The Global Network for Avian Influenza Surveillance Act (GNAIS): Environmental Context, Legislative Solution, and Policy Analysis

Nina Kishore (Manager)**, Jeff Smith** (Deputy Manager)**,**
Brook Jackson, Katie King, Matthew Klasen, Rebecca Pass, Vanessa Peña,
Jonathan Philipsborn, Leyla Pourarkin, Meghan Schloat, Melissa Wright

Columbia University
School of International and Public Affairs and The Earth Institute
Master of Public Administration in Environmental Science and Policy

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Contents

Executive Summary

Avian influenza has recently emerged as a global disease of concern with the outbreak of the H5N1 viral strain. Wild birds act as a potential reservoir and carrier for this disease. Though currently confined to wild birds and domestic poultry, the H5N1 strain has the potential to become a human influenza pandemic and kill millions of people like a similar strain did in 1918. Scientists agree that avian influenzas may be spread through wild bird migrations or through the trade of wild and domestic birds, but they disagree about which is the primary mechanism.

To supplement extensive domestic-preparedness efforts already undertaken by the U.S. government, legislators have proposed the Global Network for Avian Influenza Surveillance (GNAIS) Act. The GNAIS network, if enacted, would empower a domestic conservation non-governmental organization (NGO) to partner with other domestic and international organizations to monitor wild birds and the spread of avian diseases internationally. The Network would study wild bird migration, collect and analyze biological avian samples, and train and certify ongoing surveillance efforts. Results will be compiled into a universally accessible online database. Researchers will use these data to create predictive models in order to better understand viral change and to anticipate avian influenza outbreaks.

The GNAIS database presents a flexible framework for coordinating and standardizing international disease surveillance. The Act will encourage data-sharing and promote proactive and predictive policymaking responses to minimize future disease threats. GNAIS must overcome concerns about national sovereignty, protection of economic livelihoods, and preservation of engrained but risky cultural norms. To assess the effectiveness of GNAIS in fulfilling its purpose, evaluators should focus on the extent of international participation in the GNAIS surveillance effort; the number and quality of GNAIS researchers and analytical protocols; and the ability of the database to generate models that predict the spread of avian disease. GNAIS has the potential to improve our understanding of the ecology of migratory birds and help prevent future public health crises caused by avian disease outbreaks.

1. Introduction

Highly pathogenic avian influenza (HPAI) virus in wild birds has become a concern throughout the international community. Most recently, an HPAI strain, H5N1, has been associated with the deaths of chickens, wild birds, and some mammals - including humans – in Asia, Africa, and Europe.[i] Avian influenza viruses primarily affect birds, but certain strains of these bird viruses can be infectious to other species including pigs and humans.[ii] Already, the World Health Organization (WHO) has confirmed that there have been more than 200 cases of human infection and more than 100 deaths due to direct contact with domestic poultry carrying the H5N1 strain.[iii] Given the proper series of viral changes, avian influenza could adapt into a virus that is capable of spreading from human to human. If this change occurs, the result could be a large-scale human pandemic.

A pandemic of this magnitude occurred in the 1918 Spanish Influenza in which an estimated 40-50 million people died worldwide. Other pandemics derived from avian influenza occurred in 1957 and 1968.[iv] In these 20th century pandemics, it took 6-9 months for the human influenza virus to spread around the globe. WHO studies indicate that in the connected world in which we live, the virus could spread within less than 3 months.[v]

Health experts have been monitoring the spread of the H5N1 strain since it was identified in the Guangdong Province of China in 1996. The first human infections were identified in 1997 when 18 people in Hong Kong became sick and 6 died.[vi,vii] Cases of H5N1 outbreaks appeared again over a larger geographic area in mid-2003. From late 2003 to 2004, over 100 million birds in Southeast Asia are known to have died from disease, or were killed in order to control the outbreaks.[viii] By June 2004, new outbreaks in Asia demonstrated that the virus had continued to spread geographically.[ix] In 2005, there were reports of H5N1 infection in wild birds in Europe. Since early 2006, there have been cases of H5N1 in domestic poultry and wild birds in Africa and the Near East (Figure 1).[x] According to the WHO, the H5N1 virus has caused the largest outbreaks in domestic poultry on record since avian influenza viruses were first identified.[xi] Despite the severity of the threat, researchers are still uncertain as to how this avian influenza is spreading.

