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A Registry-Based Study on the Association Between Human Salmonellosis and Routinely Collected Parameters in Michigan, 1995–2001

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ABSTRACT

Purpose: Salmonella **serotypes are among the most common bacterial causes of foodborne gastroenteritis in the United States, associated with ~1.4 million human illnesses annually. Studies on trends of the serotypes and host-related factors are necessary for the development of effective prevention plans for foodborne diseases caused by these pathogens.**

Materials and Methods: **To determine the epidemiologic trends of human infections with the most common** *Salmonella* **serotypes in Michigan, we analyzed cases of culture-confirmed salmonellosis at the Michigan Department of Community Health (MDCH) from 1995 to 2001.**

Results: **A total of 6797 cases were reported, with an average annual incidence per 100,000 population (AAI) of 9.9. Among cases for which information on** *Salmonella* **serotype were available (6292 cases), the most common serotypes were** *S.* **Typhimurium (1596 cases, 26%), followed by** *S.* **Enteritidis (1309, 22%),** *S.* **Heidelberg (466, 8%) and** *S.* **Newport (222, 4%). From 1998 to 2001, the incidence of** *S.* **Typhimurium and** *S.* **Enteritidis decreased significantly by 39% (95% confidence interval [CI], 49% to 26% decrease) and 32% (95% CI, 44% to 18% decrease) respectively. Whereas the incidence of** *S.* **Newport increased by 101% (95% CI, 25% to 225% increase) and** *S.* **Heidelberg remained stable. Infection with these serotypes frequently occurred in the summer months. As a group, infants had the highest AAI for all** *Salmonella* **serotypes (75.0),** *S.* **Typhimurium (21.9),** *S.* **Enteritidis (14.0),** *S.* **Heidelberg (5.4), and** *S.* **Newport (1.7). Among patients whose race was known, blacks had a significantly higher AAI compared to whites for** *S.* **Typhimurium (2.5** *vs.* **1.3; RR = 2.3, 95% CI, 1.6–3.3),** *S.* **Enteritidis (1.4** *vs.* **1.1; relative rate (RR) = 1.4; 95% CI, 1.1–1.6),** *S.* **Heidelberg (0.8** *vs.* **0.3; RR = 3.6; 95% CI, 2.8–4.6), and** *S.* **Newport (0.3** *vs.* **0.1; RR = 2.8; 95% CI, 1.9–4.2). Among patients whose ethnicity was known, Hispanics had a significantly higher AAI for** *S.* **Enteritidis compared to non-Hispanics (1.0** *vs.* **0.5; RR = 1.9; 95% CI, 1.2–3.0), but not different significantly for** *S.* **Typhimurium,** *S.* **Heidelberg, and** *S.* **Newport.**

Conclusion: **This study revealed the emergence of** *S.* **Newportand the high incidence of the most common** *Salmonella* **serotypes among infants, people of African descent, and Hispanics. This information can be used by the state and local health departments of Michigan to enhance salmonellosis prevention efforts by rationalizing the allocation of appropriate public health resources and personnel.**

INTRODUCTION

SALMONELLA SEROTYPES ARE AMONG the most common bacterial causes of foodborne gastroenteritis. On a global scale, an estimated 1.3 billion cases of acute nontyphoidal gastroenteritis occur annually, resulting in 3 million deaths (WHO Report, 2000–2005). In the United States, *Salmonella* serotypes cause an estimated 1.4 million cases of foodborne illnesses annu-

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ally, resulting in over 100,000 physician office visits (Voetsch et al., 2004), 16,000 hospitalizations, and nearly 600 deaths (Mead et al., 1999).

Human infection with nontyphoidal *Salmonella* usually results in an acute self-limiting diarrhea that does not warrant antimicrobial therapy. However, these infections can also develop into life-threatening systemic infections including meningitis and endocarditis that require effective chemotherapy (Pegues et al., 2005). The estimated cost associated with salmonellosis in humans in the United States, including the costs of medical care and lost productivity, ranged from $0.5 to $2.3 billion annually (Frenzen et al., 1999).

