

Vol. 76, no. 182. 2011:58157–65 [cited 2011 May 5]. <http://www.gpo.gov/fdsys/pkg/FR-2011-09-20/html/2011-24043.htm>

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Salmonellosis and Meat Purchased at Live-Bird and Animal-Slaughter Markets, United States, 2007–2012

To the Editor: *Salmonella* spp. cause ≈1.2 million human illnesses annually in the United States (1). Infections are primarily acquired through exposure to contaminated food or infected animals (1,2). Since 2007, state and local health departments and the Centers for Disease Control and Prevention have investigated multiple salmonellosis outbreaks linked to meat purchased at live-bird markets (LBMs) and live-animal markets (LAMs), where poultry and livestock are sold for onsite slaughter. These markets typically operate in large cit-

ies and serve populations of diverse ethnic backgrounds (3).

In 2007, an outbreak involving 62 case-patients infected with 1 of 3 *S. enterica* serotype Schwarzengrund strains was investigated in Massachusetts; 61% were children <5 years of age, including 14 (23%) infants <1 year of age, and 96% were Asian (Table). A case-patient was defined as a person infected with *S. enterica* who had a pulsed-field gel electrophoresis *Xba*I restriction enzyme pattern indistinguishable from the outbreak strain. Exposure to poultry purchased at LBMs was reported, and environmental sampling at an implicated LBM identified 6 *S. enterica* serotypes, including 1 outbreak strain.

Three subsequent investigations of *S. enterica* serotype Schwarzengrund infections were conducted: a 2009 outbreak of 50 cases in New York, New York; a 2010–2011 multistate outbreak of cases predominantly in New York, New Jersey, and Massachusetts; and a 2012 multistate outbreak of cases mostly in Illinois and Michigan. Most case-patients in these outbreaks were of Asian race or Hispanic ethnicity, but 3/5 case-patients in Michigan reported Arab ethnicity; >50% were infants or children <5 years of age.

Among case-patients with available information, exposure to poultry from LBMs was reported by 88% of

case-patients in the 2009 New York investigation, 35% in the 2010–2011 multistate investigation, and 50% in the 2012 multistate investigation. In Michigan, the outbreak strain was isolated from chicken purchased at an LBM and collected from households of 2 case-patients.

During 2011–2012, the Centers for Disease Control and Prevention investigated a nationwide increase in *S. enterica* serotype I,4,[5],12:i- infections (pulsed-field gel electrophoresis *Xba*I restriction enzyme pattern JPXX01.1314). Although no single vehicle was implicated, clusters linked to LAMs were identified. In Minnesota, 14 illnesses were linked to meat from 3 neighboring LAMs. Environmental sampling identified the outbreak strain from an animal-holding pen at 1 of the markets. Seven case-patients were infants <1 year of age, and 10 reported Hmong ethnicity. In California, 10 illnesses likely associated with pork, lamb, and beef purchased at 3 LAMs were identified; case-patients reported Ethiopian and Hmong ethnicity. The outbreak strain was isolated from a pork leg collected from the freezer of a case-patient.

LBMs and LAMs appear to be preferred by certain populations for cultural, culinary, or religious reasons. Exposure to meat from these markets is being increasingly recognized as a potential source of salmonellosis. The

Table. Characteristics of outbreaks of human *Salmonella enterica* serotype Schwarzengrund infections linked to meat purchased at live-bird markets, United States, 2007–2012*

Year	Location	Outbreak strain†	No. cases	No. yes/total no. (%)‡				Exposure to meat purchased at live-bird markets
				Children <5 y of age§	Infants <1 y of age	Asian race	Hispanic ethnicity	
2007	Massachusetts	JM6X01.0240, JM6X01.0225, JM6X01.0118	62	38/62 (61)	14/62 (23)	53/54 (98)	NA	8/10 (80)
2009	New York, NY	JM6X01.0240	50	37/50 (74)	15/50 (30)	7/20 (35)	9/17 (53)	14/16 (88)
2010–2011	Multistate¶	JM6X01.0240	233	105/209 (50)	19/209 (9)	26/72 (36)	29/72 (40)	28/80 (35)
2012	Multistate#	JM6X01.0323	15	8/15 (53)	3/15 (20)	1/12 (8)	5/12 (42)	6/12 (50)

*NA, not available.

