Pneumonia Diagnostics: Current Outlook and Perspectives

UNICEF Supply Division

May 2013

unite for children

unicef

Pneumonia Diagnostic Support – Current Outlook and Perspectives

1. Summary

- New pneumonia diagnostic support aids are currently being developed by industry, academia and other partners to improve the accuracy and effectiveness of diagnosing pneumonia in resource-poor contexts.
- Despite progress and new developments, an optimal device and solution has yet to be found to fulfil the need of assisting in accurately diagnosing and differentiating between the different types of pneumonia.
- A recent workshop held in Copenhagen, hosted by UNICEF, brought partners, civil society, industry and academia together to build a platform and partnership to address the critical challenges in designing appropriate pneumonia diagnostic support aids.
- Appropriate short and long term Target Product Profiles to guide industry and clearly define benchmarks need to be developed to take the process forward.

2. General Brief and Background

Pneumonia accounts for 1.4 million deaths in children under-five years of age annually, representing 18% of all annual under-five worldwide mortality.[1] 60% of these deaths occur in just 10 countries in South Asia and Sub-Saharan Africa.[2] Many of these countries face significant challenges in the provision of effective health care, diagnosis and treatment. Pneumonia is often misdiagnosed as malaria by caregivers in resource-poor settings until it develops into a severe stage.[3]

Figure 1 Pneumonia Diagnosis Respiratory Rates in Children's Ages

Child's Age	Respiratory Rate
<2 months	60+ breaths / minute
2-11 months	50+ breaths / minute
12-59 months	40+ breaths / minute

WHO's guideline for the Integrated Management of Childhood Illnesses (IMCI) prescribes the methodology to assess suspected pneumonia in children under-five in resource-poor settings. It focuses on various signs, which include measuring the respiratory rate of children suspected with pneumonia.

Diagnostic support aids for pneumonia are expected to contribute to improved, more accurate diagnosis and classification of pneumonia, yielding improved treatment, reduced margin of error and better sensitivity and specificity.

3. Current Devices

[1] UNICEF, Pneumonia and Diarrhoea tackling the deadliest diseases of the world's poorest children, New York, 2012 at http://www.unicef.org/media/files/UNICEF_P_D_complete_0604.pdf.
[2] WHO, *Pneumonia Factsheet Nº 331*, Geneva, 2012 at http://www.who.int/mediacentre/factsheets/fs331/en/index.html.
[3] Every Woman Every Child, *Amoxicillin Product Profile*, Geneva 2012 at http://www.everywomaneverychild.org/component/content/article/1-about/305-amoxicillin--product-profile-.

Since the 1990s, WHO and UNICEF have facilitated pneumonia diagnosis by supporting Community Health Worker (CHW) use of a one-minute Acute Respiratory Infection (ARI) timer to assist in determining the length of time required to measure the respiratory rate in children, and against which to support the pneumonia diagnosis. Recent field research has identified the need to improve the current diagnostic tool/ARI timer and increase its effectiveness as a diagnostic aid, particularly when applying a respiratory rate against a prescribed age-specific threshold.[4]

Figure 2 Summary of ARI timer Field Research Findings

Challenges related to the timer	Challenges related to diagnosis
The ticking sound generated by the timer confuses CHWs	CHWs have difficulty counting irregular breathing
CHWs often count the ticks and not the breaths	Restless children often distract CHWs
The 30 second alarm scares children, patients and confuses CHWs	The need to appease scared children often interferes with diagnosis
The timer cannot synchronise the start of the breath count and timer	Parents / guardians are not convinced by a negative reading as there is no result indicator
The timer does not show an elapsed time or what it is counting	CHWs experience difficulty to accurately count irregular breathing due to a stressful environment and time pressure.
The ARI timer is not automated	The lack of light / electricity is a challenge to general diagnosis
CHWs cannot identify whether a timer is faulty and use it regardless	Fear of contracting pneumonia distracts a CHW's attention on proper diagnosis
CHWs refer to the malaria rapid diagnostic test (RDT) as a good example of communicating the need to "treat or not to treat"	Lack of adequate knowledge and training on preventative care is a limitation
	Hesitation of CHWs to refuse treatment due to cultural pressure and expectations, accentuating misuse of antibiotics

Source: Synovate / UNICEF Research 2011.

The field research also identified a need for a device that also indicates the need for treatment (or not) and which ideally differentiates between viral or bacterial pneumonia.

