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HARNESSING INFORMATION SYSTEMS IN HEALTHCARE: THE STRATEGIC ALIGNMENT PERSPECTIVE

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Abstract

Strategic alignment between business and information technology (IT) is considered key to maximizing IT impact. Nonetheless, only seldom have exceptional achievements in performance been studied from the viewpoint of the Strategic Alignment Model (SAM). This paper describes a longitudinal case study of a Health Maintenance Organization (HMO), named here MHMO, which serves over 1.7 million members. MHMO's management decided to support strategic business via alignment of business and IT, culminating in the implementation of a business process management (BPM) system to process and display performance measurement. Applying multivariate logistic regression analysis and qualitative analysis, we analyze the improvement in MHMO's clinical performance in comparison to all the HMOs in the country between 2002 and 2005. The results clearly show a greater improvement for MHMO in the period following the BPM system implementation in 2004. Plausible drivers of this achievement are discussed, paying special attention, via the lens of the Strategic Alignment Model, to the alignment between business and IT. Besides this paper's contribution in highlighting how business and IT can be aligned to achieve ambitious strategic goals, it demonstrates the feasibility and effectiveness of measuring quality of clinical care, generally considered a complex and costly mission.

Keywords: Business and IT alignment, Strategic Alignment Model (SAM), Health Informatics, Quality of care, Multivariate logistic regression analysis, Quantitative research

1 INTRODUCTION

Strategic use of information technology (IT) has been the focus of many studies in the last decades (Ross 2003). Most studies have emphasized the importance of aligning business and IT (Henderson and Venkatraman 1993) as a means to maximize the impact of IT on business performance. The importance of such alignment, however, has only seldom been empirically demonstrated in general, and in the healthcare industry in particular (Avison et al. 2004; Menachemi et al. 2006).

As healthcare expenses spiral, providers face growing pressures to control costs (Mossialos and Le Grand 1999; Schur et al. 2004), while still maintaining high quality patient care (Chassin 1996; Fendrick and Chernew 2006; Gray 1991; Iglehart 1996; Miller and Luft 1997). Most healthcare organizations, however, manage cost more closely than quality due to difficulties in acquiring the needed information to appropriately judge the level of clinical performance (Brook et al. 1996; Eisenberg 2002; Greenfield et al. 2002; McLoughlin and Leatherman 2003; Powell et al. 2003). Additionally, although there is a broad agreement that information systems facilitate collection, processing, and distribution of measurement data, the healthcare industry is slower than other industries in utilizing IT for these purposes, typically treating IT as an expense rather than an enabler of enhanced business value (Menachemi et al. 2006; Spath 2007). Consequently, it is not common among healthcare organizations to seek strategic alignment between business and IT.

This paper presents the results of a longitudinal case study in Maccabi, a health maintenance organization (HMO) that participated, along with the other three HMOs in the country, in a project initiated by the national ministry of health aimed at comparing HMO quality of clinical care. In this nation-wide project, all four HMOs were required to collect and submit pre-defined, agreed-upon, data to measure the quality of health services. The ministry of health consolidated and publicized aggregated annual results (http://www.israelhpr.org.il), leaving the data per each HMO unpublished.

In Maccabi, the studied HMO (hereinafter named MHMO), senior management thrived for business and IT alignment and implemented state-of-the-art information systems even before this national measurement project was announced. MHMO chose to leverage its information systems to not only collect and process measurements data for the national quality-indicators project, but also to process and present a more comprehensive set of indicators, including costs as well as members satisfaction measures, organization-wide. Against a national improvement of quality of clinical care, results show that the improvement at MHMO significantly surpassed this of all other HMOs, while the average cost per patient remained unchanged. In-depth investigation of the results suggests that strategic alignment of business and IT in general, and particularly the implementation of a business process management (BPM) system, was a major driver of this exceptional improvement.

Three goals motivated this paper. First, to show how the mere act of measurement can drive quality improvement, even in the important, complex, and controversial domain of clinical care. Second, to demonstrate how strategic business and IT alignment drove improvement of core business processes at MHMO above and beyond its competitors, without incurring excessive costs. Finally, to point at lessons that other healthcare organizations can draw from this example of the benefits gained from aligning business and IT.

