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The Use of Touch-Screen Technology for Health-Related Information in Indigenous Communities: Some Economic Issues[1]

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Abstract *The low health status of indigenous communities in Australia, and other countries, has been a continuing societal problem. One way to improve health status involves the provision of health-related information. Computer-based systems offer new ways to provide such information: thus their application can be seen as process innovations. This paper describes the use of touch-screen technology to present health information in a culturally relevant fashion for Aboriginal and Torres Strait Islanders in Queensland, Australia. Touch-screen kiosks incorporate both computer hardware and software. The paper also outlines some of the key economic concepts relevant to an economic analysis of an information system employing touch-screen technology. It is shown that the economic analysis involves a two-stage process, and it is somewhat more complex than setting up an Internet website.*

Keywords: Aboriginal and Torres Strait Islanders; digital divide; health information; process innovation; telemedicine; touch-screen technology

Introduction

A long-standing health issue relates to the low levels of health status of Aboriginal and Torres Strait Islander (ATSI) people, the indigenous populations of Australia. The comparatively low health status of the indigenous communities is not new and has been documented in numerous reports over many years.[2] The following statement is not a-typical:

> ATSI [people] suffer a higher burden of illness and die at a younger age than non-indigenous Australians, and this is true for almost every category of disease and condition … The health disadvantage … begins early in life … On average, indigenous mothers give birth at a younger age … [and] their babies

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> are about 2–3 times more likely to be of low birth weight and about 2–4 times more likely to die at birth …[3]

Although indigenous people are geographically dispersed throughout the country, large numbers live in northern Australia, often in remote, isolated rural communities.

There is a plethora of issues surrounding access to services, including health services, for indigenous populations, not simply in Australia, but in many other countries. An important issue associated with the rapid changes in technology experienced in recent times is 'the digital divide', a term that brings to the forefront the fact that there are numerous barriers to some people being able to access or utilise these new technologies.[4] These barriers exist not only between countries, but also between various groups within a single country.[5]

This paper is concerned with the analysis of an innovation in the health sector. The innovation involves the delivery of health information to indigenous citizens, using touch-screen technology and specially-written software modules. Thus, it is an application of telemedicine, which has been defined as follows: 'Telemedicine is the use of electronic information and communication technologies to provide and support health care when distance separates the participants'.[6]

It should be recognised that innovations associated with telemedicine are but a part of the process of technological change in the health sector. Innovations are constantly being introduced into various dimensions of health service delivery whether it be in diagnosis such as occurred with fibre optic endoscopy,[7] in the supply of blood,[8] the development of new pharmaceuticals etc.

The next section of this paper presents a brief account of touch-screen kiosks and places them in the general area of electronic technology in medicine.

The Role of Touch-Screen Kiosks

Electronic technologies, generally, offer a wide variety of mechanisms (videos, CDs etc.) for delivering health information. In addition computers have been widely used in the health sector for storing data of a utilisation kind (quantities and prices of services) by health authorities, as well as at more 'local' levels for patient records, reminder systems etc., and clinical applications. Furthermore, the advent of the Internet offers another means of providing consumer information.[9] Examples include information-only sites for depression (such as beyondblue), panic disorder, alcoholism, diabetes, etc.[10] In addition, chat rooms have also been employed by caregivers[11] and teenage smokers,[12] *inter alia*.

However the Internet has also been used as a mechanism to deliver health intervention programmes, relating to various conditions such as exercise,[13] weight loss,[14] depression[15] etc. Many of these interventions have now been evaluated by randomised controlled trials (RCTs).[16] Essentially, it is increasingly being established that, in various ways, 'format counts'.[17]

There is a non-trivial problem with Internet sites, associated with differential access of different people. Leaving aside issues of computer literacy, the use of computers and the use of the Internet by Australia's indigenous people (in 2002) was less than that of the population in general (in 2003); furthermore utilisation by indigenous people in remote areas was approximately one-half that of non-remote indigenous people.[18] Furthermore it is the experience of two of the authors of this paper that even in remote indigenous communities where centralised Internet

facilities have been made available to all community members, utilisation rates are low. These few facts indicate that an Internet-based programme of health information directed to ATSI populations may not be successful. Needless to say, as indicated above, these inequalities in access and use are but one dimension of a number of 'digital divides' that now exist.[19]

It is important to recognise that use of an Internet site actually involves the consumer having access to hardware, as well as the relevant software. This prerequisite hardware component is one of the characteristics missing in indigenous communities. Thus successful use of such new electronic technologies (as considered above) to provide health information to indigenous communities requires addressing the 'hardware gap'.

A solution for this 'gap' is an integrated hardware–software system, referred to as a kiosk. The kiosk is simply a small physical structure that incorporates both a computer (with software) and a touch-screen. The touch-screen is basically a computer display screen that is both sensitive to human touch and allows the user to interact with (or explore) the computer by touching pictures (or words or symbols) on the screen. Kiosks can be of a multi-media nature incorporating not simply written text but also sound and video.

The touch-screen technology has now not only been employed to provide consumer education in the form of health information, for example on maternal and child health,[20] cancer[21] and Alzheimer's disease,[22] but also evaluations have been undertaken by conducting randomised controlled trials, *inter alia*, on cancer,[23] prenatal diagnostic tests[24] and schizophrenia.[25] Although there have been some negative evaluations, recall that Wyatt[26] has concluded that 'format counts'.

It is relevant to note that some health authorities, for example in Britain[27] and the state of Michigan in the US,[28] have developed systems of touch-screens (geographically dispersed) to disseminate health information. The problems associated with the development of these UK and US systems fade to insignificance when compared with those associated with development and implementation of a system of health information (with sound and user-driven printout capacity) delivered to isolated indigenous communities in North Queensland. Yet, this has been accomplished and is described in Hunter, Travers and McCulloch,[29] and Hunter and Travers.[30]

Before proceeding it is important to emphasise a key characteristic of RCTs, *viz.* that they involve comparisons with *alternatives*. Consider the three RCTs referred to above. Jones *et al.* evaluate the 'effect of a computer based information system for cancer patients … with a system providing only general information and with information provided in booklets';[31] Graham *et al.* are concerned with comparing 'the effectiveness of a touch-screen system with an information leaflet for … information on prenatal tests';[32] and the study by Jones *et al.* involves a comparison of 'personalised computer education with community psychiatric nurse education'.[33] It is clear that all these cases involve comparisons of substitutes.

