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Characterization of 386 Non-typhoidal Salmonellosis Cases in North Dakota from 2000 to 2005

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SUMMARY

The objectives of this study were to compare salmonellosis incidence in North Dakota (ND) to the United States average and to describe food histories as well as to identify factors associated with severe salmonellosis and longer hospitalization. Data on salmonellosis cases (2000–2005) were obtained from the ND Department of Health. Chi-square tests, binary logistic regression, and multinomial logistic regression were used to determine variables that best predicted severe salmonellosis and long duration of hospitalization. There were 386 cases from 45/53 ND counties, with incidence rates ranging from 1 to 21/10,000. Forty-five *Salmonella* serotypes were reported, including *S.* Typhimurium (33.1%), *S.* Enteritidis (14.2%), *S.* Heidelberg (11.7%) and *S.* Newport (11.4%). Among foods associated with salmonellosis, fresh produce ranked first. Traveling, contact with farm animals, and consumption of milk products were exposure factors that were associated with development of severe salmonellosis, whereas cramps or diarrhea were symptons that predicted severity of disease. In addition, the odds of longer hospitalization increased for persons older than 60, and for those with fever, nausea, or vomiting. Salmonellosis incidence in ND (1/10,000) was lower than the national average (1.5/10,000). This information is vital in guiding health providers and consumer educators in their efforts to raise risk factor awareness of the public, food processors, and service industries in order to target achievable salmonellosis control strategies.

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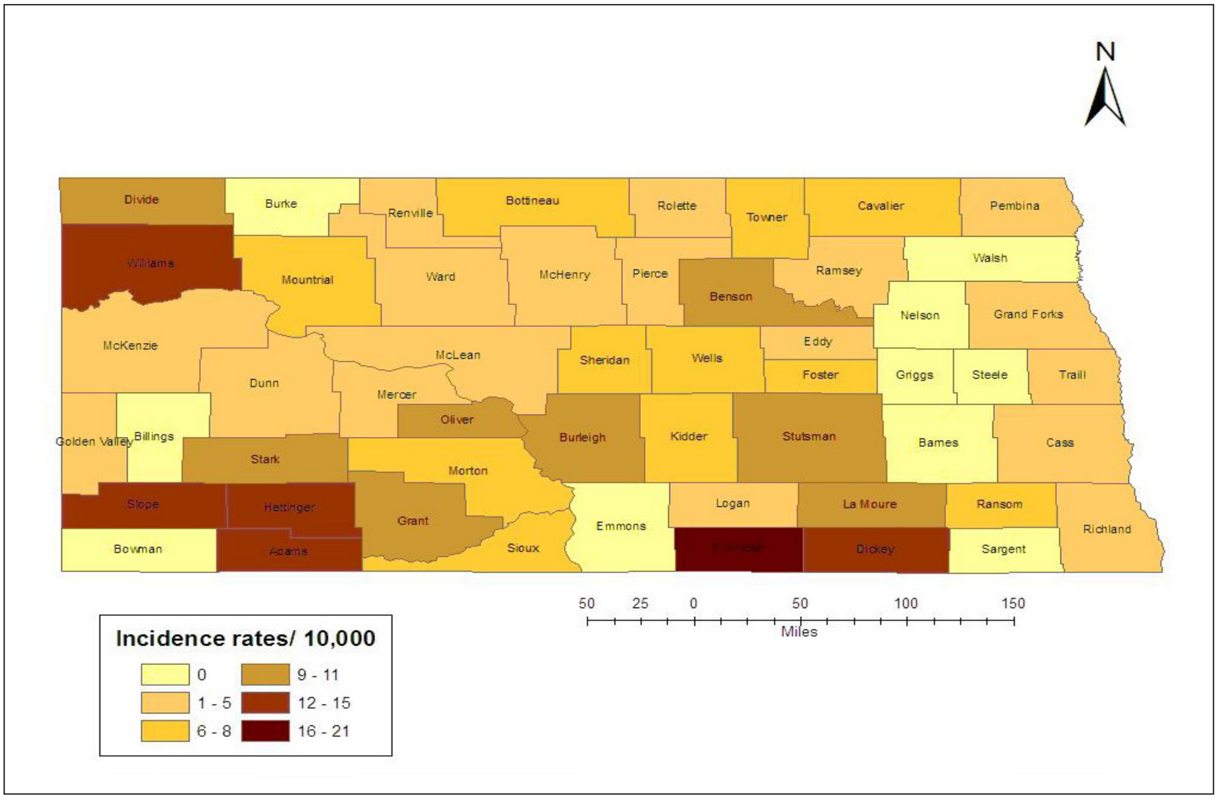
FIGURE 1. Incidence rates of human salmonellosis in North Dakota: 386 cases (2000–2005)



