

## ART in South Africa: The price to pay

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### Abstract

In developing countries especially in Sub-Saharan Africa, human immunodeficiency virus (HIV) infection together with limited resources adds to the hindrances in becoming a parent. Although the South African's Bill of Rights proclaim that South Africans can "make decisions concerning reproduction"; access to and the use of Assisted Reproduction Technology (ART) are viewed in general as excessively expensive, accessible only to the privileged few. A dissection of cost-drivers within an ART laboratory, such as procedures; sperm preparations; laboratory supplies including embryo culture media and cryopreservation are discussed in the current overview. Subject to the nature of an ART practice, i.e. private vs. public/tertiary, the structure of a unit will vary with regards to patient demographics, costs and services offered. The average fees per procedure for 20 practices in the private sector in South Africa are: (i) IUI: € 542 ± €159, (ii) IVF: € 3,255 ± € 576 and (iii) ICSI: €3,302 ± € 625. Laboratory costs can contribute between 35 and 48% of ART fees payable in the private sector. Low-cost public ART services are available to citizens of the country at a few tertiary academic units. Some private practices also cater specifically for middle-income citizens. ART procedures need not be propelled towards the must-have and cannot-do without approach, but providers should also reflect on the validity of the techniques and equipment, without compromising treatment virtue.

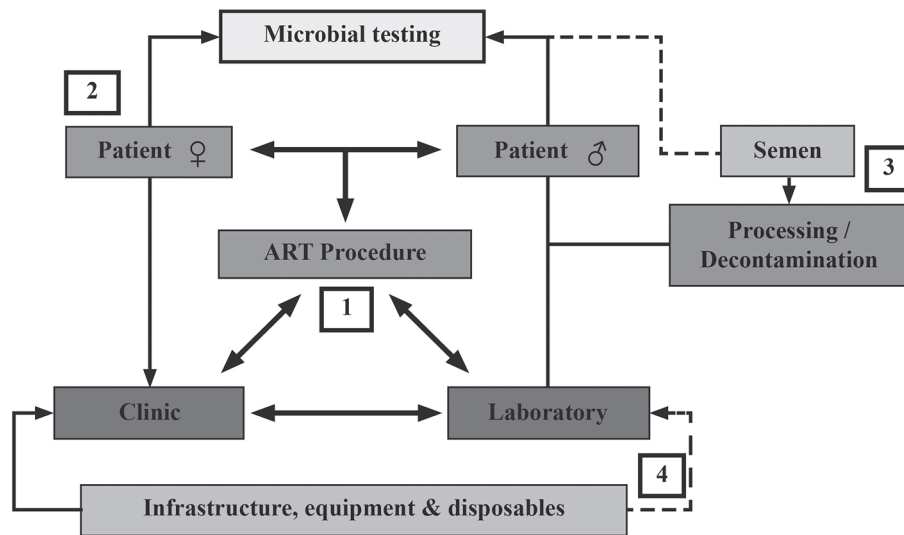
**Key words:** Affordable ART, cost-drivers, developing countries, HIV, laboratory costs, South Africa.

### Background

A couple's intentions to have a number of descendants can be thwarted in a number of ways. The most difficult of factors are those that are restrictive and outside of a couple's sphere of influence or resources. The need to have a child can be reflected in motives such as happiness, well-being (family relationships), identity, parenthood (life-fulfilment), social control and continuity (Dyer et al., 2008). Parenthood-motives may vary according to gender, societies and cultures, but neither the level of education nor wealth can substitute the inherent need for a biological child. In developing countries particularly in the Sub-Saharan African region, human immunodeficiency virus (HIV) infection together with limited resources adds to the barriers in becoming a parent. Although the South African's Bill of Rights (Constitution of the Republic of South Africa Act No 108 of 1996) decree that South

Africans can "make decisions concerning reproduction"; access to and the use of Assisted Reproduction Technology (ART) are viewed in general as prohibitively expensive and only accessible to the privileged few. Resources available in the public/tertiary ART units and to private practices and its clients, affect reproductive healthcare screening and concurrent diagnostic and therapeutic decisions which include; scheduling for intra-uterine inseminations (IUI), *in vitro* fertilization (IVF) and intracytoplasmic sperm injection (ICSI), combined with semen decontamination for HIV-seropositive males.