Human nontyphoidal *Salmonella* infections often result from the consumption of contaminated foods of animal origin such as chicken, eggs, beef, pork, turkey, milk, or cheese (Gomez et al., 1997; Olsen et al., 2000; Sanchez et al., 2002). Other food vehicles identified include fish, shellfish, fresh fruits and juice, spices, chocolate, and vegetables/produce (Gomez et al., 1997; Olsen et al., 2000; Sivapalasingam et al., 2004).

Analyses of salmonellosis surveillance data allow estimation of the overall incidence and trends, and identification of groups at risk. The objectives of this study were to determine the trends in the incidence of human infections with the most common *Salmonella* serotypes in Michigan from 1995 to 2001 and to identify the population subgroups at high risk.

MATERIALS AND METHODS

Cases of culture-confirmed salmonellosis from 1995 to 2001 at the Michigan Department of Community Health (MDCH) Bureau of Epidemiology were analyzed. To determine the serotypes involved, the cases were merged with *Salmonella* records at the MDCH laboratory, which performs complete serotyping. Cases were matched by first and last name using EpiInfo 2004 v. 3.3 (CDC, Atlanta, GA). Cases remaining unmerged due to spelling errors of the first or last name were matched manually on a case-by-case basis. The final database includes each patient's address, age, sex, race, ethnicity, event date, and *Salmonella* serotypes.

To maintain the confidentiality of study subjects, a group level analysis without any identification of study subjects was performed. The institutional review boards for research involving human subjects at MDCH and Michigan State University approved the study protocol and the use of these data.

Age-standardized annual incidences (cases per 100,000 population) of infections with all *Salmonella* and the most common serotypes were calculated based on the appropriate population estimates of Michigan from1995 to 2001 (NCHS, 2000). The year 2000 standard population was used for age standardization (Anderson and Rosenberg, 1998). Poisson regression analysis was used to estimate the change in incidence (relative rate) between 1995 and 2001 and 1998 and 2001, along with the 95% confidence interval (CI). (CDC, 2002a; Hardnett et al., 2004). The analysis was conducted using Proc Genmod in SAS v. 8.0 (SAS Institute, Cary, NC).

To examine age differences, average annual incidence per 100,000 population (AAI) was calculated for the following age categories: <1, 1–4, 5–9, 10–29, 30–39, 40–59, and ≥ 60 years based on the variation in exposure and immunologic status. Because of the immunocompetent status and a relatively lower incidence of salmonellosis among people aged 40–59 years, this age group was used as a reference age category to compute rate ratios for other age groups. Age-standardized AAIs were calculated to study differences according to sex, race, ethnicity, and type of county of residence (Table 1). We grouped counties into urban or rural based on United States Census Bureau definitions: an urban county is any county containing a city of $>50{,}000$ people or an area that has at least 100,000 people and has a substantial commuting interchange with a city of greater than 50,000 people. Poisson regression analysis was used to determine the adjusted relative rates with their 95% CI.

RESULTS

From 1995 to 2001, 6797 culture-confirmed cases of salmonellosis were reported to MDCH, with an average annual incidence of 9.9/

TABLE 1. AVERAGE ANNUAL INCIDENCE OF HUMAN INFECTION WITH ALL *SALMONELLA* SPP. BY AGE, SEX, RACE, ETHNICITY, TYPE OF COUNTY OF RESIDENCE, AND *SALMONELLA* SEROTYPE IN MICHIGAN, 1995–2001 ($N = 6797$)

