Nosocomial Infections in Pediatric Intensive Care Units

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Abstract. Nosocomial infections are a significant problem in pediatric intensive care units. While Indian estimates are not available, western PICUs report incidence of 6-8%. The common nosocomial infections in PICU are bloodstream infections (20-30% of all infections), lower respiratory tract infections (20-35%), and urinary tract infections (15-20%); there may be some differences in their incidence in different PICUs. The risk of nosocomial infections depends on the host characteristics, the number of interventions, invasive procedures, asepsis of techniques, the duration of stay in the PICU and inappropriate use of antimicrobials. Most often the child had endogenous flora, which may be altered because of hospitalization, are responsible for the infections. The common pathogens involved are *Staphylococcus aureus*, coagulase negative *staphylococci*, *E. coli* *Pseudomonas aeruginosa*, *Klebsiella*, *enterococci*, and *candida*. Nosocomial pneumonias predominantly occur in mechanically ventilated children. There is no consensus on the optimal approach for their diagnosis. Bloodstream infections are usually attributable to the use of central venous lines; use of TPN and use of femoral site for insertion increase the risk. Urinary tract infections occur mostly after catheterization and can lead to secondary bacteremia. The diagnostic criteria have been discussed in the review. With proper preventive strategies, the nosocomial infection rates can be reduced by up to 50%; handwashing, judicious use of interventions, and proper asepsis during procedures remain the most important practices. [Indian J Pediatr 2001; 68 (11) : 1063-1070]

Key words : Nosocomial infections; Intensive care; Children; Prevention

Nosocomial or hospital acquired infections are all infections that occur during a patient’s hospitalization and not present or incubating at admission. Also any infection that appears to have been acquired in hospital but does not manifest until after discharge is judged to be a nosocomial infection. Therefore, all infections diagnosed 48 hours after admission till 72 hours after discharge should be considered as nosocomial.1,2

Nosocomial infections are a significant problem in pediatric intensive care units. The National Nosocomial Infection Surveillance System (NNIS) in the United States reports a rate of 14.1 nosocomial infections per 1000 patient days for pediatric ICUs.3 The overall nosocomial infection rates in the PICUs in the west are reported to be 6-8%.5 These rates are lower than those seen in adult intensive care units.3,6 The infections in pediatric intensive care units (PICU) are more widespread than in general pediatric wards. The infection rates depend on the type of PICU: multidisciplinary, medical, surgical, or cardiac. There are no data on the incidence of nosocomial infections in Indian PICUs. It is possible that infection rates here are higher than those reported in the west.

According to NNIS, primary bloodstream infections are the commonest nosocomial infections (28%) in PICUs followed by the lower respiratory tract infections (21%) and urinary tract infection (UTI) (15%).3 In another study, lower respiratory tract infections were the commonest (35%), followed by bloodstream infections (21%) and UTI (16%).4 These variations may arise from the differences in the proportion in the children ventilated in the PICUs. In adults, UTI is the commonest nosocomial infection followed by surgical infection and lower respiratory tract infections.6 *Staphylococcus aureus*, coagulase negative *staphylococci*, *E. coli*, *Pseudomonas aeruginosa*, *Klebsiella*, *enterococci* and *Candida* are the significant pathogens in pediatric services in the various sites examined.3,4

The risk of nosocomial infections in a PICU is the direct consequence of the severity of illness,4 the level of invasive monitoring, the indiscriminate use of antimicrobials and the nature of diagnostic procedures. The NNIS data emphasizes that the duration of stay in an ICU is an important determinant of nosocomial infection; therefore, the length of stay should be one of the denominators in calculation of nosocomial infection rates.3 In addition, it highlight the importance of invasive devices (endotracheal tubes, intravascular catheters, urinary catheters) in development of nosocomial infections.3 In order to control for device usage and duration the infection rates can be represented as ratios per thousand device days. According to the latest report, ventilator associated pneumonia (VAP) occurrence is 5.7 episodes per thousand ventilator days, UTI 5.2 per thousand catheter days, and bloodstream infection is 8 per thousand central line days.3 In the same study, it was observed that 91% of all nosocomial bloodstream infections occurred in children with central venous lines, 95% of nosocomial pneumonias occurred in those on...
mechanical ventilation and 77% of UTIs in children with urinary catheters. These figures highlight the important role of various devices in nosocomial infections.

