Preventing Hospital Acquired Infections in New-born & Children

Dr Purva Mathur

Problem statement

- Children suffer significant morbidity and mortality from HAIs.
  - Prolonged hospitalization, transfer to ICUs, antibiotic therapy, invasive devices and surgical procedures.
- Profile of hospitalized paediatric population is changing.
  - Immunocompromised states, complex surgery for congenital malformations and survival of extremely premature infants
- The transfer of many former inpatient care activities to ambulatory and day treatment centres has resulted in a higher acuity of illness in children who are hospitalized
- The goal of infection control is to reduce the risk of acquiring infection in hospital to the lowest possible level.

Young children readily transmit and acquire infections

- Frequently harbour infectious organisms and may shed pathogens, especially respiratory and gastrointestinal viruses, even if they are asymptomatic
- Young children are susceptible to many infections because they have not yet developed immunity.
- The close proximity of large numbers of infectious and susceptible hosts favours transmission.
- Basic care requires frequent hands-on contact from health care personnel and parents.
- Multibed rooms, shared toys and playrooms, and visiting siblings contribute to the risk of transmission.
- Transmission rates increase with understaffing and overcrowding

Children are vulnerable to endogenous infections

- Infection may result from an altered relationship between the host and endogenous microbial flora due to the breakdown of normal barriers to infection by
  - invasive procedures
  - disease
  - therapy
- Young children have higher rates of catheter-associated bloodstream infections (BSIs), urinary tract infections (UTIs), and certain surgical site infections than older children and adults.

Magnitude of the problem: rates and infections

- Infection rates are highest in NICUs and paediatric intensive care units (PICUs), higher in paediatric hospitals than on paediatric wards in general hospitals, and lowest (usually less than 1%) in normal newborn nurseries

PLOS ONE

RESEARCH ARTICLE

Alarming rates of antimicrobial resistance and fungal sepsis in outborn neonates in North India

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Abstract

Background

There is a paucity of data on the epidemiology of sepsis in outborn neonates being referred to level-3 units in low- and middle-income countries (LMIC). The objective of the present study was to evaluate the prevalence of sepsis and outcomes of outborn neonates with sepsis, and to characterize the pathogen profile and antimicrobial resistance (AMR) patterns of common isolates in them.

Methods

In this prospective observational cohort study (2011–2015), a dedicated research team enrolled all neonates admitted to an outborn level-3 neonatal unit and followed them until discharge/death. Sepsis work-up including blood culture(s) was performed upon suspicion of sepsis. All the isolates were identified and tested for antimicrobial susceptibility. Gram-negative pathogens resistant to any three of the five antibiotic classes (extended-spectrum

Results

Of the total of 2588 neonates enrolled, culture positive sepsis and total sepsis–i.e. culture positive and/or culture negative sepsis–was diagnosed in 13.1% (95% CI 11.8% to 14.5%) and 54.7% (95% CI 52.8% to 56.6%), respectively. The case fatality rates were 23.4% and 11.0% in culture-positive and total sepsis, respectively. Sepsis accounted for two-thirds of total neonatal deaths (153/235, 63.0%). Bacterial isolates caused about three-fourths (296/401; 73.8%) of the infections. The two common pathogens–*Klebsiella pneumoniae* (n = 50, 12.5%) and *Acinetobacter baumannii* (n = 46, 11.5%)–showed high degree of multi-drug resistance (78.0% and 91.3%, respectively) and carbapenem resistance (84.0% and 91.3%, respectively). About a quarter of infections were caused by Candida spp. (n = 91; 22.7%); almost three-fourths (73.7%) of these infections occurred in neonates born at or after 32 weeks' gestation and about two-thirds (62.1%) in those weighing 1500 g or more at birth.

Conclusions

In this large outborn cohort, we report high burden of sepsis, high prevalence of systemic fungal infections, and alarming rates of antimicrobial resistance among bacterial pathogens.

Sepsis contributes to > half of deaths

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ARTICLE

Causes of death in preterm neonates (<33 weeks) born in tertiary care hospitals in India: analysis of three large prospective multicentric cohorts

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Abstract

Objective To estimate the direct causes of mortality among preterm neonates <33 weeks' gestation by examining three large multicentric, hospital-based datasets in India.

Method Three prospective hospital-based datasets: National Neonatal Perinatal Database (NNPD) of India, Delhi Neonatal Infection Study (DeNIS) cohort, and Goat Lung Surfactant Extract (GLSE)-Plus cohort were analyzed to study the causes of death among preterm neonates of less than 33 weeks' gestation admitted to the participating tertiary care hospitals in India.

Results A total of 8024 preterm neonates were admitted in the three cohorts with 2691 deaths. Prematurity-related complications and sepsis contributed to 53.5% and 19.8% of deaths in the NNPD cohort, 51.0% and 25.0% in the DeNIS cohort, and 39.7% and 40.9% in GLSE-Plus cohort, respectively.

Conclusions Nearly a quarter (20-40%) of preterm neonates less than 33 weeks' gestation admitted to Indian NICUs died of sepsis. The study results have implications for health policies targeted to reduce the neonatal mortality rate in India.

Introduction

Globally, 2.5 million neonates die each year. A vast majority of these deaths occur in low- and middle-income countries (LMICs) [1]. According to recent global estimate of causes of neonatal deaths, prematurity-related complications (35%), intrapartum-related events (birth asphyxia; 23%), and sepsis (27%) accounted for most neonatal deaths [2], 80% of which are preventable with simple interventions [3]. Understanding the cause and timing of neonatal deaths is important to inform public health policies targeted to reduce the neonatal mortality rate (NMR).

