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e-Business connections in the health sector: IT challenges and the effects of practice size

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ABSTRACT

The use of information technology (IT) in the health sector is critically important for enhanced patient care and ultimately cost savings. However, the uptake of IT in health has been slow when compared with other industry sectors, due to the range of issues and IT inconsistencies associated with the needs of its stakeholders. This study explored the challenges experienced by 108 New Zealand medical practitioners in their IT interface with other key primary and secondary health providers. We found IT interface challenges were negatively related to e-business activity (receiving) but held no effect on e-business activity (sending). Further, we tested for and found significant moderating effects of practice size, based on patient numbers. Large practices were able to buffer the negative influence of IT interface challenges on e-business activity (receiving), while small practices were severely hampered by IT interface challenges. The implications of operating in a modular industry structure are discussed.

Keywords: IT health, modularity, practice size, IT challenges

INTRODUCTION

The successful implementation and leverage of any information technology system in the health sector requires an understanding of its purpose and how it operates within the overall industry architecture. The development of IT systems in the health industry is often fraught with complex issues and high associated costs, especially when data is to be exchanged between numerous stakeholders (Dowd, Gans, Hammons & Kralewski 2005). Problems arise from the wide variety of tasks conducted between these stakeholders and their subsequent need to send and receive a diverse range of information, often via numerous information technology systems (Larsen 2008; Thielst 2007a). Such issues have led the health sector at an international level to fall behind other industries by as much as 10 to 15 years in its information technology adoption (Goldschmidt 2005). Despite these challenges, health IT systems have been associated with increased quality and safety of patient care (Harrison & Lee 2006; Menachemi 2007), efficiency (Thielst 2007a) and cost savings for health providers (Chen, Hough & Lik 2005).

We focus our examination of IT exchange issues on the New Zealand health sector, where the Ministry of Health is responsible for governing this country's organisational and IT health infrastructures. Over the past 10 years the Ministry of Health has shifted from a market-based structure to a community-oriented model. In making this shift, the Ministry has disseminated purchaser and health provider functions to 21 District Health Boards (Ministry of Health 2005; Shakir & Viehland 2005). In New Zealand currently 81 Primary Health Organisations are responsible for delivering and coordinating primary health care services. For example, Pinnacle Group Ltd is a not for profit primary health care management support organisation that provides support to a range of primary care organisations and data analyses on population, workforce and service utilization, used by the Ministry of Health, District Health Boards and Primary Health Organisations. Pinnacle Incorporated is a further example of a not for profit organisations that facilitates a general practitioner network, focusing on high quality general practice, including a secure information technology network between all its providers. The IT infrastructure falls within the framework provided by the current Health Information Strategy for New Zealand (HIS-NZ 2005) (Ministry of Health 2005).

We use the modularity literature, following Baldwin and Clark (1997) three design rules, as a framework to examine the complexities involved in the exchange of data in the New Zealand health sector. First, requires an architecture that gives an overall structural setting which encompasses the individual modules. In this setting the Ministry of Health provides the overall organisational architecture and the IT architectural framework with the HIS-NZ (2005). Second, requires interfaces that establish how the modules connect and communicate with each other. In the New Zealand health sector there are numerous organisational and IT modules. For example, there are the 21 DHB modules, as well as, individual and combined primary health provider modules that extend across general practitioners, specialist physicians, laboratories, radiology clinics, and pharmacies (Chen, Hough & Lin 2005). Third, requires a set of standards that encourage each module to conform and perform in a uniform manner in relation to the other modules. Again, this is a complex issue in the NZ health sector where the Ministry of Health strives to create a delicate balance between giving regional autonomy to the DHBs, while attempting to foster nationwide coordination. By using the modularity literature we can develop increased clarity on when and how the various organisational and IT modules in the health sector interface with each other and what standards are required to facilitate this.

Paper objectives

The objectives of this article centre on the need to better understand the IT interface challenges that occur within the modular infrastructure of the NZ health sector. We focus on the challenges experienced by general practitioners within this networked setting since they occupy a pivotal position in sending and receiving data between numerous other providers (Brailer 2005). Given the key role these providers play and the presence of numerous IT interface challenges, this article investigates the specific nature of these challenges and whether some practitioners are more likely to overcome these problems when compared with others. However, the relationship between these challenges and the ability of these practices to send and receive data electronically should not be examined in isolation, as strong IT interface challenges alone may not necessarily predict a reduced ability to send and receive electronic data.

