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IMPROVING THE EFFICIENCY OF MONITORING ADHERENCE TO ANTIRETROVIRAL THERAPY:

A CASE STUDY OF THE INTRODUCTION OF ELECTRONIC TECHNOLOGIES IN GUGULETHU, SOUTH AFRICA

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Improving the Efficiency of Monitoring Adherence to Antiretroviral Therapy: A Case Study of the Introduction of Electronic Technologies in Gugulethu, South Africa

Abstract

This paper presents a case study of the efficiency gains resulting from the introduction of electronic technologies to monitor and support adherence to highly active antiretroviral therapy (HAART) in Gugulethu, South Africa. It suggests that the rollout of HAART to resource-poor communities can be assisted significantly by the introduction of modified cell phones (to provide home-based support to people on HAART) and simple bar-coding and scanning equipment (to manage drug supplies). The cell phones have simplified the working lives of therapeutic counsellors, allowing them to spend more time with patients and less time on administration, and enabling them to key in data directly to a database through a secure internet connection. It has helped integrate the local-level primary health service provision with the kind of centralised data capture and analysis necessary to monitor a national-level HAART rollout.

1. Introduction

AIDS is a serious problem in South Africa. As of 2005, 18.2 per cent of South African adults and 10.6 per cent of the total population was estimated to be HIV-positive (see Figure 1).[1] This has implications for South African development, although the precise economic impact of AIDS remains controversial (see, for example, Barnett and Whiteside, 2002; Bell, *et al* 2004; Young 2004; Nattrass 2004). Given the scale of human suffering entailed in the epidemic, policy-makers are forced to confront the challenge of 'rolling-out'

[1] Estimate from the ASSA 2003 model (available on www.assa.org.za/aidsmodel.asp).

highly active antiretroviral therapy (HAART) to treatment sites throughout the country – many of which are likely to be in poor communities. This has implications for the health sector in terms of drug purchases, hiring and training of new personnel, the construction of additional infrastructure and the development of testing and monitoring systems (see, for example, Abdullah (2003) and Hassan (2004) on the challenge for the South African health sector, and Over (2004) for developing countries).

The ASSA2003 model (probably optimistically) assumes that by 2008, 50 per cent of people who need HAART will be receiving it in South Africa. Although this will raise HIV prevalence in the population (relative to a no-HAART scenario – see Figure 1), this is simply because people with HIV are living longer. Indeed, the ASSA2003 model estimates that there will be *fewer* new HIV infections as a result of the rollout (see Figure 2) because people on HAART are less infectious than they would be in the absence of treatment. In other words, providing treatment to people already infected with HIV should be regarded as part of a public health AIDS prevention strategy, as well as a therapeutic intervention for the individuals concerned (Cohen and Hosseinipour, 2005).[2]

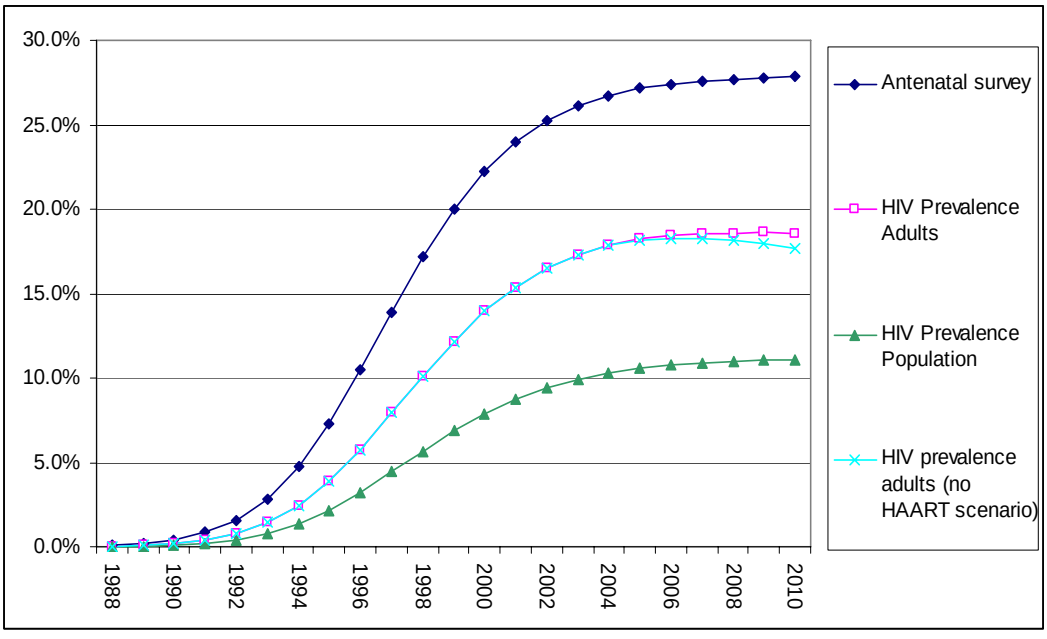

Figure 1: HIV Prevalence in South Africa (ASSA 2003 model).

