A DESCRIPTIVE ANALYSIS OF VARICELLA INFECTIONS AMONG PATIENTS PRESENTING TO EMERGENCY DEPARTMENTS IN NORTH CAROLINA

by

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ABSTRACT

Varicella, or chickenpox, is a highly communicable infectious disease which, in the prevaccine era, contributed to significant morbidity and mortality among the general population, as well as resulted in substantial costs to society. Following US vaccine licensure in 1995, a significant decline in disease, hospitalizations, and deaths began and has continued. The Healthy People 2010 goal related to varicella is disease reduction; in contrast, the goal of the CDC is disease elimination. State and national vaccination rates have steadily risen since 1995, with a current national rate of 85%. Although significant decreases in disease are evident and vaccination rates have increased, cases of disease, hospitalizations, and deaths still occur. Surveillance is a necessary component of vaccination programs in order to monitor impact, identify factors that allow cases to continue to occur, and to guide state policy. The Council of State and Territorial Epidemiologists (CSTE) recommended that each state institute an ongoing surveillance system to monitor the impact of varicella vaccination on the incidence of varicella by 2005. In response to this recommendation, North Carolina implemented a sentinel ED surveillance system. The system, although efficient, has limitations, but the resulting data demonstrate a low incidence of disease in the Emergency Department setting with minimal burden on North Carolina emergency healthcare systems.

Background

Varicella, also known as chickenpox, is a common and highly infectious disease which is also vaccine-preventable (1-3). Of the two clinical diseases caused by the Varicella-zoster virus (VZV), Varicella is the primary infection and results when susceptible individuals are exposed to the virus (4-6). VZV is a member of the Herpesviridae family (4,5,7). Infection with Varicella typically confers lifelong immunity, but re-infection known as Herpes zoster, or shingles, may occur later in life (4-6). Varicella occurs seasonally, with the highest incidence occurring in winter and early spring; it can also occur in epidemics (4,7).

Infection manifests itself with fever, malaise, anorexia, and a generalized maculopapulovesicular rash which begins on the trunk of the body (4-6). The lesions consist of maculopapules, vesicles, and scabs in varying stages of development (4). Individuals may be contagious 1-2 days before onset of the rash, and remain contagious until the lesions are crusted over (4,5). Varicella is transmitted primarily through aerosolization of virus particles, which are then inhaled by susceptible individuals, and also through direct contact with the lesions themselves (4-6). The highly-transmissible nature of varicella is evident in the fact that secondary attack rates among susceptible household contacts of individuals with varicella are as high as 90% (6,7).

Varicella is typically considered to be a childhood illness, as 90% of the cases occur in children less than 13 years of age with the highest incidence rates between 3-6 years of age (8,9). It affects both genders and all races equally (4). It is estimated, however, that 10% of individuals older than 15 years of age are susceptible to primary infection with Varicella (4). In healthy children, the disease is fairly benign, with duration of illness lasting 3-5 days and lesions healing within 1-2 weeks, and an estimated mortality of less than 2 per 100,000 cases (4,7). In adults, the disease process is not as benign and they are more likely to experience complications (7).

Complications may include cerebellar ataxia (1 in 4,000 cases), encephalitis (0.1-0.2% of cases), meningitis, transverse myelitis, Reye's syndrome, bacterial superinfection (1 in 400 cases), soft tissue infections (18%), fluid and electrolyte imbalances (19%), and pneumonitis (20% of cases) (4,6,10,11). Encephalitis in adults is a serious complication which can be life-threatening, and extends the duration of illness to 2 weeks. Encephalitis-related mortality occurs in 5-20% of the cases, and neurological sequelae have been detected in an estimated 15% of survivors (4). Varicella pneumonitis occurs more frequently in adults and immunocompromised hosts; among adults, the estimated incidence is 1 in 400 cases, and may be life-threatening if it occurs in pregnant women during the second or third trimester (4). Perinatal varicella also occurs if the mother contracts disease within 5 days prior to delivery or 48 hours post-partum, and is associated with an estimated infant mortality rate of 30% (4,6).

Prior to the advent of the varicella vaccine in 1995, an estimated 4 million cases of varicella occurred each year in the United States (US) (1-4,6). Of those cases, approximately 100-150 persons died and an estimated 11,000 persons were hospitalized (1-3,6,9,12-14), 300,000-500,000 sought medical care, and almost half of these persons required a second office visit (4). One analysis of data from the National Hospital Discharge Survey determined that approximately 57,000 days of hospitalization annually were attributed varicella (15).

The majority of varicella cases (95%) occurred in individuals less than 20 years of age, with the highest incidence occurring among children 1-4 years of age (39%), followed by children 5-9 years of age (38%) (1,6,7). Hospitalization rates were approximately 2-3 per 1,000 cases among healthy children, and 8 per 1,000 cases among adults (7). One study has shown that the majority (89%) of hospitalized varicella cases were healthy individuals with no immunocompromising conditions (15).

The risk of complications and mortality increases with age, as the fatality rate among 1-4 year olds is 1 per 100,000 cases, among 15-19 year olds is 2.7 per 100,000 cases, and among adults aged 30-49, 25.2 per 100,000 cases (7). Adults over 20 years of age accounted for 35-55% of the deaths (1,7,9,14,16).

In addition to the morbidity and mortality associated with varicella, there are direct medical costs as well as the indirect cost to society when children miss school and caregivers miss work in order to care for them. Cost studies have indicated that varicella vaccination saves money; as much as $5.40 is saved for every $1 spent on varicella vaccination (17,18). The overall savings in health care costs has been demonstrated to be $400 million in one study (18). Yet another study indicated an economic benefit of $6.6 million for every 100,000 children vaccinated (19).

Vaccination

In 1995 the US Food and Drug Administration (FDA) licensed a live attenuated vaccine, Varivax, for routine use in children over 12 months of age in the US (1,4-6,12, 20). Over 22 million doses have since been administered (20). Use of the varicella vaccine was first recommended by the American Academy of Pediatrics in May of 1995, followed by the Centers for Disease Control and Prevention (CDC) Advisory Committee on Immunization Practices (ACIP) in July of 1996 (12,20,21). In May of 1999, the CDC recommended that all states require chickenpox vaccinations for school-age children (2).

The varicella vaccine is recommended for 3 populations:

- all children at 12-15 months of age without contraindications or a reliable history of chickenpox disease;
- all children by the 13^{th} birthday without reliable history of chickenpox disease or evidence of varicella immunity; and
- all adolescents and adults without evidence of varicella immunity (2,7).

It has recently been recommended that children who received a varicella vaccination at 12-15 months of age should also receive a 2nd dose between the ages of 4-6 (22). Additionally, individuals over 13 years of age should also receive 2 doses of the varicella vaccine, separated by 4-8 weeks (22).

Antibody titers are detectable in 97% of children 12 months to 12 years of age who have received one dose of the vaccine, and over 90% maintain antibody levels for at least 6 years (7,21). One study by Vessey et al (2001) indicated an antibody persistence rate of 99.5% over a 6-year follow-up period. Antibody titers among healthy adolescents and adults are 78% after one dose, and 99% after a second dose (7,21). Antibody persistence in these individuals after one year following the second dose of vaccine is 97% (7,21).