The causes of neonatal death vary among countries depending on NMR. In high-income countries (HICs), with lower NMR and high-quality vital registration data, preterm birth and congenital malformations are the most common causes of early (0–6 days) as well as late (7–28 days) neonatal deaths. LMICs with high NMR have incomplete and poor quality vital registration data. These countries often depend on verbal autopsy (VA)-based multicause models to derive causes of neonatal death. According to global [2, 4] and national statistics [5] for causes of death based on VA models, India's biggest goal to reduce neonatal mortality is reduction in prematurity-related deaths. However, cause of death analysis using VA tools and indirect model based assumptions are fraught with a wide range of uncertainty [6].

In VA models, prematurity-related deaths are defined

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Table 3 Single most important cause of death among hospitalized preterm neonates in NNPD, DeNIS, and GLSE-Plus cohorts

Causes of death	NNPD cohort ($N = 1349$)	DeNIS cohort ($N = 828$)	GLSE-Plus cohort ($N = 514$)	Pooled estimates of the proportion of deaths in the three cohorts
Complications related to prematurity	722 (53.5)	423 (51.0)	204 (39.7)	50.1% (48.3–52.0)
Neonatal sepsis	267 (19.8)	207 (25.0)	210 (40.9)	25.4% (23.8–27.0)
Perinatal asphyxia (intrapartum-related events)	166 (12.3)	77 (9.0)	64 (12.5)	11.5% (10.2–12.6)
Congenital malformations	57 (4.2)	23 (3.0)	23 (4.5)	3.8% (3.1–4.6)
Others	137 (10.2)	98 (12.0)	13 (2.5)	9.2% (8.1–10.3)

Values expressed as *Number of deaths* (%)

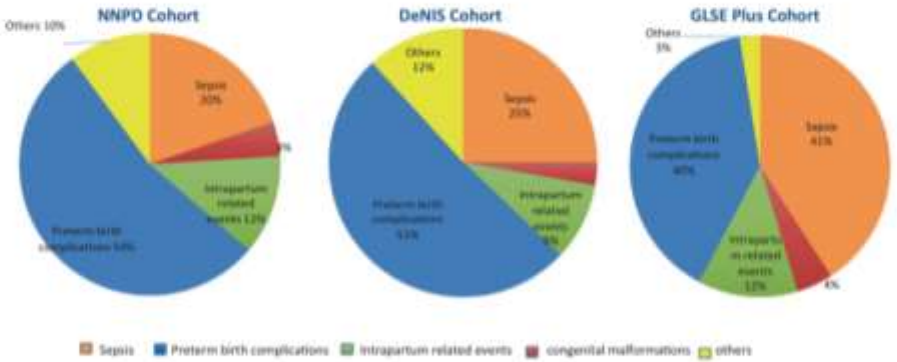

Fig. 1 Single most important underlying cause of death in preterm neonates in NNPD (2001–02) cohort, DeNIS (2011–2014) and GLSE-Plus (2016–2017) cohort

hospital mortality among preterm neonates <32 weeks' gestation admitted to Australian NICUs. Among 345 deaths in this population, the most common cause was attributed to prematurity-related complications (includes respiratory conditions, chronic lung disease, IVH, and NEC; 70%), followed by sepsis (16%) and perinatal asphyxia (7.2%). In a German very LBW cohort, 17% (37/221) of in-hospital

continuous positive air pressure and surfactant. Whereas, to combat sepsis the focus is on asepsis [20, 21], chlorhexidine cord care (in areas with high NMR) [22, 23], appropriate use of antibiotics, and topical emollient (natural plant oils) treatment for hospitalized infants [24]. Other interventions like exclusive breastfeeding, kangaroo care, thermoregulation, etc., influence both. Our study emphasizes that stra-

