

## ORIGINAL ARTICLE

# The Etiology of Nosocomial Infections in Pediatric Patients at the Department of Child Health, School of Medicine Padjadjaran University Hasan Sadikin General Hospital, Bandung

by

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## Abstract

A 9 - month prospective study on the etiology of nosocomial infections was carried out at the Department of Child Health, School of Medicine, Padjadjaran University, Hasan Sadikin General Hospital Bandung, starting from August 1988 to April 1989.

During the study, 411 episodes of nosocomial infections occurred out of 4328 hospitalized pediatric patients.

The distribution of pathogens causing nosocomial gastroenteritis was *E. coli* (69.2%), *Salmonella* sp (23.1%), rotavirus (6.4%) and *Shigella* sp (1.3%). *Klebsiella pneumoniae* seemed to be the pathogen most frequently associated with nosocomial skin infections (26.7%), followed by *Enterobacter aerogenes* (20.0%), *E. coli*, *Ps. aeruginosa* and *S. aureus*, each in 13.3% and others (13.4%). *Salmonella* sp was the pathogen most frequently associated with nosocomial bacteremia (20.2%), followed by *Klebsiella* sp (17.9%), *S. albus* (14.3%), *Enterobacter* sp (11.9%), *Pseudomonas* sp (9.5%), *S. aureus* (9.5%) and others (16.7%). In nosocomial urinary tract infections, the result was *E. coli* (32.9%), *Klebsiella pneumoniae* (20.5%), *Enterobacter* sp (13.7%), *Citrobacter diversus* (6.8%) and others (26.1%).

In general, *E. coli* was the most frequently reported pathogens (42.0%), followed by *Salmonella* sp (17.1%), *Klebsiella* sp (10.2%), *Citrobacter* sp (7.2%), *S. albus* (4.5%), *Pseudomonas* sp (4.2%), *S. aureus* (3.6%) and others (11.2%), respectively.

## Introduction

The pathogens causing nosocomial infections may be either endogenous or exogenous. Endogenous pathogens are organisms that are part of the normal flora; under a variety of conditions, such as alteration of the host's physical, immunologic or microbiologic barriers, these organisms invade the host and become pathogenic. Exogenous pathogens are organisms that are acquired from the external environment, such as the hospital environment or other hospital exposures [1].

The skin has its own microbial flora, which is more difficult to remove or destroy than the microorganisms present in animate objects [2].

Welliver and McLaughlin reported that

*S. aureus* was the most commonly isolated pathogen in nosocomial infections [3]. Polz and Jablonski reported besides *E. coli*, also *Proteus*, *Klebsiella* and *Staphylococcus* as the most frequent pathogens, accounting for 35.9%, 22.7%, 10.6% and 9.9%, respectively in NICU (Neonatal Intensive Care Unit) [4]. Larson et al. found a significant change in bacterial species causing nosocomial infections, especially *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*, causing 20.4% nosocomial infections in the old unit, but only 2.1% in the new unit.

The purpose of this study was to identify the etiology of nosocomial infections in pediatric patients.

## Materials and Methods

The prospective study was performed at the Department of Child Health, School of Medicine, Padjadjaran University, Hasan Sadikin General Hospital, Bandung, from August 1, 1988 to April 30, 1989.

The Department of Child Health has four main wards, A2, A3, R-17 and Neonatal Intensive Care Unit (NICU). The A2 ward is particularly for patients coming from low socio-economic families, whereas the A3 ward for pediatric patients from high and middle socio-economic families. Ward R-17 is the neonatal ward, while the NICU is for critically ill neonates.

Patient's records and case finding by trained nurses were used as the basis for detecting nosocomial infections. During the study period a careful monitoring of records of all patients movements was held. Infection data were collected and recorded by 13 previously trained nurses. During the study, none of the selected and

already trained nurses were transferred neither from one ward to another in the department nor to any other department in the hospital. Clinical samples for bacteriologic examinations were collected by the trained nurses in every ward from all patients at the onset of clinical signs of the suspected nosocomial infection and transported to the laboratory of the Department of Microbiology, School of Medicine, Padjadjaran University. In addition, samples for virologic and parasitologic examinations were collected if indicated.

IN (For laboratory examination, the following information were recorded): name, date of birth, medical record, ward, collecting/reporting date, samples (blood, urine, faeces, pus), results of culture. The isolated microorganisms were stored and regularly sent to the Department of Microbiology Academisch Ziekenhuis-Vrije Universiteit Brussel, Belgium for quality assurance.