The next section presents a brief survey of the literature, followed by description of the case background and the methods used in this study. The results of the quantitative and qualitative analyses are presented in the fourth section, demonstrating clear relative improvements in the clinical aspects measured while containing costs. In conclusion, we discuss the role that information systems played at MHMO in improving the quality of clinical care from the perspective of the Strategic Alignment Model (Henderson & Venkatraman 1993). We then summarize the findings and lessons that can be drawn from this case in the healthcare industry and beyond.

2 LITERATURE SURVEY

Economics of organizational IT have remained a thorny issue for the past decades, as the direct contribution of IT to business performance is difficult to demonstrate (Brynjolfsson 1993; Carr 2003). Mixed results have been documented, with some research even showing negative correlation between IT investments and business performance (Kohli and Devaraj 2003). Yet, in spite of these inconsistencies, there is broad agreement that strategic alignment between business and IT is key to leveraging positive IT impact on business achievements (Avison et al. 2004; Henderson and Venkatraman 1993; Ross 2003). Business and IT alignment is defined as applying IT in an appropriate and timely way, in harmony with business strategies, goals and needs (Luftman et al. 1999).

Several models presenting the implications of IT and business alignment have been suggested. The most frequently discussed models are the MIT90 model by (Scott Morton 1991) and the Strategic Alignment Model (SAM) by Henderson & Venkatraman (1993). In the latter, however, IT has been positioned for the first time at the same organizational level as the Business, emphasizing the role IT should play not only in supporting business strategy and processes, but also in shaping strategy and organizational structure. SAM suggests that in order for business and IT to align, at least three of four organizational domains should be aligned: business strategy, IT strategy, business infrastructure, processes and skills, and IT infrastructure, processes, and skills. While the first two domains pertain to the external strategic perspective of the alignment impact, the latter two represent the internal resource perspective. In their alignment analysis, Henderson & Venkatraman identify four patterns of Business-IT alignment that can facilitate organizational transformation: strategy execution, technology transformation, competitive potential, and service level. In the first two the alignment process leading to organizational transformation is driven by the business strategy, whereas in the last two the driver is IT strategy.

SAM has inspired several studies, extending and refining the original model. For example, (Luftman 2000) offered one extension by attempting a practical guide to either examining current Business and IT alignment in a firm, or discerning deficiencies in the required alignment. (Maes 1999) offered another extension by adding a layer between strategy and operation (termed structure), and a column between business and IT (termed information/communication). This extension, Maes maintains, lead to a more generic model of organizational information management. In addition, (Luftman et al. 1999) identified six drivers and six inhibitors to business and IT alignment, with 'senior executive support for IT' as the primary driver, and 'business/IT management lack close relationships' as the major inhibitor.

A few studies have demonstrated real-world achievements from the business and IT alignment perspective (Avison et al. 2004; Cooper et al. 2000; Heart et al. 2006), and none (as far as our literature search elicited) is from the healthcare industry (Bates et al. 1998; Mitchell and Sullivan 2001; Powell et al. 2003; Spath 2007). Indeed, examination of IT investments indicates that the healthcare industry is lagging behind other industries in strategically harnessing IT for competitive advantage (Menachemi et al. 2006). Thus there is merit in presenting a case, showing how a business-driven alignment can significantly contribute to achieving competitive edge in healthcare services.

3 METHODS

3.1 Case background

This paper describes a longitudinal case study conducted at MHMO, the second-largest HMO in a country where four HMOs jointly serve over 7 million people. MHMO employs over 3,000 physicians who treat more than 1.7 million members under an organizational structure consisting of headquarters, five regional offices, and approximately 150 branches (clinics and other entities as labs, imaging centres, etc.). Since the 1990s, MHMO has adopted, in addition to administrative systems, clinical information systems used by all care providers to document transactions associated with patient care, including visits, prescriptions, and test results. These information systems have allowed MHMO to collect and aggregate organization-wide operational data into a data warehouse (Friedman and Pliskin 2002).