INTRODUCTION

Non-typhoidal salmonellosis is a common foodborne illness in humans in the United States *(7)*. National surveillance for *Salmonella* infections was established in 1962 following recognition of the importance of *Salmonella* organisms as the cause of a potentially preventable infectious disease. All health care providers and laboratories in the US are mandated by law to report a positive associated case of this disease to the health department, which then reports to the Centers for Disease Control and Prevention (CDC) *(1)*. In spite of an efficient surveillance system, many cases may still not be reported because the ill persons do not seek medical care because of the self-limiting nature of the disease or because health-care providers do not obtain a specimen for diagnosis. In addition, the laboratories may not perform the necessary diagnostic tests, or the laboratory findings may not be communicated to public health officials, resulting in underreporting of cases. Nevertheless, CDC estimates that 1.4 million people in the US are affected annually by salmonellosis alone, of which approximately 40,000 are reported every year, and that about 600 of these die each year *(15)*.

Most persons infected with *Salmonella* develop diarrhea, fever, and abdominal cramps 12 to 72 hours after infection. The illness usually lasts 4 to 7 days, and most persons recover without treatment *(9)*. However, in some persons the diarrhea may be so severe that the patient needs to be hospitalized. In these patients, the *Salmonella* infection may spread from the intestines to the blood stream and then to other body sites, and death can result unless the person is treated promptly with antibiotics. The elderly, infants, and those with impaired immune systems are particularly likely to have a severe illness *(20)*.

Salmonella organisms can be found in many environments, including water, soil, insects, factory and kitchen surfaces, animal feces, and the unwashed hands of food handlers *(9)*. *Salmonella* is also widespread in live animals *(16, 24)*; in North Dakota (ND), there are reports of *Salmonella* infection contracted from an iguana that was kept as a pet *(2)*. Additionally, *Salmonella* was isolated from a hamster that was purchased from a pet store in ND *(17)*; fortunately, no human case of salmonellosis was associated with *Salmonella* from the hamster. Furthermore, a variety of foods, including contaminated breast milk, ice cream, raw meats, poultry, eggs, sea foods, and fresh produce *(5, 6, 8, 11, 12, 22, 23, 26, 27)*, have been implicated in human *Salmonella* infections. In North Dakota, a positive case of salmonellosis was associated with eating improperly cooked turkey meat *(18)*.

This study was designed based on the hypothesis that salmonellosis incidence rates in North Dakota are comparable to the national average rates and that consumption of certain foods is particularly highly associated with human salmonellosis. Similarly, it was hypothesized that one or a combination of exposure factors and development of certain symptoms determine severity of salmonellosis or duration of hospitalization. The objectives of this study were to compare salmonellosis incidence rates in North Dakota to the national average, and to describe the food history and other exposure factors associated with salmonellosis infections in humans in North Dakota. In addition, the study sought to develop models that would best predict severe salmonellosis and duration of hospitalization based on symptoms and exposure factors.

MATERIALS AND METHODS

Data sources

Salmonellosis cases were extracted from the enteric disease investigation database of the North Dakota Department of Health (NDDoH) for the period 2000 to 2005. The extracted variables included food history, symptoms, and several exposure factors. The NDDoH was using a similar standardized surveillance tool (questionnaire) for investigation of all enteric diseases. This form required entry of information on exposure factors two weeks prior to onset of illness in order to capture data on listeriosis, which has a much longer incubation period than most enteric organisms. The NDDoH field epidemiologists are trained to know how far back to go in history for each organism, and for the most part, they try to obtain a 3-day history. For salmonellosis investigation, therefore, data were collected on the food history for 3 days prior to illness (Goplin J, Foodborne Surveillance Epidemiologist, North Dakota Department of Heath, personal communication, January, 2007). The food items in this analysis were categorized as red meats (beef, pork, and lamb), turkey meat, eggs, chicken, cold cuts (unspecified type of red meat, turkey or chicken), sea foods (fish, crabs, oysters, and shrimps), fresh produce (vegetables, fruits, juice, and salad), and milk products (milk, ice cream, yogurt, and breast milk).

