

Oxygen for treatment of severe pneumonia in The Gambia, West Africa: a situational analysis

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SUMMARY

SETTING: Health facilities in The Gambia, West Africa.

OBJECTIVES: Oxygen treatment is vital in pneumonia, the leading cause of death in children globally. There are shortages of oxygen in developing countries, but little information is available on the extent of the problem. We assessed national oxygen availability and use in The Gambia, a sub-Saharan African country.

METHODS: A government-led team visited 12 health facilities in The Gambia. A modified World Health Organization assessment tool was used to determine oxygen requirements, current provision and capacity to support effective oxygen use.

RESULTS: Eleven of the 12 facilities managed severe pneumonia. Oxygen was reliable in three facilities. Requirement and supply were often mismatched. Both ox-

xygen concentrators and oxygen cylinders were used. Suboptimal electricity and maintenance made using concentrators difficult, while logistical problems and cost hampered cylinder use. Children were usually triaged by trained nurses who reported lack of training in oxygen use. Oxygen was given typically by nasal prongs; pulse oximetry was available in two facilities.

CONCLUSIONS: National data showed that oxygen availability did not meet needs in most Gambian health facilities. Remedial options must be carefully assessed for real costs, reliability and site-by-site usability. Training is needed to support oxygen use and equipment maintenance.

KEY WORDS: oxygen; pneumonia; Gambia; Africa; children; health service

PNEUMONIA is a leading cause of death in young children worldwide and in The Gambia.¹⁻³ Case management of pneumonia is a key component of the World Health Organization (WHO) Integrated Management of Childhood Illness (IMCI) strategy and will remain integral to the achievement of the fourth United Nations Millennium Development Goal of reducing under-5 mortality by two thirds by 2015.⁴ WHO guidelines for the management of pneumonia include appropriate use of oxygen as well as antibiotic treatment and general supportive care.

Little is known about the nature and extent of oxygen shortages in developing countries, and data are needed on which to base interventions to improve this key aspect of treatment.^{5,6} Here we report the findings of an assessment of oxygen availability in Gambian health facilities, anecdotally reported to have shortages, undertaken as part of a project to support improvements in oxygen provision for children in government health facilities in this sub-Saharan African

country. We assessed oxygen requirements, the reliability and source of oxygen supplies and approaches to child assessment and oxygen treatment.

STUDY POPULATION AND METHODS

The Gambian public health care delivery system comprises central referral hospitals, basic care facilities ('major' and 'minor' health centres) and village-based services.⁷ The country is divided administratively into divisions, and most health facilities are administered by the local Divisional Health Team. The Gambia is geographically long and narrow, extending 400 km inland from the West African coast along the Gambia River, and has a population of 1.4 million, over 40% of which is aged <15 years (2003 census).⁸

An assessment team visited every government hospital ($n = 5$) and major health centre ($n = 7$) in The Gambia during September and October 2004 (Figure). The team included the acting head of The Gambia's