	N	*AAI*	*RR (95% CI)*
Age, years			
<1	690	75.0	10.47 (9.54–11.48)
1–4	842	22.1	3.08 (2.82–3.36)
5–9	534	10.3	1.44 (1.30–1.59)
10–29	1568	8.1	1.13 (1.05–1.22)
30–39	853	7.9	1.11 (1.10–1.21)
40–59[a]	1277	7.2	1.00
≥60	974	8.8	1.23 (1.13–1.33)
Sex			
Male[a]	3178	9.3	1.00
Female	3567	10.1	1.08 (0.82–1.33)
Race[b]			
White[a]	3207	5.6	1.00
Black	737	6.8	1.30 (1.20–1.41)
Native American	13	2.5	0.48 (0.28–0.82)
Asian/Pacific Islander	25	1.6	0.37 (0.25–0.54)
Other	54	—	—
Not stated	28761	—	—
Ethnicity[b]			
Hispanic	71	2.9	1.30 (1.03–1.65)
Non-Hispanic[a]	1779	2.7	1.00
Not stated	4947	—	—
Type of county			
Urban	5436	9.8	1.05 (0.99–1.11)
Rural[a]	1359	9.5	1.00
Serotype			
S. Typhimurium	1598	2.3	0.59 (0.56–0.63)
S. Enteritidis	1309	1.9	0.48 (0.45–0.52)
S. Heidelberg	466	0.7	0.17 (0.16–0.09)
S. Newport	222	0.3	0.08 (0.07–0.09)
Other serotypes[a]	2699	3.9	1.00

[a]Reference category in Poisson regression analysis.

[b]Significantly higher AAI for blacks and Hispanics should be interpreted with cuation because only 59% and 27% of the cases had information on race and ethnicity, respectively.

AAI, average annual incidence; RR, adjusted relative rate determined by Poisson regression analysis; CI, confidence interval.

100,000. Of this total, 6292 cases (93%) have information on *Salmonella* serotype. The most common serotypes were *S*. Typhimurium (1596 cases, 26%), *S*. Enteritidis (1309, 22%), *S*. Heidelberg (466, 8%), and *S*. Newport (222, 4%). These serotypes accounted for 57% (3593 cases) of the total number of cases with a known serotype. The other 11 serotypes in the list of the 15 most common serotypes were: *S*. Java (178 cases, 3%), *S*. Thompson (178 cases, 3%), *S*. Oranienburg (174 cases, 3%), *S*. Agona (157 cases, 3%), *S*. Muenchen (130 cases, 2%), *S*. Braenderup (119 cases, 2%), *S*. Saintpaul (104 cases, 2%), *S*. Infantis (101 cases, 2%), *S*. Montevideo (99 cases, 2%), *S*. Stanley (96 cases, 2%), and *S*. Javiana (81 cases, 1%).

Temporal trends

After an increasing trend from 1995 to 1998, the incidence of infection with all *Salmonella* serotypes significantly decreased by 25% (95% CI, 31–18% decrease) from 1998 to 2001: *S*. Typhimurium decreased by 39% (95% CI, 49–26% decrease), and *S*. Enteritidis decreased by 32% (95% CI, 44–18% decrease) (Fig. 1). The incidence of *S*. Newport significantly increased by 101% (95% CI, 25–225% increase) from 1998 to 2001 where as *S*. Heidelberg remained stable.

Seasonality

Overall, high percentages of *Salmonella* cases occurred between May and September, with