However, for these preventative and therapeutic benefits to be realised, it is essential that people on HAART adhere closely to their treatment regimens (for example, Hogg *et al*, 2002). HAART patients are required to take their medications twice a day for the rest of their lives. Missed medication results in

[2] For more discussion of this issue, see Nattrass (2004).

an increase in viral load, which in turn facilitates the evolution of drug-resistant forms of HIV (Mugavero and Hicks, 2004). Not only does this have adverse implications for the health of the individual, but it threatens to undermine the public health benefits of the roll-out itself. Promoting good adherence is thus a key objective of all antiretroviral treatment sites.

In May 2001, the first South African township-based antiretroviral treatment site was opened in Khayelitsha by Medecins Sans Frontieres (MSF) in collaboration with the Western Cape Provincial Government. One of the objectives was to explore the challenges of providing HAART to people living with AIDS in a resource-poor context. The project, which included the provision of counselling and support-groups, was successful in promoting good adherence to medication, achieving good clinical outcomes and impacting positively on the lives of patients (see, for example, MSF *et al*, 2003; Coetzee and Nattrass, 2004). Since then, there has been a steady increase in the number of people accessing HAART: an estimated 86 000 people are obtaining treatment through the public sector (mostly through collaborative projects between provincial governments and donors agencies like MSF and Absolute Return for Kids); and 75 000 are obtaining it through the private sector (Hassan, 2005).

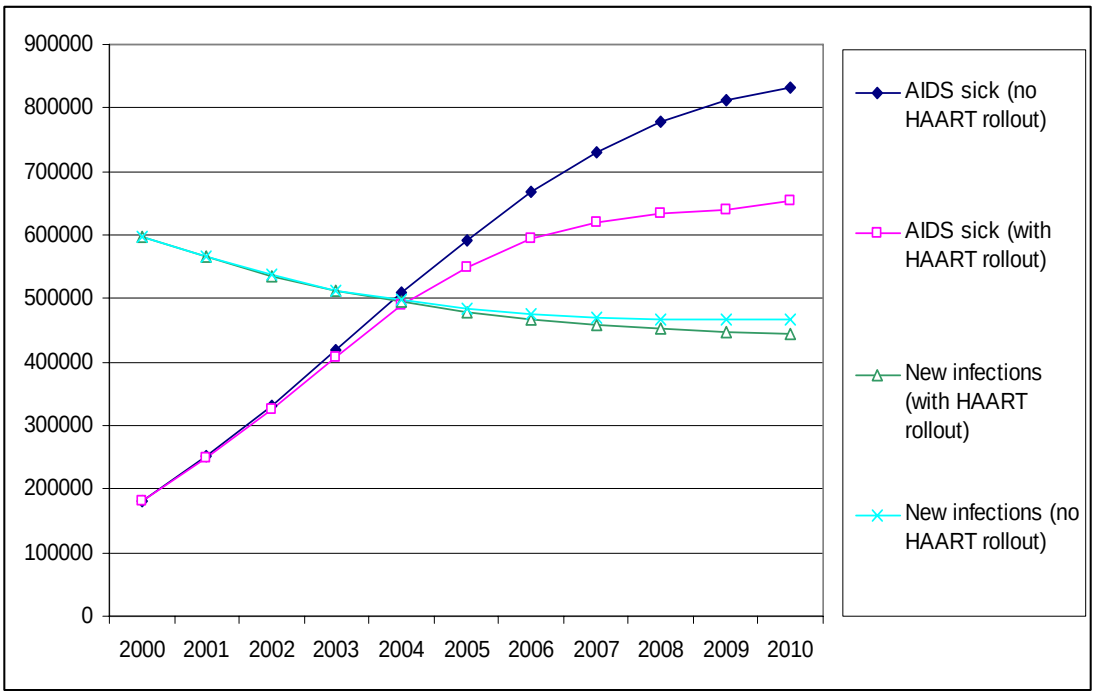

Figure 2: New Infections and number of AIDS-sick people (with and without a HAART Rollout) (ASSA2003 model)

