SHORT COMMUNICATION

Dis Manage Health Outcomes 2006; 14 (4): 197-202
1173-8790/06/0004-0197/$39.95/0

In Search of Financial Savings from Disease Management

Applying the Number-Needed-to-Decrease Analysis to a Diabetic Population

Ariel Linden[1,2] and *Thomas J. Biuso*[3,4]

1 Linden Consulting Group, Portland, Oregon, USA
2 School of Medicine and School of Nursing, Oregon Health & Science University, Portland, Oregon, USA
3 Prime Care Physicians, Albany, New York, USA
4 Hospitalist Program, St Peter's Hospital, Albany, New York, USA

Abstract

Background: In a previous article using population-level data, an *a priori* number-needed-to-decrease (NND) analysis was conducted to determine if there is potential opportunity in a given population for a disease management program to achieve financial effectiveness. Critics of that study have suggested that analysis at the entire population level does not account for differential enrollment trends. They also contend that reviewing disease-only hospitalization data disregards changes in acute utilization for comorbidities of the primary condition. This article responds to these two criticisms by critically examining the hypothesis that evaluating a specific diseased cohort elicits more reasonable projections of the financial effectiveness of a disease management program than when the analysis is conducted at the population level. To do this, this article reports the results of an *a priori* NND analysis of hospitalizations conducted on a diabetes mellitus cohort.

Methods: An NND analysis was conducted on a diabetes cohort that was identified in a health plan population using Health Plan Employer Data and Information Set (HEDIS®) criteria. Hospitalizations were categorized in three groups: diabetes-only; diabetes plus comorbid conditions; and diabetes plus comorbid conditions and diagnoses possibly associated with diabetes.

Results: To cover fees alone, it is estimated that a disease management program would have to reduce diabetes-only hospitalizations by 74%; hospitalizations for diabetes and comorbid conditions by 39%; or hospitalizations for diabetes, comorbid conditions, and diagnoses possibly associated with diabetes by 26%.

Conclusions: The findings of the present study indicate that when performing the NND analysis at the cohort level as opposed to at the population level, even more stringent levels of performance are required to break even. Given that program fees is the only variable that can truly be manipulated *a priori* by the disease management program under the current model to improve the likelihood of achieving economic effectiveness, alternative approaches to this dilemma are discussed.

Background

In a recent article,[1] the author introduced an *a priori* approach to assessing whether sufficient opportunity exists for a disease management program to demonstrate financial effectiveness; in other words, performing an analysis before the implementation of a program. A number-needed-to-decrease (NND) analysis was developed to estimate the number of condition-specific hospital discharges and/or emergency department visits that must be reduced in order to achieve various levels of return on investment in a given program year. In this paper, the NND analysis is analogous to the concept of the 'number needed to treat,' which is used in research to assess the effect of treatment in terms of the number of

patients needed to be treated with a particular therapy to prevent one adverse event.

The model was premised on hospital inpatient data, at the US population level, on four chronic conditions typically managed in disease management: asthma, acute myocardial infarction, congestive heart failure, and diabetes mellitus. As inpatient utilization represents the single largest health expenditure (30% in 2004),[2] it is logical to focus on reducing hospitalizations as a means of achieving large cost savings. Similarly, as approximately 14% of emergency department visits result in hospital admission,[3] it is reasonable to target emergency department utilization as well. Moreover, disease management programs have been unable to consistently control financially-related outcomes beyond hospital admissions and emergency department visits.[4] This result is not surprising, as physician encounters and pharmacy utilization are both likely to increase as a result of a successful disease management interventions based on evidence-based practice guidelines.[4]

Using a detailed set of assumptions, the results of the NND analysis in that article suggested that a disease management program would have to reduce disease-specific hospitalizations by 10–30% in a given year to cover program fees alone.[1] The significance of this outcome generated considerable reaction in the disease management community.[5]

The current study serves as an extension of that initial article and is intended to address the two major issues raised in its aftermath. The first concern was directed at the author's decision to analyze hospitalization rates at the total population level as opposed to limiting the analysis to the diseased cohort only.[6] Critics have argued that in approaching the analysis in this way, many of the attributes specific to the diseased cohort may be overlooked. For example, enrollment and/or disenrollment from the diseased group may change differentially from that of the entire population over the year, possibly leading to variations in case-mix and utilization patterns. Thus, it is feared that analysis at the entire population level will underestimate economic outcomes. In contrast, an argument can be made that limiting the focus to the disease-specific cohort may be more reflective of actual events.[3]

