Journal of the African Society for Paediatric Infectious Diseases
Volume 1

REVIEW

Update on community acquired pneumonia in African children

Norbertta Washaya[1*] and Diane Gray[1,2]

[1]Department of Paediatrics and Child Health, University of Cape Town, Cape Town, South Africa
[2]Medical Research Council (MRC) Unit on Child and Adolescent Health, University of Cape Town, Cape Town, South Africa

*Corresponding author: nnwashaya@gmail.com

How to cite this article:

Washaya N, Gray D. Update on community acquired pneumonia in African children. Journal of the African Society for Paediatric Infectious Diseases. 2022, 1:1-13. DOI: https://doi.org/10.15641/jafspidVol1pp1-13/1695

Article Information

Received: 19 December 2021
Accepted:28 February 2022

Key words
Community acquired pneumonia; review, aetiology; treatment; prevention; children; Africa

Abstract

Recent medical advances have led to a drop in the global incidence of pneumonia. Despite this global drop, pneumonia remains the number one cause of childhood mortality outside the neonatal period, especially in low-to-middle income countries. The purpose of this review is to give an update on the causes, diagnosis, management, and prevention of community acquired pneumonia (CAP) in African children.

Due to increased immunisation coverage, viruses have become the most common cause of CAP (respiratory syncytial virus being the most common virus), while staphylococcus aureus and non-typeable Haemophilus influenzae are the most common causes in fully immunised children.

Extensive investigations are not warranted in most cases, as a result, investigations to be carried out will be dependent upon the clinical condition and local protocol. In light of the COVID-19 pandemic all cases of CAP must be screened for COVID-19.

Antimicrobial treatment is determined by, clinical severity, local antibiotic resistance patterns, presence of complications, the causative organism, and local protocols. Broad-spectrum antibiotics such as amoxicillin-clavulanic acid or a 2nd or 3rd generation cephalosporin are normally sufficient. Special attention needs to be paid to immunocompromised children as well as those with sickle cell disease, as additional pharmacological cover is recommended.

Notwithstanding the significant burden posed by CAP in low-to-middle income countries, there remains a paucity of data on CAP from Africa, therefore, it is of paramount importance that further epidemiological data be collected from African countries to optimise the understanding, prevention and management of CAP in Africa.

Introduction

Notwithstanding the drop in the incidence of pneumonia due to advances in vaccination, diagnostics and therapy, pneumonia remains the number one cause of childhood mortality outside the neonatal period.[1,2] Of note, most childhood pneumonia deaths occur in low to middle income countries (LMICs), particularly in sub-Saharan Africa.[2] In 2017 pneumococcal pneumonia was estimated to be the leading cause of death due to lower respiratory tract infections, followed by respiratory syncytial virus pneumonia, *Haemophilus influenzae* type B pneumonia and influenza.[1]

In 2019, after neonatal causes, lower respiratory tract infections were the leading cause of morbidity in the 0–9-year age group, accounting for 11.6% (IQR 10.5–12.6) of the disability-adjusted life-years (DALYS).[3]

Childhood pneumonia has been affected by the global coronavirus disease 2019 (COVID-19) pandemic. This pandemic has complicated routine child health care, including reduced routine childhood immunisation and diversion of resources to the COVID-19 response.[4,5] Unfortunately, the impact that this has made on childhood pneumonia may only be seen in the coming years and has the potential to negatively impact the progress that has been made over the past decades.
Considering the significant burden that pneumonia poses, particularly in LMICs, it is important that we keep abreast with the changes pertaining to the causes, diagnosis, management, and prevention of pneumonia.

Definition

Community acquired pneumonia (CAP) is an acute lower respiratory tract infection of the lung parenchyma which forms part of the spectrum of lower respiratory tract infection (LRTI) in childhood.[6] LRTI encompasses infections that variably affect the airways and parenchyma depending on the organism and host response. CAP refers only to pneumonia acquired in the community and is distinct from other defined pneumonias such as hospital acquired pneumonia, ventilator acquired pneumonia and congenital pneumonia. CAP in African children will be the focus of this review.

Causative organisms

CAP can be caused by bacteria, viruses, mycobacteria, and fungi. Prior to widespread pneumococcal and Haemophilus influenza B vaccination, the most common causes of CAP were *Streptococcus pneumoniae*, *Haemophilus influenzae* type B and respiratory syncytial virus.[7] Due to increased immunisation coverage, the cause of pneumonia has changed over recent years with viruses now the most common cause of CAP in African children, while *Staphylococcus aureus* and non-typeable *H. influenzae* have become the most common bacterial causes in immunised children.[8-10] *Mycobacterium tuberculosis*, has also been recently identified as an important cause of acute pneumonia, especially in tuberculosis endemic countries.[9,11,12] Furthermore, polymicrobial infections have been documented, particularly in severe CAP.[10]

The type of organism is not only determined by patient vaccination status and local immunisation coverage but also by the age (Table 1) and immune status of the patient.

