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MOBILE HEALTH SERVICES FOR HIV SCREENING AND CARE IN RESOURCE-CONSTRAINED SETTINGS

F. X. MBOPI-KEOU, S. M. CROWE, G. C. M. KALLA, M. A. SOSSO, S. MBOUP and L. BÉLEC

ABSTRACT

***Objective*: This review paper aims at demonstrating that mobile health services for HIV infection in resource-constrained countries may be particularly useful for HIV screening and treatment of HIV disease and associated co-morbidities, especially for people who have limited access to fixed health facilities, including remote or nomadic populations and socially marginalised people.**
***Data source*: PubMed database was used to retrieve appropriate literature related to the following MeSH terms: HIV, testing, counselling, mobile counselling and testing, routine offer of counselling and testing, provider-initiated testing and counselling, home-based counselling and testing, decentralisation.**
***Study selection:* All articles that met these inclusion criteria and described work conducted in sub-Saharan Africa were considered. Articles were reviewed for information pertaining to mobile health facilities in the field of HIV infection. We also reviewed available articles describing alternative approaches to HIV screening and care delivery in resource-limited settings without time period restrictions up to December 2015.**
***Data synthesis*: Data collected were analysed and the results related to the aim of the study.**
***Conclusions*: The development of mobile services has benefitted from the simplification of laboratory tests, including reliable rapid diagnostic tests for HIV, and "point of care" ("POC") tests for CD4 enumeration. The mobile strategy aims to reach more patients, particularly those living in remote areas, to reduce loss-to-follow-up, and to improve patient outcomes. With a reduction in HIV-related stigma and associated discrimination by using these services, the mobile strategy may assist decentralisation of programs devoted to HIV screening, anti-retroviral treatment and HIV care.**

INTRODUCTION

The structure of health laboratories defined by the World Health Organisation (WHO) in Maputo did not acknowledge the role of mobile laboratory facilities (1). However, it now seems increasingly clear that there is a place for mobile screening units for detection and management of many diseases, including infectious diseases. Remote or nomadic populations, as well as impermanent and / or socially marginalised populations (clandestine prostitutes, gay people or bi-sexual men) may not or have limited access to fixed health facilities. One solution, tried and tested for close to a century, is to establish mobile medical units in addition to fixed medical facilities. These require health care worker to go to the patient, not the reverse.

The pioneers of mobile health were medically qualified soldiers who, by nature of their work, had adjusted to live and practice medicine in the precarious environments of potential combat. During the French Revolutionary and Napoleonic wars, delivery of local health care was conceived and developed by two military surgeons. In 1973 Baron Dominique Larrey provided medical and surgical treatment to the injured on the battle-field using his

surgical antennae (termed "flying ambulances") (2). Baron Pierre-François Percy invented a rapid transit system or "würst", an ambulance trolley of nurses and medical officers, equipped with tools adapted for prompt surgical care on the battlefield (3). Later on, the US army established mobile army surgical hospitals during the Korean War, similarly aimed at providing medical care at the front lines of fighting (4). These experiences have been exploited by all modern armies in more technologically advanced forms (mobile hospitals, mobile clinics, mobile units), and can be observed during the deployment of peacekeeping or humanitarian operations forces. "Mobile" health care also takes its origins from public health efforts to control major endemics, particularly in sub-Saharan Africa, during the colonial period. Doctor Eugene Jamot, a colonial army physician, was responsible for the success of large-scale implementation of "mobile health" techniques against sleeping sickness (human African trypanosomiasis) (5). For twenty years, examples of mobile health unit expansion have been reported in sub-Saharan Africa, providing ophthalmologic services (6) and minor surgery (harelip, fistula) (7). A hospital ship operates on the coast of West Africa (8). Furthermore, mobile units have also proven useful testing for HIV infection (9-10) and for antiretroviral treatment and monitoring (11).

The infrastructure and logistics associated with establishing and maintaining a mobile health unit requires meticulous organisation. Apart from the physical basics of rolling pharmaceutical stock, tent/tarpaulin, water and electricity, the success of these units depends upon the assembly of a committed health care team including medical, nursing and technical staff, as well as support from community stakeholders. Mobile services include laboratory tests with portable analyzers and sample transportation with possibly a cold chain. Mobile screening units have greatly benefited from the ongoing simplification of laboratory tests, including reliable rapid diagnostic tests for HIV, and more recently, "point of care" ("POC") tests for CD4 counting (12).