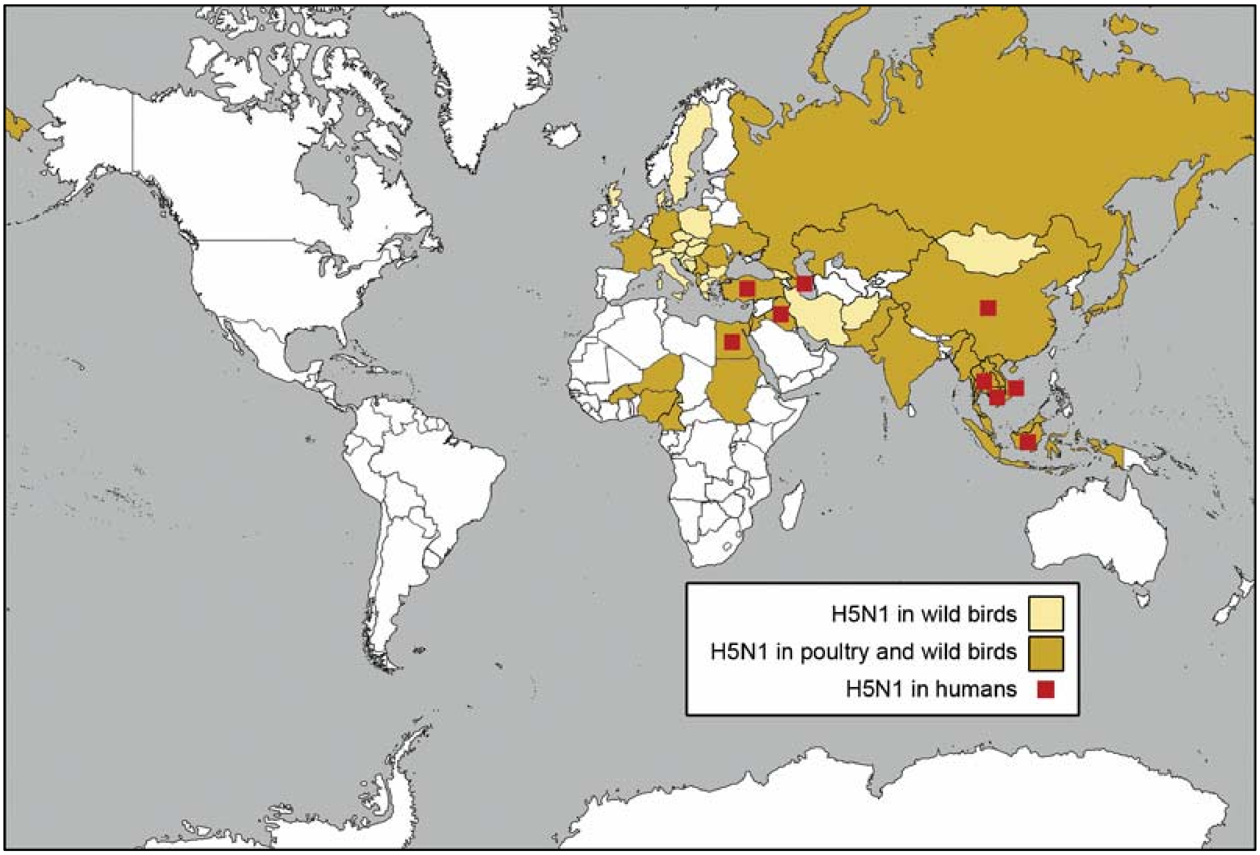

Figure 1. Nations with confirmed cases of H5N1 avian influenza, as of July 7, 2006.
Figure from HHS 2006 (www.pandemicflu.gov)

More research is needed to determine and understand avian influenza, its mechanisms of transmission and geographic dispersal, as well as its potential impacts. The international community lacks a sufficient system to gather data and monitor the spread and evolution of avian influenzas. The Global Network for Avian Influenza Surveillance (GNAIS) proposed by S. 1912/ H.R. 4476 is an international effort to monitor the movement of wild birds and its relation to the change and spread of avian pathogens. Data compiled through GNAIS will be used to create predictive models to anticipate the spread of the virus into new geographic locations. GNAIS will also enhance scientific understanding of wild bird migrations and the potential threat of avian influenzas to wild birds and natural ecosystems.

2. Scientific and Environmental Background of Avian Influenza

In order to better identify the transmission and spread of avian influenza, it is necessary to understand the basic characteristics of the virus itself.

2.1 Virology of Avian Influenza

Influenzas are viruses, or pieces of genetic material surrounded by a protective protein coat. A virus can only replicate after infecting a host cell, which avian influenza viruses accomplish by using the protein marker hemagglutinin (H) to adhere to and inject within a host.[xii] The protein marker neuraminidase (N) is responsible for the virus's capacity to reproduce its progeny once it has infiltrated its host cell's DNA. The H and N proteins are used to classify different avian influenza viruses, and scientists have found that the H5 and H7 sub-types are the most likely to mutate and become deadly human pandemics.[xiii]. The high potential mutability of H5N1, for example, is a primary reason for its growing salience among policymakers and the public.

Avian influenza exists in low-pathogenic and high-pathogenic forms. Pathogenicity refers to both the virus's ability to harm its host, and its capacity to spread between and among its host species.[xiv] Low-pathogenic avian influenza (LPAI), by definition, does not cause illness in domestic poultry.[xv] Birds that have LPAI are asymptomatic, so it is often hard for researchers to identify infected birds and collect their samples for laboratory analysis. Most importantly, though, an H5 or H7 LPAI strain has the potential to evolve into a highly pathogenic avian influenza (HPAI). In this form, the strain is frequently fatal to domestic poultry and wild birds and is easily transmissible between susceptible species.[xvi]

Low-pathogenic avian influenza spreads within a group of birds known as its *reservoir*. For an individual virus, a reservoir acts as a carrier that helps transmit the pathogen without being harmed by it, which in the case of H5N1 may be wild ducks. In such reservoirs, the virus has the ability to travel between geographic areas via wild bird migrations. Such migrations often occur along bodies of water due to the birds' resource needs. This pattern is significant because H5N1 has adapted the capability to exist and spread within water.[xvii]

2.2 Mechanisms for Mutation

A LPAI virus may gain the potential to mutate into a highly pathogenic strain as it comes in contact more frequently with other hosts. This situation may occur most readily when wild ducks come in contact with domestic poultry. The virus can be contracted from feces, nasal secretions, saliva, and blood, and so the potential for viral spread within a close community of birds is high.[xviii] A domestic bird can also acquire the virus through contact with a water body frequented by a LPAI-carrying bird. Hypothetical scenarios like this occur in developing countries where domestic birds often roam outside without restriction. After contracting LPAI, the infected domestic bird will return to its traditionally confined quarters, be it a chicken coop, pen, or cage. A bird is likely to share this limited space with many other domestic birds. Such high poultry densities create environments conducive to viral transfer between birds, increasing the probability that LPAI in domestic birds may mutate into a more threatening HPAI form.[xix]

Once a bird contracts HPAI, the virus may infect nearby domestic birds, and potentially spread to wild bird populations. An HPAI strain, by definition, has the ability to cause rapid and almost certain death within both wild and domestic bird populations.

A concern related to the spread of avian influenzas is their potential to affect currently threatened bird species. Populations already low in numbers that contract a highly pathogenic strain would be at a much higher risk of extinction than healthy populations. Threatened species thought by some to be at high risk of extinction from avian influenzas include the lesser white-fronted goose, red-breasted goose, swan goose, oriental stork, Siberian crane and bar-headed goose.[xx]

3. Avian Influenza Spread

Building on an understanding of avian influenza virology, it is now possible to examine the spread of avian influenza on a larger scale. There are two major mechanisms by which the virus is thought to propagate: migration and trade. Wild bird migration occurs at a global scale and has the potential to carry the virus along migratory pathways. Local, national and international trade of domestic and wild birds may also transmit avian viruses quickly around the globe. The GNAIS Act primarily addresses the first of these two mechanisms, as discussed in Section 6 below.

