INFORMAL CONSULTATION ON CLINICAL USE OF OXYGEN

Meeting report

2-3 October 2003
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The consultation was held to prepare for the writing of a manual “Clinical use of oxygen” which will give practical guidance on oxygen therapy in district hospitals in developing countries. The meeting discussed the factors that limit oxygen use, and how the quality of clinical care can be improved through appropriate clinical use of oxygen.

**Objectives of the meeting**

- To discuss the contents of a manual “Clinical use of oxygen”, which would address all relevant aspect of clinical oxygen therapy in small hospitals in developing countries.
- To develop the outline of the manual and present draft chapters, prepared by participants, for general discussion.
- To discuss research issues associated with the clinical use of oxygen, and to prepare a research agenda.

**Background**

Acute respiratory infections (ARI) cause more than two million deaths per year in children less than five years old; mostly in developing countries. Many of these deaths are associated with hypoxaemia, and oxygen therapy is life saving for many children with ARI. Previous work of the WHO Programme for the Control of Acute Respiratory Infections and the Division of Devices and Clinical Technology in WHO therefore focused on making oxygen available more easily to patients by promoting and field-testing oxygen concentrators. Concentrators have been estimated to be 25-50% more cost-effective than cylinders in resource poor settings (1), and concentrators do not have the limitations of requiring frequent transport for refilling. However, concentrators do need a continuous power supply and maintenance. Although some concentrators will run off a car battery that can be charged by solar panels, there is very limited experience in settings where a continuous mains electricity supply is not available.

To assure the quality and longevity of oxygen concentrators used in developing countries, WHO published specifications for a “WHO test schedule for oxygen concentrators” in 1991 (WHO/ARI/91.2). This resulted in the production of three models of oxygen concentrators by different companies, which conformed to these specifications. Field-testing and evaluation was conducted in trials in Egypt (2) and Malawi. However, due to mergers and the development of new models, these concentrators are no longer produced. Probably due to loss of interest in sales in developing countries, no new models were tested according to the WHO test schedule, which is rather demanding. To review the situation, in 2000, the WHO Departments of Blood safety and clinical technology (BCT) and Child and adolescent health and development (CAH) commissioned a review, and a meeting was organised in May 2001 in which currently produced concentrators were reviewed and assessed for their suitability in developing countries, although none of them had undergone testing according to the 1991 schedule. Summary information on the concentrators was made available to countries and to UNICEF on request, but has not been published.

Concerning other aspects of oxygen therapy, the ARI programme and the Department of Child Health and Development supported research studies on the recognition of hypoxaemia and on delivery methods for oxygen. This work was summarised in 1993 in the document “Oxygen therapy for acute respiratory infections in young children in developing countries” (WHO/ARI/93.28) (3). Since the publication of this monograph, considerable information has become available on the epidemiology of hypoxaemia in
children, detection of hypoxaemia by clinical means and with the use of pulse oximeters, and the safety and efficacy of oxygen delivery methods. CAH and the International Union against Tuberculosis and Lung Disease (IUATLD) organised a joint symposium at the IUATLD meeting in Madrid in 1999, where these aspects were reviewed, and published in a series of review papers in the Journal of Tuberculosis and Lung Disease.

Despite this activity in the last 15 years, there is some evidence and a general perception that systems for delivering oxygen have not been given a high priority at country programme level. An evaluation of hospital care for children in seven developing countries highlighted inadequate oxygen administration as a major factor in quality of care (4). There are several potential reasons why oxygen has been relatively neglected as a therapy in developing countries, while in developed countries it is taken for granted that oxygen is one of the most essential drugs in acute clinical care. These reasons include scepticism that oxygen is life saving, and lack of evidence that it is a cost-effective therapy (in comparison to other simple strategies for prevention and treatment of ARI, for example). Certainly the cost of oxygen is very high when it is provided using cylinders, and there has been little investment in more efficient oxygen concentrator technology. Although there is a wealth of experience in the beneficial effects of oxygen, there have not been any randomized trials.

Other WHO departments recommend use of oxygen for different conditions such as hypoxaemia at child birth, neonatal resuscitation, asthma, management of adult and adolescent lung diseases, trauma and shock due to haemorrhage.