Having argued that the touch-screen kiosk can be conceived of as an innovation involving substitution for existing alternatives, albeit not perfect substitutes, attention is now directed to considering some economic conceptions.

Some Economic Analysis

It can be argued that innovations fall into two categories, *viz. process* innovations and *product* innovations. Blaug defines the former term as 'novel ways of

making old goods' and the latter as 'old ways of making novelties'.[34] Although there are difficulties with these distinctions in practice, e.g. one firm's product innovation may be another firm's process innovation, as indicated by Davies,[35] and also a process innovation may create a change in the outputs or services produced, the definitions are useful, albeit somewhat arbitrary. Blaug argues, in fact, that '… the refusal to discriminate between product and process innovations would close the subject of technical progress to further analysis'.[36]

These distinctions can be seen in the health sector. The various services that comprise the *in vitro* fertilisation programme can be regarded as a product innovation, i.e. they involve the creation of a new product or service. In like manner the advent of renal dialysis in the 1960s can be described as a product innovation: prior to this medical procedure there was no treatment available for people with end-stage renal disease. Kidney transplantation, on the other hand, can be regarded as a process innovation, as it is an alternative treatment for dialysis.[37] Pharmaceuticals such as cimetidine, ranitidine, and other histamine H_2-receptor antagonists, can also be regarded as process innovations, substituting for surgical procedures, for people subject to ulcer.[38] Similarly, extra-corporal shock wave lithotripsy is a substitute for surgery to remove kidney stones. Process innovations also occur in diagnostic medicine: fibre optic endoscopy is an alternative to barium meal radiology for diagnosing diseases/conditions of the gastrointestinal tract.[39] Note that process innovations often involve a combination of innovative and mainstream technologies.

These examples also indicate Blaug's point that process innovations may well change the nature of output (or the mix of outputs), i.e. that they are not perfect substitutes for the already existing procedures. People may not be indifferent to the choice between taking ranitidine three times a day and undergoing surgery. In like manner fibre optic endoscopy involves, for most diseases/conditions, statistically significant increases in diagnostic accuracy over barium meal radiology.[40] Thus, alternatives may not be *perfect* substitutes: substitution is a relative phenomenon.

Of their very nature process innovations are substitutes for an already existing technique: a process innovation provides an alternative way of doing something. The examples mentioned previously, *viz.* the alternative ways of treating end-stage renal disease, ranitidine and ulcer surgery, fibre optic endoscopy and barium meal radiology, all have this characteristic. We turn now to describe the innovation in health-related information provision.

Touch-Screen Developments in North Queensland

The Health Information Touch-screen (HIT) project has evolved through several phases, having its origins (in 1999) as part of a three-year, community-directed, integrated and coordinated primary health care initiative at Yarrabah, funded by Smith Kline Beecham Community Partnerships (SKBCP), a corporate philanthropic organisation. As part of this project, an Internet website was discussed with the North Queensland Health Equalities Promotion Unit (a research unit of The University of Queensland and Queensland Health), as well as a touch-screen kiosk. Julia Schofield Consulting, an English software development firm, which had undertaken some health-related work in the United Kingdom for SKBCP ('Medibooks', which utilised a standard protocol and structure to produce

specific touch-screen health modules), became involved. At much the same time the Office for Aboriginal and Torres Strait Islander Health (OATSIH), of the Australian Government, provided funds for the (HIT) pilot project to be undertaken and evaluated.

The first (12-month) phase (2001–02) of development involved two modules of health information, one on 'Diabetes' and the second on various musculoskeletal conditions entitled 'Joint Pains, Sprains and Feet'. The second module was an adapted, or customised, version of the English 'Medibooks' module whereas the first (on 'Diabetes') involved scripting and producing new material. The development process was undertaken in a culturally sensitive way, with feedback from relevant focus groups, etc. The evaluation undertaken was of a 'proof of concept' kind for the pilot project, which was implemented at two sites, *viz.* Yarrabah in North Queensland and the Brisbane suburb of Inala.[41] An outcome of this evaluation was the scripting and production of a third module (for children using a holistic, inter-active learning approach) entitled 'Deadly Kids'.

Although there have been some precedents in the use of touch-screen technology in the health sector (Victoria in the early 1990s and in the Hunter Valley region of New South Wales in the mid-1990s), the North Queensland developments have taken root, unlike the earlier experiments. Subsequently, further funding for the continuation of using touch-screen technology to improve health literacy in disadvantaged indigenous communities was obtained from Queensland Health (via a Health Promotion Queensland grant for the period 2003–06) and the Alcohol Education and Rehabilitation Foundation. In addition, for the period 2005–08 the (Australian) OATSIH has funded a programme to establish a National Network of touch-screens in urban, rural, and remote areas of Australia.

The 2003–06 extension involves the development, scripting and production of health-related modules additional to the first two modules on 'Diabetes' and 'Joint Pains …', as well as location of the kiosks at four additional sites, *viz.* Lockhart River, Napranum, Pormpuraaw and Kowanyama. Given the pilot success (at Inala) of locating the kiosk in a health service facility, all four locations have been sited in community health centres. Some of the new material relates to alcohol use.

Given that alcohol-related harm has often been identified as a major health problem in indigenous communities,[42] one of the new goals in this phase of the programme was to develop a touch-screen version of the Alcohol Use Disorders Identification Test (AUDIT). AUDIT is a screening instrument to detect hazardous and harmful alcohol consumption. It was the outcome of a World Health Organization collaborative project across six countries with varying cultural backgrounds.[43] AUDIT has been shown to be robust across Caucasian, Hispanic and Afro-American men and women.[44] Needless to say the touch-screen version of AUDIT has been prepared in a culturally sensitive fashion.[45] In addition there is some reason to believe that it is appropriate in indigenous Australian communities.[46] There is also a very large evaluative and comparative literature on AUDIT and other alcohol-related screening instruments.[47]

Given that these later phases of the HIT Project are underway at the time of writing (July 2007) the following analysis is restricted, of necessity, to the Pilot Project phase. The next section addresses issues associated with the setting up of a system of touch-screen kiosks.