Information on symptoms and onset dates and times of each symptom was obtained from reviewing the medical chart, if available. This information was then confirmed by interviewing the patients (in case of adults) or caretakers (in case of children). (Goplin J, Foodborne Surveillance Epidemiologist, North Dakota Department of Heath, personal communication, January, 2007). The symptoms included fever, diarrhea, vomiting, headache, cramps, nausea, chills, blood in stool, and other complications (blood in urine, anorexia, back pain, arthritis, heart pain, or weight loss). Demographic factors included age and sex of a patient; exposure factors included animal contact (dog, cat, reptile, or farm animal), travel within or outside the US (30 days prior to onset of illness), eating in a restaurant (or commercial food establishment or group gathering) within 14 days prior to onset of illness, and drinking well water. Other information included county of residence; antibiotic use for salmonellosis; year and month of onset of illness; and date of admission and discharge from the hospital. If the interview was completed before the patient was discharged, NDDoH staff did not always go back to get information on the discharge date. Therefore, hospitalization dates but no discharge dates were available for some patients. The variable "month" was further categorized into seasons such as fall (September, October, and November), winter (December, January, and February), spring (March, April, and May) and summer (June, July, and August). Severity of salmonellosis was the outcome variable, and a severe case of salmonellosis was defined as a person with *Salmonella* infection who was hospitalized or received antibiotics as an outpatient. Duration of hospitalization as an outcome variable was derived from the difference between the discharge date and the admission date.

Statistical analysis

Data were entered into Microsoft Excel and analyzed by use of SAS, version 9.1 (SAS Institute). Mapping the spatial distribution of cases and incidence rates by county were performed with the Geographical Information Systems (GIS). The significance of various relationships between independent and outcome variables was assessed by use of a chi-square test. Independent variables were treated as binary (factor exists = 1 or factor does not exist = 0), and a univariate logistic regression analysis for each independent variable was conducted with $P < 0.05$ being the criterion for the significance of the independent variable to the outcome variable. The severity of salmonellosis infection as an outcome variable was predicted by use of a binary logistic regression model (severe = 1 or not severe = 0), and longer duration of hospitalization was predicted with a multinomial logistic regression method. Days of hospitalization either were zero or ranged from a few hours to 15 days, and these were categorized as no hospitalization = 0, less than a day = 1, 1 to 4 days = 2, and more than 4 days = 3. Further, independent variables were grouped into two broad categories: symptoms and risk factors (food history and exposure factors); separate models were developed for symptoms and risk factors that were significantly associated with severity of salmonellosis and with duration of hospitalization. To select variables for the final models (binary logistic regression model and multinomial logistic regression model), a stepwise strategy (to avoid multicollinearity) was used, with a P- < 0.25 being the criterion for acceptance into the model. The variables that ended up in the final model are those that maintained a P- < 0.05. In addition, the odds ratio (OR) and a 95% confidence interval (CI) were used to determine the significance of the variable in the model.

RESULTS

Salmonellosis cases by county

A total of 386 cases of salmonellosis were diagnosed from 43 of the 53 counties of ND in the period 2000–2005. Eight of the 43 counties (19%) contributed 262 (68%) of all cases of salmonellosis: Burleigh 67 (17.8%), Cass 62 (16.5%), Ward 27 (7.2%), Grand Forks 23 (6.1%), William 24 (6.4%), Stack 22 (5.8%), Stutsman 20 (5.3%) and Morton 17 (4.5%). Ten counties (Barnes, Billings, Bowman, Burke, Emmons, Griggs, Nelson, Sargent, Steele and Walsh) did not have any diagnosed salmonellosis case. Incidence rates were calculated to account for the population variability among counties. Figure 1 shows that McIntosh County registered the highest incidence rate of 21/10,000 (twenty-one salmonellosis cases among ten thousand people), followed by Williams, Hettinger, Adams, Slope, and Dickey, with a range of 12/10,000 to 15/10,000. The rest of the counties, with relatively high incidence rates of 9/10,000 to 11/10,000, were Divide, Oliver, Burleigh, Stark, Grant, Stutsman, La Moure, and Benson.

Salmonellosis cases by person

Salmonellosis cases were comprised of 191 (50.1%) males and 190 (49.9%) females. The majority of the cases (217, 56%) did not indicate whether they were married or not. However, among those who reported marital status, there was a slightly higher proportion of unmarried cases (90/169, 53.3%) presenting with salmonellosis. The ages of cases/patients ranged from a few months to 94 years (mean ± standard deviation was 35 ± 24 years). Salmonellosis case distribution by age group showed that patients 21–40 years had the highest percentage (93 cases, 24.1%), followed by those aged

TABLE 1. Exposure factors that predicted severity of human salmonellosis in North Dakota: 386 cases (2000–2005)

