OUTBREAK OF NON-TYPHOIDAL SALMONELLA IN THE NICU

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ABSTRACT

General Objective: To investigate the outbreak of diarrhea cases in the neonatal intensive care unit, which occurred on Jan. 17 – March 19, 2000, determine the cause, implement control measures and stop the spread of the disease.

Methods: A possible outbreak was reported on February 17, 2000. Cases were identified by isolation of salmonella in the stool or blood of suspected cases. After which an outbreak of nosocomial diarrhea at the neonatal intensive care unit from January 17, 2000 to March 19, 2000 was confirmed. An epidemic time curve was constructed to get information as to possible route of spread. Hypotheses were formulated as to the probable cause of the outbreak. Review of infection control practices was conducted and appropriate measures were instituted. Monitoring of new cases of salmonella infection was done through continued surveillance.

Setting: Tertiary government teaching hospital-neonatal intensive care unit in Manila.

Patients: NICU patients who developed diarrhea during the period stated.

Results: Nineteen cases of culture-positive non-typhoidal salmonella C were identified. Eighteen (18) of these were resistant to ampicillin and 1 was intermediate. This number confirmed an outbreak of Salmonella C diarrhea at the NICU (attack rate of 0.91%) as compared to the same period the previous year when not a single salmonella isolate was reported. Epidemic time curve pointed to a person-to-person type of spread. Several contributing factors were identified: (1) change in NICU setting. (2) increased admissions in a smaller NICU. (3) Limited access to handwashing. (4) Breaks in infection control practices. (5) Nursing personnel to patient ratio was at its lowest. Infection control measures were instituted, mostly strict handwashing, the use of alcohol hand rub, use of gloves and cohorting were implemented by NICU. Last case was reported on March 19, 2000 4 days after control measures were implemented. Surveillance showed no new cases up to the time of reporting.

Conclusion: The NICU outbreak of Ampicillin resistant Salmonella C was secondary to person to person spread most probably from an infected patient or personnel. Intensified and strict adherence to infection control practices mostly handwashing, ultimately put a stop to the outbreak with the last reported case on March 19, 2000.

INTRODUCTION

In February 17, 2000, the Pediatric Infectious Disease Section (PIDS) of the Philippine General Hospital (PGH) was alerted. Six patients in the neonatal intensive care unit (NICU) developed diarrhea with Salmonella as stool isolates. There was one mortality. Within 10 days, five other cases were identified and in March 19, 2000 the last confirmed case was reported. The total number of confirmed cases was nineteen (19).

The genus Salmonella is now considered to comprise a single specie named Salmonella enterica based on DNA structure and biochemical properties. There are seven sub-species with almost all subgroup 1 (Salmonella enterica subspecies enterica). The subspecies can be divided into serotypes based upon their O (somatic) and H (flagellar) antigens. Two main clinical syndromes are associated with Salmonella. The first is the protracted bacteremia of typhoid and paratyphoid fevers. The second is the predominantly gastrointestinal tract illness caused by animal adapted strains or non-typhoidal Salmonella[6]. *S. typhimurium*, serotype D is most commonly reported as the cause of human salmonella infection in the United States[5]. In the Philippines, *Salmonella typhimurium* D and *Salmonella worthington* were the most common strains isolated in neonates based on a five-year study at Children's Medical Center in the late 70's[8]. In a more recent study by Gatchalian, et. al. in the early 90's involving 873 infants 90 days and younger, *Salmonella spp.* was the most common etiology of serious bacterial infections other than meningitis who presented at any 1 of 3 Manila community hospitals during a 2-year study period. There were no mortalities among the 6 patients with *Salmonella* isolates[3].

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Keywords: *Salmonella* outbreak, NICU.

Many outbreaks of Salmonella gastroenteritis in hospitalized patients due to a variety of serotypes have occurred through various methods of transmissions like food-borne, common-source and person-to-person[6]. Acquisition of multiply resistant microorganisms by premature infants in special care nurseries results to increase in morbidity and mortality[5,10]. The resistance rate of non-typhoidal *Salmonella* for the year 2000 was 49.3% to ampicillin, 24.1% to chloramphenicol and 30.6% to trimethoprim-sulfisoxazole[11]. With reference to the February outbreak incident in PGH, the objective of this study is to investigate the outbreak in terms of patient demographics, setting, microbiology of the isolates; formulate hypothesis regarding possible causes of the outbreak, formulate and implement control measures to prevent and arrest the spread of the disease, and finally terminate the outbreak.

OBJECTIVES

General Objective: To investigate the diarrhea outbreak in the nursery from January 17, 2000 to March 19, 2000, identify the cause and institute appropriate control measures.

Specific Objectives:
1. To describe the case demographics and setting.
2. To determine the etiology and microbiology of the isolates.
3. To formulate a hypothesis regarding pattern of spread.
4. To implement control measures.
5. To measure outcome of the intervention.

METHODS

Case Definition

A suspect case was defined as any NICU infant who developed diarrhea from January 18 – March 19, 2000 (the epidemic period). Confirmed cases are those with stool or blood isolates of salmonella.

