A review and analysis of intensive care medicine in the least developed countries*

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Objective: **To give critical care clinicians in Western nations a general overview of intensive care medicine in less developed countries and to stimulate institutional or personal initiatives to improve critical care services in the least developed countries.**

Data Source: **In-depth PubMed search and personal experience of the authors.**

Data Synthesis: **In view of the eminent burden of disease, prevalence of critically ill patients in the least developed countries is disproportionately high. Despite fundamental logistic (water, electricity, oxygen supply, medical technical equipment, drugs) and financial limitations, intensive care medicine has become a discipline of its own in most nations. Today, many district and regional hospitals have units where severely ill patients are separately cared for, although major intensive care units are only found in large hospitals of urban or metropolitan areas. High workload, low wages, and a high risk of occupational infections with either the human immunodeficiency virus or a hepatitis virus explain burnout syndromes and low motivation in some health care workers. The four most common admission criteria to intensive care units in least developed countries are postsurgical treatment, infectious diseases, trauma, and peripartum maternal or neonatal complications. Logistic and financial limitations, as well as insufficiencies of supporting disciplines (e.g., laboratories, radiology, surgery), poor general health status of patients, and in many cases delayed presentation of severely sick patients to the intensive care unit, contribute to comparably high mortality rates.**

Conclusion: **More studies on the current state of intensive care medicine in least developed countries are needed to provide reasonable aid to improve care of the most severely ill patients in the poorest countries of the world. (Crit Care Med 2006; 34:1234–1242)**

KEY WORDS: intensive care medicine; least developed countries; Africa; Asia

The aim of this review is to give critical care clinicians in Western nations a general overview of how intensive care medicine is performed in the least developed countries (LDCs) and to stimulate institutional or personal initiatives to improve critical care services in these nations. Furthermore, it should underline the need for adequate data gathering on the current status of intensive care medicine in LDCs.

An in-depth PubMed search using the key words *critical care medicine*, *intensive care medicine*, *severe illness*, *sepsis*, *shock*, *trauma*, *obstetrics*, *major surgery*, *least developed countries*, *less developed countries*, *third world*, *developing world*, *Africa*, and *Asia* was performed. In addition, collected articles were carefully searched for citations and references that PubMed may have missed. However, in view of the significant lack of scientific data addressing this issue in the literature, this review is, to a substantial part, based on personal experience of the authors in Africa and Asia (marked as personal experience, or p.e.).

Because of the limited data available and differences between nations and regions, we wish to emphasize that statements in this review cannot necessarily be extrapolated to all intensive care units (ICUs) in LDCs, not even in countries that are well known to us.

In the following article, the term *LDCs* is used in accordance with the definition of "least developed countries (code 481)" by the United Nations Economic and Social Council (1), which summarizes the world's most impoverished countries. Currently, this definition includes approximately 50 nations in Africa, Asia, and the Pacific Region, as well as Haiti in the Latin America and Caribbean Region (1). Since almost half of LDCs are located on the African continent, the term *sub-Saharan Africa* is used in this article to describe LDCs in Africa. It was defined in accordance with definitions of the United Nations Statistic Division (2). Thus, sub-Saharan Africa refers to all African nations except for northern Africa, with the Sudan included in sub-Saharan Africa (2). From a medical point of view, South Africa must be strictly excluded from the designation of sub-Saharan Africa.

Compared with other medical specialties, intensive care medicine is a relatively young discipline (3), but it has become an essential part of the medical system in Western countries. Today, almost one fourth of hospital expenses are invested in the care of the most severely sick patients (4). In LDCs, however, the *status quo* of intensive care medicine differs enormously from Western countries. In most of these countries, less money is annually spent on the total health care sector than on intensive care medicine alone in the industrialized world (4, 5).

In view of the high incidence of poverty, illiteracy rates, unresolved and ongoing civil conflicts, maldistribution of resources, and deficits in socioeconomic, political, infrastructural, and rural aspects, general health care coverage re-

*See also p. 1288.

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Table 1. Key health indicators (5)

	Austria	Mongolia	Russian Federation	Nigeria	Democratic Republic of Congo
Mortality stratum	*A*	*B*	*C*	*D*	*E*
Total population (1000)	8111	2559	144,082	120,911	51,201
Annual growth rate, %	0.3	1.1	−0.3	2.8	2.4
Safe water access, %	100	54	NA	32	34
Life expectancy at birth, yrs	79.4	62.9	64.6	48.8	43.5
Maternal mortality rate (per 100000)	4	110	67	800	990
Mortality rate under age 5 (per 1000)					
Male	6	75	19	183	221
Female	4	66	15	181	198
Per capita GDP (USD)	28,223	1917	8486	915	346
Per capita expenditure on health (%/USD)	8/2259	6.4/122	5.4/454	3.4/31	3.5/12

NA, information not available; GDP, Gross domestic product; USD, international US Dollar.

Definitions of mortality strata: *A,* very low child mortality, very low adult mortality; *B,* low child mortality, low adult mortality; *C,* low child mortality, high adult mortality; *D,* high child mortality, high adult mortality; *E,* high child mortality, very high adult mortality (5).

mains incomplete, uncertain, and minimal in most LDCs (5). Shocking statistical figures in the annual reports of international health organizations are the inevitable consequence of poor national and international health care (Table 1).

Analogous to the eminent burden of disease, prevalence of critically ill patients in LDCs is disproportionately high (6); however, despite numerous limitations, intensive care medicine has become a discipline of its own in many LDCs.

Intensive Care Medicine in LDCs

With a delay of 15–20 yrs compared with the industrialized countries, intensive care units (ICUs) began to develop in many LDCs (7). ICUs mostly originated from postoperative care wards or recovery rooms and later grew to interdisciplinary units caring for critically ill patients with surgical and nonsurgical pathologies. Although today many district and regional hospitals have units where severely ill patients can be separately cared for, major ICUs are only found in large hospitals of urban or metropolitan areas. Striking differences in the quality of medical care can frequently be found between rural and urban areas in LDCs (8, 9). In fact, most patients who would be urgently admitted to an ICU in industrialized countries do not have access to an ICU in LDCs (10, 11). Thus, particularly in smaller hospitals in rural areas, critically ill patients are often treated on regular wards.

Depending on the location, the average number of ICU beds ranges from three (rural hospitals) to ≥15 (major hospitals). However, ICU beds rarely cover more than 2–3% of all hospital beds compared with ~10% in industrialized countries. This obvious lack of ICU beds was suggested to be a key factor for high hospital mortality rates in LDCs (12).

