tr>
<tr>
<td>Liquid egg white</td>
<td>57.0</td>
<td>986 seconds</td>
</tr>
<tr>
<td>Liquid egg white</td>
<td>59.0</td>
<td>301 seconds</td>
</tr>
<tr>
<td>10% salted yolk</td>
<td>55.0</td>
<td>176 seconds</td>
</tr>
<tr>
<td>Dried egg white</td>
<td>57.0</td>
<td>50.4 hours</td>
</tr>
</tbody>
</table>


The OIE Terrestrial Animal Health Code (2013) states that the listed temperature achieves a 7-log kill. Where scientifically documented, variances from these times and temperatures may also be suitable when they achieve the inactivation of the virus.

1.5.2 In Meat

The OIE recommends the following times and temperatures for inactivation of ND virus in meat (Table 1-3). Where scientifically documented, variances from these times and temperatures may also be suitable when they achieve the inactivation of the virus.33

Table 1-3. Inactivation of ND in Meat

<table>
<thead>
<tr>
<th>Product</th>
<th>Core temperature (°C)</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poultry meat</td>
<td>65.0</td>
<td>39.8 seconds</td>
</tr>
<tr>
<td></td>
<td>70.0</td>
<td>3.6 seconds</td>
</tr>
<tr>
<td></td>
<td>74.0</td>
<td>0.5 seconds</td>
</tr>
<tr>
<td></td>
<td>80.0</td>
<td>0.03 seconds</td>
</tr>
</tbody>
</table>


1.5.3 In Carcasses

ND viruses can survive in bird carcasses for several days at ambient temperatures and a few weeks at refrigeration temperatures. Titers in carcasses will vary depending on the strain of the virus, species of bird, and time of death in relation to clinical stage of infection. Burying, incineration, and composting are alternatives for disposal.\(^{34}\)

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Attachment 1.A References and Resources


## Attachment 1.B Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMPV-1</td>
<td>avian paramyxovirus, type 1</td>
</tr>
<tr>
<td>APHIS</td>
<td>Animal and Plant Health Inspection Service</td>
</tr>
<tr>
<td>CFSPH</td>
<td>Center for Food Security and Public Health</td>
</tr>
<tr>
<td>F</td>
<td>fusion</td>
</tr>
<tr>
<td>FAD PReP</td>
<td>Foreign Animal Disease Preparedness and Response Plan</td>
</tr>
<tr>
<td>HN</td>
<td>Hemagglutinin-neuraminidase</td>
</tr>
<tr>
<td>ICPI</td>
<td>intracerebral pathogenicity index</td>
</tr>
<tr>
<td>ICTV</td>
<td>International Committee on Taxonomy of Viruses</td>
</tr>
<tr>
<td>loNDV</td>
<td>NDV of low virulence</td>
</tr>
<tr>
<td>ND</td>
<td>Newcastle Disease</td>
</tr>
<tr>
<td>NDV</td>
<td>Newcastle Disease virus</td>
</tr>
<tr>
<td>nm</td>
<td>nanometers</td>
</tr>
<tr>
<td>OIE</td>
<td>World Organization for Animal Health</td>
</tr>
<tr>
<td>PPE</td>
<td>personal protective equipment</td>
</tr>
<tr>
<td>rRT-PCR</td>
<td>real-time reverse transcriptase polymerase chain reaction</td>
</tr>
<tr>
<td>USDA</td>
<td>United States Department of Agriculture</td>
</tr>
<tr>
<td>vNDV</td>
<td>virulent Newcastle disease virus</td>
</tr>
</tbody>
</table>