The second concern was regarding the restriction of the author's measurement of hospital utilization to the primary condition of the specific diseases under study. The concern was that use of such narrowly defined criteria will understate the program impact by disregarding changes in acute utilization for comorbidities of the primary condition; i.e. it doesn't take into account the full impact that the disease management program may have on comorbid or other conditions during that same period.[3,7,8]

The author maintains that reviewing data at the population-wide level allows for a more direct application to industry practices. In addition, there is currently little, if any, supporting evidence in the health services literature regarding either of these two concerns. However, this article reports the results of the suggested *a priori* NND analysis conducted at the disease level, specifically focusing on a diabetic cohort. Diabetes is a condition particularly suited to this evaluation in that it represents the sixth leading cause of death in the US; it contributes to numerous comorbid conditions such as heart disease, stroke, blindness, kidney disease, nervous system damage, lower extremity amputations, periodontal disease, and complications with pregnancy;[9] and it presents significant opportunity for disease management because inpatient utilization accounts for 43.9% of total diabetes expenditures[10] (compared with 30% of national expenditures for inpatient utilization in all conditions).[2]

Considerations for Conducting Analysis of a Diseased Cohort

One important consideration to address before conducting an analysis of a diseased cohort as compared with the total population is the challenge of accurate identification of patients with the disease, which is subsequently needed to determine their utilization rates. Historically, nearly all disease management programs have relied on claims analysis as the primary source of identification. The level of sophistication in this process ranges from the use of a single diagnosis code to quite complex statistical algorithms to detect the specific disease or condition. Not only do the methods vary between disease management programs, but access to the identification protocol by outside parties is usually restricted. Thus an independent assessment of model performance cannot be conducted.[11] That said, one widely accepted identification methodology available for most chronic illnesses is the Health Plan Employer Data and Information Set (HEDIS®).[12] With little or no modification, most disease management programs can readily adopt these criteria for immediate use in their populations. In any event, a standard identification methodology must be established before any analysis at the disease-specific cohort level can be generalized across people, settings, treatments, or outcomes.[13]

Another factor that must be considered at the diseased cohort level more than at the population level is the determination of appropriate diagnosis criteria for measuring hospitalizations. Counting only disease-specific hospitalizations is the most straightforward technique but may understate the true disease management program impact. Counting hospitalizations for

comorbid conditions may provide better estimates of program outcomes but can only be tracked once individuals with the disease under study are accurately identified. Finally, counting all hospitalizations, regardless of clinical association with the primary disease, will greatly overstate the effectiveness of the disease management program since many hospitalizations are not related to the primary condition.

In this article, we critically examine the hypothesis that evaluating a specific diseased cohort elicits more reasonable projections of the financial effectiveness of a disease management program than when the analysis is conducted at the population level. It should be stressed that this method should be conducted prior to the implementation of a disease management program (rather than as a *post-hoc* assessment) to determine whether the opportunity exists and whether the program is financially viable.

Methods

Claims data from a medium-sized health plan were retrieved for the period between 2001 and 2004. HEDIS® 2006 criteria[8] were used retrospectively to identify the enrollees in the health plan who had diabetes. These criteria are similar to those used in a study by Hux et al.,[14] which achieved a sensitivity of 0.86 and a positive predictive value of 0.80, thus demonstrating it to be a valid identification algorithm for diabetes.

Approximately 5% of the health plan population was identified as having diabetes (n = 12 430). Table I illustrates the basic demographic profile of this group. Approximately 78% of the diabetic patients were found in the commercial insurance line of business, followed by 14% in Medicare and 8% in Medicaid. Commercial and Medicaid members with diabetes were comparable in terms of average age, sex, and median number of months enrolled in the health plan. As expected, the Medicare group was older, included more women, and had fewer months of tenure in the health plan than the other two groups.

An *a priori* NND analysis is constructed using the assumptions based on current hospital stay costs per day and estimated disease management program fees for a given managed population or cohort. Hospitalization rates for the year are then standardized to the population size (typically 10 000 or 100 000 persons). Equation 1 demonstrates the calculation used to determine the break-even point for a disease management program (equation 1):

$$\text{NND to break even} = \frac{\text{vendor fees}}{\text{cost per hospitalization}} \quad \text{(Eq. 1)}$$

where vendor fees are calculated as (monthly fees × 12 months × 10 000 population) and cost per hospitalization is calculated as (average cost per hospital day × average length of stay). The average cost per hospital day and average length of stay were derived from the claims data.