Challenges of delivering HIV care in resource-limited settings: who is the target of mobile health services? Loss-to-follow-up of HIV-infected individuals living in remote parts of resource-limited countries is a major cause of lack of appropriate care, late initiation and discontinuation of combination antiretroviral treatment (cART), as well as continuing mortality (13-14).The issue of centralised *versus* decentralised health facilities for HIV screening and care has led to the implementation of mobile health facilities in resource-constrained settings. Successful scale-up of cART depends on the ability to decentralise care and deliver affordable health services closer to patients and the community that would include provision of primary health care (15-18). Local delivery of health care aims not only to reach more patients, but also to improve patient outcome, through prompt initiation and higher rates of retention on cART (19) and maintenance of virological suppression (20-24). Similarly, decentralisation of laboratory monitoring, typically conducted at district or central laboratories remote from primary health care settings, is critical to this approach. Some tests, such as HIV viral load assays, are often not accessible outside of central reference laboratories. Other tests, such as CD4 counting, may be accessible at district or regional laboratories, but many factors can hamper their implementation, including lack of equipment maintenance, reliable electricity, supply chain management, and quality assurance, as well as insufficiently trained personnel and inadequate transport for sending samples to and test results back from the laboratory. Patients are often required to make several clinic visits to complete the testing and evaluation process, so test results may take days or weeks to return. Lack of adequate laboratory infrastructure remains a significant impediment to initiation and monitoring of cART and mother-to-child transmission prevention interventions in many resource-limited settings (25). As transport costs and related logistical challenges are significant causes of loss-to-follow-up (26-27), tests conducted closer to the patient and ideally at point of care should improve retention and treatment success.

Remote populations, particularly indigenous people, face some of the heaviest burdens of ill health (28-29) and higher vulnerability resulting from a range of factors including stigmatisation, structural racism, poverty, discrimination and individual/community disempowerment (29-30). Many indigenous populations live in rural or remote areas and geographical distance, sometimes compounded with seasonal isolation, can limit their ability to reach health care services.

The relationship between poverty and risk of HIV infection is well recognised; those living in poverty are far less likely to have access to education, health care and food security, compounded by having limited means for income generation. HIV-positive status can further exacerbate these circumstances, creating a vicious cycle with further negative impacts on health (31). In Africa, extreme poverty is a critical contributing factor to the HIV epidemic. For example, in Uganda, the poorest households are more likely to be HIV-positive rather than wealthier households (31).

Categories of mobile health services: Table I shows the resources and capabilities of fixed and mobile laboratory infrastructure facilities in the developing world. Fixed laboratory infrastructure relates to the classification of Maputo (1), including reference

laboratory, regional laboratory (or provincial), district laboratory and laboratory of primary health centers, integrated within a national laboratory network. Mobile services include units for sample collection, screening and treatment. Mobile units allow processing of blood samples, for example, dried blood spot preparation, centrifugation, aliquoting and observance of a cold chain if necessary, including processing and transport of frozen samples for HIV viral load testing to a central laboratory.

The mobile health service laboratory: laboratory infrastructure, quality management, Screening and monitoring HIV infection: Both screening and care activities may be provided through mobile health services. Screening for HIV infection may be supplemented by screening for tuberculosis and sexually transmitted infections, important for both individual health and epidemiological reasons. HIV care is enhanced by the provision of general medical services (for example, cardiovascular health) and simple laboratory tests (for example, intestinal parasites, malaria, community infections and others.). Thus, mobile health services can readily facilitate adoption of the 2013-revised WHO guidelines for scaling-up antiretroviral treatment in adults and children living in resource-limited settings emphasizes the need of laboratory monitoring, specifically CD4 count to guide initiation of cART and, in the absence of HIV viral load testing, to monitor response to treatment (32). It is also essential for mobile health units to participate in external quality assurance programs and meet national or international levels.