Estimates of vaccine efficacy against infection are 70-90%, and against moderate or severe disease, 85-95% (6,7,23). Field studies also indicate that varicella vaccine is 80-85% effective against infection, and over 95% effective against severe disease (6,7,23-25). Vaccine efficacy over a 7-year follow-up period for a study conducted by Vessey et al (2001) was demonstrated to be 88.5% overall. Other studies, such as one conducted by Vazquez et al (2004) demonstrated that vaccine efficacy may wane, from 97% in the first year following vaccination, to 86% in the 2nd year, with further decline to 81% in years 7 to 8 after vaccination.

Although immunity is long lasting, break-through disease following vaccination may be as high as 15-20% of individuals (6) when exposed to the varicella zoster virus. One study conducted by Vessey et al (2001) demonstrated a much lower rate of break-through disease; for a 7-year follow-up period break-through disease ranged from 0.2-2.3%. When break-through disease does occur, it is generally milder with fewer lesions (>50) and without fever (6,7,10,21-23). Despite the fact that break-through disease is mild, the individuals are contagious and may transmit the disease to susceptible persons

(6,10,21-23); however, this has not been documented in the absence of a rash (6). According to Jumaan et al (2002), only 3 cases of documented secondary transmission have occurred from a healthy vaccinee to a healthy contact with one of the varicella vaccines since 1995.

Although unproven, some potential risk factors for break-through disease could include history of asthma, steroid use, time since vaccination (3 or more years) (5), and administration of the live viral vaccine Measles Mumps Rubella (MMR) less than 30 days prior to administration of the varicella vaccine (5,7). Age younger than 15 months at initial vaccination has been suggested in several studies to be associated with break-through disease as well (5,7,10,25-27).

Since vaccine licensure in 1995, cases of varicella have declined approximately 80-85% (6,22). In addition, during the years 1995-2001, varicella-related hospitalizations decreased by 72-75% (5,6,13,22). In numbers, this corresponds to a decrease from 14,212 in 1993 to 3,720 in 2001 (5). One study documented a drop in hospitalization rate from .5 hospitalizations per 10,000 US population in 1993 to .13 per 10,000 in 2001 (28).

Another study conducted by Zhou et al (2005) noted similar results during the time frame 1994-2002, with varicella-related hospitalizations decreasing by 88%, from 2.3 hospitalizations per 100,000 US population to .3 per 100,000. Ambulatory care visits related to varicella have also decreased during the same time period by 59%, from 215 per 100,000 US population to 89 per 100,000 (29). The age group most affected by the decrease in both hospitalizations and ambulatory care visits was the 0-4 age group (28,29).

Medical expenditures directly associated with these hospitalizations and ambulatory care visits have decreased as well, by an estimated 74% (29). Davis et al (2004) note the estimated monetary costs in 2001 dollars associated with varicella-related hospitalizations to be $161.1 million in 1993 and $50.9 million in 2001. Similarly, Zhou et al (2005) note the associated costs of hospitalizations and ambulatory care visits to be $84.9 million in 1994/1995 and $22.1 million in 2002.

A corresponding decrease in varicella-related deaths has also occurred (13,22). For the time period from 1990-1994, there was an average of 145 deaths per year related to varicella, with the majority (89% of children and 75% of adults) of the deaths occurring in persons without associated high-risk conditions (13,30). This number decreased to 66 for the time period 1999-2001 (13), which resulted in a decrease in mortality of greater than 50% among those 50 years of age and younger (13,22) with the greatest decrease among children aged 1-4 years (3,13,31). This number has further decreased, with a total of 8 deaths reported to the CDC during the January 2003-June 2004 time frame, 6 of which occurred in children and adolescents <20 years of age (32). Of these 8 deaths, 6 occurred in unvaccinated individuals (32).

The CDC's 2001 National Immunization Survey estimated the varicella vaccination rate among children aged 19-35 months of age in individual states ranged from 52.8% to 89.9%, with a national average of 76.3% (12,33). This number increased to 81% in 2002 (29), and 85% in 2003 (33,34). The Healthy People 2010 goal is for the national coverage rate to be 90% (35). As of November 2004, 44 states including North Carolina have enacted mandates which require varicella vaccination for entry into daycare, elementary school, or middle school (34); this has most likely influenced the rate of vaccination, as it has in other states (36).

Surveillance

Varicella surveillance is necessary in order to measure and monitor the impact of the vaccination program, identify factors that allow cases to continue to occur despite a low incidence of the disease, as well as to guide future state and federal immunization policy. Two methods of surveillance are commonly used: passive and active. Passive surveillance is the more common method and requires less effort and resources, although it also tends to miss more cases. Active surveillance usually detects more cases, but is generally short-term, and requires more effort and funding than its counterpart (37).

Disease surveillance systems based upon these methods include national notifiable disease reporting; physician-, hospital-, laboratory-, and population-based surveillance; and sentinel surveillance (38). Many of these systems utilize case-based reporting (CBR), which typically entails the completion of a report form on new cases of disease including details such as demographic information, medical history, vaccination status, source of infection, severity of illness, and any other applicable comments and co-morbidities. Sentinel surveillance requires the recruitment of a representative proportion of healthcare providers, hospitals, or health departments within a designated area and the collection and submission of data from these sites.

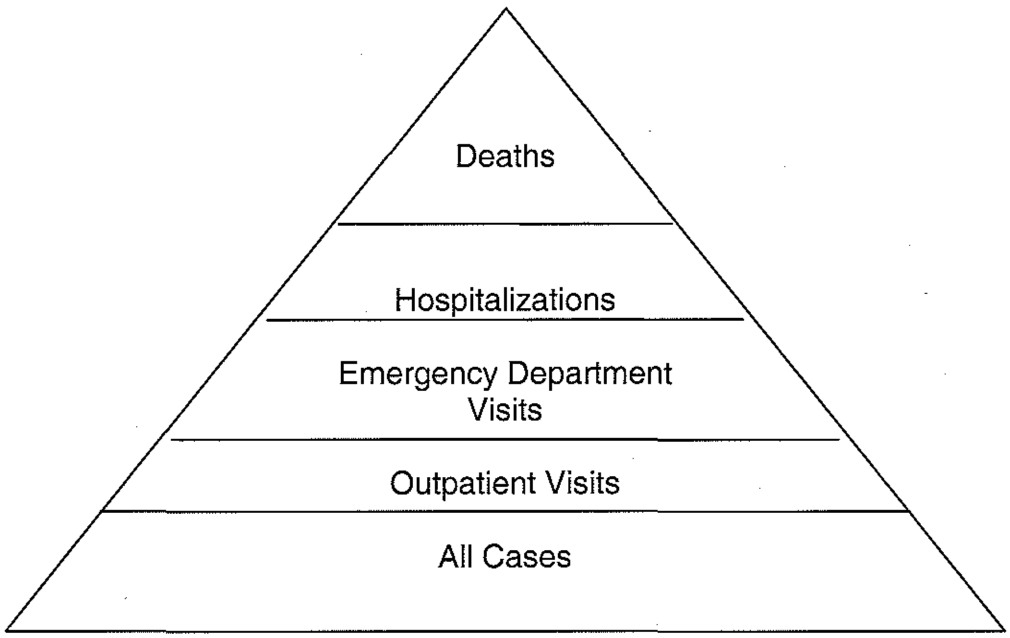
In 1997, the Council for State and Territorial Epidemiologists (CSTE), an organization comprised of public health officials at state health departments and the CDC, passed a resolution, and in 1998 a recommendation, to initiate surveillance for varicella a part of the National Public Health Surveillance System. CSTE recommended one of the following approaches: either individual or aggregate CBR on deaths related to varicella; hospital discharge data review; sentinel systems reporting; or appropriately designed random digit dialing surveys in order to monitor changes in varicella-related mortality and to understand why the deaths occurred. CBR or sentinel surveillance systems were the preferred methods. Case-based reporting on varicella deaths would be operationally feasible as the number of deaths attributed to varicella continued to decrease nationwide and thus the burden of reporting on individual states would be minimal (39,40). In 1999, CSTE recommended ongoing systematic morbidity surveillance to monitor the impact of varicella vaccination on the incidence of varicella within each state by 2005 (41). In the same year, CSTE also recommended that states report varicella-related deaths to CDC's National Immunization Program (NIP) (32-34), and thus varicella-related deaths became nationally notifiable.