**Epidemiology of hypoxaemia**

**Epidemiology of hypoxaemia in children**

A systematic review of the literature on the epidemiology of hypoxaemia was presented (5). This included the incidence of hypoxaemia in acute lower respiratory infection in children, and the normal ranges for oxygen saturation at varying altitudes. Evidence was presented that hypoxaemia was often more severe in acute lower respiratory infection in children at higher altitudes than in coastal settings.

In the discussion, gaps in the review were highlighted, including hypoxaemia in HIV positive children especially those with *Pneumocystis carinii* pneumonia (PCP); and hypoxaemia in children with asthma.

**Epidemiology of hypoxaemia in neonates**

Hypoxaemia is a major complication of neonatal illnesses, because of the frequency of primary respiratory disease (hyaline membrane disease, pneumonia, transient tachypnoea of the newborn) and because apnoea is a common and non-specific response to many common neonatal conditions. The incidence of hypoxaemia in referral hospitals is estimated to be up to 30-40% (6,7,8), depending on the level of pre-selection for more severe illness.

In the discussions, and in the presentation on oxygen use in obstetric care, it was emphasized that there is now good evidence that the immediate resuscitation of newborn babies with perinatal asphyxia can be done effectively with positive pressure ventilation via a self-inflating bag and mask, using room air. This does not apply to the resuscitation of older infants, children or adults, or to the acute treatment of other conditions associated with hypoxaemia, where use of oxygen (often in conjunction with positive pressure) is the international standard of care. Where oxygen is used inappropriately, such as in one country where oxygen is given to all normal babies at the time of birth, this vital therapy may be perceived as being an unnecessary expense.
Epidemiology of hypoxaemia in adults (internal medicine)

No data on the epidemiology was presented at the meeting. It was stated that, although there has been the generation of good data on the epidemiology of hypoxaemia in childhood illness over the past 15 years, including the recent findings that hypoxaemia is also seen in non-ALRI conditions, there has been less evidence of the burden of hypoxaemia in adult illness. This may be a factor in the limited advocacy of oxygen as a broad-based therapy.

Epidemiology of hypoxaemia in obstetric care

Data on the epidemiology of hypoxaemia in childbirth was not presented, but the use of oxygen in obstetric care was discussed. According to common practice, oxygen is indicated for severe complications (e.g. eclamptic status, post-haemorrhagic shock, surgery under anaesthesia; general, spinal/epidural). In many countries oxygen is given to the mother during fetal distress, while waiting for delivery of the baby (during both normal or caesarean section deliveries). There may be value in reviewing the utility of this exercise.

Epidemiology of hypoxaemia in surgical care

There were no data presented on the epidemiology of hypoxaemia in surgical patients. It was stated that hypoxaemia occurs in up to 30% of patients in the early post-operative period, so oxygen is vital for perioperative care. Hypoxaemia is likely to be a common complication in surgically ill patients at first referral level hospital; during emergency care, transportation, anaesthesia and post-operative period, and critically ill patients in the intensive care unit. The availability of oxygen is necessary for safe implementation of spinal and even apparently simple anaesthesia using ketamine. This is especially so for patients with underlying co-morbidity, including chronic respiratory disease, shock or obesity.

Availability of oxygen in district hospitals in developing countries

There is evidence of a mismatch between supply and demand of oxygen in hospitals in developing countries. Oxygen was available in the majority of teaching hospitals surveyed in the seven-country study, but less available in district hospitals. Lack of availability of systems for effective oxygen delivery was also found in a survey of 13 district hospitals in Kenya. There is evidence that while oxygen is available in some way in some wards in most hospitals, the equipment for delivering oxygen (flow meters, regulators, etc.) was less commonly available. In a survey in the United Republic of Tanzania, for example, 75% of district hospitals had an oxygen supply for less than 25% of the year (9). In Kenya only about half of the district hospitals had a triage process for administration of oxygen. Cylinders of oxygen were often shared between wards, no concentrators or oximeters were available and few hospitals had guidelines for ARI. Where doctors prescribed oxygen in the emergency departments only about 60% of children received it on the hospital wards. There were no guidelines on when to cease giving oxygen.
Experience with introduction of oxygen as part of the Child Lung Health Programme (CLHP) in Malawi

