# Technology Solutions to AMR: Focus Paediatric Population

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**Abstract:**

Leveraging technology is a boost to healthcare as evidenced by literature. Addressing concerns of antimicrobial resistance (AMR) through deploying technology is an option to be seriously considered while framing the pathway forward. While AMR is a concern across all age groups it is becoming a vital concern for the paediatric population due to the longer nature and the potentially serious consequences it can have across the life span of the individual. This chapter addresses the increased risk posed by AMR right from the child in the womb. The risk has multiplied manifold due to the increased reliance on antibiotics which plays on the parent's desire for quick healthcare improvements during a child's illness episodes. The close link between nutrition and AMR further aggravates the scenario for the paediatric population. All this multiplies the healthcare challenges posed by AMR among the paediatric population. It is in this context that the diversity of technology solutions offers a way to address the manifold challenges. This chapter provides a detailed overview of this technology options classified into five broad areas of AMR databses; Data and storage solutions: EMR and Laboratory technology: genome sequencing; AMR Apps and Artificial Intelligence Solution for Physician Assistance in Diagnosis and Dosage. This chapter concludes with a five point call to action agenda for addressing AMR challenges in peaditric population by leveraging technology.

## Introduction

Antimicrobial resistance (AMR) has been effectively combated in the past by the use of technology. This chapter will explore the effects of AMR on the paediatric population and how technology could be used as an effective solution. The chapter is organised to provide an overview of issues of AMR in children. This is provided through the lens of the paediatric population, nutrition perspective as well as gender perspective. The review discusses the trend in ways nutrition impacts gender-specific health in children. Different upcoming technology including artificial intelligence is reviewed to address these challenges. The chapter concludes with a call to action.

## Risk of AMR starts from birth

The risk of antimicrobial resistance is borne by everyone right from the moment of birth. With shift to increase in institutional delivery this has tremendously seen a spike. Increase of AMR in turn impacts the cost of care including the treatment modalities. Introducing the use of antibiotics at a young age in children and repeated abuse of antibiotics lead to developing resistance against the microbes and further making the treatment of disease a challenge (Roubaud-Baudron et al., 2019).

### AMR in the paediatric population

Infants and children have immature immune systems. Research further suggests that there are a number of children staying in an unhygienic environment not suitable to promote good nutrition in developing countries due to various reasons that include financial and environmental (Matariya, Lodhiya, and Mahajan, 2016). Thereby, exposing these underprivileged children to antibiotics at an early age of life further increasing the chances of AMR many-folds. Children living in low-resource settings with limited access to health services face an even greater risk of acquiring and falling sick due to drug-resistant microbes. Lack of safe water, sanitation, and hygiene, and inadequate infection control, further enable the spread of AMR.

An increase in AMR can increase child mortality especially if resistance to treatments like antiretrovirals, antimalarials, and TB and antifungals are there. Malaria, TB, pneumonia, dysentery are the most common causes of childhood diseases and children being resistant to

available treatment is a cause for great alarm. This will immediately increase childhood mortality and morbidity.

Newborns, infants and children under the age of 5 are particularly prone to infections. Many babies who face non-infectious causes of respiratory distress are still prescribed antibiotics till the time their sepsis screen is reported negative. Thus, in retrospect, there is a large incidence of antibiotic overuse in this age group. While children need the full-course antimicrobials at the right time and when needed, it is also important that health workers and caregivers guard against AMR by avoiding mis- or over-use of antimicrobials.

**Gender and nutrition: relevant for understanding AMR patterns**

Time and again researchers have proved that nutrition has a long-term effect on human health particularly in children (Corkins et al., 2016). As the positive relationship between nutrition and health has been proved for ages, so is the impact of malnutrition (Muller, 2005).

There are many studies to state that malnutrition increases the risk of infections, morbidity, and mortality in children (Walson and Berkley, 2018). There is a direct and complex relationship between nutrition and infection. Malnourished children indicate children who do not receive optimum nutrition to their age. These children fall ill quite frequently and are exposed to antibiotics at an early age of life (Schulfer and Blaser, 2015). This trend was surprisingly observed higher in developing countries than the developed ones. For example, a research study as early as 2013 concluded that the evidence was not enough to continue with regular antibiotics in severe acute malnutrition (SAM), in particular addressing the areas having less prevalence of HIV (Alcoba et al., 2013).

Recently, studies suggested how gender bias could influence nutrition thus, overall affecting the health of children and adults (Marino et al., 2011). To add on, the female child was neglected over the male child. Another study found that if many siblings of the same sex were born to parents, the latest one had poor health outcomes as received less attention (Goyal et al., 2017), less focus on diet and health, and considered as more of a burden. However, the preference for the male gender always had supremacy as compared to the female children. Poor health outcomes increased the risk of infections in these children, in particular the female child.