Active surveillance for varicella has been in place since 1995 in 2-3 communities in the US (32,34). Passive reporting of aggregate (total number) cases has taken place in 23 states since 1995; this increased to 24 in 2004 (34). Currently, data from the National Center for Health Statistics suggests that there is significant underreporting of varicella-related deaths to the NIP (34). In addition, varicella hospitalizations are notifiable in approximately half of the states (34).

As previously discussed, with the increase in vaccine administration and resulting decrease in disease incidence, CSTE recommends that each state establish CBR systems (34,39,40). Options for initiating CBR are state-wide reporting, in which all sites within the state report individual cases of varicella, and sentinel site reporting, in which only select sites within the state report the individual cases (34). The plan for those states implementing sentinel site reporting is that it will expand to state-wide reporting when feasible (34).

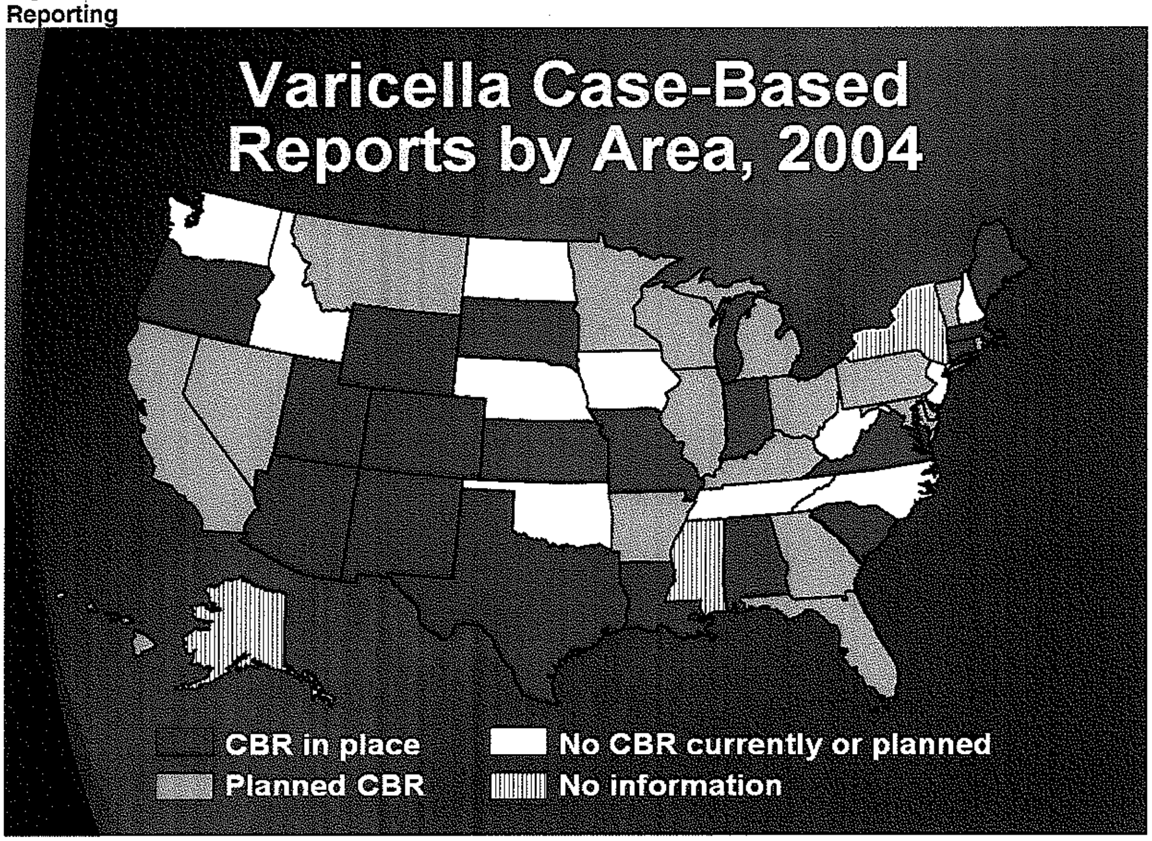
Different surveillance systems yield varying levels of results. CBR mortality surveillance is the least sensitive, captures the least number of cases, and provides a minimum of information necessary in order to evaluate the impact of the vaccination program. Individual state-wide CBR mortality and morbidity surveillance, on the other hand, provides the greatest amount of information and allows a state to assess varicella epidemiology by demographics, disease severity, and provides the most complete data to guide future policy (34) (Figure 1).

Figure 1. Information Available from Various Surveillance Methods



According to a 2004 survey of 51 jurisdictions (including Washington, D.C.) conducted by the CDC National Immunization Program in response to the CSTE recommendation for CBR by 2005, 23 conduct CBR. Another 17 indicated plans to implement CBR, and 2 conduct sentinel reporting. The remaining jurisdictions, of which North Carolina is one, either did not plan to implement CBR at that time or there was no information available (34). Figure 2 is a map showing the 2004 NIP survey results.

Figure 2. CDC National Immunization Program 2004 Survey Results for Varicella Case-Based Reporting



Source: CDC National Immunization Program, Current Issues in Immunizations net Conference Archive, January 19, 2005, available at: http://www.cdc.gov/nip/ed/ciinc/January_05.htm

States performing surveillance for varicella for which the methods are available include Virginia, Kansas, Michigan, Colorado, and Indiana. Virginia performs a combination of aggregate state-wide reporting and individual CBR, while both Michigan and Indiana perform sentinel site surveillance. Varicella-related hospitalizations were reported in Colorado from 1998-2003 and in 2004, state-wide CBR reporting was initiated. State-wide CBR reporting also occurs in Kansas. For the years 2000-2005 Virginia reported 592, 563, 605, 682, 1240, and 1817 cases of varicella, respectively (42). The numbers increased as the emphasis on reporting increased. A slight increase of 1.6% in cases between 2003 and 2004 was noted in Michigan, with 4,171 reported cases in 2003 and 4,240 cases in 2004 (43). Kansas reported a total case count (confirmed and probable) of 259 for 2004 (44). Colorado reported a significant decrease in hospitalizations, from 123 in 1998 to 32 in 2003, a decrease of 77%. The largest proportional rate decreases occurred in the <1, 1-4, and 5-9 year age groups. The number of varicella cases reported through CBR also decreased from 2004 to 2005, with 2,040 cases in 2004 and 1,797 cases in 2005 (45). In Indiana, the number of varicella-related hospitalizations has also decreased over the time period 2000-2003, with 184 hospitalizations in 2000, 129 for both 2001 and 2002, and 114 in 2003 (46).