Access to clean water, preferably distilled water, and electricity (through batteries, generator and/or solar panels) is critical. Managing waste, particularly infectious waste that must be stored in appropriate biohazard containers and appropriately destroyed, is mandatory and a challenge for mobile units. Many patients in resource-limited settings are lost to care after HIV diagnosis before receiving their CD4 results. As highlighted in a recent systematic review (33), only about one half of persons who test positive for HIV in various care programs in sub-Saharan Africa had documentation of CD4 testing and receipt of results, and less than 20% of persons were retained from a positive HIV test through disease staging and cART initiation (if eligible).

Rapid or POC testing may circumvent several of the challenges associated with blood having to be sent from remote clinics to regional or reference laboratory facilities for testing. Rapid tests generally have been defined as tests that give a result during the clinic visit, preferably in less than thirty minutes. POC tests must be simple so they can be performed in any health care settings, especially primary health care clinics, requiring minimal staff training. The POC tests would preferably meet the WHO's "ASSURED" criteria, being "*Affordable, Sensitive, Specific, User-friendly (simple to perform in a few steps with minimal training), Robust/Rapid, Equipment-free (or small equipment that is solar- or battery-powered), and Deliverable to those who need the test*" (34).

Rapid tests are particularly useful for serological diagnosis of HIV infection. The strategy generally recommended by the WHO is the use of two serial rapid tests in settings where the prevalence is higher than 5% and three serial tests where the prevalence is less than 5% (35). This strategy must be carefully validated in the field, and have a sensitivity and specificity greater than 99% (35). Since most rapid test kits do not have internal quality controls and are commonly used outside traditional laboratory settings, participation in quality assurance programs is needed to ensure reliable results.

Amongst POC CD4 enumerator currently available we have the robust single-platform Muse® Auto CD4/CD4% Assay (Merck Life Sciences, KGaA, Darmstadt, Germany) (36) and the Alere Pima™ CD4 analyzer (Alere, Jena, Germany) (37-40). Several other POC CD4 testing options are undergoing validation, such as the Visitect CD4 developed by Burnet Institute (and licensed to Omega Diagnostics, UK). Visitect™ CD4 does not require any instrumentation. POC CD4 testing is one of the few interventions that has been demonstrated to increase retention in care and rates of cART initiation among treatment-eligible patients (41). A POC system for measuring HIV viral load is in development (12).

As an alternative to POC CD4 testing a number of cost-efficient and technically less complex analyzers using flow cytometry-based technology have been developed (12, 42-44) and may be appropriate for use within a mobile health unit [11]. Their robustness and reliability after long-distance transport should be ensured and regular validation of their results should be obtained through comparison to results from duplicate samples sent to a fixed laboratory structure. These include the mini flow cytometer Auto 40 (Apogee Flow Systems Ltd, Hemel Hempstead, UK; www. ApogeeFlow.com) (11, 45), and the CyFlow Counter (Partec GmbH, Münster, Germany) using lyophilized reagents (46). The use of heat-thermoresistant reagents may be particularly useful in tropical areas (47-49).

Screening for sexually transmitted infections. In many countries with a high burden of sexually transmitted infections, laboratory services for screening are too expensive, or not available or of limited availability (50). A recent study in Guatemala demonstrated that the use of a mobile van for screening for HIV and other sexually transmitted infections is effective at reaching at-risk populations (51). In Peru, a recent multicomponent community-randomised controlled

trial aimed at preventing sexually transmitted infections in urban communities (Peru PREVEN) used mobile teams and laboratory support systems in intervention cities to deliver clinical and preventive services to female sex workers (FSWs) (52). Each mobile team was made up of a nurse or midwife and a FSW peer educator. Mobile teams' activities included two visits to each sex venue during each of 20 cycles (each cycle lasting 8 weeks) to provide periodic presumptive treatment with metronidazole for trichomoniasis and bacterial vaginosis to FSWs who were not pregnant or breastfeeding, and willing to forego alcohol consumption for 72 hours. Self-obtained vaginal swabs were collected for local *Trichomonas vaginalis* culture and for nucleic acid amplification in Lima for *Neisseria gonorrhoeae* and *Chlamydia trachomatis*. The teams returned 1 week later, providing test results and treatment for specific infections identified (ciprofloxacin for gonorrhoea, azithromycin for chlamydia, and metronidazole for positive *T. vaginalis* cultures not treated a week earlier). FSWs were also encouraged to visit local government clinics for periodic syphilis and HIV testing. Finally, syndromic management of sexually transmitted infections, presumptive treatment for trichomoniasis, and condom promotion was demonstrated to reduce the composite prevalence of any of the four curable sexually transmitted infections investigated in this trial (52).