†Defined by pulsed-field gel electrophoresis *Xba*I restriction enzyme pattern.

‡Denominators are dependent on number of case-patients interviewed and may vary from case counts.

§Includes infants <1 y of age.

¶Case distribution includes New York (91, 39%), New Jersey (52, 22%), and Massachusetts (44, 19%).

#Case distribution includes Illinois (8, 53%) and Michigan (5, 33%).

cause is uncertain, but one factor may be an increased number of markets: in New York, New York, the number of LBMs nearly doubled from 44 to >80 during 1994–2002 (4). Most case-patients in these outbreaks had minimal direct contact with poultry or livestock at these markets; many case-patients were infants or young children who had not visited the markets or consumed meat. Therefore, one risk factor appears to be living in a household where the meat purchased from these markets is handled or consumed.

Several factors could make meats from these markets more risky for acquiring salmonellosis. Although LBMs and LAMs must meet sanitation requirements and prevent product adulteration (5–7), most are exempt from Food Safety and Inspection Service pathogen reduction performance standards (8,9) and probably do not require suppliers to use pathogen control measures on the farm or employ them during slaughter. Regulatory oversight by state agencies varies. Investigation findings, including environmental sampling, indicate that these markets could be heavily contaminated with *S. enterica*.

Preliminary results of a Massachusetts study found that fresh-killed chickens from LBMs had higher *Salmonella* and *Campylobacter* spp. contamination rates than those for chickens purchased at grocery stores (10; T. Stiles, unpub. data). High-risk cultural preferences identified in these outbreaks included consuming raw or undercooked meat and cooking parts (e.g., feet, intestines) that are more likely to harbor *Salmonella* spp. Further processing (e.g., de-feathering, butchering) conducted inside homes could lead to cross-contamination in the household environment. Because of language and cultural barriers, existing food safety messages may not have been effective.

The number and type of LBMs and LAMs, the populations these markets serve, and regulatory authority vary considerably by state, and many

case-patients and market owners have been reluctant to speak with public health authorities. Therefore, illness prevention requires a local, targeted approach. To strengthen regulations, some states have created guidelines and begun regular inspection of these markets. Educational outreach has included distribution of posters, flyers, and magnets with safe food handling messages in multiple languages; collaboration with community groups; and education of market owners and workers. Given the various communities who use LBMs and LAMs, multifaceted interventions, including collaboration between human and animal health agencies, are needed to reduce disease risk among market patrons and their families.

Acknowledgments

We thank state and local health and agriculture departments for providing assistance and contributions to these investigations, and Kristin Holt, Thomas Gomez, and Fidelis Hegngi for providing helpful advice and insights.

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DOI: <http://dx.doi.org/10.3201/eid2001.131179>

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MLB1 Astrovirus in Children with Gastroenteritis, Italy

To the Editor: Astroviruses are notable agents of gastroenteritis in many mammalian and avian hosts. Astroviruses are nonenveloped RNA small, round, viruses (SRVs) with a single-stranded, positive sense RNA of 6.1 to 7.9 kb (1). The genome contains 2 nonstructural genes, open reading frame (ORF) 1a and 1b, and a capsid gene, ORF2, with short 5' and 3' untranslated regions. Human astroviruses, a major cause of gastroenteritis, are classified in the human astrovirus species, comprising 8 serotypes (1). Recently, astroviruses genetically unrelated to canonical human astroviruses have been identified in human stools in several countries. These unusual astroviruses form 2 main genetic clades. One clade contains