North Carolina

North Carolina (NC) implemented varicella vaccine mandates for children entering daycare effective April 2002 (for children born on or after April 1, 2001), and is expected to implement mandates for elementary school entry in 2006 and middle school entry in 2012 (12). According to the 2001 CDC survey NC ranks 8th among all other states for varicella vaccination, with a rate of 83.1% (12,33) among children aged 19-35 months. NC vaccination rates for other mandated vaccines (DTP, Polio, MMR, Hib, HepB) are between 92.1 and 98.3% (12,33).

During the 1-year period of February 1, 2003 – February 4, 2004, the Immunization Branch of the NC Division of Public Health undertook a sentinel case-based surveillance study to assess the success of the varicella vaccine program. Elementary schools, child care facilities, private providers, health departments, and a hospital were included in the study. Across the 20 reporting sites, 220 cases of varicella disease were reported. Forty-five percent (99) of the 220 cases had received the varicella vaccine; of these, the known age of vaccination was less than 15 months of age for 65% (57) a suggested risk factor for break-through disease (47,48). Of the 217 cases with known ages, 41 or 19% occurred in children 4 years of age and younger; 65.8% (27) of these children had received the varicella vaccine. This study estimated the number of varicella cases in NC to be 6,600 cases per year, for an estimated incidence of 77.27 cases per 100,000 persons (utilizing 2004 state demographic information available at http://demog.state.nc.us/) (Christopher Summers-Bean, NC

Immunization Branch, oral presentation to the NC Immunization Advisory Council on September 21, 2004).

North Carolina began to conduct sentinel surveillance for varicella in hospital EDs across the state in 2005. An established database was utilized, and a report specific to varicella was created. The remainder of this paper will focus on describing the surveillance system and presenting the analysis of data from this surveillance system.

Study Design/Methods/Study Population

A retrospective emergency department population-based study examining the trends in varicella emergency health care utilization in NC and describing the demographics of this population was undertaken. Data were obtained from a static dataset comprised of data from patients presenting to select hospital emergency departments (ED) in NC. In NC, select hospital emergency departments (ED) have been voluntarily submitting data since 2003 for use in syndromic surveillance, an emerging method of surveillance that is designed to detect outbreaks earlier than traditional methods of surveillance. In 2005, mandatory reporting of specified electronically available ED data was signed into law. These data are collected, stored, analyzed, and parsed into syndrome categories by the North Carolina Emergency Department Database (NCEDD), a dynamic ED database which updates every 12 hours, and serving as a syndromic surveillance tool and the secure data repository for the state of NC. This system is designed to track the trends of several syndromes, including influenza-like illness, neurological illness, fever and rash illness, and gastrointestinal illness in patients seeking treatment in NC EDs. As of July 10, 2006, the database collects data from 82 (of 113) hospital EDs, and another 22 are sending test data in preparation for real-time production.

The data in NCEDD are covered by public health authority under HIPAA (Health Insurance and Portability and Accountability Act) and comprise only the limited data set as defined by HIPAA. While NCEDD does collect individual patient medical record numbers, this information is not considered to be a unique identifier, but an identifier within the healthcare system. NCEDD stores these numbers, but does not display them, so that DPH may retrieve them during times of public health investigation. Data elements within NCEDD and utilized in this analysis include International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) diagnostic codes, arrival date and time, 5-digit zip code, chief complaint, initial recorded temperature and other vital signs, ED nurse triage note, hospital name, type of insurance, age, date of birth, gender, race, ethnicity, mode of transportation (e.g., ambulance, private vehicle), allergy history, disposition (e.g, discharge home, admit to hospital), and admit diagnosis. As this study conducted analysis of secondary data which were de-identified, it did not require institutional review board approval or informed consent.

A static dataset comprised of all emergency department data housed within the NCEDD database from January 1, 2005 through March 31, 2006 was created. A subset of this dataset was created to include only those ED visits made by residents of NC, and a second subset was created to include only those ED visits made by residents of NC with a discharge International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) diagnostic code of varicella, 052.0-052.9. These ICD-9-CM diagnostic codes are:

- 052.0: post-varicella encephalitis (052.0),
- 052.1: varicella pneumonitis,
- 052.7: varicella with other unspecified complications,
- 052.8: varicella with unspecified complications, and
- 052.9: varicella without mention of complication.

We searched for the varicella discharge diagnostic code in any diagnostic position (up to 20 total positions) included for each ED patient visit.

All ED patient visits in the NC Varicella dataset were independently reviewed by 3 expert reviewers in order to confirm that the visits met clinical case criteria for either suspected or confirmed chickenpox. The expert reviewers were 3 currently practicing epidemiologists associated with the NC Division of Public Health and have formal training in pediatrics and family medicine. Two of the 3 have been active in the development and implementation of syndromic surveillance in NC. We defined varicella-related ED patient visits as those with a discharge diagnostic code of varicella (052.0-052.9) in any position and 1) mention of 'rash' or 'chickenpox' in the chief complaint, triage note, or admit diagnosis fields; or 2) either initial ED temperature or mention of 'fever' in the chief complaint, triage note, or admit diagnosis fields. We excluded patient visits for which there was either no supporting documentation for a discharge diagnosis of varicella within the available data fields, or the available documentation supported a discharge diagnosis of herpes zoster (ICD-9-CM 053.xx).

Data Analysis

Analyses were designed to describe in North Carolina 1) the incidence of varicella in ED visits; 2) the burden of varicella on healthcare systems; and 3) demographic characteristics of the population presenting to the state's EDs for treatment of varicella. We conducted all analyses utilizing SAS, version 9.1, statistical software (SAS Institute Inc, Cary, NC).

Analyses were performed on severity of illness (e.g., outcome) based on specific ICD-9-CM code as well as age; age and ethnicity; gender and ethnicity; race; county of residence; and type of insurance. In addition, ED use trends were analyzed for season and day of week.

Results

For the 15-month period of time between January 1, 2005 and March 31, 2006, the NC ED dataset contained 673,175 patient visits made by 464,733 patients. The NC Varicella dataset contained 210 patient visits made by 205 patients for the same time period. Following the independent expert review, 33 visits were excluded, leaving 183 patient visits for analysis. These visits were made by 179 residents of NC. Visits were excluded for the following reasons: no evidence of fever (documented or stated); documentation of shingles; and documentation did not correlate with a final discharge diagnostic ICD-9-CM code of varicella (e.g., leg pain after fall).