Although this target is well short of the estimated 500 000 – 700 000 needing antiretroviral therapy, the roll-out thus far has exposed a set of challenges which require addressing if expanded access is to be possible. These include: an apparent lack of political will on the part of the national government to provide

the necessary resources to antiretroviral treatment sites (Nattrass, 2004); confusing messages from the Ministry of Health about the relative benefits of antiretroviral therapy and vitamin supplements (Hassan, 2005); the absence of a human resources strategy for the rollout and the usual concerns about the sustainability of an affordable drug supply and national capacity to conduct the necessary viral load and CD4 cell count tests. This suggests that the expansion of the number of treatment sites is likely to be slower than optimal, and that more and more pressure is likely to be placed on existing treatment sites to expand the numbers of people on antiretrovirals. In other words, the issue of *efficiency* is likely to become of central concern for existing treatment sites.

Unfortunately, there are as yet no economic studies of the efficiency gains that could result from the introduction of new technologies and management systems. Up until now, economic analyses of the provision of antiretroviral therapy have concentrated on the total and marginal costs of expanding the existing health service (see the review of economic studies in Boulle *et al*, 2003 and Wessels, 2005). Whilst these studies differ in terms of their assumptions about rationing and the cost-saving implications of HAART (in terms of fewer opportunistic infections),[3] they all assume that improved health outcomes are only possible through the expanded allocation of existing inputs, and that the relationship between these inputs and health outcomes is fixed. None of them investigates whether new ways of managing a HAART rollout at primary health-care clinic level can achieve benefits in terms of improved efficiency.

This paper explores the issue of efficiency gains through the introduction of new technologies to monitor and support adherence to antiretroviral therapy at primary health care level. As noted above, promoting good adherence is a central challenge for those providing antiretroviral therapy. For this reason, all treatment sites include clinical and various forms of psycho-social support for patients. The challenge they will all face in the future as the rollout continues, is how to provide access to more people, without compromising the quality of care – and at a lower average cost per patient on treatment.

We explore this issue by means of a case study of the Hannan Crusade Treatment Centre (HCTC) in Gugulethu – a primary health care facility and research site operated by the Desmond Tutu HIV Centre at the University of Cape Town (UCT).

The HCTC is a particularly interesting case because it introduced an electronic system based on cell-phone technology to improve the management of drug supplies and the monitoring of adherence and side-effects in patients. We argue here that although this imposed additional upfront costs, the benefits that this

[3] For example, contrast the studies by Boulle *et al* (2003) and Nattrass and Geffen (2005).

project provided in terms of greater efficiency helped facilitate the HCTC's expansion of the number of people on treatment without compromising the quality of care.[4] Indeed, there is reason to believe that the service provided to each patient improved as a consequence. The case study suggests that electronic systems can be used to good effect to link primary health-care service provision to a central database – which in turn can feed necessary information back to the clinics. In the case of the HCTC, the central database was located at UCT. However, it is a model which could easily be transferred to the public sector (if the will existed to do it).

2. Cell-phone based electronic technology at the HCTC

The HCTC began operations in September 2002 as part of a research initiative into the provision and monitoring of HAART in Gugulethu. This township, which comprises an estimated 60 000 households, dates back to 1958 when it was known as Nyanga West. Assuming that HIV prevalence in the population is similar to that amongst black South Africans in general, it is likely that about a fifth of adults in the area are HIV-positive (although clinic staff at HCTC estimate that prevalence is closer to 25 per cent – 27 per cent (Dr Catherine Orrell, 2005, interview, 30 June)). The HTCT is the only site providing HAART in Gugulethu and is currently providing treatment to over 1000 patients. It is located in the Gugulethu Community Health care centre, but operates independently of it – being linked instead to the Desmond Tutu HIV Centre at UCT. Although this is problematic at one level (because the provision of HAART is not integrated into the public sector in the same way that the MSF clinic in Khayelitsha is), it has the advantage of providing a stand-alone case study of a monitoring system which could be adopted by the public sector at a later date.