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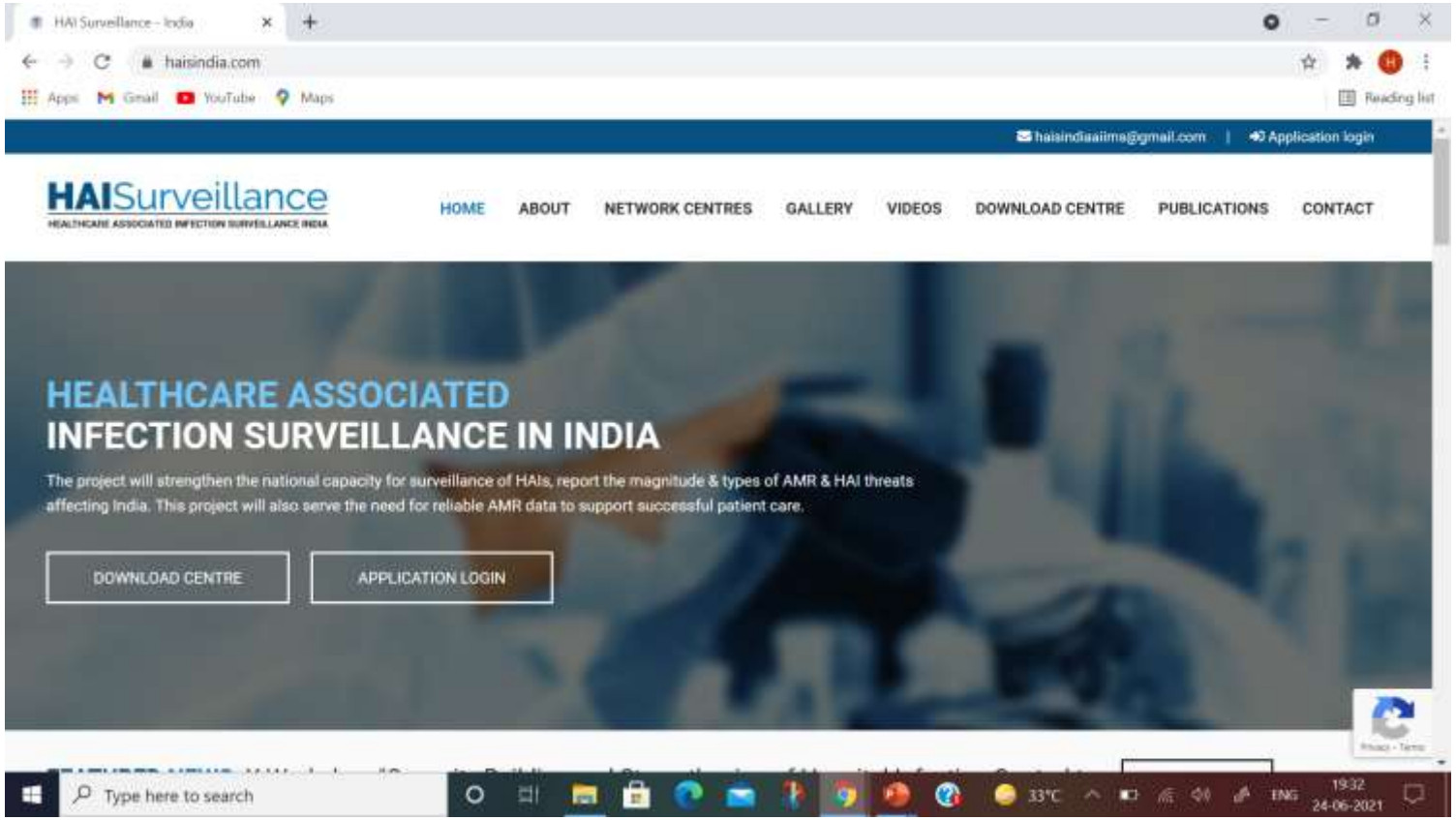
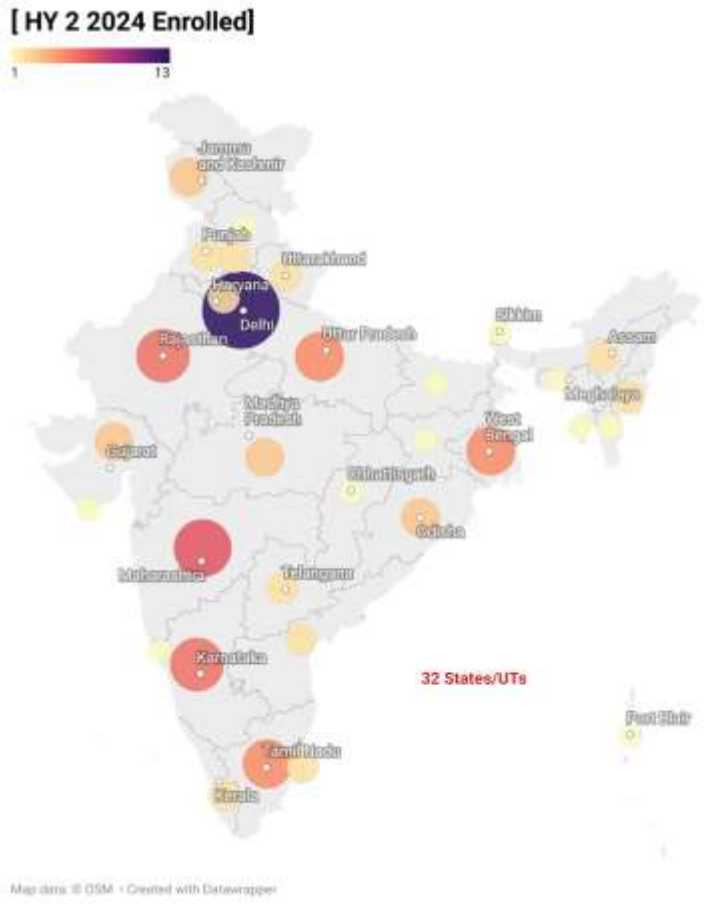




NICU/PICU
HAI Surveillance data

May, 2017 to April, 2025

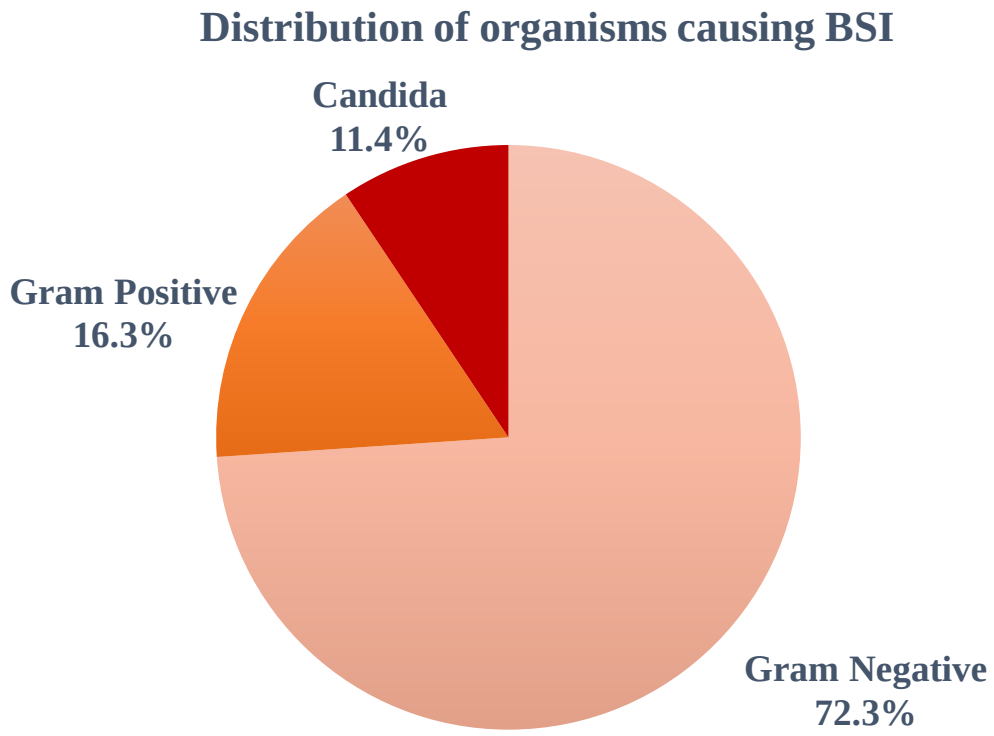
BSI Case Distribution
Total events: 5,952