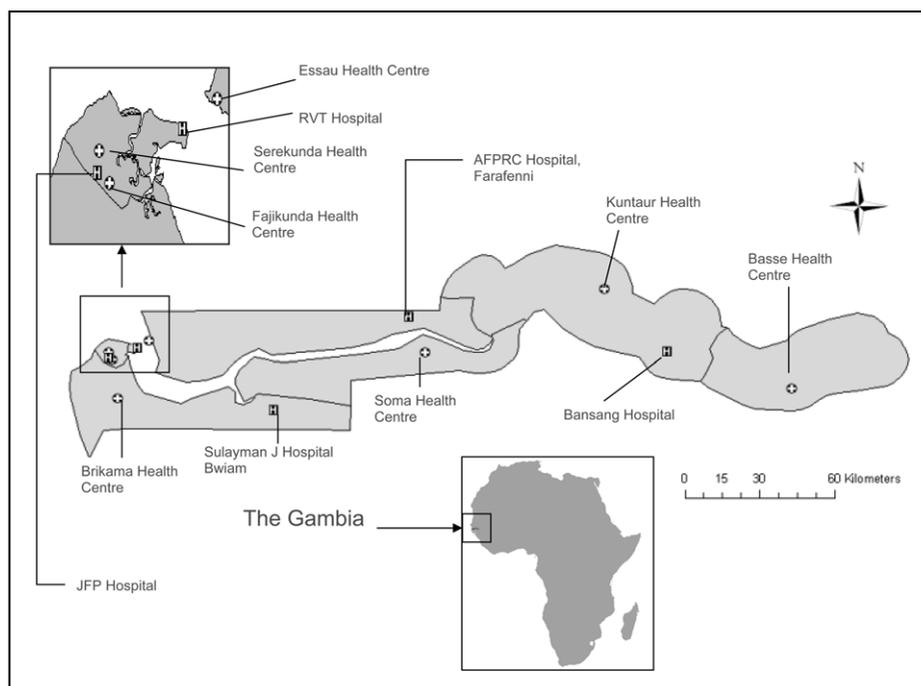


Figure Map of The Gambia showing the location of its public hospitals and major health centres.

IMCI Programme, a registered nurse and a public health physician; a member of the local Divisional Health Team joined the team wherever possible. Information was collected from records, interviews with health care workers and direct observation. The assessment used a standardised questionnaire adapted for this project from a broader-based health facility assessment tool developed by the WHO.⁹ The questionnaire contained 133 questions covering patient numbers, all aspects of oxygen supply and treatment, and other factors relevant to the management of sick children, including staffing, training and patient flows. A questionnaire was usually filled out by each team member, and answers compared for concordance, with discrepancies resolved by consensus. In all cases three or four team members were present, and in most cases a corresponding number of questionnaires were completed; for every facility a minimum of two questionnaires were completed.

To estimate the relative oxygen requirements of each facility, data from in-patient registers were collected on the total number of all-cause admissions and acute respiratory infection (ARI) admissions for children aged <5 years. In most facilities, these data had been collated by staff prior to the assessment visit. Where they had not been collated, the assessment team reviewed the in-patient register and collated the data themselves. ARI was defined as any recorded diagnosis of 'ARI', 'acute lower respiratory infection (ALRI)' or 'pneumonia'. Data were collected for a full 12-month period where available, and where they were collected over a shorter period (one site), numbers were extrapolated to give a 12-month estimate. The

comparative case loads were examined, and relative requirements were categorised as 'high', 'moderate' and 'low' (see Table 1 for category definitions).

Ethical approval for the study was given by the Gambia Government–Medical Research Council Joint Ethics Committee.

RESULTS

ARI case load and oxygen requirements

The admission load of each health facility, the bed capacity and relative oxygen requirements are summarised in Table 1. All facilities recorded fatalities from ARI; the case fatality rates of the hospitals were between 5% and 10% (except Sulayman Junkung Hospital at <5%), while the major health centres had rates of <5%, with the exception of Basse (12%) and Soma (6%).

Oxygen availability and support

Oxygen was currently available, or had been available within the previous year, in 6 of 12 health facilities, including all four in-patient hospitals and two major health centres (Table 2). The Royal Victoria Teaching Hospital (RVTH), the largest facility and one with good reliability of supply, used around 150 oxygen cylinders per month in 2004 (each containing 6000 litres), of which 100 were used for children.

Facilities used a mixture of cylinders and concentrators to supply oxygen. The RVTH and Basse Health Centre relied solely on cylinders, while Sulayman Junkung Hospital, Bwiam and Essau Health Centre each relied on a single oxygen concentrator. Armed Forces

Table 1 Total and ARI 12-month caseload (children aged <5 years), paediatric beds and oxygen requirement

	Total under-5 admissions	ARI under-5 admissions n (%)	Number of paediatric beds	Oxygen requirement*
Hospitals				
Royal Victoria Teaching Hospital, Banjul	6303	653 (10)	115	High
JFP Hospital, Bundung†	—	—	—	—
Sulayman Junkung Hospital, Bwiam	299	46 (15)	12	Low
AFPRC Hospital, Farafenni‡	1100	142 (13)	29	Moderate
Bansang Hospital, Bansang	1920	564 (29)	43	High
Major health centres				
Serekunda	1671	519 (31)	16§	High
Fajikunda	975	303 (31)	12	Moderate
Brikama	2646	365 (14)	23	High
Essau	1213	169 (14)	10	Moderate
Soma	1455	153 (11)	20	Moderate
Kuntaur	225	78 (35)	8	Low
Basse	556	100 (18)	25¶	Moderate

* High = annual all-cause under-5 admissions > 1500 or annual ARI under-5 admissions > 500; moderate = all-cause 500–1500 or ARI 100–500; low = all-cause < 500 or ARI < 100.