In Malawi, the International Union Against Tuberculosis and Lung Disease, in conjunction with the Ministry of Health and Population, has introduced an Integrated Child Lung Health Programme (CLHP) that was incorporated into the existing ARI/IMCI health services. Baseline data showed that oxygen was often not available, consistent with other surveys in Africa. Up to October 2003, the CLHP has provided 16 DeVilbiss 515KS oxygen concentrators with flow-splitters, appropriate spares and supplies necessary for providing oxygen therapy. Another eight concentrators will be installed by the beginning of 2004, covering all 24 district hospital paediatric wards. The 16 districts have set up either a separate “intensive care” room or an area where the oxygen concentrator is located in the “acute side” of the paediatric ward set aside for severely ill children. Some districts have set up four individual cots for children receiving oxygen, which should decrease cross-infection significantly. Five-day workshops on installation, use, and maintenance of oxygen concentrators have been conducted for biomedical engineers from each of the three central hospitals, anaesthetic clinical officers (ACO) and senior state registered nurses (SRN) working in paediatrics. The workshop consisted of presentations, a video, and practical sessions on how to use and maintain the oxygen concentrator and flow-splitters. A reference manual “Oxygen therapy for acute respiratory infections in young children in emergent countries with an oxygen concentrator” was prepared. Practical sessions demonstrated the correct installation of the concentrator on the paediatric ward. The biomedical engineers from each of the three central hospitals carry out regular maintenance visits.

Oxygen sources

Oxygen concentrators

Since the concentrator specifications were first designed in the early 1990s there has been limited commitment from manufacturers to supplying machines appropriate for developing countries. This is partly because of the large market in rich countries for oxygen concentrators for individuals (mostly the elderly, but some ex-preterm newborns) who have chronic lung disease and chronic hypoxaemia. However, there is now a small range of models that are consistent with WHO specifications for district hospitals. These have flow rates of 5-8 litres per minute. Getting companies to routinely manufacture appropriate flow-splitters (necessary for delivery of oxygen to more than one child) has been a challenge, but these are now available in at least two models on the market, and the cost for this attachment is now less than when flow-splitters need to be manufactured as a special item.

One of the higher flow rate models has two main outlets, allowing eight patients at any time to receive oxygen at 1 litre per minute (using two four-way flow splitters). Flow models of 8 litres were designed for nebulizing beta-2 agonist bronchodilators (e.g. salbutamol) for patients with asthma, but these models may be useful in hospitals where eight patients can be nursed in a high-dependency area.

Some oxygen concentrators have sufficiently high flows (up to 700 litres per minute) to service the needs of an entire hospital, and there has been experience from Canada, Kyrgyzstan, Zambia and other countries where these have been installed and run successfully. The equipment and installation costs of such systems are considerable and likely to be
beyond the reach of most district hospitals in developing countries. However, the principle is not well recognised that oxygen concentrators are now clearly shown to be the most cost-effective method of delivering oxygen, and that the technology is flexible to suit particular needs. Evidence of this is that most countries still buy oxygen in cylinders.

### Indications for oxygen therapy

#### Clinical signs of hypoxaemia in neonates

Recent studies in India, Papua New Guinea and the WHO Young Infant Study have characterized the clinical signs predicting hypoxaemia in young infants (6,7,8). It was proposed that the following would be recommended indications for oxygen delivery:

- Where oxygen supplies are ample and oximetry is not available, oxygen should be given to all neonates who have RR>60 or cyanosis or are too sick to feed. Where supplies are limited, oxygen may need to be restricted to newborns with a RR>60 and cyanosis, as inability to feed is a non-specific sign.
- Where pulse oximetry is available, oxygen should be given to all neonates who have an SpO₂<90%. It was recognized that this threshold may need to be adjusted in settings where oxygen supplies are limited and at higher altitudes where normal values for SpO₂ are lower than at sea-level.

#### Clinical signs for hypoxaemia in children

The published studies that have explored the relationship between individual clinical signs and hypoxaemia have recently been reviewed (10). Summarising the evidence presented in this literature is difficult because different thresholds for defining hypoxaemia have been used (often to adjust for the independent effect of high altitude) and often different groups of signs have been evaluated. In many cases studies were limited to children with severe acute respiratory tract infection, however, oxygen may also be required in the management of children with severe or prolonged convulsions, shock of any cause (including severe sepsis and trauma) and severe anaemia complicated by respiratory distress.

- As for young infants, it was suggested that at low altitudes hypoxaemia be considered present if SpO₂ was < 90%. Where these measurements are possible and where oxygen supplies are adequate, this threshold should therefore be used to initiate and stop oxygen therapy. The optimum definition of hypoxaemia at high altitude remains uncertain. However, one uncontrolled study at 1600m has shown that using an SpO₂ of 85% as a threshold for giving supplemental oxygen resulted in a 40% lower mortality than when clinical signs alone were used (11). This does not imply that there would not be a greater survival from using a higher threshold, but that above 1500m a SpO₂ threshold of 85% may be safe.