This paper also examines how the sizes of medical practices combine with IT interface challenges with other health providers to influence the ability of these practices to send and receive data electronically. The literature suggests that large firms, more specifically health provider practices (Ebben & Johnson 2005) are more likely to be able to use their resources to build and

leverage sound IT infrastructures. However, we want to investigate whether these findings still hold for New Zealand general practitioners who are positioned within a variety of modular networks. For example, the general practitioners under examination are positioned within the Pinnacle network and the general practitioner network and their regional District Health Board network. There does not appear to be any prior empirical investigation into the direct relationship between IT interface challenges in the health sector and how they impact on the ability of primary medical practitioners to send and receive data electronically. Nor, does it appear that there has been any prior research into the impact of practice size on the ability of medical practitioners to overcome IT interface challenges in sending and receiving electronic data.

The following section reviews the literature. We start by identifying the challenges surrounding the development of a national health IT infrastructure. Next, we review more general IT interface challenges, IT programme incompatibility, data standardisation inconsistencies and differences in the rate of IT diffusion by health providers, which we broadly categorize as IT interface challenges. These provide the base to test our first two hypotheses. We then review further literature on the relationship between IT interface challenges and its use, with medical practice size, in preparation to test our final two hypotheses.

IT INTERFACE CHALLENGES

Drawing from the IT health literature we conceptualize primary medical practitioner IT challenges to be those key problems associated with sending and receiving patient related data. Included in this conceptualization is the assumption that all primary practices possess and use basic computer related technologies and have installed an electronic patient management system. We focus on the development of four IT challenges that include: IT infrastructure challenges, IT interface incompatibility, data standardisation inconsistencies and differences in rates of diffusion of IT implementation by health providers. The following section provides a more detailed discussion of each IT challenge.

IT infrastructure challenges

We suggest the New Zealand health IT infrastructure and its modular design follows the building of a modular organisational structure, which is unlike much of the work on modularity that argues for the contrary (Frigant & Talbot 2005; Sanchez 2000). In the New Zealand health sector there are numerous modularised stakeholder groups that include policy makers, primary and secondary health providers, who are required to address the requirements of the HIS-NZ (2005). This strategy provides the blue print for the health IT infrastructure, encouraging the development of secure connections and access to health information, while ensuring that national systems anchors are in place. The development of an Electronic Health Record System (EHRs) lies at the heart of an integrated IT infrastructure. This system enables individual patient health data to be entered, stored, and retrieved by authorized medical personnel over a number of sites. Benefits from implementing EHRs include increased coordination between health providers, improved patients care; increased patient safety where recent and historic patient histories are available through a single data source (Kerr 2004; Thielst 2007a). At this point in New Zealand there is no national EHRs infrastructure but rather several District Health Boards have implemented partial EHRs, some of which include Counties-Manukau and Taranaki. The systems operating in these District Health Boards currently enable the exchange of some patient data between primary and secondary health providers, where individual health providers apply for, and are then screened before access is granted to this system. Data fed into this system is also linked to the National Health Index that enables the medical history of a patient admitted to hospital in one region to be accessed in another.

Despite the benefits of a seamless integrated IT infrastructure that a national EHRs would offer, its development is inevitably complex (Harris 2008; Larsen 2008). Challenges include the need to accommodate a diverse range of health provider needs, data standardisation of clinical terminology, concerns regarding patient privacy and confidentiality, difficulties of integrating these records with existing information records, and the potential for human error, especially at the point of data entry (Goldschmidt 2005; Menachemi 2007).

IT programme incompatibility

It is readily acknowledged that the more compatible IT systems are in the health care sector (Ministry of Health 2005) the greater the interoperability and access to data within these modular units at the regional level, for example between general practitioners, or between primary health provider groups; and also at the national level, between District Health Boards. Further, there is less likelihood of healthcare provider error, through decision making based on incomplete information (Thielst 2007c). As health care continues to evolve to become more specialized and more data is subsequently generated, the issues involved in the compatibility of computer programmes inevitably increase in complexity. For example, facilitating IT programme compatibility between general practices and hospitals, where this has not already been done, is undoubtedly challenging. However, such an interface enables, for example, general practitioners to electronically advise a hospital if their patient has had a prior test, thereby reducing the patient's stress. Conversely, if medical practices were to electronically receive a range of hospital outpatient data this would enhance the development of post-hospital patient care programmes (Larsen 2008).

It has been suggested that improved IT compatibility can result in substantial savings. For example, Brailer (2005) reported that the United States health sector could create savings of as much as US$77 billion per annum through increased IT compatibility between health providers. Interface problems can be exacerbated by the often very different IT needs of providers. For example, primary care practices require IT systems to manage several hundred patients, compared to large hospitals that serve several thousand patients, whereas specialist physicians are likely to have considerably fewer patients at any one time. Hence, the issue becomes one of ensuring the IT systems implemented by individual health providers are optimal in meeting their individual needs; while simultaneously ensuring that these mechanisms can 'talk to each other' (Thielst 2007a, p.8) through the development of standardised IT interfaces between them.

