


TRANSFORMING THE CARE OF BABIES WITH SEPSIS



INTRODUCTION

Antibiotic resistance is a leading threat to child survival and development. Babies are a particularly vulnerable population as their underdeveloped immune systems struggle to fight infections. A recent study has found that 140,000 newborn deaths were directly attributable to bacterial antimicrobial resistance in 2019.¹ Yet children and babies are not prioritised in terms of investment in research and development (R&D). This is particularly the case for antibiotics where overall the return on investment is not attractive. Therefore, private sector-led R&D is insufficient to construct and sustain a pipeline of paediatric treatments.

BABIES REMAIN NEGLECTED AND INVISIBLE WITHIN THE BROADER RESPONSE TO ANTIBIOTIC RESISTANCE.



Policymakers have yet to develop a comprehensive plan to protect babies, whether strengthening infection prevention and control, ensuring access to existing antibiotics or accelerating R&D of new tools to improve management and care.

Neonatal sepsis, a life-threatening bloodstream infection which affects up to 3 million newborns each year, is a major contributor to global mortality of children². Deaths from neonatal sepsis occur most often in low- and middle-income countries (LMICs) and are likely to be underestimated³.



DECADES OF NEGLECT OF THE IMPACT OF DRUG-RESISTANT INFECTIONS ON BABIES HAS SIGNIFICANTLY WORSENERD THE CRISIS OF NEONATAL SEPSIS.

PUTTING CHILDREN FIRST

The Global Antibiotic Research & Development Partnership (GARDP) is working with partners to develop new and improved antibiotics to treat drug-resistant infections in children and babies, an area of unmet need.

GARDP's paediatric activities focus on accelerating late-stage clinical development of antibiotics to ensure that they reach children and babies as rapidly as possible.

Typically, antibiotics are licensed first for adults. Further studies are required to support use at younger ages, for example, to assess safety and identify appropriate dosing, as well as to obtain regulatory approval. Such studies are not always a priority for antibiotic developers.

GARDP undertakes multiple activities with a wide range of partners, including laboratory evaluation of antibiotic treatments, initial clinical studies on children, and observational studies that clarify current treatment practices, pathogen resistance and unmet

needs. Ongoing dialogue with antibiotic developers globally provides a way to identify possible new treatment options for children that can be evaluated further. Clinical evaluation goes hand-in-hand with the development of plans to ensure global access and effective stewardship when treatments are introduced.

The focus of GARDP's neonatal sepsis programme is to develop alternative treatments to the current WHO-recommended empiric treatment for neonatal sepsis (first-line: ampicillin and gentamicin; second-line: cefotaxime/ceftriaxone), in areas with a high prevalence of multidrug-resistant bacteria. The programme has identified potential candidates to replace ampicillin and gentamicin.





WHAT HAPPENS WHEN A BABY GETS SEPSIS?

When germs get into a newborn baby's body, they can cause an infection. If it isn't stopped, it can cause sepsis because newborns don't yet have an immune system that can fight infection. Neonatal sepsis is life-threatening. Without timely treatment, it can rapidly lead to tissue damage, organ failure, and death.

NEONATAL SEPSIS: A LEADING KILLER OF BABIES THAT IS WORSENING DUE TO ANTIBIOTIC RESISTANCE

While under-5 mortality has fallen sharply in recent decades (although it remains unacceptably high in certain regions, particularly sub-Saharan Africa), neonatal survival has lagged. Within hours, a baby with sepsis can be in a life-threatening situation. To make matters worse, antibiotic resistance

reduces the odds of a baby surviving neonatal sepsis due to delays in the provision of appropriate treatment. Often effective therapy is neither available nor affordable. Babies who survive are often left with long-term and disabling health effects.

"Antibiotic resistance is a major problem. It breaks my heart to see a baby dying when an antibiotic hasn't worked. We are running out of options. If we don't get more antibiotics on board, more babies are going to die."