As was the case for the MSF clinic in Khayelitsha, treatment outcomes have been very positive at HCTC with average adherence rates in the range of 94-98 per cent (Orrell *et al*, 2003). Adherence support is provided to patients by 'therapeutic counsellors', that is, members of the community who are themselves HIV-positive, and who have been hired and specially trained to provide such services by the HCTC. Each patient is assigned a counsellor who helps with the initiation and continuation of treatment. One of the most

[4] The research for this paper was conducted by Xanthe Wessels (see also Wessels 2005) under the supervision of Nicoli Nattrass, and with the support of Ulrike Rivett. Quantitative and qualitative information was obtained from interviews with staff at all levels working at the HCTC, the Desmond Tutu HIV Centre, and at Cell-Life.

important functions of the therapeutic counsellors is to help monitor adherence and to look out for adverse side-effects.

The main tool for monitoring adherence at HCTC is to count the number of pills in a patient's possession (and then compare this to the number expected to be remaining if the patient had adhered completely to the treatment regimen). Every time patients come to the clinic for their monthly visit, they are required to bring their remaining tablets with them. These are then counted by the doctor during the appointment. This is the main adherence measure used by doctors on site (Catherine Orrell, 2005, interview, 30 June). The therapeutic counsellors supplement this data by making surprise visits to the homes of HAART patients and conducting pill counts in 'the field'. These, together with other information pertaining to side-effects and health problems, are noted down by the therapeutic counsellors and then relayed to a central secure database by means of a cell phone.

This innovative use of cell phone technology was pioneered by the 'Cell-Life' project which was initially conceived in the Department of Civil Engineering at the University of Cape Town.[5] The project transformed cell phones into data acquisition and transmission tools by installing menu applications directly on the SIM card of the handset. The data, once entered on the handset, are sent via a Short Messaging Service (SMS) to a central secure database.[6] The system is designed so that accredited administrative, managerial and clinical staff can access the database to retrieve patient information via a secure internet connection. Reports of relevant cohort data can also be downloaded from the website in encrypted format.

Prior to the introduction of this cell-phone based monitoring system, the process of data capture and entry was a great deal more labour-intensive. The therapeutic counsellors would note down the pill counts and other relevant information in their 'patient diaries', then they would transcribe the information onto data capture forms and deliver these to the clinic when they had the time. These forms, in turn, were then entered manually into the database by a third party at the Desmond Tutu HIV Centre at UCT. The cell phone system was designed to cut out all these stages, enabling the therapeutic counsellor to key in data directly from the patient's home to the database. However, owing to the problem of cell-phone theft, Sister Lulu Mtwisha (the supervisor of the therapeutic counsellors) advised the therapeutic counsellors not to take the cell phones with them on home visits, but rather to continue recording patient information into their diaries (Sister Lulu Mtwisha, supervisor of the therapeutic counsellors at HCTC, 2005, interview, 30 June). They then enter the data into

[5] For more information about Cell Life, see http://www.cell-life.org.
[6] See http://www.cell-life.org.

their cell phones in the evening. Despite this unanticipated crime-related glitch, the cell phone system appears to have improved the working lives of the therapeutic counsellors a great deal as the following quotes reveal:

> I would not want to work without my phone as I would have to keep my own paper records and every week I would have to submit the pieces of paper to the clinic and this is a lot of work (Flora, a therapeutic counsellor at HCTC, 2005, interview, 26 June).

> With the paper-system it is a lot of work and it is not professional. With the cell-phones you don't spend a lot of time writing down the pill counts and filling in forms (Thembekha, a therapeutic counsellor at HCTC, interview, 2005, 26 June).

Not only is the electronic system easier for the therapeutic counsellors, but it has improved the data base immensely by overcoming the problem of mislaid forms that plagued the previous paper-based system:

> Paper is something that you or your supervisor can lose and at the end of the day it appears as though you have not done your visit, as the record is lost. With the cell-phones it's much better than working on paper (*ibid)*.

> The cell-phones are much quicker and easier to use. You don't lose patient records as often and most of the information is already on the database so it is not too much of a problem if some patient data is lost (Fundi, a therapeutic counsellor at HCTC, interview, 2005, 28 June).

The introduction of the cell-phone system appears also to have reduced the administrative burden of data capture and analysis, and to have improved the flow of information to the benefit of doctors and patients alike. According to Sister Lulu Mtwisha, the electronic system is vastly superior to the old paper-based system:

> It is incomparable, the paperwork was good for that particular period, but with the advent of Cell-Life it is something that I don't wish to revisit. With the old system I would get the information a week after everything had happened. I would make the counsellors hand in the paperwork of their visits for the past week on a Monday or Tuesday. I would then bring the pile of forms back to my office at Desmond [The Desmond Tutu HIV Centre at UCT] and only when I had time would I peruse and check. I may not have noticed anything going wrong for an entire month and only at the end of the month when I could look at the data for that whole month, would I notice that a certain patient had not

> been visited. Now with the Cell-Life system I can pick this up quickly and there is really nothing that can fall off the plate without me noticing. The system allows me to prevent situations from happening rather than having to fix a situation once it has already happened. It's a form of damage control (Sister Lulu Mtwisha, supervisor of the therapeutic counsellors at HCTC, interview, 2005, 30 June).