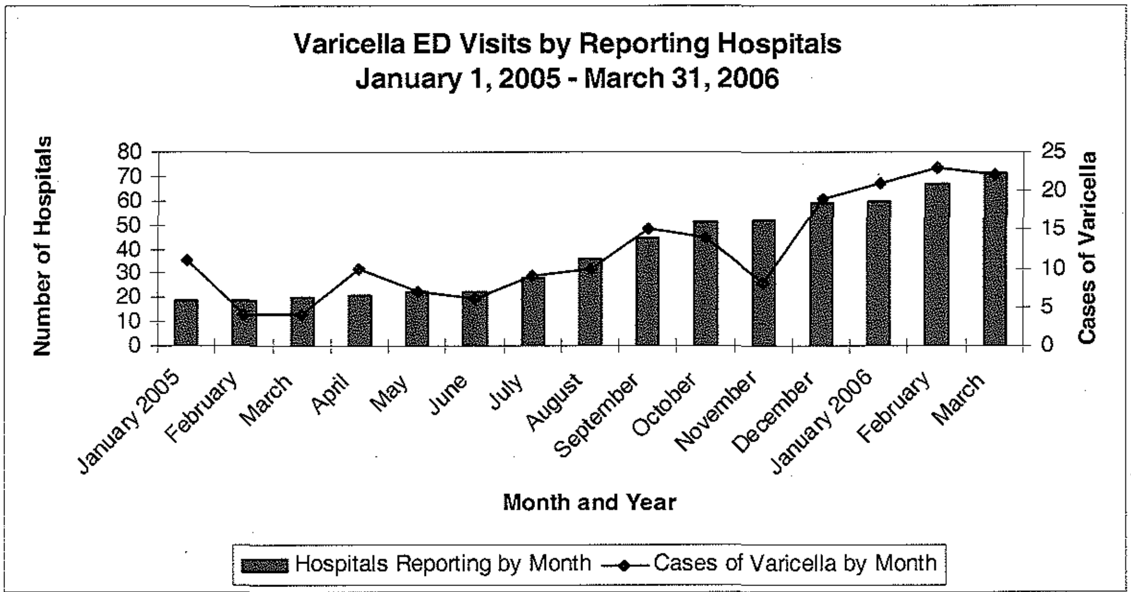
Patients with a discharge diagnosis code of varicella (179) comprised a small proportion, .04%, of all NC residents presenting to EDs during the 15-month time period. Similarly, varicella-related patient visits (183) comprised .03% of all NC ED visits made by NC residents.

The majority (78.7%) of the 183 varicella discharge ICD-9-CM diagnostic codes were located in the principal diagnostic code position. The remainder fell into positions 2 (17.5%), 3 (2%), 4 (1%), and 5 (.5%).

Varicella Visits & Reporting Hospital Emergency Departments

As reporting of available electronic ED data was voluntary beginning in 2003, and the mandate became effective January 2005, the number of hospitals in active production reporting ED data has gradually increased over the time of the study period. Thus, 19 hospital EDs were reporting January 1, 2005, and 71 were reporting at the conclusion of the study period March 31, 2006. It follows logically, then, that as the study period progressed, the trend in the number of ED visits related to varicella correlated with the increasing number of reporting hospital EDs. This did in fact occur, and is demonstrated in Figure 3.

Figure 3. Varicella-related Emergency Department Visits and Number of Reporting Hospitals during Study Period

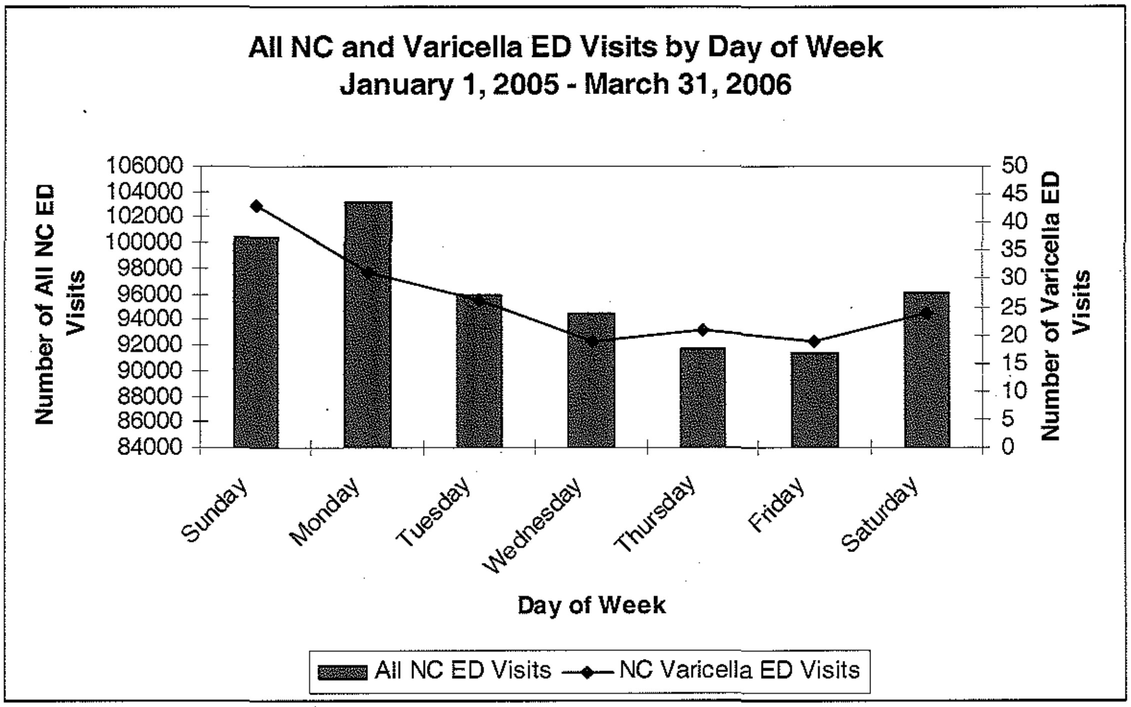


Seasonal & Weekday Trends

As Figure 3 demonstrates, the number of ED visits related to varicella varied over the study period as additional hospitals began reporting ED data. It is difficult, then, to differentiate seasonal trends. For example, the percentage of varicella-related ED visits occurring in February and March 2005 was 2.2% as compared to 12.6% in February 2006. Furthermore, the percentage of varicella-related visits compared to all NC ED visits was negligible, less than .0004% per month.

23.5% of the varicella-related ED visits occurred on Sundays, with the smallest percentage occurring on Wednesdays and Fridays, both with 10.4%. This did not differ significantly from the overall ED visit trend, as the highest percentage occurred on Mondays (15.3%), followed closely by Sundays (14.9%), with the lowest percentages occurring on Fridays (13.6%). Figure 4 displays the number of overall ED visits and varicella-related ED visits by weekday.

Figure 4. All North Carolina and Varicella-related Emergency Department Visits by Day of Week