3.1 Wild Bird Migration

Migratory birds typically migrate twice a year following warmer weather north during the Northern Hemisphere summer, and south during the Northern Hemisphere winter.[xxi] Globally, wild birds approximately follow eight major flyways, or migration routes, typically determined by the geographic locations in which bird populations breed and winter (Figure 2).[xxii]

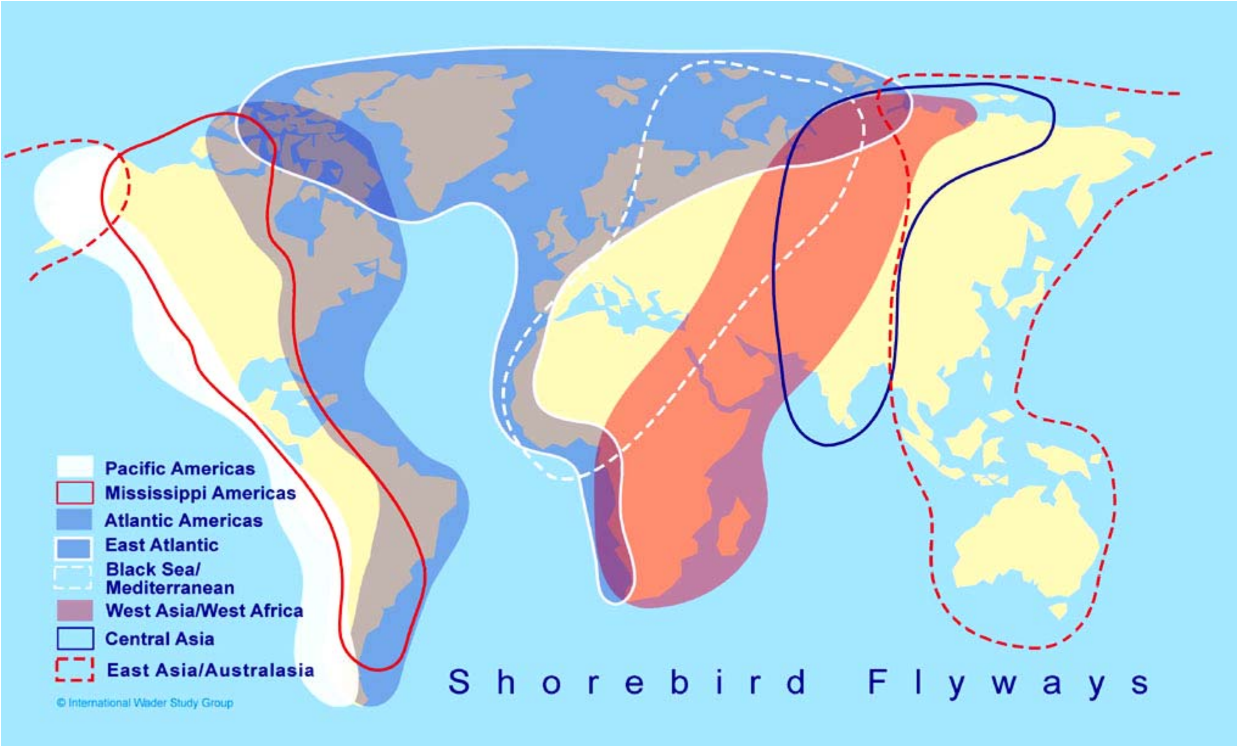

Figure 2. Global shorebird flyways based on current data. There is much uncertainty regarding exact migration routes.
Figure from IWSG (http://web.uct.ac.za/depts/stats/adu/wsg)

What is of particular interest in studying the spread of avian influenza through wild bird migration is that these flyways often overlap in polar continental areas. Despite the fact that most migrations occur longitudinally – in a north-south direction – the overlap between migratory routes in these regions may permit viral transmission in an east-west (latitudinal) direction as well. For example, a species of goose that migrates north along a given flyway may come in contact with individuals of a different species that share the same breeding ground. Given that avian influenza can exist and spread within freshwater systems,[xxiii] it is possible that birds may be infected with and spread avian diseases at high-density breeding areas. The newly infected bird may then carry the virus along a different flyway, spreading the disease both longitudinally and latitudinally.

High concentrations of migratory bird species also occur at natural hotspots at intermediate locations along migratory routes. These are commonly referred to as Important Bird Areas, or IBAs. Israel, for example, experiences seasonally concentrated bird populations due to its presence as a bottleneck between the Red and Mediterranean Seas and inhospitable deserts.[xxiv] Stops along the migration pathways present opportunities for wild birds to come in contact with domestic birds. Domestic poultry practices in developing countries often permit poultry to wander unrestricted. Such practices may permit domestic birds to interact with migrating wild birds, especially near bodies of water. This may facilitate the spread of avian influenzas between wild and domestic bird populations.

3.2 Poultry and Wild Bird Trade

The second possible mechanism driving the global spread of H5N1 avian influenza is the trade of wild and domestic birds.[xxv] The movement of domestic and wild birds occurs on a global scale through both legal and illegal trade. Legal trade of domestic poultry is carried out through local auctions and markets, farms, wholesalers, and multinational corporations. Illegal trade of pets, wildlife products, and bush meat is also significant. Avian diseases may potentially spread from countries with lax regulatory or detection standards to previously disease-free areas through shipments of birds or bird products. The implications of trade as a potential mechanism for H5N1 spread are uncertain, but may require the complex integration of disease risks, economic concerns, and cultural norms. This issue will be further discussed in Section 9 below.

The limits of currently available data add to the uncertainty surrounding H5N1 and its spread. The present sample size of HPAI-infected wild birds available for testing is quite small because HPAI's lethality typically kills wild birds before they can be located and sampled.[xxvi] Thus, a need for additional data has been identified. Improved disease detection and wildlife surveillance is a reason for promoting the GNAIS Act, which seeks to add to scientific understanding of avian disease through additional field research, sample analysis, international collaboration, and data sharing.

When analyzing the science of avian influenza, it is important to recognize that there will always be a level of uncertainty associated with avian disease dynamics. This is the nature of virology, as the randomness of mutations allows for a perennially incomplete understanding of the disease, hampering predictive capacity. The randomness of mutation makes it impossible to know whether or not the current HPAI strain of H5N1 will mutate into a stronger version, or if it will ever gain the ability to transmit among humans.

4. Existing Avian Influenza Efforts

As the H5N1 epidemic gained worldwide salience as a global health threat in 2005, the U.S. government recognized the need for a swift policy response to the crisis. Its response was informed by recent experiences with West Nile Virus (WNV) and Sudden Acute Respiratory Syndrome (SARS). Policy approaches to combat the spread of these two zoonotic diseases are detailed in Appendix 1.

To bolster existing government avian influenza resources, the U.S. Congress appropriated $3.79 billion in avian influenza funds within a December 2005 emergency military spending bill, H.R. 2863.[xxvii] Such funds were primarily dedicated to the Department of Health and Human Services (HHS) for vaccine production and development and for other domestic preparedness efforts. Only $408.5 million of the total was designated for international surveillance, preparedness, and research activities, and none of these funds were explicitly appropriated for international wild bird surveillance. On the domestic front, $10.1 million was dedicated to domestic wild bird surveillance to be conducted by the U.S. Geological Survey (USGS), Fish and Wildlife Service (FWS), and National Park Service (NPS). This wild bird component represents only 0.29% of the total avian flu expenditure and does not include the international surveillance of wild birds.