Nosocomial infections may be caused by organisms that originate from exogenous sources in hospital or from endogenous sources such as child’s own flora. Because of alteration of child’s flora associated with the illness and hospitalization, such distinction may not be easy. A recent study has shown that the mean number of days after admission to PICU to abnormal colonization were as follows: gastric aspirate, 2 days; tracheal aspirate, 5 days; urine 10 days; and stool, 4 days. The altered flora mainly included gram-negative bacilli and Staphylococcus aureus, which were often antibiotic resistant.

The hospital environment contributes minimally to acquisition and spread of most endemic nosocomial infections directly. Even if environmental surfaces are contaminated with microbes, they can be spread to patients by hand contact only. Occasionally, environment may be responsible for life threatening nosocomial infections such as aspergillus in immunocompromised individuals.

It is estimated that the overall mortality attributed to nosocomial infections is about 10%. The mortality is associated with nosocomial infections is multifactorial; some of these factors are the type of patient, the number of altered organs, and the microbes responsible for the infection. Blood stream infections caused by Klebsiella pneumoniae or the fungi have mortality range of 18-20%. The nosocomial infections increase the duration of stay in hospital and also the cost of therapy.

We restrict further discussion to nosocomial pneumonias, bloodstream infection and urinary tract infections.

**NOSOCOMIAL PNEUMONIAS**

Pneumonias constitute a common but potentially life threatening complication of hospitalization. The mortality rates associated with nosocomial pneumonia ranges from 20-50%. Other studies have reported lower mortality rates.

While a few pneumonias represent hematogenous seeding of the lungs from a distant supplicative focus; in most patients, subclinical aspiration of oropharyngeal secretions containing bacteria that have colonized the upper airway of the patient is responsible for nosocomial pneumonia. This flora includes both gram-positive and gram-negative bacteria, which the patient acquires within 1-4 days after hospitalization. The risk factors for upper airway colonization include acidosis, hypotension, endotracheal intubation, and broad-spectrum antimicrobial therapy. Only a few patients will develop nosocomial pneumonia in absence of colonization of the upper airways. Most nosocomial pneumonias are caused by gram-negative organisms. Bacteria of enterobacteriaceae family e.g. *E. coli, Klebsiella* are usually isolated from the hypopharynx and rectum before they are isolated from the trachea. However, non-Enterobacteriaceae e.g. *P. aeruginosa, Acinetobacter* are rarely demonstrated prior to their isolation from the trachea. This suggests that colonization with enterobacteriaceae occurs from patient’s endogenous flora and that non-Enterobacteriaceae bacteria have environmental origin. Therefore, the hands of the health care workers and components of the respiratory therapy equipment may be important factors in the transmission of bacteria.

The most important risk factor for nosocomial pneumonia in children is endotracheal intubation. Nosocomial pneumonias are nearly four times more common in intubated patients than in non-intubated patients. The risk may be greater with tracheostomy tubes. The filtration system of upper airways and mucociliary system of the large airways is bypassed during intubation, predisposing the patient to colonization with potential pathogens. Children with asymptomatic or symptomatic aspiration are at risk. Children with tracheoesophageal fistula, pharyngeal aspiration, gastroesophageal reflux, pulmonary disease, malnutrition or immunodeficiency are at greater risk. The etiologic microorganisms for nosocomial pneumonia vary from hospital to hospital. The pediatrician must be familiar with the common microbes and the antimicrobial susceptibility of these microbes at his/her hospital. Gram-negative bacilli are the most important cause, staphylococci are the most important gram-positive organisms. Viruses such as respiratory syncytial virus are also important pathogens responsible for nosocomial pneumonia in PICUs. However, some authors have suggested that viruses are less frequent as nosocomial pathogens in PICUs than in other areas of pediatric hospitals.