Not only has the new system improved the monitoring of adherence, but it has also saved lives. For example, a data base administrator noticed that one of the patients was experiencing erratic and unusual symptoms. He alerted Sister Mtwisha, who in turn notified the doctor who diagnosed lactic acidosis – a potentially fatal side effect of antiretroviral therapy requiring immediate cessation of the medication. This patient owes his life to the new system which was able to collect the information needed to save him (*ibid)*.

It would thus appear incontrovertible that the electronic system has enormous benefits over the old paper-based system. It has resulted in greater efficiency in terms of time-saving for the therapeutic counsellors (and the clinic staff who were previously involved in shuffling piles of paper and searching for lost forms) and in terms of the quality of care provided to patients. But all this, of course, comes at a cost. Cell-Life estimates that the costs of implementing the system in HCTC for an average patient load of 500 (including all training, hardware, software, cell-phones and airtime to be R55 a month per therapeutic counsellor). This amounts to R450 000, which discounted over two years, results in a cost of R37.48 per patient per month.[7] The economic question that needs to be confronted is whether the improved system can be justified by the additional resources required to implement and maintain it. This is the task undertaken in Section 4 below. However, before we approach this subject, it is necessary to describe the second component of the electronic adherence monitoring system at HCTC, i.e. the antiretroviral drug dispensary and stock recording system.

[7] Data provided by Cell-Life. For more detail, see Wessels (2005).

3. Electronic antiretroviral drug dispensary and stock recording

Prior to the introduction of the electronically-based "pharmacy plan" at HCTC, all dispensary and stock recording functions were performed physically by pharmacy staff and recorded using a paper-system. Paper records indicated which patients were due for renewed dosages, drug pick-ups by patients were recorded manually, and at the end of the day the remaining drug stock was counted and recorded manually onto paper. This system was time-consuming and plagued by stock misplacement, theft and unnoticed drug expirations.

The automated pharmacy plan, which was implemented at the beginning of 2003, comprises bar-code labelling and scanning, a basic stock control system and a cellular and internet based monitoring of patient antiretroviral drug collections. This has greatly simplified supply chain management. The patient receives a prescription of drug type and dosage from the doctor, which is handed to the pharmacist at HCTC on collection of the initial treatment dose of antiretroviral therapy. The pharmacist enters the prescribed triple therapy for a particular patient into the system via the computer. Each prescription lasts six months, but drugs are dispensed in one-month dosages ensuring that the patient visits the clinic at least once a month. This periodic collection of drugs forms part of the adherence monitoring process by allowing the pharmacist to keep a record of which patients have, or have not, collected their regimens for the month.

The database provides and stores information on the exact combination of drugs that need to be packaged for each patient every month. Drugs are packaged each month at the Desmond Tutu HIV Centre and are bar coded.[8] The bar code system is used both for stock recording and for patient collection record purposes. When drugs are scanned out, the bar code system records a set of information indicating that the drugs have left the Desmond Tutu HIV Centre. This system notifies management of the specific drug type, the quantum, and the patient label for whom the drugs are intended. On arrival at the HCTC, the drugs are scanned into the system for stock recording, and simultaneously, the Desmond Tutu HIV Centre is notified over the network that the drugs have arrived safely at the clinic. When the patient arrives to collect a month's supply of drugs, the system identifies the triple therapy required for that patient; the correct stock is taken off the shelves and scanned out of the clinic. The bar code scanning process concurrently records the stock supply reduction and the fact that a certain patient has collected his or her prescription. This simultaneously notifies the pharmacist at the Desmond Tutu Centre that the patient's pill pack

[8] The previous system outsourced pill packaging to an external company.

for the subsequent month can be packaged. Barcode scanning thus ensures a continuous feedback process allowing the drugs to be tracked down at any location, at any time. As Jalal Ghiassi-Razavi, the Systems Support Manager at Cell-Life, puts it, "a great benefit of the system is that just like a DHL package you can track it and know exactly where it is" (Jalal Ghiassi-Razavi the Systems Support Manager at Cell-Life, interview, 2005, 2 July).