Though these expenditures represent a tangible approach to tackling the public health threats posed by the H5N1 epidemic, their reactive responses do not address the international surveillance of wild birds. This omission is potentially significant given that wild birds may be the crucial viral reservoir for H5N1 and may be contributing to the worldwide spread of the disease. We now turn to the proposed legislative solution offered to fill this gap, the Global Network for Avian Influenza Surveillance Act.

5. The Legislative Solution

The Global Network for Avian Influenza Surveillance Act (GNAIS) was introduced in the U.S. Congress in late 2005 by Sen. Joe Lieberman (D-CT) and Rep. Rosa DeLauro (D-CT) as S. 1912 and H.R. 4476, respectively.[xxviii,xxix] In order to address the current lack of funding for international wildlife surveillance for combating avian influenza, GNAIS would create an international partnership between the U.S. Department of Health and Human Services (HHS), a wildlife non-governmental organization (NGO), and cooperating organizations and institutions worldwide. The network intends to track the spread and pathogenic characteristics of H5N1 and other avian diseases and provide information to the public through an online database. GNAIS would improve global knowledge of migratory bird disease and improve predictive capacity for H5N1 and future avian disease threats.

5.1 Establishment and Structure of GNAIS

At the federal level, existing public health efforts are coordinated by the Secretary of Health and Human Services (Secretary), who oversees the Centers for Disease Control and Prevention (CDC), National Institutes of Health (NIH), and Food and Drug Administration (FDA). Upon enactment of GNAIS, the Secretary would be required to establish the Network by contracting with one or more domestic wildlife-conservation NGOs. The selected NGO(s) would be required to have experience in global wild bird health and conservation, and must currently manage accredited American zoological facilities. GNAIS itself is to be managed and directed by the NGO partner(s).

In order to accomplish the network's goals, the contracting NGO(s) would be required to partner with existing groups and institutions with experience in monitoring avian disease (Figure 3). Such partners may include the following:

- *Federal Agencies* such as the CDC and FWS;
- *International Entities* such as the World Health Organization (WHO), World Animal Health Organization (OIE), and U.N. Food and Agricultural Organization (FAO); and
- *Other Experienced NGOs*, such as BirdLife International or the World Conservation Union (IUCN)

Though the managing NGO(s) would be required to partner with the federal agencies and international entities listed above, the Network would have discretion to include additional experienced NGOs, along with any other entities it wished. By partnering with a wide variety of experienced groups, the Network would build on the wildlife disease expertise already held by existing institutions. In addition, it would promote the coordination of wildlife monitoring efforts and ensure that information is shared among Network partners and with the Secretary.

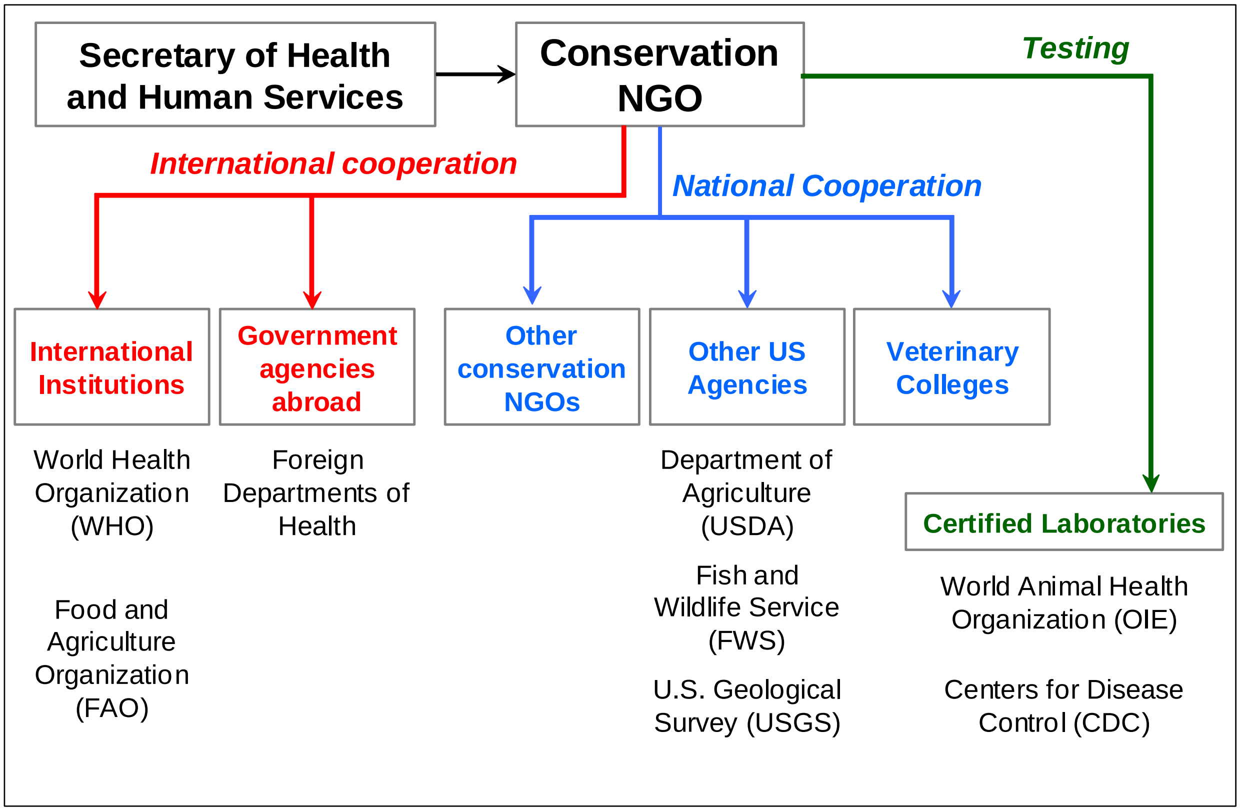

Figure 3. Structural components of GNAIS network, including major domestic and international partners and certified laboratories.
Data from GNAIS Act (S. 1912 / H.R. 4476)

5.2 GNAIS Tasks

The GNAIS legislation contains several prescriptive requirements for the Network as part of its overall mission to detect, monitor, and predict avian disease outbreaks. To support these tasks, the GNAIS legislation authorizes the appropriation of $10 million for each fiscal year from 2006 to 2010. With these funds, the Network must ensure the collection and testing of field samples, train Network partners and participants in wildlife monitoring and laboratory procedures, and establish an open-access online database to share monitoring results with the international community.