Nowadays, most ICUs are multidisciplinary units usually focusing on postoperative care. In major metropolitan areas, specialized ICUs exist for the treatment of critically ill children or other patients suffering from neurologic or infectious diseases or for patients undergoing neuro- or cardiosurgical interventions (13, 14).

Management Structures

As, for example, in Senegal (15), most public hospitals and health care facilities in LDCs are financed by the government, public funds, insurance companies, and/or clerical or other nonprofit institutions (16). In view of frequently disorganized and unprofitable public insurance systems, the ICUs in LDCs are no income source for the hospital, as in industrialized countries, but rather are the main source of expenses (17).

Thus, a substantial part of costs for drugs, laboratory tests, and ICU procedures must be covered by the patients or their relatives. In India, a country that does not officially belong to LDCs, 78% of health care costs must still be paid by patients or their relatives (18). This not only puts an enormous financial burden on patients but also substantially limits public accessibility to hospitals and in particular to ICUs. Table 2 gives a brief overview of the relationship between the monthly salary of an average worker in a civil war area in the Democratic Republic of Congo in comparison to the prices of frequently used drugs and procedures in the ICU. Precarious ethical dilemmas often arise from this mode of ICU financing. A severely ill patient commonly requires more expensive treatment that puts a higher financial burden on the family, whereas the patient has a higher probability of dying, with all the money invested being lost. To avoid a tragic scenario with a bankrupt family mourning over their dead family member, therapies often remain inadequate because of limited funding (p.e.).

Table 2. Costs (US dollars) for treatment in an intensive care unit in a civil war area in the democratic Republic of Congo[a]

Daily cost for ICU bed	8
500 mL crystalloid solution	2.5
500 mL colloid solution	5
1 vial ampicilline (1 g)	0.5
1 vial furosemide (20 mg)	2
1 vial oxytocin (5 IU)	5
1 vial dopamine (200 mg)	4
1 tablet fluconazol (200 mg)	25
Abdominal surgery	150–200
Cesarean section	120
Average monthly per capita income	50
Dependency ratio (per 100)[b]	98

ICU, intensive care unit.

[a]Data from the Hôpital Charité Maternelle, Goma/Democratic Republic of Congo 2002; [b]A measure of the portion of the population which is composed of dependents (too young or too old to work). A dependency ratio of 98 means that there are 98 dependents for every 100 working-age people.

In almost all LDCs, private medical institutions exist that are accessible for patients who have money (19). These hospitals frequently offer state-of-the-art medical care on a standard that is comparable to Western countries (20). Although some of these institutions also provide ICU services, most facilities special-

ize in surgical, internal, or diagnostic medicine (21). In view of the wide-ranging lack of local distributors of necessary supplies and drugs, intensive care is also often limited in those institutions (22).

ICU Working Staff

Physicians

Although there are no data on the education and specialty of ICU physicians in LDCs available in the literature, our experience indicates that the majority of clinicians in charge of ICUs are anesthesiologists. However, in many LDCs, anesthesiologists are not graduated physicians but are specially trained nurses or medical assistants. Internal or surgical physicians are also involved in the treatment of critically ill patients. Specialized ICUs (e.g., pediatric or neurosurgical) are run by either anesthesiologists or physicians of other specialties (13). For most ICUs in LDCs, a characteristic factor limiting adequate therapy for the severely ill patient is the lack of a physician on call for 24 hrs (p.e.). Particularly in smaller hospitals in rural areas, physicians are only sporadically present on the ICU, and most responsibilities are left to inadequately trained medical assistants/officers or nursing personnel. Reasons for inadequate care, therefore, are not only a high workload of single physicians but also a lack of understanding of some personnel about how to comprehensively care for a critically ill patient (p.e.).

A major limitation of intensive care medicine in LDCs is the deficiency of a broad training and educational program for (intensive care) physicians (23). Lack of knowledge of contemporary therapeutic standards often results in stereotypical, obsolete drug therapies (e.g., high rate of glucocorticoid prescriptions, insufficient antibiotic therapies) and frequent avoidable problems such as a high incidence of nosocomial infections (24).

Nursing Staff

Nurses are the main "pillars" of intensive care medicine in LDCs. Being permanently present in the unit, they have to care for the patient and in many cases also perform the work of physicians during their absence. The educational level of nurses working in the ICUs of the LDCs is, however, highly variable (25). Only a minority of nurses are educated in governmental nursing schools, and most of the remaining are semiskilled or hospital-trained nurse assistants (25). With three to four nurses per shift for a 17-bed Indian ICU, several nurses were found to perform tasks that may be beyond their limits of efficiency or medical capabilities (18). Because of nurses' extensive medical duties and limited amount of nursing education, most of the patient care is done by the patient's family. These circumstances often lead to crowded ICUs, disorganization, increase in nosocomial infections, and irregularities in documentation and drug therapies (p.e.).

Salary or the Benefit/Risk Ratio

Although in many LDCs, the salary of health care workers is above the average wage, it is usually not high enough to raise and feed a family (Table 3). Although the workload in the ICU requires more time, efforts, dedication, and motivation than work on other hospital wards, there is often no difference in the salary of ICU staff and other hospital personnel (p.e.). For example, in the Democratic Republic of Congo, anesthesiologists and intensive care physicians earn significantly less money than specialists from other disciplines, such as surgery or gynecology (p.e.). Consequently, high workload combined with irregular and low salary as well as various logistic restraints may lead to burnout syndromes and low motivation of the ICU working staff (26).

In view of these problems, well-trained physicians and nurses frequently leave their home countries to work in more developed nations where salary and working conditions are significantly better. In many LDCs, this "brain drain" prevents development of specialized units or centers (27, 28).

Due to insufficient safety measures (lack of plastic bags for disposal of soiled linen, widespread shortage of gloves, etc.), the risk of acquiring an occupational infection is disproportionately high (29). The annual occupational risk of HIV transmission in Tanzania is estimated to be 0.27% for the average health care worker and up to 0.7% for specialized personnel in the ICU or operating theater (30).

Infrastructure

Buildings and ICU Structure. Whereas planning, construction, and maintenance of Western ICUs are highly professional, an arbitrarily chosen room without specific equipment serves as a facility to treat critically ill patients in many hospitals in LDCs. Basic architectural requirements can rarely be met. Additional needs such as mosquito protection and water purification systems in tropical areas, or effective heating systems in Central Asia, put even higher demands on the ICU structure than in most Western nations (31, 32).