Screening for tuberculosis. Recent development in screening for tuberculosis using low-cost, POC tests, such as for antigen detection, could allow increasing the screening of bacillus patients and have them referred to the nearest antituberculosis centre for therapeutic management, thereby interrupting the transmission chain in the geographical area, and facilitating the tracking of contacts of infected persons (53-54). Recent studies have demonstrated that mobile active tuberculosis case finding in deprived populations with a high burden of HIV and tuberculosis is feasible, and results in treatment success (55).

Lessons learned: The Cameroonese, the Senegalese and the Zambian experiences with HIV mobile units. Task shifting of cART services to mobile health services has been shown to be possible and effective, but can place additional strain on the workloads of nurses and other healthcare workers that may be unsustainable.

The Cameroonese experience. With the aim of increasing the number of individuals tested for HIV and enhancing cART scale-up, a strategy based on bringing healthcare closer to hard-to-reach populations by using mobile HIV testing units has been in use since 2005 (9). This pilot programme in the Central African region clearly demonstrated the acceptability, feasibility and effectiveness of using mobile units as a means for mass HIV testing in individuals with limited access to voluntary counseling and testing (9). The National Public Health Laboratory "Hygiene Mobile" acquired a 7.5-meter long van comprising seats for the driver and medical team, and adapted the back seats for providing laboratory facilities. HIV testing was conducted using two rapid tests in series using the WHO recommended alternative algorithms II (56). Since its implementation, twelve vans are now operational and 186 villages have been reached (with 62 villages covered more than once) (Figure 1). Up to the end of 2012, 157,560 people have undergone testing for HIV. Of these, 9,555 (6.1%) were found infected, and have been referred to district medical centers to receive treatment.

Successful HIV testing with mobile units was unexpected in Cameroon (9), given the resistance and sociocultural impediments in Central Africa to HIV testing, arising from HIV stigma and discrimination (33, 57). The success suggests that the traditional drawbacks to HIV testing in Africa are reducing, and the offer of HIV testing coupled with appropriate counseling is beginning to be accepted by the

population (9).

Table 1

Resources and capabilities of fixed and mobile laboratory infrastructure facilities in the developing world