It is noteworthy that, as regulator of the national health insurance in the country, the ministry of health since 2002 has required all four HMOs to provide data about operational quality indicators for clinical care, which are being audited, processed, consolidated, and published (http://www.israelhpr.org.il) by The National Institute for Health Policy and Health Services Research (NIHP). NIHP also provides each HMO with its own performance indicators relative to the national performance

Coincidently, having by then in place a well-crafted business strategy aimed at improving the quality of clinical care while containing costs, MHMO's top management commissioned in 2002 development of the integrated hierarchical Health Value Added (HVA) model, based on the balanced scorecard (Kaplan and Norton 2007). HVA covers 21 performance measures, categorized into three major dimensions, each of which is composed of several areas. The six areas under the first *clinical-quality* dimension are: diabetes, mammography, flu vaccinations, cardiovascular disease (CVD), depression, and appropriate use of antibiotics. The two areas under the second *perceived-quality* dimension are:

satisfaction and member retention. The two areas under the third *cost* dimension are: total cost per patient and conformance with budgetary objectives. Each of the ten areas is composed of several performance measures, the elaboration of which is beyond the scope of this paper except for the first dimension – clinical quality.

In the clinical-quality area, each measure is defined as the percentage of members meeting the performance goal relative to the total target population for the specific area (see Appendix 1 for the full list of the 24 clinical measures). One of the diabetes measures, for example, is the percentage of patients among the total diabetic population, receiving a required screening test such as glycohemoglobin (HbA1C) once a year. Another area is vaccination, for which the total population includes members who are chronically ill and/or aged 55 and above.

On the basis of the HVA model, an intranet-based Business Performance Management (BPM) system was built and implemented at MHMO for calculating and presenting performance scores relative to target goals at the headquarters, region, and branch levels, as well as national averages published by NIHP. Data for calculating performance were extracted from the existing data warehouse system, storing routinely collected data and updated on a monthly basis. HVA measures were presented within the organization and approved during 2003, and the BPM system was up and running since February 2004. Since then, the BPM system regularly presents actual MHMO performance against set targets, to a broad organizational audience, and especially at monthly meetings of senior management.

Since the set of HVA measures has included NIHP's national performance measures, the latter have been used by MHMO as a control group for comparison. Thus, for example, the total population for *primary CVD prevention* measure included 298,821 MHMO members and 760,095 other-HMOs members, for *appropriate medications after bypass surgery* - 1,302 and 13,412, and for *mammography* - 128,309 and 495,607 for MHMO and other-HMOs members respectively. NIHP data is available for diabetes, mammography, and flu vaccination for 2002-2005, and for CVD for 2003-2005. Because data is regularly published by NIHP, each HMO can compare its own indicators to those of the other three HMOs combined.

3.2 Data collection and analysis methods

Quantitative data underlying the analysis presented in this study are collected from primary organizational sources (Kohli and Devaraj 2003), and are identical to figures submitted to NIHP. These figures are thoroughly audited by NIHP to verify their correctness, attesting to their validity and objectivity. Similarly, qualitative data were scrutinized to ensure academic rigour (Friedman 2006).

A multivariate logistic regression analysis was used to assess the impact of various factors on the performance of MHMO (Kohli and Devaraj 2003). Three dummy variables were defined for this analysis: the first reflecting changes over time for all HMOs (set equal 1 for the years 2004-5 and 0 before), the second differentiating MHMO from all other HMOs (set equal 1 for MHMO and 0 for others), and the third variable, the interaction between the first and second variables, reflecting the changes at MHMO in 2004-5, after the implementation of the BPM system. The crude ratios of all measures over time are presented in Appendix 1. A graphical representation of the improvement rate is displayed in Appendix 2. The results of the multivariate logistic regression analysis are presented in Appendix 3 by Odds Ratio (OR) - the exponent of the appropriate coefficient of the logistic regression. OR indicates the increase (decrease for OR<1) in odds of the dependent variable being positive, based on a positive independent variable - with 95% confidence interval (CI). The two-sided (Wald) P-values, obtained from the logistic regression, were considered as significant under 0.05. All analyses were performed using SAS 9.1.3 (SAS Institute Inc. NC, US).

Complementing the quantitative analysis, for triangulation purposes and for eliciting executives' perceptions as to the major drivers of the improvement in clinical quality, qualitative data was collected at MHMO. The qualitative data were collected via semi-structured interviews with 29 key informants (selected so as to obtain a wide range of views), participant observations, and documentary evidence (protocols, directives, transcripts, and work plans). Due to space limitations, the qualitative analysis is presented only briefly.