TANUSHA RAMDIN

Senior Neonatologist at the Charlotte Maxeke Johannesburg Academic Hospital in South Africa, and Sub-principal Investigator in Neonatal Sepsis Study



CHALLENGES TO FINDING IMPROVED TREATMENT FOR NEONATAL SEPSIS

Research to identify new treatment strategies for neonatal sepsis in hospitals, especially in LMICs, has been held back by:

- limited knowledge of current approaches to treatment and care
- incomplete data on the most common pathogens and resistance patterns
- a lack of suitable tools for characterizing neonatal sepsis

Improved clinical care and the ability to run robust clinical trials are needed. However, the lack of use of standardized definitions of neonatal sepsis, difficulty in collecting appropriate samples and inadequate diagnostics stand in the way.

In most cases, blood culture does not identify a causative pathogen, and culture results are typically not obtained for several days.

Moreover, since babies in LMICs do not form an effective commercial market for private developers, there are few affordable and accessible diagnostics that can be used to guide choice of treatment.

Furthermore, existing tools for assessing the severity of neonatal sepsis have been developed in high-income countries and often require additional tests that may not be available in many LMICs. Those that are more appropriate for LMICs identify mild cases and are unable to discriminate between the more serious cases seen in hospital settings.

“There is no question that neonatal sepsis is increasing around the world. Antibiotic resistance will be the main challenge in the future. A lot of research should be dedicated towards preventing antibiotic resistance as well as developing new antibiotics.”

PAOLO ROSSI

Professor of Paediatrics and Chairman, Department of Paediatrics, Bambino Gesù Hospital, Rome, Italy

“Children are not miniature adults. The antibiotics that work in adults won’t necessarily work in children and babies. They have a different metabolism. We need to take the toxicity of the drugs into account. We need to make sure we have antibiotics that have the least impact on their organs, as well as a high rate of efficacy.”

RAMESH AGARWAL

National Coordinating Investigator for India, Neonatal Sepsis Study

THE NEONATAL SEPSIS OBSERVATIONAL STUDY

GARDP, together with the Penta – Child Health Research, St George’s, University of London, the Medical Research Council Clinical Trials Unit at University College London, and the University of Antwerp, has completed one of the largest ever observational studies on the care of babies with sepsis.

Previous important studies, including the Burden of Antibiotic Resistance in Neonates from Developing Societies (BARNARDS study)⁴, have focused on characterising the multidrug-resistant bacteria that cause neonatal sepsis (Sands et al.)⁵ and their effects in LMICs. This includes assessing, based on observational data, the use and effectiveness of existing empirical antibiotic therapies commonly used to treat neonatal sepsis.



The Delhi Neonatal Infection Study (DeNIS study) focused on clinical and microbiology observational data, collected from three tertiary hospitals in New Delhi, India. The study demonstrated a high incidence of sepsis and significant antibiotic resistance among pathogens in neonates born in these hospitals⁶.

GARDP's neonatal sepsis observational study collected prospective clinical, microbiology and antibiotic use data. The results from this study will fill critical information gaps that can be used to **improve priority setting** and **inform the development** of treatment, diagnostic and vaccine strategies.



Bangladesh
Brazil
China
Greece
India
Italy
Kenya
South Africa
Thailand
Vietnam
Uganda

The neonatal sepsis observational study, which has looked at **over 3200 newborns** at **19 sites** in **11 countries** on **4 continents**, is providing evidence to fill knowledge gaps, help transform treatment and save lives.

“There are virtually no studies underway on developing novel antibiotic treatments for babies with sepsis caused by multidrug-resistant infections. This study has allowed us to design a major new global trial of new treatments, with a goal to reduce mortality from neonatal sepsis.”

MIKE SHARLAND

Principal Investigator, St George's, University of London and AMR Programme Lead at Penta



AIMS OF STUDY

In a context of inadequate public and private investment to both study and improve neonatal sepsis diagnosis and treatment, the neonatal sepsis observational study set out to address these deficiencies by generating data and tools to support future antibiotic trials for neonatal sepsis. Its specific aims were:

- To provide a clearer picture of mortality rates in hospital settings.
- To map the care and antibiotic treatment provided and range of treatment strategies adopted.
- To characterize the microbial causes of neonatal sepsis, including patterns of antibiotic resistance.
- To generate a simple severity score that could be used in any neonatal intensive care unit.
- To inform the design of trials evaluating treatments for neonatal sepsis.