In many hospitals in low-income countries pulse oximetry is not available and oxygen supplies are scarce. It was suggested therefore that the clinical indications for oxygen be prioritized on the basis of their observed association with true hypoxaemia and/or the clinical severity of the condition. All inpatient children, not just those with ARI, are to be considered.

#### Clinical signs for hypoxaemia in adults

There was no presentation made on clinical signs of hypoxaemia in adults.
Pulse oximetry

Oximetry was first developed in the USA to monitor pilots flying at high altitude. It is the most accurate non-invasive method for the detection of hypoxaemia, but experience in developing countries is limited. Most of the available data on the use of pulse oximetry in developing countries has been generated by hypoxaemia epidemiology studies in Gambia, Kenya, Malawi, South America and Papua New Guinea (7,11-19). There is much less evidence of impact and cost-effectiveness, and consequently there is uncertainty whether, and at what level of hospital, this technology is appropriate. There is some evidence from Papua New Guinea that pulse oximetry, when combined with ample oxygen supply, can reduce case fatality rates from severe pneumonia by up to 40%, but this study was a before and after comparison in a highly supervised atypical setting, and could not be completely controlled for severity of illness and other confounding (11). Nonetheless, pulse oximetry may overcome the limitations in predictive power of clinical signs. Because of cost savings that would occur from not using oxygen in children without hypoxaemia (but who would be given oxygen based on clinical signs), oximetry may be a cost-effective intervention in some district hospitals. There is a need for further studies of the use of pulse oximetry in developing countries, particularly evaluating impact and cost-effectiveness. There is a need to describe ideal specifications for pulse oximeters that are appropriate for small and medium-sized hospitals in developing countries, and to explore their full range of uses.

Use of blood gas analysis

Because of the cost of doing blood gases and maintaining the necessary analyser, doing blood gas analysis was considered not to be a cost-effective analysis for small hospitals. It was generally agreed that in the absence of mechanical ventilators, there was limited use in obtaining paCO₂ measurements; that oxygen saturation can be more cheaply and non-invasively obtained with a pulse oximeter; and in most cases SaO₂ is a practical and sufficient surrogate for partial pressure of arterial oxygen (paO₂).

Methods of oxygen delivery and humidification

Over the last 10 years there has been considerable generation of information on methods of oxygen delivery and humidification needs and effectiveness in tropical environments. Humidification is considered unnecessary for nasal prongs and nasal catheters, but is necessary when using nasopharyngeal catheters. There was a general agreement that where nasal prongs can be afforded, they are the preferred method of delivery as they are well tolerated, have a low complication rate, and do not require humidification. Nasal catheters have a role where prongs are not available. Nasopharyngeal catheters (NP) supply higher concentrations of oxygen and greater positive end-expiratory pressure (PEEP) at a given flow rate than nasal prongs or catheters (20), but because of a higher complication rate (21), NP catheter use should be limited to where nasal prongs are unavailable, where staff are familiar with insertion techniques, where oxygen is in limited supply, or in an individual patient where cyanosis or oxygen desaturation is not relieved by nasal prongs or nasal catheter. Simple flow continuous positive airways pressure (CPAP) devices for neonates with apnoea and for severe respiratory infections were discussed, but considered to be too complicated for many settings, and would require trials first.
Concerning oxygen delivery methods in different age groups, it was considered that the same methods can be used for neonates, infants and children, discouraging the use of head boxes or incubator oxygen as being wasteful and potentially harmful. No statements were made on the uses of particular methods in adults, but nasal prongs were considered to be the most widely used methodology, which is most acceptable to adults.

**Oxygen delivery to surgical patients**
A recent WHO publication (Surgical Care at the District Hospital) (9) gives guidance on the safe use, supply, equipment and maintenance of oxygen. This training manual has emphasized the importance of oxygen as an essential therapy to patients requiring surgical procedures in trauma, obstetrics, orthopaedic, general surgery, resuscitation and emergency care, who should have access where needed.