Determination of Existence of an Outbreak

To ascertain whether the cluster of patients with salmonella gastroenteritis represented a real outbreak, the current number of confirmed cases during the epidemic were determined and had to be compared with the pre-epidemic period (i.e., August 1999 to January 2000) and the months of the previous year (i.e., January to March 1999). A twice or more increase in the number of cases points to an outbreak. The presence of even one case of Salmonella where there was none before is also proof of the presence of an outbreak. After the presence of a real outbreak was established, initial measures to control the spread of infections were instituted.

Epidemiological Investigation
Setting

The UP-PGH NICU is a tertiary facility hospital room measuring 306 square meters with an average capacity of 60 to 90 babies. It is a rectangular room divided into 3 areas namely: NICU IIIA, where infants who needed tertiary care such as those that are intubated, needs ventilatory support or oxygen support are placed: NICU IIIB, a transition area for patients from NICU A who needs further observation but less frequent monitoring; and NICU II, where infants who only needed up-building (growers) and completion of medications are placed.

In January to March, 2000 the average monthly admissions was 696 babies. During this period NICU was closed due to physical improvements and renovations. NICU IIIA and IIIB was then a much smaller room 100 square meters in measurement while NICU II were transferred to 3 rooms (Rooms 416, 417 and 418) in the paywards. Each room measuring about 90 square meters. In contrast, the average monthly admissions from January to April of the previous year (1999) was 350 babies.

Table 1. Comparison of Conditions at NICU during the outbreak and the same period of the previous year.

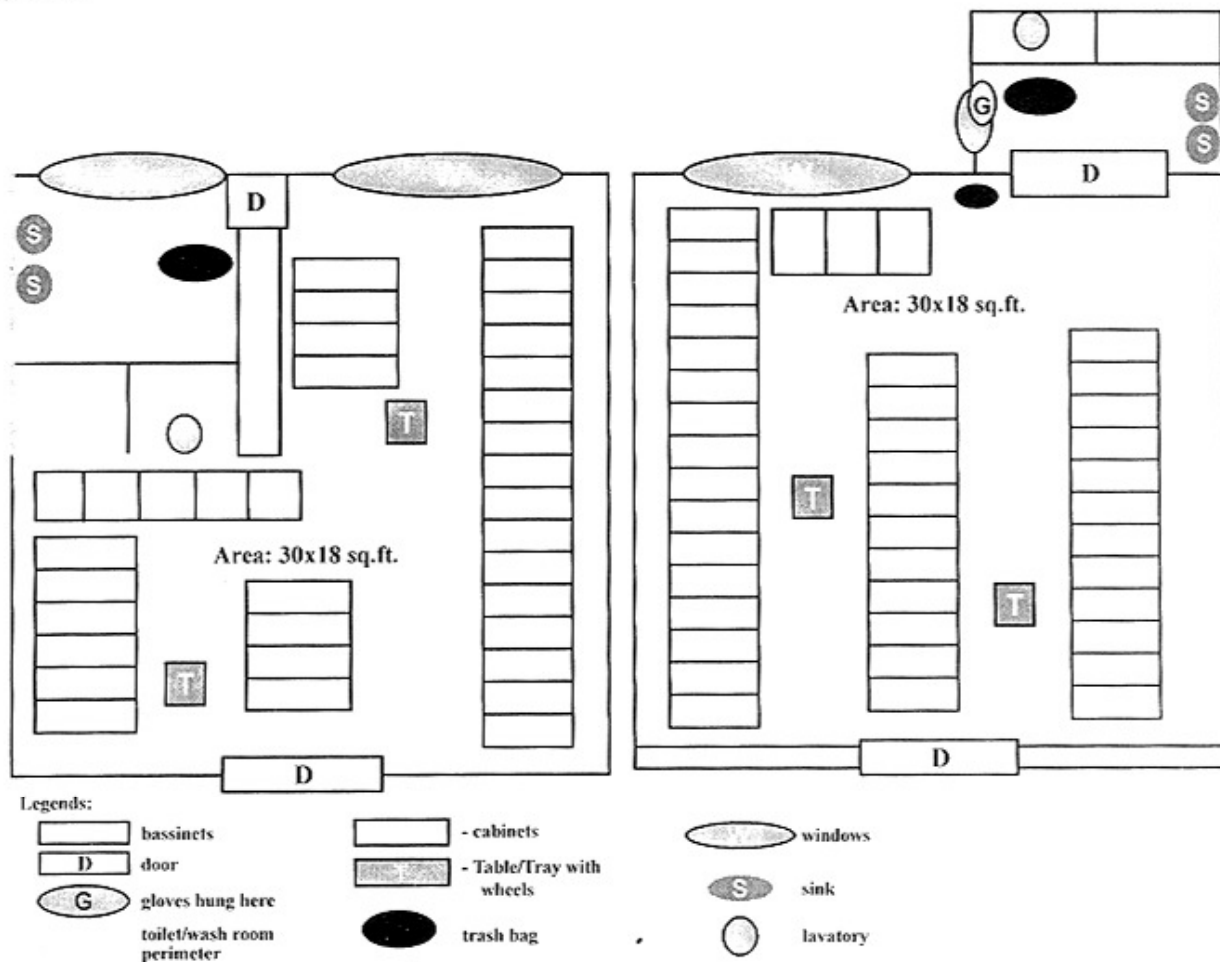|	JANUARY-MARCH 1999	JANUARY-MARCH 2000
Total Area of NICU	400 sq meters (2 rooms)	370 sq. meter (4 rooms)
Average No. of Admissions	350 babies/ month	696 babies/ month
No. of functioning sinks	11	10
Visibility of sinks	Yes	Not in NICU II (3 rooms)
Nurse to Patient Ratio	1:15	1:18.5