A LANDMARK STUDY

SIZE

More than 3200 newborns were recruited at 19 hospitals in 11 countries, making it one of the largest hospital-based multi-country prospective observational studies of neonatal sepsis ever run.

GEOGRAPHICAL BREADTH

The study was carried out in multiple WHO regions, ensuring that its findings are of wide relevance.

RANGE OF SETTINGS

Data collection was obtained from hospitals in high-, middle- and low-income countries, enabling comparisons to be made across settings.

REAL-WORLD RELEVANCE

Antibiotic-prescribing practice varied markedly, with limited use of WHO-recommended regimens in many hospitals.

DATA QUALITY

The study generated comprehensive, consistent and high-quality data on clinical signs, care provided, microbiology, multiple laboratory tests and outcomes, focusing on 28-day mortality.

RANGE OF FACILITIES

The study sites included district general hospitals, general tertiary-level hospitals and specialist children's and maternity hospitals.

“With infections still the major cause of death in neonates worldwide, the development of antibiotic resistance and the lack of suitable formulations are of major concern. It is a priority for Penta and GARDP to join efforts to tackle these issues.”

CARLO GIAQUINTO

University of Padova and President of the Penta Foundation



“This study has given us a wealth of data on neonatal sepsis to design new and improved treatments specifically for babies.”

SALLY ELLIS

Children’s Antibiotics Project Leader, GARDP



KEY FINDINGS

The neonatal sepsis observational study generated a wealth of data on neonatal sepsis around the world, especially in LMICs.

In this study only a minority of patients (13%) received the WHO standard of care of ampicillin and gentamicin, and there was increasing use of last-line agents such as carbapenems or even polymyxins in some LMIC hospitals. This is alarming and foretells the impending crisis of a lack of antibiotics to treat sepsis caused by multidrug-resistant organisms.

KEY FINDING # 1

In-hospital mortality was high but variable, ranging from 1 – 27% across sites.

KEY FINDING # 3

Last-line antibiotics (carbapenems) were prescribed to 15% of babies with neonatal sepsis enrolled in the study.

KEY FINDING # 2

Antibiotic-prescribing practice varied markedly, with limited use of WHO-recommended regimens in many hospitals.

KEY FINDING # 4

Drug resistance to commonly used antibiotics plays a major role in determining outcomes of newborns with neonatal sepsis in hospitals.

“We are now starting the process to review and update the WHO guidelines for the treatment of neonatal sepsis. These findings as well as GARDP’s upcoming NeoSep1 trial will provide important evidence for this process.”

HANAN BALKHY

Assistant Director-General for AMR, World Health Organization

KEY FINDINGS (CONTINUED)

MORTALITY

Mortality at 28 days was high - 11.3% overall and 17.7% for cases where a pathogen was cultured from blood samples. More than half of infection-related deaths (59%) were due to hospital-acquired infections.

TREATMENTS

Huge variation in treatment was seen across sites (see Annex). The WHO-recommended first-line treatment (ampicillin plus gentamicin) was used in only a quarter of cases and recommended second-line treatments (third-generation cephalosporin-based regimens) were used even less frequently, reflecting the growing impact of antimicrobial resistance. The most common treatments were those offering some activity against extended-spectrum beta-lactamase (ESBL) strains and/or pseudomonas infections (a third of cases) and carbapenem-based regimens (20% of cases) which are classified by WHO as “Watch” antibiotics. These are critically important and their use should be limited.

PATHOGENS

Multiple pathogens were identified by culture. Microorganisms were cultured from one in five blood samples, and patterns of infection differed across patient subgroups (e.g., early-onset versus late-onset). *Klebsiella pneumoniae* was the most common pathogen isolated and is usually associated with hospital-acquired infections, which are increasingly resistant to existing antibiotic treatments.