Since the implementation of the pharmacy plan, the various functions of the pharmacist have been greatly simplified and organised into a single system whereby stock recording, collection recording and adherence monitoring are all performed simultaneously. Jalal Ghiassi-Razavi explains:

> The system has made her [the pharmacist] life a lot easier, she currently has over 1000 patients on the system and I wonder how she would have managed this on paper. When we started there were about 500 patients, even less, on the pharmacy system and now we have a massive database (*ibid).*

While the pharmacy plan has contributed significantly to solving the previous difficulties experienced in the paper-based stock management and drug dispensary processes, it has the disadvantage of implementation and maintenance costs. Cell–Life estimates a total (appropriately discounted) cost of the system to be R32.00 per patient per month (assuming a patient load of 500). These costs are inclusive of design and development, implementation, training and testing, and maintenance per annum (see Wessels, 2005 for more details).[9]

The pharmacy and cell-phone systems monitor adherence by functioning interactively. The pills issued to the patient by the pharmacy are recorded on collection onto the database, and the surprise pill counts performed in the field are sent over the network onto the same database. The two measures are directly comparable and complement each other. If a patient who is due to collect his or her treatment has not arrived in a week, this is identified on the system and a counsellor will be sent out to locate the client. Discontinuation of treatment is thus prevented.

Furthermore, the possibility of issuing the incorrect drugs to clients is significantly reduced – as is the danger of issuing drugs that have passed their expiry date to patients. Expiry dates on drugs are recorded and pharmacy staff are automatically notified when the expiry date of a certain batch of drugs is

[9] In addition, the Desmond Tutu HIV Centre is now responsible for packaging the drugs (when previously they had been outsourced). For the purposes of this analysis, we assume that the additional costs for the Desmond Tutu Centre are equivalent to the previous costs of the outsourcing.

imminent. More importantly, the system enables management to make decisions regarding drug type and manufacturers. For example, the database will allow management to identify if certain drug batches are resulting in similar side effects (such as Nevirapine rashes) or whether clients who have been issued with a specific drug experience similar symptoms. The system operates to single out these drugs enabling management to make more reliable decisions in terms of drug quality.

In short, it appears that there are clear benefits for management of drug supplies, for adherence monitoring and for monitoring side effects and other health related events amongst patients. As was the case with the introduction of cell-phone technology to assist with the monitoring of adherence by therapeutic counsellors, the economic question that needs to be posed is whether these benefits are sufficient to justify the increased costs. Section 4 below considers this issue with regard to the introduction of both the electronic supply management system and the cell-phone monitoring system.

4. Exploring the nature of improved efficiency

In economics, the concept of efficiency relates specifically to the relationship between inputs and output: if the ratio of inputs to output falls, then greater efficiency has been achieved. Put differently, improvements in efficiency occur when a greater output is achieved for a similar level of inputs – or if the same amount of output is achieved for a lower level of inputs. The tricky issue when thinking about improved efficiency in the provision of health care is how to measure inputs and outputs and conceptualise the relationship between them. For example, if the relevant 'input' is staff hours per patient and the relevant output is 'patient care', then efficiency can be said to increase if either the same quality of care is provided for a lower number of hours, or if an improved quality of care is produced using the same labour effort. But in this regard, the notion of 'quality of care' is extremely difficult to measure as it is a function of the number of hours in the company of doctors, nurses and counsellor, the skills and dedication of such personnel, and of the support systems they are provided with. Understanding efficiency in this context thus requires both qualitative and quantitative analysis.

With regard to the HCTC case study, interviews with key players suggest very strongly that the introduction of the electronic systems has improved two outputs: adherence data and quality of care for patients. This is clearest with regard to the pharmacy plan, which appears to have improved managerial efficiency at the level of the clinic, to have provided supplementary data on adherence to the patient database, and to have provided a better and safer service

for patients. The overall impact on quality of care with regard to the introduction of the cell-phone system is less clear. Although there are strong indications that it has improved the quality of adherence data, reduced the administrative burden on therapeutic counsellors, and improved the management of health-related information for the benefit of patients, we need to consider the rising burden of care being placed on the therapeutic counsellors as the rollout progresses. It may well be that the cell phone technology has important benefits – but if these are overwhelmed by rising patient numbers per counsellor, then the overall implications for the quality of care per patient is moot.