With the immune system in children still not fully developed this puts them at the risk of resistant bacteria. Several studies suggest that exclusive breastfeeding goes long way in providing immunity in children. Whereas, data suggests that the breastfeeding rate is four times lower in girl babies than to boy babies (Vasquez-Garibay, Guzmán-Mercado, Larrosa Haro and Muñoz-Esparza, 2019). This increases the chances of a high infection rate in female children than male children and a higher chance of antibiotics being introduced at an early age of life (Scott et al., 2016).

A study concluded after many trials, where nutritional supplements were provided to the limited response on the growth and development of malnourished children, there were concerns over the side – effects of processed food supplementation (Briend et al., 2015). This is another huge area of concern where research is required. On the other hand, new studies are emerging that find that dietary intervention can reduce antibiotic resistance in the intestines of obese children. It further proved that gut bacteria can be managed by dietary interventions and can be useful in managing antibiotic resistance. However, the data is limited and requires further in-depth studies (Sanchez, Panahi, and Tremblay, 2014).

Trials further suggested that the presence of AMR microorganisms in our agricultural food production systems and food chain is a potential route of exposure to everyone including children. To add on, the prudent use of antibiotics in animal foods adds to the chances of antibiotic resistance in meat consumers (Vidovic and Vidovic, 2020).

Along with the food, the hygiene and sanitation conditions where the food is grown and cooked as well as the hygiene of the surrounding environment did make a striking contribution to the poor health outcomes of the children (Prüss-Ustün et al., 2019) and further increasing their dependency to be treated with antibiotics.

All of this evidence brings out numerous challenges in the paediatric population due to AMR.

### Healthcare challenges due to AMR among paediatric population

Institutional deliveries, use of neonatal ICU, on one hand save lives on the other they are also points where there is an increased use of antibiotics. This reaches the children at a very early age. However, the data on this is very poor at the individual child level. This is due to absence of electronic medical records, self medications which prevent its reporting into hospital records. This necessitates good medical reporting and documentation practices.

Protocols for AMR stewardship was skewed to the adult populations. It is only in recent years there has been an acknowledgement of the impact on paediatric population as well as need for AMR stewardship for paediatric population in a different manner. This will require action to be taken at appropriate levels within the healthcare provider facility as well as inter-provider and with the government providing appropriate regulation on the same.

The ability to address the challenge of AMR requires different healthcare providers that child will meet across different age group of the child to work in a coordinated manner. However the doctors are prescribing their antibiotics without being sensitised to AWaRe guidelines. The most common causes of childhood mortality like malaria, respiratory infections and their treatment options have already shown the impact of children being resistant to common modalities. It is important that continuous professional education among the medical and healthcare fraternity are carried out to update.

Nutrition implications highlight the vulnerability of the children at both ends of the spectrum – those who are malnourished as well as those who are obese. Both categories at a higher risk of AMR due to the need for antibiotics to treat both ends. Hence prevention and health promotion are also vital in AMR.

This evidence also brings out the need for multisectoral coordination beyond the boundaries of a healthcare facility. The risk to nutrition increases as the food itself can become a conduit due to the use of antibiotics both in animals as well as in soil.

## Technology solutions to address these AMR issues in children

A review of technology options highlights the possibility of addressing these challenges faced by the paediatric population due to AMR.

The diverse technology in AMR can be classified under the following headings

1. Database like CARD (comprehensive antibiotic resistance database) ; AWaRe Classification (Act Watch Reserve) Database
2. Data and storage solutions: EMR and
3. Laboratory technology: genome sequencing
4. Apps
5. Artificial Intelligence Solution for Physician Assistance in Diagnosis and Dosage

## 1. Database

Recognising the global problem posed by AMR WHO published a global action plan on antimicrobial resistance which had a focus to improve quality via improving hospital antibiotic usage. WHO programme brought out AWaRe (Act, Watch, Reserve) guidelines. This provides a comprehensive database of all antibiotics classified under these three categories. These guidelines have been updated for the paediatric population. It is important that all providers access this database which is regularly updated. This is a necessity in all hospital stewardship programmes. There are several other databases that go into details of the resistance like the CARD(comprehensive antibiotic resistance database) database. Technology allows large datasets to be captured and reported in the form of a database.

## 2. Data and Storage Solutions including range of Hospital Management Information System

AMR has also brought out voluminous data. This could be in multiple forms. It could be patient data along with medical history as well as antibiotic medication prescription history. Technology today provides a lot of solutions for data management, data retrieval, data storage and reporting. This includes from computerised medical records evolved to electronic medical records and now electronic health records.

Neo4j is one such technology solution provider which facilitates data storage and management. It also provides a very user-friendly reporting system that is user-centric via the graph database. This is being used by the physician community to offer a patient the right antibiotic for the right diagnosis at the right dosage. The knowledge graph supports physicians to treat their patients in the most effective way by providing up to date information of antibiotics in a user-friendly manner.