Patient Days	10,37,433
Central Line Days	1,77,825
CLABSI	1,833 (30.8%)
NON- CLABSI	3,784 (63.6%)
Secondary BSI	335 (5.6%)

Total BSI Rate	5.7
CLABSI Rate	10.31
Sec. BSI Rate	3.64
NON-CLABSI Rate	2.32

Organisms causing BSI

Organism Type	Number
Gram Negative	4,669
Gram Positive	1,052
Candida	733
Total	**6,454**



Percentage distribution of Organisms causing BSI

Organisms	Number of isolates	Percentages (%)
Klebsiella spp.	1,969	30.5
Acinetobacter baumannii spp.	1,283	19.9
Candida spp.	730	11.3
Staphylococcus aureus spp.	607	9.4
Escherichia coli	444	6.9
Enterococcus spp.	426	6.6
Pseudomonas spp.	354	5.5
Enterobacter spp.	207	3.2
Burkholderia spp.	134	2.1
Serratia spp.	59	0.9
Citrobacter spp.	55	0.9
Stenotrophomonas spp.	39	0.6
Proteus spp.	11	0.2
Others	136	2.1
Total	**6,454**	**100**

Outcome in BSI

Outcome	14 Day n (%)	Final outcome n (%)
Died	**1,932 (32.5)**	**2,257 (37.9)**
Still in Surveillance	**1,852 (31.1)**	**-**
Discharged	**891 (15.0)**	**2,624 (44.1)**
LAMA	**385 (6.5)**	**523 (8.8)**
Transferred to other hospital	**43 (0.7)**	**77 (1.3)**
Transferred to another ward/unit	**838 (14.1)**	**-**
Unknown	**11 (0.2)**	**471 (7.9)**
Total	5,952	5,952

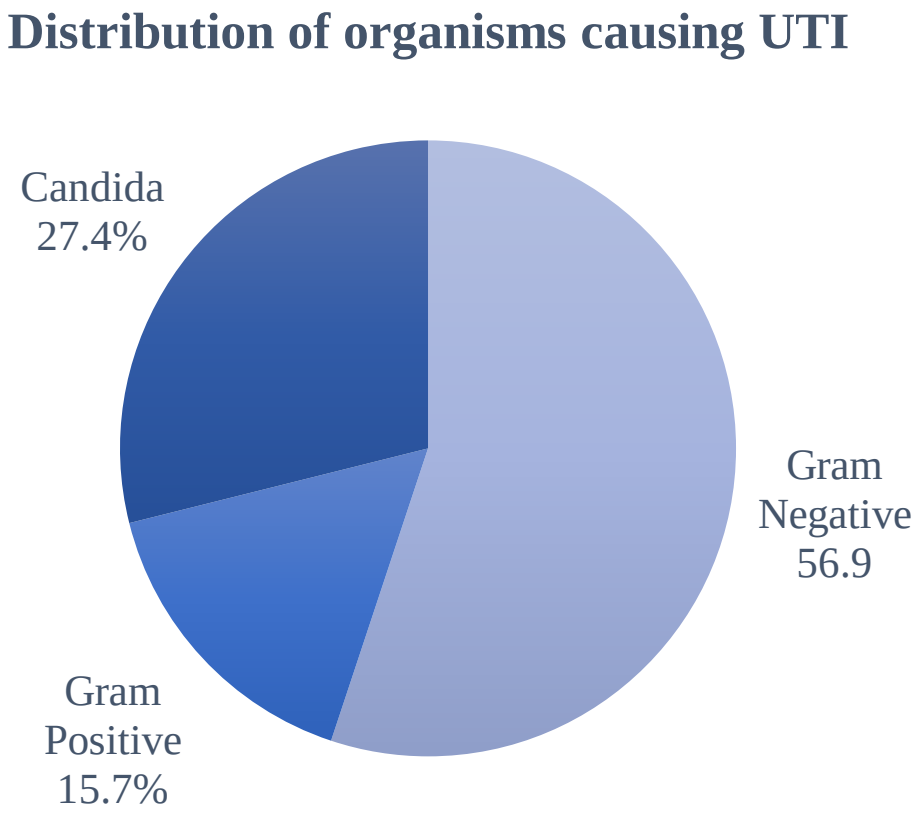
UTI Case Distribution
Total events: 501

Patient Days	**10,37,433**
Urinary Catheter Days	**1,43,635**
CAUTI	**309 (61.7%)**
NON- CAUTI	**192 (38.3%)**

Total UTI Rate	**0.48**
CAUTI Rate	**2.15**
NON-CAUTI Rate	**0.18**

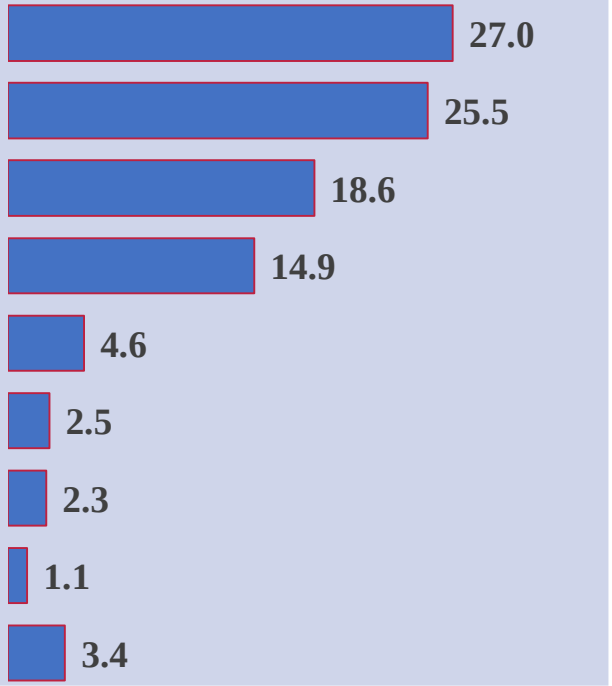
Organisms causing UTI

Organism Type	Number
Gram Negative	297
Gram Positive	82
Candida	143
Total	**522**