Fig. 1. Rooms 417(Left Room) and 416 (Right Room)

There was only one door into and out or the room where people and garbage pass. Doors were opened by turning knobs. The patients in bassinets were placed side by side in rows. There were 25-30 patients per room a day. Sinks were at the opposite end of the room inside the comfort room. Trash bags were uncovered and inside the far end of the room. The CR floors dirty. Recommendations for infection control ideally would include that: (1) patient beds be at least 3 feet apart. (2) Separate entrance and exit of people and garbage into the room. (3) Trash cans should be clean and covered. (4) Swinging doors allow the hands to be free especially after handwashing. (5) Sinks should be in sight and at bedside for handwashing in between patients. (6) Use of alcohol hand rubs in between patients after an initial handwash with soap and water provided hands are not visibly contaminated with organic material like blood or feces (Mayhall, 2000; CDC Guidelines)
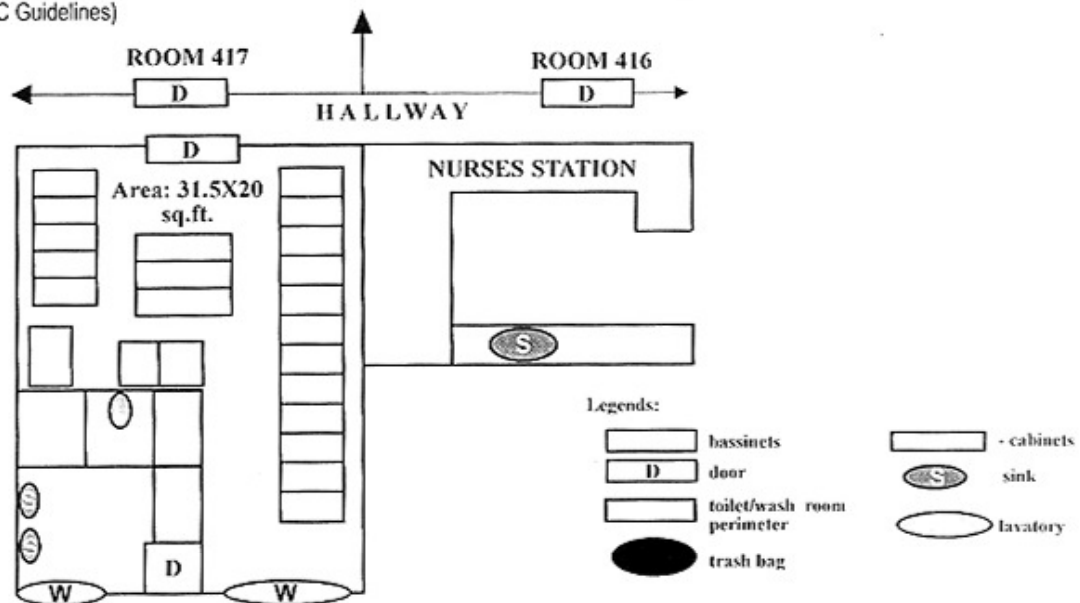

Fig. 2. NICU II (Room 418)

There were about 10-15 patients in this room. Most were for observation of 12-24 hours prior to direct roomig.

Legends:

- bassinets
- door
- swing door
- toilet/wash room perimeter
- table

- cabinets
- Table/Tray with wheels
- trash bag
- bili bed

- windows
- sink
- sink-out of order
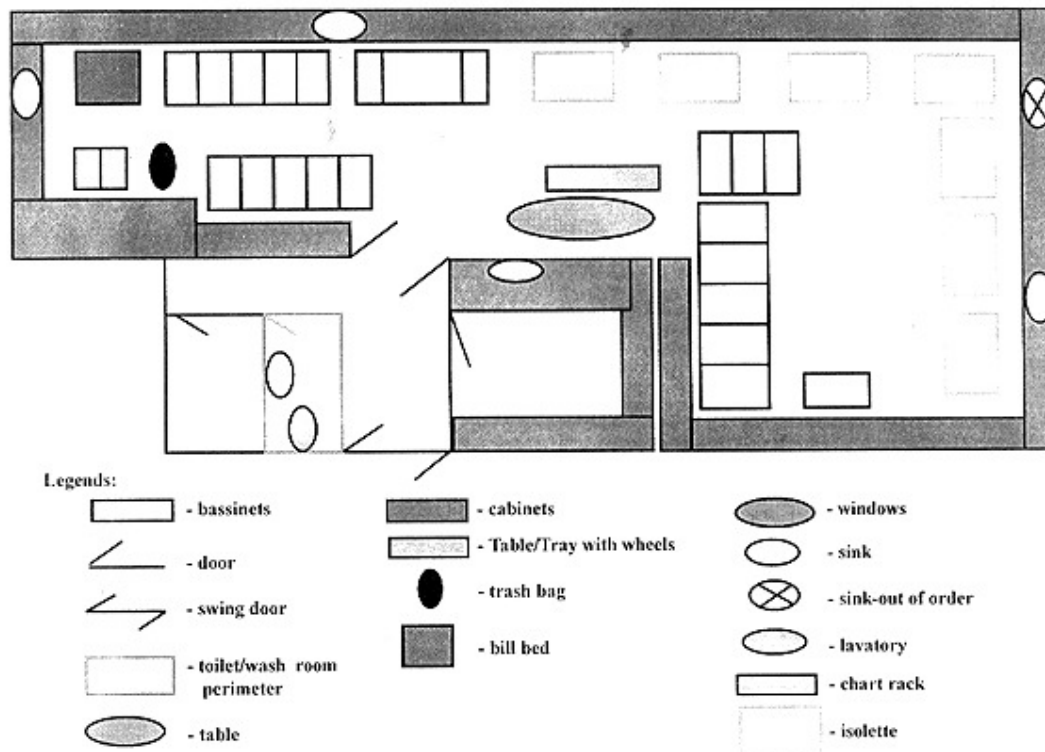- lavatory
- chart rack
- isolette