An Economic Description of the Health Innovation

The Two-Stage Process

In the previous description of touch-screen kiosks, some emphasis was placed on the fact that such kiosks involved more than the establishment of an Internet site: the key characteristic is that a kiosk involves the provision of hardware *and* software. What this means is that there is a two-stage process, first, setting up the infrastructure (involving capital expenditure, some of which is fixed and sunk), and second, the running of modules. By comparison the establishment of an Internet site is less complex.

Thus, we have, say, the total programme costs (TC_{Prog}) which is the sum of setting-up costs ($TC_{\text{S-u}}$) and programme running costs (RC_{Prog}). In other words

$$TC_{\text{Prog}} = TC_{\text{S-u}} + RC_{\text{Prog}} \tag{1}$$

The Setting-up Stage

Let us consider the setting-up or infrastructure stage, i.e. the first part of the right-hand side of equation (1). There are two quite separate parts to this establishment phase. First, there is the development process, i.e. the writing of health-related modules, and the production and programming thereof. Costs associated with this process are of a fixed capital nature but are sunk, in that assets created are so specific that there is virtually no market for them: thus their re-sale value is zero. The second part of the infrastructure phase involves the size of the touch-screen network, i.e. the number of kiosks that are to be connected to the network. This decision involves capital expenditure but does not involve sunk costs, as the capital expenditure on the touch-screens has a re-sale value. Thus

$$TC_{\text{S-u}} = DC + COK \tag{2}$$

where *DC* is developmental costs (programming, graphics, content development), and *COK* is the cost of capital (kiosks, server etc.) and the costs associated with kiosk installation, testing etc. (This phase is different in degree, but not kind, to a commercial bank setting up a system of automatic teller machines.)

This first part of the process can be depicted as in Figure 1, which has two parts. Part (a) indicates total costs, whereas Part (b) indicates average and marginal costs of setting-up the network. It is important to realise that the unit of output in this first stage is the number of kiosks connected to the system. Thus, the size of the network (measured by the number of kiosks) is indicated on the *X*-axis. As indicated in Figure 1(a), developmental costs are fixed, and independent of the number of kiosks connected to the system. The capital costs associated with the kiosks are indicated by *COK* which has been drawn on the assumption of a constant price per kiosk. [Non-linear pricing of the kiosks can be easily incorporated in Figure 1(a).]

Vertical summation of these two cost components gives the total costs of setting-up the system ($TC_{\text{S-u}}$). As indicated in Figure 1(a) $TC_{\text{S-u}}$ is a linear function of the number of kiosks. Where the health enterprise is located on this cost curve depends on the available development (or infrastructure) budget. [Two possible budgets, $B^1_{\text{S-u}}$ and $B^2_{\text{S-u}}$ are indicated in both Figure 1(a) and Figure 1(b).] Figure 1(b) indicates average development costs (*ADC*), which fall as the system expands