Table 1 provides some indicative hourly and costing data on this issue.[10] It shows that between November 2002 and November 2004, the numbers of people on antiretroviral therapy rose sharply from 44 to 437. Although there was a significant expansion in all categories of staff at HCTC, this was not sufficient to prevent a decline in the ratio of clinic staff to HAART patients. Whilst this is not necessarily a problem because one would expect an antiretroviral treatment site to start operations with significant excess capacity (particularly with regard to doctors and nurses), the trend is more worrying with regard to therapeutic counsellors (whose employment one would expect to be more closely correlated with the numbers of patients on HAART). As can be seen from the table, the number of patients per therapeutic counsellor rose from 5.5 to 15.6 over the period.

The immediate issue posed by these figures is whether the therapeutic counsellors, despite the advantages provided to them by the cell-phones, have been swamped by the demands imposed on them by the increased number of people on HAART. However, according to interviews conducted with the therapeutic counsellors, each patient continues to receive the same amount of attention (Wessels, 2005). The therapeutic counsellors seem to have been able to find the extra time to devote to the higher number of patients by spending less time on administration and data recording. When asked whether the cell phone enabled the therapeutic counsellors to spend less time with each patient, one of them replied sharply “No, because my cell-phone does not have wheels” (Flora, a therapeutic counsellor at HCTC, interview, 2005, 26 June). Rather, the advantage of the cell phones (as discussed in Section 2) appears to have been to reduce the amount of time counsellors were forced to spend recording and entering data.

[10] The analysis reported in Table 1 differs from Wessels (2005) in that it assumes that all categories of staff are working full-time on the antiretroviral treatment programme. Wessels (2005) allows for small differences in the numbers of hours which affects the point estimates, but not the overall result.

Table 1: Key Input Indicators, November 2002 – November 2004

	November 2002	*November 2004*
Number of patients	44	437
Number of doctors	1	4
Number of nurses	2	3
Number of counsellors	8	28
Administrative staff	2	4
Total staff	13	39
Total staff per ARV patient	0.3	0.1
Number of patients per therapeutic counsellor	5.5	15.6
If each patient is visited once a week for one and a half hours (including travel), % of time spent by therapeutic counsellors visiting patients	20%	60%
% of time used by therapeutic counsellors for administration, data entry etc	80%	40%
Monthly cost of the pharmacy plan (R32 per ARV patient) – data from Cell-Life		R13,984
Monthly cost of the cell phone adherence system (R37.48 per ARV patient) – data from Cell-Life		R16,378
Indicative monthly salary bill (in 2005 prices)*		
Therapeutic counsellors	R29,280	R102,480
Total salary bill (i.e. including doctors, nurses, administrative staff and therapeutic counsellors) at HTCT	R120,054	R322,095
Salary bill for therapeutic counsellors plus cost of the cell phone adherence system	R29,280	R118,859
Salary bill for therapeutic counsellors plus the cost of the cell phone adherence system per ARV patient	R666	R272
Total salary bill plus costs of electronic system	R120,054	R352,458
Total salary bill plus costs of electronic system per ARV patient	R2,729	R807

* These are not actual salaries from HCTC. They are indicative salaries based on the average cost estimates for 2001 provided in Geffen *et al* (2003), inflated by 10% per annum to provide a 2005 figure.

Table 1 reports that if we assume that patients are indeed enjoying the same amount of time with the therapeutic counsellors, and that each patient is visited once a week and that the visit and round trip takes up one and a half hours of therapeutic counselling time, then the amount of hours spent by therapeutic counsellors on administration has probably dropped from about 80 per cent to 40 per cent as a consequence of the introduction of the cell phone technology.

However, this drop is probably overstated by the fact that the therapeutic counsellors were no doubt spending more time in the early period being trained and learning how best to conduct home visits. They thus would no doubt have become more productive over the period anyway, and this is not captured by the simple exercise reported here.

In short, we can reasonably conclude that the quality of care provided to patients on antiretroviral therapy by the therapeutic counsellors has probably not declined, and hence that the introduction of cell phone technology has improved the efficiency of this service in the sense that more people are accessing quality care for a smaller input of total therapeutic counselling hours. But has this outcome been too expensive in terms of the additional costs required to implement and operate the cell-phone system? Table 1 shows that if we use the estimated monthly cost of R37.48 per patient on antiretroviral therapy provided by Cell-Life and add these costs to an estimated salary bill for the therapeutic counsellors, then the total monthly cost rises almost four fold over the period. However, as the rate of growth of patients on antiretroviral therapy was double that, the cost of providing therapeutic counselling services to people on antiretroviral therapy more than halved from R666 to R272. In other words, not only has the introduction of cell-phone technology freed up the time available to therapeutic counsellors to spend with their patients, but it has probably had the additional benefit of helping to lower the average cost of providing such services to people on HAART.