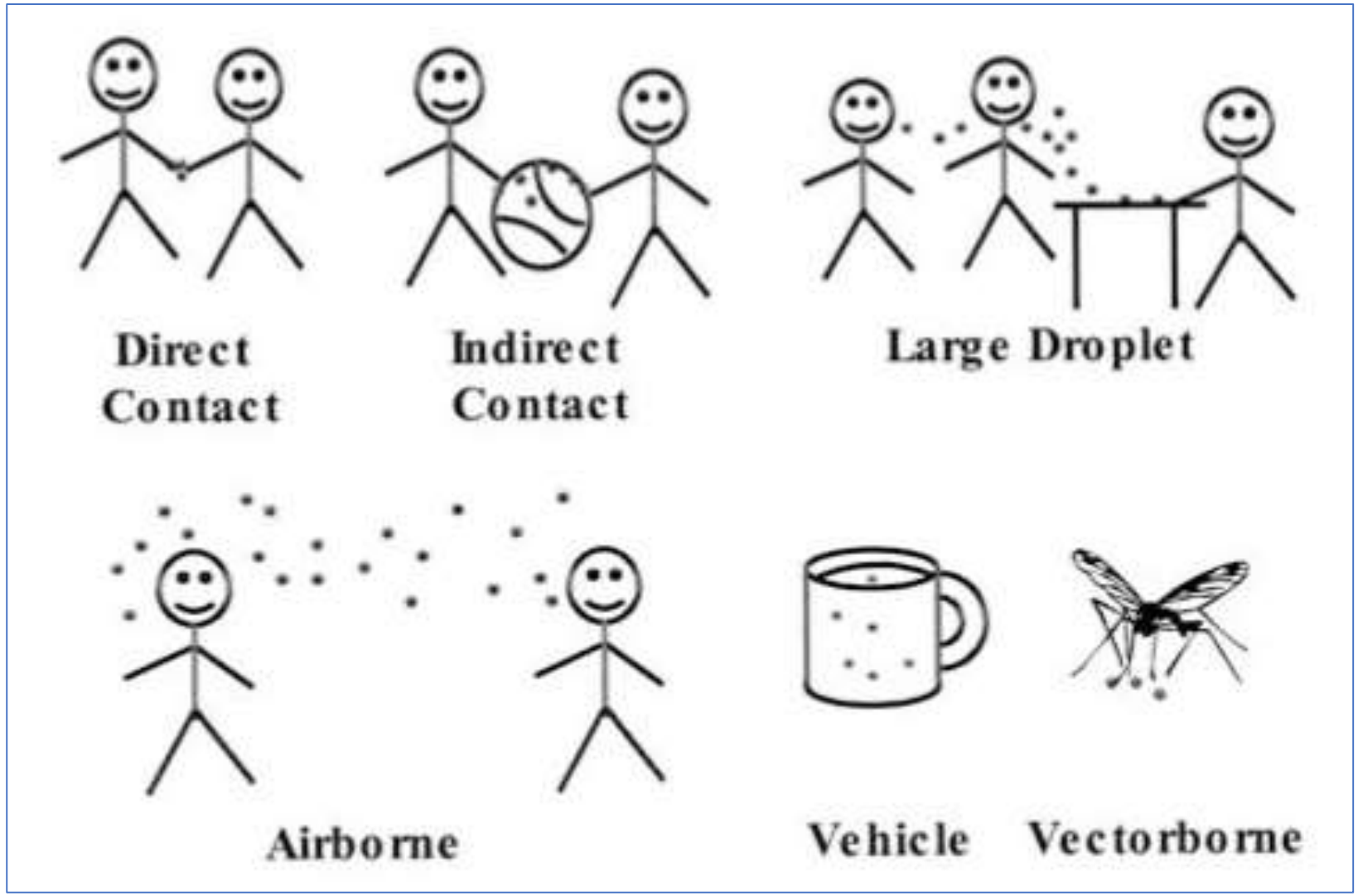
Percentage distribution of Organisms causing UTI

Candida spp.	141	27.0
Escherichia spp.	133	25.5
Klebsiella spp.	97	18.6
Enterococcus spp.	78	14.9
Pseudomonas spp.	24	4.6
Enterobacter spp.	13	2.5
Acinetobacter baumannii spp.	12	2.3
Citrobacter spp.	6	1.1
Others	18	3.4
Total	522	



Outcome in UTI

Outcome	14 Day n (%)	Final outcome n (%)
Died	**75 (15.0)**	**97 (19.4)**
Still in Surveillance	**160 (31.9)**	**-**
Discharged	**80 (16.0)**	**282 (56.3)**
LAMA	**40 (8.0)**	**55 (11.0)**
Transferred to other hospital	**3 (0.6)**	**4 (0.8)**
Transferred to other ward/unit	**140 (27.9)**	**-**
Unknown	**3 (0.6)**	**63 (12.6)**
Total	**501**	**501**


Direct Contact
Indirect Contact
Large Droplet
Airborne
Vehicle
Vectorborne

Contact transmission

- Most frequent route of transmission
- Includes
    - Direct contact (direct physical contact between infected and susceptible patients) and
    - Indirect contact (via contaminated intermediate surfaces such as the hands of personnel, bedrails, equipment and toys).
- Appropriate routine patient care practices should prevent most of the transmission by this route.