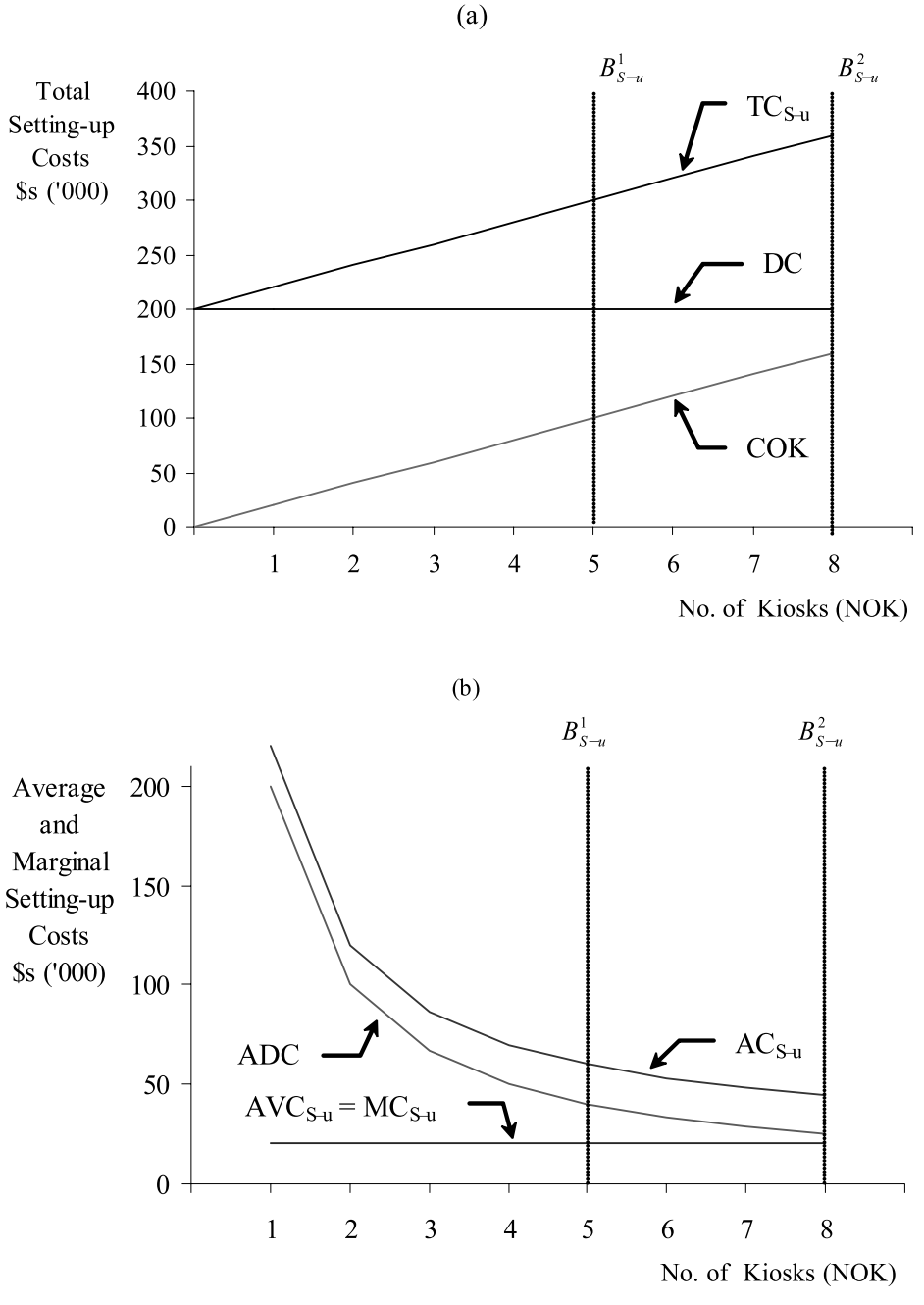


Figure 1. Total, average and marginal costs of setting-up a touch-screen network.

with more kiosks (NOK is the number of kiosks), average costs of kiosks (AC_{S-u}), marginal costs of kiosks (MC_{S-u}), and the average variable cost of setting-up the system (AVC_{S-u}). By definition, in Figure 1

$$ADC = DC / NOK \tag{3}$$

$$AVC_{S-u} = COK / NOK \tag{4}$$

$$AVC_{S-u} = MC_{S-u} \tag{5}$$

and

$$AC_{S-u} = ADC + AVC_{S-u} \tag{6}$$

Assuming a kiosk costs \$20,000, and development costs of \$200,000, if the setting-up phase had a budget of \$300,000 (see Figure 1) then there would be a network of five kiosks. On the other hand, if the setting-up budget were \$360,000 then the network would consist of eight kiosks (see Figure 1). In Figure 1(b), the marginal cost associated with the setting-up process is constant (and is equal to the price of a kiosk, \$20,000), i.e. the average variable cost. In the two cases, $B^1_{S\text{-}u}$ and $B^2_{S\text{-}u}$ in Figure 1, the relevant relationships are as follows:

$$B^1_{S-u} = \$200,000 + \$100,000 = \$300,000$$

$$B^2_{S-u} = \$200,000 + \$160,000 = \$360,000$$

Note that the average cost of setting-up the network falls as the number of kiosks increases: this is explained by the spreading of the fixed (development) cost over more units (i.e. the kiosks). In the case of the \$300,000 budget, the size of the network is five kiosks, whereas when the size of the network is eight kiosks, the budget is \$360,000. The size of the network would be 15 kiosks if the budget were \$500,000. This latter case is not shown in Figure 1.

Running Modules on the Network

Once the network (of a given size) is established and the capital costs (some of which are sunk costs) have been incurred, the second stage of the process begins. This stage involves running health-related modules on the touch-screen kiosks. In the second stage it is imperative to define and measure the output of the touch-screen system. The output in this second stage is *not* the same as the output in the setting-up stage.

From what has been written above, it is clear that *the outputs produced by a touch-screen kiosk are informational in nature*. Such health-related information can be delivered in a number of ways, traditional ones being verbal advice, books, leaflets etc. The touch-screen technology, of course, offers an alternative system of information delivery to such conventional mechanisms. Thus the touch-screen technology is on a par with other activities in the health sector, such as radiology and pathology, in that the outputs produced are *information*. In the conventional settings of medical practice, information produced by such diagnostic tests becomes an input into another stage, i.e. therapy. What use is made of such information is a separate question. In like manner the *use* of information conveyed by a touch-screen kiosk is a different matter. How are we to measure the information provided by the touch-screen?

Before we address this question it may be useful to consider the above definition (output is information) in more detail: some may wish to argue that this is too

narrow a focus, and assert that the effect on health status should be taken into account. To approach this question, it is useful to consider the definition and measurement of output in a different health context, *viz.* that of a hospital: there is a vast literature on this institution, part of which is reviewed in Butler.[48]

Some people argue that the output of a hospital is *improved health status* for the people admitted for treatment. A statement of this position is given by Tatchell as follows: 'Output measures should reflect what is believed to be the ultimate objective of the health system—the improvement of health levels'.[49] There are critics of this position: a theoretical argument is that, being a producer of services, a hospital is no more a producer of health than a beauty salon is a producer of beauty.[50] In addition there are numerous practical problems, one of which is determining the relative impact of hospital-based services on health status. Health status is determined by numerous variables such as genetic, socio-demographic, nutrition, sanitation etc. factors, as well as environmental and regulatory regimes. For a review see Connelly and Doessel.[51] A second formidable practical problem is that, although there are numerous *specific* measures, there is no universally acceptable measure of health status. See McDowell and Newell for a review of this diverse literature.[52]

A second approach defines hospital output as *the treatment provided* by the hospital rather than the change in patients' health status. This emphasis on treatments provided lies in the early work of A. A. Scitovsky on the construction of medical price indices based on the costs of treatment of selected illnesses (appendectomies, tonsillectomies etc. etc.).[53] The emphasis in her work is to define outputs in terms of medical treatments.

Another way of considering this issue is to ask the following question: 'what is it that patients buy (or receive) when they go to hospital?' Are patients buying improved health status or health treatments? Clearly hospitals are not remunerated on the basis on the *success* of treatments, but rather the treatments themselves. Thus focussing on what is traded in a market leads to the view that the outputs of a hospital are the treatments provided. Thus, there is a case for considering hospital services as an *intermediate* output in the production of health.

This conception of output implies that the unit of measurement is a *treatment of an episode of illness*, i.e. the service provided when a patient is admitted and then discharged. A problem with this measure, however, is that it may not be homogeneous. Recognition of such heterogeneity lies behind various case-mix systems, the best known being the Diagnosis Related Group (DRG) framework.[54] A third conception of hospital output, the time-related measure of the occupied bed-day, is not relevant in this context and will not be considered.