Data standardisation inconsistencies

The next set of challenges surround establishing what kind of standardised interfaces are required and how they should be implemented. Best practice in the health sector is continuing to be encoded in protocols and clinical guidelines. Attention has already been drawn to the value of developing protocols for the routine exchange of predictable data such as fixed forms, predefined items and layout, such as those used in child health centers or laboratories (Thielst 2007a; Ginneken 2002). However, Diamond, Halamka, Overhage, Ricciardi, Rishel and Shirky (2005) suggested that flexibility should be practiced in the development of these standards where appropriate to allow for the unique requirements of data held by some health providers such as potentially sensitive information on alleged child abuse cases held by pediatricians. Moreover, care is required to ensure that standards continue to be developed to facilitate data exchange across multi-health provider interfaces where often several sets of standards need to be coordinated and bundled. For example, when a medical practice sends a script electronically to a pharmacy this requires the packaging of demographic, clinical and patient data.

In New Zealand, the overall development of standards and protocols for the exchange of

data across the health sector falls within the infrastructure provided by the HIS-NZ (2005) that takes into account factors such as New Zealand's ageing population and rising rates of some chronic diseases. In 2003 the Health Information Standards Organisation (HISO) was formed to facilitate the implementation of current and subsequent health information strategies. HISO is charged with the task of promoting regional autonomy, in the development of standards within the modular units at the regional, District Health Board level (Ministry of Health 2005) while actively promoting national health standards. For example, HISO's standard HL7 permits data originating in a variety of formats to be reconfigured and exchanged between primary and secondary health providers, and makes available international diseases classification systems such as ICD-10 and SNOMED-CT (Kerr 2004). Though a core set of data standards is continuing to be built and refined between numerous health providers IT systems there is still much work to be done (Shakir & Viehland 2005).

Differences in rates of IT implementation by health providers

Government based health providers such as District Health Boards, occupy a key and pivotal position in the New Zealand health IT architecture between stakeholders who range from the Ministry of Health to numerous primary health providers in the region, as already indicated. However, the pace of IT development within these regional architectures has often been reported to be very slow (Goldschmidt 2005; Thielst 2007a). Reasons for this apparent lack of speed of are numerous. For example, these organisations are required to understand the needs of various stakeholders and the extent each provider would benefit from their implementing or changing a particular IT system. Planning is required to ensure that the IT systems of the individual providers can 'talk to each other' (Thielst 2007a, p.8). Moreover, these organisations are required to adhere to a complex range of government policies, objectives, and operational issues, whereby agreements are reached over the nature, content and security of IT systems before they are implemented (Thielst 2007b). Furthermore, decisions are required on which IT system or component part of an IT systems should be funded first (Larsen 2008; Wicks 2007). Thielst (2007a, p.8) suggested these regional units 'need help to accelerate HIT adoption and utilization'.

In comparison the rate of IT adoption by some primary health provider groups such as general practitioners has been very rapid. The computer adoption rate and use of electronic patient management systems by general practitioners has been reported to very high, standing at 90% globally, and 99.8% in New Zealand (Didham, Martin, Wood & Harrison 2004). However, there is still considerable variation in computer usage and recording of, for example patient appointments by some specialist health providers. Also, paper files are still often kept by both primary and secondary providers. For example, for the receipt of patient communication from specialist referrals is manually filed by general practices. As a consequence, there is often some variation in the use of manual and computerized mechanisms (Dowd, Gans, Hammons & Kralewski 2005).

Our outcomes for the present study reflect a common approach to e-business activity where firms that electronically exchange data have both distinct and different aspects to consider in terms of the costs and response trade-offs associated with sending and receiving this data (Larsen 2008). We suggest that the four aspects noted above combine to create an overall measure of IT interface challenges that will be negatively related to the e-business activity of practices. This leads to our first set of Hypotheses.

Hypothesis 1: General practices with higher IT interface challenges with other health providers are likely to have lower e-business activity (sending).

Hypothesis 2: General practices with higher IT interface challenges with other health providers are likely to have lower e-business activity (receiving).