SEVERITY SCORE

A neonatal sepsis Severity Score was developed, based on 10 independent predictors of mortality, including infant characteristics, supportive care, and clinical signs. The scoring system could be readily applied by clinicians, when patients are first assessed, to identify high-risk cases. This could guide clinical care, ensuring those at particular risk receive special attention more quickly. Importantly, the Severity Score could be used to identify high-risk cases for enrolment in clinical trials of new antibiotic treatments.

KEY FINDINGS (CONTINUED)

The study team is also developing a recovery score based on factors that, during treatment, are associated with either recovery or deterioration. This will provide clinicians with key information, for example on the need for treatment escalation. It will also support antibiotic stewardship by enabling clinicians to prescribe “standard” regimens with greater confidence, knowing that responses predictive of recovery or deterioration are monitored.

Further analysis of the bacteria causing the infection and antibiotic use at trial sites is currently underway. This will provide important information to guide choice of antibiotic treatment and help to identify remaining knowledge gaps. The findings of the study will be valuable in improving and strengthening vaccine, treatment, and diagnostic development for neonatal sepsis.



“Findings from the study will help us to better understand the burden of neonatal sepsis, which we will be able to share with policymakers. It will give us the opportunity to assess and potentially review our practices and improve on them.”

SITHEMBISO VELAPHI

*Head of Paediatrics and Neonatal Sepsis Study Principal Investigator
at Chris Hani Baragwanath Hospital in Soweto, South Africa*

BABY OKWENATHI: FIGHTING FOR HIS LIFE AGAINST A DRUG- RESISTANT INFECTION

Busisiwe Sibango has been keeping vigil by her baby's bedside for the past six weeks.



Okwenathi was tiny when he was born prematurely at 27 weeks (6 and a half months) at Tygerberg Children's Hospital in Cape Town. Soon after being born, he developed an inflammation of the intestines and was put on a course of antibiotics. He fought back bravely and overcame the inflammation, but then picked up a life-threatening antibiotic-resistant infection in the hospital. Faced with limited choices, doctors had to turn to the antibiotics of last resort to treat Okwenathi. On top of this, the newborn still weighs under one kilogram, needs oxygen by nasal prongs to support his immature lungs and has a central line catheter to receive the antibiotics along with other medications and fluids. He has also contracted meningitis, an infection of the membrane lining the brain. Due to a lack of rapid diagnostics, it is difficult to find the actual germs causing the infection as well as determine the effectiveness of the antibiotics that are being used.

While caring for Okwenathi, doctors and nurses also have to take extra special care to ensure that the infection does not spread to other babies in the ward, which would lead to a disastrous outbreak. Busisiwe says she is hoping and praying that her baby gets better and that she will be able to take him home soon. But for fragile Okwenathi, now six weeks old, it's a fight for his life.

Angela Dramowski, Head of the Clinical Unit: General Paediatrics at Tygerberg Hospital, Cape Town, says Okwenathi's story reflects the crisis in antibiotic resistance. "Over the past decade we have seen a year-by-year increase in antibiotic resistance. We urgently need new antibiotic options. We are also hopeful that the study by GARDP and partners will go far in working out the best treatment options for babies, with the right dose and the least possible toxicity. This will help us in treating babies like Okwenathi."

LESSONS LEARNED

The neonatal sepsis observational study illustrates the significant detrimental impact that neonatal sepsis has upon babies, with mortality rates exceeding 25% in some settings. It highlights challenges with appropriate and timely diagnosis and antibiotic-prescribing practices that reflect the uncertainty that comes with having to treat empirically in settings of emerging and endemic resistance levels.

There remains an urgent need to develop novel antibiotic treatments to keep pace with rising rates of resistance and to ensure appropriate access and stewardship to these treatments across the world. These challenges represent decades of neglect – by policymakers, governments, institutions, and companies – to collectively address a systemic failure that is leading to the avoidable deaths of babies, especially in LMICs.