Basic Supplies: Water and Electricity. Except in cases of war or natural catastrophes, the majority of hospitals have access to water and electricity (33). Power supply in many LDCs is characterized by intermittent voltage peaks (up to 500–600 V), which prohibit usage of electronic medical devices without an upstream voltage stabilizer (34). Moreover, frequent power surges and uneven water supply are recurrent problems of intensive care medicine. Whereas temporary water shortages do not significantly impair ICU practice, unpredictable power surges, which are reported to occur hourly in war and catastrophe areas and daily in most LDCs, abruptly paralyze the ICU (34). In contrast to other institutions (major hotels, government buildings), hospitals rarely have automatic emergency power supplies to bridge electrical power surges. In our experience, delayed activation of small gasoline aggregates may lead to fatal therapeutic complications due to prolonged inactivation of oxygen con-

Table 3. Average salary and costs of living given in US Dollars

	Mongolia	Democratic Republic of Congo
Salary doctor[a]	200	300
Salary nurse[a]	80	150
Monthly payment for housing	50–200	50–100
1 kg flour	0.5	0.3
1 L milk	0.2	0.1
1 kg meat	2	1.5
1 L gasoline	0.5	0.3
Dependency ratio (per 100) (3)	59	98

[a]Including 5–8 night shifts/month.

centrators, ventilators, or syringe pumps that administer cardiovascular active drugs.

Oxygen and Compressed Air. Oxygen is expensive and unavailable in most hospitals (35). In 1998, for example, only 12 of 20 Ugandan hospitals had oxygen reserves, whereas the remaining eight had no oxygen at all (34). Two common regimes are used to administer oxygen in ICUs of LDCs (35, 36). Oxygen concentrators, which produce 70–95% purified oxygen by nitrogen absorption, are expensive and difficult to obtain but simple and cheap to maintain (Fig. 1*A*) (37, 38). Oxygen cylinders are cheap to buy but cumbersome and expensive to maintain (38). Separate gas systems for pressurized oxygen (Fig. 1*B*) or compressed air exist only in a few ICUs in selected major hospitals. Small, oil-free, or industrial oil compressors support compressed air systems and allow modern ventilator therapy in some of these hospitals (Fig. 1*C*). Except for mechanical ventilation in the immediate postoperative phase, ventilator therapy in LDCs is associated with very high mortality rates (58–74%) (39, 40). Patients who had to be intubated because of myasthenia gravis had complete recovery in one report from Sri Lanka, whereas ventilated patients with severe head injuries, subarachnoid hemorrhage, nontraumatic coma, or chest injuries were reported to have a mortality rate of 100% (40).

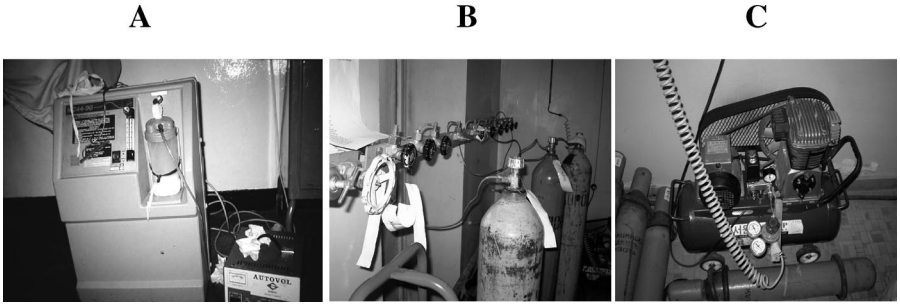

Figure 1. Difference sources of oxygen and compressed air: *A*, oxygen concentrator; *B*, oxygen bottle system; *C*, industrial air compressor.

Technical Services

Medical and Nursing Equipment. Average technical and nursing equipment of most ICUs in LDCs range well below the standards of the first ICUs in Europe in the 1950s (41). Patient monitors, ventilators, defibrillators, and syringe pumps are rare and almost only available in hospitals that have received donations from Western countries (42, 43). Reports from Uganda found that a sphygmomanometer and a stethoscope were the only monitoring devices in the majority of hospitals in rural Uganda (34, 44). Invasive surveillance and diagnostic procedures are almost nonexistent because of their dependence on expensive and locally unavailable supply materials. Equipment-related problems arise from common maintenance insufficiencies and the impossibility to calibrate on a regular basis due to lack of supply materials and reagents (34, 42, 43). Bastos et al. (45) suggested that the inadequate medical-technical equipment of most ICUs substantially contributes to the high mortality rate of critically ill patients in LDCs.

Availability of Drugs. Although most drugs of the Essential Medicine List suggested by the WHO (46) can be purchased in LDCs, only a few of these drugs are immediately available at the patient's bedside. Aside from shortages in vital medications (e.g., epinephrine, colloid infusions, dopamine, broad-spectrum antibiotics, furosemide, nitrates, etc.), LDCs have to deal with low-quality and "fake" drugs, a phenomenon that is widely unknown to industrialized countries (47). Vials filled with sodium chloride or *aqua bidest* but labeled with specific drug names can lead to substantial therapeutic problems, particularly during resuscitation of severely ill patients (48). Small drug stocks explain low-dose, standardized prescriptions of a very small contingent of medications, which frequently leads to antibiotic and antimalarial drug resistance (49, 50). Although in a Nigerian laboratory survey, *Staphylococcus aureus* was found to be 100% susceptible to vancomycin, which is not available in most LDCs, it was 100% resistant to commonly used antibiotics such as ampicillin or penicillin (51).

Supporting Disciplines

Biochemical and Microbiological Laboratory. Although many hospitals have a laboratory, determination of hemoglobin, hematocrit, and leukocytes are usually the only blood analyses available (52). In tropical LDCs, thick drop microscopy and HIV testing can be done on request in most hospitals (23). Limited resources of expensive and locally unavailable test kits allow for only selective laboratory testing (52). Microbiological laboratories are rare and only exist in metropolitan areas. Many of these laboratories were found to be short of test kits, to lack quality control, and to provide unreliable results (23).