## Results

During the 9-month study a total number of 4328 hospitalized pediatric patients were observed. It was revealed that among them a total number of 342 patients had one or more nosocomial infections, yielding 411 episodes of nosocomial infections. From Table I, it can be seen that a total of 249 isolated microorganisms (86.3%) were gram-negative and 29 (8.7%) were gram-positive microorganisms that might have been the cause of the suspected nosocomial infections. Rotavirus was found in 10 specimens (3.0%). In general *E. coli* was the most frequently reported pathogens (42.0%), followed by *Salmonella* species (17.1%), *Klebsiella* species (10.2%) and *Enterobacter* species (7.2%), then followed by *S. albus*, *Pseudomonas* species and *S. aureus*, 4.5%, 4.2% and 3.6%, respectively. The table also shows the distribution of pathogens according to ward.

### Nosocomial gastroenteritis

It was evident that 48 out of 182 specimens (26.4%) did not show any growth in the culture, in other words the culture was sterile. In 92 specimens, one pathogen was found; in 42 specimens more than one pathogen was isolated. The distribution of pathogens causing nosocomial gastroenteritis is demonstrated in Table II. *Escherichia coli* was the pathogen most frequently associated with nosocomial gastrointestinal tract infections (69.2%), followed by *Salmonella* species

(23.1%), rotavirus (6.4%) and finally by *Shigella* species (1.3%).

### Nosocomial skin infections

*Klebsiella pneumoniae* seemed to be the pathogen most frequently associated with nosocomial skin infections (26.7%), followed by *Enterobacter aerogenes* (20.0%), whereas *E. coli*, *Pseudomonas aeruginosa* and *Staphylococcus aureus*, was found each in 13.3% (Table III).

### Nosocomial bacteremia

It revealed that *Salmonella* species was the pathogen most frequently associated with nosocomial bacteremia, i.e. in 17 patients or 20.2%, followed by *Klebsiella* species in 15 subjects or 17.9%, *Staphylococcus albus* in 12 or 14.3%, and *Enterobacter* species in 10 or 11.9% (Table IV).

### Nosocomial postoperative wound infections

Nosocomial postoperative wound infections occurred in 4 children (three were neonates) with *E. coli*, *Enterobacter aerogenes*, *Serratia* species and *Pseudomonas* species as the pathogens.

### Nosocomial urinary tract infections

Table V shows clearly that in this study *E. coli* was the pathogen most frequently associated with nosocomial urinary tract infections (32.9%), followed by *Klebsiella pneumoniae* (20.5%), *Enterobacter* species (13.7%) and *Citrobacter diversus* (6.8%).

Table I. Frequency distribution of pathogens causing nosocomial infections by ward during August 1988-April 1989 at the Department of Child Health, Hasan Sadikin General Hospital, Bandung

Type of pathogens	A2 (n=102)		A3 (n=14)		R.17 (n=193)		NICU (n=24)		OVERALL (n=333)	
	No. of NIs	% of total	No. of NIs	% of total	No. of NIs	% of total	No. of NIs	% of total	No. of NIs	% of total
Gram-negative :										
<i>E. coli</i>	37	36.3	8	57.2	90	46.6	5	20.8	140	42.0
<i>Salmonella</i> sp	12	11.8	1	7.1	42	21.8	2	8.3	57	17.1
<i>Klebsiella</i> sp	12	11.8	-	-	15	7.8	7	29.2	34	10.2
<i>Enterobacter</i> sp	10	9.8	1	7.1	10	5.2	3	12.5	24	7.2
<i>Pseudomonas</i> sp	6	5.9	1	7.1	6	3.1	1	4.2	14	4.2
<i>Serratia</i> sp	-	-	-	-	2	1.0	5	20.8	7	2.1
<i>Citrobacter</i> sp	4	3.9	-	-	2	1.0	-	-	6	1.8
<i>Proteus</i> sp	3	2.9	-	-	1	0.5	-	-	4	1.2
<i>Shigella flexner</i>	-	-	-	-	3	1.6	-	-	3	0.9
<i>Providencia</i> sp	2	2.0	-	-	-	-	-	-	2	0.6
Non ferm Gr(-)	2	2.0	-	-	-	-	-	-	2	0.6
Arizona	-	-	-	-	1	0.5	-	-	1	0.3
Total	88		11		172		23		294	
Gram-positive :										
<i>S. aureus</i>	7	6.9	-	-	4	2.1	1	4.2	12	3.6
<i>S. albus</i>	2	2.0	2	14.3	11	5.7	-	-	15	4.5
<i>S. pneumonia</i>	1	1.0	-	-	-	-	-	-	1	0.3
Enterococcus	-	-	-	-	1	0.5	-	-	1	0.3
Total	10		2		16		1		29	
Rotavirus	4	3.9	1	7.1	5	2.6	-	-	10	3.0

n : total number of pathogens isolated  
NIs : Nosocomial infections

Table II. Frequency distribution of pathogens causing nosocomial gastroenteritis by ward during August 1988-April 1989 at the Department of Child Health Hasan Sadikin General Hospital, Bandung