Several factors can impact on the financial health of an ART programme. Cost-drivers with emphasis on ART laboratory set-up and procedures in South Africa will be discussed in this review, structured on a previous examination of cost-drivers in South Africa (Huysen and Boyd, 2012), i.e. (1) ART procedures, (2) detection and prevention of infections, (3) sperm preparations, and (4) laboratory facilities,



**Fig. 1.** — Selected cost-drivers of ART programmes:

- (1) procedural factors
- (2) microbial screening
- (3) sperm preparations
- (4) facilities and supplies

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including supplies needed to perform procedures (Fig. 1). These ART elements are interrelated and underscore laboratory efficiency and repertoire.

### ART procedures

The first two tertiary ART institutions in South Africa were established in Pretoria and Cape Town in 1982 (Fourie et al., 1988; Kruger et al., 1985), with the first “test tube” babies born in 1984. Different forms of ART services are provided in the country, i.e. public service academic-centred ART units or private ventures with independent specialists utilizing office-based or corporate pathology laboratories, and larger established ART associates consisting of clinical and laboratory ART specialists. It is questionable if the current (approximately) 28 national ART service providers (cross-referenced with known providers in provinces and [www.ivf-worldwide.com](http://www.ivf-worldwide.com)) are providing an adequate reproductive health service within a nation of 52 million people with a variety of cultures and languages (<http://www.southafrica.info/about/people/population>). The speciality, repertoire and type of ART structure, i.e. private vs. public/tertiary, will impact on capacity, services offered, revenue generated and patient population of the unit. South Africa has four national tertiary ART units, situated in Cape Town (Groote Schuur and Tygerberg/Vincent Palotti, [www.aevitas.co.za](http://www.aevitas.co.za)), Bloemfontein (Femspes Group - [www.femspes.co.za](http://www.femspes.co.za)) and in Pretoria (Steve Biko Academic Hospital formerly known as

Pretoria Academic Hospital, and previously as the HF Verwoerd Hospital) (<http://www.pah.org.za/departments/endocrine.html>). Two out of the four national tertiary ART units, situated in Cape Town and Pretoria are entirely dependent on public funding.

The Reproductive and Endocrine Unit, as part of the Department of Obstetrics and Gynaecology at the University of Pretoria provides both diagnostic and therapeutic ART procedures, including semen decontamination for HIV+ patients, and general cryopreservation (Huyser and Fourie, 2010), and is an accredited training unit for clinical technologists and medical biological scientists in Reproductive Biology. The majority of patients presently attending the ART program at the Unit for diagnostic purposes are from the lower to middle income groups with an average gross household income of € 1,405 ± € 967 (<sup>1</sup>) per month. Patients that participate in an ART attempt have a slightly higher average gross household income of € 2,260 ± € 1,730 per month (random sampling of 100 non-overlapping patients from 2012 in the diagnostic and therapeutic groups, respectively).

Two different ART cost groupings, i.e. state subsidized and private patient structured categories are available at our Unit, with a third low cost option that can be accessed by both categories:

(<sup>1</sup>) All costs were obtained in ZAR, with an exchange rate of € 1 to ZAR 11, 89 (14/05/2013). All fiscals include 14% Value Added Tax (VAT).

[A] A subsidized category through state funding, for couples without medical aid and an annual income of less than € 4,205 per household; with patients contributing towards registration fees (€ 4.00 per consultation/visit), medications with partial media costs. The actual procedures will cost € 97.00 for an IUI and € 1,269.00 for IVF/ICSI in this category.

[B] A private category (including medication, clinical-, pathology- and laboratory fees) for couples with a medical aid and/or a household income above € 8,410 p.a. will be classified as “private” patients. A fee of up to € 435 (case-dependent) is payable for an IUI attempt and a maximum of € 1,830 for IVF/ICSI procedures.