Fig. 3 NICU III
There were from 20-33 critically ill patients at NICU III. There were functioning sinks within sight. The floors were dirty during review and the uncovered trash bag was near patients. The confirmed case here was located near the trash bag.

Description of Cases

The following information were collected from case-patients (confirmed cases) as well as suspects (suspected cases): (1) name and case number, (2) demographics such as age, sex, gestational age, location and duration of stay at NICU at the time of onset of signs and symptoms; (3) clinical data such as date of onset, presenting signs and symptoms, and laboratory findings; and (4) other factors like birth weight, presence of intravenous catheters, umbilical catheters, receipt of total parenteral nutrition (TPN), intubation, type of milk feeding (breastmilk, formula or mixed), manner of feeding, exchange transfusion, and other underlying medical conditions.

Staffing and Mapping

The daily nurse-patient ratio and patient census were determined and compared for the epidemic period and for an earlier period. Definite exposure of patients to nurses as well as to nursing aids could not be traced since handling of babies of each nurse is not limited to the babies assigned to him or her due to the amount and variability of workload at any given time. Nurses rotated every 2 weeks, Medical Interns every week, Pediatric Residents and Fellows every month. Spot mapping was not feasible in our setting since babies were moved from one place to another based on their condition and needs

(e.g., ventilation, oxygen support, completion of antibiotics, grower), although the area in the NICU (IIIA, IIIB, II) where the infant was, at the onset of symptoms was ascertained.

Procedure Review

Procedures such as routine handwashing in between patient contacts, milk preparation, feeding practices and disposal of soiled diapers were reviewed and surveillance done.

Microbiologic Investigation

Once a patient was suspected to have salmonella gastroenteritis, stool culture was requested together with blood culture. With a positive blood culture, cerebrospinal fluid was also cultured.

RESULTS
Background Rates

For the period of January to March 2000, the incidence rate for diarrhea was 1.6% (34/2087). This could not be compared with the same months of the previous year because the average incidence rate of diarrhea per month at the nursery is largely undocumented. Compared to the previous year, however, no salmonella was isolated from stool or blood of NICU patients as reported by the bacteriology laboratory.

Case Characteristics

During the study period, there were 34 cases of acute diarrhea and 19 confirmed salmonellosis. The first 2 confirmed cases started to have diarrhea on January 23, 2000. Both were located beside each other in NICU II (Room 417) near the comfort room. Further investigation revealed that the index case was in fact 13 days already in NICU II when salmonella was isolated in stool after a bout of diarrhea. There were 6 other confirmed cases by February 17, 2000 with 1 mortality. Two of the cases were from NICU III hence Nursery staff was alarmed and informed the Pediatric Infectious Disease Section of the increasing number of cases. One of the NICU III cases was located beside the trash bag. Subsequent cases were seen in NICU II (Room 416) and contained here with the last confirmed case identified about 2 months later. The chronology of confirmed and suspected patient as well as their location follows in Table II.

Table 2. Chronology of Outbreak and location of patients

CASE	DIAGNOSIS	DATE ONSET OF SYMPTOMS	AREA IN NICU
1*	Suspect	1-18-00	II (417)
2	Suspect	1-19-00	II (417)
3	Confirmed	1-23-00	II (417)
4	Suspect	1-23-00	II (417)
5	Confirmed	1-23-00	II (417)
6	Confirmed	2-3-00	II (417)
7*	Confirmed	2-10-00	II (417)
8	Suspect	2-10-00	II (417)
9	Confirmed	2-13-00	II (417)
10*	Suspect	2-14-00	III (PSU)
11	Confirmed	2-16-00	III (PSU)
12	Suspect	2-16-00	II (417)
13	Confirmed	2-17-00	III(PSU)
14	Confirmed	2-17-00	II (417)
15	Suspect	2-18-00	II (417)
16	Suspect	2-18-00	II (417)
17	Confirmed	2-18-00	III (PSU)
18	Suspect	2-18-00	II (417)
19	Suspect	2-18-00	II (417)
20	Suspect	2-18-00	II (417)
21	Confirmed	2-18-00	II (416)
22	Confirmed	2-20-00	II (416)
23	Suspect	2-20-00	II (417)
24	Suspect	2-21-00	II (416)
25	Suspect	2-21-00	II (416)
26	Suspect	2-21-00	II (416)
27	Confirmed	2-21-00	II (416)
28	Confirmed	2-25-00	II (417)
29	Confirmed	2-25-00	II (417)
30	Confirmed	2-26-00	II (416)
31	Confirmed	2-26-00	II (416)
32	Confirmed	2-26-00	II (416)
33	Confirmed	3-18-00	II (416)
34	Confirmed	3-19-00	II (416)