Equation 2 demonstrates the calculation used to establish the percent reduction in hospitalizations from baseline in order to break even (equation 2):

$$\text{Percent reduction to break even} = \frac{\text{NND}}{\text{hospitalizations per 10 000 patients}} \quad \text{(Eq. 2)}$$

where NND is the product of equation 1, and hospitalizations per 10 000 is the rate in the period(s) prior to program implementation. Thus, this equation estimates the percentage of hospitalizations that must be cut from the current level in order to cover disease management program fees.

Results

Table II presents a break-even NND analysis for this specific diabetes cohort under three separate scenarios, grouping hospitalizations for (i) diabetes only; (ii) diabetes plus known comorbid conditions; or (iii) diabetes plus known comorbid conditions plus additional diagnoses possibly associated with diabetes. A total of 1150 primary diagnosis codes for the hospital claims of the cohort were independently evaluated by an expert in this medical specialty (the second author) and categorized into the three groupings. These diagnoses were then cross-referenced to a comprehensive

Table I. Characteristics of patients with diabetes mellitus enrolled in a medium-sized health plan between 2001 and 2004

Characteristic	Insurance type			Totals
	commercial	Medicare	Medicaid	
Number of patients (%)	9670 (77.8)	1765 (14.2)	995 (8.0)	12 430 (100)
Mean age [years] (95% CI)	48.9 (48.7, 49.1)	73.1 (72.6, 73.5)	46.5 (45.6, 47.4)	52.2 (51.9, 52.4)
Percentage of females (95% CI)	59.8 (58.6, 60.9)	66.0 (63.4, 68.6)	60.3 (56.7, 63.9)	60.7 (59.6, 61.7)
Median number of months enrolled in health plan (95% CI)	25.0 (23.0, 26.0)	20.0 (18.0, 23.0)	27.0 (22.1, 31.0)	24.0 (23.0, 25.0)

CI = confidence interval.

Table II. Break-even point[a] for a diabetes mellitus disease management program based on data analysis of patients with diabetes who were enrolled in a medium-sized health plan between 2001 and 2004 (n = 12 430)

Assumptions	Hospitalizations		
	diabetes only	diabetes + comorbidites	diabetes + comorbidities + possibly associated diagnoses
Hospitalizations per 10 000 diabetic patients	377	658	1018
Average length of stay (days)	4.3	4.7	4.5
Hospital days per 10 000 diabetic patients	1621	3093	4581
Cost per hospital day ($US)	2000	2000	2000
Cost per hospitalization ($US)	8600	9400	9000
Total costs per 10 000 diabetic patients ($US)	3 242 200	6 185 200	9 162 000
Program fees ($US)[b]	20	20	20
Total program fees per 10 000 diabetic patients ($US)	2 400 000	2 400 000	2 400 000
NND to break even	279	255	267

a Break-even point indicates that program fees are equal to current hospital costs.

b Program fees are per eligible diseased member per month (estimates provided by Disease Management Purchasing Consortium).

NND = number (of hospitalizations) needed to decrease in 1 year from the current year's level.

list of chronic conditions of diabetes presented in the appendix of the American Diabetes Association publication on the economic costs of diabetes in the US.[10]

The NND analysis was constructed using assumptions derived from various sources: (i) the average length of stay and hospitalization rates were derived from the claims analysis; (ii) an average cost per hospital day in a medical/surgical ward was set at $US2000; and (iii) disease management program fees for a diabetes cohort were provided by the Disease Management Purchasing Consortium ($US20 per eligible diseased member per month [PEDMPM]) [personal communication from Alfred Lewis of the Disease Management Purchasing Consortium; June 10, 2006]. Equation 3 demonstrates the calculation used to determine the break-even point for a disease management program when diabetes-only hospitalizations are measured (equation 3):

$$\text{NND to break even} = \frac{\text{vendor fees}}{\text{cost per hospitalization}} = \frac{\$US2\,400\,000}{\$US8\,600} = 279 \quad \text{(Eq. 3)}$$

where vendor fees are calculated as $20 PEDMPM × 12 months × 10 000 population and cost per hospitalization is calculated as $US2000 per hospital day × 4.3 days (average length of stay, as presented in table II). Thus, using the diabetes-only hospitalization criteria, the disease management program would have to reduce the number of admissions each year by 279 in order to break even.

Equation 4 demonstrates the calculation used to establish the percent reduction in hospitalizations from baseline in order to break even (equation 4):

$$\text{Percent reduction to break even} = \frac{\text{NND}}{\text{hospitalizations per 10 000 patients}} = \frac{279}{377} = 74\% \quad \text{(Eq. 4)}$$

where NND is the product of equation 3, and hospitalizations per 10 000 diabetic patients is the rate in the period(s) prior to program implementation. Thus, using the diabetes-only criteria, the disease management program would have to cut hospitalizations by 74% from the current level in order to cover fees.