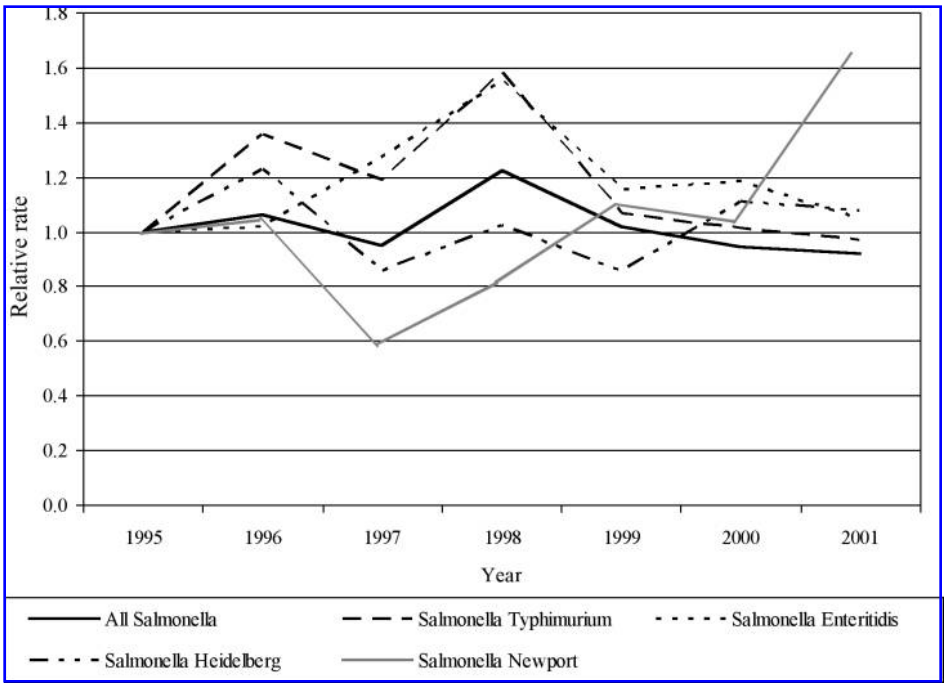

FIG. 1. Relative rates compared with 1995 of infection with all *Salmonella* and the most common serotypes in Michigan, 1995–2001.

the peak in July (Fig. 2). This general pattern was consistent for *S*. Typhimurium, *S*. Enteritidis, *S*. Heidelberg, and *S*. Newport.

Type of county of residence

The age-standardized AAI for infection with all *Salmonella* did not differ significantly in urban and rural counties. No significant difference in the age-standardized AAI was noted for *S*. Typhimurium (2.3 *vs.* 2.1; RR, 1.09; 95% CI, 0.79–1.52), *S*. Enteritidis (1.9 *vs.* 1.9; RR, 1.00; 95% CI, 0.70–1.42), *S*. Heidelberg (0.7 *vs*. 0.5; RR, 1.31; 95% CI, 0.69–2.51), or *S*. Newport (0.7 *vs*. 0.5; RR, 0.71; 95% CI, 0.27–1.83).

Age

The average incidence of infection with all *Salmonella* was highest among infants aged <1 year (AAI = 75.0) compared to other age categories. Incidence decreased abruptly after infancy, remained relatively constant through the adult years, and increased slightly among persons >60 years. The AAI for infants was significantly higher among infants aged 1–5 months than infants aged 6–11 months (95.4 *vs*. 53.0; RR, 1.80; 95% CI, 1.54–2.10). Similar patterns of age-specific incidence were noted for infections with *S*. Typhimurium, *S*. Enteritidis, *S*. Heidelberg, and *S*. Newport.

Sex

Age-standardized AAI was not different significantly between females and males for all *Salmonella*, *S*. Typhimurium (2.3 *vs.* 2.2; RR, 1.07; 95% CI, 0.82–1.38), *S*. Enteritidis (1.9 *vs*. 1.8; RR, 1.07; 95% CI, 0.80–1.42), *S*. Heidelberg (0.7 *vs.* 0.6; RR, 1.22; 95% CI, 0.75–1.99), and *S*. Newport (0.4 *vs*. 0.3; RR, 1.23; 95% CI, 0.61–2.48).

Race

Of the 6797 *Salmonella* cases, only 4036 (59%) have information on race. Among the cases in which race was known, blacks had a significantly higher age-standardized AAI than whites for infection with all *Salmonella*, *S*. Typhimurium (2.5 *vs.* 1.3; RR, 2.27; 95% CI, 1.98–2.61), *S*. Enteritidis (1.4 *vs.* 1.1; RR, 1.35; 95% CI, 1.13–1.62), *S*. Heidelberg (0.8 *vs*. 0.3; RR, 3.56; 95% CI, 2.77–4.58) and *S*. Newport (0.3 *vs*. 0.1; RR, 2.83; 95% CI, 1.92–4.18). Native Americans and Asians/Pacific Islanders had a significantly lower age-standardized AAI than whites.