The optimal approach for diagnosing nosocomial pneumonia remains elusive. Clinical features, chest radiographs and culture of respiratory secretions have been used to establish the diagnosis. However, this approach is likely to overestimate the diagnosis. Fever and leukocytosis are also non-specific. Cough and sputum production are infrequently diagnostic of pneumonia in intubated children. Purulent tracheal secretions may be due to tracheitis, tracheobronchitis or pneumonia; differentiation can be difficult. Conditions such as atelectasis, pulmonary edema, pulmonary hemorrhage and acute respiratory distress syndrome (ARDS) may be confused with pneumonia. Therefore, clinical suspicion has to be strong for diagnosing nosocomial pneumonia. A change in the child’s status such as desaturation, increased requirement for supplemental oxygen, increase in ventilator settings or fever that are not explained by other events can be helpful in the diagnosis. In view of these problems and controversies Centers for Disease Control and Prevention have provided clinicians with guidelines for diagnosis of nosocomial LRTI.
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Once nosocomial pneumonia is suspected attempts should be made to identify the etiologic agent. Qualitative cultures obtained from endotracheal tubes do not predict the causative agent of lower respiratory tract infections. Quantitative cultures appear to be superior to qualitative cultures. Blood cultures are usually negative. Transtracheal aspiration in non-intubated patients, percutaneous thin needle lung aspirations, bronchoalveolar lavage (bronchoscopic or blind), and protected bronchoscopic samples of the lower airways have all been suggested as methods for diagnosis, where contamination of lower respiratory secretions with upper airway flora is prevented. In the absence of gold standard criteria for the diagnosis of ventilator-associated pneumonia, quantitative cultures and microscopic examination of the lower respiratory tract secretions are the diagnostic tests of choice. This can provide accurate diagnosis and identification of causative organism. These can also help in diagnosis of ventilator-associated pneumonia in children with ARDS.

Prevention of Nosocomial Pneumonias

The colonization of upper airways by pathogenic microbes and thereby, the risk of nosocomial pneumonia can be reduced by several measures. Effective hand washing by the health care personnel can reduce the risk of nosocomial pneumonias. Various chemicals such as chlorhexidine or rubs containing alcohol may be used. The reduction in the number of microorganisms on hands is related to the volume and number of times they are used. In addition, the hospital workers should comply with hospital infection control policies.

The gastrointestinal tract is an important source for endogenous upper airway colonization. Use of antacids and H2 blockers raise gastric pH and facilitate gastric microbial colonization. When indicated, instead of H2 blockers and antacids, sucralfate may be used for prophylaxis against gastric bleeding as the gastric pH remains low with its use. The use of selective decontamination of the gut using antimicrobial such as tobramycin, gentamycin, polymyxin and nystatin is controversial and is not recommended.

Contaminated respiratory therapy equipments have been implicated in nosocomial pneumonias. Resuscitation bags, ventilator tubings, nebulizers should be disinfected. Only sterile fluids should be nebulized or used in humidifiers. Personnel taking care of intubated children should wash their hands before and after delivering care. The ventilator circuit tubings should be changed no more often than every 48 hours. Care should be taken to prevent contamination during suctioning; endotracheal suctioning should be performed as needed to remove secretions. Positioning of patients with head end elevation does reduce the risk of aspiration and nosocomial pneumonia.

Other Nosocomial Respiratory Tract Infections

Bacterial tracheitis usually is secondary to a primary viral upper respiratory tract infection, most often parainfluenza virus. The data on nosocomial bacterial tracheitis is scant. Most nosocomial upper respiratory tract infections are viral and appear 2 weeks after admission. Bacteria are implicated in sinusitis and otitis media. Sinusitis may occur in a significant number of patients who have undergone nasotracheal intubation. Nasogastric tubes also predispose to sinusitis. The diagnosis usually has to be confirmed by radiology.

BLOODSTREAM INFECTIONS

While intravascular catheters provide lifesaving therapy, they also provide a route for microorganisms to bypass normal host defenses and can cause serious infections. Primary bacteremia is defined as a bloodstream infection occurring in a patient with no evidence of localized infection while secondary bacteremia is defined as a bloodstream infection with evidence of infection at another site that is the source of the bloodstream infection. More than 90% of all nosocomial bloodstream infections are in children with central venous lines.

Infections may occur due to microbes from the skin moving along the catheter surface where catheter enters the skin or due to microbes gaining access to the catheter through the catheter hub and moving down the endoluminal surface of the catheter to the bloodstream. The former mechanism is more often seen in short-term catheters and the latter in long-term catheters. Formation of biofilms over the implanted devices also may have a role in occurrences of the infections.