Using these same equations for hospitalizations for diabetes plus comorbid conditions, a reduction of 255 hospitalizations (a 39% decrease) is needed to break even. As further illustrated in table II, even when all possible diabetes-related hospitalizations are included in the analysis, a 26% reduction from the current level must be achieved in order for the disease management program to break even on their fees.

Discussion

The concept of performing an NND analysis prior to program implementation is meant to provide both the supplier and the consumer of disease management services with an idea of what lowered levels of acute utilization must be attained in order to break even on fees. With this information at hand, both parties can then enter the partnership with a reasonable expectation of what targets need to be reached.

In the previous study,[1] the *a priori* NND analysis was conducted at the population level and produced results suggesting that a disease management program would have to reduce hospitalizations for chronic disease by 10–30% to cover program fees alone. Based on responses to that article, this article presents the results of an *a priori* analysis in which alternative assumptions to those used in the initial paper were explored. Here, the NND analysis was limited to a diabetes cohort (to address a specific diseased cohort as opposed to a population) while hospitalizations were expanded to include comorbid conditions as well as hospitalizations for diagnoses that may possibly be associated with diabetes (to address the possibility that a disease management intervention may have a 'spill-over effect' on comorbid conditions).

Given this set of assumptions, the findings from the present study would suggest that even more stringent levels of performance by disease management would be expected than those presented in the initial article. Even when all hospitalizations for comorbid conditions plus those possibly associated with diabetes are included, the disease management program would still have to achieve a 26% reduction in acute stays to break even on fees. It can therefore be concluded that no additional information is provided (i) by evaluating utilization in a disease-specific cohort as opposed to measuring utilization rates at the population level; and (ii) by expanding the admitting diagnoses to include comorbid or even possibly associated conditions. Given these results, the likelihood of a disease management program achieving a 4 **:** 1, or even 2 **:** 1, return on investment seems remote at best.

As indicated by equation 1, program fees is the only variable that can truly be manipulated *a priori* by the disease management program to improve the likelihood of achieving economic effectiveness. This topic is a sensitive one for an industry that has high administrative costs as a function of its prevailing business model. High-salaried professionals such as doctors, nurses, dietitians, social workers, and pharmacists make up the clinical team that provides services to participants. Alternative approaches to this dilemma would include changing the service offerings to more cost-effective ones and changing the way in which disease management demonstrates its value to clients.

Technological advances in healthcare may offer basic or supplemental services to a disease management population in a more cost-effective manner than is being delivered today. Integrated voice recognition and Internet-based software programs can replace costly human resources while allowing for services to be expanded to a much larger population. Similarly, the use of remote physiological monitoring in a high-risk group of participants will alert the disease management program when a clinical indicator is triggered, enabling the clinical team to provide an immediate intervention before the condition escalates to become an adverse health event. Another intervention strategy becoming increasingly popular in disease management is motivational interviewing-based health coaching, which has been shown to be a cost-effective technique in getting participants to change health-related behaviors.[15]

If the NND analysis ultimately shows that a program may not be able to show a financial return on investment based on a reduction of short-term acute utilization, disease management programs may have to consider alternative measures of economic effectiveness. These include (i) cost-effectiveness analysis in which program effectiveness is measured in quality-adjusted life-years gained;[16] (ii) period-over-period changes in health status as measured by the Short-Form 12 (SF-12), which has been shown to predict medical expenditures;[17] and (iii) changes in patient self-efficacy, which has been shown to correlate with healthcare utilization (office visits, emergency department visits, and number and length of hospital stays).[18] As illustrated in this paper, the structure of the NND design is intended to provide an estimate for the first program year only. We would expect that each additional program period will decrease acute admissions beyond that established in the first year, and thus the cumulative effect will be heightened. The NND analysis can easily be expanded to include future periods; however, estimates will most likely be less precise.

The data used herein were comprehensive and incorporated a wide range of ages and the main lines of business of any health plan. However, the results of the current study may not be generalizable to other populations or settings. Thus, an NND analysis must be conducted using data from a specific setting before implementing a disease management program in that population.

Conclusions

The findings of the present study indicate that in performing an *a priori* NND analysis at the diseased cohort level to determine the

potential for a disease management program to achieve economic success, even more stringent levels of performance must be achieved than those measured at the population level.[1] Given that program fees is the only variable that can truly be manipulated *a priori* by the disease management program under the current model to improve the likelihood of achieving economic effectiveness, alternative approaches to this dilemma would include changing the service offerings to more cost-effective ones or changing the way in which disease management demonstrates its value to clients.

