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Salmonella in the tropical household environment – Everyday, everywhere☆

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Summary *Objectives:* To determine the prevalence of *Salmonella* in the environment of case and control houses, and compare serovars isolated from cases and their houses.
Methods: From 2005 to 2008, we tested samples from houses of 0–4 year old cases and community controls in Darwin and Palmerston for *Salmonella*. Case isolates were compared with environmental isolates. S. Ball and S. Urbana isolates were compared using Multiple Amplification of Phage Locus Typing (MAPLT) and Multiple-Locus Variable number of tandem repeat Analysis (MLVA).
Results: Salmonella were found in 47/65 (72%) case houses and 18/29 (62%) control houses; these proportions were not significantly different. In 21/47 (45%) houses, case and environmental isolates (from animal faeces, soil and vacuums) were indistinguishable. Multiple serovars were isolated from 20 (31%) case and 6 (21%) control houses. All but one environmental

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Vacuum cleaner

isolate are known human pathogens in the Northern Territory (NT). Each of the four pairs of S. Ball and S. Urbana were indistinguishable.
Conclusions: Animal faeces were the most likely source of salmonellosis in cases. The similar prevalence of house isolates suggests that *Salmonella* is ubiquitous in this environment. The distinction of S. Ball and S. Urbana subtypes enabled linkage of human illness to environmental exposure. Environmental contamination with *Salmonella* is an important source of sporadic infection in children in the tropics.

Introduction

Salmonella is a significant cause of diarrhoeal disease worldwide, and food and water contamination have usually been implicated as possible transmission routes.[1] In the Northern Territory of Australia (NT), salmonellosis is the most common notifiable enteric disease[2] disease. From 2001 to 2006, notification rates were consistently about 5 times the national rate (mean annual rate 188/100,000 vs 38/100,000).[3] Most cases of salmonellosis in the NT are sporadic, reported in Darwin (population 120,000) and mainly affect children while point source outbreaks are uncommon. The seasonal increase in December to April coincides with increasing humidity and rain.[2] The viability of *Salmonella* is known to increase with increasing humidity[4,5] and temperature.[6]

Salmonellosis in infants and young children has two characteristics that differ from disease in adults: dietary patterns and immune capacity. Salmonellosis in younger children has been attributed to a variety of environmental sources including well and beach water, soil, reptiles, amphibians, domestic pets and dry dog and cat food.[7–21] From 2000 to 2005 in the United States, seven outbreaks of salmonellosis had been linked to animal contact including owls, dairy cattle, rodents, wallabies and horses.[22,23] *Salmonella* is found naturally in the gastrointestinal tract of reptiles and amphibians.[8] A given *Salmonella* serovar may be present in many animal species, many serovars may be present in one species, and one serovar may predominate in several species in a given location.[7,24,25]

There have been few studies focussing on the distribution of *Salmonella* in the household environment[9,15,22,26,27] with their focus more on the microbiology of faeces of pets than on other potential sources in the home. The isolation of the same serovar of *Salmonella* from children with salmonellosis and from household samples have been reported in five studies and implicated pet dogs and rats, lizard, cockroach, vacuum cleaner contents, soil, food, kitchen and other household members.[9,15,22,26,27]

Our observations on the high notification rate of childhood salmonellosis in the NT prompted the following questions: (i) What is the prevalence of *Salmonella* in case and control houses? (ii) Do the serovars of environmental isolates match those from infected children? (iii) What are the likely sources of environmental *Salmonella*?

Materials and methods

We collected and tested environmental samples from case and control houses for *Salmonella*, and compared isolates from cases with those identified in their household environment. Case households were defined as those in which a 0–4 year old Darwin child had been notified with salmonellosis between July 2005 and June 2008. Control households were included for comparison only from June 2006 to June 2008; cases notified between July 2005 and June 2006 were therefore identified as being part of a case series. For the initial 5 months of the study (up to November 2005), only children with S. Ball were included.

Children without salmonellosis (controls) were selected randomly from a listing of all children in the Darwin community who had received any service from Northern Territory Health and Community Services. Control households were excluded if the parent reported evidence of the child or another household member having infectious diarrhoea in the preceding month or the household could not be contacted by telephone after 6 attempts. Ethics approval to conduct the study was obtained from the Menzies School of Health Research Human Research Ethics Committee.

Samples were collected from the house where the case or control children spent most time in the 3 days before symptom onset and were guided by parental description of their child's play areas, pets and behaviours. The number of samples from case series' houses was not restricted. Samples from the case and control homes however were limited to 3 except where more than one pet was present. These were categorised as samples from household vacuum cleaner, faeces from the child's most used play area and pet faeces. Samples were also collected from a childcare centre (CCC) attended by 3 children with salmonellosis who lived in different households. Interviewers were not blinded to the disease status of the children.

Parents in case and control households identified sources of pet faeces. Faeces of green tree frogs (*Litoria caerulea*) and geckos (*Hemidactylus frenatus* or *Gehyra australis*) was characterised by average measurements, colour, content and the observation of the animal in the location of the faeces by parent of the child with salmonellosis or interviewer.

Sample jars were filled with up to 80 mL of animal faeces or environmental samples and were stored in the dark at 4 °C until processing by Berrimah Veterinary Laboratories, NT Department of Resources. The minimum volume of faeces collected depended on the species it came from, thus a minimum of one pellet of faeces was used, excepting cockroach faeces. Berrimah Veterinary Laboratories processed environmental samples using both direct and enrichment culture techniques. Laboratory staff did not know the disease status of households. The culturing techniques are consistent with WHO recommendations for isolating *Salmonella*.[28]