† JFP Hospital had no in-patients at the time of the study (patients requiring further treatment being referred on to another facility).

‡ ARI admissions at Farafenni are for 0–14-year olds (all other facilities 0–4-year olds only) and data from March to August 2004 (6 months) have been doubled to give a 12-month estimate.

§ Sixteen beds but no separate paediatric beds.

¶ Twenty-five beds but no separate paediatric beds.

ARI = acute respiratory infection; JFP = Jammeh Foundation for Peace; AFPRC = Armed Forces Provisional Ruling Council.

Provisional Ruling Council (AFPRC) and Bansang Hospitals used a combination of cylinders and concentrators. In addition to seven functioning oxygen concentrators seen during the assessment, a further 28 non-functioning concentrators were seen, 21 of these at RVTH, the details of which have been re-

ported previously.¹⁰ The most common functioning model was the DeVilbiss 515 (DeVilbiss Healthcare, Somerset, PA, USA; five units with duration of use ranging from 3 months to 4 years), while the commonest non-functioning model was the DeVilbiss MC-44 (18 units).

Table 2 Oxygen availability, source and reliability of supply in Gambian health facilities

Facility	Oxygen requirement	Oxygen available?	Oxygen source(s)		Reliability of supply*
			Cylinders	Concentrators	
Hospitals					
Royal Victoria Teaching Hospital, Banjul	High	✓	✓	—	Good
JFP Hospital, Bundung†	—	—	—	—	—
Sulayman Junkung Hospital, Bwiam	Low	✓	—	✓	Good
AFPRC Hospital, Farafenni‡	Moderate	✓	✓	✓	Fair
Bansang Hospital, Bansang	High	✓	✓	✓	Excellent
Major health centres					
Serekunda	High	x	—	—	None
Fajikunda	Moderate	x	—	—	None
Brikama	High	x	—	—	None
Essau	Moderate	✓	✓§	✓	Fair
Soma	Moderate	x	—	—	None
Kuntaur	Low	x	—	—	None
Basse	Moderate	✓§	✓§	—	Poor

* Excellent = 24-h supply; good = oxygen available at most times but with occasional interruptions or requires movement of equipment; fair = oxygen available only at some times of day (e.g., when generator is on); poor = oxygen not available at time of assessment visit.

† JFP Hospital had no in-patients at the time of the study (patients requiring further treatment were referred on to another facility).

‡ ARI admissions at Farafenni are for 0–14-year-olds (all other facilities 0–4-year-olds only) and data from March to August 2004 (6 months) have been doubled to give a 12-month estimate.

§ Cylinders usually used as a source of oxygen but currently empty.

ARI = acute respiratory infection; JFP = Jammeh Foundation for Peace; AFPRC = Armed Forces Provisional Ruling Council.

Table 3 Availability and source of electricity at 12 health facilities in The Gambia

Facility	Main electricity source		Electricity availability, per 24 h
	Electricity utility company	Generator	
Hospitals			
Royal Victoria Teaching Hospital, Banjul	✓	SS	24
JFP Hospital, Bundung*	✓		20–23
Sulayman Junkung Hospital, Bwiam		✓	4–11
AFPRC Hospital, Farafenni†	SS	✓	4–11
Bansang Hospital, Bansang	SS	✓	12–19
Major health centres			
Serekunda	✓	SS	4–11
Fajikunda	✓		4–11
Brikama	✓	SS	12–19
Essau		✓	4–11
Soma	✓		4–11
Kuntaur		✓	4–11
Basse		✓	24

* JFP Hospital had no in-patients at the time of the study (patients requiring further treatment were referred on to another facility).