Trained GNAIS partners will be required to test wild migratory and resident waterfowl for relevant strains of avian influenza, mutations and other avian diseases of potential global significance within IBAs and high-traffic trade zones. The legislation does not mandate particular testing or sampling procedures, so the contracting NGO and partners will have discretion to develop the most appropriate collection and analytical techniques. To ensure accurate and consistent results, however, samples must be analyzed in certified laboratories that meet international standards, such as those at the CDC's Influenza Branch or at the OIE. If the

Network identifies salient changes in the abundance, distribution, or pathogenicity of H5N1 or other wildlife diseases, it must report these results to the Secretary.

In addition to tapping into the expertise of its managing wildlife NGO and its worldwide partners, GNAIS also aims to enhance the knowledge base and skill sets of participating institutions and organizations. Such training will help ensure that all Network partners are fully aware of the most advanced sampling and testing procedures in order to best monitor and predict the spread of H5N1 avian influenza and other avian diseases. Training will be run by Network partners and by accredited American veterinary colleges in order to promote long-term, sustainable avian disease monitoring efforts.

All GNAIS data are to be managed through a centralized database accessible to all interested agencies, NGOs, and individuals worldwide. This database will include the results of all laboratory analyses and information on the geographic distribution and dynamics of wild bird populations. Such a database will provide a useful tool for compiling and standardizing currently disparate H5N1 sampling efforts and sharing these results with interested members of the global community. By increasing the data's accessibility to researchers and government agencies worldwide, the Network would ensure that its information is fully analyzed and used to inform future predictive modeling of avian disease in order to assist national policymaking endeavors.

6. Evaluation of GNAIS

GNAIS represents a novel approach to minimizing the risk of potential human epidemics caused by avian diseases through the exclusive surveillance of wildlife. It seeks to accomplish this task by contracting with an expert NGO that will coordinate its international partnerships and data collection. We now turn to evaluating the merits of the GNAIS solution by critically analyzing the advantages and disadvantages of the system as proposed.

6.1 Advantages of GNAIS Approach

GNAIS provides an innovative framework for coordinating international surveillance of avian disease through its collaborative, NGO-led structure. It represents a policy evolution toward a more coordinated, international approach to addressing the interconnections between animal and human disease. GNAIS is advantageous for monitoring the spread of H5N1 and of other avian diseases because it coordinates existing expertise, allows a competent international NGO to coordinate its activities, promotes the universal dissemination of monitoring results, and addresses the H5N1 problem proactively.

Most GNAIS tasks will be performed by the contracting NGO and partners rather than by the U.S. government itself. The empowerment of an NGO partner to conduct GNAIS surveillance will allow the surveillance to be conducted outside the realm of intergovernmental politics. The partnership will minimize duplication of wildlife monitoring efforts, thereby improving overall monitoring efficiency.

Explicit provisions calling for an accessible online database will provide database access and analytical capabilities to governments, scientists, and the general public worldwide. This information-transfer component is missing in current government avian influenza efforts, including the HPAI Early Detection Data System (HEDDS) managed by the U.S. Geological Survey.[xxx] Providing timely information to all interested parties will reduce the potential for worldwide panic and help prevent fear-induced culls of threatened wild bird populations.

Finally, unlike crisis-motivated government responses, the GNAIS response to avian influenza and avian disease is largely proactive. GNAIS will not be able to fully prevent a potential H5N1 outbreak, but it does allow for the improvement of future avian disease surveillance, discovery of incipient avian zoonotic diseases, and enhanced predictive capacity for minimizing future outbreaks.

6.2 Disadvantages of GNAIS Policy Design

Despite these advantageous features of GNAIS, uncertainties remain about its ability to fully monitor and eventually predict future outbreaks. In particular, the program's limited resources and its lack of attention to trade-based movement of avian diseases call into question its effectiveness as a policy tool.

Appropriations for GNAIS represent 1/360 of the total government expenditures to combat avian influenza.[xxxi] Congress, responsible to the American people, has concentrated on promoting domestic preparedness and improving human disease monitoring. Further appropriations for GNAIS would likely increase the network's effectiveness at detecting future disease outbreaks. More GNAIS funding might also reduce the need for emergency, crisis-type appropriations such as the recent $3.6 billion emergency authorization for avian disease.[xxxii].

Using an enhanced GNAIS-type precautionary approach, government resources could be more efficiently allocated to combat future avian-based disease outbreaks.

Though wild birds may be the primary natural reservoir for avian influenza, the limited correlation between the recent spread of H5N1 and wild bird migration patterns may imply that they have a limited impact on global H5N1 spread. If so, GNAIS's focus on wild birds may be somewhat misdirected, and GNAIS may succeed only in disproving the link between H5N1 and wild bird migrations. However, even this result would be useful in suggesting the role of trade in avian influenza spread and increasing global knowledge of migratory birds. This issue will be further addressed within Section 9 below.

7. Scientific Underpinnings of the Solution

Despite the seriousness of avian influenza, the international community currently lacks a sufficient system to gather data and monitor the spread and evolution of the threat.[xxxiii] Not only is there no single entity responsible for gathering data on avian influenza and other pathogens, there is no entity responsible for coordinating data-gathering efforts. Furthermore, the international community has not set guidelines for responses to and containment of avian influenza outbreaks. A lack of coordination and the questionable reliability of data already obtained have led to confusion about the types of animals infected, the extent of damage to the poultry industry, and the spread of the disease. In addition, some governments may not release information about avian influenza because of the potential economic consequences of disclosure. Such consequences include negative impacts on tourism industries and trade bans imposed on poultry industries.[xxxiv] A comprehensive international surveillance program would provide accurate information to decision-makers and interested parties.

At the moment, scientists understand relatively little about the transmission of avian influenza between individuals and its dispersal across regions. The scientific community agrees that both migratory bird flyways and wild bird trade likely contribute to the spread of the disease. However, researchers disagree over the relative extent to which migratory routes and trade are responsible for the geographic spread of HPAI.[xxxv] Without sufficient molecular, epidemiological and ecological data on avian influenza, the scientific community cannot inform policy decisions and international responses to disease outbreaks.[xxxvi] The GNAIS surveillance system will fill in current information gaps on the characteristics of avian influenza and the interface of domestic birds, wild birds and people.[xxxvii] Surveillance results will help researchers determine the patterns of disease transmission and environmental factors that contribute to or hinder its spread.[xxxviii] GNAIS data will be applied to evaluations of avian influenza as a threat to the environment and to people.

7.1 GNAIS Data-Gathering

The GNAIS project entails a massive data gathering and compilation effort.[xxxix] Test results from biological samples and ecological observations from wild bird populations will feed into the database. Stored as geographically referenced files, these data can be analyzed for spatial and temporal patterns. Because of the unprecedented magnitude of this biological data-gathering effort, legislation specifies that the GNAIS project will also develop standardized protocols for testing methods and sample collection.[xl] GNAIS funding will also be used to provide training to partner organizations in specified data-gathering, testing, and analysis. When applied, the GNAIS database will function as an early detection system to track avian influenza and other avian pathogens. The ultimate interest of the system is to contain the spread of avian influenza, minimize damage to wildlife populations, and prevent new infectious disease outbreaks.