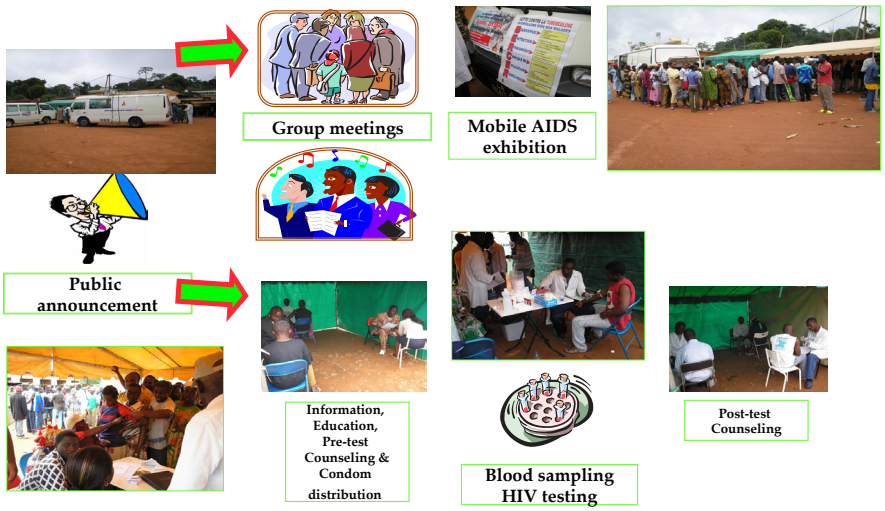
	Laboratory facilities	Specialised biology	Routine classical biology	Biology with rapid diagnostic tests**	Biology with point-of-care tests**	Quality assurance / Quality control	Health care setting (personnel)	Resources and capabilities
Fixed	Reference (IV*)	Yes	Yes	Yes	Possible	Yes/Yes	Capital or major cities (biologists, engineers, technicians)	Completion of laboratory tests using the techniques of reference validation kits, laboratory path of ISO 15189 Accreditation, available water, including distilled water, electricity available with inverters, drives the "national network of laboratories"
	Regional level (III*)	No	Yes	Yes	Yes	Yes/Yes	Provincial urban hospitals and health clinics (biologists, engineers, technicians)	Completion of laboratory tests according to algorithms validated by the reference laboratory, available water, including distilled water included, electricity available with an energy inverter
	District level (II*)	No	Possible	Yes	Yes	Yes/Yes	Hospital and health clinics (engineers, technicians)	Dependable electricity and clean water available; trained personnel available; dedicated laboratory space; cold storage available; room temperature sometimes controlled; venipuncture routine; sputum acceptable (except children); time to answer usually less crucial with hospitalized patients, but still important for clinic patients; physician oversight routine.
	Community level (I*)	No	No	Possible	Yes	Yes/No	In the community (technicians, or other health-care worker)	No reliable electricity and clean water; minimal trained personnel; no or minimal laboratory space; cold storage occasionally available; room temperature rarely controlled; venipuncture unlikely; sputum difficult to process; rapid answer required to prescribe treatment before patients leave; no physician oversight.
Mobile	Sample transportation	NA	NA	NA	NA	Yes/No	Logistician (driver); technician	Several storage temperatures of samples (room temperature 4-8 ° C - 20 ° C -80 ° C), depending on usage
	Screening unit	No	No	Yes	Yes	Yes/No	Mobile Team: logistician (driver), counselors, social and community workers; samplers / nursing, senior laboratory technician, supervision by a biologist	Water in tank built into container; supplies stored in durable plastic containers and transported to site via container; two counseling rooms built into container, tents pitched; rooms are private, equipped with curtains; tents zip closed; laboratories facilities for screening according to medical purposes (HIV; sexually transmitted infections; malaria; tuberculosis); medicines for syndromic or etiological approach
	Screening and care mobile unit	No	Possible	Yes	Yes	Yes/No	Idem	Idem; in addition: CD4 count (classic transportable) or point-of-care, antiretroviral drugs, antibiotics like Bactrim®

* Classification of laboratory levels according to the Maputo World Health Organization classification (WHO, 2008);
** Rapid tests are defined as tests that give a result in < 30 minutes;
*** POC tests are defined as tests that are simple and can be performed at all health care settings, especially at primary health care settings, with minimal training and no equipment (or small equipment eg solar- or battery- powered).

NA: Not applicable

Figure 1

Voluntary mobile HIV counseling and testing campaign in the North-West region of Cameroon



The Senegalese experience. In Senegal, voluntary counseling and testing have become an essential component in the fight against HIV. Until 2004, only about 80,000 people were screened and in most cases this occurred within a few diagnostic health facilities. In 2009, mobile HIV testing units were introduced by the National Council for the Fight against AIDS to provide care to difficult-to-reach people by virtue of their occupation, or residence in places that are remote or inaccessible from health care facilities. Mobile screening unit vehicles were equipped with a mobile laboratory, comprising a car seat for collecting blood, and an area to handle samples, provide access to water, storage cupboards and a desk. In addition, the unit carried dismantled tents, folding chairs and tables for counseling. Operationally, these mobile screening units have been used during twice-yearly national campaigns with a schedule developed with regional committees collaborating with regional stakeholders. The mobile screening unit remains in each region for a week except in the south, where because of high HIV prevalence, the mobile screening unit remains for two weeks. The selection of sites is based on accessibility to the test population. Mobile screening units are placed in popular weekly markets to increase access by remote populations. Since the introduction of mobile screening units, more than 200,000 people have been screened annually in Senegal, with over 20% screened by these units. These mobile screening units have improved the proportion of people aged 15-49 years who received an HIV test in the last 12 months and know their test status. This indicator increased from 1.5% in 2005 to 12.6% in 2010. Subsequently, these persons have received treatment.