† ARI admissions at Farafenni are for 0–14-year-olds (all other facilities 0–4-year-olds only) and data from March to August 2004 (6 months) have been doubled to give a 12-month estimate.

SS = secondary source also available; JFP = Jammeh Foundation for Peace; AFPRC = Armed Forces Provisional Ruling Council; ARI = acute respiratory infection.

Of those facilities with oxygen concentrators, none had trained maintenance staff, and none were able to service their concentrator units. Nursing staff in two of the four facilities had carried out basic maintenance and repairs (including one paediatric nurse who had repaired a broken humidifier). Maintenance staff in one facility had replaced a broken electric socket on a concentrator unit.

Table 3 summarises the availability of electricity for running concentrators at the 12 facilities. Three health facilities had electricity for 24 h or nearly 24 h per day, while the majority (7/12) had electricity for less than 12 h per day. Of those relying on the national grid as their main source (6/12), half ($n = 3$) had ≥ 12 h of electricity per day. Only two of six facilities relying mainly on generators had power for ≥ 12 h per day, and in one of these the supply was maintained by a donor. All seven major health centres had solar panels to supply a vaccine refrigerator, as part of the Expanded Programme of Immunization (EPI). In all cases, solar power was used solely for this purpose, and was not sufficient to contribute to the facility's overall power capacity.

User perspectives on oxygen supply options

Cylinders were regarded by most interviewees as reasonably simple to operate but awkward to move, prone to running out without warning and difficult to maintain reliable resupplies of. There was generally less familiarity with operating oxygen concentrators, with notable exceptions, although they were regarded

as being easier to move around, and with the advantage that they did not have the same resupply issues as cylinders. The need for a continuous power supply was regarded as a problem, as was their vulnerability to breakdowns. Both cylinders and concentrators were regarded as expensive.

Child assessment and oxygen administration

In the majority of the health facilities, the first point of contact for children presenting to the facility was the out-patient department or the maternal-child health clinic. The first person to assess the sick child was usually a trained nurse, although in some cases an auxiliary nurse did this. In many facilities, nurses were also responsible for the diagnosis and initial treatment of sick children, although doctors also fulfilled this role. Staff shortages were reported in all facilities.

All six facilities that administered oxygen did so using nasal prongs, while four facilities also used face masks (usually in an emergency situation or for severely ill children). Only one facility split the oxygen flow between more than one patient; this was improvised using a three-way tap.

The typical flow rates of oxygen given to children in these health facilities ranged from 0.5 to 3 l/min. No staff reported having received training in the administration of oxygen. Four of the 12 health facilities had visible guidelines for the diagnosis and management of ARI. None of the six facilities with oxygen had specific guidelines for its administration. Pulse oximetry for the measurement of oxygen saturation was available in the children's ward in two facilities, both of which were referral hospitals.

DISCUSSION

This study shows that all 12 hospitals and major health centres in The Gambia treated children with severe ARI. Oxygen was available at least some of the time in half of the Gambian health facilities. Only three of the 12 facilities had 'excellent' or 'good' reliability. The correspondence between the supply available at a facility and its apparent requirements was limited. While hospitals were more likely to have oxygen than major health centres, larger health centres had in-patient loads comparable to hospitals (with the exception of RVTH). These results provide a foundation for health service planning for oxygen provision in The Gambia and provide national data from a sub-Saharan African country.

A number of reasons for the gap in provision are likely, one of which is expense. Cylinder oxygen is expensive to produce, and the capital costs of concentrators are considerable. One locally produced 6000 l cylinder of oxygen, which will supply one child 2 l/min of oxygen for around 2 days, costs US\$38, which is equivalent to a cost of around US\$7000 to treat one child at a time continuously for a year. Oxygen con-

concentrators cost in the order of US\$1000–2000, a formidable sum for most health services despite the relatively low running costs thereafter.