4 RESULTS

4.1 Quantitative results

As evident in Appendix 1, MHMO out-performed the other HMOs on 7 out of 9 diabetes (DM) measures (all but DM5 - % members with DM, with LDL<100, and DM6 - % members with DM, with LDL<130). This advantage was kept throughout the four years of the study. While this might seem incidental, the superior improvement rate is even more impressive for the other measures. MHMO performance in the mammography area (Measure 10) was similar in 2002 to the performance of all other HMOs combined, went down in 2003 while the combined group of all other HMOs improved, but then gained 43% improvement by 2005 reaching 62.81%, compared to 1% improvement for all HMOs that only reached the level of 53.87%. In the area of flu vaccination (Measure 11) MHMO's performance was initially similar to the combined group of all HMOs, yet MHMO was able to maintain a high level of improvement – 22%, three times better than all other HMOs, who started at a lower rate (42.57% compared to 51.51% for MHMO in 2003).

Comparison of the performance improvement (%) between the average of 2004-5 and the average of 2002-3 for both MHMO and other HMOs is depicted by the bar chart in Appendix 2 (except where data were missing in 2002, in which case performance in the later period was compared to 2003). The chart shows that MHMO's improvement rate was larger than that of the other HMOs for 14 of the 21 measures, and the improvement was nearly identical for 2 measures. Only for 5 of the 21 measures the improvement rate of the other HMOs exceeded that of MHMO. In spite of initially performing better on most diabetes measures, MHMO's improvement from 2003 to 2005 is greater than or equal to that of the other HMOs in 6 out of 9 DM measures. Even more notable is the improvement rate in the 10 cardiovascular (CVD) measures. Here, MHMO achieved improvement rates greater than (or equal to for CVD2) all other HMOs for all measures but two (CVD1 and CVD5). Particularly remarkable is the improvement rate in CVD7 and CVD8, 102% and 78% respectively for MHMO, compared to 3% and -4% respectively for the other HMOs.

Next, a multivariate logistic regression analysis was performed to substantiate the results in a more illustrative manner, and to assess the effect of the BPM system. This analysis, presented in Appendix 3, allows estimation of the impact of different factors, adjusting for the others. For each measure, the OR and its confidence interval (CI) are presented for the three covariates: Column 3 in Appendix 3 presents the effects, *pre-post the BPM system*, on both MHMO and the other HMOs, and column 4 presents the effect of *being a member of MHMO* during the four years. When comparing the 2002-2003 period (pre-BPM) to the 2004-2005 period (post-BPM), it is evident that there was an improvement at the post-BPM period (Column 3) in all measures but two (DM2, CVD8) nation-wide. Note that DM3 is a negative measure, where a smaller value is better. The changes range from OR of 1.973 in DM8 to OR of 1.015 for DM2. All differences were statistically significant. Examination of Column 4 shows that for 10 out of 21 measures, MHMO performed better than the other HMOs for all measured years, since the calculated OR is greater than 1. All differences between MHMO and the other HMOs were statistically significant.

Column 5 in Appendix 3 demonstrates the potential positive effect of the actual introduction of *the BPM system* at MHMO in 2004-5 on achieving the rapid improvement pace. For 12 out of the 21 measures, OR is greater then 1 (<1 for DM3), indicating that during 2004-5, MHMO not only performed statistically significantly better than in 2002-3, but also the rate of improvement was higher than it was for the other HMOs in these years. These results substantiate the evidence of accelerated rate of improvement displayed by the bar chart in Appendix 1, but suggest that the majority of improvement has been achieved during the last two years of the study, after the introduction of the BPM system.

Table 1 depicts the total costs (in 2005 values) per patient reported during 2002 to 2005, including spending on doctors, consultants and specialists, medications and treatments, and hospitalizations. As evident in Table 1, costs per patient in 2004 and 2005, when performance improvement has been most significant, are similar to (and somewhat lower then) those of 2002. Hence, the improvement in quality of clinical care has been achieved while containing costs. Budgetary goals were also reached as a result of cost stagnation.

