Practice of Communicable Disease Surveillance in North Carolina
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SLIDE 1

Hello. I am Jean-Marie Maillard, a medical epidemiologist with the North Carolina Division of Public Health. After the previous lecture on definitions, legal framework and description of the methods of conducting disease surveillance at the state and national level, I will talk in this lecture about the use public health officials in NC make of communicable disease surveillance data. For this, I will draw on several examples from the past few years.

SLIDE 2

At the end of this lecture, you will be able to 1) describe the network of surveillance partnerships for communicable disease in North Carolina; 2) interpret reported data as a function of true disease incidence within the community; and, 3) list 4 public health uses of surveillance data.

SLIDE 3

Before getting into some examples, let me begin by acknowledging our partners in public health practice. First, we depend on the active involvement of clinicians and laboratories as the source of information on communicable diseases. While recently we've worked hard to automate some aspects of disease surveillance, reporting clinicians and laboratories, together with the local health departments, form the foundations of a network of health professionals involved in the collection and use of surveillance data. Others are the 7 regional teams working on public health preparedness and response; the 11 hospital-based public health epidemiologists (PHEs), who form a network of dedicated public health partners who are employees in the largest hospital systems in the state; the 9 regional Immunization consultants, primarily working on childhood vaccine preventable diseases; and the Disease Intervention Specialists (DIS), primarily working with contacts of persons reported with sexually transmitted diseases, and on some occasions, also in response to other diseases.

SLIDE 4

At the Centers for Disease Control and Prevention, we find our main federal partners for building standardized surveillance systems, as well as for discussing with national experts about reported cases and other surveillance findings. At the state level, other branches in the Epidemiology Section are sometimes the better match to find the needed expertise for some of the issues brought to the Communicable Disease Branch. These are the Occupational and Environmental Epidemiology Branch, the Office of Public Health Preparedness and Response, the State Laboratory of Public Health, and the Office of the Chief Medical Examiner.

SLIDE 5

This diagram summarizes the flow of communicable disease surveillance data in North Carolina. Physicians report to the local health departments, where the data are entered into the NC Electronic Disease Surveillance System, or NC EDSS. The system allows two-way communication with subject matter experts of the Communicable Disease Branch at the state level. Laboratories can also report directly into this electronic system, although with the notable exception of two very important laboratories, the State Laboratory of Public Health and LabCorp, this is essentially still a work in progress, and other laboratories still report by sending their reportable results to us by secure fax, encrypted email or regular mail. We hope to make significant progress in this area soon, by capitalizing on current efforts with Electronic Health Records and Health Information Exchange. Lastly, this system is used to notify CDC of reportable communicable disease data in a format that does not identify patients.

SLIDE 6

While collecting disease data, however, we keep in mind that reported cases provide us with an indicator of disease incidence in the community, but typically not a complete representation of it. You can see on this pyramid where the base is the general population, that of the subset of persons ill in the community, a gradually reduced fraction consults a physician, has a specimen collected, and laboratory test conducted, not all of whom have a positive result, and even less get reported. So the information that eventually reaches public health professionals is carefully considered, with the knowledge that it may be the tip of a larger occurrence of illness in the community.

SLIDE 7

In the traditional model of disease surveillance, the information that reaches public health professionals is fragmentary and not timely. As shown on this graph, just one or a few cases may be reported to the local health department over a week after onset of illness. In this example of an outbreak in a child care facility of shigellosis, a disease that's easily transmitted from child to child, the system as imperfect as it is, works for limiting the spread of illness *if* the person receiving the initial report(s) at the local health department immediately calls the patient, or his or her parents, and verifies whether the case is associated with attendance at a child care facility, then further contacts the facility to learn whether there is an outbreak in the facility.

SLIDE 8

Next, let me remind you of the uses we can make of surveillance data, as already discussed in the lecture by Dr. Fleischauer. We may use surveillance data to count cases and measure trends, identify risk factors associated with certain diseases, verify that control measures have an effect on disease incidence, or to document the need to allocate resources.

SLIDE 9

In most of this presentation, I will use data reported by clinicians and laboratories, but before we get to this, here is a graph that uses two other data sources, to illustrate that disease surveillance is a dynamic process and we may resort to different systems as needed to monitor the health status of the population in North Carolina. This shows the surveillance of Influenza-Like Illness using data from hospital Emergency Departments in the blue line, and from reports from the network of volunteer practice offices (also called (ILI-Net) in the purple line. Even though the magnitude of data points is not identical in the two systems (the patient population is not exactly the same, and the case definition also may differ slightly), we clearly are following the same type of event with these two systems. The increase seen in early May 2009, on the left side, is contemporary of the recognition of a novel influenza virus in North America, and the more than tripling of incidence seen in September occurred when schools reopened after the summer.