The role of practice size

It has often been reported that large practices will be significantly advantaged over small practices in the market place (Ebben & Johnson 2005) achieving economies of scale and market power when making purchases (Bowen & Wiersema 2005). Moreover, large practices will generally have greater funds and associated resources at their disposal when making a purchase, and hence may prefer to invest in more sophisticated IT systems (Leonard 2007). As such, large practices may also undertake larger scale IT development such as transferring all patient records to an electronic database that may not be possible in small practices (Macher & Boerner 2006). It has been suggested that small practices face many obstacles relating to e-business activity (Baron, Fabens, Schiffman & Wolf 2005), and as such, there is interest in how these practices can manage e-business (e.g. Lee, Cain, Young, Chockley & Burstin 2005). The present study explores the interaction effects of practice size on the relationship between IT interface challenges and e-business activity, suggesting that large practices may have the capacity to over-ride issues and keep activity levels high even when their IT challenges increase.

Large practices may also benefit from their increased visibility and prestige, and more importantly their presumed capacity to endure environmental shocks (e.g., Hannan & Freeman 1984). It has been reported that large firms, in this instance practices, may have more formal and advanced systems than small firms, making them more equipped to plan and implement technology, thereby facilitating increased efficiencies (Ebben & Johnson 2005). We would, therefore, expect small practices to have less access to financial reserves and hence engage in fewer and potentially smaller IT systems that lead to significantly less benefit than large practices are able to achieve. We acknowledge that the practices being examined in this study are positioned within the overall architecture prescribed by the Ministry of Health and furthermore, are positioned within the architecture offered by Pinnacle; however, we would still expect large practices to be able to more effectively employ their resources to overcome any potential interface problems in their data exchange. Hence, we develop our second set of hypotheses.

Hypothesis 3: Practice size will moderate the IT interface challenges these practices have with other health providers and their ability to engage in e-business activity (sending); where large practices are more able to buffer the negative influence of the IT interface challenges on e-business activity (sending).

Hypothesis 4: Practice size will moderate the IT interface challenges these practices have with other health providers and their ability to engage in e-busines activity (sending); where large practices are more able to buffer the negative influence of the IT interface challenges on e-business activity (receiving).

These relationships are depicted in Figure 1.

Method

Sample and procedures

Data for this study was undertaken in two phases. Phase one had interviews with six randomly selected General Practitioners in this region regarding IT usage and issues. Further, items generated for a survey were then pilot tested with three General Practitioners and two academic staff unrelated to the study. Feedback was used to clarify and improve the survey instrument. The final questionnaire, together with a personalised cover letter and reply paid envelope were mailed out in early October 2006. A follow up questionnaire was sent out to non-respondents two weeks later. Survey items related to General Practitioners IT activities (sending and receiving), as well as

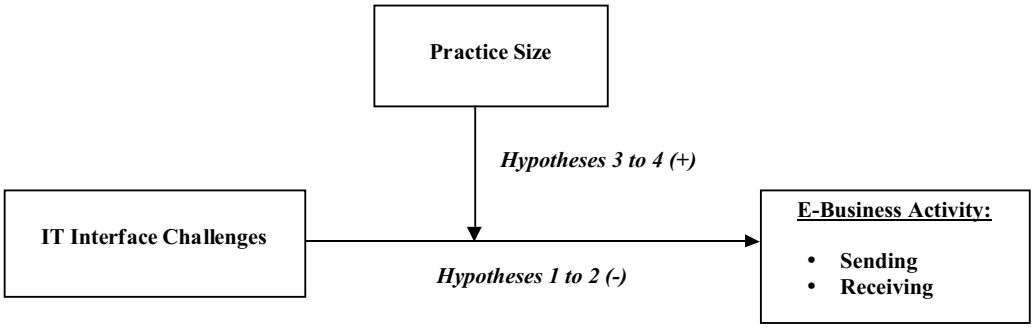

FIGURE 1: MODEL OF DIRECT AND MODERATOR RELATIONSHIPS

IT issues and practice characteristics (e.g. number of GPs, number of patients etc.). Data analysis was conducted early in 2007.

In total, 250 General Practitioners based in the greater Waikato Region were posted a survey via their practices. The survey was sent to all General Practitioners in early October 2006 and by 20 October 2006 there had been 85 responses, representing a 34% return rate of which 80 were complete and usable. By 27 October 2006 a further 27 responses had been received of which 24 were usable. There were no significant differences in respondents between these time frames. In total, 108 usable survey responses were received. Given the time demands for General Practitioners time, this 41% response rate represents a good response rate. Further data was collected via a telephone survey to check for non-response bias where four General Practices who had chosen not to respond were contacted. GPs worked in practices employing on average 4.5 nurses, 4.7 administrators, with 5.1 GPs, 13.7 screens, and 6751 patients.