[C] An affordable low cost option for IVF/ICSI is also available to patient categories [A] & [B], and is based on initiatives for accessible IVF (Ombelet and Campo, 2007; Ombelet et al., 2008; Ombelet, 2009); this includes basic medication, minimal clinical-, pathology- and laboratory fees. Approximate costs range from € 401 to € 962 (category [A] & [B] dependent) for an IVF or ICSI cycle.

Patients can select the low cost option, but need to comply with criteria based on aetiology, age and case history. Access to the subsidized category is subjected to budget allocation, and only a small number of patients qualify for a subsidy in this category per year. The patient ratio of 1:6:1 for the cost categories A to B to C, respectively in 2011-2012 (Huyser and Boyd, 2012), vs. a patient ratio of 1:4:2 for 2012- early 2013 could indicate a personal budget decline in the present time. A retrospective cost analysis in 1986 for the set-up of our ART unit indicated that the cost for an IVF cycle amounted to € 135.50 (Fourie et al., 1988).

The average cost for procedures from 20 private South African ART units (mostly from Gauteng), were obtained telephonically (in April '12 with a follow up in April '13) (Fig. 2). Total cost estimations including medications, ultrasound scans and laboratory fees were obtained for a standard IUI, IVF and ICSI procedure. In the private sector, IVF procedures increased in 2012-13 on average from 2,930 to 3,255 € with a similar trend found for the ICSI procedures. The average costs ( $\pm$  standard deviation) per procedure in the private sector are: (i) IUI: € 542  $\pm$  € 159, (ii) IVF: € 3,255  $\pm$  € 576 and (iii) ICSI: € 3,302  $\pm$  € 625. The cost for an IUI procedure can vary depending on the number of inseminations. Dyer and Kruger (2012) referred to general “out-of-pocket” costs for a standard IVF cycle of € 841 (subsidized in the public sector) and € 2,944 (within the private sector) in South Africa, which reflects the previous mentioned fee structure in 2012.

The average percentage of the major cost-drivers of an IVF cycle at an active private practice in South Africa in 2012 were the following: 8% of costs are allocated for clinic fees, 28% to medication, 29% to clinicians’ fees & consultations, and 35% for laboratory fees (for use of equipment and the laboratory, disposables, culture media and staff expenditures) (Huyser and Boyd, 2012). Interestingly, laboratory expenses accounted for 39.2% of the total IVF cycle cost at our Unit in 1986 (Fourie et al., 1988). Converting from an IVF procedure to an ICSI procedure can result in a 13% increase in cost. Items used in the laboratory can amount to nearly 48% of all costs per ICSI cycle. Approximately 70% (14 out of 20 practices) of the South African ART units that were contacted during the present study (Fig. 2) provided a singular quote for IVF/ICSI costs. IUI

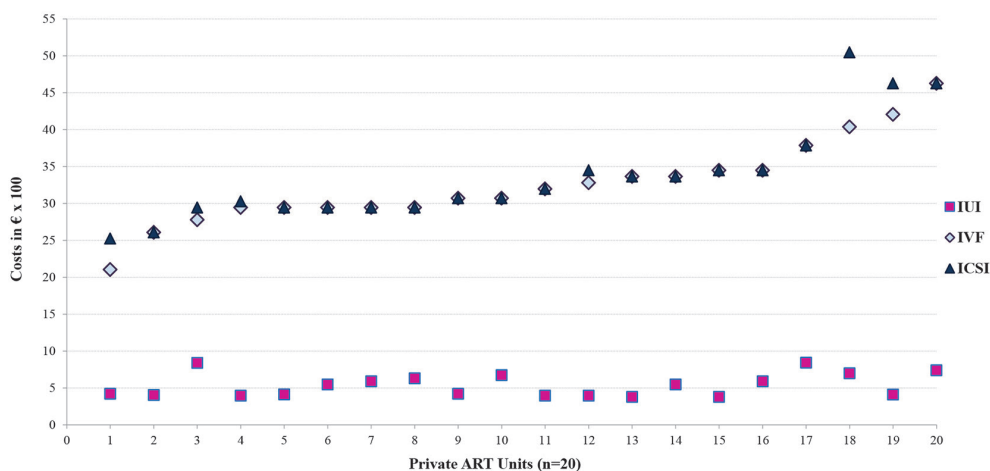


Fig. 2. — Costs appraisals for ART procedures within 20 private practice ART units (April/May 2013)