Exposure Factors (0.15)	Severity cases/Total cases	Univariate Odds Ratio (95% CI)	Univariate *P*-value (0.05)	Stepwise *P*-value
Travel	63/75 (84.0)	5.8 (3.0–11.1)	< 0.0001	0.0002
Restaurant	93/125 (74.4)	3.6 (2.2–5.7)	< 0.0001	.
Well water	24/34 (70.6)	2.1 (0.9–4.6)	0.0494	.
Cat	45/58 (77.6)	3.4 (1.8–6.5)	0.0002	0.0101
Dog	80/109 (73.4)	3.1 (1.9–5.0)	< 0.0001	.
Reptiles	13/21 (61.9)	1.4 (0.6–3.4)	0.4946	0.2441
Farm animals	33/40 (82.5)	4.4 (1.9–10.3)	0.0005	0.0029
Meats	54/77 (70.1)	2.3 (1.3–3.9)	0.0027	.
Fresh produce	91/125 (72.8)	3.1 (2.0–5.0)	< 0.0001	.
Cold cuts	17/27 (62.9)	1.4 (0.6–3.2)	0.3712	0.0982
Sea foods	26/32 (81.3)	4.0 (1.6–9.6)	0.0031	.
Turkey	9/10 (90.0)	7.8 (0.9–61.8)	0.0511	0.2308
Eggs	70/87 (80.5)	4.6 (2.6–8.3)	< 0.0001	0.1837
Chicken	48/65 (73.9)	2.7 (1.5–5.0)	0.0009	0.1825
Milk products	34/43 (79.1)	3.5 (1.6–7.6)	0.0012	0.0233

41–60 years (92 cases, 23.8%), over 60 (63 cases, 16.3%), 3–12 years (58 cases, 15%), 13–20 years (46 cases, 11.9%) and last 0–2 years (34 cases, 8.9%).

Salmonellosis cases by time

The distribution of annual salmonellosis cases showed that 2005 (96, 24.9%) had the highest number of cases, followed by 2001 (73, 18.9%), 2000 (73, 18.9%), 2002 (53, 13.7%), 2004 (46, 11.9%), and last 2003 (45, 11.7%). The number of salmonellosis cases higher in 2000 and 2001, dropped during the period 2002–2004, but then rose again in 2005. The annual distribution of salmonellosis cases was significantly different ($P < 0.0001$). The distribution by season showed that the largest number of salmonellosis reported cases occurred in summer (153, 39.6%), followed by fall (83, 21.5%), winter (77, 20%) and spring (18.9%) ($P < 0.0001$).

Salmonellosis cases by food history

Patients sought medical assistance from primary care physicians without any evidence of a causative vehicle. Overall, 177 (45.9%) of the cases did not report the food items that they had eaten. Among those who mentioned a food item they had eaten, 188/209 (90%) mentioned more than one food. Turkey meat consumption was reported by 10 (2.6%) cases, cold cuts by 27 (7%), seafood by 32 (8.3%), milk and milk products by 43 (11.1%), meats by 77 (20%), chicken by 65 (16.8%), and eggs by 87 (22.6%); the greatest percentage had eaten fresh produce (125, 32.4%).

Salmonellosis cases by serotype

Forty-five different serotypes were recovered from 71.8% (277/386) of the patients. The four major ones, contributing over 70% of the cases, were *S.* Typhimurium (93, 33.1%), *S.* Enteritidis (40, 14.2%), *S.* Heidelberg (33, 11.7%) and *S.* Newport (32, 11.4%). The rest of the serotypes were *S.* Saintpaul and *S.* Montevideo from eight cases each; *S.* Thompson from five cases; *S.* Hadar from four cases; and *S.* Stanley, *S.* Poona, *S.* Mbandaka, *S.* Javiana, *S.* Braenderup and *S.* Bredeney from three patients each. *S.* Reading, *S.* Oranienburg, *S.* Hillington, *S.* Derby, *S.* Urbana, and *S.* Albany were recovered from 2 cases each. One case each was associated with *S.* Agona, *S.* Berta, *S.* Bleadon, *S.* Blockley, *S.* Chameleon, *S.* Ealing, *S.* Edinburgh, *S.* Havana, *S.* Ibadan, *S.* Indiana, *S.* Infantis, *S.* Istanbul, *S.* Lexington, *S.* Litchfield, *S.* Manhattan, *S.* Marina, *S.* Miami, *S.* Mississippi, *S.* Muenchen, *S.* Newport, *S.* Othmarschen, *S.* Sandiego, *S.* Schwarzengrund, *S.* Senftenberg, *S.* Sepsis, *S.* Syrsis, *S.* Tripoli, *S.* Uppsala, and *S.* Weltevereden.

Salmonellosis cases by symptoms

Symptoms that were recorded from patients seeking medical attention included cramps by 221 (57.3%) of the cases, diarrhea (206, 53.4%), fever (154, 39.9%), nausea (122, 31.6%), blood in the stool (77, 19.6%), vomiting (71, 18.4%), headache (21, 5.4%), chills (21, 5.4%), and other complications (16, 4.1%). When univariate logistic regression is used, the results show that age was not significantly different for patients who had fever, diarrhea, cramps, headache, blood in the stool or chills. The 21–40

TABLE 2. Demographic characteristics that predicted severity of human salmonellosis in North Dakota: 386 cases (2000–2005)