Fecal, serum, tissue and cloacal samples will be collected from wild and domestic birds.[xli] To maximize the benefits of sample collection, efforts must be concentrated in locations where outbreaks of avian influenza are likely to occur. Such high-risk areas include poultry markets where wild and domestic birds mingle in unsanitary conditions, along international boundaries between uninfected and infected countries, and within IBAs used as migratory stopovers and breeding grounds for wild birds.[xlii] In the past, all three of these interfaces have been implicated in the movement of avian influenza.

7.2 Likely GNAIS Surveillance Targets

Wet animal markets act as one point of convergence and dispersal for a large number of domestic birds, particularly in Asia. In wet markets, domestic poultry is sold and slaughtered for consumption in the same location.[xliii] Wild birds are often traded in the same markets.[xliv] Some of the unsanitary factors of wet markets include unsafe transport, live-animal storage, contaminated equipment, unsafe food preparation, and improper waste management.[xlv] Bird cages are often stacked upon each other or otherwise arranged so that fecal matter and body fluids from one cage can fall directly into another cage. Birds are often slaughtered and their meat sold in the same space, leading to potential contamination of food products and excess of body waste. These conditions are compounded by the high concentration of birds present at markets and are conducive to viral dispersal. Wild birds may also alight in the market and come into contact with domestic birds and any diseases they may carry.[xlvi] Depending on the severity of disease resulting from the virus, the wild bird may then spread the virus through its own population.

International boundaries are another logical interface upon which to focus bird sampling efforts in order to contain the spread of avian pathogens. Illegal smuggling of wild birds can pose a risk to international biosecurity.[xlvii] For example, in 2004, a pair of crested-hawk eagles was seized in Belgium from an illegal trader who had brought the birds from Thailand for a falconer. A few days later the pair was found to be infected with highly pathogenic avian influenza. If not intercepted, these birds could have spread H5N1 to Europe.[xlviii] Though GNAIS is not directed to investigate illegal bird trade, investigators should acquire samples from wild birds that are captured in transit in order to determine whether the birds carry pathogens.

The spread of avian pathogens across international boundaries is not attributed only to trade. Natural migratory patterns also traverse international boundaries. For example, in Alaska the East Asian-Australian flyway overlaps with the Mississippi-Americas flyway. Data collection efforts for wild bird populations should be focused in these migratory stopovers and IBAs. Currently, the United States Department of Agriculture (USDA) plans to collect 75,000 – 100,000 samples in Alaska from live and dead birds in 2006.[xlix] In these areas, GNAIS scientists should gather samples seasonally, as in the Alaskan example. They should also collect samples when unexplained high mortality is observed.[l] Greater than average death rates over a short period of time could be indicative of a potential disease outbreak and should trigger investigation.[li] Collection of samples at the site and in the surrounding area will help scientists ascertain the lethality of pathogens in wild birds. By focusing on the health of wild birds, scientists may establish the extent to which wild birds can carry highly pathogenic diseases without showing signs of infection.

7.3 Monitoring Logistics

Even if scientists limit data-gathering efforts to the high-risk areas and the important study sites for wild birds, the magnitude of effort required for surveillance—both spatially and in terms of number of samples and records to collect—would far exceed what is practical for any group. However, scientists can include volunteers in the data-gathering component of GNAIS. Bird watchers already pursue their hobby within IBAs.[lii] These hobbyists can be trained to quantify their observations in ways useful to scientists. Hunters, trappers and other outdoor professionals and sportsman can also collect data and samples from the wild birds they shoot or trap and then send these samples to professionals in laboratories for analysis.[liii] These volunteers can be trained to identify high-morbidity events. Likely first responders, these GNAIS volunteers can quickly gather samples in the case of such an event, saving time and resources that may then be more efficiently reallocated elsewhere around the globe.

Non-governmental organization professionals or veterinary colleges will train volunteers to handle wild birds safely, avoid contamination of samples, identify high-mortality trigger events, and ship samples according to protocols.[liv]

7.4 Sample Analysis and Data Parameters

GNAIS legislation specifies that all samples will be sent to an accredited laboratory. Researchers will conduct diagnostic tests both to analyze results and fine-tune methods and laboratory protocols.[lv] Diagnostic procedures will characterize the virus according to protocols developed. Virologists may detect for the viral presence, sequence viral RNA and determine the envelop protein present. Viral detection identifies infection in an organism and alerts researchers to the possibility that the organism has shed the virus and infected other individuals.

Genetic sequencing reveals changes in the virus over time and elucidates the frequency of change by mutation and reassortment. Sequenced viral strains can also be compared to each other for similarities and points of divergence.[lvi] By employing this sort of forensic analysis, scientists can investigate relationships and points of origin for new viral strains.[lvii] Finally, the change of the RNA as it relates to the observed infection capability of the virus will provide insight as to the genetic loci responsible for changes in viral pathogenicity.[lviii]

Characterizing the type of hemagglutinin and neuraminidase proteins enables scientists to determine if the virus matches that of a highly pathogenic strain.[lix] Variations in the loci that code for these envelope proteins affect the pathogenecity of the virus and the threat it may pose to bird populations. Protein identification also permits classification of the viral strain within the library of known strains.[lx]

Epidemiological data and evaluation of monitored habitats will be combined with results from samples collected in each geographic location. The GNAIS project will also refine both quantitative and qualitative data-gathering protocols for epidemiological studies.[lxi] However, at a minimum, the following should be recorded upon sample collection: date, location, species infected, number of individuals susceptible to the outbreak, number of individuals that contracted the disease, and number of deaths resulting from the outbreak.[lxii] Any precautionary containment measures undertaken at the site of outbreak should also be recorded. Results of analyses and the name and location of the laboratory conducting the analysis should be attached to each record. Supplemental population-based records in IBAs should include the degree of species overlap, habitat preferences, seasonal patterns, and spatial observations on habitat occupancy and migration.[lxiii] Any alteration of habitat that may affect wildlife health should be noted.[lxiv]

Data gathered will inform scientists as to the distribution, movement, and prevalence of the virus in wild populations.[lxv] These three metrics may clarify the relationship of the disease to its environment, its method of geographic spread, and the susceptibility of potential host species to the virus. Data will illuminate which interface of domestic and wild birds—trade and markets or migration and local farms—is the major contributor to the spatial dispersal of avian influenza.