The point of this discussion is that hospital services can be an input into health status, and the practical problems of attributing improved health status to hospital services are virtually insurmountable. Thus we can say that the ultimate (or final) output is improved health status, which we are unable to measure. In like manner the output of touch-screen kiosks can be an input into improving people's health status, but there are virtually insurmountable problems in measuring that contribution. Thus, we are left with *an information-based definition of output*. We can refer to this as an intermediate, a semi-ultimate (or semi-final) output. In other words we regard this output (information from a touch-screen) as being of a non-final kind, rather than final. Measures of this concept of intermediate output are those such as the number of activations of the kiosk, or the number of individuals who use the technology, or the number of purposeful uses of the touch-screen. These

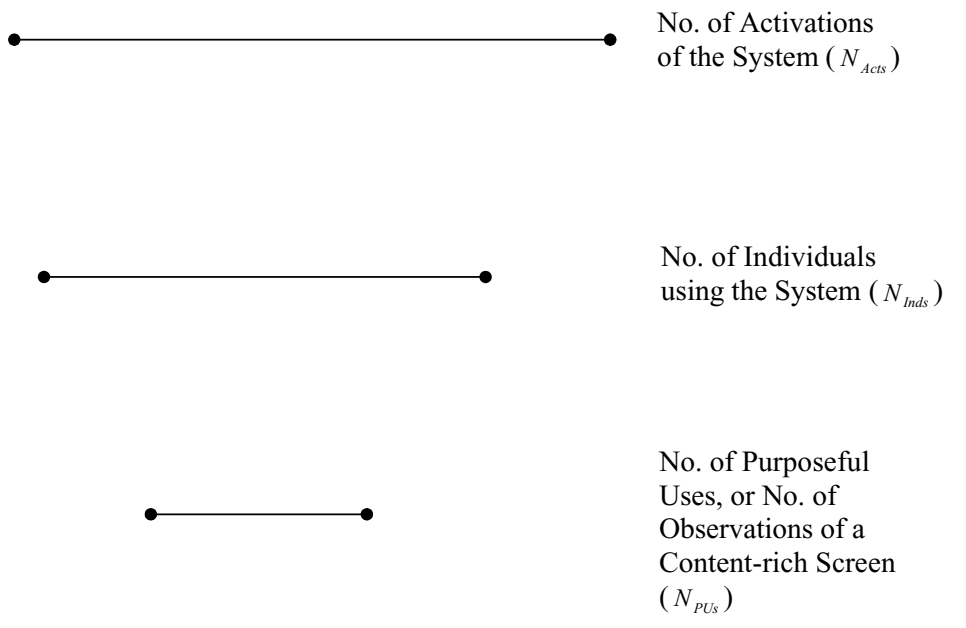


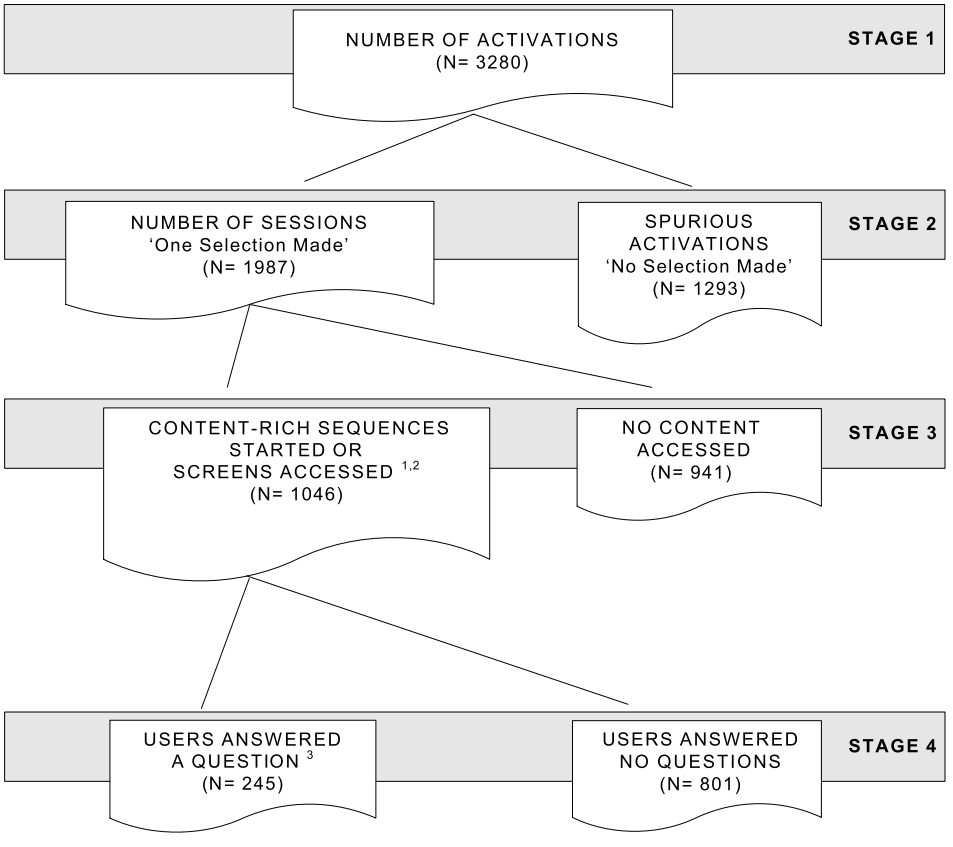
Figure 2. Relationships between three measures of output for a health innovation using information technology.

distinctions are indicated (conceptually) in Figure 2, which depicts a rank categorisation, or hierarchy, of measures of the output of a touch-screen kiosk. We turn now to a more detailed consideration of measurement.