Children and neonates must be placed at the centre, not the periphery, of the international response to antibiotic resistance. This requires marshalling the support of the public and private sectors towards the common objective of reducing neonatal morbidity and mortality.



“Doctors prescribing medicines need to exercise caution so that antibiotic resistance can be curbed. The proper use of antibiotics needs to be enforced and encouraged in health centres and pharmacies. Preventative measures will also help to reduce neonatal sepsis.”

JOLLY NANKUNDA

Principal Investigator for Neonatal Sepsis Study: Mulago National Referral Hospital and Mulago Specialized Women and Neonatal Hospital, Uganda

“The research and clinical teams have done an amazing job collecting huge and unique amounts of data. This is giving us the answers that people need to treat neonatal sepsis better in the future. We hope it will ultimately lead to giving babies a better chance of surviving and thriving.”

NEAL RUSSELL

Principal Investigator, Neonatal Sepsis Study, St George’s, University of London

GARDP RECOMMENDATIONS

GARDP recommends that policymakers, researchers, the private sector and funders take steps to strengthen the international response to neonatal sepsis and to mitigate the impacts of antibiotic resistance upon children and babies.

- ▶ **Consider the results of the neonatal sepsis observational study when updating guidance for the empiric treatment of neonatal sepsis, especially for countries that participated in the study.**
- ▶ **Further evaluate the neonatal sepsis Severity Score in the near term.** Clinical trial networks should do this to facilitate recruitment into clinical trials of new antibiotic treatments, and ultimately as a tool to guide clinical care by healthcare providers.
- ▶ **Consider other preventive measures in the context of neonatal care.** These measures include infection prevention and control (IPC) that is adapted for neonatal units, access to antenatal care, maternal vaccination, and water, sanitation and hygiene.
- ▶ **Develop and fund AMR National Action Plans that fully account for the needs of children and newborns, including improved infection prevention and control and access to antibiotics.** There must be substantial additional government investment, planning and commitment to facilitate access for babies to the right treatments at the right time. There should be investment by public, private, and not-for-profit entities that develop, manufacture, and distribute antibiotics. Governments and private hospitals should invest in tools that can ensure rapid access and appropriate use of priority antibiotics and diagnostics, including through support for guideline dissemination, mentorship, development of best practices, and strengthened stewardship programmes.
- ▶ **Invest in increasing surveillance of the pathogens and resistance patterns, including in children and newborns.**
- ▶ **Prioritize development of new tools and other measures for diagnosis, treatment, and care of neonates with drug-resistant infections, especially novel treatments that enhance neonatal care.** This requires investments in platform trials and accelerators of paediatric clinical research, including not-for-profit entities that prioritize the development of new treatments for children and neonates.

NEXT STEPS

Data from the neonatal sepsis observational study have informed the planning of a groundbreaking GARDP-funded interventional trial — NeoSep1. The first phase is due to launch in 2022 in two to three sites in Kenya and South Africa, expanding to up to ten countries. The main trial is scheduled for 2023.

The NeoSep1 trial will generate high-quality data on the safety and effectiveness of three potential new treatments and existing commonly used antibiotic regimens for neonatal sepsis. Such evidence can help identify the right treatment for the right patient, at the right time, and at the right dose.

The trial will also provide information on factors that impact their effectiveness, such as patterns of antibiotic resistance. The objective is to provide evidence to inform global, national and institutional policy on antibiotic treatment regimens, particularly in LMICs,

but also globally. This trial will be groundbreaking for the design of future clinical trials that seek to study the effectiveness of antibiotics.

Observational studies and clinical trials that take place in LMICs and beyond are a critical precondition to quicker and appropriate access. This contrasts with conducting trials predominantly in the United States and the European Union and then waiting for subsequent studies in LMICs that are delayed or never occur.