7.5 Impacts of GNAIS Findings

GNAIS will provide an early detection system whereby science informs response and policy decisions regarding avian influenza outbreaks.[lxvi] Scientifically, the generation of information will spark further investigations, a cycle that will continue to enhance the quality and usefulness of GNAIS. Data will inform future research efforts and direct these efforts to the most pressing areas for study.[lxvii] In the public health and policy realms, the data from the system can be used to generate analytical tools such as statistics of outbreaks and characteristics of the virus, timelines of events, and maps of disease movement.[lxviii] These outputs will inform containment measures in the field and enable officials to focus political, economic and social responses to disease occurrences.[lxix] Potential actions to prevent viral spread include culling infected poultry, keeping free-range poultry and domestic waterfowl separated from wild birds, and targeting vaccinations in domestic or wild birds.[lxx] Some may also promote the killing of potentially infected wild birds. Regulation of wildlife trade and guidelines for sanitation in shipping of trade equipment are also likely steps toward controlling avian influenza outbreaks.[lxxi]

Though education of local farmers is not covered under GNAIS, data can be used to target education to the area of outbreak.[lxxii] Farmers can be taught about sustainable and safe farming practices, the safe transportation and handling of birds in markets, and the risk of local habitat degradation that may facilitate contact between their own birds and potentially infected birds.[lxxiii] As the project progresses, the analyses may identify other crucial educational needs.

Ultimately, this early detection system may turn into a predictive model capable of forecasting the spread of H5N1 and other avian pathogens. Patterns will emerge from the data, allowing analysts to extrapolate trends from GNAIS-provided disease data. Predictive modeling may forecast likely sites for future outbreaks and anticipate viral changes that may be devastating to wild and domestic birds.[lxxiv] Collaborative efforts may prevent transmission of the virus into farming communities and protect endangered wild birds from contracting the disease.[lxxv]

The applicability of GNAIS extends beyond avian influenza to other avian pathogens emerging from the environment.[lxxvi] Though GNAIS legislation explicitly addresses avian pathogenicity, wild bird surveillance will also inform ecological studies. Scientists will learn more about wild bird habits and migratory patterns on the global scale.[lxxvii] Data on habitat degradation will also lead scientists to an understanding to the function of this variable in relation to the emergence of avian pathogens.[lxxviii] Surveillance and wild bird monitoring through GNAIS will make the database the most comprehensive compilation of wild bird data that currently exists.

8. Evaluating the Network's Success

A comprehensive plan to measure success is necessary in order to track the achievement of the GNAIS objectives. GNAIS must address the difficulties of establishing an early-warning system, which consists of obtaining reliable data, securing international collaboration, maintaining a user-friendly database, and developing predictive modeling capabilities.

8.1. Short- and Long-Term GNAIS Goals

The goals of GNAIS can be seen in two forms: short-term and long-term. The immediate goals are to set up a surveillance network that obtains reliable data, which in turn helps achieve better understanding of wild bird migrations and their relation to avian disease. Long-term goals pertain to the overall efforts in predicting avian influenza outbreaks as well as protection of human and wildlife health.

Short-term success depends on international collaboration and cooperation in order to obtain reliable data and make such data globally accessible. This entails providing and meeting standardized sampling, monitoring and laboratory analysis protocols. Using this quality-controlled information, the GNAIS database will allow further analysis and understanding of the movement and characteristics of avian disease.

Long-term goals are to obtain a greater understanding of wild bird migration, predict future pandemics, and reduce the overall health risk to humans and animals. Although planning for these goals is not defined in the Act, the successful implementation of the short-term goals can make these visions tangible.

8.2 Metrics for Success

Short-term success can be measured by specific metrics. The degree of international participation can be measured by the number of countries participating as well as the number of permits and visas allowed. The number of countries participating in the program indicates the willingness of foreign nations to commit efforts towards avian influenza research and outbreak prevention, and demonstrates confidence in the effectiveness of GNAIS.

GNAIS must promote universal standards in order to obtain reliable data. Standardized protocols for information collection will require a minimum amount of samples and data gathered. Consistent testing procedures and technologies must be utilized by trained individuals at certified labs in order to ensure data reliability. Continual audits of GNAIS procedures would ensure standardization and the development of robust quality controls. Each of these measures will help maintain the quality of GNAIS-gathered data.

Achievement of short-term goals will enable progress towards the overarching long-term objectives. The end result of compiled GNAIS data will be an accurate and well-maintained

GNAIS database that includes both raw data, such as test results, and predictive tools, such as outbreak-risk maps. Collectively, these outputs increase the ability to predict the global spread of avian influenza, and will allow for countries to better respond to future avian influenza outbreaks.

9. Controversial Facets of GNAIS Surveillance

It is important to recognize the issues and controversies surrounding the implementation of GNAIS in order to make wise policy decisions. Obtaining reliable data is one aspect of GNAIS in which there are scientific issues, and political, economic, and social controversies. The second area of major controversy lies in the focus of study itself, and whether wild bird migration is the most significant mechanism driving the virus's global spread.

9.1 Scientific Issues

In order to implement a successful international wild bird monitoring program, reliable data are a necessity. Aspects of a large-scale, resource-intensive project may make obtaining reliable data difficult. Collaborative data collection can be time- and resource-intensive, and ensuring proper training and coordination of GNAIS actors is a daunting challenge. GNAIS requires effective communication between the designated NGO and the national governments involved in order to expedite the process of sample transport through international borders. Another crucial scientific concern is ensuring the standardization of all scientific methods used by GNAIS and encouraging all designated laboratory facilities to adopt up-to-date testing methods and technologies. With overall scientific consistency in the field, it is more likely that the GNAIS database will contain reliable data.

9.2 Political, Economic, and Social Controversies

In addition to the scientific controversies presented by GNAIS, there are several controversies in the political, economic, and social realms that may affect GNAIS data-collection. Addressing these controversies must be a primary goal of GNAIS's managing NGO and its global partners.

Politically, GNAIS requires that nations demonstrate transparency. This would allow domestic researchers to have access to, and make available, necessary information on avian disease spread. However, the controversy lies in that nations are sovereign entities and as such have the ability to determine who may enter and sample within that country. In this way, each government has the ultimate say in permitting or denying the flow of monitoring data between itself and the GNAIS database. Non-cooperative governments can make gathering reliable data very difficult, for example, by denying entrance visas to foreign scientific teams for the purpose of conducting research.