Radiology. Many hospitals only have immobile radiograph machines, requiring in-hospital transfer of critically ill patients for radiographic examinations (53). Ultrasound imaging, if available, can rarely be performed at the bedside (54). Performance of computed tomography scans is sporadically possible in major urban hospitals (55) but usually requires unsafe intra- or interhospital transfers and incurs high costs.

Surgery. Trained and experienced surgeons mostly work in major cities, whereas doctors in rural areas have to cope with highly variable demands on their surgical skills (56). Therefore, a major portion of surgical interventions are performed either by nonsurgeons or by clinical officers and nurses (57–59). Moreover, most sterilization and anesthesiology units are not prepared and equipped to care for critically ill patients during the perioperative period (34).

Transfusion Service. Despite restrictive transfusion thresholds in LDCs, many ICUs are short of blood products (60). Less than 71 of the 191 member states meet the WHO recommendations for a national blood program (61). Thus, in most LDCs, each hospital has to organize its own blood transfusion service where resources are frequently based on the patient's family (62). Since only 46% of LDCs screen blood for HIV because of financial limitations, HIV and hepatitis transmission *via* blood transfusion is a major concern (63). Up to 15% of HIV transmissions in LDCs are estimated to be blood-product related (64).

Spectrum of Disease in the ICU. Table 4 displays patient characteristics from ICUs in Mongolia (capital city), the Democratic Republic of Congo (city in a metropolitan area), and the United Republic

Table 4. Spectrum of diseases in the intensive care unit

	Mongolia[a]	Democratic Republic of Congo[b]	Tanzania[c]
ICU beds (n)	10	3	10
Ventilators (n)	5	0 (Ambu Bag)	1
Annual ICU admissions (n)	627	141	715
Age (yrs)	48.7 ± 17.5	24.4 (range, 1–87)	28 ± 18
Sex (% male)	54.2	44.6	41.2
Admission diagnoses	Hemorrhagic stroke Gastric ulcus/surgery Peritonitis Ileus Colorectal surgery Sepsis	Brain trauma Severe trauma Military trauma Severe malaria Hypertensive crisis	Post surgery Severe malaria Pre/eclampsia Sepsis Peripartum hemorrhage Trauma/burns
Mechanical ventilation (%)	20–25	0–1	~2
Length of stay (days)	4.4 ± 0.6	7.3 (range, 1–19)	3.8 (range, 1–25)
Mortality (%)	9.5	7.8	16.9

ICU, intensive care unit.

[a]Data from the intensive care unit of the Central University Hospital, Ulaanbaatar 2004; [b]data from the intensive care unit in the DOCS Hospital (Orthopedic and Trauma Center), Goma 2004; [c]data from the intensive care unit of the St. Francis Hospital, Ifakara 2001. Data are given as mean ± SD, if not indicated otherwise.

of Tanzania (city in a rural area). Although overall mortality rate in most ICUs in LDCs is higher compared with Western ICU facilities (65, 66), the quality of intensive care medicine is still overestimated: First, the young age of most ICU patients bears a significant survival benefit over the geriatric critically ill patient population of many Western countries. Second, limited accessibility to health care facilities and in particular to ICUs as well as nonexistent preclinical patient care usually result in admission of less severe patients to the ICU (67).

With exception of data from the hospital in the Democratic Republic of Congo, Table 4 presents hospital and patient characteristics at peacetime. During periods of war or humanitarian catastrophes, the spectrum of diseases in the ICUs is significantly different. Whereas trauma patients make up a comparably minor portion of critically ill patients except in military hospitals, there is an abrupt increase in acute cardiac, cerebrovascular, and medical diseases (68). Simetka et al. (69) reported on a significant increase in the rates of low birth weight, stillbirths, neonatal deaths, and maternal mortality during civil war in Sri Lanka. Particularly in times of war, occupancy of ICU beds is often paradoxically lower than during peace, since ongoing conflicts, lack of transportation possibilities, high numbers of severely injured civilians, and extreme poverty with lack of financial resources prevent patients from presenting to hospitals or other health care facilities (70, 71).

The four most common admission diagnoses to ICUs in LDCs are postsurgical care, infectious diseases, trauma, and peripartum maternal or neonatal complications. Most patients undergoing surgical interventions in LDCs require emergency procedures (e.g., incarcerated hernia, intestinal obstruction, etc.) (72, 73). Major elective surgery requiring postoperative intensive care is usually only performed in central hospitals (abdominal/thoracic oncologic surgery, cardiac surgery, orthopedic surgery, neurosurgery, etc.) (56). Major surgery is associated with significant perioperative risks. Ugwu et al. (74) found that medium/major surgery in Nigeria was associated with an incidence of cardiac arrest of 0.4%. A specific postoperative complication in tropical LDCs is the occurrence of acute malaria attacks. Since many patients in those regions are chronic, asymptomatic carriers of plasmodium merozoites, perioperative stress may trigger acute decompensation of host defense mechanisms and cause acute, mostly severe malaria infection in the immediate postoperative period (56).

Accordingly, in tropical LDCs, malaria is the single most important infectious disease, both in terms of admission to ICUs and as a cause of death (75). In LDCs outside of the tropics, pneumonia, gastroenteritis, meningitis, tuberculosis, and measles are the leading infectious causes for ICU admission (76). Important predisposing factors are an underlying chronic infection with HIV and/or *Mycobacterium tuberculosis*, as well as malnutrition (77, 78). Spectacular infectious diseases such as acute viral hemorrhagic fevers are also rare entities in central Africa and Asia and usually occur only in periodical outbreaks (79, 80).

The second leading cause of death in LDCs younger than 40 yrs is trauma (81). Unlike in Western countries, multiple trauma patients usually do not reach the ICU early enough (82). Therefore, most trauma patients treated in the ICU suffer from severe single trauma. Major causes of trauma are road traffic accidents, occupational trauma, and injuries from wild animal attacks (e.g., in sub-Saharan Africa, buffalo, hippopotamus, crocodile, lion) (83). In 1997, 5,686 road traffic accidents occurred in Mozambique with only 12,350 cars being officially registered (84). Burns are another common cause of injury, particularly in children (56). Burns >30% of the body surface area have been associated with excessively high mortality rate in Malawi (85).