on the other hand can be viewed as the most cost-effective ART procedure (Garceau et al., 2002), and is revealed in the low comparative costs for medications, 8% of the total expenses, vs. 23-28% for an IVF or ICSI cycle (proportional data communicated by one of the largest ART units in South Africa) (Huyser and Boyd, 2012). Chambers and co-workers (2009) indicated that “the cost of (ART) treatment reflects the costliness of the underlying health-care system rather than the regulatory or funding environment”. Within South Africa, access to ART is restrictive due to limited health insurance coverage of ART procedures, restrained access to a few ART units within the public sector (Dyer and Kruger, 2012), and limited funding to public sector ART providers.

### *Screening of patients for pathogens: detection and prevention*

Funding of ART centers and treatment of infertility competes with a range of health priorities. Similar to the debate on prevention vs. treatment of infertility (Dyer and Pennings, 2010), the detection and thus prevention of pathogen transmission will be less expensive and more beneficial to a large number of people than treatment alone. Screening of the couple should however, be directed by the incidence of disease(s) in the specific patient population, medical history and physical examination of the couple (Elder et al., 2005).

With the prevalence of HIV in Sub-Saharan Africa, the question arises should all ART participants be screened/re-screened for blood borne viruses (BBV)? Correspondingly, since a variety of bacteria species are present in approximately 50% of all semen samples obtained for ART procedures, with gram-negative species present in only a fraction of samples (Fourie et al., 2012), should all semen samples be submitted for bacteriological culture and sensitivity? An answer could be prophylactic or empiric anti-microbial treatment options, with concurrent costs (Huyser and Boyd, 2012) especially in a rural setting in the absence of pathology services or due to logistical reasons.

Without a South African technical directive regarding the screening and treatment of ART patients for BBV/pathogens it is doubtful if requirements of the European Union Tissue and Cells Directives ([www.eur-lex.europa.eu](http://www.eur-lex.europa.eu)) for ART units in the EU, whereby “biological screening must be carried out at the time of donation” i.e. of sperm or oocytes, can be used as a blue print for South African ART units. The repeated screening (for HIV, HBV, HCV) of patients was probed by Wingfield and Cotell (2010), who suggested an initial baseline screening with ap-

propriate risk reduction measures to prevent cross-contaminations during an ART procedure. With rapid screening technology available at affordable costs (approximately € 1.30 per HIV rapid test) in South Africa, all ART patients could easily and repeatedly be screened prior to each ART attempt. Currently the cost for a single HIV rapid test<sup>(2)</sup> is approximately 1.5% of a RT-PCR quantitative (HIV-1 RNA) and 8% of an ELISA HIV-1 test. Rapid tests are inexpensive, simple to perform, individually packaged with a shelf-life of approximately 12 months (World Health Organization, 2004) and are well suited for resource constrained settings. Preliminary experiences in our laboratory on using rapid tests (HIV, HCV, HBV) as a first-line screening indicates that the tests are easy to execute, and takes approximately 20 minutes per test to perform. All HIV positive results were confirmed with a secondary more extensive rapid test and patients are counselled to undergo a confirmatory viral validation (preferably with CD4 and viral load analysis). No false positive or false negative results were encountered for the rapid tests up to date. Eight percent of patients that have never undergone an HIV-test previously, tested positive with the rapid tests (n = 100 individuals), with a 3:1 ratio for females to males (Stander, 2013, personnel communication).

A layered risk-reduction approach is practised at our Unit when dealing with contaminants in semen prior to an ART cycle, i.e. provide guidelines on sample collection in native languages to male patients to reduce skin contaminants; prescribe suitable treatment based on susceptible testing of semen prior to an assisted reproduction procedure (opposed to prophylactic antibiotic treatment); use semen washing/decontamination procedures combined with a physical device (e.g. the ProInsert™, [Nidacon, Sweden]) together with discontinuous density gradients to diminish microbe re-contamination (Huyser and Fourie, 2010; Fourie et al., 2012).