The most common organisms in bloodstream infections are coagulase negative Staphylococcus, Staphylococcus aureus and enterococci. Among the gram-negative bacteria Enterobacter, Pseudomonas aeruginosa, Klebsiella pneumoniae, and E. coli are the most important organisms. In immunocompromised children and those who have received a variety of broad spectrum antibacterials, fungal infections are more frequent.

The most important risk factor for catheter related bloodstream infections is the type of catheter used. Central venous catheters account for about 2% of all catheters inserted and more than 90% of all catheter-related bloodstream infections. The risk is probably greater with multilumen central venous catheters. Sub optimal care of central venous catheters especially when used for total parenteral nutrition (TPN) is another risk factor. Lipid infusions have specifically been associated with risk of catheter-related bloodstream infections due to coagulase negative Staphylococcus. The risk of infection increases linearly with the duration of catheterization. The site of insertion is an important determinant of the risk of infection; rates for femoral catheters are higher than those for jugular or subclavian catheters. Peripherally inserted central catheters (PICC lines) may have lower infection rates. Inadvertent contamination during insertion may be an important risk factor for infection. This is highlighted by an inverse relation between the
total number of catheters inserted by the physician inserting the catheter and the risk of significant catheter colonization. Improper management of catheter after insertion significantly increases the risk of infection. Transparent dressings may be associated with a higher rate of blood stream infections.

Local catheter-related infections usually manifests with local inflammation erythema, tenderness and/or purulent discharge from the catheter tract. The presentation of bloodstream infections may be either acute or insidious. There may be signs of sudden deterioration, elevated body temperature, chills and tachycardia or there may be intermittent fever and failure to improve from their basic illness. Whenever catheter related bacteremia is suspected, blood cultures should be obtained from peripheral blood as well as all catheter sites to correlate and differentiate colonization from infection. Catheter related bloodstream infection is defined as the isolation of same organism from blood cultures that is shown to be significantly colonizing the catheter of a patient with clinical features of bloodstream infection in the absence of any other local infection caused by the same organism that could give rise to bloodstream infection. Prevention of Bloodstream Infections

The major factors associated with development of catheter-related nosocomial infections are: (i) the sterility of the technique of insertion and maintenance of the catheter throughout its life, (ii) type of solution being administered through the intravenous line, (iii) number of "break ins" into the catheters system and intravenous tubing, (iv) the presence of infection elsewhere in the body. The following measures may help in reducing catheter-related infections:

- Selection of subclavian, basilic or cephalic vein site rather than femoral or internal jugular vein.
- Using maximal aseptic technique for catheter "insertion."
- Mupirocin ointment may reduce the risk of bacterial colonization of catheters but may increase colonization rate of fungi.
- Using cotton gauze rather than transparent dressing.
- Having an experienced physician insert the catheter.
- Avoid use of TPN catheters for other than infusion of TPN.
- Have adequate staff for management of patients with central venous catheters.

There have been some technologic advances to prevent catheter-related bloodstream infections. These include a short-term chlorhexidine-silver sulfadiazine-impregnated catheters, minocycline-rifampicin-impregnated catheters, a catheter hub containing an iodinated alcohol solution, and chlorhexidine-impregnated sponge dressings.

**NOSOCOMIAL URINARY TRACT INFECTIONS**

Urinary tract infections are common nosocomial infections in pediatric practice. Pediatric patients have a cumulative risk of UTI of 30% when catheterized. Risk figures seem to be higher in infants but still compare better than with the cumulative risk observed in catheterized adults. Catheter associated UTI (CAUTI) rank second after intravascular catheter related bloodstream infections as a cause of secondary bacteremia. CAUTIs may extend hospital stay, increase cost of therapy and often lead to unwarranted antimicrobial therapy especially when the UTIs are asymptomatic. CAUTIs have been shown to significantly increase hospital death rates in adults independent of the occurrence of sepsis of urogenital origin. However, a similar effect has not been seen in the pediatric age group. The urinary tract can be an important hospital reservoir of nosocomial antimicrobial-resistant organisms ranging from resistant enterobacteriaceae, pseudomonas, staphylococci and candida.