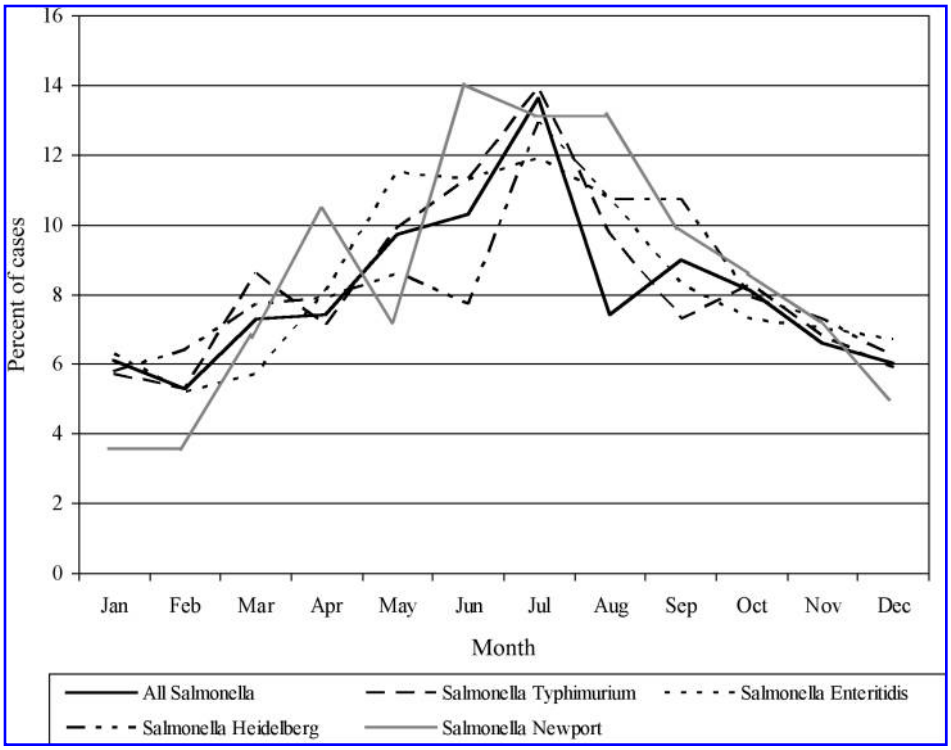

FIG. 2. Cases of infections with all *Salmonella*, *S*. Typhimurium, *S*. Enteritidis, *S*. Heidelberg, and *S*. Newport by month, in Michigan, 1995–2001.

Ethnicity

Only 1850 cases (27%) have information on ethnicity. Among the cases whose ethnicity was known, Hispanics had a significantly higher age-standardized AAI than non-Hispanics for infection with all *Salmonella* and *S*. Enteritidis (1.0 *vs*. 0.5; RR, 1.9; 95% CI, 1.21–2.98).

Invasive salmonellosis

Of the 6797 cases, 341 (5%) *Salmonella* isolates were from blood and 6 (<1%) were from cerebrospinal fluid, and the AAI of invasive salmonellosis was 0.5. The AAI of invasive salmonellosis was highest among infants aged <1 year (3.6) (Table 2). Seventy-four percent of the 347 invasive salmonellosis cases were caused by 10 *Salmonella* serotypes: *S*. Heidelberg (19.3%), *S*. Typhimurium (18.7%), *S*. Enteritidis (16.7%), *S*. Typhi (3.7%), *S*. Oranienburg (3.2%), *S*. Dublin (2.9%), *S*. Poona (2.9%), *S*. Montevideo (2.6%), *S*. Agona (2.0%), and *S*. Hadar (1.7%).