SLIDE 10

We're now going to look at several examples of interpretation of surveillance data. Changes in incidence may be expected or not, and may reflect trends. And because we are epidemiologists studying the distribution and determinants of disease frequency in human population, we analyze the data in terms of time, place and persons.

SLIDE 11

And while a change in disease frequency may reflect a true change in disease incidence, we carefully rule out other possible explanations before rushing to conclusions, and want to verify that changes are not consequent to reasons such as population change, changes in the reporting procedure, changes in personnel which may affect increases or decreases, depending with how systematic and thorough different persons may be, or scientific progress, with for example, the availability of new tests, or their use extending from research to commercial availability. If observed changes are not explained by such reasons, we may consider that they reflect true changes in disease incidence in the community.

SLIDE 12

This is an interesting, fairly old slide. It shows the incidence of Salmonellosis in the United States over two decades, and we can observe that every year there is a distinct seasonality with a summer peak. Combined with this pattern is a gradual increasing trend over the years. Lastly, there is a marked sharp peak in 1985 reflecting a large outbreak with over 16,000 confirmed cases that was associated with a faulty pasteurization process of milk distributed in a large metropolitan area.

SLIDE 13

Here is the trend of tuberculosis incidence in the 1980's and early 1990's. Starting in 1985, there is a departure from the expected decreasing trend based of the experience in the early 80's. One of the definitions of an outbreak is having more cases observed than expected. This is what happened as a result of the spreading AIDS epidemic, with tuberculosis being an frequent opportunistic infection in AIDS patients.

SLIDE 14
Following investigation and modification of tuberculosis control policies and practices, the pre-existing trend was restored and the decreasing slope resumed, parallel to what it had been prior to the first years of the AIDS epidemic.

SLIDE 15
As another example of observation accompanying efficient control measures, this trend documents how the Haemophilus influenzae B vaccine effectively prevented numerous cases of this infection.

SLIDE 16
Another success story is seen with the surveillance of acute hepatitis B.

SLIDE 17
In children aged less than 20, a 91% decline in incidence was observed between 1991 and 2005. In adults, the decline was 75%. The Sixth Graders vaccination campaigns were organized to shorten the lag time for vaccination to be followed by a decrease in incidence, due to the fact that most hepatitis B cases are the result of sexual transmission. Vaccination of all birth cohorts alone starting in 1994 would have resulted in having to wait until this birth cohort would reach an age where sexual activity would start. Vaccinating older children shortened this lag time.

SLIDE 18
Here is the trend of Hepatitis A incidence in North Carolina over the past 50 years. (This trend is closely similar to that of the US). Outbreak peaks were cyclical, coming back every few years, and in recent years, the magnitude of these peaks has declined and the interspace between peaks is longer. These changes are contemporary of improvements in hygiene and food preparation, better understanding of the risks, and of the measures available to control the spread of hepatitis A, such as the post-exposure administration of Immune Globulin or hepatitis A vaccine.

SLIDE 19
Concentrating our attention on recent years, one can see the population outbreak of 1988-1990, followed by years of what appears to be a relative steady state of about 200 cases or less reported in NC in most years.

SLIDE 20
Let's drill down now, and analyze the data by person characteristics, first stratifying by gender. Notice that males exceed females most years, and this differential is most obvious in 2001, 2002, and 2003, where over half of reported cases were males.

SLIDE 21
Now, further stratifying these surveillance data, we can see that most cases were young adult males. While hepatitis A is largely known to be a foodborne disease, which can also be transmitted from person-to-person, these observations were documenting an

ongoing outbreak of hepatitis A among the gay community, and we targeted risk communication to this community.

SLIDE 22

Analyzing surveillance data by *place*, we can map cases by the county of residence of reported patients. In the summer of 2001, there was noticeable clustering of cases of Salmonella enteritidis infection in the areas around Charlotte. Careful investigation through a case control study revealed that these cases were associated with egg consumption, with eggs that came from a farm in proximity to that area that had been associated with a prison outbreak six months earlier.

SLIDE 23

This map represents reported cases of Lacrosse encephalitis plotted by their county of residence of these cases. LaCrosse encephalitis is an infection resulting from the bite of mosquitoes carrying the responsible virus, and the geographical location of these cases closely follows that of the habitat of the mosquito vector, the "tree hole mosquito."