Since 99% of worldwide annual maternal deaths occur in LDCs and more than half of them in sub-Saharan Africa (86), peripartum maternal and neonatal complications are a common cause for ICU admission. Leading causes of maternal death vary from location and country. In a report from Zimbabwe, severe preeclampsia/eclampsia, peripartum hemorrhage and uterine rupture, sepsis after unsafe abortion, and puerperal sepsis were the most common causes for maternal ICU admission and death (87). The general lack of antenatal care is responsible not only for most maternal deaths but also for high neonatal morbidity and mortality rates (88). Most common diagnoses for admission of critically ill neonates are peripartum asphyxia with its

numerous complications, sepsis, and malformations (89). Moreover, as a consequence of low sociodemographic status and poor maternal health, the rate of preterm delivery is significantly higher in LDCs than in the industrialized world (90). Even in metropolitan areas, survival of preterm neonates is low with a birth weight <1500 g and minimal <1000 g (91).

A major factor influencing the course of critical illness is a preexisting tuberculosis or HIV infection. Although most LDCs show significantly higher tuberculosis and HIV prevalence than Western nations, the HIV pandemic has reached an unexpected magnitude in sub-Saharan Africa (92). In 2003, sub-Saharan Africa was home to two thirds of the world's people living with HIV/AIDS but only 11% of the world's total population (5). Today, about one in 12 African adults lives with HIV/AIDS; among hospitalized patients, an estimated 20–60% are infected with HIV (3). HIV carrier status substantially impairs survival chances of critically ill patients in LDCs (92). Overwhelming sepsis refractory to treatment often causes acute death even in asymptomatic HIV-infected patients. The implication of HIV/AIDS in sub-Saharan Africa and Southeast Asian corresponds to hepatitis B on the central Asian continent. In some of these populations, chronic carrier rates of hepatitis B are as high as 15–20%, with most infections occurring in the perinatal period (93). Accordingly, chronic hepatitis leads to frequent liver-related admissions to the ICU (p.e.).

A significant part of patients admitted to ICUs in LDCs are children (94–96). Injuries and various infectious diseases are the most common admission diagnoses (65, 95, 96). Mortality of critically ill children is often significantly higher than that of an average adult ICU population (95, 97). The two most important factors leading to this unexpected high mortality are chronic malnutrition and HIV infection. In one analysis from South Africa, 29.2% of all children admitted to the hospital were HIV positive (77). HIV infected children were significantly more often malnourished than children without HIV/AIDS (65.8% vs. 33.1%, $p < .001$) and had a higher probability of dying (17% vs. 4.6%, $p < .001$) (77). In Burkina Faso, 87% of pediatric deaths could be attributed to severe malnutrition (78). It is estimated that ~50–80% of adolescent deaths in LDCs could be avoided by adequate vaccination (98).

LIMITING FACTORS OF INTENSIVE CARE MEDICINE

Poor Health Status

A major factor contributing to high morbidity and mortality in ICUs is the population's poor health status. Inadequate and mostly nonexistent antenatal care, vaccination and nutritional programs, and drug therapies for chronic cardiovascular and pulmonary diseases account for a high number of emergencies and serious illnesses (5, 6). For example, a high number of severe cerebrovascular accidents, surpassing even the cases of acute coronary syndromes, occur in Mongolia and China because of inadequate control of chronic arterial hypertension (99).

Delay in Admission to the ICU

Long distances and high transportation costs commonly result in delayed presentation of critically ill patients (100, 101). Since major ICUs are located in metropolitan or urban areas, travel may take several days, during which the patient's condition deteriorates toward a set pathology often detrimental to survival (100).

In a retrospective analysis of emergencies at the university hospital of Dakar/Senegal, the mean delay between onset of emergency and hospital admission was 17 ± 9 hrs (102). Similarly, average time between onset of symptoms to hospital presentation was 5 days (range, 3–7 days) in patients with acute appendicitis in Nigeria (103). Parikh and Dilip (18) reported that 65% of patients in an Indian ICU had been treated unsuccessfully in other hospitals before their admission. Table 5 displays the most common reasons for delayed hospital admission resulting in brought-in maternal deaths in southwest Nigeria (104).

Most patients, 78% in one Senegalese study (102), are transferred to hospitals by private or public transportation services (105). In most LDCs, prehospital emergency medical systems are nonexistent. Rare ambulance services are seldom staffed with doctors and often serve as a mere transportation facility with descriptive medical character (106–108).

In numerous LDCs, people with serious diseases seek traditional health care before accepting modern medical services (109, 110). Research done at the Mogopane Hospital in northeastern Transvaal in South Africa showed that 90% of patients presenting to the outpatient department had consulted traditional healers first (111). Although traditional medicine can be helpful for several chronic health problems, it is usually not effective in critical illness. Thus, patients are frequently admitted in a significantly deteriorated state after unsuccessful or even poisonous traditional treatments (112).

Table 5. Reasons for delayed admission to the intensive care unit resulting in "brought-in maternal death" in South-West Nigeria (104)

Inability to obtain transportation in time	41.7%
Inability of the healthcare staff to detect an obstetric emergency early enough and refer to an appropriate center	33.3%
Inability of the referring hospital to perform cesarean section	33.3%
Fear of cesarean section	25%
Unwillingness of drivers to travel by night	25%
No money to pay for hospital costs	16.7%

More than one reason could be given by interviewed relatives.

Cooperation With Western Countries

Although reports on private and institutional projects to improve anesthesia, emergency, and surgical care in LDCs exist in the literature, little is known about the efficacy of cooperation between LDCs and Western countries to improve intensive care medicine.

From our personal experience, we can report on three successful projects to install critical care services in hospitals in rural Tanzania, in a major city in a civil war area in the Democratic Republic of Congo, and in the capital of Mongolia. By implementing these projects and starting a theoretical and practical cooperation, the quality of care as well as capacity of the cooperating ICUs could be significantly improved. Thus, for example, introduction of basic critical care procedures (hygienic procedures, invasive pressure systems, echocardiography, modern ventilator and cardiocirculatory therapy, renal replacement therapy) to a Mongolian ICU could reduce annual mortality rate from 19% to 9.5% within only 1 yr.

In view of these encouraging data, cooperation between Western medical institutions and hospitals in LDCs seems to have a great potential to improve critical

care services in LDCs. One of the most important preconditions for the successful accomplishment of such projects is a realistic assessment of the basic requirements and development status of the hospital to be supported. Further important steps are not only the provision of reasonable and locally useable medical devices and supply materials, as well as the optimization of ICU architecture and infrastructure, but particularly the initiation of theoretical educational programs and practical cooperation at the ICU bedside.