Year	2002	2003	2004	2005
Cost per patient	3,219	3,183	3,194	3,189

Table 1: Costs per patient, 2002-2005 (in 2005 values)

4.2 Qualitative results

The implementation of the HVA model was followed by in-depth, semi-structured interviews with 29 executives, representing a broad view of MHMO's operations and management (Friedman 2006). Some of the questions in the interviews relate to the plausible explanations for the improvement in the various measures. In a response to an open question "what in your opinion caused the changes in performance", twenty six respondents (89.66%) ranked the process of clearly setting indicators and targets, which are presented in the BPM system, as the main reason for the improvement. Specifically, the visibility and credibility of the previously unavailable data, was said to have the main effect. "The BPM system allows an on-line update as part of our ongoing management. Without this tool it would have been impossible to achieve the current results". Furthermore, the interviewees maintained that having the measurement results regularly displayed, through the BPM system, in top management meetings and throughout the organization, was a major driver for competitive advantage and improvement. One interviewee even complained of "over measurement" and said that even though the BPM system was a driver for change, it took its toll on employees who were tired of the continuous exposure.

5 DISCUSSION

Notwithstanding the contribution of this case study, detailed next, several limitations should be noted. First, this case is an organizational-level study, where real-life, longitudinal field data is used, as opposed to experimental or laboratory data. Concerns about data accuracy might arise, as is often the case when using real-world data. Because real-life data have been used, the study cannot be classified as a "controlled" experiment. Nonetheless, the fact that the data used for this study is rigorously audited by NIHP, and the existence of objective, control-group data, provides the critical comparison required for rigour. Another concern is the large sample size, where significance is likely to be achieved at any case. While this might be true, the qualitative data reinforces the quantitative results, thus rejecting the likelihood of no real significance. Finally, concerns might arise as to the true process of aligning business strategy and IT at MHMO, since such alignment is often found at hindsight rather than as a systematically planned objective. Although we cannot be utterly positive this was not the case at MHMO, there is good evidence, mainly from the qualitative data not presented here in details, that management did consider alternative options for achieving the improvement goals, finally convinced about the effectiveness of the BPM system. This concern, however, still remains a somewhat questionable issue.

As evident from the 2002-2003 data, MHMO initially performed better on most indicators. Therefore, with all other factors being equal, the other HMOs should have demonstrated an accelerated improvement rate since the organizational and the general health environment were stable and similar for all HMOs. This, however, was not the case for 16 out of 21 measures. More interestingly, the rate of improvement post-implementation of the BPM system was significantly greater for MHMO than for all other HMOs. This is evident in the results of the statistical multivariate logistic regression analyses, substantiated by the qualitative data. Although performance was sporadically measured in MHMO during 2002 and 2003, the rapid pace of performance improvement is generally evident in 2004 and 2005, when the strategic alignment between business and IT has matured. While investigating managerial drivers other than alignment (such as bonuses, already in existence in 2002-2003), the major change in 2004-2005 was the organization-wide distribution of the results via the BPM system. During this period, not only clinical quality performance has improved, but also other indicators, such as members' satisfaction and cost performance (Friedman 2006). Clearly, MHMO has succeeded in transforming its business processes to facilitate effective and more efficient clinical care, above and beyond its competitors, gaining competitive advantage. The improvement in quality of care at MHMO, while containing costs, can therefore be attributed to strategic business and IT alignment.

In the SAM context, the alignment perspective in this case is that of "strategy execution" (Henderson & Venkatraman, 1993, p. 477), where business strategy drives the organizational transformation, causing business and IT infrastructures to follow suit. MHMO's business strategy was to gain competitive edge by improving efficiency and effectiveness of clinical care. To achieve these ambitious goals, MHMO has successfully not only implemented, with support from business executives, information systems that facilitate efficiency and effectiveness of clinical care, such as computerized medical records, data warehouse, and the BPM system, but also pursued major transformation in business infrastructures, processes, and skills. For example, all management levels transformed their managerial style to management by organization-set, quantifiable goals, as opposed to management by local interests and intuition, practiced before. Complying with Henderson and Venkatraman (1993), top management played the role of strategy formulator, while IT management played the role of strategy implementer. IT infrastructure became a cost center, measured by the degree to which IT facilitated achieving business goals, which in this case, it clearly did. The broad presentation of the results via the BPM system is perhaps the most significant contribution of IT to the organizational transformation, as evident in the quantitative results, and enforced by the qualitative ones. The BPM system clearly drove rapid change in employees' and mid-management way of conducting routine tasks, aimed at achieving the set goals.