GARDP MILESTONES IN CHILDREN'S ANTIBIOTICS PROGRAMME

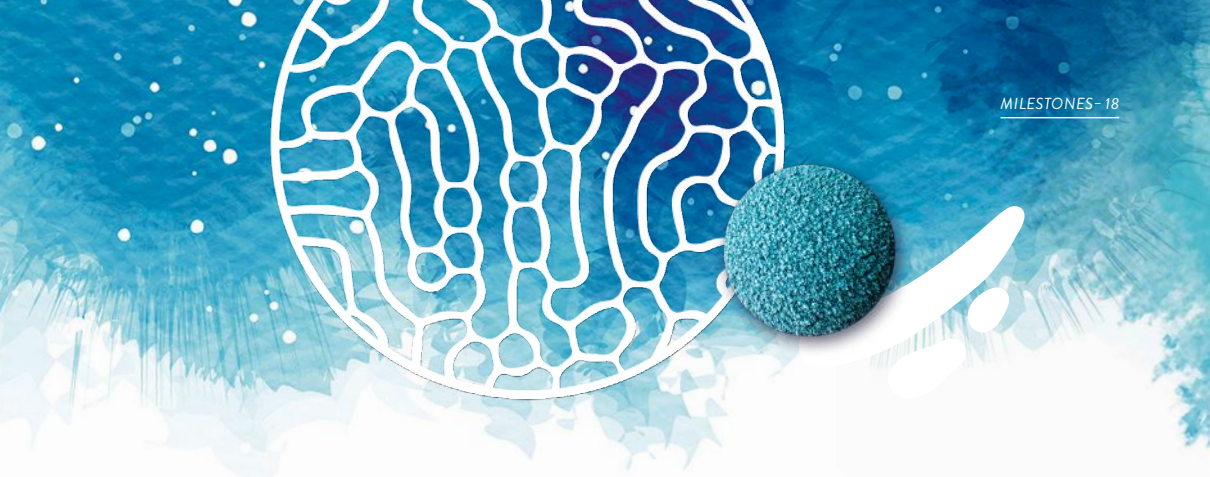
Completed global neonatal sepsis observational study, one of the largest ever on the care of babies with sepsis, together with key partners. The research looked at over 3200 newborns across 19 sites in 11 countries from 2018 to 2020.

Identified five antibiotics as potential treatments for neonatal sepsis, with three showing particular promise when evaluated in combination using the Hollow Fibre Infection model: amikacin, fosfomycin, and flomoxef.

Partnered with InfectoPharm to investigate the pharmacokinetics and safety of fosfomycin in 120 newborn babies with clinically diagnosed sepsis at the Kilifi County Hospital in Kenya. Findings indicated fosfomycin, an antibiotic regularly used in adults, offered significant potential as part of a combination antibiotic regimen for newborns.


Worked with Venatorx Pharmaceuticals to study the use of cefepime-taniborbactam in children and newborns. GARDP and Venatorx have completed three non-clinical studies. Clinical studies are planned for 2023. GARDP and Venatorx are also partnering to distribute the drug on an affordable basis, through a collaboration and licence agreement.

Collaborating with Shionogi on cefiderocol and bringing it to children and adult patients around the world, especially LMICs. A study which will establish the correct dose for infants under three months old is planned to start in late 2022.



Supported aspects of a clinical trial on infection prevention and control which evaluated chlorhexidine wash and was conducted by key partners, including St George's, University of London.

Launching a strategic public health clinical trial that will validate the flomoxef-fosfomycin dosage and evaluate and rank three new combinations (fosfomycin-amikacin, flomoxef-amikacin, and flomoxef-fosfomycin) alongside currently used combinations of antibiotics as reported from the neonatal sepsis observational study. The trial, which aims to enrol over 3,000 babies globally, gets underway in South Africa and Kenya in 2022, and will expand to up to 10 countries.



Partnered with outstanding and dedicated people in institutions across the world to achieve our collective goal of a better outcome for babies with neonatal sepsis.

“Our work with partners has helped us build an incredibly dedicated and talented network that will be able to conduct robust trials and studies that aim to impact neonatal management and care across the world. Investing in this pivotal work is an investment in our children and in future generations.”