Summary

Intensive care medicine is a developing discipline in almost all LDCs. Financial restraints due to inadequate insurance and national health systems together with severe logistic and educational problems account for high morbidity and mortality rates in ICUs of LDCs. More studies on the current state of intensive care medicine in LDCs are needed to provide reasonable aid to improve the care of the most severely ill patients in the poorest countries of the world.

REFERENCES

1. United Nations Economic and Social Council. Available at: http://www.un.org/docs/ecosoc. Accessed February 7, 2005
2. United Nations Statistics Division. Available at: http://unstats.un.org/unsd. Accessed February 1, 2005
3. Berthelsen PG, Cronqvist M: The first intensive care unit in the world: Copenhagen 1953. *Acta Anesthesiol Scand* 2003; 47: 1190–1195
4. Jacobs P, Noseworthy TW: National estimates of intensive care utilization and costs: Canada and the United States. *Crit Care Med* 1990; 18:1282–1286
5. Beaglehole R, Irwin A, Prentice T: The World Health Report 2004. Changing History. Geneva, Switzerland, World Health Organization, 2004
6. Watters DAK, Wilson IH, Leaver RJ (Eds): Care of the Critically Ill Patient in the Tropics and Sub-tropics. Basingstoke, UK, Macmillan, 1991
7. Meiring Pde Y, Lumsden JD, Morrison AG, et al: An intensive care unit in a provincial general hospital. *S Afr Med J* 1969; 43:806–810
8. Ricketts TC: The changing nature of rural health care. *Annu Rev Public Health* 2000; 21:639–657
9. Kotilainen H: Rehabilitation of the hospital infrastructure in a developing country. *World Hosp Health Serv* 2001; 37:25–28
10. Muller O, Traore C, Becher H, et al: Malaria morbidity, treatment-seeking behaviour, and mortality in a cohort of young children in rural Burkina Faso. *Trop Med Int Health* 2003; 8:290–296
11. Louis JP, Trebucq A, Hengy C, et al: Healthcare accessibility and adequacy of healthcare system in the Sanaga basin (Central Cameroon). *Med Trop (Mars)* 1991; 51:327–333
12. Nouira S, Roupie E, El Atrouss S, et al: Intensive care use in a developing country: A comparison between a Tunisian and a French unit. *Intensive Care Med* 1998; 24: 1144–1151
13. Mukhida K, Shilpakar SK, Sharma MR, et al: Neurosurgery at Tribhuvan University Teaching Hospital, Nepal. *Neurosurgery* 2005; 57:172–180
14. Khwa Otsyula BO: Cardiothoracic surgery in sub-Saharan Africa: Problems and perspectives. *East Afr Med J* 1993; 70:129–130
15. Gueye AS, Faye D, Tall AB, et al: Cost analysis of operating the oral health service of the regional hospital center of Ziguinchor (Senegal). *Odontostomatol Trop* 2004; 27:7–14
16. Murray CJL, Govindraj R, Musgrove P: National health expenditures: A global analysis. *In:* Global comparative Assessments in the Health Sector: Disease Burden, Expenditure and Interventional Packages. Murray CJL, Lopez AD (Eds). Geneva, World Health Organization, 1994, pp 141–155
17. Balique H: Public hospital in French-speaking Africa. *Med Trop (Mars)* 2004; 64: 545–551
18. Parikh CR, Dilip KR: Quality, cost, and outcome of intensive care in a public hospital in Bombay, India. *Crit Care Med* 1999; 27: 1754–1759
19. Hanson K, Berman P: Private healthcare provision in developing countries: A preliminary analysis of levels and composition. *Health Policy Plann* 1998; 13:195–211
20. Palmer N, Mills A, Wadee H, et al: A new face for private providers in developing countries: What implications for public health? *Bull World Health Organ* 2003; 81:292–297
21. Streefland P: Public healthcare under pressure in sub-Saharan Africa. *Health Policy* 2005; 71:375–383
22. Bhat R: Characteristics of private medical practice in India: A provider perspective. *Health Policy Plann* 1999; 14:26–37
23. Gray IP, Carter JY: An evaluation of clinical laboratory services in sub-Saharan Africa. Ex Africa semper aliquid novi? *Clin Chim Acta* 1997; 267:103–128
24. Khuri-Bulos NA, Shennak M, Agabi S, et al: Nosocomial infections in the intensive care units at a university hospital in a developing country: Comparison with National Nosocomial Infections Surveillance intensive care unit rates. *Am J Infect Control* 1999; 27:547–552
25. Makumki D: An overview of perioperative nursing in Kenya: Issues, challenges, and trends. *Semin Perioper Nurs* 1998; 5:230–233
26. Olley BO: A comparative study of burnout syndrome among health professionals in a Nigerian teaching hospital. *Afr J Med Sci* 2003; 32:297–302
27. Scott ML, Whelan A, Dewdney J, et al: "Brain drain" or ethical recruitment? *Med J Aust* 2004; 180:174–176
28. Coombes R: Developed world is robbing African countries of health staff. *BMJ* 2005; 330:923
29. Ansa VO, Udoma EJ, Umoh MS, et al: Occupational risk of infection by human immunodeficiency and hepatitis B viruses among health workers in south-eastern Nigeria. *East Afr Med J* 2002; 79:254–256
30. Gumodoka B, Favot I, Berege ZA, et al: Occupational exposure to the risk of HIV infection of healthcare workers in Mwanza Region, United Republic of Tanzania. *Bull World Health Organ* 1997; 75:133–140
31. Trew R: Planning appropriate hospitals for developing countries. *Health Estate J* 1995; 49:2–5
32. Barss P, Comfort K: Ward design and neonatal jaundice in the tropics: Report of an epidemic. *BMJ (Clin Res Ed)* 1985; 291: 400–401
33. Kimaro E, Towey FM: Anaesthesia in rural Tanzania. *Trop Doct* 2001; 31:102–104
34. Hodges SC, Hodges AM: A protocol for safe anaesthesia for cleft lip and palate surgery in developing countries. *Anaesthesia* 2000; 55:436–441
35. Archampong EQ: Getting oxygen into our hospitals theatres and wards. *West Afr J Med* 1992; 11:233
36. Perrelet A, Zellweger JP, Talla I, et al: The oxygen concentrator: An appropriate technology for treating hypoxaemic children in developing countries. *Int J Tuber Lung Dis* 2004; 8:1138–1141
37. Oduro KA: Trends in the supply of oxygen in hospital–oxygen concentrators–Korle Bu experience. *West Afr J Med* 1992; 11:244–246
38. Mokuolu OA, Ajayi OA: Use of an oxygen concentrator in a Nigerian neonatal unit: Economic implications and reliability. *Ann Trop Paediatr* 2002; 22:209–212
39. Sinclair JR, Watters DA, Davison M: Outcome of mechanical ventilation in Central Africa. *Ann R Coll Surg Engl* 1988; 70:76–79
40. Rajapakse VP, Wijesekera S: Outcome of mechanical ventilation in Sri Lanka. *Ann R Coll Surg Engl* 1989; 71:344–346
41. Benad G, Röse W: Die geschichtliche Entwicklung der Intensivmedizin in Deutschland. Zeitgenössische Betrachtungen: Folge 4: Strukturelle Entwicklungen der Intensivmedizin in der ehemaligen DDR. *Anaesthesist* 1999; 48:251–262
42. Handa F: Anesthesia in a children's hospital in Nepal. *Masui* 2000; 49:1395–1397
43. Binam F, Lemardeley P, Blatt A, et al: Anesthesia practices in Yaounde (Cameroon). *Ann Fr Anesth Reanim* 1999 18:647–656
44. Lederer W: Peripartum general anaesthesia without tracheal intubation. *Anaesthesia* 2000; 55:1140
45. Bastos PG, Knaus WA, Zimmermann JE, et al: The importance of technology for achieving superior outcome from intensive