Touch-screen kiosks, of their very nature, involve a process, or sequence of steps. Thus there is a choice as to where, in a time-related sequence, one takes a measurement. An aggregate measure is the number of times that a kiosk is activated or first touched. This is specified as Stage 1 in Figure 3. However, to accept this measure ('number of activations') as output involves an assumption that all activations are purposeful, i.e. that there are no 'accidental', 'random', 'experimental', 'playful' or 'vandalistic' activations of the kiosk. Such an assumption is likely to be unrealistic. Such activations are described as 'spurious' in Stage 2 of Figure 3. If an activation is not 'spurious', then it can be defined as a 'session', with a least 'one selection made' (see Stage 2 of Figure 3).

When a 'selection' is made, there is a further possibility in that the person can proceed to view, or access, a 'content-rich sequence' or a 'content-rich screen', or no content may be accessed. This is Stage 3 in Figure 3. This is the measure of the concept 'number of purposeful uses' referred to above, and in Figure 2 particularly. Finally, there is a facility on the kiosk for users to provide information about themselves, e.g. their age, gender, ethnicity etc., as well as condition-specific health status and their prior use of a kiosk and ease of use (see Stage 4 of Figure 3). The actual data indicated in the four stages of Figure 3 relate to the use of the Pain and Diabetes modules at two kiosks (at Yarrabah and Inala) for almost nine months to June 2002.

At the time of project implementation (October 2001–30 June 2002), these kiosks were 'loaded' with two modules, *viz.* those on 'Diabetes' and 'Pains, Sprains …'. During this period, there were 3,280 'activations' of the kiosks, 1,293 of which



Notes:

(1) The variable 'number of purposeful uses' is measured here by 'content-rich sequences started'.
(2) Further disaggregations of data are possible, e.g. the 1,046 content-rich sequences started consist of 541 for the 'Pain, ...' module and 505 for the 'Diabetes' module.
(3) Questions relate to demographic variables (age, gender, ethnicity etc.) and details of experience with the touch-screen kiosk (ease of use, prior use etc.).
(4) See text for descriptions of sequences.

Figure 3. Use of 'Pain' and 'Diabetes' modules at two health kiosks in Queensland, mid-October 2001 to 30 June 2002.

were 'spurious' and the remainder, 1,987, involved the start of a 'session'. However, of these sessions there were 941 in which there was 'no content accessed'. In other words, there were 1,046 'sessions' in which 'content-rich screens' were accessed. This is the 'purposeful use' referred to previously. Subsequently, there were only 245 users who provided some information about themselves by 'answering a question'. What this means is that this technology is not able to produce a reliable count of the 'number of individuals using the system', a possible measure in Figure 2.

As stated above, the processes are indicated in Figure 3 by Stages 1, 2, 3 and 4. Of these four stages it is our view that Stage 3 is the most appropriate point at which information output should be measured. Stage 3 can be characterised as

involving a 'purposeful use' of the kiosk, i.e. 'those uses in which a content-rich sequence was accessed during one session'.[55]

An alternative statement of the possible output magnitudes (in Figure 2) is as follows:

$$N_{\text{PUs}} < N_{\text{Inds}} < N_{\text{Acts}} \tag{7}$$

where N_{PUs} is the number of purposeful uses; N_{Inds} is the number of individuals using the system, and N_{Acts} is the number of activations of the touch-screen system.

Before proceeding it is very important to consider an attribute of the touch-screen technology, i.e. that the technology can be employed to produce multiple outputs. Expression (1) does not recognise this characteristic.

The capacity for joint production is embedded in the computing technology, as different health-related programmes can be stored and run on the system, in exactly the same way that a computer can store and run, not simply a word-processing package but also statistical, econometric and other software. Thus the programmes run on a touch-screen system are (generally) limited only by the number of relevant programmes that have been written or are available, and are able to be stored on the system. This argument implies that the variables in expression (7) need to be disaggregated by the number of programmes installed on the system. Put otherwise, programmes concerned with various health issues such as smoking, sexual behaviour, ischaemic heart disease, safe driving habits, diabetes, mental health etc. can be employed. Of the various output concepts of intermediate outputs (N_{Acts}, N_{Inds}) in expression (7), attention is directed to the number of purposeful uses. This argument about joint production leads to the conclusion that N_{PUs} in expression (7) should be disaggregated. Thus

$$N_{\text{PUs}} = N^1_{\text{PUs}} + N^2_{\text{PUs}} + \cdots + N^n_{\text{PUs}} \tag{8}$$

where N^i_{PUs} is the number of purposeful uses for health-related programme *i*.

One reason that it is necessary to define output relates to the fact that a measure of output is necessary to undertake any meaningful analysis of costs of running a system of health-related touch-screen kiosks. It is to this issue that we now turn.

Programme Running Costs

Once the network (of a given size) has been established, and the development costs have been incurred, i.e. the setting-up stage has been completed, the touch-screen programme is then ready to incur running costs [see the second component of equation (1) above]. In this operational context the relevant output is the number of purposeful uses (N_{PUs}), or the number of observations of a content-rich screen (see above).

The *annual* 'running costs' for the system can be classified as fixed and variable in the usual way, i.e. costs which do not vary with output (N_{PUs}), and those that do vary with output. However it must be emphasised that this distinction (fixed and variable) is made with respect to the measure of output in the second stage, *viz.* the number of purposeful uses (measured by the number of content-rich screens accessed). In fact most of the costs of 'running the system' are *time-related*, which is *not* the measure of output of the touch-screen kiosk. Costs such as telephone line rental, insurance (if applicable), Internet access, etc. are *time-related*. An example is

the rental access (of $30 per month or $360 per year) of a telephone line. The only cost that varies with use of the kiosk is the incremental cost of electricity that occurs when the kiosk is being activated. This is so small that it can be taken to be (virtually) zero. Thus, the programme running costs, RC_{Prog} of equation (1), are predominately fixed. It should be noted that the magnitude of these costs will depend on the decision (in the setting-up stage) as to the size of the network, i.e. the number of kiosks in the system. (This point is illustrated in Figure 1 by the different budgets $B^1_{\text{S-u}}$ and $B^2_{\text{S-u}}$.) Assuming linearity in the prices for the time-related costs in the second stage of 'running the network', cost differences will be manifested by a vertical displacement of the 'fixed running costs' curve in Figure 4 [see the two lines 'Fixed Running Costs ($B^1_{\text{S-u}}$)' and 'Fixed Running Costs ($B^2_{\text{S-u}}$)'].