*Mortality

Initial Control Measures:

In response to the alert, PIDS gave NICU a general infection control guideline on February 18, 2000 to help contain and improve the situation. Universal precautions was strongly recommended. The role of effective handwashing as a mainstay of prevention cannot be over-emphasized in controlling the spread of enteric infections within the hospital environment. As such, basic control measures were intensified especially strict handwashing which was stressed to all NICU personnel. Body substance isolation in the form of proper use of gloves in between patients and after handwashing was reiterated. Gowns, plastic, aprons, masks or goggles should be worn when secretions, blood or body fluids are likely to soil or splash on clothing, skin or the face. Soiled reusable items, linen, and trash should be contained to prevent leaking. Double bagging is not necessary unless the outside is visibly soiled. Needles (without recapping them) and sharps should be placed in puncture-resistant rigid containers. Cohorting of both patients and their nursing staff was recommended. Cleaning and disinfection of the crib and the environment was also recommended. Included among the initial control measures was a provision regarding sick personnel. Any staff member with signs/symptoms that suggest infection like diarrhea or fever should be excluded form contact with patients for at least 2 days after resolution of the illness. If stool culture reveal the presence of an infectious pathogen, the employee should not return to food handling and should not care for patients in high-risk areas (e.g., Intensive Care Unit, newborn nurseries and transplant services) until three (3) stool specimens obtained a minimum of 24 hours apart are negative for the pathogen. Surveillance of actual practices and changes in procedure followed.

Review of Procedures

Lapses in procedure was noted among nursing and medical personnel. The following were reported during the review:

1. Handwashing was inconsistent in between patient contacts. A personnel was observed not to wash her hands at all in between changing diapers.
2. Waste disposal:
   a) Soiled linen were discarded in a partition under a small table with wheels. This table also carried linen, medications, thermometers and even patients' charts at times.
   b) The toilet/wash rooms in 2 rooms (417 and 416)

used as NICU II were located in the farthest opposite of the entrance to the rooms. (Fig. 1). The garbage bin (basically a large black plastic bag) with its un-segregated contents was un-covered. A foot away were 2 sinks but only one was functioning. Gloves were also washed and hung to dry in this comfort room.

c) Soiled diapers were thrown directly into another small uncovered waste basket which was in the far end of the room, beside the entrance to the toilet/wash rooms. Personnel would traverse the entire length of the room and all babies along the way if he/she happened to be in the opposite end.

3. Feeding per ANF would find some half-drank milk bottles fallen inside the bassinet with the nipples in contact with the linens or the bassinet since these bottles would just be propped by linen. When the infant cried, the bottles are simply propped on back.

4. The floor in NICU III beside the trash bag was very dirty and with some litter (Fig. 3). Floors in the NICU II comfort rooms were dirty and so were the sinks.

Follow-up

Follow-up on implementation of guidelines was made through a second letter on the 2nd week of March 2000 with an attempt to do stool cultures of nursery personnel. NICU staff implemented strict hand washing, the proper use of gloves, alcohol hand rub, cleaning of their floors and proper garbage disposal also by the 15th of March, 2000.

Staffing

The average daily census of babies was 69 in January 2000, 84 in February and 75 in March 2000. In April 2000, it was an average of 80 patients per day. Nurse to patient ratio was 1:18.5 at NICU II, whereas it was 1:15 previous to the study period. At NICU III, the ratio of nurse to patient was 1:6 compared to 1:4-6 in the months before January 2000. Nurses are expected to monitor babies every hour at NICU III and every 4 hours for babies in NICU II. A nurse exclusively assigned to the cohorted patients with salmonellosis would aggravate the existing nurse to patient ratio.

Mapping

The bassinets in NICU II (rooms 416, 417, 418) were placed side by side in 3 rows (see Fig. 1) to accommodate the many patients. There was no specific bed location for patients. Beds got moved around as the room was cleaned or patients were bathed. After the outbreak was confirmed, cohorting of symptomatic patients was started. Confirmed cases remained cohorted in NICU II (Rm. 416) even after the regular or main nursery re-opened on April 2000.

Clinical Profile of Cases

The mean age of confirmed cases was 34.8 weeks with a mean weight of 1862.5 grams. Diarrhea was noted after a mean stay in the NICU of 17.26 days. There were no striking differences in mean age, mean weight and number of mean stay of patients in NICU for the case suspects (Table III and IV).