Type of pathogens	A2 (n=35)		A3 (n=5)		R.17 (n=113)		NICU (n=3)		OVERALL (n=156)	
	No. of NIs	% of total	No. of NIs	% of total	No. of NIs	% of total	No. of NIs	% of total	No. of NIs	% of total
Gram-negative :										
<i>E. coli</i>	24	68.6	3	60.0	79	69.9	2	69.9	108	69.2
<i>Salmonella</i> sp	7	20.0	1	20.0	27	23.9	1	33.1	36	23.1
<i>Shigella flexneri</i>	-	-	-	-	2	1.8	-	-	2	1.3
Rotavirus	4	11.4	1	20.0	5	4.4	-	-	10	6.4



Table III. Frequency distribution of pathogens accounted for nosocomial skin infections by ward during August 1988-April 1989 among pediatric patients at Hasan Sadikin General Hospital, Bandung

Type of pathogens	A2		R.17		NICU		OVERALL	
	No.of NIs	% of total	No.of NIs	% of total	No.of NIs	% of total	No.of NIs	% of total
Gram-negative :	3	27.3	-	-	1	33.3	4	26.7
Klebsiella pneumoniae	2	18.2	1	100.0	-	-	3	20.0
Enterobacter aerogen	2	18.2	-	-	-	-	2	13.3
Pseudomonas aeruginosa	1	9.1	-	-	1	33.3	2	13.3
E. coli	1	9.1	-	-	-	-	1	6.7
Providencia1	1	9.1	-	-	-	-	1	6.7
Pretus vulgaris	1	9.1	-	-	-	-	1	6.7
Gram-positive :								
s. aureus	1	9.1	-	-	1	33.3	2	13.3

Table IV. Frequency distribution of pathogens causing nosocomial bacteremia by ward at the Department of Child Health, Hasan Sadikin General Hospital, Bandung, from August 1988-April 1989.

Type of pathogens	A2 (n=19)		A3 (n=1)		R.17 (n=49)		NICU (n=15)		OVERALL (n=84)	
	No.of NIs	% of total	No.of NIs	% of total	No.of NIs	% of total	No.of NIs	% of total	No.of NIs	% of total
Gram-negative :										
Salmonella sp	3	15.8	-	-	13	26.5	1	6.7	17	20.0
Klebsiella sp	-	-	-	-	9	18.4	6	40.0	15	17.9
Enterobacter sp	5	26.3	-	-	3	6.1	2	13.3	10	11.9
Pseudomonas sp	1	5.3	-	-	6	12.2	1	6.7	8	9.5
E. coli	1	5.3	-	-	3	6.1	1	6.7	5	6.0
Serratia sp	-	-	-	-	1	2.0	4	26.7	5	6.0
Shigella flexneri	-	-	-	-	1	2.0	-	-	1	1.2
Citrobacter freundii	1	5.3	-	-	-	-	-	-	1	1.2
Non fer.Gr (-) bac	1	5.3	-	-	-	-	-	-	1	1.2
Gram-positive :										
S.albus	2	10.5	1	100.0	9	18.4	-	-	12	14.3
S.aureus	4	21.0	-	-	4	8.2	-	-	8	9.5
S. pneumoniae	1	5.3	-	-	-	-	-	-	1	1.2

Table V. Frequency distribution of pathogens causing nosocomial urinary tract infections by ward at the Department of Child Health, Hasan Sadikin General Hospital Bandung from August 1988-April 1989.

Type of pathogens	A2 (n=19)		A3 (n=1)		R.17 (n=49)		OVERALL (n=15)	
	No.of NIs	% of total	No.of NIs	% of total	No.of NIs	% of total	No.of NIs	% of total
Gram-negative :								
E. coli	11	31.4	5	62.5	8	26.7	24	32.9
Klebsiella pneumoniae	9	25.7	-	-	6	20.0	15	20.5
Enterobacter sp	3	8.6	1	12.5	6	20.0	10	13.7
Citrobacter diversus	3	8.6	-	-	2	6.7	5	6.8
Salamonella sp	2	5.7	-	-	2	6.7	4	5.4
Proteus sp	2	5.7	-	-	1	3.3	3	4.1
pseudomonas aeruginosa	2	5.7	1	12.5	-	-	3	4.1
Serratia sp	-	-	-	-	1	3.3	1	1.4
Providencia rettgeri	1	2.9	-	-	-	-	1	1.4
Arizona	-	-	-	-	1	3.3	1	1.4
Non fer.Gr (-) bacilli	1	2.9	-	-	-	-	1	1.4
Gram-positive :								
S. albus	-	-	1	12.5	2	6.7	3	4.1
S. aureus	1	2.9	-	-	-	-	1	1.4
Enterococcus	-	-	-	-	1	3.3	1	1.4