MLB1, MLB2, and MLB3 (2–4). The second clade contains VA1, VA2, VA3 (also known as HMO-C, HMO-A, and HMO-B, respectively) and VA4 (5,6). More recently, a VA1/HMO-C-like virus was detected in brain tissue from an immunocompromised child with encephalitis (7). The discoveries of these viruses provide novel candidate agents of human disease and raise concerns inherent of possible zoonotic implications. Here we describe the detection and genome characterization of MLB1-like astrovirus in a 4-year-old male child hospitalized with severe gastroenteritis during January 2007 at the University Hospital of Parma, Italy. Clinical signs included vomiting and severe diarrhea, with moderate dehydration. The child was treated with rehydration and maintenance therapy (balanced glucose-electrolyte solutions) and completely recovered after 3 days.

Fecal samples collected at admission were subjected to routine virologic (electron microscopy [EM], cell cultures, latex agglutination, and reverse transcription PCR) and bacteriologic (culturing with selective and differential media) examinations. Fecal samples tested negative for common bacterial (*Clostridium difficile*, *Shigella* spp., *Salmonella* spp.,

Yersinia enterocolitica, *Staphylococcus aureus*, and *Campylobacter* spp.) and viral (adenovirus, rotavirus, norovirus, human astrovirus, enterovirus and sapovirus) enteric pathogens. However, through EM, SRV particles were observed in the feces of the patient (Figure, panel A). Despite several efforts with additional consensus primer sets for calicivirus and enterovirus, it was not possible to identify the SRVs detected by EM, and the case was archived as undiagnosed. However, beginning in 2008, several astroviruses genetically unrelated to canonical human astroviruses have been described (2). Broadly reactive consensus primers for astrovirus (8) spanning the RNA-dependent RNA polymerase (RdRp, ORF1b), along with sets of specific primers for these novel astroviruses (2), have been designed. By using these sets of primers, astrovirus RNA was detected in the sample. Upon sequence analysis of a small ORF2 fragment, the astrovirus strain (ITA/2007/PR326) displayed up to 97.8% nucleotide identity to MLB1-like viruses. Fragments of the genomic RNA in ORF1a (1,173 nt), ORF1b, and the genome 3' end (2,930 nt), including the full-length ORF2, were sequenced by using primers specific for MLB1-like astroviruses and

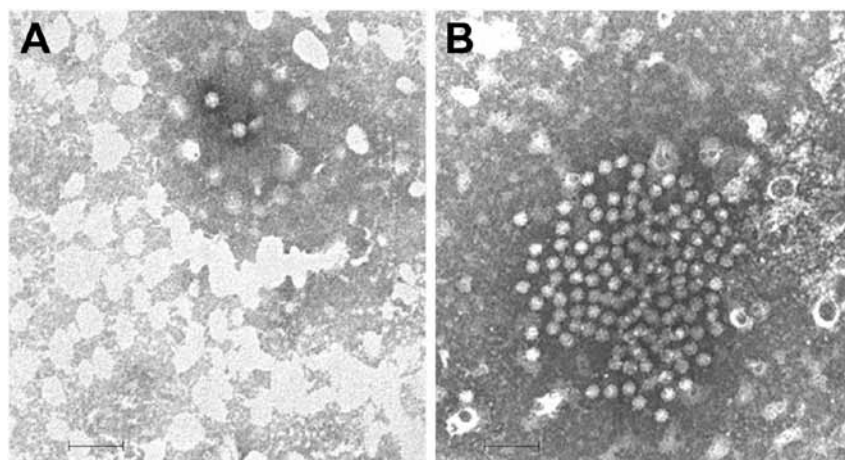


Figure. Electron microscopy images of astrovirus-like particles in fecal samples from 2 patients in Italy: A) strain ITA/2007/PR326, from a 4-year-old child hospitalized in January 2007; and B) strain ITA/2008/PR3147, from a 14-month-old child hospitalized in November 2008. The viral particles are \approx 28–30 nm in diameter. Scale bars indicate 100 nm.