**Recommendations**

**Updated technical resources**

A technical publication “Clinical use of oxygen” should be produced. This will involve an update to the 1993 WHO manual on the use of oxygen in children with ALRI. It will include the following topics for which considerable new information has been generated in the last 10 years, and topics that were beyond the scope of the 1993 publication:

- Updated information on the epidemiology of hypoxaemia in children.
- Updated information on hypoxaemia in adults in surgical, obstetric and internal medical care, and on co-existing conditions (e.g respiratory) and acute care.
- Expanded information on neonatal hypoxaemia.
- Prevalence of hypoxaemia in asthma (adults and children).
- A definition of hypoxaemia at various altitudes.
- Updated description on the role of humidification.
- Updated information on oxygen sources and equipment, particularly on the types of oxygen concentrators available, and experience in countries where concentrators have been used. Types of flow meters: orifice and floating ball.
- A description of pulse oximetry and how it can be used to screen patients for hypoxaemia, to monitor patients receiving oxygen and to decide when to cease oxygen.
- Details of the Malawi “kit” used in the Lung Health Project: this details all the attachments and spare parts that are necessary when using concentrators.
- Appropriate and safe use of oxygen: flow charts or simple protocols for how to administer oxygen. An appendix could include “how-to-do-it” charts that could be photocopied to put up on the wall of health facilities.
- Chapter on the organization of oxygen therapy at health facilities, including training of staff (clinical and technical); maintenance, spares/supplies, central organization across the health facility.
- Guidance for policy makers (description of a ministry of health, hospital administrators) to improve oxygen systems as part of a general quality of hospital care initiative.

The aim would be to write most of the manual aiming at the health-care provider such as at the clinical officer level, and add summary charts. There would be specific administration/organization sections of the manual that are aimed at hospital administrators or ministry of health officials. To facilitate this project the participants at the meeting agreed to write sections of this book relating to their areas of expertise and interest. It is
aimed that the draft sections will be complete by the end of the year, and a further consultation meeting will be held in about six months time to finalize contributions.

**Preparation of revised specifications for oxygen concentrators**

Mr David Peel has maintained a detailed observational record over the shifting market, and will compile an updated list of specifications matched to available models. This will also include surge protectors, necessary for the protection of equipment in developing countries.

**Preparation of specifications for pulse oximeters**

A list of requirements was drawn up and discussed during the meeting. These included:

- **Size.** There are various sizes that are appropriate for district hospitals: from very small hand-held devices to machines about the size of a small portable laptop computer. Although the very small hand-held machines are cheaper than the larger portable models, the battery life of hand-held machines is shorter and there may be a greater risk of theft from hospital wards than with larger devices.

- Although some SpO$_2$ monitors can also measure other physiological parameters such as blood pressure and the electrocardiograph, the simpler machines monitoring SpO$_2$ and heart rate have fewer attachments that need replacing over time, require much less training to use and are much less expensive.

- Oximeters should have robust hard plastic casing, and be resistant to knocks and vibration. Oximeter technology functions well at high altitudes; most also function well in humid and hot environments.

- **Re-chargeable internal battery** with a life of 6-12 hours, and an AC power adapter.

- **Visible plethysmographic wave**, or another graphical display of the pulse wave detected by the digital probe. This is useful for health workers to ascertain the accuracy of the SpO$_2$ measurement, but if an oximeter does not have such a plethysmographic display, the heart rate displayed by the oximeter should be checked with the patient’s pulse to ensure the reading is accurate.

- **Digital probes.** There is a wide range of digital probes available. Some are disposable, but can be re-used on several patients over a week or more until the light signal fades, but they are difficult to clean and adhesive wears off after a few uses. There are several types of longer life digital probes that are more expensive; for adults there are hard plastic probes, but these will not attach well to infants or children. The most ideal probes for a wide range of patient ages and sizes are peg-type devices with soft rubber coating or ‘shoes’. Because the probe casing is soft they will mould to the digits of neonates, older children or adults. For neonates these soft digital probes can be attached to the foot or hand. It is important always to have a spare probe on hand in case one fails.