Table 1. Causes of community acquired pneumonia in children at different ages

Age group	Causative organisms
Neonates	Bacteria • Group B Streptococcus, *Escherichia coli, Listeria species* Viruses • Respiratory Syncytial Virus, Cytomegalovirus, Herpes simplex virus
1 – 6 months	Viruses • Respiratory Syncytial Virus, Influenza, Adenovirus, Parainfluenza Bacteria • *Streptococcus pneumoniae, Haemophilus Influenzae, Staphylococcus aureus, Moraxella catarrhalis, Bordetella pertussis, Chlamydia trachomatis, Ureaplasma urealyticum*
6 – 12 months	Viruses • Respiratory Syncytial Virus, Influenza, Adenovirus, Parainfluenza, Rhinovirus Bacteria • *Streptococcus pneumoniae, Haemophilus Influenzae, Staphylococcus aureus, Moraxella catarrhalis* Mycobacteria* • *Mycobacterium tuberculosis*
1 – 5 years	Viruses • Respiratory Syncytial Virus, Influenza, Adenovirus, Parainfluenza, Rhinovirus, Varicella zoster Bacteria • *Mycoplasma pneumoniae, Streptococcus pneumoniae, Staphylococcus aureus, Haemophilus influenzae, Chlamydia pneumoniae* Mycobacteria* • *Mycobacterium tuberculosis*
> 5 years	Viruses • Influenza, Adenovirus, Epstein Barr virus, Rhinovirus Bacteria • *Mycoplasma pneumoniae, Streptococcus pneumoniae, Chlamydia pneumoniae* Mycobacteria • *Mycobacterium tuberculosis*

*In high tuberculosis prevalence settings
Adapted from Paediatric pneumonia: a guide to diagnosis, investigation and treatment and Kendig's Disorders of the respiratory tract in children.[13,14]

According to the Pneumonia Aetiology Research for Child Health (PERCH) study, ten pathogens were responsible for 79–90% of cases with severe pneumonia requiring hospital admission in HIV uninfected children aged 1-59 months.[9] In this study respiratory syncytial virus was the most common cause contributing 31.1% (CI 28.4–34.2), with the following pathogens contributing more than 5% each, human rhinovirus, human metapneumovirus, parainfluenza, *Streptococcus pneumonia*e, *Haemophilus influenzae* and *Mycobacterium tuberculosis*.[9] Pertussis is an important cause in young children, particularly in the unimmunised or partially immunised child.[15-17]

Immunocompromised patients such as those that are living with Human Immunodeficiency virus (HIV) and whose viral load is unsuppressed are prone to atypical organisms such as *Pneumocystis jiroveci* and cytomegalovirus.[18]

Clinical features and classification of pneumonia

Patients may present with fever, cough, tachypnoea, tracheal tug, use of accessory muscles, grunting, hypoxia and poor feeding.[14] Older children may complain of chest pain or abdominal pain.[14] According to the World Health Organization (WHO) CAP can be classified as severe or non-severe.[19] Non-severe pneumonia in a child older than 2 months of age presents with fast breathing and or lower chest indrawing.[19,20] A child with severe pneumonia presents with a general danger sign (not able to drink, persistent vomiting, convulsions, lethargy or unconsciousness, stridor in calm child) or hypoxia or severe respiratory distress if less than 2 months of age or lower chest indrawing if malnourished and/or HIV infected.[19,20]

Investigations

Investigations are helpful in confirming the diagnosis of CAP, determining the causative agent(s), grading the severity, and identifying complications.[20] However, extensive investigations are not warranted in most CAP cases as they do not change clinical management.

A chest x-ray should be done in all patients with CAP requiring admission. Those patients with CAP who can be managed as outpatients do not warrant a chest x-ray unless tuberculosis (TB) is suspected and/or they have not responded to initial empiric treatment.[21] A lateral chest x-ray projection is not always necessary unless TB is suspected, or a complication that requires characterisation on the lateral projection is suspected, for example, diaphragm paresis or an abscess.[20,22] It is important to note that chest x-ray cannot differentiate between viral and bacterial causes of CAP accurately.[21]

In addition to a thorough clinical examination, investigations such as pulse oximetry and arterial or venous blood gas measurement can help grade the severity of CAP. CAP with hypoxemia has a poorer outcome compared to CAP without hypoxemia.[23,24] Pulse oximetry detects hypoxaemia, which can be used as a non-invasive indicator of hypoxia. Ideally, pulse oximetry should be available at primary health care level, but unfortunately this is not the case in many low-middle income countries. A study done in Malawi indicated that the availability of pulse oximetry may help in identifying more cases of potentially fatal pneumonia in an outpatient setting, that would otherwise be missed when using the WHO clinical referral guidelines alone.[25] Despite the small sample size, in this study oxygen saturations of less than 90% identified 6% (1/16) of deaths at community health worker level and 23% (3/13) of deaths at health centre level not identified by clinical signs.[25] In a similar but bigger study, absence of pulse of oximetry would have led to, 68.7% (390/568) severely hypoxaemic children at study health centres and 61.9% (52/84) severely hypoxaemic children seen by community health workers being considered ineligible for referral to the next level of healthcare.[26] Highlighting the difficulty of accurately assessing severity on clinical signs alone and the critical role oximetry plays in reducing mortality from CAP. In light of the above findings African governments need to identify low cost and sustainable solutions that would enable availability of pulse oximetry at primary health care level in order to avoid preventable pneumonia deaths.