Measures

Dependent variables

E-business activity was measured using 10-items created for this study, based on the e-business activity literature, including sending and receiving. Items were coded (1) = never, (2) = seldom, (3) = sometimes, (4) = usually, (5) = always. A higher score indicates greater e-business activity. An exploratory factor analysis (principal components, varimax rotation) was run to explore the nature of the measure. Items used, factor analyses outcomes, and reliabilities are shown in Table 1.

As expected, the factors split into two both having eigenvalues greater than one. These were *E-Business Activity (Sending)* 5 items, for example 'send patient referrals to private radiology clinics', 'send patient referrals to Private Physicians', with Cronbach's alpha of .87; and *E-Business Activity (Receiving)*, 5 items, 'receive laboratory and radiology results from Waikato DHB, 'receive laboratory and radiology results from non Waikato DHB providers', with Cronbach's alpha of .74.

Independent variable

IT Interface Challenges was measured using 4-items created for this study, drawn on the literature discussed earlier. Items were coded (1) = never, (2) = seldom, (3) = sometimes, (4) = usually, (5) = always. Respondents were asked to indicate the frequency with problems in using computer-based technology. A higher score indicates greater problems. An exploratory factor analysis (principal components, varimax rotation) was run to explore the nature of the measure. Items used, factor analyses outcomes, and reliabilities are shown in Table 2.

Overall, the items loaded onto a single factor with eigenvalues greater than one, and the measure had an adequate Cronbach's alpha of .81.

TABLE 1: EXPLORATORY FACTOR ANALYSIS OF E-BUSINESS ACTIVITY

Indicate the extent to which you use computer-based technology for the following tasks. Please indicate the frequency: (1) = never, (2) = seldom, (3) = sometimes, (4) = usually, (5) = always.	Factor Loadings: E-Business Activity (Sending)	Factor Loadings: E-Business Activity (Receiving)
Patient communication with **private** physicians	**.782**	.255
Patient communication with **public health** physicians	**.815**	.041
Send patient referrals to private radiology clinics	**.690**	.189
Send referrals to local Hospital	**.879**	–.012
Send referrals to **private** physicians	**.841**	.056
Use the Internet to find supporting information during a patient consultation	.112	**.741**
Use secure health networks to receive patient reference number (patient ID number)	.085	**.703**
Use secure health networks for special authority with NZ National funding agency (Pharmac)	–.069	**.731**
Receive laboratory and radiology results from local Hospital	.175	**.651**
Receive laboratory and radiology results from other providers (non-local Hospital)	.139	**.678**
Eigenvalues	3.306	2.567
Percentage variance	33.1%	25.7%
Number of items in measures	5-items	5-items
Cronbach's Alpha	.87	.74

Interaction variable

Practice Size was measured using a number of similar but distinct dimensions, specifically: number of screens (number of computer screens), number of GPs (total number of GPs in practice), number of nurses (total number of nurses), number of administrators (total number of administrators), and total number of patients. While all these variables had a high level of skewness (all > 1.0) a number of transformations are available to deal with such problems (Cohen and Cohen 1983). Log-transformation was conducted on all variables to induce normality (Stone and Hollenbeck 1989). After the log transformation, the skewness score for each variable was within acceptable boundaries of ±1.0 for all variables (all

TABLE 2: EXPLORATORY FACTOR ANALYSIS OF IT INTERFACE CHALLENGES

Indicate how often you encounter the following problems in using computer-based technology? Please indicate the frequency: (1) = never, (2) = seldom, (3) = sometimes, (4) = usually, (5) = always.	Factor Loadings: IT interface challenges
Interface challenges in the standardisation of electronic forms between health service providers	**.869**
Interface challenges between health service providers e.g. only some operate online	**.829**
Lack of computer programme compatibility between GPs and some health service providers (e.g. national screening programmes)	**.811**
Speed of implementation of IT applications by local Hospital Board	**.706**
Eigenvalues	2.599
Percentage variance	65.0%
Number of items in measures	4-items
Cronbach's Alpha	.81

< ±0.2). All five variables were highly correlated with each other (.85 < r < .63, all p < .01). As such, exploratory factor analysis (principal components, varimax rotation) was run to explore the nature of these items. Overall, the items loaded onto a single factor with eigenvalues greater than one (3.988), accounted for 79.8% of the variance, and had a Cronbach's alpha of .94. We combined these items to create a composite variable for practice size. The combined measure had a skewness score of 0.09.