### *Sperm preparations*

‘Semen quality is taken as a surrogate measure of male fecundity in clinical Andrology, male fertility, reproductive toxicology, epidemiology and pregnancy risk assessments’ (Cooper et al., 2010). The

<sup>(2)</sup> HIV-1/2 Ag/Ab Combo fourth generation rapid *in vitro* immunoassay (Determine®) compared to a quantitative HIV-1 RNA reverse transcriptase polymerase chain reaction (RT-PCR, Cobas AmpliPrep-Cobas Taqman HIV-1 version 2), compared to an automated enzyme linked immunosorbent (ELISA, Abbot 4<sup>th</sup> Generation assay) test.



appropriateness of sperm preparation techniques and costs to obtain purified sperm should be considered, since the post-processed sperm sample's quality greatly governs the choice of ART procedure to follow. Also, if further washing steps after density gradient centrifugation (DGC) will be sufficient to wash sperm free of HIV.

A Cochrane based review by Boomsma et al. (2011) showed that no specific semen preparation technique (i.e. DGC; swim-up; as well as wash and centrifugation techniques) improved clinical outcome with reference to IUI procedures. The reason being that a minimum threshold of > 1 million motile spermatozoa is needed for successful conception through IUI, irrespective of the type of sperm preparation method used (Ombelet et al., 2003). This implies that basic sperm washing techniques can successfully be applied for IUI procedures. One such option is an office-based semen preparation device called SEP-D (Surelife Media Technologies (cat no: SL 001)) with a current price tag of € 23.00/device, consisting of a semen preparation kit containing a syringe pre-filled with a buffered culture media. Motile sperm is separated from seminal plasma through a direct swim-up technique, where after the motile sperm fraction is retained in approximately 300 µl medium within the device, which is then connected to an IUI catheter (€ 7.00/catheter when purchased separately, cat no: SL 002-12), and used for insemination (www.surelifeivf.com). Within the South African market the kit is promoted with IUI catheters. A couple who qualifies for an IUI procedure and resides in a rural town, could travel to a local general practitioner or clinic for repeated inseminations. Gentis and co-workers (2012) reported a good clinical outcome for IUI patients in a randomized controlled study at a South African ART unit while using the SEP-D semen processing device.

The risks associated with sperm preparation techniques should be discussed with patients (WHO, 2010; Eke and Oragwu, 2011). Data on sperm washing for HIV-seropositive patients are merely observational in nature according to a Cochrane review by Eke and Oragwu (2011). The term 'sperm washing' refers to a sequential three phase procedure, i.e. DGC, washing of the sperm pellet and swim-up step; as was initiated by Semprini and co-workers (1992) to prepare semen samples for ART from HIV-positive males. No seroconversion in treated patients or in children conceived through this procedure occurred. The bold undertaking was prior to the initiation of highly active antiretroviral treatment or validation of viral particles in the washed sperm sample (Semprini et al., 1992, 2007). This safety record is backed by published data from cen-

ters worldwide using IUI, IVF and ICSI procedures for HIV-positive males. Various factors may contribute to the lack of randomized trials in this area of ART, including HIV-regulations, inequalities in ART treatment modalities, as well as costs of sperm washing and ART procedures (with particular reference to resource-poor countries in Africa) (Eke and Oragwu, 2011).

The choice of a sperm preparation technique is however vital when processing sub-optimal semen samples for IVF or ICSI, with discontinuous DGC being the preferred method to optimize samples. Quotes for seven known brands of gradients and wash solutions were received from South African agencies in April 2013. Five of the seven brands are included in the listed culture media products (see section: Laboratory facilities, supplies and environmental aspects), together with PureSperm® media (Nidacon™, Sweden; www.nidacon.com) and Sil-Select™ (FertiPro N.V., Belgium; www.fertipro.com). A single processing (2 ml semen sample) will cost on average € 16.82 ± € 3.34 (ranging from 10.11 to 19.33 €). The price for DGC solutions increased with 7% between 2012 and 2013.