Arterial blood gas (ABG) measurement has the advantage over pulse oximetry in that it measures hypoxemia more accurately. It also measures carbon dioxide as well as other metabolic parameters that aid in assessing the severity of the child's illness. This is of particular importance in the child who is receiving non-invasive ventilation and yet continues to deteriorate, a child requiring invasive ventilation or a child that has multiple organ involvement. However, the blood gas machine and reagents are expensive, rendering them unavailable even in some tertiary care centres in LMICs.

Determining the exact cause of CAP in children can be challenging because CAP can be due to a single organism or multiple organisms[10,27]; the challenges associated with obtaining an appropriate respiratory

specimen; the difficulty between differentiating colonisation versus infection and the fact that reliable results are dependent on the laboratory capacity to process the sample.[10,27,28]

Respiratory tract samples that may assist in detecting the cause include upper respiratory tract samples such as nasopharyngeal aspirates and cough swabs, and lower respiratory samples such as expectorated sputum or induced sputum. More invasive samples that may be obtained include bronchoalveolar lavage and tracheal aspirates. Respiratory samples are not required in all cases of CAP, but recommended in cases of suspected tuberculosis, outbreak scenarios, complicated CAP, severe CAP requiring intensive care treatment and patients with chronic or recurrent respiratory disease.[20,21]

Table 2 describes the spectrum of respiratory samples that may be collected in different scenarios and the type of tests that can be performed on them.

Due to the COVID-19 pandemic it is important to screen all cases of CAP for COVID-19. Even though the SARS-CoV-2 virus has been associated with severe pneumonia, children are much less affected than adults, with fewer infections, very few hospitalisations and <1% of COVID-19 deaths globally, even in settings with high pneumonia risk factor prevalence. Upper or lower respiratory samples, such as sputum and tracheal aspirates, can be utilized for testing.[29] The most common sample being collected currently is the mid-turbinate swab. The laboratory technique of choice in making a diagnosis of COVID-19, is a COVID-19 polymerase chain reaction (PCR) test.[29] Other laboratory techniques that may be utilized, particularly as screening tests or in settings where PCR might be unavailable, include antigen detection tests and antibody detection tests, however they have a lower sensitivity compared to PCR.[29] The sensitivity of PCR is as follows, sputum (97.2%, 95% CI 90.3-99.7%), saliva (62.3%, 95% CI 54.5-69.6%), nasopharyngeal aspirate/swab and throat swab (73.3%, 95% CI 68.1-78.0%).[30] Specificity of PCR is 98.6% for a throat swab and 90.0% on sputum samples.(30) It is important to note that some patients will present with CAP with COVID-19 as a coinfection rather than the sole cause of the respiratory symptoms.

Other investigations that may be used to identify the causative organism include lung aspirate, blood culture, urine, stool, and pleural fluid analysis.[20,31] Blood cultures have a low yield, and hence not recommended routinely unless the patient has features suggestive of bacteraemia such as fever, chills or rigors, "toxic" looking, hypotension, altered level of consciousness and/or multiorgan involvement.[21,27] Traditionally, pleural fluid analysis was noted to yield no bacterial growth as it tended to be done after antibiotic administration.[21,31] However, the recent PERCH study demonstrated the value of culture and PCR testing on pleural fluid collected within 72 hours of admission.[31] Furthermore, the type of cells that predominate as well as the biochemistry may help support a bacterial cause, or in tuberculosis endemic areas, to support a diagnosis of tuberculosis. It may also be used to rule out non infective causes of pleural effusion.

Transthoracic lung aspiration, though not done routinely, is relatively safe.[31] The specimen can be sent for culture, PCR testing and histology.[31] Clinicians in Africa need to consider utilising this test further, particularly in children with non-responding chronic pneumonia.

Acute phase reactants such as procalcitonin and c-reactive protein (CRP) have not been found to be helpful in distinguishing between bacterial and viral infections, as a result they should not be done routinely in CAP and considered only in cases with multiorgan involvement or requiring intensive care treatment.[20,21] Where resources permit, a CRP level of ≥40mg/L has been shown to be positively associated with bacterial pneumonia and negatively with RSV pneumonia.[32] A CRP level of ≥100mg/L is even more specific for bacterial pneumonia, but is not as sensitive as the cut off of ≥40mg/L.[32] However, how CRP relates to viruses other than RSV, still needs to be investigated.

Table 2. Clinical scenario and suggested respiratory sample types and tests*, **, ***