MANICA BALASEGARAM
GARDP Executive Director



GARDP stands ready to work with all stakeholders to ensure that newborns are placed at the heart of the AMR response.

Together, let's work to ensure that all infections are treatable for everyone, everywhere.

The time to act is now.

ANNEX

A) ANTIBIOTICS STARTED WITHIN 24 HOURS OF BASELINE BLOOD CULTURE AFTER ENROLMENT, AND B) PATHOGENS IN BASELINE BLOOD CULTURE.

A. INITIAL REGIMEN	N=3,142	B. BASELINE PATHOGENS*	N=564
Ampicillin + Gentamicin	403 (12.8)	Klebsiella pnxaeumoniae	132 (4.1)
Piperacillin/Tazobactam + Amikacin	356 (11.3)	Coagulase-negative Staphylococci	84 (2.6)
Ceftazidime	296 (9.4)	Acinetobacter spp. **	72 (2.3)
Meropenem + Vancomycin	241 (7.7)	Staphylococcus aureus	54 (1.7)
Meropenem	197 (6.3)	Escherichia coli	47 (1.5)
Ceftazidime + Amikacin	139 (4.4)	Enterobacter spp.	39 (1.2)
Cefotaxime	93 (3.0)	Serratia spp.	20 (0.6)
Ampicillin + Amikacin	86 (2.7)	Streptococcus agalactiae	19 (0.6)
Cefotaxime + Ampicillin	77 (2.5)	Elizabethkingia meningoseptica	15 (0.5)
Cefoperazone/Sulbactam+Amikacin	61 (1.9)	Enterococcus faecalis	14 (0.4)
Benzylpenicillin (Penicillin G) + Gentamicin	60 (1.9)	Candida albicans	13 (0.4)
Amoxicillin/Clavulanic acid + Amikacin	59 (1.9)	Burkholderia spp.	12 (0.4)
Ceftriaxone	58 (1.9)	Enterococcus faecium	10 (0.3)
Ciprofloxacin + Amikacin	58 (1.9)	Citrobacter spp.	10 (0.3)
Amoxicillin/Clavulanic acid	56 (1.8)	Klebsiella oxytoca	7 (0.2)
Colistin (± other drug)	54 (1.7)	Pseudomonas spp.	7 (0.2)
Piperacillin/Tazobactam	54 (1.7)	Elizabethkingia anophelis	7 (0.2)
Ceftazidime + Benzylpenicillin (Penicillin G)	53 (1.7)	Candida spp. (other)	6 (0.2)
Cefotaxime + Amikacin	50 (1.6)	Bacillus spp.	4 (0.1)
Meropenem + Amikacin	49 (1.6)	Streptococcus pneumoniae	3 (0.1)
Ampicillin + Tobramycin	35 (1.1)	Streptococcus pyogenes	3 (0.1)
Other	607 (19.3)	Other	18 (0.6)

Note: Results are number and percentage per group. *Includes organisms classified as pathogens by the site. In 29 babies, more than one pathogen was detected. ** 64/72 = Acinetobacter baumannii, 2=Acinetobacter iwoffii, 6 =unspecified.

ABOUT GARDP



The Global Antibiotic Research and Development Partnership (GARDP) is a Swiss not-for-profit organization developing new treatments for drug-resistant infections that pose the greatest threat to health. GARDP was created by the World Health Organization (WHO) and the Drugs for Neglected Diseases *initiative* (DNDi) in 2016, and legally founded in 2018, to ensure that everyone who needs antibiotics receives effective and affordable treatment. GARDP is funded by the governments of Australia, Germany, Japan, Luxembourg, Monaco, Netherlands, South Africa, Switzerland, United Kingdom, the Canton of Geneva, as well as Médecins Sans Frontières and private foundations. GARDP is registered under the legal name GARDP Foundation. www.gardp.org



FUNDERS

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ENDNOTES

¹ Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *Antimicrobial Resistance Collaborators, Lancet* (2022) [https://doi.org/10.1016/S0140-6736\(21\)02724-0](https://doi.org/10.1016/S0140-6736(21)02724-0).

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