Analysis

To examine the direct effect of IT interface challenges on E-Business activity (receiving and sending) (Hypotheses 1 and 2), and the potential moderating effects of practice size on these relationships (Hypotheses 3 and 4), separate hierarchical regression analyses were computed with the two E-Business activity measures as the dependent variables. The independent variable (IT interface challenges) was entered in Step 1. The potential moderator variable (practice size) was entered in Step 2. Lastly, the interaction variable (IT interface challenges multiplied by practice size) was entered in Step 3. The centering procedure (Aiken & West 1991) was followed where interaction effect variables were z-scored. For interpreting moderation results we followed the recommendations of Cohen and Cohen (1983), where regression coefficients for the main effects were obtained from Step 1, moderator effects from Step 2, and interaction effects from Step 3. A total of two regression models were run: E-Business activity (sending), and current E-Business activity (receiving). All tests were single-tailed because we expect the direct effects to be negative, and size to have a positive interaction effect, hence hypothesizing in a specific direction.

Results

Descriptive statistics for all variables are shown in Table 3.

The mean score for IT interface challenges (2.4) is below the mid-point of 3.0, indicating that overall IT associated issues is not that common (between seldom and sometimes). The mean score for E-Business Activity (Sending) (M = 2.5) and E-Business Activity (Receiving) (M = 3.8) are below and above the mid-point (3.0) respectively. This indicates that practices are receiving more e-business than they are sending. Further, a paired-samples t-test confirms this difference is significant (t = 9.791, p < .001).

IT interface challenges was significantly and negatively correlated with E-Business Activity (Receiving) (r= –.45, p < .01), but not with E-Business Activity (Sending) (r= .01, *non significant*). E-Business Activity (Sending) was significantly correlated with E-Business Activity (Receiving) but not to a large extent (r = .24, p < .05).

Results of the regressions for Hypotheses 1 to 4 are shown in Table 4.

Table 4 shows that IT interface challenges are not significantly related to E-Business Activity (Sending) (β = .00, *non significant*). This fails to support Hypothesis 1. However, IT interface challenges were significantly related to E-Business Activity (Receiving) (β = –.44, p < .001), supporting Hypothesis 2. From Step 2 we can see that IT interface challenges do not significantly effect E-Business Activity (Sending) adding only 1% to

Table 3: Correlations and descriptive statistics of study variables

Variables	M	SD	1	2	3	4
1. IT Interface Challenges	2.4	.83	—			
2. Practice Size	3.0	.64	–.03	—		
3. E-Business Activity (Sending)	2.5	1.2	.01	.14	—	
4. E-Business Activity (Receiving)	3.8	.91	–.45**	.05	.24*	—

N=108, *p< .05, **p< .01

TABLE 4: HIERARCHICAL REGRESSION ANALYSIS FOR MODERATOR EFFECTS OF PRACTICE SIZE ON IT INTERFACE CHALLENGES AND E-BUSINESS ACTIVITY (SENDING AND RECEIVING)

	E-Business Activity					
	Sending			Receiving		
Variables	Step 1 Direct Effects	Step 2 Moderator Effects	Step 3 Interaction Effects	Step 1 Direct Effects	Step 2 Moderator Effects	Step 3 Interaction Effects
IT Interface challenges	.07	.07	.08	–.43***	–.43***	–.42***
Practice Size		.14	.13		.04	.03IT
Interface challenges x Practice Size			.15			.17*
R^2 change	.01	.02	.02	.19***	.00	.03†
Total R^2	.01	.03	.05	.19	.19	.22
Adjusted R^2	.00	.00	.02	.18	.17	.19
F - Change Statistic	.437	1.207	1.558	21.523***	10.746***	8.495***

† p< .1, * p< .05, ** p< .01, *** p< .001, Standardised regression coefficients. All significance tests were single-tailed.

the variance, but do account for a significant and large 19% (p < .001) of the variance for E-Business Activity (Receiving).

Practice size did not have a significant interaction effect on IT interface challenges and E-Business Activity (Sending) (β = .15, *non significant*), failing to support Hypothesis 3. Practice size did have a significant interaction effect on IT interface challenges and E-Business Activity (Receiving) (β = .17, p < .05), accounting for an additional 3% (p < .1) of the variance towards E-Business Activity (Receiving). To facilitate interpretation of the significant moderator effects of practice size on E-Business Activity (Receiving), a plot of the interaction is presented in Figure 2. On this Figure, IT interface challenges low and high represents points below and above the mean (M = 2.4), and this is the same for the graphed lines for practice size (M = 6751), labeled small sized practice (below the mean) and large size practice (above the mean).