A number of alternative products at various stages of development have been designed to aid pneumonia diagnosis. Some of these devices have been presented to UNICEF and focus on one or a combination of different approaches which measure respiratory rate, oxygenation or heart rate to diagnose pneumonia. These are included in Figure 3. Devices based on alternative technologies not presented in Figure 3, such as existing accelerometric, speedometric, molecular and biomarker diagnostic devices should also be evaluated.

The IMCI guidelines, which focus on breathing counts as the preferred diagnosis, have influenced the development of many of these different diagnostic tools and devices. However, the guidelines do not restrict devices from exploring other possible solutions (e.g., blood, mucus

[4] Synovate, *ARI Timer Research Report*, UNICEF, 2011 at http://www.unicefinnovation.org/sites/unicef.jjcdev2.com/files/Unicef%20Report_V2_web.pdf

or urine testing), or applying a solution that may require more than one diagnostic device, if it ensures greater accuracy.

Figure 3 Different Pneumonia Diagnostic Aids Concepts Reviewed

Device Name	Description
ARI Counting Beads	Counting beads designed as a simple, cheap and effective way to improve a CHW's ability to keep track and count a patient's breathing rate. To be used in conjunction with the ARI Timer. The beads are colour-coded to ease diagnosis.
Inspire™	An automated device using a sensor to detect respiratory rates and accelerometry through pattern recognition and comparative analysis displaying data via LED display.
mPneumonia	An android prototype mobile phone application in development which uses the IMCI pneumonia protocol, paired with a respiratory rate counter and pulse oximetre to guide and inform diagnosis.
Respiratory Rate Application	A mobile phone application that tracks a CHW's count rate using an "any button" press function on the phone to count and then calculate a patient's mean respiratory rate.
Solar and Cell Phone Pulse	A device powered by using old mobile phone batteries charged by solar cells measures the saturation level of a patient's haemoglobin. It determines whether a patient is receiving sufficient oxygen through breathing, as well as the patient's heart rate.
StethoCloud	A concept still in development which records the respiration rate through a stethoscope attached to a smart phone or a cloud device. The data is processed against an existing database used to diagnose pneumonia.
The Nossal 'Smart Cable' Project	A device that transforms a simple mobile phone into capturing data from three sensing devices: oximetre, respiratory rate counter and thermometer.
The Phone Oximetre™ for Sepsis	An oximetre device and application that attaches to a smart phone and measures respiratory rate, peripheral blood flow and heart rate, facilitating diagnosis.

Source: UNICEF Pneumonia Diagnostic Workshop.

4. Pneumonia: Improving Diagnosis Workshop – Copenhagen, Jan 31st - Feb 1st, 2013

In 1Q 2013, UNICEF Supply Division hosted a two-day workshop facilitated by Frog Design Inc. focused on innovation and improving pneumonia rapid diagnostic aid devices. The workshop included the participation of WHO, The Bill and Melinda Gates Foundation (BMGF), USAID and representatives of civil society, industry and academia.

The workshop focused on building a common understanding of pneumonia diagnosis in resource-limited settings and previewed existing devices and technology. Participants also collectively defined a common operating context and platform that addresses the critical challenges faced. The group sought to define the parameters of future Target Product Profiles (TPP) to meet the short- and medium-term needs for pneumonia diagnostic device aids. To achieve this, the group agreed to create a preliminary roadmap set against a two and five year milestones. The group initially drafted an outline covering the three-year timeframe, from

February 2013 to August 2016 culminating in the development of new pneumonia diagnostic devices. The roadmap focused on addressing tools, partners, research and regulatory policy.

The workshop also defined initial criteria for the evaluation of products and devices, focusing on seven key aspects, described in the next table.

Cost	The cost effectiveness and affordability of the product
	The existence of recurring costs and rates of consumption of any consumables during the life cycle of the product
	Cost and burden to government procurement
Robustness	The duration of life cycle replacement, to be measured in years
	The recharge frequency, duration, and life span of battery cells and charger
	The need for a maintenance / care regime and recycling options
Scale / Applicability	The products ability to reach urban, rural, regional or global scale, fit and adaptability
	User context and cultural sensitivity
	Manufacturer supply capacity, scalability and sustainability
CHW Skills	Need for literacy and numeracy, to be measured in terms of high, medium or low necessity
	Need for training, to be measured in terms of minutes, hours, weeks in duration
	Familiarity with technology, to be measured in terms of whether based on analogue, mobile/smart phone or computer based technology
Accuracy / Scope	The level of sensitivity and specificity
	The level of automation, to be defined in terms of whether the device is dependent on human count, assisted count or fully automated count
	The level of decision making support, to be defined in terms of whether there is a classification, a classification to remedy, or a classification to remedy and treat
	The level of functionality, to be defined in terms of whether the device measures breaths, multiple data points or multiple data points beyond pneumonia
Credibility	The level of community trust the device inspires in how the device reads and presents the test results
Extensibility	The presence and need for hard coding
	Whether the device is a single device or provides a platform base for additional functions