Clinical scenario		Respiratory sample type	Tests
Non-severe CAP			
Severe CAP requiring ICU	NIV	Nasal pharyngeal aspirate	RV multiplex PCR
		Induced or expectorated sputum	RV multiplex PCR; MCS
	IV	Tracheal aspirate	RV multiplex PCR; MCS
		BAL	RV multiplex PCR; MCS
CAP with suspected TB	Out-patient	Induced or expectorated sputum	Xpert MTB/RIF Ultra; TB MCS
	NIV	Induced or expectorated sputum	Xpert MTB/RIF Ultra; MCS; TB MCS
	IV	Tracheal aspirate	Xpert MTB/RIF Ultra; MCS; RV multiplex PCR; TB MCS
		BAL	Xpert MTB/RIF Ultra; MCS; RV multiplex PCR; TB MCS
Immuno-com-promised With severe CAP	NIV	Induced or expectorated sputum	MCS; Xpert MTB/RIF Ultra; TB MCS; RV multiplex PCR; *Pneumocystis jiroveci* PCR; CMV VL on blood****; Fungal MCS
	IV	Tracheal aspirate	MCS; Xpert MTB/RIF Ultra; TB MCS; RV multiplex PCR; *Pneumocystis jiroveci* PCR; CMV VL; Fungal MCS
CAP with pleural effusion	No respiratory Support	Induced or expectorated sputum	MCS; Xpert MTB/RIF Ultra; TB MCS
		Pleural fluid	MCS; Xpert MTB/RIF Ultra; TB MCS; Bacterial PCR; Cell count; Biochemistry
	NIV	Induced or expectorated sputum	MCS; Xpert MTB/RIF Ultra; TB MCS
		Pleural fluid	MCS; Xpert MTB/RIF Ultra; TB MCS; Bacterial PCR; Cell count; Biochemistry
	IV	Tracheal aspirate or BAL	MCS; TB MCS; Xpert MTB/RIF Ultra; RV multiplex PCR
		Pleural fluid	MCS; TB MCS; Xpert MTB/RIF Ultra; Bacterial PCR; Cell count; Biochemistry

ICU: intensive care unit; NIV: Non-invasive ventilation; IV: invasive ventilation; RV multiplex PCR: respiratory virus multiplex polymerase chain reaction; MCS: microscopy, culture, and sensitivity; BAL: Bronchoalveolar lavage; CMV VL: cytomegalovirus viral load; *All patients to be screened for COVID-19 using the local protocol ** Performance of tests dependent on clinician expertise, patient stability, local protocol, resources, and laboratory capacity; ***Additional tests such as CRP or blood cultures to be done according to clinical severity; ****Test done on blood

Point of care lung ultrasound (LUS) has recently gained interest in thoracic imaging. It has various advantages including lack of radiation exposure, it is non-invasive, it can be used to guide procedures in real time, and it can be repeated with minimal discomfort to the patient.[33-35] Point of care LUS has been shown to be an accurate tool for the diagnosis of pneumonia.[33] In cases of pleural effusions it can help characterise the collection (simple versus complex) and hence guide the therapeutic option chosen.[34] In tuberculosis endemic areas, LUS has been found to be helpful in identifying mediastinal lymphadenopathy, it can also detect more abnormalities and has a higher inter-reader agreement when compared to chest x-ray.[35] Further studies especially on the role of LUS in LMICs are required.

Fortunately, chest computed tomography (CT) of the chest is rarely required. It is expensive, exposes children to radiation, in younger children requires general anaesthesia and requires expertise in its performance and interpretation. Chest CT may be considered in cases of complicated CAP such as necrotising pneumonia, abscess formation, and complex empyema.[20]

Management

The management of the patient includes pharmacological and non-pharmacological management.

Pharmacological management depends on the clinical severity, local antibiotic resistance patterns, presence of complications, the causative organism, and local protocols. In the outpatient setting a five-day course of a broad-spectrum antibiotic such as high dose amoxycillin or amoxicillin-clavulanic acid is sufficient.[14,20] In patients requiring admission who cannot tolerate oral antibiotics, broad-spectrum cover such as ampicillin and gentamicin, amoxicillin-clavulanic acid, or a 2nd or 3rd generation cephalosporin is recommended.[14] When treating with ampicillin, in neonates or immunocompromised patients, adding gram negative cover with an aminoglycoside such as gentamycin is recommended.[14] Once the patient responds to treatment and can tolerate oral antibiotics, they can be switched to oral antibiotics to complete 5-7 days.

Very ill immunocompromised patients such as those with HIV should also be treated for pneumocystis pneumonia (high dose cotrimoxazole and prednisone) and cytomegalovirus (ganciclovir). In general, neonates with CAP should be managed in hospital and not in the outpatient setting.[20] Sickle cell disease is a common cause of pneumonia in several African regions. Unfortunately, there are no random controlled trials (RCTs) that have been done to recommend the best treatment for CAP in sickle cell disease.[36] Children with sickle cell disease are prone to CAP from encapsulated organisms such as *S. pneumoniae*, *Salmonella species*, *H. influenzae* type B, *C. pneumoniae* and *Mycoplasma pneumoniae*, as such, when they present with acute chest syndrome they must be covered for atypical organisms with a macrolide.[37]

Table 3. Treatment guidelines for CAP[14,19,20,37]

Characteristic	**Suggested treatment***
Age <1 month	Ampicillin 50mg/kg IV 6-hourly Or benzylpenicillin 50 000 U/kg IV 6-hourly And gentamycin 7.5mg/kg IV daily Poor response in 48–72 hours change to Cefotaxime 50mg/kg IV 8-houry Or Ceftriaxone 50mg/kg 12-hourly Switch to oral amoxicillin-clavulanic acid when tolerating orals and if cultures negative Complete 5 days total antibiotic duration
Age >1 month, outpatient	Amoxicillin 45mg/kg/dose orally 12-hourly for 5 days Poor response switch to Amoxicillin-clavulanic acid 45mg/kg/dose orally 12-hourly for 5 days
Age >1 month, inpatient	Amoxicillin-clavulanic acid 30mg/kg/dose IV 8-hourly for 5 days Or amoxicillin-clavulanic acid 45mg/kg/dose orally 12-hourly for 5 days Or Ampicillin 50mg/kg IV 6-hourly
Pertussis	Azithromycin 10mg/kg daily oral for 5 days Or Clarithromycin or erythromycin**