Acknowledgments

The authors would like to thank Susan Butterworth, PhD, for her review and editing of the manuscript. No sources of funding were used to assist in conducting the study. Neither author has any conflict of interest that is directly relevant to the content of the study.

References

1. Linden A. What will it take for disease management to demonstrate a return on investment? New perspectives on an old theme. Am J Manag Care 2006; 12: 217-22
2. US Centers for Medicare and Medicaid Services, Office of the Actuary, National Health Statistics Group. National health expenditure tables, historical and projected [online]. Available from URL: http://new.cms.hhs.gov/NationalHealthExpendData/02_NationalHealthAccountsHistorical.asp [Accessed 2006 Jun 26]
3. McCaig LF, Burt CW. National Hospital Ambulatory Medical Care Survey: 2003 emergency department summary. Advance Data from Vital and Health Statistics, No. 358 [online]. Hyattsville (MD): National Center for Health Statistics, 2005 May 26. Available from URL: http://www.cdc.gov/nchs/data/ad/ad358.pdf [Accessed 2006 Jun 26]
4. US Congressional Budget Office. An analysis of the literature on disease management programs [online]. Washington DC: Congressional Budget Office, 2004 Oct 13. Available from URL: http://www.cbo.gov/showdoc.cfm?.index=5909&sequence=0 [Accessed 2006 Jun 26]
5. Editor. New standard for DM outcomes measurement proposed. Dis Manag News 2006; 11 (8): 1,4-5
6. Editor. Duncan: new DM outcomes standard has pluses, minuses. Dis Manag News 2006; 11 (8): 4-5
7. Kuraitis V. Re: New press release on www.dismgmt.com on proving measurement valid (April 2006, week 4, message 7304; 2006 Apr 23) [online]. Message posted to the Disease Management Forum electronic mailing list. Available from URL: http://health.groups.yahoo.com/group/DMFORUM/ [Accessed 2006 Jun 1]
8. Wilson T. Re: New press release on www.dismgmt.com on proving measurement valid (April 2006, week 4, message 7311; 2006 Apr 240 [online]. Message posted to the Disease Management Forum electronic mailing list. Available from URL; http://health.groups.yahoo.com/group/DMFORUM/ [Accessed 2006 Jun 1]
9. US Centers for Disease Control and Prevention. National diabetes fact sheet – 2002 [online]. Available from URL: http://www.cdc.gov/diabetes/pubs/pdf/ndfs_2003.pdf [Accessed 2006 May 3]
10. American Diabetes Association. Economic costs of diabetes in the US in 2002. Diabetes Care 2003; 26: 917-32
11. Linden A. Measuring diagnostic and predictive accuracy in disease management: an introduction to receiver operating characteristic (ROC) analysis. J Eval Clin Pract 2006; 12 (2): 132-9
12. US National Committee for Quality Assurance. HEDIS® 2006: Health Plan Employer Data and Information Set. Volume 2: technical specifications. Washington, DC: National Committee for Quality Assurance, 2005
13. Linden A, Adams J, Roberts N. The generalizability of disease management program results: getting from here to there. Manag Care Interface 2004; 17 (7): 38-45
14. Hux JE, Ivis F, Flintoft V, et al. Diabetes in Ontario: determination of prevalence and incidence using a validated administrative data algorithm. Diabetes Care 2002; 25: 512-6
15. Linden A, Butterworth SW, Roberts N. Disease management interventions II: what else is in the black box? Dis Manag 2006; 9 (2): 73-85
16. Laupacis A, Sackett DL, Roberts RS. An assessment of clinically useful measures of the consequences of treatment. N Engl J Med 1988; 318: 1728-33
17. Fleishman JA, Cohen JW, Manning WG, et al. Using the SF-12 health status measure to improve predictions of medical expenditures. Med Care 2006; 44: I-54-I-63
18. Lorig KR, Ritter P, Stewart AL, et al. Chronic disease self-management program: 2-year health status and health care utilization outcomes. Med Care 2001; 39 (11): 1217-23

About the Author: Dr. Linden is a health services researcher whose focus is on evaluating the effectiveness of disease management and health promotion initiatives. In this area alone, he has recently published more than 40 peer-reviewed articles, book chapters, editorials, and a position paper for the Disease Management Association of America. He is President of the Linden Consulting Group and holds adjunct positions in both the School of Medicine and the School of Nursing at Oregon Health and Science University.

Correspondence and offprints: Dr. *Ariel Linden*, Linden Consulting Group, 6208 NE Chestnut Street, Hillsboro, OR 97124, USA.
E-mail: alinden@lindenconsulting.org