The term "sperm decontamination" was coined at our laboratory to distinguish *sperm washing* from the *decontamination procedure* used for samples possibly containing various infectious microbes e.g. bacteria, HIV, HCV and CMV (Huysier and Fourie, 2010). This involves the layering of density gradients and the semen using a ProInsert™ kit (www.tekevent.com/nidacon/proinsert), at a cost of € 10.10 for the device (cat no: NI-P115-5, Nidacon™). The kit consists of two conical tubes with two elongated pipettes and a ProInsert™ device. The purified motile sperm pellet (after centrifugation) is retrieved using the elongated pipette without re-contaminating the pellet with infectious microorganisms. A final washing step follows to get rid of density particles and a portion of the purified sperm sample can be submitted for testing (HIV-1 proviral DNA and RNA using a sensitive molecular based technique such as reverse transcription polymerase chain reaction (RT-PCR)). More than a decade of research in the treatment of HIV+ semen samples culminated in the clinical application of procedures during ART treatment of patients at our Unit. A 100% and 98.1% success rate in the removal of HIV-1 RNA and DNA respectively, is maintained for the decontamination procedure at our laboratory (n = 100 semen samples, post-processing PCR validations, 2011-2012). Since the costs of RT-PCR viral validations on purified sperm samples are expensive especially in a developing country, (€ 86.20 per test for DNA or RNA at a national pathology laboratory) the question arises if all purified sam-

ples should be tested? Due to restricted access to pathology laboratories and cost implications, only qualitative viral validations are available in most developing countries. Within South Africa, molecular viral testing is more accessible, and in our experiences up to 32% of patients with an undetectable HIV blood load can have a positive HIV-1 RNA seminal viral load (n = 100 patients). Patients are informed of the procedure failure rate, HIV-related health screening (CD4+ cell levels) and additional infectious disease tests, general risk-reduction methods, extra costs for viral validations and cryopreservation of semen samples prior to the initiation of an ART attempt (Huyser and Boyd, 2012).

Financial pressures can result in procedural shortcuts and the demand to maximize patient throughput in some private practices and laboratories offering sperm processing procedures. In the absence of national directives on the ART treatment of HIV+ patients within a developing country, best practice frameworks and directives from developed countries could be adapted and used as guidelines for assisted reproduction laboratories in the developing world.

#### *Laboratory facilities, supplies and environmental aspects*

All ART related laboratory items except for general pharmacy articles are imported from various parts of the world to South Africa. Equipment, sperm processing solutions, embryo culture media and disposables have to be couriered with concomitant imported taxes. Setting-up an ART laboratory in any part of the world depends on economics, availability and optimal maintenance of items. Procedures should be best-practice-based with reliable equipment, disposables, and techniques within a risk-reduction environment. This section will discuss the costs applicable to selected ART equipment and mainstream embryo culture media that is commercially available and currently in use within South Africa. The price tag for six different benchtop incubators and five media brands in South Africa is compared.

The costs to purchase six different benchtop incubators (listed alphabetically): i.e. **BT37**(ORIGIO/PLANER ScanLab Equipment A/S, Lyngø, Denmark; www.origio.com); **G85** and **G185** Standard (K-SYSTEMS Kivex Biotec Ltd, Birkerød, Denmark; www.k-systems.dk); **K-MINC™** -1000 (Cook®Medical, Brisbane, Australia; www.cookmedical.com), **Labo C-Top** (Labor-Technik-Göttingen, Germany; www.labotect.com); **Miri®** Multi-room Incubator for IVF (ESCO Medical, Singapore; www.medical.escoglobal.com) were obtained in South Africa and Belgium.

Table I demonstrates the South African price range from 3,769.80 to 22,763.57 € for benchtop incubators which can accommodate 8 to 48 petri dishes (35 mm Ø), respectively. The costs are VAT inclusive and may consist of installation, a start-up kit or humidification container where applicable. For more details see the individual websites. When the same incubators are purchased in Belgium, three out of the six incubators are currently between 6.59-28.69% less expensive, and three incubators are 1.44-25.98% more expensive compared to purchase prices in South Africa. The differences in cost are probably due to handling fees and company profile. A similar cost extrapolation should be applicable to all ART equipment and disposables imported into South Africa.