Mycoplasma pnemoniae	Azithromycin 10mg/kg daily orally for 5 days Or Clarithromycin or erythromycin**
Chlamydia trachomatis	Azithromycin 10mg/kg daily orally for 5 days Or Clarithromycin or erythromycin**
Pnemocystis jiroveci	Cotrimoxazole: Trimethopim 250mg/m2 stat then 150/m2 8-hourly (<11 years) 12-hourly (>10 years). Switch to oral therapy once tolerating for a total of 21 days And prednisone 2mg/kg per day oral for 1 week, then 1mg/kg per day for 1 week then, 0.5mg/kg/day for 1 week
Cytomegalovirus	Ganciclovir 5mg/kg IV 12-hourly; Switch to valgancyclovir once tolerating for a total of 6 weeks. Valganciclovir 15mg/kg 12-hourly orally
Methicillin sensitive *S. aureus*	Amoxicillin-clavulanic acid 30mg/kg/dose IV 8-hourly Or Ceftriaxone 50mg/kg IV 12-hourly Or Cloxacillin 50mg/kg IV 6-hourly (maximum 1–2g) Switch to oral antibiotics once tolerating for a total of 2–4 weeks; Amoxicillin-clavulanic acid 45mg/kg/dose orally 12-hourly Or Flucloxacillin 12.5–25mg/kg 6-hourly (maximum 500mg)
Methicillin resistant *S. aureus*	Vancomycin 25–30mg/kg stat then 15–20mg/kg 8-hourly Monitor levels, duration dependent on clinical picture
Moraxella catarrhalis	Amoxicillin-clavulanic acid 45mg/kg/dose orally 12-hourly for 5 days
Influenza	Oseltamivir: <38 weeks 1mg/kg/dose 12-hourly per os for 5 days >38 weeks–8 months 3mg/kg/dose 12-hourly per os for 5 days ≥9 months 3.5mg/kg/dose (maximum 75mg) 12-hourly per os for 5 days
HIV-infected and -exposed infants with severe CAP	Empiric treatment: Ampicillin 50mg/kg IV 6 hourly Or benzylpenicillin 50 000 U/kg IV 6-hourly And gentamycin 7.5mg/kg IV daily Poor response in 48–72 hours change to Cefotaxime 50mg/kg IV 8-houry Or Ceftriaxone 50mg/kg 12-hourly Switch to oral amoxicillin-clavulanic acid when tolerating orals and if cultures negative Complete 5 days total antibiotic duration
	Add *Pnemocystis jiroveci* cover in infants or severely immunocompromised Cotrimoxazole: Trimethopim 250mg/m2 stat then 150/m^2 8-hourly (<11 years), 12-hourly (>10 years). Switch to oral antibiotics once tolerating for a total of 21 days And Prednisone 2mg/kg per day orally for 1 week, then 1mg/kg per day for 1 week then, 0.5mg/kg/day for 1 week
	Add cytomegalovirus cover***: Ganciclovir 5mg/kg IV 12-hourly Switch to oral valgancyclovir once tolerating for a total of 6 weeks Valganciclovir 15mg/kg 12-hourly orally
Sickle cell disease	Amoxicillin-clavulanic acid 30mg/kg/dose IV 8-hourly for 5 days And azithromycin 10mg/kg daily oral for 5 days or clarithromycin or erythromycin** Or amoxicillin-clavulanic acid 45mg/kg/dose orally 12-hourly for 5 days And azithromycin 10mg/kg daily per os for 5 days or clarithromycin or erythromycin**

Adapted from Diagnosis and management of community-acquired pneumonia in children: South African Thoracic Society guidelines, Kendig's Disorders of the respiratory tract in children.[20,14] WHO Guidelines Approved by the Guidelines Review Committee. Revised WHO Classification and Treatment of Pneumonia in Children at Health Facilities: Evidence Summaries and How I treat acute chest syndrome in children with sickle cell disease.[19,37]

* Once the microbiological results are available use specific therapy according to the sensitivity of the organism; ** Erythromycin contraindicated in neonates; *** Treatment can be stopped if the cytomegalovirus viral load is low

Cases of complicated CAP such as empyema, necrotising pneumonia and abscess require prolonged antibiotics and sometimes surgical management. The duration is usually a total of 2–3 weeks from the day the patient became apyrexial, this can be completed as an outpatient.[38]

Certain organisms require specific therapies. *Staphylococcus aureus* pneumonia requires a total of 2–4 weeks of anti-staphylococcal cover, which can be amoxycillin-clavulanic acid, 3rd generation cephalosporin or cloxacillin. In the event of methicillin resistant staphylococcus isolation then vancomycin instead is used. Atypical organisms such as pertussis, chlamydia and mycoplasma require cover with a macrolide such as azithromycin.[14,20] Tuberculosis is treated with anti-tuberculosis drugs according to local protocols. Oseltamivir is recommended early in the treatment of influenza, but it is unavailable in most LMICs.