- Additional precautions (gloves, gowns and dedicated equipment) may be warranted for organisms of very low infective dose (eg, rotavirus) and for situations in which extensive contamination of the patient’s environment is expected
  - eg, watery diarrhea which cannot be contained within a diaper or a young child with respiratory infection and copious respiratory tract secretions.

- Respiratory and gastrointestinal viruses may remain viable on surfaces for several hours

Droplet transmission

- Important in paediatrics.
- Large droplets are expelled from the respiratory tract and deposited onto the respiratory mucous membranes of persons close to the infected child.
- Special ventilation is not required because large droplets do not stay suspended in the air but settle on surfaces close to the source patient.
- Surgical masks are recommended for those within 1 m of the patient.

- Some organisms transmitted by this route are very fragile and do not survive in the environment or on hands.
  - *Haemophilus influenzae* type b
  - *Neisseria meningitidis*
  - *Bordetella pertussis*
- Other organisms survive long enough on surfaces to be picked up on the hands of patients or personnel.
  - RSV
  - Influenza
  - Parainfluenza
  - Rhinovirus
- Thus, respiratory viruses may be transmitted by the inhalation of large droplets or by the inoculation of nasal mucosa or conjunctiva by contaminated hands (contact).

Airborne transmission

- Occurs when infectious particles survive in aerosols of small droplet nuclei or skin squames, which remain suspended in the air and are dispersed over large distances by air currents.
- Organisms may be carried around, through corridors, and in and out of windows.
- Control requires a negative pressure room with air exhausted outside of the building or passed through a high efficiency particulate air (HEPA) filter before recirculation.
- Special dust mist masks are recommended for susceptible persons who must enter a patient’s room.

- Airborne transmission is uncommon, but important, because varicella, measles and tuberculosis are spread by this route.

- Although children with tuberculosis rarely transmit the infection, their adult visitors may have contagious tuberculosis and should be assessed.

- Whether airborne transmission of influenza occurs is controversial, but contact and large droplet transmission appear to be the major routes of transmission

- Common vehicle transmission refers to the infection of several persons by a single contaminated source such as food, water or medication.
  - Such transmission is rare but important because it often results in an explosive outbreak that requires urgent investigation and intervention.

- Vector borne transmission refers to the spread of infection by insects, and is prevented by proper hospital construction and maintenance.

Routine practices

- Good infection control measures should reduce transmission from all patients, including those with asymptomatic or unrecognized infections.
- The American Academy of Pediatrics states that "*each neonate should be approached as though he or she harboured colonies of unique flora that should not be transmitted to any other neonate*".
- This may become a reasonable principle for all patients in acute care hospitals.

- Standard Precautions

- Hand Hygiene is the most important measure in the prevention of transmission
-
- Compliance may be increased by measures that make hand cleansing easier, such as more convenient sink placements and the provision of waterless, alcohol-based hand rinses.

- Gloves are recommended for contact precautions.
- Wearing gloves may also deter personnel from inadvertently touching their mouths, noses or eyes during patient care.
- Gloves are needed for many aspects of routine infant care, such as diaper changing, feeding a drooling child or wiping a child’s nose.
  - They are not mandatory for routine diaper changes in children if the procedure can be done without direct hand contact with stool, and may not be warranted for feeding and nose-wiping if gross contamination of the hands is avoided and hands are washed afterwards

- Masks protect personnel from the acquisition of infection by inhalation or splashes, and may also help to keep the hands away from the nose and mouth.

- Eye shields may give added protection against viruses that infect via the conjunctiva.

- Gowns protect the clothing and forearms in situations of extensive contact with a patient’s infective secretions, colonized skin or contaminated environmental surfaces

- Adherence to enhanced routine practices is particularly relevant during the current era of MDROs

- Whether it is more effective to take cultures of patients at risk for MDROs on admission and isolate those patients with positive cultures or to upgrade practices for all patients is controversial.

- A negative pressure room is essential for airborne precautions.

- For large droplet and contact precautions, single-bed rooms are preferable because they facilitate the physical separation of patients and control of the activities of their visitors, and deter the sharing of toys and equipment.

Postexposure prophylaxis

- May be indicated for patients, families or personnel when precautions have not been taken & significant exposure has occurred.
- Immunoprophylaxis is indicated for some nonimmune individuals exposed to
  - varicella
  - measles
  - hepatitis A
- Antibiotic prophylaxis may be indicated after exposure to
  - Meningococcus
  - Invasive *H influenzae* type b infection
  - Pertussis
  - Tuberculosis.

  Personnel should be aware of policies for prophylaxis after occupational exposure to bloodborne viruses.

Prevention of transmission from personnel

- All personnel who care for children, including physicians, be immune to vaccine-preventable diseases such as measles, rubella, mumps, varicella, hepatitis B, polio and diphtheria, and receive yearly influenza vaccination.
- Patients may not be immune to these diseases because of their young age or illness, and personnel are at risk for occupational exposure.
- The above infections may be more severe in adults than in children, and immunization protects both personnel and their patients.

- The transmission of pertussis in hospitals is often associated with atypical pertussis in personnel, and vaccination should be considered when the acellular vaccine becomes available to adults.
- Personnel should undergo pre-employment assessment for tuberculosis exposure.
- Personnel may acquire and transmit infections, such as respiratory viral infections, which may be minor in a healthy adult but have severe consequences in a young or immunocompromised patient

Prevention of transmission from visitors

- Parents and families need to be informed about infection control issues
- Advised of the hazards of bringing visitors with infections into the hospital.
- Parents should be questioned about recent exposures
- Visiting siblings should be assessed for signs of transmissible infections.
  - Particularly important for siblings visiting immunocompromised patients or patients in ICUs.