These products, concepts and devices were categorised into the following classifications:

Mechanical / Manual devices	ARI Timer
	Counters
Mobile based devices	Mobile phone applications (Android/Java/Windows/IOS)
	Accessories
	Smart phone or tablet based
Automative devices	Single use / multiple uses
	Connected / not connected
Alternative devices	Counting beads

5. The Need

UNICEF looks forward to fully developed, evaluated and regulatory approved pneumonia diagnostic aid devices that offer effective simple, robust, low-tech-based solutions in accordance

with two different Target Product Profiles (TPPs). The first TPP will define devices to be fully developed over a maximum three year period (TPP3) that can:

- Be easily placed in contact with the child for the shortest time possible,
- Not distract the patient or CHW during the assisted diagnosis process,
- Measures accurately the respiratory rate,
- Provides a qualitative indicator of parameters relative to the age of the child,
- Communicates the parameters in a way that can be easily communicated to the child's parents or guardian,
- Be robust, durable and able to withstand extreme environmental conditions,
- Does not need disposables, renewables or such (e.g., electrodes, masks, mouth pieces, probes or sensors),
- Rely on renewable energy, whether through rechargeable cells or battery,
- Have a clean, but sophisticated look, adding to its credibility,
- Be of light weight, compact, easy to clean with disinfectant, water resistant and culturally acceptable.

The second forthcoming TPP will define devices to be fully developed over a possible five-year period (TPP5+) that could ideally differentiate between viral and bacterial pneumonia.

In the short term, while the process for developing new and improved pneumonia diagnostic devices in accordance with the two TPPs is on-going, UNICEF anticipates making some changes to the existing ARI Timer. Modifying the noise generated by the timer and the improvement to battery life are relatively simple and straightforward changes which can be implemented within a six-month timeframe. Additional changes, such as adding sensor or indicator lights will require a longer duration. None of these changes, however, will substitute for the need for a new and improved pneumonia diagnostic aid.

6. Proposed Steps Forward

See next page for timeline and proposed milestones.

- The document and timeline presented is a concept draft shared with partners for consultation. UNICEF invites commentary / input and discussion on the content, including the process for the development of TPPs. Some aspects of the process will be informed, developed and defined by the results and outcome of some key steps during the the process itself.
- UNICEF will be pursuing active engagement and close collaboration with partners and workshop participants to improve and guide the process and track progress.
- A consultant will be hired to review the frameworks, models and processes for TPPs during Q3 and Q4 2013.

	Q3 2013	Q4 2013	1H 2014	2H 2014	2015	2016	2017	2018	2019
Market Data	Priorities and research needs in support of product development identified	Preliminary market research data on amoxicillin and ARI Timer shared and updated annually	Market perspectives for TPP3 and TPP5+ devices shared Forecasts finalized				**TPP3** product initial uptake and evaluation		
Funds/Financing	Analysis of how currrent pneumonia diagnostics is funded	Funding source for TPP development identified Explore potential for advanced procurement contract mechanism	Final Design of TPP + "Bring-to-Market" Mechanism Funding made available for field testing and end-user consultations of selected TPP3 devices Funding made available for field testing and end-user consultations of TPP5+ concepts	Funding available for contracting, including special contracting terms as needed per mechanism.					
Products	UNICEF ARI Timer procurement specifications modified and adapted	TPP models, processes and frameworks reviewed in consultation with partners and industry Draft **TPP3** shared with partners and industry	**TPP3** Finalized Final **TPP3** launched through RfP	Response to **TPP3** results reviewed by independent evaluation committee End-user consultations **TPP3** device selection	Field test, evaluation, development & regulatory approval	**TPP3** device / products available for procurement			
			Draft **TPP5+** shared with partners and industry	Final **TPP5+** published through EoI Response to **TPP5+** EoI reviewed by independent evaluation committee **TPP5+ concepts** selected for end-user consultations	Results from end-user consultations concluded Validated **TPP5+** concepts selected	Product development	Field test Evaluation Development	**TPP5+** product/s fully developed Regulatory approval	**TPP5+** product/s available for procurement

For further questions or additional information, please contact:

Bo Strange
Project Officer
UNICEF Supply Division
+45 3527 3143
bssorensen@unicef.org

Aadrian Sullivan
Information Management Specialist
UNICEF Supply Division
+45 3527 3048
asullivan@unicef.org