Largely, the origin of the organisms causing the UTI can be traced either to the patient's own large bowel, perineum or to the hands of care providers. Contamination of the urinary tract by microbes occurs either through the catheter lumen or by ascending up along the catheter during or after insertion. Extraluminal contamination is the commonest; it can occur by direct inoculation when the catheter is inserted or later, by the ascent of microbes from the perineum by capillary action in the thin mucus film contiguous to the external catheter surface. Intraluminal contamination occurs by reflux of microorganisms gaining access to the catheter lumen because of failure of closed drainage or contamination of urine in the collection bag. Pyelonephritis from bloodstream infections are rare but may occur in newborns and infants.

The most important risk factor for nosocomial UTI is catheterization. The timing, purpose and duration of catheterization are also important. Malnutrition, renal dysfunction, urological procedures and stenting, open drainage, diathesia, perirethral skin contamination also play a role in nosocomial UTIs.

The criteria for the diagnosis of an UTI would depend on the catheterization status as follows. Some uncertainty still exists in the diagnosis in catheterized children. The catheter, by simple irritation to the bladder, may cause pyuria; the drainage provided by the catheter may mask the clinical symptoms, and in some patients, the underlying disease process may cause fever or render the patient incapable of indicating the symptoms. The following are the guidelines for diagnosis of UTI:

- Clean catch mid stream urine growing $>10^5$ bacteria/ml of urine.
- Any growth in a suprapubic sample (gold standard for confirmation of diagnosis).

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Bacterial counts of \(>10^2/\text{ml}\) in samples aspirated with a needle from the catheter in those patients
with indwelling catheters.\(^\text{49}\)

**Prevention of Nosocomial Urinary Tract Infections**

A multitude of practices have been recommended and
used to prevent the occurrence of UTIs. Controlled trials
are yet to prove the efficacy of some of these. The
catheterizations should be kept to a minimum. The need
for catheterization must be strictly evaluated and
catheterization must be replaced by a closed condom
drainage whenever possible.\(^\text{50}\) Suprapubic catheterization
may be linked to a lesser risk of a CAUTI and may be
more comfortable to some patients.\(^\text{50}\) When thought to
have fulfilled their need the catheters must be
immediately removed.\(^\text{51}\) Strict asepsis should be
maintained during insertion of the catheter using sterile
gloves, drapes, and local antiseptics.

Closed drainage must be strictly maintained and this
has been shown to bring down the rates of infection to less
than 25\% for up to 2 weeks of catheterization.\(^\text{52}\) The closed
drainage must be maintained with the collection tubing
and bag below the level of the patient’s bladder and the
tubing must always be above the level of the bag. Other
positions, by allowing backflow of urine, increase the risk
of infection by two-fold.\(^\text{53}\) When in place the closed
drainage system must be handled and manipulated as
infrequently as possible. Antibiotic prophylaxis does
reduce the frequency of infections but is not universally
recommended as it selects multidrug resistant strains
when the infection occurs.

Antifungal lubricants, sealed catheter tubing
junctions, antireflux valves, bladder or bag irrigation with
antifungal solution, antibiotic, silver hydrogel
impregnated catheter materials are the newer techniques
being studied for their role in reducing the risk of
nosocomial UTIs.\(^\text{56}\)

**STRAATEGIES TO REDUCE THE INCIDENCE
OF NOSOCOMIAL INFECTIONS**

For reducing the incidence of nosocomial infection, each
PICU should have an infection control program. There
should be a written description of the goals, objectives,
and structure of program. A team of health professionals
should ensure implementation of the policies and
compliance on the part of the PICU team. Well-directed
infection control activities can reduce the nosocomial
infection rates by up to 50\%.\(^\text{54}\)

The importance of hand washing and hand disinfection
is well understood. The appropriate hand washing
technique includes wetting the hands, taking soap,
rubbing hands to produce a lather, and performing wash
movements that include rubbing palm to palm, right
palm over left dorsum and vice versa, palm to palm with
fingers interlaced, backs of fingers to opposing palm with
fingers interlocked, rotational rubbing of right thumb
clapped in left palm and vice versa, rotational rubbing
with clasped fingers of right hand in palm of left hand and
with changed roles.\(^\text{55}\) The whole procedure should not
take less than 30 seconds. After washing, hands should be
dried with disposable paper or cloth towel. It has been
noticed that health personnel practice hand washing in
only 25-50\% of the opportunities.\(^\text{56}\) In order to improve
compliance, various hygienic hand rubs can be used.
Rubbing of 3-5 ml of a fast acting antiseptic preparation
on to both hands can be an effective substitute to hand
washing. The various preparations available include
n-propanol, isopropanol, ethanol, and chlorhexidine
diacetate.\(^\text{55}\)

In addition to the specific measures mentioned earlier
for prevention of specific nosocomial infections, proper
sterilization/disinfection of various medical items is
mandatory. Aseptic precautions should be followed
strictly whenever any invasive procedure is being carried
out.