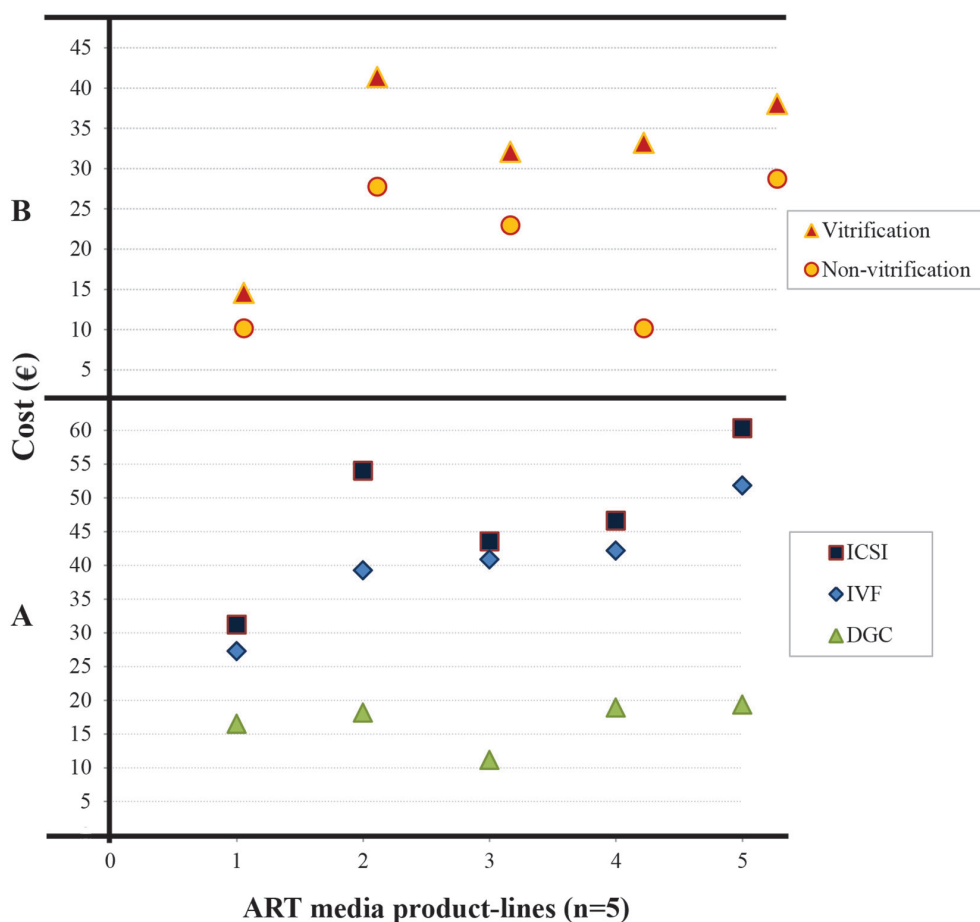
A cost analysis for the set-up of the ART programme at our Unit in the eighties, indicated that the total cost for laboratory equipment amounted to € 11,606. A single inverted microscope, two water jacketed upright incubators, a stereo as well as a light microscope, a single laminar flow and biological safety cabinet, hygrometer, dry-oven, centrifuge, refrigerator, osmometer, pH-meter and electronic balance constituted the laboratory to initiate the ART programme (Fourie et al., 1988). More than 90% of this equipment was still fully functional twenty years on (2005/6), when the laboratory moved to new purpose built laboratories within Steve Biko Academic Hospital (Pretoria, South Africa). Similar equipment to date will cost between 67,283 and 92,515 €, depending on the model size and/or brand type (Huyser and Boyd, 2012). The previously mentioned historical cost analysis article by Fourie and co-workers (1988) did not refer to a micro-manipulator (for ICSI procedures), or any cryopreservation equipment during the initiation phase of the laboratory.