Demographic Information

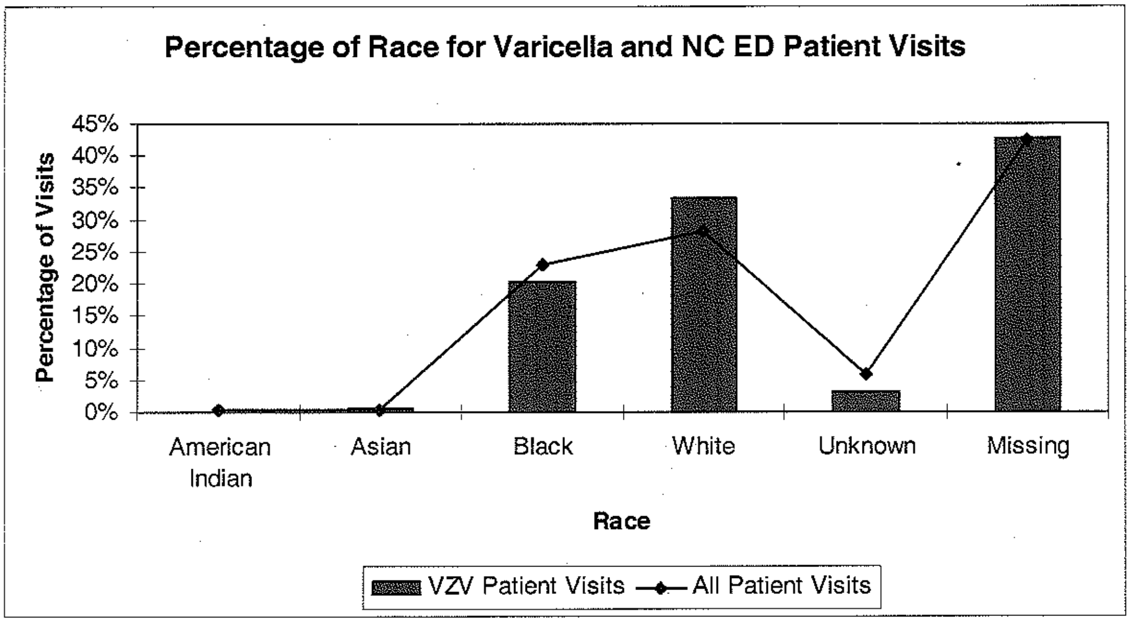
Gender

Both the varicella ED visits and NC ED visits were similar in gender distribution, with females making up 54.6% of the varicella visits and 55.1% of the NC ED visits. Males therefore comprised 45.4% of the varicella visits and 44.9% of the NC ED visits.

Race/Ethnicity

A significant proportion of data on race for both populations were missing, approximately 42.5% for both. The available data, however, displays a similar trend for both the varicella and NC ED visits, with a higher proportion of visits in persons of Caucasian descent, 33.3% and 28.3% respectively, followed by persons of Black descent, 20.2% and 23% respectively (Figure 5).

Figure 5. Percentage of Race for both Varicella and North Carolina Emergency Department Visits

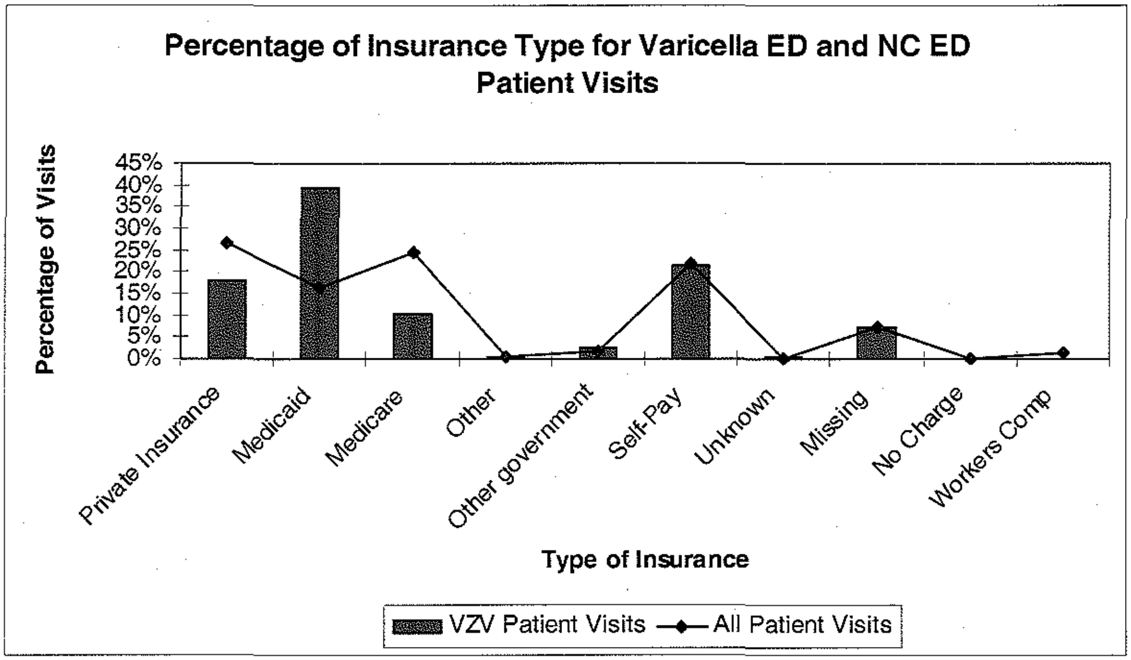


A similar situation exists with the ethnicity data, in that approximately 42.5% of the data for both populations are missing. A high proportion of ethnicity data was also entered as 'unknown'; 38.8% for varicella visits and 53.4% for NC ED visits. Of the available data for varicella visits, however, individuals of Hispanic origin comprise 18% of the visits, as compared to 3.6% of all other NC ED visits.

Insurance

Types of insurance include private, Medicaid, Medicare, other, other government, self-pay, workers compensation, and no charge. For both varicella-related ED visits and NC ED visits, approximately 7% of the data were missing for insurance type. Figure 6 displays the proportion of insurance types for both populations of ED visits. The most significant difference between the type of insurance utilized by the two ED populations was Medicare and Medicaid; Medicaid was the most common type of insurance for varicella-related ED visits with 39.3% as compared to 16.5% of the NC ED visit population claiming Medicaid. Similarly, Medicare was utilized by only 10.4% of the varicella-related ED population visits, while 24.2% of the NC ED population visits claimed Medicare.

Figure 6. Percentage of Insurance Type for both Varicella-related and North Carolina Emergency Department Visits



Severity of Illness

Of the 183 varicella-related ED patient visits, almost all (178, or 97%) contained the ICD-9-CM discharge diagnostic code of 052.9, or varicella without mention of complications (Table 1). In addition, the majority of the cases (96%) were discharged to home. Of the remaining 5 cases with ICD-9-CM discharge diagnostic codes other than 052.9, 1 was a case of post-varicella encephalitis, 2 were cases of varicella with unspecified complications, 1 was a case of varicella pneumonitis, and 1 was a case of varicella with specified complications (which were not available in ED visit information). This last patient was the only one admitted to the hospital, and was admitted to the intensive care unit.

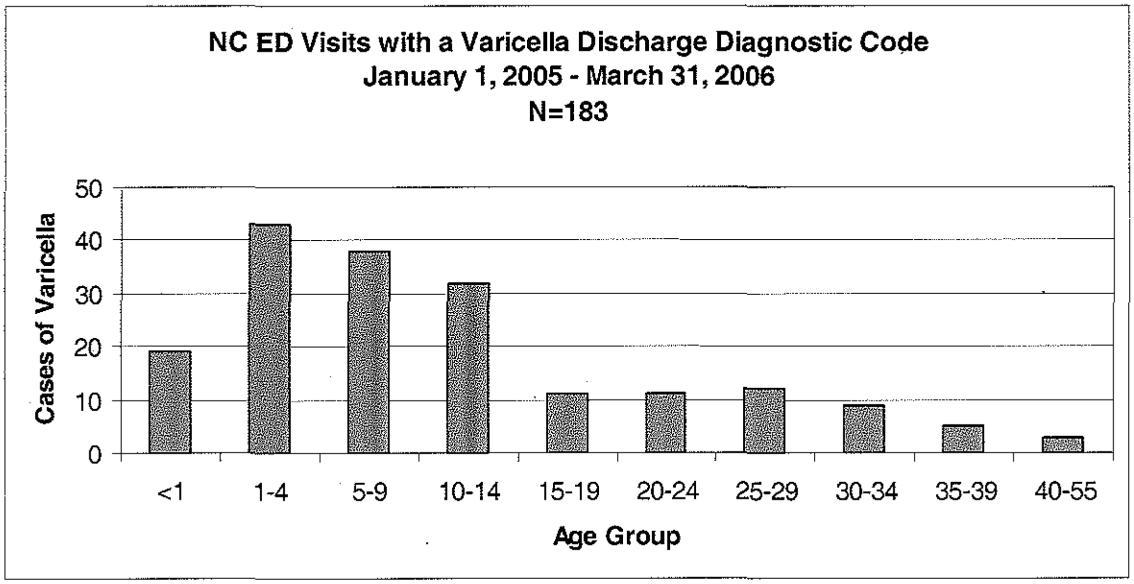
Table 1. Number and percentage of Varicella ICD-9-CM codes