Plotting the interaction terms (Figure 2) illustrates that when IT interface challenges are low, there is no difference between responding prac-

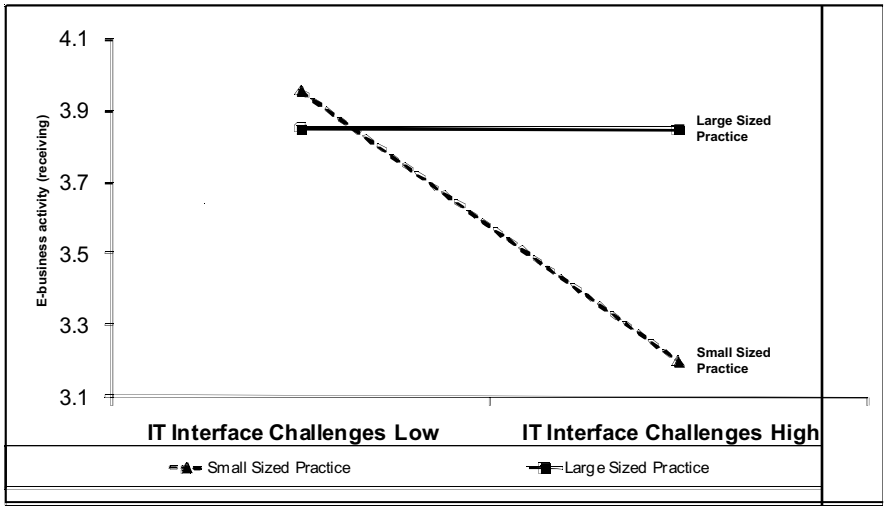

FIGURE 2: INTERACTION EFFECTS OF PRACTICE SIZE TOWARDS IT INTERFACE CHALLENGES AND CURRENT E-BUSINESS ACTIVITY (RECEIVING)

tices, regarding their levels of E-Business Activity (Receiving). However, when IT interface challenges increase to high, larger sized practices report a stable level of E-Business Activity (Receiving), while smaller sized practices report significant reductions in E-Business Activity (Receiving). Overall, this effect supports Hypothesis 4.

Overall, the regression model for predicting E-Business Activity (Sending) was not significant (R^2 = .05, F = 1.558, *non significant*), while the model for predicting E-Business Activity (Receiving) was significant (R^2 = .22, F = 8.495, $p < .001$). Finally, we examined the variance inflation factors (VIF) for evidence of multicollinearity, which occurs at values of 10.0 or higher (Ryan 1997). All the scores were well below the suggested scores, with the interaction effects being less than 1.1. Overall, the findings indicate no evidence of multicollinearity unduly influencing the regression estimates.

In using the modularity literature we are able to acknowledge that IT systems in the health sector can often be successfully introduced into one area without affecting the need to simultaneously change other areas. However, understanding when and how the modules in the health sector interface and what standards are required become very important issues.

Discussion

The role of IT in the health sector is undoubtedly an important one, with numerous complexities involved in its implementation and maintenance (Larsen 2008, Thielst 2007a). In this study we explored some of the challenges experienced by a group of medical practitioners in their electronic exchange of data with other health providers. More specifically, we aimed to develop a better understanding the IT interface challenges and their underlying rationale for health provider firms who operate within a modular IT infrastructure that has been built upon a modular organisational infrastructure.

We found support for our hypothesis that greater IT interface challenges negatively influence e-business activity. However this finding was only towards receiving electronic data and not towards sending it. Consequently, we found medical practices that experienced greater problems associated with IT programme incompatibility, standardisation, and differences in IT diffusion rates were unable to maximise the efficiency of e-business regarding receiving data. However, these same IT challenges were not found to influence sending activity, indicating that the issues mentioned above do not hamper medical practices that wish to send electronic health data.

A potential reason why medical practices may be less troubled with sending data electronically could be related to the high overall level of adoption of computer related technologies by general practitioners as a modular group, as indicated earlier (Didham et al. 2004). Another reason could arise from the strong interface that exists between these general practitioners and the modular management support unit. All participants in this study were affiliated to Pinnacle Group Ltd, the not for profit primary health care management support group. The other associated company, Pinnacle Incorporated, also undoubtedly played a role in facilitating the electronic receipt of data with its active promotion of up to date IT systems among practitioners.

Conversely, problems experienced by general practitioners in electronically receiving data may arise from the vast range of information they require from a wide variety of sources. In such instances much of the data being fed into the general practitioner information 'silo' is only going to be as timely and comprehensive as the interface between the sender and the sender's IT or other data transmissions systems and policies captured within their modular unit. For example, a medical insurance assessor may request additional data from a general practitioner, however, if that assessor is only geared to use a facsimile and sends its request to the wrong number this will inevitably delay the receipt of general practitioner data. Also, when different IT systems are used between, for example radiologists and gener-

al practitioners, this may also either restrict or delay data exchange. Interestingly, it would appear that the strong support that Pinnacle provides this general practitioner group cannot work to surpass the interface issues in the receipt of data, as it does in the sending of data.