Five different brands of culture media are currently used in South Africa: i.e. **Global®** media (LifeGlobal® one-step protocol; IVFonline, USA, www.lifeglobal.com), **MediCult** media (Embryo-Assist™ & BlastAssist™ two-step protocol; Origio, Denmark, www.origio.com), **Quinns Advantage®** media (Sage® media products two-step protocol; CooperSurgical, (USA, www.coopersurgical.com); SydneyIVF (K-SICM & K-SIBM two-step protocol; Cook®Medical Ireland, www.cookmedical.com); and **Vitrolife - G-series™** media (G-1™ & G-2™, two-step protocol; Scandinavia IVF Science, Göteborg, Sweden; www.vitrolife.com). Quotes for the media brands were obtained in April/May in 2013 from South African distributors. Total costs per media brand for a full ART cycle including DGC, IVF, and ICSI are indicated in Fig. 3A and for cryopreservation procedures in Fig. 3B. Costs

**Table I.** — Specifications of benchtop incubators (n = 6) and a cost comparison when purchased in South Africa or Belgium.

BENCH TOP INCUBATORS										
No.	PRODUCT FEATURES						PURCHASE COST (€)			
	Individual chambers	Number Dishes		Humidification	Input gas	Weight (kg)	South Africa (1)	Belgium (2)	% Cost difference (1) compared to (2)	
		∅ 35	∅ 65	Yes/No						Type
1	2	8	4	Yes	Glass bottle	Premixed CO <sub>2</sub>	3.5	<b>3 769.80</b>	4 591.95	-21.81%
2	2	20	8	Yes	Reusable block	Pre-mixed trigas	8.8	<b>13 359.94</b>	13 552.00	-1.44%
3	2	20	8	Yes	Disposable flask	Pre-mixed trigas	15.5	13 998.32	<b>9 982.50</b>	28.69%
4	2	20	8	Yes	Disposable flask	Pre-mixed trigas	12	<b>16 778.80</b>	21 138.70	-25.98%
5	10	40	10	No	N/A	CO <sub>2</sub> , N <sub>2</sub>	40	18 958.13	<b>17 708.35</b>	6.59%
6	6	48	24	Yes	Reservoirs	CO <sub>2</sub> , N <sub>2</sub>	35	22 763.57	<b>16 940.00</b>	25.58%

Quotes obtained April/May 2013, Exchange rate 14/05/13 **Indicates lowest price tag**



**Fig. 3.** — The costs of ART media product-lines currently in use within South Africa (April/May 2013).

were calculated per ml of medium used per patient, per cycle attempt according to laboratory protocol, with embryo culture in micro-drops under oil. A similar cost analyses were performed in 2012 (Huyser and Boyd, 2012). Culture media for an IVF procedure for six oocytes amounts to € 40.26 ± € 8.76 (ranging from 27.25 to 51.79 €) and costs approximately 15% less than media used in an ICSI procedure (mean cost of € 47.14 ± € 11.04 (ranging from 31.22 to 60.32 €)). An average annual increase of 8% in costs for IVF culture media was noted. Cryopreservation solutions for non-vitrification procedures cost on average € 19.96 ± € 9.20 (ranging from 10.18 to 28.74 €), with a 37% difference in cost for a vitrification attempt (mean cost of € 31.85 ± € 10.37 (ranging from 14.55 to 41.38 €)). An average annual increase of 7% for vitrification cryopreservation, whereas an annual average decrease of 3% for non-vitrification solutions was noted. These costs exclude the cryopreservation carriers/devices available as open or closed single-straw systems, cryo-storage tanks, or liquid nitrogen.

Courier services and/or company representatives, which manage the transport and delivery of ART culture media timeously, play a vital role in failures or successes in the ART laboratory. Durable packaging and protection of temperature sensitive culture media while in transit through developing countries are also extremely important during (occasional) protracted customs clearance, especially in summertime.

## Conclusions

The dual demand for ART in South Africa is mirrored in the provision of low cost accessible ART services to lower-income nationals including middle-income private patients in the public service. The country's foreign-exchange rate can be "two sides of the same coin"; i.e. equipment is more expensive to import than the purchase price within a confederacy, however comparative cut-rate ART costs can lure non-nationals to South Africa as a choice destination for reproductive tourism. The downturn in the global economy on the other hand has a sobering effect transnationally and should influence manufacturers of ART products to develop products that can stand the test of time. ART procedures need not be propelled towards the must-have and cannot-do-without approach, but providers should also reflect on the validity of the techniques and equipment, without compromising treatment virtue. ART treatments should be globally within the reach of a much larger part of the population.

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