SLIDE 24

The trend of Rocky Mountain Spotted Fever cases reported in NC over the past two decades includes a steady increase starting in the year 1998. This is the year laboratory reports indicative of this infection became reportable. Laboratories became aware of this requirement, possibly gradually. Also, dedicated and tenacious public health staff reviewed these reports, and pursued all reports until it was known whether each case met the case definition or not. So, while there may be true increased incidence over these years that may have truly occurred, we can reasonably suspect that artifact contribute to the direction of the trend. In addition, less than 5% of these case reports included sufficient laboratory data to meet the case definition as confirmed cases of Rocky Mountain Spotted Fever.

SLIDE 25

With a finer time distribution of close to 3,000 reported cases of Rocky Mountain Spotted Fever, by month of onset of illness instead of by year, the seasonal pattern of tick activity is recognizable.

SLIDE 26

Here is a test. If you did not know what reported disease this is, what kind of inference could you make regarding its mode of transmission? Cases affect mostly young adults in the 20 to 34 year old age group.

SLIDE 27

Sexual transmission is the predominant mode of transmission of hepatitis B, and this is reflected in the age distribution of reported cases.

SLIDE 28

In possible artifacts to rule out when analyzing disease surveillance data, change in the population was mentioned. The incidence of foreign-born cases of tuberculosis (represented here in light gray) reported in the US was quite stable over the years, but in 2008 and further in 2009, a decrease in these cases was observed. One possible explanatory factor is the economic crisis in these years, during which some of the foreign-born population of immigrants may have returned home due to the lack of available jobs.

SLIDE 29

Measles surveillance provides us with another opportunity to analyze data by person characteristics. Typically, the expected baseline of measles incidence is about zero case per year, with occasionally imported cases being identified. In 1989 however, over 180 cases were reported in North Carolina. While measles is generally known as a childhood disease, almost 80% of the reported cases were aged 10 to 24 years. A loosely enforced vaccination policy using a single dose of vaccine resulted over the years in a significant pool of susceptible in the community. When a case or a few cases of measles, which is highly transmissible, were introduced in this population, all exposed susceptibles were infected. In terms of using surveillance for guiding actions, this resulted in policy changes. Measles vaccination now consists of the administration of two doses of vaccine, rather than one dose of vaccine, and immunization requirements for admission to schools and universities is now strictly enforced.

SLIDE 30

In the recent past, major improvements were made in the conduct of surveillance for communicable diseases. *Electronic reporting* was implemented, mostly as a result of dedicated federal funding. For example, in North Carolina we have NC EDSS (for case reports and laboratory results); NC DETECT for near real-time reporting of hospital Emergency Department visits, Poison Center calls, EMS data; and lastly, the reporting of events providing earlier warning was added to the traditional surveillance of diagnosed cases. Examples include electronic reporting of laboratory results; syndromic surveillance – rather than surveillance of diagnosed cases, as is done in North Carolina with mandatory reporting of hospital Emergency Department visits; public health use of non-traditional sources of data – ambulance runs, Poison Center calls, school absenteeism, pharmaceutical drug sales, for example. Also recently, healthcare-associated infections became the focus of national debate, and public health officials in North Carolina and other states are building new surveillance systems to monitor the occurrence of these infections.

SLIDE 31

Following the anthrax outbreak of 2001, syndromic surveillance gained attention as a possible counter-measure against bioterrorism. On the upper part of this slide, traditional surveillance is represented with the red line, showing that it takes several days for information on diagnosed cases to reach public health officials. Syndromic surveillance, on the other hand, can provide an early warning; early enough to administer post-exposure prophylaxis to exposed persons, such as antibiotics, and therefore avoid a fatal outcome in many of them, as shown on the lower part of the slide.

SLIDE 32

As mandatory reporting of emergency department visits was implemented in North Carolina with a new law effective January of 2005, we can conduct true population based surveillance for conditions that may lead patients to seek care in emergency departments. As of recording of this lecture, all 112 targeted hospitals report Emergency Department visits to a state system called NC DETECT.

SLIDE 33

To end on a good note, this slide represents participation to the national BioSense surveillance system for Emergency Department visits. The excellent level of coverage reached in North Carolina is apparent on the national map of non-Department of Defense reporting hospitals, with the dense network in North Carolina being clearly visible.

I hope you find your work in conducting surveillance for communicable disease as much of a passion as it is for many of the speakers invited to participate in the recording of this series of lectures. Thank you for your attention.