Logistical issues are especially important where access to the cylinder supplier is hampered by difficulties with transportation, as in The Gambia. The intermittent nature of the power supply, typical in Gambian facilities, is a major hindrance to the use of oxygen concentrators, as is the lack of capacity to maintain equipment.¹⁰

Most facilities with oxygen relied on a combination of concentrators and cylinders, the exception being RVTH, the sole tertiary referral hospital, and Basse Health Centre, which relied on cylinders alone. The high number of non-functioning oxygen concentrators observed during the assessment highlights the challenges of applying technology successfully in this setting. We recently reported a case study of 21 broken-down concentrators at RVTH, and this wider health facility assessment confirmed that it is a nationwide issue.¹⁰ Nevertheless, oxygen concentrators can be an appropriate technology for this kind of setting, as the examples of their successful use here and elsewhere attest.^{11,12} In addition to a good power supply and maintenance capacity, another important barrier to their success is the reliability of the units. None of the units observed in this assessment, functioning or non-functioning, met current WHO standards for oxygen concentrators, while there are models available now that do.¹³ Although no publications have reported on the reliability and sustainability of oxygen concentrators in significant numbers in the field, we are aware that the WHO is evaluating programmes in Malawi and Papua New Guinea that have used oxygen concentrators for several years to obtain data on sustainability using the same tool as that reported in this paper (David Peel, personal communication).

The ability to use available oxygen effectively in the treatment of patients depends on appropriately trained and equipped staff instituting care for the hypoxaemic patient without delay. It is encouraging that trained nurses are typically the first point of contact for sick children in Gambian facilities, and notable that the decision to give oxygen may be made by a nurse or a doctor. Nevertheless, these staff members felt the need for training in oxygen administration, under-lining the importance of in-service training to maintain knowledge, skill and morale. The wider availability of pulse oximetry may also facilitate better use of the oxygen available by allowing reliable detection of hypoxaemic children.^{14,15}

Nasal prongs, the WHO-recommended delivery method, was the method of choice in Gambian health facilities. Appropriate flow-splitters, which allow oxygen from one source to be given to more than one patient, were not in evidence, although one facility improvised such a device. This should be avoided where possible, as it is difficult to ensure a reliable flow to

the patient. Appropriately used flow-splitters have the advantage of maximising the efficient use of a scarce resource and should be available anywhere that oxygen supplies are not plentiful.¹⁶

In 2003, a WHO consultative meeting on oxygen highlighted the importance of addressing a lack of baseline information on oxygen availability and delivery in the developing world.⁵ Anecdotally, there is compelling evidence that oxygen is in short supply in the developing world, but the extent and nature of the problem is not well documented. Data from five hospitals in Papua New Guinea showed that oxygen was not available on the day of admission for 22% of children, while in Malawi an assessment showed that supplies were unreliable in four of five hospitals surveyed.^{17,18} In addition, a number of efforts to improve supplies in the developing world, often innovative, have been reported at both health facility and national levels.^{11,12,19–24}

The main limitation of this study is that assessments were done on one occasion only, providing a snapshot of what is in fact a dynamic and changing situation. Nevertheless, that snapshot, while it might become outdated in a particular instance, is likely to give a valid overall picture of the state of health facilities as a group at the time of the assessment. Data from in-patient registers are likely to vary in accuracy of collection and collation from site to site. The most valid figures are likely to be from the RVTH, where the numbers were relatively large and more likely to be reliable following efforts to increase the accuracy of record-keeping. The number of patients needing oxygen and absolute oxygen requirements were difficult to quantify from this assessment. An earlier study from the RVTH showed that 6% of children admitted for any diagnosis were severely hypoxaemic (oxygen saturation <90%).²⁵ If this were true of the whole under-5 years in-patient load in the health facilities described in this study, it represents over 1000 severely hypoxaemic young children annually. A more reliable estimate of requirements would be gained if routine pulse oximetry were being used in all health facilities and included in routine data.

Since this assessment was done there have been encouraging reports of improvements in oxygen supplies resulting from improved power supplies and the donation of oxygen concentrators to health facilities, spearheaded by the government. Sustainability is, however, a great challenge in this setting where improvements and deteriorations can occur rapidly.

CONCLUSIONS

Oxygen availability did not meet needs in most health facilities in The Gambia, a sub-Saharan African country. Training is needed to support oxygen use and equipment maintenance. The long-term success of efforts to improve supply can be enhanced by carefully

considering the technical options available in the light of the situation on the ground. Oxygen cylinders and oxygen concentrators have advantages and disadvantages quite distinct from one another, suggesting that an analysis of this kind, taking into account real costs, reliability, usability and logistics, would be needed to determine the role of both in each setting. This is currently being undertaken in The Gambia to improve pneumonia case management, and is likely to be needed in other developing countries if supplies are to be sustainably improved.