## Discussion

The relative frequency of the microorganisms isolated from the various infection sites has confirmed the significance of gram-negative microorganisms, particularly *E. coli* and *Salmonella* species, in all types of nosocomial infections. In the study the gram-negative microorganisms (the majority Enterobacteria) accounted for 88.3% of all isolated pathogens, and gram-negative bacteria were 10 times more frequent than gram-positive microorganisms (cocci). *E. coli* was the most frequently reported pathogen, which was reported also by Polz and Jablonski [4] and Chandrasekar et al. [6]. On the contrary Ford Jones et al. found in nosocomial infections among pediatric patients in the Hospital for Sick Children Toronto, higher percentage of gram-positive microorganisms, i.e., 50%, than gram-negatives, i.e. only 18% [7]. Other authors

detected higher percentage of gram-positives rather than gram-negatives, such as by Cotton et al. in black South African children [8]. It was interesting that in this study *Salmonella* species was one of the most frequently isolated after *E. coli*, i.e., 17.1% of all isolated pathogens. This is very significant since salmonellosis in Indonesia is still highly endemic and in this study it was revealed that this bacterial species is almost 100% resistant to chloramphenicol which up till now has been considered as the drug of choice for *Salmonella typhi*. Rotavirus was encountered only in 3.0% of all isolated pathogens. A higher percentage was reported by other investigators such as by Welliver and McLaughlin who reported that rotavirus was found in 12.1% of isolated pathogen from nosocomial infections cases [3].

*Nosocomial gastroenteritis*

*E. coli* was the pathogen most frequently reported (EPEC, possibly EHEC and EIEC). Nosocomial gastroenteritis caused by *Salmonella* species was the second most frequent reported, especially in neonates and children less than one year of age. It was supported by the findings reported by McAllister et al. [9], Hughes and Jarvis [10] namely that nosocomial gastroenteritis caused by *Salmonella* species often occurred in infants, especially in developing countries. Rotavirus was the third most frequently reported pathogen in nosocomial gastroenteritis. It seems that in developing countries rotavirus is not yet reported as the most common cause of nosocomial diarrhea, except in Hongkong as reported by Lam et al., where rotavirus was found to be the predominant cause of nosocomial gastroenteritis, being 3.4 times more frequent than bacterial pathogens [11].

*Nosocomial skin infections*

Also in this study gram-negative microorganisms were the most frequent cause of nosocomial skin infections as compared with gram-positive microorganisms (6.5 : 1), with *Klebsiella pneumoniae* and *Enterobacter aerogenes* as the leading pathogens.

*Nosocomial bacteremia*

Gram-negative microorganisms accounted for 75.0% of all isolated micro-organisms. *Salmonella* species was the pathogen most often encountered, 20.2% of all

gram-negative microorganisms, or 27.0% of all gram-negative microorganisms, and almost all occurred in neonates. *Klebsiella* species was the second most frequent cause of nosocomial bacteremia, 23.8% of all gram-negative microorganisms. There was one neonate in the newborn nursery with *Shigella flexneri* bacteremia. As we know shigellosis is uncommon in the newborn nursery as was also mentioned by Beers et al. [12]. It is widely believed by both physicians and microbiologists that bacteremia is a rare event in shigellosis. Shigellosis bacteremia was reported by Martin et al. in Canada [13], and Struelens et al. in Bangladesh [14].

*Nosocomial urinary tract infections*

Gram-negative microorganisms were the most frequent pathogens causing nosocomial urinary tract infections as compared with gram-positive microorganisms (13 : 1), especially in neonates and children of over 5 years of age, *E. coli* has been the most frequently isolated pathogen. *Klebsiella pneumoniae* was the second most frequently isolated pathogen, and *Enterobacter* species the third. *E. coli* as the most frequent pathogen causing nosocomial urinary tract infections were also mentioned by Welliver and McLaughlin [3] and Mayon-White et al. [15] in all ages, 40.3% and 29.0%, respectively. McCracken also reported *E. coli* to be the most frequent etiologic agent of acute, uncomplicated urinary tract infections in infants and children [16].

**Conclusion**

Gram-negative microorganisms were the most frequent encountered isolates in nosocomial infections, especially *E. coli* and *Salmonella* species. EPEC was most frequently reported in nosocomial gastroenteritis, followed by *Salmonella* species.

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