Table 3. Clinical Profile of 19 Patients with Confirmed Salmonella

SEX	GESTATIONAL AGE (weeks PA)	BIRTH WEIGHT (grams)	NO. OF DAYS IN THE NICU PRIOR TO ONSET OF DIARRHEA	UNDERLYING DISEASE	STOOL CULTURE	BLOOD CULTURE
F	36-37	1620	13	SGA	Salmonella C	(-)
F	36-37	1800	4	Breech, SGA	Salmonella C2	S-epidermidis
F	34	1810	15	Breech, Low APGAR	Salmonella B	(-)
M*	30	1600	13	PT, SGA	Salmonella C	Salmonella C
F	28-29	1350	30	PT, SGA	Salmonella C	(-)
M	39	2000	10	SGA, MCA	E. coli	Salmonella C1
M	41	3300	23	R/O MAS	Salmonella C	Salmonella C
M	34	1193	30	SGA	E. coli	Salmonella C
F	39-40	2990	6	NPO	Salmonella C	(-)
F	32-33	1467	10	PT, AGA	Salmonella C	(-)
F	35-36	1770	19	PT, SGA	Salmonella C1	(-)
F	35	1200	30	PT, SGA	Salmonella C	(-)
F	35-36	2200	7	PT, AGA	Salmonella C1	(-)
M	33-34	2030	13	PT, AGA	(-)	Salmonella C2
M	34	1193	38	PT, SGA	Salmonella C1	(-)
F	30	1600	22	PT, SGA	Salmonella C1	(-)
M	39-40	2810	18	AGA, TORCH	Salmonella C	Achromobacter
M	36-37	1625	14	SGA	Salmonella C	(-)
M	36-37	1830	13	SGA	Salmonella C1	Enterobacter
	X = 34.8	X = 1836	X = 17.26			

*Mortality, SGA:small for gestational age, PT:preterm, AGA:advance for gestational age, MCA:multiple congenital anomaly, MAS:meconium aspiration syndrome, NG:no growth

Table 4. Clinical Profile of 15 Patients suspected to have Salmonellosis

SEX	GESTATIONAL AGE (weeks PA)	BIRTH WEIGHT (grams)	NO. OF DAYS IN THE NICU PRIOR TO ONSET OF DIARRHEA	UNDERLYING DISEASE	STOOL CULTURE	BLOOD CULTURE
M*	31	1160	16	SGA, 1st of Twin	E. coli	NG
M	32	1569	24	HMD	E. coli	NG
F	35-36	2365	2	PROM	NG	NG
M	38-39	3925	32	Congenital HCP	NEPEC 'B'	NG
M*	38	1855	10	SGA, 2nd of Twin	Klebsiella pneumonia c	Enterobacter cloacae
F	37	1490	52	PDA	E. coli	H. alvae
F	34	1260	34	SGA	NG	NG
F	38	1470	30	SGA, 2nd of Twin	Klebsiella	NG
M	30	1700	10	Preterm	NG	NG
M	35-36	1650	22	SGA	E. coli	NG
F	35	2100	35	Sepsis	Klebsiella	NG
M	36	1900	24	SGA	E. coli	NG
M	30	1700	26	SGA	Klebsiella ozanae	NG
M	38-39	3030	2	Sepsis	NG	NG
M	38	2480	11	Sepsis	E. coli	Klebsiella ozanae
	X = 35	X = 1976.9	X = 22			

*Mortality; M:male, F:female, PA, pediatric aging, HMD:hyaline membrane dse, SGA:small for gestation age, PROM:premature rupture of membranes, HCP:hydrocephalus, PDA:patient ducturs anteriosus, NEPEC:non-enteropathogenic E. coli, NG:no growth.

Microbiologic Investigation

Sixteen (84.2%) of the 19 confirmed patients grew Salmonella in the stools and 5 (26.3%) also had Salmonella isolate on blood culture. Two (10.5%) had Salmonella both in their stools and blood (Table V). All 5 patients with blood isolates underwent lumbar tap and were all negative for salmonella meningitis.
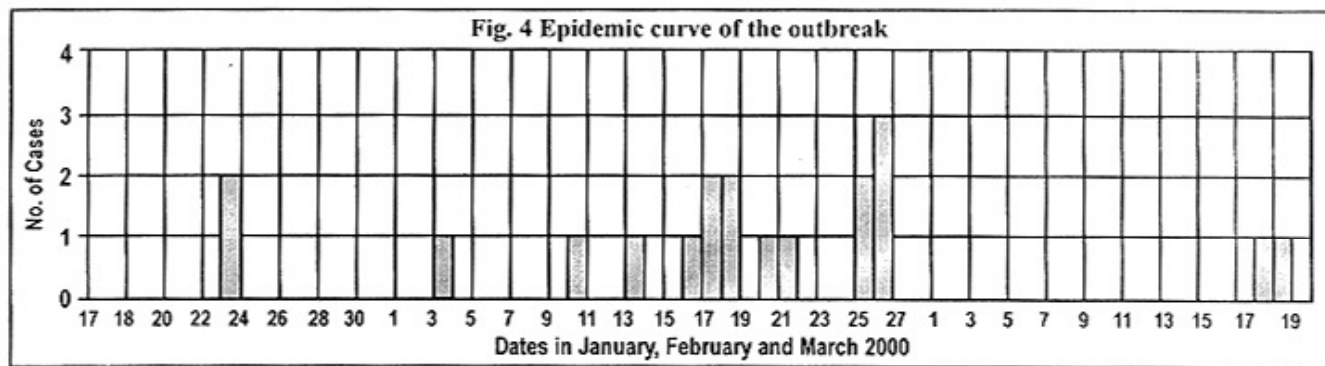
Hypothesis

Initial investigation gave a hint that person to person transmission considering the lapses in hand washing was the possible route of spread (later confirmed by the epidemic curve see Fig. 4) or an infected newborn possibly from an infected mother brought into the NICU. However, the index case was already 13 days in NICU by the time salmonella was isolated in the stool and the incubation period of salmonella gastroenteritis is about 72 hours at most, hence the hypothesis of an infected newborn from an asymptomatic mother was not probable.