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RÉSUMÉ

CONTEXTE : Services de santé en Gambie, Afrique de l'Ouest.

OBJECTIFS : L'oxygénothérapie est vitale en cas de pneumonie, cause principale de décès chez les enfants au niveau mondial. Dans les pays en développement, il y a des carences en oxygène, mais peu d'informations sur l'étendue du problème. Nous avons évalué la disponibilité de l'oxygène au niveau national et son utilisation en Gambie, un pays africain sub-saharien.

MÉTHODES : Une équipe menée par le gouvernement a

visité 12 services de santé en Gambie. On a utilisé un outil d'évaluation modifié de l'Organisation mondiale de la Santé pour déterminer les besoins en oxygène, les provisions actuelles et la capacité de financer une utilisation effective de l'oxygène.

RÉSULTATS : Onze des 12 services ont traité des pneumonies graves. L'oxygène a été fiable dans trois services. Les besoins et la fourniture sont souvent non liés l'un à l'autre. Les oxyconcentrateurs et les cylindres d'oxygène ont été tous deux utilisés. L'utilisation des concentra-

teurs est rendue difficile par une distribution suboptimale de l'électricité et par une maintenance insuffisante, alors que les problèmes logistiques et le coût freinent l'utilisation des cylindres. Les enfants sont généralement triés par des infirmières formées qui ont signalé un manque de formation dans le domaine de l'oxygène. L'oxygène a été administré typiquement par sondes nasales ; l'oxymétrie de pouls a été disponible dans deux services.

CONCLUSIONS : Les données nationales ont montré que la disponibilité de l'oxygène ne répond pas aux besoins dans la plupart des services de santé de Gambie. Des options correctrices doivent être évaluées soigneusement en ce qui concerne les coûts réels, la fiabilité et les possibilités d'utilisation de site à site. Une formation est nécessaire pour appuyer l'utilisation de l'oxygène et l'entretien de l'équipement.

RESUMEN

MARCO DE REFERENCIA : Los establecimientos sanitarios en Gambia, África occidental.

OBJETIVOS : El tratamiento con oxígeno es primordial en el tratamiento de la neumonía, la principal causa de mortalidad infantil en el mundo. En los países en vías de desarrollo se observa escasez de oxígeno, pero existe poca información sobre la amplitud del problema. Se llevó a cabo una evaluación de la accesibilidad y utilización del oxígeno en Gambia, un país de África subsahariana.

MÉTODOS : Un grupo dirigido por el gobierno visitó los establecimientos sanitarios en Gambia ($n = 12$). Con el fin de determinar las necesidades de oxígeno, la provisión actual y la capacidad de respaldar un uso eficaz del oxígeno, se aplicó una herramienta modificada de la Organización Mundial de la Salud.

RESULTADOS : Once de los 12 establecimientos atendían casos de neumonía grave ; la administración de oxígeno era fiable en tres de ellos. Con frecuencia no coincidían

las necesidades con los suministros. Se utilizaban concentradores y cilindros de oxígeno. La deficiencia en el suministro de corriente eléctrica y el mantenimiento de los equipos obstaculizaban la utilización de los concentradores de oxígeno, y los problemas logísticos y el costo dificultaban el uso de los cilindros. Las enfermeras capacitadas que realizaban la selección de los niños informaron sobre la falta de formación en el uso del oxígeno. El oxígeno se administraba generalmente por cánulas nasales ; dos establecimientos contaban con oximetría del pulso.

CONCLUSIONES : Estos datos nacionales pusieron en evidencia que en la mayoría de los establecimientos sanitarios de Gambia el suministro de oxígeno no satisface las necesidades locales. Es necesario evaluar con cuidado los costos reales, la fiabilidad y la facilidad de utilización de las soluciones propuestas en cada centro. Se precisa impartir capacitación sobre el uso del oxígeno y sobre el mantenimiento de los equipos.