care. Brazil APACHE III Study Group. *Intensive Care Med* 1996;22:664–669
46. Laing R, Waning B, Gray A, et al: 25 years of the WHO essential medicine lists: Progress and challenges. *Lancet* 2003; 361:1723–1729
47. Raufu A: India agrees to help Nigeria tackle the import of fake drugs. *BMJ* 2003; 326: 1234
48. Newton PN, White NJ, Rozendaal JA, et al: Murder by fake drugs. *BMJ* 2002; 324: 800–801
49. Kakai R, Wamola IA: Minimising antibiotic resistance to *Staphylococcus aureus* in developing countries. *East Afr Med J* 2002; 79:574–579
50. Bloland PB, Kachur SP, Williams HA: Trends in antimalarial drug deployment in sub-Saharan Africa. *J Exp Biol* 2003; 206: 3761–3769
51. Umolu PI, Okoli EN, Izomoh IM: Antibiogram and beta-lactamase production of *Staphylococcus aureus* isolates from different human clinical specimen in Edo State, Nigeria. *West Afr J Med* 2002; 21:124–127
52. Mundy CJ, Bates I, Nkhoma W, et al: The operation, quality and costs of a district hospital laboratory service in Malawi. *Trans R Soc Trop Med Hyg* 2003; 97:403–408
53. Schandorf C, Tetteh GK: Analysis of the status of X-ray diagnosis in Ghana. *Br J Radiol* 1998; 71:1040–1048
54. Kobal SL, Lee SS, Willner R, et al: Hand-carried ultrasound enhances healthcare delivery in developing countries. *Am J Cardiol* 2004; 94:539–541
55. Loembe PM, Idoundou-Antimi JS, Kouakou MO, et al: How to manage intracranial empyemas in the absence of computerized tomography? *Sante* 1997; 7:173–176
56. Jellis JE: Surgery in the Tropics. In: Manson's Tropical Diseases. Cook GC, Zumla A (Eds). London, Saunders, 2003, pp 485–498
57. Longombe AO: Surgical training of nurses for rural areas: Necessity of aberration? *East Centr Afr J Surg* 1997; 3:43–48
58. Garrido PI: Training of medical assistants in Mozambique for surgery in a rural setting. *S Afr J Surg* 1997; 35:144–145
59. Vaz F, Bergstrom S, Vaz Mda L, et al: Training medical assistants for surgery. *Bull World Health Organ* 1999; 77:688–691
60. Acquaye JK, Aryee ME: Blood demand in a teaching hospital in Ghana. *West Afr J Med* 1997; 16:97–101
61. World Health Organization: Blood Safety for Too Few. Press Release WHO/25, April 7, 2000
62. Emeribe AO, Ejele AO, Attai EE, et al: Blood donation and patterns of use in southeastern Nigeria. *Transfusion* 1993; 33:330–332
63. Raufu A: Rising HIV infection through blood transfusion worries Nigerian health experts. *AIDS Anal Afr* 2000; 11:15
64. Wake DJ, Cutting WA: Blood transfusion in developing countries: Problems, priorities and practicalities. *Trop Doct* 1998; 28:4–8
65. Williams EH, Hayes RJ, Smith PG: Admissions to a rural hospital in the West Nile District, Uganda over a 27 year period. *J Trop Med Hyg* 1986; 89:193–211
66. Sodipo JO: Experience with an intensive care unit in a developing country. *Crit Care Med* 1975; 3:166–169
67. Muyembe VM, Suleman N: Head injuries at a provincial general hospital in Kenya. *East Afr Med J* 1998; 75:364–369
68. Halpern P, Rosen B, Carasso S, et al: Intensive care in a field hospital in an urban disaster area: Lessons from the August 1999 earthquake in Turkey. *Crit Care Med* 2003; 31:1410–1414
69. Simetka O, Reilley B, Joseph M, et al: Obstetrics during Civil War: Six months on a maternal ward in Mallavi, northern Sri Lanka. *Med Confl Surviv* 2002; 18:258–270
70. Michael M: Medical supplies donated to hospitals in Bosnia and Croatia, 1994–1995. Report of a survey evaluating humanitarian aid in war. *JAMA* 1996; 276:364–368
71. Loretti A: Armed conflicts, health and health services in Africa. An epidemiological framework of reference. *Med Confl Surviv* 1997; 13:219–228
72. Andreu JM: Emergency surgery in Africa (does tropical emergency exist?). *Med Trop (Mars)* 2002; 62:242–243
73. Otu AA: Tropical surgical abdominal emergencies: Acute intestinal obstruction. *Afr J Med Sci* 1991; 20:83–88
74. Ugwu BT, Isamade ES, Isamade EI: Intraoperative cardiac arrest—A tropical experience. *West Afr J Med* 2000; 19:277–280
75. Adelman CC, Norris J: WHO, the Global Fund, and medical malpractice in malaria management. *Lancet* 2004; 363:1161
76. Petit PL, van Ginneken JK: Analysis of hospital records in four African countries; 1975–1990, with emphasis on infectious diseases. *J Trop Med Hyg* 1995; 98:217–227
77. Meyers TM, Pettifor JM, Gray GE, et al: Paediatric admissions with human immunodeficiency infection at a regional hospital in Soweto, South Africa. *J Trop Pediatr* 2000; 46:224–230
78. Savadogo LG, Ouedraogo HZ, Dramaix M, et al: Nutritional status on admission and hospital mortality under-five year old children with infectious disease in Ouagadougou, Burkina Faso. *Rev Epidemiol Sante Publique* 2002; 50:441–451
79. Arthur RR: Ebola in Africa–Discoveries in the past decade. *Euro Surveill* 2002; 7:33–36
80. Taniguchi K: Viral hemorrhagic fevers—Ebola hemorrhagic fever, Marburg virus disease, and Lassa fever. *Nippon Nakai Gakkai Zasshi* 2004; 93:2303–2308
81. Odero W, Garner P, Zwi A: Road traffic injuries in developing countries: A comprehensive review of epidemiologic studies. *Trop Med Int Health* 1997; 2:445–460
82. Mbembati NAA, Museru LM, Lisokotala: The pattern of pre-hospital fatal injuries in Dar-es-Salaam. *East Cent Afr J Surg* 1999; 5:7–10
83. Vanwersch K: Crocodile bite injury in Southern Malawi. *Trop Doct* 1998; 28:211–222
84. Jacobs G, Aeron-Thomas A: Africa Road Safety Review. Final Report. US Department of Transportation/Federal Highway Administration 2000. Available at: http://safety.fhwa.dot.gov. Accessed February 16, 2005
85. James J, Hofland HW, Borgstein ES, et al: The prevalence of HIV infection among burn patients in a burns unit in Malawi and its influence on outcome. *Burns* 2003; 29:55–60
86. World Health Organization: Maternal Mortality in 1995: Estimates developed by WHO, UNICEF, UNFPA. WHO/RHR01.9, 2001
87. [No authors listed]: Almost 9 in 10 maternal deaths could be prevented, Zimbabwe study shows. *Safe Mother* 1995; 16:10
88. [No authors listed]: Millions of women lack maternity care. *Safe Mother* 1994;14:1–2
89. Zupan J: Perinatal mortality and morbidity in developing countries. A global view. *Med Trop (Mars)* 2003; 63:366–368
90. Wasunna A, Mohammed K: Low birthweight babies: Socio-demographic and obstetric characteristics of adolescent mothers at Kenyatta National Hospital, Nairobi. *East Afr Med J* 2002; 79:543–546
91. Kambarami RA: Levels and risk factors for mortality in infants with birth weights between 500 and 1,800 grams in a developing country: A hospital based study. *Cent Afr J Med* 2002; 48:133–136
92. Sibanda EN, Stanczuk G, Kasolo F: HIV/AIDS in Central Africa: Pathogenesis, immunological and medical issues. *Int Arch Allergy Immunol* 2003; 132:183–195
93. World Health Organization: Towards the Elimination of hepatitis B: A guide to the implementation of National Immunization Progress in the Developing World. The International Task Force on hepatitis B Immunization. Geneva, WHO, 1991
94. Luo C, Brabin BJ, Bunn J: Paediatrics in the tropics. *In:* Manson's Tropical Diseases. Cook GC, Zumla A (Eds). Saunders, 2003, pp 467–484
95. Nolan T, Angos P, Cunha AJLA, et al: Quality of hospital care for seriously ill children in less-developed countries. *Lancet* 2001; 357:106–110
96. Simoes EA, Peterson S, Gamatie Y, et al: Management of severely ill children at first-level health facilities in sub-Saharan Africa when referral is difficult. *Bull World Health Organ* 2003; 81:522–531
97. Menge I, Esamai F, van Reken D, et al: Paediatric morbidity and mortality at the Eldoret De Hospital, Kenya. *East Afr Med J* 1995; 72:165–169
98. Campbell JD, Sow SO, Levine MM, et al: The causes of hospital admission and death among children in Bamako, Mali. *J Trop Pediatr* 2004; 50:158–163
99. Robbie A: Emergency medicine in China: Redefining a specialty. *J Emerg Med* 2001; 21:197–207
100. Bickler SW, Kyambi J, Rode H: Pediatric surgery in sub-Saharan Africa. *Pediatr Surg Int* 2001; 17:442–447
101. Buor D: Analysing the primacy of distance in