- Young children should be supervised by responsible adults
- Should not visit children other than their own siblings
- Should not use patients’ playrooms or toys.
- Adults with infections should be advised of precautions to take if they must visit.

Immunocompromised children require protection

- They need to be protected from exposure to other patients with transmissible infections, especially respiratory viruses.
- They should be accommodated in single rooms or assigned carefully selected roommates.
- Handwashing before patient contact is essential
- Use of an antiseptic agents is usually recommended.
- The routine use of gloves, gowns or masks is controversial and may not be beneficial.
- Equipment should be reserved for the patient or disinfected before use.

- Children with prolonged severe neutropenia, hematopoietic cell transplantation, recent organ transplantation and some other severe immune deficiencies require protection from exposure to fungal spores in dust and air.
- Rooms with positive pressure air flow and HEPA filtration reduce exposure to airborne fungi
  - should be considered for patients at highest risk.
- The patient’s room should be maintained free of dust by frequent cleaning, and all articles brought into the room should be clean and dust-free

Recommendations for Prevention and Control of Infections in Neonatal Intensive Care Unit Patients: CLABSIs

Centers for Disease Control and Prevention National Center for Emerging and Zoonotic Infectious Diseases Division of Healthcare Quality Promotion
Date: February 2022

Key Question 1: Does the use of non-sterile gloves after hand hygiene, compared with hand hygiene alone, prevent CLABSI in NICU Patients?

- Unresolved issue.

No Recommendation

Key Question 2: Does the use of one central line catheter type, compared with another, prevent CLABSI in NICU patients?

- Recommendation 2.A. **Choose the central line type** (e.g., umbilical venous catheter (UVC), peripherally inserted central catheter (PICC), tunneled catheter, etc.) **based on the clinical needs** of the NICU patient.

Recommendation

- Recommendation 2.B. **The choice of central line type** to insert in a NICU patient **should not be based solely on CLABSI prevention**.

Recommendation

Key Question 3: Does the use of one central line catheter insertion site, compared with another, prevent - CLABSI in NICU patients?

- Recommendation 3.A. **Choose the insertion site** appropriate to the central line type to be inserted in a NICU patient **based on the clinical needs of the patient.**

Recommendation

- Recommendation 3.B. The choice of insertion site in NICU patient **should not be based solely** on CLABSI prevention.

Recommendation

Key Question 4: Does the use of single-lumen, compared with double-lumen, umbilical venous catheters prevent CLABSI in NICU patients?

- Recommendation 4. – Consider choosing the **fewest number of lumens** based on the clinical needs of the NICU patient.

Conditional recommendation

Key Question 5: In NICU patients requiring skin antisepsis for catheter insertion and maintenance, **does the use of alcoholic chlorhexidine, compared with alcoholic povidone-iodine, prevent CLABSI**?

- Recommendation 5. **Consider the use of alcohol-containing chlorhexidine** for skin antisepsis to prevent CLABSI in NICU patients **in whom the benefits are judged to outweigh the potential risks**. Gestational age, chronologic age, and skin maturity should be considered when assessing risks and benefits of CHG containing agents in determining eligible patients.

Conditional Recommendation

Key Question 6: Does chlorhexidine bathing, compared with no bathing or bathing with placebo, prevent CLABSI in NICU patients?

- Recommendation 6.A. **Consider use of CHG bathing** to prevent CLABSI in NICU patients in whom the **benefits are judged to outweigh the potential risks**.

  Conditional Recommendation.

- Recommendation 6.B. The **identification of NICU patients** who might benefit from CHG bathing remains **an unresolved issue**

  No recommendation.

- Recommendation 6.C. If undertaken, the **frequency** of CHG bathing NICU patients **remains an unresolved issue**.

  No recommendation.

Key Question 7: In NICU patients with central line catheters, **does minimizing the number of times central line hubs are accessed prevent CLABSI?**

Recommendation 7. Minimize the number of times central line hubs are accessed and minimize blood sampling through central lines to **decrease the risk for CLABSI in NICU patients.**

Recommendation

Key Question 8: In NICU patients with central line catheters, **does the use of central line antimicrobial locks**, compared with standard of care, **prevent CLABSI**?

- Recommendation 8. **Consider central line antimicrobial locks** for NICU patients **in addition to core infection prevention and control strategies** when a unit is experiencing ongoing CLABSIs.

Conditional Recommendation.

Key Question 9: What is the **optimal duration of umbilical artery and umbilical venous catheters** to prevent CLABSI in NICU patients?

- Recommendation 9.A. **Remove** umbilical venous and umbilical arterial catheters in NICU pts **as soon as possible** and when no longer needed due to the concern for increasing risk of CLABSI associated with each day of increasing dwell time.

Recommendation

- Recommendation 9.B. **Consider removal of umbilical artery catheters at or before 7 days** of dwell time in NICU pts

Conditional Recommendation

- Recommendation 9.C. **Consider removal of umbilical venous catheters at or before 7 days** of dwell time in NICU pts

Conditional Recommendation

- Recommendation 9.D. Consider **removal of umbilical** venous catheters and **inserting a peripherally inserted** central catheter (PICC) or other long-term central venous catheter at or before 7 days of umbilical venous catheter dwell time for NICU pts requiring long-term central venous access.

Conditional Recommendation

Key Question 10: What is the **optimal duration** for peripherally inserted central catheters **(PICC)**to prevent CLABSI in NICU patients?

- Recommendation 10.A. For NICU patients, **remove** peripherally inserted central catheters (PICCs) **as soon as possible** and when no longer needed due to the concern for increasing risk of CLABSI associated with increasing dwell time.