DISCUSSION

In this study, 6797 cases of human infections with *Salmonella* spp. were reported to the MDCH from 1995 to 2001 with an average of 971 cases annually and AAI of 9.9. This study revealed that the most common *Salmonella* serotypes in Michigan during those years were *S*. Typhimurium, *S*. Enteritidis, *S*. Heidelberg, and *S*. Newport. *S*. Typhimurium is ubiquitous in many food animals; *S*. Enteritidis and *S*. Heidelberg have poultry as the primary reservoir; and the primary reservoir for *S*. Newport is cattle (CDC, 2002b; Ferris et al., 2000; van Duijkeren et al., 2002; Wray and Wray, 2000).

The incidence of infections with all *Salmonella*, *S*. Typhimurium, and *S*. Enteritidis decreased significantly from 1998 to 2001. The decline in the incidence may suggest that important progress toward the reduction of salmonellosis to the national health objective of an AAI of 6.8 (CDC, 2002a; DHHS, 2003) is being made. The decline in incidence rates are unlikely to be due to changes in surveillance, be-

TABLE 2. CASES OF THE MOST COMMON *SALMONELLA* SEROTYPES ASSOCIATED WITH INVASIVE INFECTION, BY AGE, IN MICHIGAN, 1995–2001

	Age (years)						
	<1 (n = 33)	*1–9 (n = 71)*	*10–19 (n = 42)*	*20–39 (n = 74)*	*40–59 (n = 75)*	*≥60 (n = 50)*	*Total (%) (n = 347)*
S. Heidelberg	7	12	11	15	17	5	67 (19%)
S. Typhimurium	5	19	3	16	11	10	64 (18%)
S. Enteritidis	3	14	6	9	17	9	58 (17%)
S. Typhi	2	4	0	0	5	2	13 (4%)
S. Oranienburg	1	2	2	4	1	1	11 (3%)
S. Dublin	0	1	2	5	1	1	10 (3%)
S. Poona	0	4	0	2	4	0	10 (3%)
S. Montevideo	4	1	1	1	2	0	9 (2%)
Other *Salmonella* spp.	11	14	17	22	17	22	103 (29%)
AAI for all *Salmonella*	3.6	0.8	0.4	0.4	0.4	0.5	0.5

AAI, average annual incidence; RR, adjusted relative rate determined by Poisson regression analysis; CI, confidence interval.

cause no modifications to the diagnostic criteria for salmonellosis were made and only passive surveillance was conducted throughout the study period.

The decline in the incidence of all *Salmonella*, *S*. Typhimurium, and *S*. Enteritidis in this study is consistent with the trend of salmonellosis in the United States from 1998 to 2001. Based on the Summary of Notifiable Diseases, the incidence of salmonellosis in the United States decreased from 16.2 in 1998 to 14.2 in 2001 (CDC, 2002a). Based on the Public Health Laboratory Information System (PHLIS), the number of *S*. Typhimurium isolates decreased from 8818 (3.3/100,000) in 1998 to 6999 (2.5/100,000) in 2001. *S*. Enteritidis decreased from 6029 (2.2/100,000) in 1998 to 5614 (2.0/100,000) in 2001 (CDC, 2002b). However, a recent FoodNet report comparing 2005 to the average annual incidence for 1996–1998, found only the incidence of *S*. Typhimurium decreased significantly in 2005 (42%; 95% CI, 34–48%) (CDC, 2006). The estimated incidence of *S*. Enteritidis increased 25% (95% CI, 1–55%), and *S*. Heidelberg increased 25% (95% CI, 1–54%). The estimated incidence of *S*. Newport increased compared with the baseline, but the increase was not statistically significant (CDC, 2006).