Extending the discussion somewhat beyond SAM, (Tallon et al. 2000) identify three types of focused organizations: operations-focused, market-focused, or dual-focused. Dual-focused organizations improve operational effectiveness (internal perspective) and strategic positioning (external perspective) simultaneously, achieving the highest value from business and IT alignment. MHMO clearly demonstrates such a focus, since the improved quality of clinical care enables re-positioning in the market vis-à-vis competitors, whereas the contained costs mean improved internal processes.

Although a specific HMO has been the focus of this study, the lessons learned may, after more research is conducted, apply to other organizations as well, in the healthcare industry and beyond. First, this study demonstrates the plausibility of measuring quality of clinical care, and the positive effect that might be accrued. While generally considered complex and costly (Spath 2007), the described case suggests ways quality improvement can be achieved in healthcare without incurring excessive costs. Second, it shows how data for such measurements can be collected through infrastructural, routinely used operational IT, with only minimal requirements for special systems (such as the BPM system). This, however, is possible by careful planning for adequate IT infrastructure, processes and skills, developed in parallel to similar adjustments in business infrastructure. Evidently, such alignment can facilitate an organizational transformation from internally focused on costs to also externally focused, in this case on quality of care. Hence, this study clearly demonstrates benefits accrued through business and IT alignment, where such alignment guides the careful planning of both IT and business resources, aimed at achieving ambitious strategic goals.

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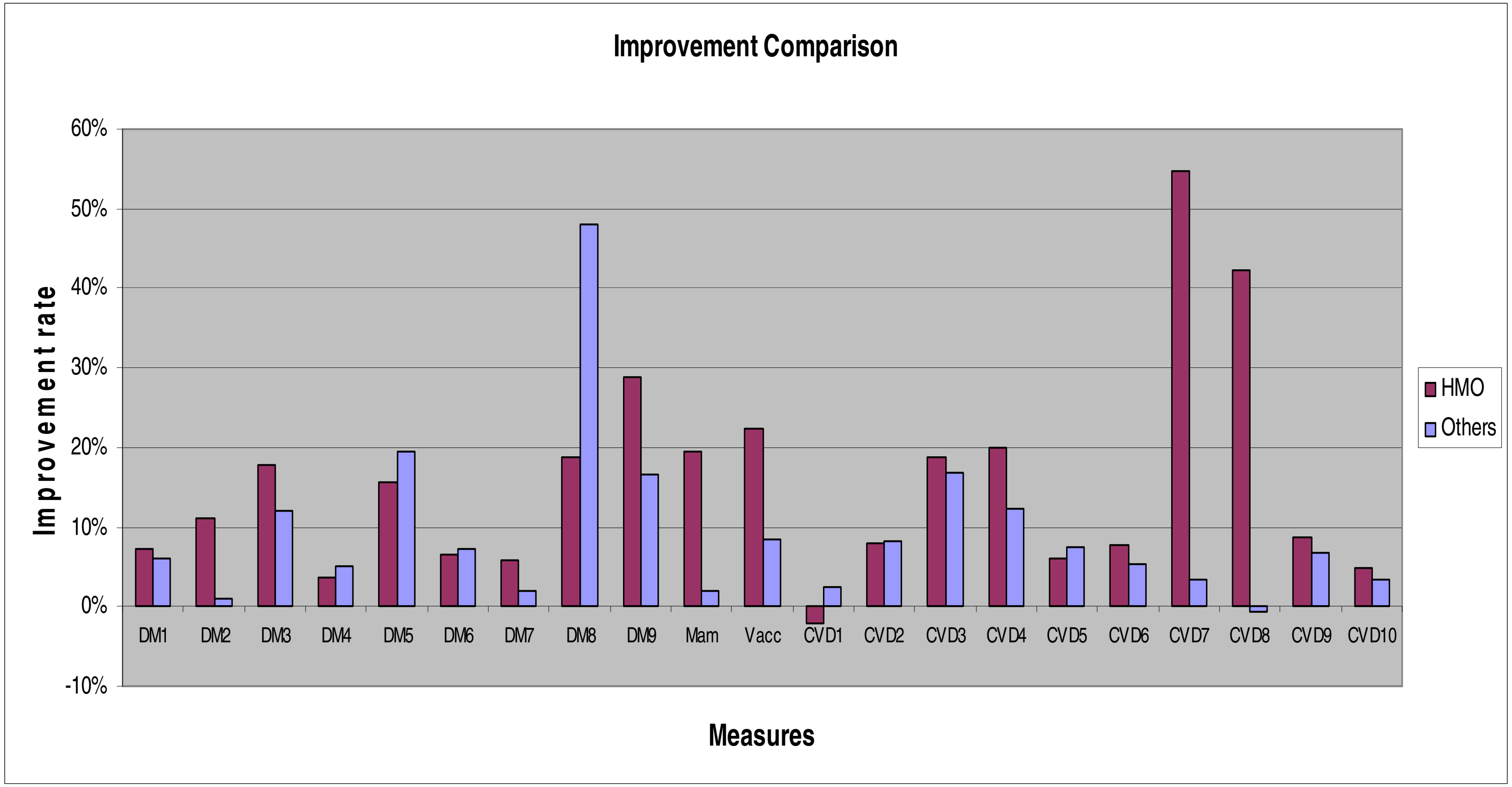
Appendix 1: Annual performance in selected quality measures - HMO versus all other HMOs in the country: 2002-2005.