Table 5. Sensitivity Pattern of Salmonella Isolates

	STOOL CS (N=14)			BLOOD CS (N=5)		
	S	I	R	S	I	R
Amikacin	3	1	0	1	0	0
Ampicillin	0	1	13	0	0	5
Amoxycillin-Clavulanic Acid	10	0	0	0	0	0
Sulbactam-Ampicillin	1	0	0	1	0	0
Chloramphenicol	5	0	0	1	0	0
Ceftriaxone	1	1	0	4	0	0
Ceftazidime	2	0	0	2	1	0
Cotrimoxazole	3	0	3	0	0	3
Imipenem	3	0	0	0	0	0
Piperacillin-Tazobactam	2	0	2	0	0	0
Netilmycin	1	1	4	0	1	0

Legend: S:sensitive, I:intermediate, R:resistant

Fig. 4 Epidemic curve of the outbreak

No. of Cases

17 18 20 22 24 26 28 30 1 3 5 7 9 11 13 15 17 19 21 23 25 27 1 3 5 7 9 11 13 15 17 19
Dates in January, February and March 2000

The epidemic curve generated when all confirmed cases were plotted (Figure 4) showed a person-to-person type of spread. Taking the stool cultures of all NICU personnel (nurses, aides, interns, residents and fellows) was not cost-effective. The stool cultures of personnel in direct contact with food (milk) handling was recommended as a start but since the epi curve did not show a food or common source outbreak, stool cultures were not done.

Outcome

One of the 19 confirmed cases died with a case fatality rate of 5.26%. The patient who died was a preterm, 30 weeker, small for gestational age, 1600 grams male neonate.

He was on piperacillin-tazobactam and amikacin for sepsis. Feeding per oro-gastric tube (OGT) with milk formula, the infant stayed 13 days in NICU II (Rm. 417) when he manifested with watery stools on February 10, 2000. Stool and blood cultures grew *Salmonella C*.

The 18 other confirmed cases were successfully managed medically. The antibiogram of the *Salmonella C* isolate showed resistance to ampicillin, cotrimoxazole, piperacillin-tazobactam and netilmycin but sensitive to ceftriaxone (Table V). Ceftriaxone was then given at 100mg/kg/day in 2 divided doses to those with salmonella gastroenteritis for 5 days. Those with salmonella sepsis (blood and stool grew *Salmonella C*) were given ceftariaxone for 10-14 days. Surveillance showed no new cases after lapses in infection control were corrected and NICU continued to practice infection control. The outbreak was contained with the last confirmed case reported on March 19, 2000.

DISCUSSION

An outbreak is an increase in occurrence of a complication or disease above the background rate or maybe one episode of a rare occurrence[6]. There were 19 confirmed *Salmonella* cases at NICU during the study period where there were none in the previous 12 months. NICU took notice because results of stool cultures of patients grew *Salmonella Salmonella* organisms are gram-negative bacilli that belong to the *Enterobacteriaceae* family. Most serotypes that cause human disease are in serotypes A through E. In 1997, the most frequently reported human isolates in the United States were *Salmonela typhimurium* (serogroup B), *Salmonella heidelberg* (B), *Salmonella enteritidis* (D), *Salmonella newport* (C2), *Salmonella infantis* (C1),

Salmonella agona (B), *Salmonella thompson* (C1), and *Salmonella montevideo* (C1) (Red Book, 2000). *Salmonella C, C1, and C2 (infantis, newport, thompson, montevideo)* were isolates during the outbreak. A study by Po in the late 70's only showed strains Salmonella typhimurium present in the Philippines. The Gatchalian study only reported *Salmonella spp*. These results were consistent with that most commonly reported in the Red Book.

There was 1 *Salmonella B* isolate early on in the study period. It was unfortunate, however, that this isolate and all other isolates were no longer available to confirm the identification of the organism. This single Salmonella B isolate may really be also Salmonella C. The similarity in the antibiogram of the Salmonella isolate (i.e., all were sensitive to ceftriaxone except for 1 isolated in the end of the study period: all were also resistant to ampicillin and 1 intermediate to ampicillin (3rd to the last confirmed case) can only point to *Salmonella C* as the most probable etiology of the outbreak. This is because the antimicrobial susceptibility patterns (antibiogram) and serological typing (serotype) are no longer considered as reliable as newer molecular methods like bacteriophage (phage typing) or plasmid analysis and chromosomal enzyme analysis in characterizing microbial epidemic strains. These molecular microbiologic methods are not available in our hospital.