Demographic characteristics	Severity cases/Total cases	Univariate Odds Ratio (95% CI)	Univariate *P*-value (0.05)	Stepwise *P*-value (0.15)
Age: 0–2	18/34 (52.9)	0.8 (0.4–1.9)	0.8963	0.0214
Age: 3–12	27/58 (46.6)	0.7 (0.3–1.3)	0.2208	0.0106
Age: 13–20	23/46 (50.0)	0.8 (0.4–1.5)	0.5525	0.0066
Age: 21–40	53/93 (57.0)	Ref	Ref	Ref
Age: 41–60	52/92 (56.5)	1.1 (0.5–1.8)	0.6046	0.6840
Age: > 60	38/63 (60.3)	1.1 (0.6–2.2)	0.2693	0.0909
Sex: Female	109/192 (56.8)	Ref	Ref	Ref
Male	100/191 (52.4)	0.8 (0.6–1.2)	0.3794	.

TABLE 3. Symptoms that predicted severity of human salmonellosis in North Dakota: 386 cases (2000–2005)

Symptoms	Severity cases/Total cases	Univariate Odds Ratio (95% CI)	Univariate *P*-value (0.05)	Stepwise *P*-value (0.15)
Fever	117/154 (75.9)	4.6 (3.0–7.3)	< 0.0001	.
Diarrhea	153/206 (74.3)	6.1 (3.9–9.4)	< 0.0001	0.0004
Vomiting	60/71 (84.5)	5.9 (3.0–11.7)	< 0.0001	0.0663
Cramps	164/221 (74.2)	7.2 (4.5–11.4)	< 0.0001	<0.0001
Nausea	99/122 (81.2)	5.8 (3.5–9.8)	< 0.0001	0.0006
Headache	16/21 (76.2)	2.7 (1.0–7.8)	0.0458	.
Blood in stool	61/77 (79.2)	4.0 (2.2–7.3)	< 0.0001	0.0669
Chills	19/21 (90.5)	8.6 (2.0–37.3)	0.0039	0.1226
Complications	12/16 (75.0%)	2.0 (0.8–8.1)	0.1065	0.0467

year age group had reduced odds of vomiting (OR = 0.4; 95% CI = 0.2–0.9) and reduced odds of other complications (OR = 0.2; 95% CI = 0.03–0.9) compared to 13–20 years old.

Severity of salmonellosis

A severe case of salmonellosis was defined as one in which a person with *Salmonella* infection was hospitalized or received antibiotics as an outpatient. The number of cases that reported taking antibiotics for the treatment of salmonellosis was 168 (43.5%), and the number hospitalized for salmonellosis was 119 (30.8%). Overall, the number of cases that reported either taking antibiotics or getting hospitalized for the disease (severe salmonellosis) was 211 (54.7%). Table 1 shows that severe salmonellosis was reported in 63 of 75 (84%) cases that had traveled, 93/125 (74.4%) that had eaten in a restaurant, 24/34 (70.6%) that had drunk well water, 45/58 (77.6%) that had been in contact with a cat, 9/10 (90%) that had eaten turkey, and 91/125 (72.8%) that had consumed fresh produce.

Severe salmonellosis, as shown in Table 3, was diagnosed in 117 cases out of 154 (75.9%) who had fever, 153 of 206 (74.3%) who had diarrhea, 60 of 71 (84.5%) who had vomiting, 164 of 221 (74.2%) who had cramps, 99 of 122 (81.2%) who had nausea, and 19 of 21 (90.5%) who had chills. Univariate logistic regression analysis (_ = 0.05), shows that the odds of having severe salmonellosis increased 4.6 times if a case had fever (95% CI = 3.0–7.3) compared to one without fever, and increased 6.1 times if a case had diarrhea (95% CI = 3.9–9.4), vomiting (OR = 5.9; 95% CI = 3.0–11.7), cramps (OR = 7.2; 95% CI = 4.5–11.4), nausea (OR = 5.8; 95% CI = 3.5–9.8), chills (OR = 8.6; 95% CI = 2.0–37.3), and blood in the stool (OR = 4.0; 95% CI = 2.2–7.3) (Table 3).