- **Alarms.** An adjustable in-built lower saturation alarm is included in all models. A high saturation alarm is useful if there is a need to limit the oxygen saturation achieved by administered oxygen, such as when managing very premature neonates, to avoid the risks of retinopathy (eye damage). A low battery alarm is essential to alert health workers when the machine needs to be plugged into the AC mains.
Market research based on generic specification leading to a list of manufacturers and (internet) details of available machines (concentrators, oximeters and oxygen delivery attachments)

There is a need to provide potential users (hospitals, ministries of health, etc) with enough information to purchase equipment that is appropriate to their needs and budgets. After the specifications have been finalized, the UNICEF supplies section will investigate costs within the industry. Because nasal prongs are preferable to nasopharyngeal or nasal catheters for most children and adults requiring oxygen (in terms of lower complication rates and better patient comfort, and there is no requirement for humidification compared to NP catheters), there is a need to investigate manufacturers who will supply these in bulk at comparable cost to oxygen catheters or feeding tubes. At present the much greater cost of nasal prongs limits their availability in most developing countries. The use of nasal prongs might overcome some parental resistance and health worker fear of oxygen that partly results from the unease about inserting a catheter in a sick child.

Evaluation of true costs, impact and cost-effectiveness of oxygen delivery systems: a demonstration project

There is a need for further documentation of the introduction of systems of oxygen delivery. Published accounts of country experience of implementation, and what has been required to sustain working systems would be informative. There are a few countries that have reported short-term experience with setting up systems, but no reports of overall costs, long-term requirements for sustainability, etc.

One or several demonstration projects should carefully evaluate impact and cost-effectiveness. A multi-country project would have greatest potential for generalizability and greatest impact on policy. It would not be ethical or acceptable to randomize children or hospitals to receive oxygen or not. However, there are clearly problems with pre-and post comparisons, as case fatality rates varies greatly from year to year, so retrospective controls can only be used if details are available about the severity of disease. An ethical alternative would be a step-wedge design where hospitals progressively receive an improved oxygen system. This would also be a practical approach as the experience of implementation in one hospital could be used to improve the implementation in the next, and so on. A pre-and post-comparison could be done (of case fatality rates for severe pneumonia), plus contemporaneous comparison between hospitals (some of which would have implemented the system and some which would do so later) would help control for confounding. Such studies should also evaluate feasibility, acceptability, sustainability and ‘cost-effectiveness’. The latter could include both the estimated cost per life saved of the oxygen delivery system and a cost comparison between delivering oxygen by concentrators with what would be required to administer the same amount of oxygen by cylinders.

Other research issues

As part of the demonstration project there is a need for evidence of impact and cost-effectiveness, and the true costs of setting up and maintaining various oxygen delivery systems in developing country settings. It would be useful to have more published accounts of country experience of implementation of their oxygen delivery programmes.

In the absence of RCTs, before/after studies assessing the impact of providing oxygen, coupled with cost-effectiveness assessments would be ethically sound.
Follow-up meeting

After the drafting of various chapters for the oxygen manual, it would be useful to hold another meeting to finalize drafts and their contents. This could be held in Geneva. Alternatively a meeting in Egypt, where the largest experience of using concentrators was documented a decade ago, might be valuable. Obtaining some follow-up information about sustainability would also be important.

Session on oxygen at IUATLD meeting

It was proposed that there be a session on oxygen at the annual IUATDL meeting in Paris in November 2004. Penny Enarson (IUATLD) will consider and coordinate this.

Not another vertical intervention

Oxygen should not be seen as another vertical intervention for ARI. Quite the contrary, promotion and implementation of oxygen systems could be a vehicle for improving quality of care in district hospitals. Thus oxygen delivery systems should be part of larger quality systems (e.g. in-patient care) and be broad-based, servicing the needs of all acute care disciplines and all ages. Indeed, receiving appropriate oxygen therapy might be a key indicator of quality of hospital care. There is a need for advocacy in this area, perhaps presentations at national paediatric conferences and conferences in other disciplines such as emergency, trauma, surgery, obstetrics and intensive care. This might be an issue that the International Paediatric Association could take up.


Agenda

DAY 1

9:00-9:15  Introduction  Martin Weber (CAH)
Objectives of the meeting  Meena Cherian (EHT)
Introduction of participants

9:15-9:30  Epidemiology and burden of hypoxaemia in child health  Juan Lozano

9:30-9:45  Epidemiology and burden of hypoxaemia in neonatal care  Trevor Duke

9:45-10:00  Epidemiology and burden of hypoxaemia in Internal medicine  NCD/IMAI

10:00-10:15  Epidemiology and burden of hypoxaemia in obstetric care  Luc de Bernis (RHR)

10:15-10:30  Epidemiology and burden of hypoxaemia in surgical care  Meena Cherian (EHT)