The epidemic curve (Figure 4) generated was compatible with person-to-person transmission as illustrated by an epidemic curve of long duration with few, if any, peaks. The chronology of cases (Table 1) showed that the first 5 confirmed cases were all located in NICU II (Rm. 417) from January 18, 2000 to February 13, 2000. Two cases were identified to have been located near the toilet/washroom (WR). Was the WR the source of the non-typhoidal salmonella outbreak? Another confirmed case was located this time in NICU III (PSU) on February 16, 2000. This case was also identified to have been located beside the trash bag cum garbage disposal container. If garbage or the WR were the source of salmonella, cleaning the WR, proper waste disposal and effective handwashing would indeed control and stop the spread. There were 2 other confirmed cases in NICU III for a total of 3 days which may have been spread by personnel either on diaper change, blood extraction or monitoring and then no more cases after infection control breaks were corrected. On the other hand, NICU II (Rm. 416) continued to have one more confirmed case in February 17 (at which time

PIDS was informed of a possible outbreak) before the last 2 confirmed cases were identified in March 19, 2000. There were no cases seen in room 418 maybe because there were less patients here who had to stay for 12-24 hour-observation prior to direct-rooming-in. This room was also located across the hallway or corridor (Fig. 2) from the rooms where cases were identified hence may not have favored transfer of the salmonella whether by patients, nurses or other personnel.

Other contributing factors would be over-crowding in a much smaller room. The physical layout of Room 417 (Fig. 1), show that the area was the same as that Room 416 but it was smaller since the WR occupied almost a fourth of the entire space. Another contributing factor were breaks in infection control practices. The sinks were not visible and accessible for frequent handwashing between patients.

The epidemic curve showed person-to-person transmission not common source type hence the possibility that milk and its preparation as the source of the outbreak was not very likely. Therefore, an environmental culture in this direction was far-fetched, thus was not done. A contaminated patient equipment (Khan, et. al: Ip, et al; McAllister) was also not likely because epidemic curves of this type of transmission would show cases simultaneously occurring in different areas.

Person-to-person transmission being very likely. PIDS still suggested stool culture for possible asymptomatic carriers among NICU personnel but it was not cost-effective to do stool cultures of all NICU personnel. A questionnaire-interview could have been undertaken to see who among NICU personnel were sick or symptomatic during the said period but honesty may be a drawback here. On the other hand, the probability that this outbreak was brought into NICU by an infected newborn from an asymptomatic mother was nil since the incubation period of salmonella gastroenteritis is 72 hours at most. The initial or index case on January 23, had diarrhea after 13 days of NICU stay. The other January 23 confirmed case was born 9 days after the index case and developed diarrhea after 4 days stay in NICU II (Rm. 417). They were located beside each other. Both mother and the index case were long discharged before February 17 when PIDS was alerted and the investigation began.

PIDS recommended general infection control guidelines to prevent and arrest the outbreak on February 22, 2000. Another guideline was drawn on March 12, 2000 based on lapses observed in infection control practices as seen in the results of 'Review of Procedures'. Nevertheless, in response to the heightened infection control awareness brought about by the outbreak, the NICU personnel responded positively and implemented control measures by the 15th of March. Universal precautions and the conscious use of gloves, effective handwashing and the use of alcohol hand rub in between patients, soiled linen and proper waste disposal were done, in addition to cohorting of infected patients. The cohorted patients stayed in Room 416 until discharged, even as the renovated regular NICU re-opened on April 2000. The last case was reported on March 19, 2000 four days after control measures were implemented. The incubation period of salmonella diarrhea is 72 hours (Red Book, 2000).

Decongestion of NICU was also recommended (attempted) considering the twice increased census during the study period (69 to 84 average daily mean of 74.7 patients per day) in a much smaller and "fragmented" NICU. Nothing came out of this due to the "Admit All" policy of the hospital. The increased admissions was aggravated by an under-staffed NICU due to migration of nurses abroad. We also have to consider that NICU II then was in reality 3 small rooms in the Pay Ward of the hospital (Rooms 417, 416 and 418). The ideal nurse to patient ratio in the intensive care units is 1:2. The NICU set-up during that period under study was not the usual much less the ideal and easily allowed the breaks in infection control listed earlier.

Despite the number of diarrhea cases seen during the period of the outbreak, there was only 1 mortality among the confirmed cases. Case fatality rate was 5.26% (1/19). Antimicrobial therapy usually is not indicated for patients with uncomplicated (non-invasive) gastroenteritis caused by nonthyphoidal *Salmonella spp.* because therapy does not shorten the duration of disease[9]. Nevertheless, confirmed cases still with diarrhea were given intravenous ceftriaxone (based on the common sensitivity pattern of the isolates) for 5 days and 10 days for those with Salmonella blood isolates. This was consistent with recommendation that support treatment of Salmonella gastroenteritis in patients with increased risk of invasive disease, including infants younger than 3 months of age or immunocompromised either from illness or therapy[9]. Age-specific attack rates for *Salmonella* infection being highest in persons younger

than 5 years of age and with a peak early during the first year of life (Red Book). Attack rate for this outbreak was 0.91% (19/2087).

CONCLUSION

The NICU outbreak of Ampicillin-resistant *Salmonella C* was secondary to person to person spread most probable from an infected patient or personnel. Intensified and strict adherence to infection control practices, particularly handwashing, alcohol hand rub and the use of gloves in addition to cohorting ultimately terminated the outbreak with the last reported case on March 19, 2000.

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