As discussed in Section 3 the second arm of the electronic system introduced at HCTC entailed the pharmacy plan to manage drug supplies and stocks. Whilst this, too, entailed extra costs in terms of systems implementation and management, it appears to have at least been consistent with a general shift towards greater efficiency at HCTC. As shown in Table 1, the average amount spent per HAART patient on the wage bill plus the total (monthly) costs of the electronic systems declined sharply over the period from R2,729 to R807. Note that this does not include the total costs of operating the HCTC.

Such a calculation would require information about rent, drug costs, equipment etc. The analysis reported here was limited specifically to human resources and systems costs in order to explore the more limited question of the efficiency gains of introducing an electronic system for managing the health and adherence of patients on antiretroviral therapy.

5. Conclusion

The introduction of the electronic cell-phone and pharmacy systems appears to have improved adherence monitoring and health evaluation. As Sister Mtwisha describes:

> Now it's efficient because the counsellors are given the information today and today Catherine [Dr. Catherine Orrell], can get her results. She can quickly see the adherence, and is able to check if it is right. The system can even measure the adherence of a patient for the whole program in a jiff. Whereas before we had to wait for weeks on end before Catherine could get this information (Sister Mtwisha, interview, 2005, 30 June).

However, there remain some glitches in the system. While surprise pill counts from the field and data on pills issued from the pharmacy are sent directly through to a single database, clinic-based return pill counts that are calculated during the patients' periodic clinic visits continue to be noted on paper records by the doctors. This means that without a direct comparison of clinic pill counts with surprise pill counts, discrepancies between the two values cannot easily be identified at an individual level. While adherence data gathered by the clinic serves well as a cohort comparison, whereby average values and adherence results can collectively be compared to those of other sites, on an individual patient basis, the clinic information is not relayed to the source of pill issuance fast enough for the pill count values to be of significant use to doctors.

It is thus unsurprising that during interviews, Mr Ghiassi-Razavi (from Cell-Life) and Dr Catherine Orrell (from the HCTC) recommended that a complete electronic system be introduced, whereby all patient information that is collected by doctors at the clinic is entered into and stored on the same database instead of in separate components (Wessels, 2005). This, however, would require additional resources for administration at the clinic-level – perhaps even the addition of a post for a data capturer and analyst. There is clearly a need for more resources to be allocated to making the most of the information that is currently being collected. Consider the case referred to earlier of the data base administrator noticing the irregular symptoms of the patient with lactic acidosis and reporting it to the clinic. This anecdote is both comforting and alarming: comforting in that the system is capable of identifying problems, but alarming because it was the result of an observant individual perusing the data and not the result of the kind of systematic on-going analysis of the available data that is necessary to generate the best health outcomes for all patients. There are clearly still challenges ahead to transform data collection from what is essentially an after-the-fact research tool, to an ongoing, immediate tool for use by clinicians.

While this will obviously raise costs, it is unlikely to do so to anywhere near the extent that would be required to reverse our overall conclusion of improved efficiency. As can be seen in Table 1, the new system helped facilitate the expansion of HAART to more people at a cost that was about a quarter of the cost per patient two years earlier. Furthermore, by improving the integrity of the database for adherence monitoring, additional benefits in terms of improved health outcomes will result.

In sum, this exploratory case study points to the potential of simple electronic technologies to monitor adherence and drug supplies at primary health care level. It suggests that the rollout of HAART to resource-poor communities can be assisted significantly by the introduction of cell-phone based technologies, and simple bar-coding and scanning equipment. Most importantly from the perspective of providing support services to people on HAART, the cell phone technology is easily accessible to peer-counsellors who, being HIV-positive and from the community themselves, do not always possess high levels of schooling. The cell-phone based technology has made their lives simpler, has enabled them to spend more time with patients and less time on administration – whilst at the same time enabling them to key in data directly to a database through a secure internet connection. It has, in other words, helped integrate the local-level primary health service provision with the kind of centralised data capture and analysis necessary to monitor a national-level HAART rollout. As such, it is a rare example of good news in a sea of Cassandra-like academic writing on the infrastructural and administrative challenges/obstacles facing the national HAART rollout.

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