Supportive management is determined by the clinical severity and includes oxygen therapy, respiratory support (non-invasive ventilation and invasive ventilation), analgesia and antipyretics and nutritional support.[20]

Non-invasive ventilation in the form of continuous positive airway pressure (CPAP) or high flow nasal canula (HFNC) improves survival in children with severe CAP in LMICs.[39] It has various advantages, including its potential to be used even out of the intensive care unit setting in areas with a high burden of respiratory illness or limited resources.[39]

Complications

Fortunately, complications in CAP are rare, they can be divided in to acute and chronic and are dependent on the causative organism. Acute complications should be suspected in patients who remain ill, continue to be pyrexial or deteriorate despite at least 48–72 hours of appropriate therapy.[21,38] Acute complications include local complications such as parapneumonic effusions, empyema, pyopnuemothorax, pneumothorax, abscess formation, expansile pneumonia and necrotising pneumonia.[21,38] Systemic complications include acute respiratory distress syndrome (ARDS), sepsis, multiorgan failure and disseminated intravascular coagulation.[21,38] Though the course of complicated CAP tends to be protracted, most previously well children recover completely, although in all children, LRTI is associated with slightly reduced subsequent lung function; and so each episode of LRTI matters.[38,40]

Chronic complications include bronchopulmonary fistula, bronchiectasis, bronchiolitis obliterans, lung fibrosis and persistent lung cavities.[21] Chronic complications should be suspected in cases with recurrent and/or persistent symptoms. To prevent further lung damage clinicians must have a high index of suspicion in patients who do not recover completely after an episode of CAP.
It is in cases of acute or chronic complications of CAP where further imaging such as CT scan of the chest are beneficial.[20]

Prevention

Prevention of CAP is related to preventing the known risk factors for CAP. Known risk factors include malnutrition, prematurity, immunosuppressed states including HIV, exposure to indoor and outdoor pollution, lack of breastfeeding, maternal smoking during pregnancy, incomplete or inadequate immunisation and poor socioeconomic status.[8,20,41,42]

Immunisation has come to the forefront especially with the COVID-19 pandemic. Routine child immunisation particularly with pneumococcal vaccine and *H. influenzae* type B reduces the risk of CAP in children.[20,43] Other vaccines that are of benefit include yearly influenza vaccination, COVID-19 vaccination and pertussis boosters every ten years and pertussis boosters for pregnant women.[20,44,45]

Due to respiratory syncytial virus being the most common organism isolated in cases of CAP various modalities have been used to prevent infection and severe disease. The mainstay of prevention utilized has been universal precautions and immuno-prophylaxis in the form of palivizumab, a monoclonal antibody used in at risk infants, but it is very expensive and not routinely used in LMICs.[20] Recently

maternal immunisation has been shown to be effective.[20] Furthermore, a long-term immune-prophylaxis option, nirservimab, a monoclonal antibody, was shown to prevent respiratory syncytial virus infection. It is administered once during the respiratory syncytial virus season.[46]

Chemoprophylaxis is recommended in certain at-risk populations. For example, cotrimoxazole prophylaxis in HIV infected children and other immunosuppressive conditions, as well as tuberculosis preventative therapy in children who are less than 5 years and/or are immunocompromised who have been exposed to active tuberculosis.[20]

Conclusion

CAP causes significant morbidity and mortality in children. Accordingly, the following are key measures to reduce the impact of CAP on child health: prevention, accurate and early diagnosis and prompt management using best practice medicine.

As we experience medical advances, with improved science and technology, it is essential that clinicians continue to carry out robust clinical studies that lead to increased characterisation of this illness in LMICs as well as improvements in therapeutic options. Moreover, clinicians need to advocate for children, particularly in LMICs, to ensure access to appropriate and quality healthcare.

Finally, as noted in this review, there is a paucity of literature on CAP in Africa, with most of the literature emanating from the PERCH study and South African publications. The PERCH study had no sites in Central or North Africa. It is important that further CAP epidemiological data is collected from other African countries to improve understanding of CAP in African children and how prevention and management of CAP can be optimised.

Author contributions: NW and DG developed the concept and wrote the review
Funding: This project was unfunded
Ethics approval and consent: not applicable
Competing interests: The authors declare no competing interests