Year		2002	2003	2004	2005	2002	2003	2004	2005	2002	2003	2004	2005
Measure		1) % members with DM tested for HbA1c (DM1)				2) % members with DM with HbA1c < 7% (DM2)				3) % members with DM with HbA1c > 9% (DM3) [*less is better*]			
	HMO	86.72	96.72	98.01	98.72	N.A	41.82	44.32	51.55	N.A	16.14	14.48	12.08
	Other	80.71	83.15	86.19	87.79	37.81	41.99	39.80	40.83	22.73	18.14	18.54	17.40
Measure		4) % members with DM tested for LDL (DM4)				5) % members with DM with LDL < 100 mg/dl (DM5)				6) % members with DM with LDL < 130 mg/dl (DM6)			
	HMO	86.31	87.91	89.64	91.07	36.85	34.09	38.15	43.92	71.31	68.99	72.84	76.63
	Other	80.69	82.75	85.69	86.07	37.52	40.21	44.36	48.59	72.75	75.08	77.91	80.49
Measure		7) % members with DM with an eye test (DM7)				8) % members with DM with urine testing for microalbumin (DM8)				9) % members with DM receiving flu vaccine (DM9)			
	HMO	58.19	58.58	60.32	63.25	50.19	54.77	58.69	65.85	42.79	49.73	60.20	58.93
	Other	57.02	56.12	57.19	58.29	32.25	35.94	47.27	53.68	35.40	36.57	39.32	44.58
Measure		10) % women ages 52-74 having mammography in last 2 years (Mamm)				11) % of members ages 65+ receiving influenza vaccine (Vacc)				12) % of members ages 35-54 with LDL<130 mg/dl (CVD1)			
	HMO	51.79	43.97	51.53	62.81	46.12	51.51	59.96	59.41	N.A.	58.94	57.94	57.56
	Other	51.12	53.39	52.63	53.87	45.04	42.57	46.03	48.90	N.A.	63.07	63.76	65.50
Measure		13) % of members ages 55-74 with LDL<130 mg/dl (CVD2)				14) % of patients with history of coronary artery bypass surgery with LDL<100 mg/dl (CDV3)				15) % of members with history of coronary angiography with LDL<100 mg/dl 9CVD4)			
	HMO	N.A.	52.18	54.88	57.81	N.A.	41.14	44.35	53.29	N.A.	41.27	45.91	53.05
	Other	N.A.	59.77	63.08	66.23	N.A.	46.98	52.55	57.14	N.A.	50.64	54.54	59.24
Measure		16) % of patients with history of coronary artery bypass surgery treated with statins (CVD5)				17) % of members with coronary angiography treated with statins (CVD6)				18) % of patients with history of coronary artery bypass surgery who were treated with ACEI/ARB (CVD7)			
	HMO	N.A.	83.80	87.76	89.86	N.A.	76.98	81.48	84.39	N.A.	44.54	47.96	89.86
	Other	N.A.	70.78	74.26	77.77	N.A.	74.90	77.51	80.31	N.A.	75.51	78.56	77.77
Measure		19) % of members with coronary angiography who treated with ACEI/ARB (CVD8)				20) % of patients with history of coronary artery bypass treated with beta blocker (CVD9)				21) % of members with history of coronary angiography treated with beta blocker (CVD10)			
	HMO	N.A.	47.28	50.12	84.39	N.A.	60.98	64.42	68.20	N.A.	64.74	66.75	69.12
	Other	N.A.	83.95	86.48	80.31	N.A.	63.63	66.93	68.82	N.A.	66.07	67.89	68.80