A well-nourished child is less likely to acquire
nosocomial infection than a malnourished one. Even in
PICU, nutrition should be given due attention. Enteral
nutrition appears to be better than parenteral nutrition.
Enteral nutrition may have a favorable impact on
gastrointestinal immunologic function and infectious
morbidity.\(^\text{57}\) There has been considerable interest in the
role of immune-enhancing enteral diets (containing
glutamine, arginine, mRNA, omega-3 fatty acids from fish
oil) in reduction of nosocomial infections and mortality in
ICUs.\(^\text{58,59}\)

Appropriate and rational prescription of antibiotics is
essential to prevent emergence of resistant strains.\(^\text{60}\) There
should be constant surveillance and periodic review of the
antibiotic policies and prescriptions. With careful
microbiologic monitoring, cycling of antibiotics for
empiric therapy can help in reducing the emergence of
drug resistance.\(^\text{56}\)

Adequate and well trained staff- both nursing staff and
physicians- are essential for infection control. Various
studies have demonstrated the adverse effects of
understaffing on nosocomial infection rates.\(^\text{60,61}\)
Education of the staff about various infection control practices and
procedure-specific guidelines has an important role in the
reduction of incidence of nosocomial infections. The
education program should be on a continuing basis with
periodic evaluation of the knowledge and practices.

Surveillance of nosocomial infections is an essential
element of any infection control program. The most
important goal of surveillance is to reduce the risk of
acquiring nosocomial infections. This provides data useful
for identifying infected patients, determining the site of
infections and identifying the factors that contribute to
nosocomial infections. Use of uniform definitions is
critical for proper collection of data and inter-hospital
comparisons. Standard CDC definitions that include
laboratory and clinical criteria may be used.\(^\text{1,2}\) The major
purpose of surveillance is to establish baseline infection
rates and identifying outbreaks. This data can be used
effectively to convince health care workers to accept recommended preventive practices. Control measures can be evaluated objectively if the surveillance is good.

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APPENDIX
Nosocomial Infections : Definition of Infection Sites
(modified from Ref 1, 2)

INFECTION SITE : Pneumonia
DEFINITION : Pneumonia must meet at least one of the following criteria :

Criterion 1 : Patient has crepitations or dullness to percussion on the physical examination of the chest
And
At least one of the following :
   a. new onset of purulent sputum or change in character of sputum
   b. organisms cultured from blood
   c. isolation of an etiologic agent from a specimen obtained by transtracheal aspirate, bronchial brushing, or biopsy.

Criterion 2 : Patient has a chest radiographic examination that shows new or progressive infiltrate, consolidation, cavitation, or pleural effusion
And
At least one of the following :
   a. new onset of purulent sputum or change in character of sputum
   b. organisms cultured from blood
   c. isolation of an etiologic agent from a specimen obtained by transtracheal aspirate, bronchial brushing, or biopsy.
   d. isolation of virus or detection of viral antigen in respiratory secretions
   e. histopathologic evidence of pneumonia.

Criterion 3 : Patient ≤ 1 year of age has at least two of the following signs or symptoms: apnea, bradycardia, wheezing, rhonchi, or cough
And
At least one of the following :
   a. increased production of respiratory secretions
   b. new onset of purulent sputum or change in character of sputum
   c. organisms cultured from blood
   d. isolation of an etiologic agent from a specimen obtained by transtracheal aspirate, bronchial brushing, or biopsy.
   e. isolation of virus or detection of viral antigen in respiratory secretions
   f. histopathologic evidence of pneumonia.