Specific ICD-9-CM Code	# Cases	Percentage
052.0 (Post-varicella encephalitis)	1	0.55%
052.1 (Varicella pneumonitis)	1	0.55%
052.7 (Varicella w/specified complications)	1	0.55%
052.8 (Varicella w/unspecified complications)	2	1.09%
052.9 (Varicella w/o mention of complications)	178	97.27%
Total	183	100.00%

Age-Related Patterns

The age distribution of varicella-related ED visits in NC displayed in Figure 7 follows a predictable and common trend, with the highest number of visits occurring in children 1-4 years of age comprising 23.5% of the visits, followed closely by children aged 5-9 years with 20.8% of the visits. The median age for all ED varicella visits was 9 years of age, with a range of 0-51 years of age.

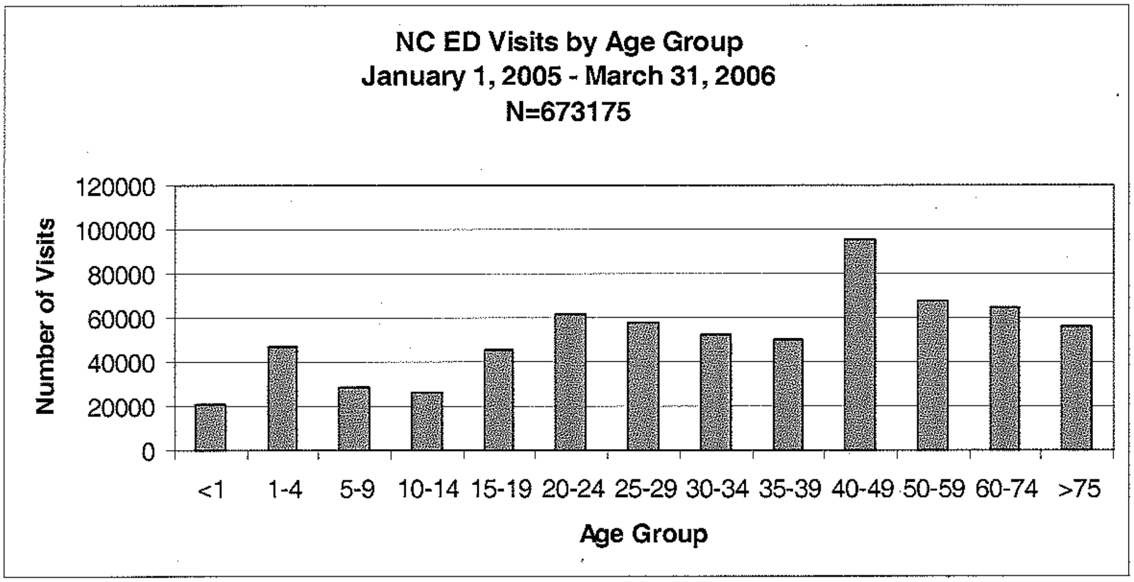
Figure 7. North Carolina Emergency Department Visits with an ICD-9-CM Varicella discharge diagnostic code



The case of post-varicella encephalitis occurred in a child less than 1 year of age. Similarly, the cases of varicella with unspecified complications occurred in 2 children, one less than 1 year of age, and a 2 year old. A child 9 years of age suffered from varicella pneumonitis, and an adolescent aged 19 years was hospitalized in an ICU for varicella with specified complications. There was no change in the median age or age range of the remaining cases.

The age range distribution of the varicella visits differed significantly from the overall ED population, as the largest number of visits were made by those individuals 40-49 years of age, comprising 14.2% of all ED visits, followed by those aged 50-59, with 10.1% of all ED visits (Figure 8). The 1-4 year age range comprised only 7% of all ED visits, and the 5-9 year age range even less with 4.2% of all ED visits.

Figure 8. All North Carolina Emergency Department Visits by Age Group



Geographic Distribution

Of the 100 counties in NC, 54 of them housed a total of 76 hospital EDs in active production which reported data for some portion, if not all, of the time period during this study. 42 counties reported varicella-related ED visits, with 3 counties reporting a significant proportion of these visits, at 83 cases or 45.4% of all varicella-related ED visits. Thirteen other counties reported between 3 and 9 cases each (Table 2).

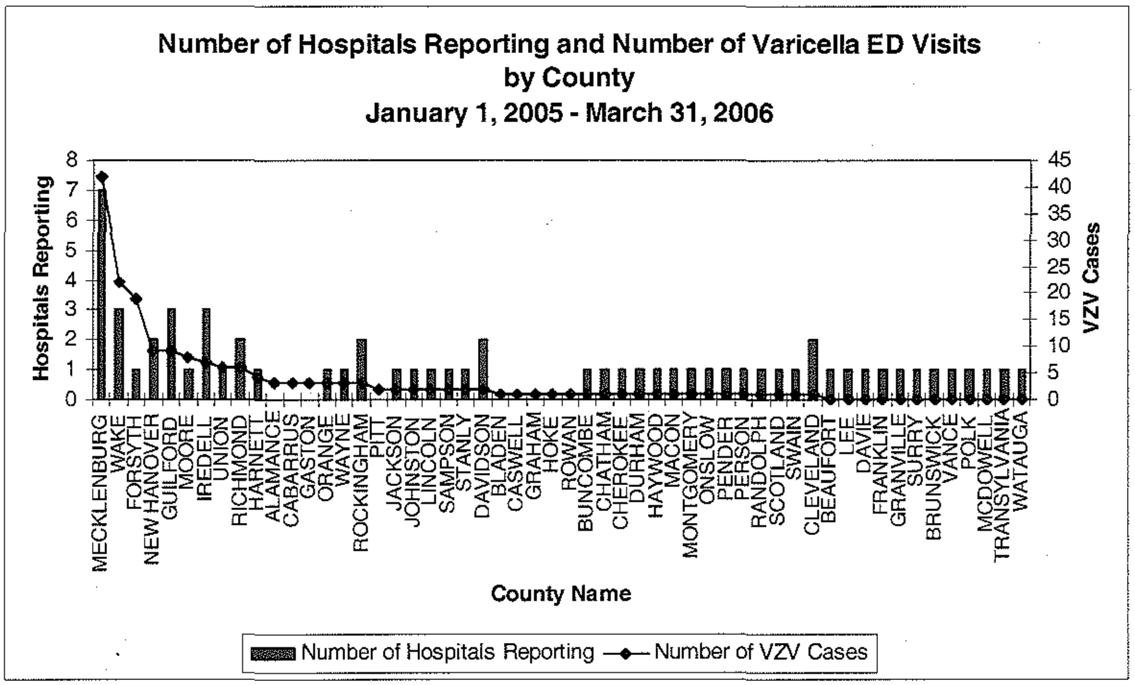
Table 2. North Carolina Counties reporting >3 Varicella-related ED Visits