References

1. Global, regional, and national age-sex-specific mortality for 282 causes of death in 195 countries and territories, 1980-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018;392(10159):1736-88.
2. Liu L, Johnson HL, Cousens S, Perin J, Scott S, Lawn JE, et al. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. Lancet. 2012;379(9832):2151-61.
3. Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet. 2020;396(10258):1204-22.
4. Causey K, Fullman N, Sorensen RJD, Galles NC, Zheng P, Aravkin A, et al. Estimating global and regional disruptions to routine childhood vaccine coverage during the COVID-19 pandemic in 2020: a modelling study. Lancet. 2021;398(10299):522-34.
5. Zar HJ, Dawa J, Fischer GB, Castro-Rodriguez JA. Challenges of COVID-19 in children in low- and middle-income countries. Paediatr Respir Rev. 2020;35:70-4.
6. Mackenzie G. The definition and classification of pneumonia. Pneumonia (Nathan). 2016;8:14.
7. Ruan I, Boschi-Pinto C, Biloglav Z, Mulholland K, Campbell H. Epidemiology and etiology of childhood pneumonia. Bull World Health Organ. 2008;86:408-16.
8. Marangu D, Zar HJ. Childhood pneumonia in low-and-middle-income countries: An update. Paediatr Respir Rev. 2019;32:3-9.
9. Causes of severe pneumonia requiring hospital admission in children without HIV infection from Africa and Asia: the PERCH multi-country case-control study. Lancet. 2019;394(10200):757-79.
10. Zar HJ, Barnett W, Stadler A, Gardner-Lubbe S, Myer L, Nicol MP. Aetiology of childhood pneumonia in a well vaccinated South African birth cohort: a nested case-control study of the Drakenstein Child Health Study. Lancet Respir Med. 2016;4(6):463-72.
11. Nantongo JM, Wobudeya E, Mupere E, Joloba M, Ssengooba W, Kisembo HN, et al. High incidence of pulmonary tuberculosis in children admitted with severe pneumonia in Uganda. BMC Pediatr. 2013;13:16.
12. Oliwa JN, Karumbi JM, Marais BJ, Madhi SA, Graham SM. Tuberculosis as a cause or comorbidity of childhood pneumonia in tuberculosis-endemic areas: a systematic review. Lancet Respir Med. 2015;3(3):235-43.
13. Crame E, Shields MD, McCrossan P. Paediatric pneumonia: a guide to diagnosis, investigation and treatment. Paediatrics and Child Health. 2021;31(6):250-7.
14. Scotta MC, Marostica PJC, Stein RT. 25 - Pneumonia in Children. In: Wilmott RW, Deterding R, Li A, Ratjen F, Sly P, Zar HJ, et al., editors. Kendig's Disorders of the Respiratory Tract in Children (Ninth Edition). Philadelphia: Elsevier; 2019. p. 427-38.e4.
15. Muloiwa R, Dube FS, Nicol MP, Zar HJ, Hussey GD. Incidence and Diagnosis of Pertussis in South African Children Hospitalized with Lower Respiratory Tract Infection. Pediatr Infect Dis J. 2016;35(6):611-6.
16. Moore DP, Baillie VL, Mudau A, Wadula J, Adams T, Mangera S, et al. The Etiology of Pneumonia in HIV-uninfected South African Children: Findings from the Pneumonia Etiology Research for Child Health (PERCH) Study. Pediatr Infect Dis J. 2021;40(9s):S59-s68.
17. Moore DP, Baillie VL, Mudau A, Wadula J, Adams T, Mangera S, et al. The Etiology of Pneumonia in HIV-1-infected South African Children in the Era of Antiretroviral Treatment: Findings from the Pneumonia Etiology Research for Child Health (PERCH) Study. Pediatr Infect Dis J. 2021;40(9s):S69-s78.
18. Nuttall JJC. Current antimicrobial management of community-acquired pneumonia in HIV-infected children. Expert Opin Pharmacother. 2019;20(5):595-608.
19. World Health Organization. Guidelines Approved by the Guidelines Review Committee. Revised WHO Classification and Treatment of Pneumonia in Children at Health Facilities: Evidence Summaries. Geneva: World Health Organization. Copyright © World Health Organization 2014.; 2014.