Criterion 4 : Patient ≤ 1 year has a chest radiographic examination that shows new or progressive infiltrate, consolidation, cavitation, or pleural effusion
And
At least one of the following :
   a. increased production of respiratory secretions
   b. new onset of purulent sputum or change in character of sputum
   c. organisms cultured from blood
   d. isolation of an etiologic agent from a specimen obtained by transtracheal aspirate, bronchial
Criterion 2: Patient < 1 year of age has at least one of the following:

- (e.g. H. influenzae, S. pneumoniae)
- signs and symptoms and positive laboratory results are not related to an infection at another site.

INFECTION SITE: Symptomatic urinary tract infection

DEFINITION: A Symptomatic urinary tract infection must meet at least one of the following criteria:

Criterion 1: Patient has at least one of the following signs or symptoms with no other recognized cause: fever (>38°C), urgency, frequency, dysuria or suprapubic tenderness and

- Patients has a positive urine culture that is \( \geq 10^6 \) microorganisms per cm\(^2\) of urine with no more than two species of microorganisms.

Criterion 2: Patients has at least two of the following signs or symptoms with no other recognized cause: fever (>38°C), Urgency, frequency, dysuria, or suprapubic tenderness and at least one of the following:

- pyuria (urine specimen with \( \geq 10 \) WBC/mm\(^3\) or \( \geq 3 \) WBC/high power field of unspun urine)
- organism seen on Gram stain of unspun urine
- at least two urine culture with repeated isolation of the same uropathogen (gram-negative bacteria or S. saprophyticus) with \( \geq 10^2 \) colonies mL in nonvoided specimens
- \( \leq 10^2 \) colonies/mL of a single uropathogen (gram negative bacteria or S. saprophyticus) in a patient being treated with an effective antimicrobial agent for a urinary tract infection
- physician diagnosis of a urinary tract infection
- physician institutes appropriate therapy for a urinary tract infection

Criterion 3: Patient \( \leq 1 \) year of age has at least one of the following signs or symptoms with no other recognized cause:

- fever(>38°C), hypothermia (<37°C), apnea, or bradycardia
- at least one of the following:
- physician institutes appropriate therapy for a urinary tract infection

Criterion 4: Patient \( \leq 1 \) year of age has at least one of the following signs or symptoms with no other recognized cause: fever (38°C), hypothermia (<37°C), apnea, bradycardia, dysuria, lethargy, or vomiting
- at least one of the following:
- physician institutes appropriate therapy for a urinary tract infection

INFECTION SITE: Laboratory-confirmed bloodstream infection

DEFINITION: Laboratory-confirmed bloodstream infection must meet at least one of the following criteria:

Criterion 1: Patient has a recognized pathogen cultured from one or more blood cultures

- Organism cultured from blood is not related to an infection at another site.

Criterion 2: Patient has at least one of the following:

- common skin contaminant is cultured from at least one culture from a patient with an intravascular line, and the physician institutes appropriate antimicrobial therapy
- positive antigen test on blood (e.g. H. influenzae, S. pneumoniae) and signs and symptoms and positive laboratory results are not related to an infection at another site.

Criterion 3: Patient \( \leq 1 \) year of age has at least one of the following:

- common skin contaminant is cultured from at least one culture from a patient with an intravascular line, and the physician institutes appropriate antimicrobial therapy
- positive antigen test on blood (e.g. H. influenzae, S. pneumoniae) and signs and symptoms and positive laboratory results are not related to an infection at another site.

INFECTION SITE: Clinical sepsis

DEFINITION: Clinical sepsis must meet at least one of the following criteria:

Criterion 1: Patient has at least one of the following clinical signs or symptoms with no other recognized cause: fever (>38°C), hypothermia (>38°C), chills, or hypotension

- At least one of the following:
- patients have at least two of the following signs or symptoms with no other recognized cause: fever (>38°C), hypothermia (<37°C), apnea, or bradycardia

Criterion 2: Patient < 1 year of age has at least one of the following clinical signs or symptoms with no other recognized cause: fever (>38°C), hypothermia (>37°C), apnea, or bradycardia

- Blood culture not done or no organisms or antigen detected in blood
- No apparent infection at another site
- Physician institutes treatment for sepsis.

Criterion 3: Patient < 1 year of age has at least one of the following:

- isolation of virus or detection of viral antigen in respiratory secretions
- histopathologic evidence of pneumonia.

- Expectorated sputum cultures are not useful in diagnosis of pneumonia
- Findings from serial chest x-rays may be more useful than a single x-ray.