the utilization of health services in the Ahafo-Ano South district, Ghana. *Int J Health Plann Manage* 2003; 18:293–311
102. Ka Sall B, Kane O, Diouf E, et al: Emergencies at a hospital centre and university in a tropical area. An anesthesiologist's point of view. *Med Trop (Mars)* 2002; 62:247–250
103. Otu AA: Tropical surgical abdominal emergencies: Acute appendicitis. *Trop Geogr Med* 1989; 41:118–122
104. Orji EO, Ogunlola IO, Onwudiegwu U: Brought-in maternal deaths in south-west Nigeria. *J Obstet Gynecol* 2002; 22:385–388
105. Forjuoh S, Mock CN, Freidman D, et al: Transport of the injured to hospitals in Ghana: The need to strengthen the practice of trauma care. *Prehosp Immediate Care* 1999; 3:66–70
106. Thomson N: Emergency medical services in Zimbabwe. *Resuscitation* 2005; 65:15–19
107. Mock CN, Tiska M, Adu-Ampofo M, et al: Improvements in prehospital trauma care in an African country with no formal emergency medical services. *J Trauma* 2002; 53:90–97
108. Ramalanjaona G: Profile of the prehospital system in Madagascar. *Prehosp Emerg Care* 2001; 5:317–321
109. Bernstein JA, Stibich MA, LeBaron S: Use of traditional medicine in Mongolia: A survey. *Complement Ther Med* 2002; 10:42–45
110. Shiferaw T: Illness burden and use of health services in a rural community, Southwestern Ethiopia. *East Afr Med J* 1993; 70: 717–720
111. Oskowitz B: Bridging the communication gap between traditional healers and nurses. *Nursing RSA* 1991; 6:20–22
112. Tagwireyi D, Ball DE, Nhachi CF: Traditional medicine poisoning in Zimbabwe: Clinical presentation and management in adults. *Hum Exp Toxicol* 2002;21:579–586