The Zambian experience. Mobile health units have been used to expand access to cART to remote populations in Zambia. Presumably through reducing the long distances required for patients to travel to health services, mobile screening has led to increase in the number of cART clients in the study district, (58). Clients found to be HIV-infected through these mobile units could be initiated on cART at an early stage of HIV disease (58). Furthermore, involvement of the community such as lay counselors and support groups increased the number of patients retained at the original site compared to hospitals (58). Thus, in Zambia, transfers and lost-to-follow-up patients at the mobile sites during the first six months of cART were less frequent, the higher retention rates (70–76%) (58) than observed in other African hospital-based services (60%) (59).

Assessment of mobile strategies for screening and management of HIV infection, HIV screening and monitoring in mobile health units. In Uganda, the AIDS Information Center, with support from Uganda Program for Human and Holistic Development

(UPHOLD)/USAID, provides mobile HIV counseling and testing services to communities that cannot easily access HIV counseling and testing from established HIV counseling and testing sites (60). The AIDS Information Center works closely with the Ministry of Health, non-governmental organizations and community-based organizations that provide related services in the local communities (61). An evaluation of the AIDS Information Center mobile van used for promoting HIV counseling and testing showed that 90% of clients were satisfied with the service (62).
In a qualitative assessment of why uptake rates had been low before mobile HIV counseling and testing in Zimbabwe, the cost of testing, the cost of transport to Harare (both less than US$1) and the time to travel to Harare were cited as considerable barriers – despite the fact that most people wanted to know their HIV status (63). Women pointed out that community-based mobile HIV counseling and testing meant that they did not have to ask men for money to go to urban testing sites, or for permission to seek HIV counseling and testing (62). Mobile HIV counseling and testing has also been pioneered in Kenya among remote populations (63) and in rural Ethiopia using home-based care providers who provide support counseling and care at community level (64). In Zimbabwe, employees were randomized to receive HIV counseling and testing either at the workplace (on-site HIV counseling and testing) or at a chain of free-standing centre (off-site HIV counseling and testing) (65). One thousand nine hundred and fifty-seven of the 3,950 employees randomized to on-site HIV counseling and testing received their HIV test results and post-test counseling (mean uptake by site: 51.1%) as opposed to 586 of the 3,532 employees allocated to off-site HIV counseling and testing (mean uptake by site: 19.2%), suggesting that convenience and accessibility are important determinants for use of community-based HIV counseling and testing (65). Previous successful experiences in South Africa (66-67) and Kenya (10) showed that mobile services for HIV screening tended to be accessed by younger people and those with newly diagnosed HIV infection a different target populations, compared to those attending fixed facilities. Adding HIV counseling and testing through mobile services mobile to existing "stand-alone" HIV screening centers may be a cost-effective for expanding HIV screening coverage and identifying HIV-infected individuals and referring patients to treatment and care (10).

Cost effectiveness of mobile health units. Monitoring of CD4 T cell count is cost-effective —and maybe cost-saving— when compared to clinical monitoring alone for determining the timing of treatment initiation, allowing cART initiation before disease progression (68-72). The issue of whether the monitoring of patients on cART with a mobile unit is a valid economic option remains unresolved. Mobile health vans are expensive,, frequently costing two to three times more per patient compared with traditional clinics (73-74). In Uganda, the mobile clinic care for provision of cART has shown to be less cost-effective than facility-based care (10-year mean costs per patient: $US3212 for facility-based care and $US4782 for mobile clinic care), but would be competitive in targeted "hard-to-reach" populations without easy access to hospital-fixed health care (75).

In conclusion, mobile HIV testing and antiretroviral treatment services, including laboratory facilities, counselors and support groups, is beneficial and effective to improve cART accessibility in remote or landlocked areas. These mobile health units could constitute a useful means to promote large-scale HIV testing and care in sub-Saharan Africa, and could be integrated into national HIV control programs (9). These mobile HIV health units may also allow for provision of additional care including tuberculosis and STI screening.

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