Figure 4 is *not* a 'conventional' cost diagram from microeconomic theory despite its superficial similarity. The essential characteristic of Figure 4 is that the costs are *annual*, or time-related. The curve 'Fixed Running Costs ($B^1_{\text{S-u}}$)' in Figure 4(a) indicates the telephone, electricity (in having the system 'turned on'), Internet etc., costs of running a network of *five machines*. The curve 'Variable Running Costs ($B^1_{\text{S-u}}$)', which has been drawn disproportionately different from the *X*-axis, indicates the only cost category that varies with the use of the kiosk, *viz.* infinitesimally small amounts of electricity. (These costs are so small that the Variable Running Costs curve is virtually coincidental with the *X*-axis.) The curve, 'Total Running Costs ($B^1_{\text{S-u}}$)', involves the vertical summation of the Fixed and Variable Running Cost curves for the budget allocation of $B^1_{\text{S-u}}$ in the setting-up stage. The three curves in Figure 4(a) 'Variable Running Costs ($B^2_{\text{S-u}}$)', 'Fixed Running Costs ($B^2_{\text{S-u}}$)' and 'Total Running Costs ($B^2_{\text{S-u}}$)' are the relevant curves that apply to the case where the budget (in the setting-up stage) is $B^2_{\text{S-u}}$.

Attention is now directed to Figure 4(b), which derives the average running costs (and components thereof, i.e. average fixed and variable costs) for the first budget, i.e. $B^1_{\text{S-u}}$ in Figure 1. [Figure 4(c), to be discussed below, indicates the average running costs for the second, larger, budget of $B^2_{\text{S-u}}$.] Not surprisingly, average variable running costs are trivial, and virtually coincide with the *X*-axis. Average fixed running costs have the shape of a rectangular hyperbola, with initially, sharp falls as output expands from zero, and then a 'long, flat' tail given that it is asymptotic to the *X*-axis. Because fixed costs massively dominate total costs (given the insignificant magnitudes of variable running costs) the average total running cost curve is virtually indistinguishable from the average fixed running cost curve. This is simply the outcome of the dominance of fixed costs in total costs, as indicated in Figure 4(a).

The curves in Figure 4(c), not surprisingly, have the same general shapes as those in Figure 4(b), with average variable running costs virtually coinciding with the *X*-axis, and average fixed costs dominating average total running costs. The difference between Figures 4(b) and (c) is simply a matter of degree. And as output rises, the curves for the two sizes of the system (as indicated by the two budgets) move closer together and become virtually indistinguishable. It is for this reason that the two cases have been presented in two separate diagrams.

The analysis here, based on *annual* costs (given that nearly all costs are fixed on a time-related basis) can be regarded as a special case of the conventional microeconomic cost analysis. This analysis would be the conventional short-run analysis if the network was not expanded in the 12-month period. If the network expanded after 12 months, then a new structure would be in place.