10:30-10:45  Coffee

10:45-11:15  Discussion of epidemiology

11:15-11:30  Availability or oxygen in district hospitals: review of experience  Mike English

11:30-12:00  Oxygen concentrators in Malawi: the IUATLD project  Penny Enarson
Oxygen sources
Concentrators
Cylinders
Central sources

12:00-12:30  Discussion

12:30-13:30  Lunch

13:30-13:45  Humidification of oxygen  Martin Weber (CAH)

13:45-14:00  Discussion
14:00-14:15  Indications for oxygen therapy and detection of hypoxaemia by clinical means in neonates  Trevor Duke

14:15-14:30  Discussion

14:30-14:45  Indications for oxygen therapy and detection of hypoxaemia by clinical means in children  Mike English

14:45-15:00  Discussion

15:00-15:15  Indications for oxygen therapy and detection of hypoxaemia by clinical means in adults  IMAI/NCD

15:15-15:30  Discussion

15:30-15:45  Tea

15:45-16:00  Use of pulse oximeters for the detection of hypoxaemia in developing countries  Mark Steinhoff

16:00-16:15  Discussion

16:15-16:30  Use of blood gas analysis in developing countries  Mike English

16:30-16:45  Discussion

16:45-17:00  Summary of the day  Harry Campbell

DAY 2

9:00-9:30  Oxygen delivery methods  Lulu Muhe

Nasal prongs
Nasal and oral catheters
Naso- and oropharyngeal catheters
Face masks
Head boxes, incubators and tents

9:30-10:00  Discussion of specific recommendations for delivery methods for neonates  Jelka Zupan (RHR)

Special issues: Apnoea and CPAP

10:00-10:30  Discussion of specific recommendations for delivery methods for children  Martin Weber/Lulu Muhe

10:30-10:45  Coffee
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<th>Activity</th>
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<tr>
<td>10:45-11:15</td>
<td>Discussion of specific recommendations for delivery methods for adults</td>
<td>RHR/NCD/IMAI</td>
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<td>11:15-12:00</td>
<td>Discussion of missing areas</td>
<td>Harry Campbell</td>
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<td>12:00-13:00</td>
<td>Lunch</td>
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<td>13:00-14:00</td>
<td>Discussion of further procedure, finalisation of chapters</td>
<td>Harry Campbell</td>
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<td>14:00-15:00</td>
<td>Introduction and promotion of the manual</td>
<td>Harry Campbell/Trevor Duke</td>
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List of participants

Dr Harry Campbell  Edinburgh, Scotland
Dr Trevor Duke  Melbourne, Australia
Dr Mike English  Kilifi, Kenya
Dr Juan Lozano  Bogota, Colombia
Dr Mark Steinhoff  Baltimore, USA
Mr David Peel  UK

UNICEF
Dr Monique Supiot, Unicef Supply Division, Copenhagen

IUATLD
Penny Enarson, Paris, France

Secretariat
Dr Luc de Bernis, RHR (unable to attend)
Dr Meena Cherian, EHT
Dr Thomas Cherian, IVB
Dr Rita Kabra, RHR
Dr Lulu Muhe, CAH
Dr Shamim Qazi, CAH
Dr Robert Scherpbie, CAH
Dr Martin Weber, CAH
Dr Jelka Zupan, RHR
Draft table of contents for the book "Clinical use of oxygen"

Epidemiology and burden of hypoxaemia

Child health
  Acute respiratory infections
  Neonatal care

Internal medicine

Obstetric care

Surgery and anaesthesia

Trauma

Oxygen sources
  Concentrators
  Cylinders
  Central sources

Humidification of oxygen

Indications for oxygen therapy and detection of hypoxaemia
  By clinical means
    In neonates
    In children
    In adults
  By pulse oximeters
  By blood gas analysis

Oxygen delivery methods
  Nasal prongs
  Nasal and oral catheters
  Naso- and oropharyngeal catheters
  Face masks
  Head boxes, incubators and tents

Specific recommendations for delivery methods by group of patients
  Neonates
  Children
  Adults

Appendices:
  annotated list of oxygen concentrators
  annotated list of pulse oximeters
  outline of oxygen delivery and organization of care in a hospital, including maintenance and technical issues
  list of parts and spare parts required for oxygen delivery in a hospital ward
  sample flow charts and protocols for oxygen delivery and monitoring
  description of how a Ministry of Health might improve oxygen systems as part of a general quality of hospital care initiative
For further information please contact:

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