The reasons for the decrease in the incidence rates in Michigan are not clear. However, several reports have suggested that the nationwide decrease in the incidence of many *Salmonella* serotypes, including *S*. Typhimurium and *S*. Enteritidis, may be partly attributed to several control measures including the implementation of the Pathogen Reduction/Hazard Analysis Critical Control Point (HACCP) systems regulations in meat and poultry slaughter and processing plants by the United States Department of Agriculture (USDA) Food Safety Inspection Service (FSIS) on July 25, 1996 (CDC, 2002a; FSIS, 1996). Additional interventions that may have resulted in decreases in the incidence rates include egg-quality assurance programs for *S*. Enteritidis and public health food safety education such as FIGHT BAC! that targets consumers and food handlers (CDC, 2002a; FIGHT BAC).

Even though the incidence of all *Salmonella* infections decreased significantly from 1998 to 2001, the incidence of *S*. Newport increased significantly during this period. This increase is consistent with the trend of *S*. Newport infection in the United States. The number of *S*. Newport isolates reported to the CDC increased by 23% from 2566 in 1995 to 3158 in 2001 (CDC, 2002b). In the FoodNet sites, the incidence of *S*. Newport increased by 32% from 1996 to 2001 (CDC, 2002a). The reasons for the significant increase in the incidence of *S*. Newport from 1998 to 2001 in Michigan are not known. In the United States, increases in the incidence of *S*. Newport were due to the emergence of multidrug-resistant *S*. Newport (CDC, 2002b; Gupta et al., 2003). The increase in the

incidence of infection with *S*. Newport in Michigan should be further investigated for the possible risk factors and for the presence of multidrug-resistant strains. This is important because human infections with multidrug-resistant strains of *Salmonella*, such as *S*. Typhimurium DT104, have worse outcomes than infections with antimicrobial-susceptible strains (Helms et al., 2002; Martin et al., 2004; Varma et al., 2005).

Although the incidence of *S*. Heidelberg remained stable, the public health importance of this serotype cannot be underestimated. Approximately 1900 *S*. Heidelberg isolates were reported to the PHLIS each year from 1995 through 2004 (CDC, 2005). Furthermore, *S*. Heidelberg is the third most commonly reported serotype to cause human illness in 1998 and the fourth most commonly reported to cause human illness in 1999 to 2001, 2003 and 2005 (CDC, 2005). Eggs and chicken have been implicated in *S*. Heidelberg infections (Hennessy et al., 2004; MacDoughall et al., 2004). A recent report revealed that the most common food vehicles implicated in *S*. Heidelberg outbreaks in the United States were poultry, eggs, egg-containing food items, pork, and beef (Chittick et al., 2006).

Similar to findings in other studies (Olsen et al., 2001; Schutze et al., 1995. Trevejo et al., 2003), infections with *Salmonella* occurred more frequently in the summer months. This may be due to more people cooking foods of animal origin at picnics, barbecues, and on camping trips. During these activities safety controls such as thermostat-controlled cooking, refrigeration, and washing facilities are usually not available (Olsen et al., 2001). Furthermore, humid and hot conditions in summer favor the rapid growth of *Salmonella* in foods that are not kept refrigerated.

This study shows that the age-standardized AAI of *S*. Typhimurium, *S*. Enteritidis, *S*. Heidelberg, and *S*. Newport did not differ significantly between residents in urban and rural counties. These findings suggest similar levels of exposure to potential sources of these serotypes, possibly as a result of a more integrated food distribution system and the increased consumption of meat and poultry (Altekruse and Swerdlow, 1996).