TABLE 4. Exposure factors that predicted longer duration of hospitalization of human salmonellosis cases in North Dakota: 386 cases (2000–2005)

Exposure Factors	Admission duration/ Total cases	Univariate Odds Ratio (95% CI)	Univariate *P*-value (0.05)	Stepwise *P*-value (0.15)
Travel	25/75 (33.3)	1.4 (0.8–2.4)	0.2219	.
Restaurant	47/125 (37.6)	1.6 (1.0–2.6)	0.0323	.
Well water	10/34 (29.4)	1.0 (0.5–2.2)	0.9765	.
Cat	20/58 (34.5)	1.3 (0.8–2.4)	0.3097	.
Dog	42/109 (38.5)	1.8 (1.1–2.9)	0.0124	0.0818
Reptiles	5/21 (23.8)	0.8 (0.3–2.1)	0.6183	0.1673
Farm animals	15/40 (37.5)	1.4 (0.7–2.8)	0.3173	.
Meats	28/77 (36.4)	1.4 (0.8–2.4)	0.2036	.
Fresh produce	47/128 (36.7)	1.8 (1.1–2.8)	0.0144	.
Cold cuts	10/27 (37.0)	1.4 (0.6–3.2)	0.3691	.
Sea foods	13/32 (40.6)	1.7 (0.8–3.5)	0.1615	.
Turkey	3/10 (30.0)	0.9 (0.3–3.9)	0.9942	0.1780
Eggs	31/87 (35.6)	1.5 (0.9–2.4)	0.1332	.
Chicken	27/65 (41.5)	1.8 (1.1–3.2)	0.0272	.
Milk products	21/43 (48.8)	2.1 (1.1–4.0)	0.0201	0.0782

A model that best predicted severe salmonellosis

Symptoms and risk factors were binary (factor exists = 1 or factor does not exist = 0), and the probability of developing severe salmonellosis (π) could be estimated by use of an individual factor or a combination of factors that are significant ($P < 0.05$). A binary logistic regression model, stepwise strategy was used with the assumption that some factors were not significant or some factors were correlated with others and would drop out of the model; for instance, travelers normally eat from restaurants, and hence travel is highly correlated with eating in a restaurant; a person who is in contact with one pet can also be in contact with another; and eating one food item does not mean that a person will not eat the other.

The exposure factors that best predicted severity of salmonellosis in the final model as shown in Table 1 were consumption of milk products ($P = 0.0233$), travel ($P = 0.0002$), contact with farm animals ($P = 0.0029$), and contact with a cat ($P = 0.0101$). The demographic characteristic that best predicted severity of salmonellosis in the final model as shown in Table 2 was age: 21–40 years compared with ages 3–12 years ($P = 0.0106$) or ages 13–20 years ($P = 0.0066$). The symptoms that best predicted severity of salmonellosis in the final model as shown in Table 3 were development of cramps ($P < 0.0001$), diarrhea ($P = 0.0004$), nausea ($P = 0.0006$), and other complications ($P = 0.0467$).

Duration of hospitalization

Overall, 274 (71%) salmonellosis cases were not hospitalized. The number of cases hospitalized for less than a day was 9 (2.3%), the number hospitalized from one to four days was 80 (20.7%), and the number of cases hospitalized for more than four days was 23 (6%). Table 4 shows that of the 75 cases who had traveled, 25 (33.3%) were hospitalized with severe salmonellosis; 47 out of 125 (37.6%) that had eaten in a restaurant were hospitalized, 47/128 (36.7%) of cases who had consumed produce were hospitalized, and 3/10 (30%) of the cases who had consumed turkey meat were hospitalized. Table 5 shows that the age of many patients hospitalized for salmonellosis was over 60 years (28/66, 42.4%).

A univariate logistic regression with duration of hospitalization as an outcome variable was developed. The odds of staying in hospital longer (Table 6) increased 3.9 times if a case had fever (95% CI = 2.5–6.1) compared to one without fever, and 3.6 times if the case had diarrhea (95% CI = 2.2–5.8) compared to one without diarrhea. The odds of staying in hospital longer (Table 6) increased by 3.9 times if a case was vomiting (95% CI = 2.4–6.6) compared to one who was not vomiting, 3 times if the case had cramps (95% CI = 1.9–4.9), 3.4 times if the case had nausea (95% CI = 2.1–5.3), 2.5 times if the case had a headache (95% CI = 1.1–5.8), and 1.9 times if the case had blood in the stool (95% CI = 1.1–3.2), compared to cases without those symptoms.

Models that best predicted duration of hospitalization

Symptoms and risk factors were binary (factor exists = 1 or factor does not exist = 0), and a multinomial logistic

TABLE 5. Demographic characteristics that predicted longer duration of hospitalization of human salmonellosis cases in North Dakota: 386 cases (2000–2005)