The other major aspect of the present study was the exploration of medical practice size as a potential moderator of the relationship between IT interface challenges and e-business activity. We hypothesized that large practices would have additional resources to leverage (Leonard 2007) which would enable them to endure environmental shocks (Hannan & Freeman 1984), such the inevitable IT interface challenges present within the complex health environment setting. As anticipated, we found large practices were better able to buffer the negative influence of IT interface challenges, where large medical practices were able to maintain a relatively similar level of e-business activity (receiving) irrespective of whether IT interface challenges were low or high. We believe this buffering from the larger practices may arise from their increased staff capacity to electronically access data, where this data is actually available to all practices such as that held on secure health networks such as Pharmac. Or, it may be that these large practices are less risk averse generally, hence their increased willingness to search for data via electronic means.

Further, small practices held similar levels of e-business activity (receiving) as large practices until their IT related challenges became high. These small practices reported a significant drop in e-business activity (receiving), reducing their level of activity to well below that of large practices. As such, it appears that large practices are able to maintain stronger levels of e-business activity even when there are pressing issues relating to IT, interface, standardisation and differing in rates of adoption. Personal communication with some small practices indicates the presence of several key factors that impede their overall ability to navigate and absorb IT challenges when compared with their larger counterparts. These include limited financial reserves that inevitably lead to more stretched use of administration staff in areas such as policy development, as well as having a smaller team environment. Of further interest here is the role of Pinnacle. It would appear that the strong support provided through the organisational and IT interface provided by Pinnacle Group Ltd and Pinnacle Incorporated was unable to continue to benefit the small practices in the electronic receipt of data, once these challenges grew.

While information is undoubtedly a valuable asset in the health sector, it is fortunate that issues and problems relating to it transmission via ITs, do not always appear to adversely affect medical practices (Dowd et al. 2005). The lack of affect on e-business activity (sending) means that practices wishing to conduct their business through the Internet are not affected by the interface challenges in the system. However, whether the activities of the medical practices are efficient and constructive is an area where further research is required. For example, if e-business is conducted outwards from the practice irrespective of problems and issues, but e-business traffic entering the practice is affected by IT challenges, how do medical practices know they are operating efficiently? Indeed, they might assume other practices, specialists, and hospitals are receiving their information adequately, and the evidence found here is that this might not be the case.

We encourage further moderation studies of medical practices as a group to investigate whether practice size has a consistent effect to buffer the challenges associated with working in modular organisational and IT infrastructures. More especially studies should investigate whether there is any difference between those practices that have a close organisational interface with other primary health support groups and those who do not receive such support. Further, it would be interesting to investigate the differences in risk taking between the smaller and larger practices. We also encourage further research into the impact of IT interface issues on other

specific primary health provider groups such as pharmacies, specialists and radiology firms, keeping in mind the large variation each provider has in the number and regularity of patient contact as well as their service type offered and whether these providers have interfaces with any support agencies, and if so, what this role might be.

Ultimately, we suggest that further research be conducted into the overall health IT infrastructure required by particular countries, and regions within each country. However, in order to complete this work, other studies such as this one are required, in order that findings may be collated, to determine the interface issues and capabilities of each provider group. It will only be upon the receipt of such information that a sound IT infrastructure can be built and regional EHRs can be linked together through a series of well coordinated interfaces in order to develop national EHRs. Such actions, we believe, will then inevitably lead to improved quality and cost savings in the health sector overall.

As with all cross-sectional studies, there are limitations attached to this study that mean some caution must be exercised in interpreting the findings. Specifically, while a large number of practices were surveyed, the overall sample size is still small (n = 108), which limits the generalisability. Additional studies on a greater range of general practices are required before the results found here can be generalised to the wider medical sector. However, our overall response rate of 43% is good, and within the 20% to 80% range achieved by other researchers both in the health sector, both in New Zealand and internationally (Arroll, Goodyear-Smith, Patrick, Kerse, Harrison, Halliwell, Peason, Lay-Yee & von Randow 2005; Didham, Martin, Wood & Harrison 2004). We encourage further studies in other countries to explore to what extent the IT interface challenges explored here hold universally hold.

Overall, we find that the modular environment of the health sector in New Zealand does appear to detrimentally affect the ability of general practices to operate their IT effectively, although larger practices are able to buffer and more able to overcome the challenges associated with data exchange in the electronic environment. The implication for general practices looking to add or expand to their electronic data exchange functionalities is that larger sized practices will be more likely to be in a position to facilitate higher levels of e-business activity regarding the receipt of data. This situation might ultimately encourage consolidation amongst smaller practices to overcome these issues.

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