The incidence of infections with *Salmonella* in this study were highest among infants aged <1 year, similar to other studies (Olsen et al., 2001; Schutze et al., 1995; Trevejo et al., 2003; Voetsch et al., 2004). Beside the immature immune system (Buzby, 2001), other reasons for the high incidence among infants in Michigan are largely unknown. Olsen et al. suggested that the reasons for the high incidence among infants aged <1 year may include host susceptibility and exposure differences (Olsen et al., 2001). Infants may contract salmonellosis from infected family members (Delarocque-Astagneau et al., 2000; Wilson et al., 1982), contaminated infant formula (Park et al., 2004), or food containing undercooked eggs, meat, or vegetables (Delarocque-Astagneau et al., 2000; Espie et al., 2005). A significantly higher incidence of salmonellosis among infants aged 1–5 months compared to infants aged 6–11 months suggest that modes of transmission involving non-food vehicles may play an important role. The infant behavior of putting things in the mouth (Berger and Thompson, 1995) may also contribute to the high incidence of infant salmonellosis.

The finding that the incidence was higher among blacks compared to whites in this study should be interpreted with caution because only 59% of the cases have information on race. However, the results indicate the magnitude of salmonellosis problem among blacks in Michigan and further studies should be conducted to determine the actual risk factors. Among cases whose race was known, the incidence of infection with *S*. Typhimurium, *S*. Enteritidis, *S*, Heidelberg, and *S*. Newport were significantly higher among blacks compared to whites. An analysis of FoodNet data for the years 1998–2001 also demonstrated a higher incidence of *S*. Enteritidis among blacks (Marcus et al., 2002).

Only 27% of the cases in this study have information on ethnicity. Among cases whose ethnicity was known, the incidence of infection with *S*. Enteritidis was significantly higher among Hispanics than non-Hispanics. An analysis of FoodNet data for 2000–2001 demonstrated that Hispanics were more likely than non-Hispanics to eat sprouts, parsley, cilantro, mangoes, yogurt, soft ice cream, unpasteurized milk, runny eggs, and oysters (Banerjee et al.,

2002). We speculate that the high incidence of *S*. Enteritidis among Hispanics in Michigan may be due to frequent consumption of undercooked eggs or foods containing undercooked eggs such as mayonnaise, hollandaise sauce, ice creams, and desserts. In the period 1994–1996, Hispanics consumed more eggs than whites (USDA–ARS). Since only 27% of the cases in this study have information on ethnicity, the significantly higher incidence of *S*. Enteritidis in Hispanics in this study should be interpreted with caution.

This study shows that the incidence of invasive salmonellosis in Michigan was highest among infants aged <1 year. This finding is a public health concern because invasive salmonellosis can result in meningitis, osteomyelitis, endocarditis, arthritis, urinary-tract infection, and pneumonia (Pegues et al., 2005). The reasons for the high incidence of invasive salmonellosis among infants in Michigan are not known. However, other studies suggest that immunocompromise and predisposing clinical conditions (eg, hematological malignancy or sickle-cell hemoglobinopathy) are possible risk factors (Yang et al., 2002).

The main limitation of this study is that it was based on passive surveillance data. Although most culture-confirmed cases are reported to the MDCH, this surveillance system unavoidably underestimates the actual incidence (Voetsch et al., 2004). To be identified as a laboratory-confirmed *Salmonella* case, a person must have symptoms that are severe enough to consult a physician, and provide a clinical specimen. To be counted as a case, the physician or laboratory must report the case to the local health department. The degree of underreporting of salmonellosis has been estimated to be between 19- and 38-fold (Mead et al., 1999; Voetsch et al., 2004). Missing information on race and ethnicity is another limitation in this study. The surveillance data set contained both sporadic and outbreak cases. Therefore, large outbreaks may have led to certain demographic characteristics to be more represented.

Despites the limitations of the data and the decreasing trend in the incidence of all Salmonella, this study reveals the emergence of *S*. Newport infection and higher incidence of salmonellosis among infants, blacks, and Hispanics in Michigan. Information from this study can be used by the state and local health departments of Michigan to enhance salmonellosis prevention efforts by rationalizing the allocation of appropriate public health resources and personnel. Further studies should be conducted to determine the risk factors for the emergence of *S*. Newport and the high incidence of *Salmonella* serotypes among at-risk populations.

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