County	Number of Varicella ED Visits	Percentage of Varicella ED Visits
MECKLENBURG	42	22.95%
WAKE	22	12.02%
FORSYTH	19	10.38%
GUILFORD	9	4.92%
NEW HANOVER	9	4.92%
MOORE	8	4.37%
IREDELL	7	3.83%
RICHMOND	6	3.28%
UNION	6	3.28%
HARNETT	4	2.19%
ALAMANCE	3	1.64%
CABARRUS	3	1.64%
GASTON	3	1.64%
ORANGE	3	1.64%

ROCKINGHAM	3	1.64%
WAYNE	3	1.64%

The number of reporting hospital EDs by county ranged from 0-7, with a median of 1. Ten counties with varicella-related ED patient visits attributed to them did not house any active production reporting hospital EDs. By county, the number of hospitals actively reporting electronic ED data and the number of varicella-related ED visits is displayed in Figure 9.

Figure 9. Number of North Carolina Hospitals Reporting ED Data and Number of Varicella-related ED Visits



Discussion

This is the first analysis of data from the emergency department sentinel surveillance system for varicella infection in NC. Patients with a discharge diagnosis code of Varicella comprise only a small proportion, .04%, of all NC residents presenting to EDs during the 15-month time period, and varicella-related visits comprise .03% of all NC ED visits. However, in children 9 years of age and younger, approximately 1% of all ED visits were for varicella infection.

Based upon this first review of the data, the severity of disease is moderate in those presenting to our EDs, as 178 of 183 visits had a discharge ICD-9-CM diagnostic code of varicella without complications. Of the remaining 5 varicella-related ED visits with complications, only 1 was hospitalized. Three of the varicella visits with complications occurred in children 2 years of age or younger. One additional varicella visit with complications occurred in a 9 year old. Only one varicella visit with complications occurred in an adult; this 19 year old was hospitalized in the intensive care unit as a result. This correlates with data demonstrating that severity of varicella illness is greater in older adolescents and adults.

The age range distribution of the varicella visits differed significantly from the overall NC ED population, with the highest percentage of visits occurring in children 1-4 years of age (23.5% of visits) and children aged 5-9 years (20.8% of visits) while the highest percentage of visits among the NC ED population occurred among the people over 40 years of age (42.3%). This finding is consistent with the known epidemiology of varicella infection (7). The percentage of varicella-related visits was highest in the 1-4 year old age range despite research indicating that the greatest decrease in national disease, hospitalizations, and deaths occurred in the 0-4 year age group (3,13,28,29, 31). It is important to state, however, that the peak age for infection in the pre-vaccination era was 1-4 years, and thus even if the greatest decrease did occur in this age group, it still may have the highest proportion of overall cases.

Although the method of sentinel surveillance differed between our study and that performed by the NC Immunization Branch in 2003-2004, it is interesting to note that children less than 4 years of age continue to suffer from varicella infection. Due to the differing natures of these 2 NC studies, it is difficult to compare trends in order to determine whether there has been a true change in the incidence or prevalence of the disease in our state. Of the 220 cases identified in the 2003-2004 study, 41 or 19%

were children 4 years of age and younger, while in our study of the 183 ED visits with an ICD-9-CM discharge diagnostic code of varicella, 62 or 34% were children 0-4 years of age.

Medicaid was the most common type of insurance for varicella-related ED visits with 39.3% as compared to 16.5% of the NC ED visit population. Similarly, Medicare was utilized by only 10.4% of the varicella-related ED population visits, as compared to 24.2% of the NC ED population visits. This difference is most likely related to the difference in age distribution, as the varicella predominantly affected children, who are subject to more liberal eligibility criteria for Medicaid than adults.

While Hispanics comprised 18% of the varicella-related ED visits, as contrasted to 3.6% of all NC ED visits, this information may be skewed as a significant proportion of this variable was not available for either population (>40%). Therefore, it is difficult to determine the significance of ethnicity as a factor in the varicella-related ED visits. It is, however, necessary to briefly mention that varicella is not endemic in Central and South America (49,50), and thus our finding may truly reflect that the Hispanic population is disproportionately affected in NC.

One strength of our sentinel surveillance approach is that it utilizes an existing system which is currently being developed for other uses; therefore it is efficient, useful, and consistent. The availability of electronic data also is an added benefit; however, the data is limited in utility when the electronic data is not populated by the ED personnel. Therefore, a limitation of the surveillance system and this study is that it relies on the completion and accuracy of the data fields as entered by individuals who may or may not understand the importance of such completeness or accuracy.

Similarly, the primary purpose of ED data is documentation of care and not public health surveillance. Thus the information obtained is limited to the electronically available text and data fields and may not be entirely useful or relevant for surveillance.

Likewise, information which would be particularly useful for varicella-related surveillance, such as vaccination information, is not readily available. Because this vaccination information is not available, we are unable to assess the success of vaccination utilizing this data source at the current time.

Finally, the primary purpose of ICD-9-CM codes is for administrative billing, and not for surveillance. This information is assigned by coders some time following the patient visit; thus, this information is typically not available in a timely manner. A study by Travers et al (2003) found that over half of the hospital EDs in NC and Washington State did not have electronic diagnosis data available until 1 week or more after the ED visit. Another study by Travers et al (2006) which utilized the same database upon which this study was based, found that 24 hours after the initial transmission of ED visit data, only 12% of the visits had at least one diagnosis code; by the 2 week interval, 64% of the visits had diagnosis data available, and at 12 weeks 86% of the visits had one or more diagnoses available for surveillance.

Compared to other surveillance methods and in spite of the delays in the availability of ICD-9-CM diagnostic codes, the data available from EDs is rich, and is available in a much timelier manner than hospitalization data, which in NC is not available until at least one year later. Additionally, ED visit surveillance for varicella provides a higher yield of cases, as well as valuable information related to demographics and severity of illness, than is yielded by surveillance for varicella deaths or hospitalizations alone. Sentinel ED surveillance, however, most likely identifies fewer cases and less detailed information than a sentinel outpatient-visit surveillance system designed specifically for varicella infections might identify.

Conclusions

Since the US licensure of the varicella vaccine in 1995, a drastic decline in associated morbidity and mortality has taken place. However, in spite of the high national rate of vaccination, disease and death from varicella infection still occur. In order to better evaluate the impact of the vaccination program and identify factors that allow cases to continue to occur, the implementation of timely and complete surveillance systems is necessary. In 2005, North Carolina implemented a sentinel ED surveillance system with the intent of capturing varicella-related ED visits in order to better estimate the incidence of disease and its characteristics. The system proved efficient, cost-effective, and useful, producing data that demonstrated a low incidence (proportion) of disease with minimal burden on healthcare systems. Further research is planned to confirm these results; however in order to do so, a more comprehensive system may need to be implemented. Ultimately, although not as efficient and more burdensome, the optimal surveillance for varicella will be individual case-based surveillance which will best guide future state immunization policy. This ED surveillance over time will help to guide our state in determining when it may be feasible to effectively implement this individual case-based surveillance.

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