Recommendation

- Recommendation 10.B. For neonates **with ongoing need for** central venous access, whether to remove and replace a PICC that has been in place for a prolonged period of time to reduce CLABSIs in NICU patients **remains an unresolved issue.**

No Recommendation

Key Question 11: Does the use of **dedicated catheter care teams** compared with standard of care, prevent CLABSI in NICU patients?

- Recommendation 11. **Consider implementing a dedicated catheter care** team to prevent CLABSI in NICU patients.

Conditional recommendation

Key Question 12: What are the **optimal elements** of central line insertion and maintenance bundles to prevent CLABSI in NICU patients?

- Recommendation 12**. Use "bundled" interventions for central line insertion and maintenance as part of a single or multiple intervention quality improvement effort** to reduce rates of CLABSI in NICU patients. Elements of insertion and maintenance bundles for all patients have been recommended by CDC

Recommendation

Key Question 13: What is the efficacy of **prophylactic antimicrobials**, compared with standard of care, to prevent CLABSI in NICU patients?

- Recommendation 13. **Do not use prophylactic antimicrobial** infusions routinely to decrease the risk of bacterial CLABSI in NICU patients.

Recommendation.

Key Question 14: What is the efficacy of **prophylactic anticoagulant infusions**, compared with standard of care, to prevent CLABSI in NICU patients?

- Recommendation 14. **Do not use prophylactic anticoagulant** infusions for the purposes of preventing CLABSI in NICU patients.

Recommendation

Preventing VAP and/or VAEs in neonatal patients

Essential practices for preterm neonates

- Avoid intubation

(Quality of Evidence: HIGH).

Minimize duration of mechanical ventilation

- Manage patients without sedation whenever possible (QoE: LOW).
- Use caffeine therapy for apnea of prematurity within 72 hours after birth to facilitate extubation (QoE: HIGH).
- Assess readiness to extubate daily (QoE: LOW).
- Take steps to minimize unplanned extubations and reintubations (QoE: LOW).
- Use nasal CPAP or nasal NIPPV in the post-extubation period to help prevent the need for reintubation.
- Provide regular oral care with sterile water (extrapolated from practice in infants and children, no data in preterm neonates) (QoE: LOW).
- Change the ventilator circuit only if visibly soiled or malfunctioning or per manufacturers' instructions for use (extrapolated from studies in adults and children, no data in preterm neonates) (QoE: LOW).

Additional approaches for preterm neonates

These interventions have minimal risks of harm, but their impact on VAE and VAP rates is unknown.

- Lateral recumbent positioning (QoE: LOW)
- Reverse Trendelenburg positioning (QoE: LOW)
- Closed/in-line suctioning (QoE: LOW)
- Oral care with maternal colostrum (QoE: MODERATE)

Approaches that are generally not recommended for preterm neonates

- Regular oral care with an antiseptic or Biotene (QoE: LOW)
- Histamine H2-receptor antagonists (QoE: MODERATE)
- Prophylactic broad-spectrum antibiotics (QoE: MODERATE)
- Spontaneous breathing trials (QoE: LOW)

Approaches that are not applicable to preterm neonates

- Daily interruption of sedation (QoE : LOW)
  - Sedation is not routinely used for neonates on mechanical ventilation.
- Prophylactic probiotics and synbiotics (QoE : LOW)
  - Currently, no products have been approved by the FDA for preterm neonates.
  - Limited data suggest that these may benefit some patients, but multiple cases of Lactobacillus bacteremia have been reported in infants and children following probiotic therapy.
- Endotracheal tubes equipped with subglottic secretion drains. (QoE : NA).
  - Products sized for neonates are not commercially available.
- Silver coated endotracheal tubes.
  - Products sized for neonates are not commercially available (QoE : NA).

Essential practices for pediatric patients

- Avoid intubation if possible
- Use noninvasive positive pressure ventilation (NIPPV) or high flow oxygen by nasal cannula whenever safe and feasible (QoE: MODERATE).

Minimize duration of mechanical ventilation

- Assess readiness to extubate daily in patients without contraindications (QoE: MODERATE).
- Take steps to minimize unplanned extubations and reintubations (QoE: LOW)
- Avoid fluid overload (QoE: MODERATE).
- Provide regular oral care (QoE: LOW)
- Elevate the head of the bed unless medically contraindicated (QoE: LOW)

Maintain ventilator circuits

- Change ventilator circuits only when visibly soiled or malfunctioning or per manufacturers' instructions (QoE: MODERATE).
- Remove condensate from the ventilator circuit frequently (QoE: LOW).
- Endotracheal tube selection and management
  - Use cuffed endotracheal tubes (QoE: LOW).
  - Maintain cuff pressure and volume at the minimal occlusive settings to prevent clinically significant air leaks around the endotracheal tube, typically 20–25 cm H2O.
  - This "minimal leak" approach is associated with lower rates of post-extubation stridor (QoE: LOW).
  - Suction oral secretions before each position change (QoE: LOW).

Additional approaches to preventing VAP and VAE in pediatric patients

- Minimize sedation (QoE: MODERATE).
- Use endotracheal tubes with subglottic secretion drainage ports (QoE: LOW).
- Consider early tracheostomy (QoE: LOW).

Approaches that are generally not recommended for VAE and VAE prevention in pediatric patients

- Prolonged systemic antimicrobial therapy for ventilator associated tracheitis (QoE: LOW)
- Selective oropharyngeal or digestive decontamination (QoE: LOW
- Prophylactic probiotics (QoE: LOW)

No impact on VAP rates for pediatric patients

- Oral care with chlorhexidine (Quality of Evidence: MODERATE)
- Stress-ulcer prophylaxis (Quality of Evidence: LOW)

Lowers VAP rates but no impact on duration of mechanical ventilation, length of stay, or mortality

- Silver-coated endotracheal tubes

References

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