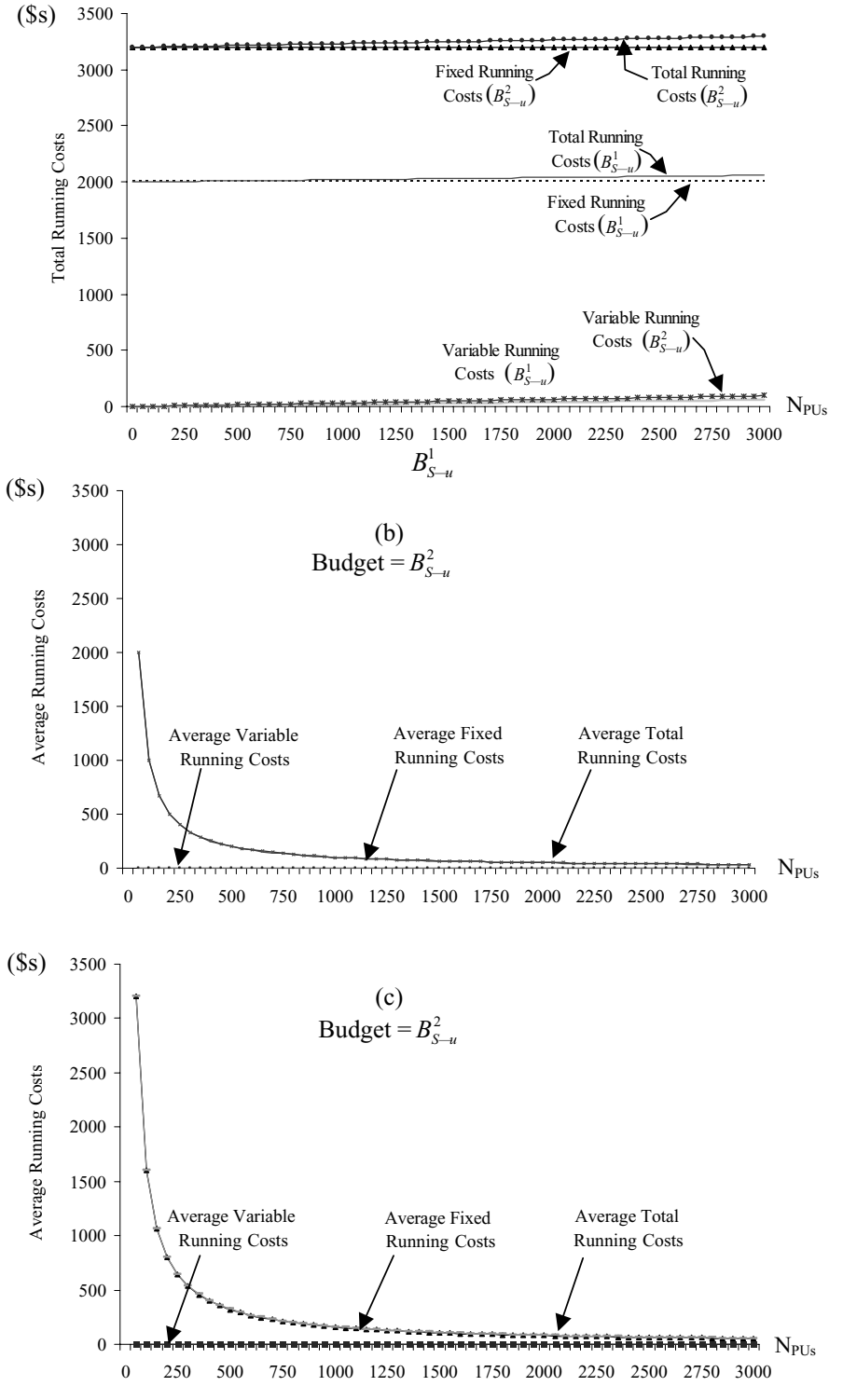


Figure 4. Annual total running and average costs (and components thereof) associated with a touch-screen network of two given sizes, and budgets.

Some Qualifications

A limitation to this study must be recognised. Given the state of knowledge in the health sector, we do not know what is the effect on health status of the health information provided to people in these remote indigenous communities. Put otherwise, there are no data on what has been referred to as 'the ultimate output' in Figure 1 above: from necessity we have had to work with an intermediate output (or throughput), 'number of purposeful uses', which is described above as a 'semi-ultimate output'.

There is reason to believe that simply providing information does not change people's behaviour. Other human attributes (commitment etc.) are also necessary for behaviour to change. For example, although it is now well known that certain activities are health-related, such as tobacco consumption, regular exercise, appropriate nutrition etc., not all people act on such information. Also, in the context of ATSI health, there is some reason for pessimism on the efficacy of health 'one-off' information leading to improved health status for indigenous people. An RCT involving a 13-year follow-up after an intervention (a multi-component health assessment relating to nutrition, cardiovascular status, alcohol consumption etc.) for Aboriginal residents in the Kimberley region of Western Australia, has shown that the intervention has been non-efficacious in terms of mortality.[56]

Although the emphasis in this paper has been the innovative use of the touch-screen technology *per se*, it is also relevant to observe that the *style* of content presentation has been subject to change. The early modules can be fairly described as presenting material in a didactic fashion with the consumer adopting the role of a passive receiver of information. Later modules have incorporated games and quizzes in an interactive fashion, thus incorporating a more user-centric approach to learning. More recent innovations have involved health messages being embedded in video dramatisations of familiar life situations, such as a family's weekend at the local football match. These modules incorporate various outcomes or scenarios which are subject to choice by the users, thus incorporating interactive and constructionist learning behaviour.

The cost analysis presented here is illustrative, in that the available data related to the touch-screen technology when it was partly funded by the Australian Government and other sources. In addition, some inputs were provided 'in kind' by people not funded by the HIT project. The HIT team demonstrated that such a system could 'work', and have continued to attract funds to expand content, and enlarge the network. This later phase of the innovation is currently underway and is not yet capable of being analysed in this way.

Summary

This paper has been concerned with describing and analysing an innovation that involves both computer hardware and software, i.e. a touch-screen kiosk. This innovation has been undertaken in the context of a digital divide between 'mainstream' Australia and the indigenous community, particularly in remote settlements in North Queensland. It is the integration of hardware and software in a single piece of capital equipment that, it is hoped, may improve familiarity with the digital technology in these isolated communities. However learning to use the new electronic technology was not the primary objective of the programme: it would be simply a

beneficial by-product. The objective was to employ the touch-screen technology to present health-related information to members of the indigenous community.

The content of the modules accessible from the kiosks was of a health-promotion kind: thus the use of the touch-screen technology in this way can be regarded as a process innovation in that it is an alternative (or substitute) way of presenting health information to more conventional mechanisms such as verbal advice, posters, leaflets, books etc. In saying this, it is not implied that this new technology is a perfect substitute for the more traditional health promotion techniques.

The nature of the technology is such that its implementation involves a two-stage process, and in this respect, use of the touch-screen is more complex than the construction of an Internet website. The first stage, referred to here as the developmental phase, involves the scripting and production of the specific health-related content, as well as decisions on the size of the kiosk network. In this respect the developmental phase is not unlike the first stage of a bank setting up a network of automatic teller machines. The second stage involves the running of the system, the content and network size having been determined in the first stage.

Analysis in this second stage requires the definition, or specification, of the output of the touch-screen technology. It is shown that the use of the kiosk involves a time-related process, and that the output of the system is appropriately described as the 'number of purposeful uses' of the system. This *concept* of output can be *measured* by the number of 'content-rich' screens accessed by users. (Other possible output measures, e.g. the number of activations of the system, changed health status, numbers of people etc. are considered but set aside for various reasons.) It is shown, using some illustrative data, that the touch-screen technology involves quite small running costs: the technology is developmental and capital intensive, and much of the developmental costs are sunk, i.e. once incurred the re-sale values are virtually zero. (Although these data are described as 'illustrative', they are approximately correct for the stage of the process described in this paper.) At this early stage of 'demonstration/proof of concept', much time and effort was provided by people in paid employment elsewhere. Thus many inputs were provided in kind.

It is important to recognise that cost structures vary, not only between different firms in the same industry, but also between industries producing different types of goods. This latter case is relevant when considering touch-screen technology. Put otherwise, the relative proportions of total costs which are fixed, sunk and variable can vary considerably across industries. Consider the car industry, where most costs (tyres, engines, transmissions, brakes, labour, etc.) are variable, the restaurant trade (where most costs, such as rent, light, the opportunity costs of the owner's time, are fixed), and the computer software industry where costs are predominantly sunk.[57] The cost structure of the touch-screen technology is most like that of the computer software industry, that is high sunk costs and *very* low marginal and variable costs.

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