Demographic characteristics	Admission duration/ Total cases	Univariate Odds Ratio (95% CI)	Univariate *P*-value (0.05)	Stepwise *P*-value (0.15)
Age: 0–2	10/34 (29.4)	1.3 (0.5–3.1)	0.8721	0.3624
Age: 3–12	13/58 (22.4)	0.9 (0.4–1.9)	0.2270	0.0294
Age: 13–20	11/46 (23.9)	0.9 (0.4–2.1)	0.3803	0.1321
Age: 21–40	23/93 (24.7)	Ref	Ref	Ref
Age: 41–60	27/92 (29.3)	1.4 (0.7–2.6)	0.5560	0.5133
Age: > 60	28/63 (44.4)	2.3 (1.2–4.5)	0.0056	0.0018
Sex: Female	54/190 (28.4)	1.0 (0.6–1.6)	0.8821	.
Male	55/191 (28.8)	Ref	Ref	Ref

regression, stepwise strategy was used. Table 5 shows that patients over 60 years of age had a higher likelihood ($P = 0.0018$) than did 21–40 year olds of staying longer in hospital. Table 6 shows the factors that best predicted hospitalization: fever ($P < 0.0001$), nausea ($P = 0.0147$), and vomiting ($P < 0.0001$). The probability of duration of hospitalization in any of the models could be estimated with use of an individual factor or a combination of factors.

DISCUSSION

NDDoH received 386 salmonellosis case reports distributed over 6 years (2000–2005). With a population of 642,200 *(28)*, the state had a calculated annual salmonellosis incidence rate of approximately 1/10,000, compared with the United States rate, which is approximately 1.5/10,000 *(1)*. This could be due to the short summer season that the state has compared with most states; a considerable number of outbreaks occur in summer *(21)*. A plausible explanation for the higher number of cases in summer than in other seasons could be the frequency of outdoor activities that are associated with leaving food unrefrigerated for a relatively long time *(21)*. This practice exposes food to degradation due to heat, rendering it favorable for microbial proliferation *(21)*.

Further reports from the NDDoH show that no cases of salmonellosis were reported in 6 years from 10 of North Dakota's 53 counties. The majority of cases were contributed by the most populated counties. For instance, the Bismarck metro area is located in Burleigh County; Fargo, the largest city in North Dakota, is in Cass County; the Grand Forks metro area is in Grand Forks County; the Dickinson metro area is located in Stark County; and Jamestown is located in Stutsman County. Cities are known to have higher human traffic, which is normally associated with more travel and with a higher number of restaurants and social activities that expose large numbers of people to the same contamination source *(13)*. However, these counties did not register the highest incidence rates; instead, counties that are less populated, such as McIntosh, Adams, Hettinger, Dickey, and Slope County, showed higher incidence rates. For instance, there was only one salmonellosis case in Slope County, but because the population is as low as 700 people, that put the incidence rate at 14/10,000, in comparison with Cass County, which had 64 salmonellosis cases but which has a population of 123,138, resulting in an incidence rate of 5/10,000.

The number of reported cases was higher in 2005 than in the other years. This increase was attributed to a cluster of *Salmonella* cases identified in Williams County; two salmonellosis outbreak clusters of four and eleven cases, respectively, were reported to be linked epidemiologically by time and place or by matching DNA patterns with pulse-field gel electrophoresis (PFGE) at the Division of Microbiology. Ten of the 15 *S.* Typhimurium cases reported in this time frame had 100% matching DNA patterns; the other five matched within 90% *(19)*. In addition, NDDoH implemented an electronic laboratory reporting system in 2004, which greatly improved reporting of cases. Prior to that, disease reports were in paper form or cards that were completed and mailed to the NDDoH. In 2004, a web-based electronic patient database and electronic laboratory reporting systems were initiated, which improved and speeded up reporting from health care facilities (Goplin J, Foodborne Surveillance Epidemiologist, North Dakota Department of Heath, Personal Communication, 2005).

The limitation of the study was that the food was not available for culture to confirm or rule out its role as the vehicle for *Salmonella* infection. Also, there was a high probability of recall bias associated with data on food history, as patients could not possibly remember all the foods that they had eaten in the past three days. This is a wide time period, given that the clinical course of human salmonellosis is usually of acute onset *(9)*. This limitation of a wide time period (3 days) during which data were collected also applied to people who had traveled, making it difficult to associate occurrence of salmo-

TABLE 6. Symptoms that predicted longer duration of hospitalization of human salmonellosis cases in North Dakota: 386 cases (2000–2005)

Symptoms	Admission duration/ Total cases	Univariate Odds Ratio (95% CI)	Univariate *P*-value (0.05)	Stepwise *P*-value (0.15)
Fever	70/154 (45.5)	3.9 (2.5–6.1)	< 0.0001	<0.0001
Diarrhea	83/206 (40.3)	3.6 (2.2–5.8)	< 0.0001	0.2267
Vomiting	40/71 (56.3)	3.9 (2.4–6.6)	< 0.0001	<0.0001
Cramps	85/221 (38.5)	3.0 (1.9–4.9)	< 0.0001	.
Nausea	59/122 (48.4)	3.4 (2.1–5.3)	< 0.0001	0.0147
Headache	12/21 (57.1)	2.5 (1.1–5.8)	0.0361	0.1726
Blood in stool	30/77 (39.0)	1.9 (1.1–3.2)	0.0135	.
Chills	8/21 (38.1)	1.6 (0.7–3.9)	0.2846	.
Complications	8/16 (50.0)	2.1 (0.8–5.7)	0.1242	.

nellosis with a specific source of infection. The NDDoH plans to address this issue by improving the food history section of the form by, for instance, including dates and times for consumption of each food item entered on the form and requesting that particular food items eaten at restaurants and events be listed.