20. Zar HJ, Moore DP, Andronikou S, Argent AC, Avenant T, Cohen C, et al. Diagnosis and management of community-acquired pneumonia in children: South African Thoracic Society guidelines. Afr J Thorac Crit Care Med. 2020;26(3).
21. Harris M, Clark J, Coote N, Fletcher P, Harnden A, McKean M, et al. British Thoracic Society guidelines for the management of community acquired pneumonia in children: update 2011. Thorax. 2011;66 Suppl 2:ii1-23.
22. Richter-Joubert L, Andronikou S, Workman L, Zar HJ. Assessment of airway compression on chest radiographs in children with pulmonary tuberculosis. Pediatr Radiol. 2017;47(10):1283-91.
23. Le Roux DM, Nicol MP, Vanker A, Nduru PM, Zar HJ. Factors associated with serious outcomes of pneumonia among children in a birth cohort in South Africa. PLoS One. 2021;16(8):e0255790.
24. Rahman AE, Hossain AT, Chisti MJ, Dockrell DH, Nair H, El Arifeen S, et al. Hypoxaemia prevalence and its adverse clinical outcomes among children hospitalised with WHO-defined severe pneumonia in Bangladesh. J Glob Health. 2021;11:04053.
25. Colbourn T, King C, Beard J, Phiri T, Mdala M, Zadutsa B, et al. Predictive value of pulse oximetry for mortality in infants and children presenting to primary care with clinical pneumonia in rural Malawi: A data linkage study. PLoS Med. 2020;17(10):e1003300.
26. McCollum ED, King C, Deula R, Zadutsa B, Mankhambo L, Nambiar B, et al. Pulse oximetry for children with pneumonia treated as outpatients in rural Malawi. Bull World Health Organ. 2016;94(12):893-902.
27. Zar HJ, Andronikou S, Nicol MP. Advances in the diagnosis of pneumonia in children. Bmj. 2017;358:j2739.
28. Claassen-Weitz S, Lim KYL, Mullally C, Zar HJ, Nicol MP. The association between bacteria colonizing the upper respiratory tract and lower respiratory tract infection in young children: a systematic review and meta-analysis. Clin Microbiol Infect. 2021;27(9):1262-70.
29. Lai CKC, Lam W. Laboratory testing for the diagnosis of COVID-19. Biochem Biophys Res Commun. 2021;538:226-30.
30. Böger B, Fachi MM, Vilhena RO, Cobre AF, Tonin FS, Pontarolo R. Systematic review with meta-analysis of the accuracy of diagnostic tests for COVID-19. Am J Infect Control. 2021;49:21-9.
31. Ebruke BE, Deloria Knoll M, Haddix M, Zaman SMA, Prosperi C, Feikin DR, et al. The Etiology of Pneumonia from Analysis of Lung Aspirate and Pleural Fluid Samples: Findings from the Pneumonia Etiology Research for Child Health (PERCH) Study. Clin Infect Dis. 2021;73(11):e3788-e96.
32. Higdon MM, Le T, O'Brien KL, Murdoch DR, Prosperi C, Baggett HC, et al. Association of C-Reactive Protein with Bacterial and Respiratory Syncytial Virus-Associated Pneumonia Among Children Aged <5 Years in the PERCH Study. Clin Infect Dis. 2017;64(suppl_3):S378-s86.
33. Alzahrani SA, Al-Salamah MA, Al-Madani WH, Elbarbary MA. Systematic review and meta-analysis for the use of ultrasound versus radiology in diagnosing of pneumonia. Crit Ultrasound J. 2017;9(1):6.
34. Brogi E, Gargani L, Bignami E, Barbariol F, Marra A, Forfori F, et al. Thoracic ultrasound for pleural effusion in the intensive care unit: a narrative review from diagnosis to treatment. Crit Care. 2017;21(1):325.
35. Heuvelings CC, Bélard S, Andronikou S, Lederman H, Moodley H, Grobusch MP, et al. Chest ultrasound compared to chest X-ray for pediatric pulmonary tuberculosis. Pediatr Pulmonol. 2019;54(12):1914-20.
36. Martí-Carvajal AJ, Conterno LO. Antibiotics for treating community-acquired pneumonia in people with sickle cell disease. Cochrane Database Syst Rev. 2016;11(11):Cd005598.
37. Miller ST. How I treat acute chest syndrome in children with sickle cell disease. Blood. 2011;117(20):5297-305.
38. de Benedictis FM, Kerem E, Chang AB, Colin AA, Zar HJ, Bush A. Complicated pneumonia in children. Lancet. 2020;396(10253):786-98.

39. Ekhaguere OA, Mairami AB, Kirpalani H. Risk and benefits of Bubble Continuous Positive Airway Pressure for neonatal and childhood respiratory diseases in Low- and Middle-Income countries. Paediatr Respir Rev. 2019;29:31-6.
40. Gray DM, Turkovic L, Willemse L, Visagie A, Vanker A, Stein DJ, et al. Lung Function in African Infants in the Drakenstein Child Health Study. Impact of Lower Respiratory Tract Illness. Am J Respir Crit Care Med. 2017;195(2):212-20.
41. Ngocho JS, de Jonge MI, Minja L, et al. Modifiable risk factors for community-acquired pneumonia in children under 5 years of age in resource-poor settings: a case-control study. Trop Med Int Health. 2019;24:484-92.
42. Negash AA, Asrat D, Abebe W, Hailemariam T, Hailu T, Aseffa A, et al. Bacteremic Community-Acquired Pneumonia in Ethiopian Children: Etiology, Antibiotic Resistance, Risk Factors, and Clinical Outcome. Open Forum Infect Dis. 2019;6(3):ofz029.
43. Alicino C, Paganino C, Orsi A, Astengo M, Trucchi C, Icardi G, et al. The impact of 10-valent and 13-valent pneumococcal conjugate vaccines on hospitalization for pneumonia in children: A systematic review and meta-analysis. Vaccine. 2017;35:5776-85.
44. Campbell H, Gupta S, Dolan GP, Kapadia SJ, Kumar Singh A, Andrews N, et al. Review of vaccination in pregnancy to prevent pertussis in early infancy. J Med Microbiol. 2018;67(10):1426-56.
45. Principi N, Esposito S. Is the Immunization of Pregnant Women against COVID-19 Justified? Vaccines (Basel). 2021;9(9).
46. Griffin MP, Yuan Y, Takas T, Domachowske JB, Madhi SA, Manzoni P, et al. Single-Dose Nirsevimab for Prevention of RSV in Preterm Infants. N Engl J Med. 2020;383(5):415-25.

The *Journal of the African Society for Paediatric infectious Diseases Society* (JAfSPID) is a free, open-access, online journal. *JAfSPID* publishes a wide variety of manuscripts including full-length research articles, short research communications, review articles, commentaries, case reports, medical images, conference reports, short commentaries on a published landmark paper or report, letters to the editor and invited editorials on all aspects of infectious diseases in neonates, children, and adolescents. Contributions are reviewed by one editor. In addition, all research manuscripts, review articles, commentaries, case reports, medical images and conference reports are subjected to double-blind peer-review by at least one external, independent referee.