Economic concerns may also prevent GNAIS scientists from gathering reliable data. There are potential financial repercussions at the local, national, and international levels from acknowledging a case of avian influenza. At the local level, it may be difficult to gather reliable data from farmers who fear disclosing outbreaks in their domestic poultry stock to the national government. Local farmers may fear that disclosure will only lead to the slaughter of their entire poultry stock and the loss of their economic livelihoods. Thus, without compensation provided by national governments to local farmers who have to cull their flocks, there is no way to ensure that farmers will accurately disclose disease outbreaks. At the national level, governments may also resist disclosure because of the trade and export bans the international community may impose and the resulting loss of GDP, foreign investment, and tourism.

The information that GNAIS gathers on avian influenza may indirectly encourage people to change their customs and routines in order to curtail transmission of H5N1 or other zoonotic diseases. GNAIS itself does not directly confront this dilemma, but this controversy is nevertheless likely to arise. Many existing outbreaks have occurred in rural areas and parts of Asia, Africa, and the Middle East. Fear of intrusion from Western nations and overt international scrutiny of non-western cultures may hinder GNAIS's ability to gather reliable data. People may be unwilling to change daily routines or cultural practices, despite evidence suggesting that traditional habits may be conducive to the propagation of avian influenza. Debate lies in making sure that all research is conducted in a culturally sensitive manner while still enabling researchers to collect accurate and reliable data.

9.3 The Trade Controversy

One final controversy lies in whether wild bird migration is the vehicle of transmission. There is speculation that trade of domestic and wild birds, both legal and illegal, is an important mechanism of transmission.[lxxix] Available data on the spread of H5N1 since 2003 indicates that the disease has moved more rapidly than if it had spread solely through the annual seasonal migrations of wild birds.[lxxx] This adds to the possibility that an alternative mechanism for avian influenza transmission is the global poultry trade, which could send an infected bird across international borders over short timeframes.

There is also the possibility that avian influenza may be spread through a combination of both wild bird migration and trade. In either case, controversy lies in determining whether wild bird migration and surveillance is the necessary area to study. GNAIS only touches on the notion of trade as a potential mechanism, but it is important to acknowledge trade as an alternative theory. Regardless of which theory is ultimately proved correct, however, GNAIS will assist scientists in assessing the role of wild bird migration in H5N1 spread and either proving or disproving its relevance to national and international health policymakers.

Obtaining reliable data is essential for providing the international database with information that can help predict the spread of avian disease. GNAIS implementation will likely prompt scientific, political, economic, and social controversies that, if not overcome, will disrupt proper functioning of the surveillance and database efforts.

10. Conclusion

The Global Network for Avian Influenza Surveillance legislation represents an essential, unprecedented effort in the control of emerging infectious diseases. By addressing the role of wild birds in the spread and transmission of the disease, the legislation fills a missing piece in the struggle to understand avian influenza. Prior policy measures have focused largely on reactions to avian influenza outbreaks. GNAIS monitors migratory birds in order to understand the means of disease dispersal and ultimately predict avian influenza outbreaks. Its legislation is based on the conviction that the health of the environment and wildlife are linked inextricably to the health of people.

The world-wide scale of GNAIS is unparalleled in the realm of public health policy. Current migratory bird surveys study only at local or regional scales. GNAIS, however, calls for surveillance of migratory birds on a global scale, coupled with the collection of biological samples, integrated laboratory analysis, and the creation and maintenance of a results database. All countries will have access to the database and may contribute to its records. The coordination of all of these components will be orchestrated by a qualified non-governmental organization that utilizes international scientists, laboratories, governments, and interested parties.

Through its accessible database and predictive modeling capacity, GNAIS will coordinate efforts to track viral change, define the mechanisms for disease transmission and spread, and better define wild bird flyways. This comprehensive strategy provides for a forward-looking, potentially preventive system. Because its data can be used to model the future spread of avian influenza, a functional GNAIS will help policymakers prepare for outbreaks before they occur. However, only by collecting accurate data can GNAIS provide useful predictive modeling tools to policymakers.

Despite the essentiality of standardized, accurate data, achievement of this goal will not be easy. GNAIS findings will ultimately impact current political, economic and social realms. Its structure incorporates sound information-gathering and worldwide standardization as prerequisites for informing actions in each realm. Gathering data from often remote areas all over the world and shipping these data to accredited laboratories will be difficult. Moreover, the innovation and flexibility that characterize GNAIS also present challenges to those responsible for its implementation. However, if these challenges can be overcome, the data and outputs of the Global Network for Avian Influenza Surveillance will provide scientists and policymakers with a better understanding of wild birds, a clearer picture of the spread of avian influenza, and a potential tool for improving future disease response.

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Appendix 1: Comparative Disease Scenarios

In order to fully evaluate the GNAIS solution, it is useful to examine two other recent zoonotic disease events and judge the policy responses to these events. West Nile Virus (WNV) and Severe Acute Respiratory Syndrome (SARS) are both zoonotic diseases that, like H5N1 avian influenza, abruptly gained public attention and posed potential human disease threats.

WNV first emerged in North America in Queens, New York City, in 1999. WNV is a traditional Old World disease, and its expansion to the United States caused alarm among American public health authorities. Scientists quickly determined that WNV spread primarily through the *Culex. pipiens* mosquito vector, and that the likely disease reservoirs were migratory birds. Like with H5N1, there was concern that WNV could have devastating effects on endangered American wild birds.[lxxxi] Some state health departments established GNAIS-like public databases for wild bird surveillance information, such as an effort in Florida that allowed state residents to directly add information to the database.[lxxxii] Government efforts were focused on assisting already competent state and local health departments, not on recruiting an expert NGO to coordinate surveillance and control efforts. And though accessible state databases were established to track the spread and abundance of WNV-infected birds and humans, these databases were not nationally standardized.

SARS, like H5N1, provoked an international response following the disease's emergence in Asia and human transmission to North America, South America, and Europe in 2002. Research into the wildlife dynamics of the disease was hampered by incomplete information about its true reservoir. Though civet cats were first implicated as the primary disease reservoir,[lxxxiii] later scholarship has suggested that wild bats are the original source of the disease.[lxxxiv] The U.S. government, as it later did with H5N1, focused primarily on domestic public-health preparedness, and did not propose to conduct international wildlife or animal monitoring to investigate or predict SARS. Scientists at the time suggested that wildlife monitoring would be an efficient method of predicting the future risk to humans,[lxxxv] and some proposed an international surveillance working group for *all* zoonotic pathogens that would monitor human, domestic, and wildlife health and their interactions.[lxxxvi] Despite these innovative, GNAIS-like policy proposals, few were implemented, most likely because SARS has recently disappeared as a global disease threat.[lxxxvii] Nevertheless, SARS-motivated disease control measures closely mimicked the evolution of H5N1 policy in the scientific community. SARS and WNV represented important steps in disease policymaking adaptation, and provided a forum for international coordination of wildlife-monitoring activities between disparate international institutions and NGOs.

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