A free open source and independent R package is available - AMR for R . This package used evidence-based methodology to work with microbial and antimicrobial data and properties. This simplifies the analysis and prediction of AMR.

## 3. Laboratory Technology Solutions

This is another area where different technology is being developed to aid the work to accelerate the pace to combat AMR. Besides developments in diagnostic technology for quicker identification but also complex and higher technology for genome sequencing are also available.

### 4. Apps

There is a slew of apps that has come out that addresses various AMR challenges. While these may not be specific for the paediatric population, this technology shows what is possible via app as a technology for addressing AMR concerns. From the playstore on one's smartphone a range of apps can be accessed. A simple search in Google playstore revealed over 25 different apps. They revealed apps which brought out the organisational policy like "Standford Guide" which brough their institute guidelines of antimicrobial therapy, or AIIMS antibiotic policy via the app "AIIMS antibiotic policy"; or the apps titled "WHO Antibiotic Resistance" "Antimicrobial resistance app" or "The Antibiotic Guide" or "Antibiotics Flashcards" or "Antimicrobial stewardship" or "CliMic- Antimicrobial tool" or "ABS-Antibiotic Stewardship".

## 5. AI based solutions

Over and above all other technology the emergence of Artificial Intelligence and the possibilities it offers will tremendously aid to address AMR with the pediatric population. The interest for reducing AMR in peadiatric populations stems from the tremendous scope it offers as a support for diagnostic decisions. Artificial intelligence methods can speed up the process of exploring optimistic antibiotic combinations.Sequencing-based AI applications have been employed to study AMR. Collecting clinical data to build clinical decision support systems could help physicians monitor trends in AMR to increase the rational use of antibiotics. The advantage AI offers is the ability to handle large datasets. It is also possible to employ AI to design new antibiotics and synergistic drug combination investigations. Deep learning approach within AI could mark a paradigm shift for future antibiotic discovery to design new antibiotics and optimize existing molecules.

## Call to action

**Technology development and deployment as a critical strategy in addressing peadiatric AMR challenges:** Power of technology is critical to leverage to address the complex set of challenges brought by AMR for the paediatric population.

**AI application in AMR :** This is really the future of unravelling the complexity of AMR work and must be taken up in a phased manner to convert machine learning to deep mind.

**Gender-disaggregated data on resistance are crucial:** This will increasingly be a necessity to monitor the situation and help to track the effectiveness of policies in addressing the AMR threat. Gend

**Paediatric AMR Stewardship is key:** This can be given greater emphasis with use of technology to support physicians in decision making as well as in online training on these vital issues.

**Ensure children and their caregivers have equitable access to antimicrobials:** In recognition of children's right to health requires governments to develop and implement policies and regulations to facilitate this. Observe the opportunity of World Children's Day as an opportunity to sensitive children and relevant stakeholders on ABR. Guided by the Convention on the Rights of the Child, recognition of children's right to health requires governments to develop and implement policies and regulations that ensure children and their caregivers have equitable access to antimicrobials, and to inform them on when and how to use the medicine. In addition, policies, regulations and protocols must be in place to prevent over prescription of antimicrobials by health professionals and to avoid over-the-counter sales.

For example, reducing the incidence of infections and preventing malnutrition by encouraging breastfeeding and improving water and sanitation standards is key for reducing antibiotic use. To add on, preventing the development and spread of antibiotic resistance through prudent use of antibiotics in food animals by awareness amongst animal producers.

However, this is an emerging topic to be considered, limited studies are available and a huge research gap is there in particular to gender and requires further studies in this area.

## Conclusion

In conclusion, introducing antibiotics at an early age of life and repeated abuse of antibiotics lead to developing resistance against the microbes that make the situation further challenging (Aslam et al., 2018). Henceforth, the prevention of antibiotic resistance particularly for the paediatric population is a task that should involve many approaches and different sectors. It requires international cooperation collaboratively working in this field. The aim should be to prevent and control infections through the awareness and support of the developing countries to reduce the use of antibiotics at early ages of life. Continued efforts for robust National and Global initiatives need to be taken for identifying problems, resolving them in time including creating relevant policies and adopting them.

Opportunities like World Antimicrobial Awareness Week, must be used to not only increase awareness of AMR but also encourage best practices among the public, health workers and policy makers. They also aim to bring to the forefront, children's rights to health. World Children's Day, which falls around the same period, is an opportunity to celebrate and reflect on collective efforts to ensure that children's rights, including their rights to good health and health care – are respected, protected and fulfilled. Right to health means being entitled to quality health care, including access to essential drugs and medicines, such as antimicrobials. It also means having a right to access appropriate health information, including on the proper use of antimicrobials and the risks associated with their mis- or overuse.

Children must not be left behind in the global AMR response. Their unique needs and vulnerabilities must be addressed and their rights to health upheld. It is the responsibility of adults to protect them against this rising threat.

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