*Appendix 2: % Improvement in clinical measures (average 2004-5 to average 2002-3).**



* For CVD measures and DM2, DM3: 2002 data is not available. Comparisons were made to 2003

Appendix 3: Multivariate logistic regression analysis

(1) Area (# of measures)	(2) Quality Measure	(3) Pre-Post Effect OR (95% CI)	(4) HMO Effect OR (95% CI)	(5) BPM System Effect (Interaction) OR (95% CI)
	% tested HbA1c	1.475 (1.456 – 1.493)	2.545 (2.471 – 2.623)	3.552 (3.335 – 3.785)
	% HbA1c<7%	0.934 (0,923 -0.946) [2]	n.s.	1.380 (1.341 – 1.420)
	% HbA1c>9%	n.s.	0.69 (0.841 – 0.897)	0.802 (0.772 – 0.835)
	%LDLtest	1.358 (1.342 – 1.375)	1.516 (1.479 – 1.554)	n.s.
Diabetes (DM 1-9)	%LDL<130	1.343 (1.328 – 1.359)	0.824 (0.808 – 0.840)	0.946 (0.920 – 0.972)
	%LDL<100	1.366 (1.353 – 1.380)	0.859 (0.843 – 0.875)	0.936 (0.913 – 0.960)
	%Eyetest	1.050 (1.041 – 1.060)	1.078 (1.060 – 1.097)	1.100 (1.075 – 1.125)
	%Urinetest	1.973 (1.955 – 1.991)	2.142 (2.106 – 2.179)	0.758 (0.741 – 0.776)
	%DM Vaccine	1.288 (1.277 – 1.300)	1.544 (1.518 – 1.570)	1.315 (1.285 – 1.346)
Mammography	%Mammography	1.040 (1.035 – 1.046)	0.834 (0.826 – 0.842)	1.413 (1.395 – 1.431)
Vaccine (Vacc)	%Vaccine	1.162 (1.156 – 1.168)	1.232 (1.220 – 1.245)	1.329 (1.311 – 1.347)
	%LDL<130 (age 35-54)	1.072 (1.065 – 1.078)	0.841 (0.833 – 0.849)	0.888 (0.878 – 0.898)
	%LDL<130 (age 55-74)	1.233 (1.223 – 1.242)	0.734 (0.724 – 0.744)	0.962 (0.947 – 0.978)
	%LDL<100†	1.371 (1.310 – 1.434)	0.789 (0.706 – 0.882)	n.s.
	%LDL<100††	1.293 (1.251 – 1.336)	0.685 (0.647 – 0.726)	1.087 (1.015 – 1.164) [1]
CVD (1-10)	%Statin†	1.308 (1.249 – 1.370)	2.136 (1.867 – 2.451)	n.s.
	%Statin††	1.260 (1.217 – 1.304)	1.121 (1.054 – 1.191) [3]	1.159 (1.076 – 1.250) [3]
	%Ace†	1.161 (1.106 – 1.219)	0.260 (0.235 – 0.289)	2.241 (1.960 – 2.565)
	%Ace††	0.949 (0.912 – 0.988) [1]	0.171 (0.162 – 0.181)	2.505 (2.340 – 2.681)
	%BetaBlocker†	1.207 (1.156 – 1.260)	0.893 (0.805 – 0.993) [1]	n.s.
	%BetaBlocker††	1.110 (1.076 – 1.145)	0.943 (0.893 – 0.995) [1]	n.s.

† Patients with history of coronary artery bypass surgery
††Patients with history of coronary angioplasty
1 - P<0.05
2 - P<0.01
3 - P<0.001
All others: P<0.0001
n.s: Not significant