Fresh produce ranked highest among food items reported among salmonellosis cases. This observation was not a total surprise as there has been a registered increase in fresh produce-related human infections in the United States in recent years *(23)*. The CDC estimates that contaminated fresh produce currently accounts for 12% of foodborne illnesses and 6% of foodborne outbreaks in the United States *(4)*. Also, *Salmonella* and *E. coli* O157:H7 were reported as the two most common etiological agents responsible for fresh produce-related outbreaks in the past 10 to 15 years, in various states *(12)*. Several reasons for the increase in fresh produce-related human infections have been proposed, including changes in dietary habits, high per capita consumption of fresh or minimally processed fruits and vegetables, and advanced methods of microbial detection and surveillance, as well as modifications in agronomic practices, processing and packaging technologies *(29)*.

In addition to contaminated food, as etiological agents, contact with cats, dogs, and farm animals increased the odds of acquiring severe salmonellosis; human salmonellosis occurs when individuals have contact with infected animals *(2, 30)*. For decades, pets such as dogs, cats and reptiles have been known to harbor *Salmonella* spp. However, numerous animal owners remain unaware that animal contact places them and other household members, including children, at greater risk for salmonellosis. *Salmonella* is found in the intestinal tract of animals and is transmitted by ingestion of feces, which might occur from eating contaminated foods or through contact with animals or their environments. Domestic animals acquire the infection in the same way as humans, that is, through consumption of contaminated raw meat, poultry or poultry-derived products *(25)*. However, studies carried out on cats and dogs show that the risk of transmission of salmonellosis from these pets seems to be rather low *(10, 14)*. Severe salmonellosis due to contact with cats and dogs could probably be a confounding factor owing to the high incidence of dog and cat ownership in this country.

The clinical course of human salmonellosis is usually characterized by acute onset of fever, cramps, diarrhea, and sometimes vomiting *(9)*. These symptoms were the most reported ailments, were common among cases that developed severe salmonellosis and increased the odds of staying longer in hospital. However, serious complications such as anorexia, weight loss, and arthritis occur in a small proportion of cases *(10)*, as was seen in this study. However, it was surprising that these complications were not significantly associated with severe salmonellosis. Because the symptoms in this study were self reported after considerable time, the information is subject to possible recall bias and other sources of information bias, depending on the time, place, age or mood of patient and the data collector.

The association between serotype and symptom or between serotype and risk factor, including foods consumed, was not linked in the study, because the serotype-food item/risk factor relationship was not investigated at the time of data capture. However, the distribution of the most commonly reported serotypes (*S.* Enteritidis, *S.* Typhimurium, *S.* Heidelberg, and *S.* Newport) was similar to what has been reported at the national level *(3, 5)*. Of the 5,942 (92%) *Salmonella* serotypes isolated from humans in the United States, five serotypes accounted for 56% of infections: *S.* Typhimurium, 1,170 (20%); *S.* Enteritidis, 865 (15%); *S.* Newport, 585 (10%); *S.* Javiana, 406 (7%); and *S.* Heidelberg, 304 (5%) *(5)*.

In summary, there were 386 salmonellosis cases reported from 45 of the 53 North Dakota counties, with incidence rates ranging from 1 to 21/10,000. The overall incidence of salmonellosis in ND (1/10,000) during the study period was lower than the national average (1.5/10,000); cases were distributed throughout the year but peaked in summer. Forty-five serotypes were recovered, of which the four major ones were *S.* Enteritidis, *S.* Typhimurium, *S.* Heidelberg, and *S.* Newport, in that order. Traveling, contact with farm animals or a cat, consumption of milk products, and development of cramps or diarrhea were associated with severe salmonellosis, whereas the odds of staying in the hospital longer increased if a person was older than 60 or had a fever, nausea or vomiting. Fresh produce, eggs, red meats and chicken ranked highest, in that order, among food items reported among salmonellosis cases.

CONCLUSIONS

Salmonellosis incidence rates in North Dakota were lower than the national average. Fresh produce ranked highest among food items reported by salmonellosis cases. Additionally, exposure factors and symptoms associated with severe disease and increased odds of longer hospitalization among salmonellosis cases in North Dakota were identified. This information is vital in guiding public health providers and consumer educators in identifying the target population, as well as raising the risk factor awareness of the general population, food processors, and service industries. This would enhance the development of achievable salmonellosis control strategies for the state.

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