Measuring Effectiveness of Continuing Medical Education Using the Transtheoretical Model of Behavior Change

Sara S. Johnson, PhD,[1] Carol Cummins,[1] Andrea Paiva, PhD,[1] Jennifer J. Brown, PhD[2]
[1]*Pro-Change Behavior Systems, Inc., and University of Rhode Island, Kingston, Rhode Island, USA;*
[2]*Medscape Education, New York, New York, USA*

ABSTRACT

Background: Documenting performance change after participation in continuing medical education (CME) is becoming increasingly important. The transtheoretical model (TTM) is a promising evaluation framework, but few published studies have applied the TTM to a series of CME activities. The purpose of this study was to apply the TTM to evaluate an Internet curriculum including a series of 13 related CME activities designed to promote the adoption of evidence-based, individualized, early, and aggressive treatment for rheumatoid arthritis.

Methods: Pretest and posttest scores on knowledge and key TTM constructs related to the desired performance were compared to determine if they had changed from pretest for the first CME activity to posttest of the final activity. One-sample t tests and analyses of variance on complete case and imputed data among all participating physicians and rheumatologist samples were used. The effect of including TTM-based behavior change statements to facilitate the adoption of the desired performance was examined.

Results: Participating in multiple CME activities correlated with higher posttest physician knowledge scores, movement to more advanced stages of change for adopting the desired performance, and improvements in TTM constructs. Including more behavior change statements per CME activity was associated with larger differences in scores on TTM variables.

Conclusion: Applying the TTM permits inclusion of behavior change statements to ensure that activities meet the needs of physicians, even those who are not prepared to formally adopt the desired performance. It also allows CME providers to evaluate effects on participants who have varied levels of readiness to change. In this study, serial CME activities increased physicians' readiness to adopt the desired performance, which is expected to improve patient care.

INTRODUCTION

Forces such as pay for performance [1] and maintenance of licensure and certification standards are transforming the goal of continuing medical education (CME) from knowledge transmission to improving performance [2-4]. Researchers have postulated that the transtheoretical model (TTM) offers promise in guiding the implementation and evaluation of CME [5-9]. Use of the TTM can guide CME planners in designing and evaluating education that helps clinicians at all stages of readiness to improve performance.

The TTM is an integrative model that describes behavior change as a progression through a series of five stages:

- Precontemplation (not intending to adopt the best practices)
- Contemplation (intending to adopt the best practices in the next 6 months)
- Preparation (intending to adopt the best practices in the next 30 days)
- Action (adopted the best practices less than 6 months ago)
- Maintenance (adopted the best practices more than 6 months ago) [10]

The TTM includes other behavior change variables, such as decisional balance, defined as the relative weighing of the pros and cons of the change in performance. Self-efficacy is another variable, defined as confidence to change performance. These are systematically related to the stages of change in predictable ways [11,12]. TTM has been successfully applied to behavior change interventions including smoking cessation [13], medication adherence [14],

Correspondence: Jennifer J. Brown, PhD, Medscape Eduation, 825 Eighth Avenue, New York, NY 10019; 212-417-9506; fax: 646-390-1449 (e-mail: jjbrown@medscape.net).

CE Meas. 2012;6:32-40. doi:10.1532/CEM08.12100

weight management [15], stress management [16], and CME [17].

Despite criticism of TTM-based interventions [18-20], a number of longitudinal randomized, controlled trials show that tailored TTM-based interventions are effective [14-16]. Two systematic meta-analyses indicate that tailoring on TTM variables significantly increases the effectiveness of interventions [21,22]. Many studies that claim that TTM is ineffective have tailored interventions only to stage of change [23], ignoring other crucial behavior change variables [21], or have been poorly designed (e.g., small sample sizes, poor recruitment rates, or high loss to follow-up) [24,25].

Effective CME is tailored to the educational needs and goals of the learner [26]. Tailoring educational content to readiness to adopt a performance change is also likely to play a key role [5, 7, 9]. Research on the TTM consistently demonstrates that tailoring messages to an individual's readiness to change can increase effectiveness of interventions [14-17], and improve performance significantly more than standard education [17].

In addition, the application of the TTM heavily influences evaluation [5, 27]. Utilizing the TTM in CME evaluation permits an examination of the effectiveness of the activity or curriculum for the entire spectrum of participants. Rather than restricting the outcomes to the dichotomy of adopting the desired performance or not, more sensitive analyses can be conducted to analyze movement through the readiness to change continuum [5-7]. Stage progress can be examined from the pretest of the first activity to the posttest of the final activity within a curriculum to determine effects of the curriculum on readiness to adopt the performance change. Few studies have applied the TTM to the implementation and evaluation of a series of CME activities.

The purpose of this study was to apply the TTM to the design and evaluation of a curriculum of Internet CME activities to promote the adoption of an evidence-based treatment approach in clinical practice. The area of study was rheumatoid arthritis (RA). This condition affects more than 1 million adult patients and requires early treatment with disease-modifying antirheumatic drugs or newer biologic therapies to preserve both physical functioning and quality of life [28-30]. Each CME activity incorporated TTM-based statements to facilitate adoption of the desired performance. The CME outcome evaluation examined changes in knowledge; shifts in readiness to adopt an evidence-based treatment approach; and improvements in decisional balance and self-efficacy for physicians who participated in a single or multiple activities. Finally, the study examined how behavior change outcomes relate to the number of behavior change statements included in each activity.

METHODS

Educational Interventions

The overall study design included: a pre-assessment, one to 13 educational interventions, and a post-assessment for analysis of change among participants (Table 1). The curriculum addressed practice gaps identified through a formal needs assessment. The content was created by rheumatology faculty and delivered in interactive multimedia formats (Table 2). These included "Interactive Clinical Review", a text-based CME article with interactive polling questions throughout the program showing immediate feedback in comparison with peers; "Roundtable Expert Discussion", a video webcast discussion among 3 faculty members with a moderator with downloadable slides and transcript; "Clinical Case Study", a text-based presentation of 2 cases with interactive questions and answers showing immediate feedback in comparison with peers; and "Conference Coverage", a text- or video-based, multi-article activity summarizing presentations at annual clinical meetings. The activities were offered to all physicians registered on Medscape, a healthcare information website. Registration for the site and all educational content were available at no charge to participants. Each activity was certified by Medscape for CME credit (0.5 to 1 credit each). Activities were certified for 1 year and were launched in 2008 to 2009.

The activities included brief behavior change statements (e.g., a faculty highlighting the numerous ways patient outcomes and quality of life are improved when rheumatologists adopt an individualized approach; faculty pointing out how patient assessments can routinely be collected with minimal burden on the practice). These were designed to move physicians through the stages of change for adopting an evidence-based treatment approach. These statements included benefits (pros), tips on overcoming barriers (cons), and models of how to handle difficult situations to build self-efficacy.

Participants and Data Collection

Rheumatologists practicing in the United States were the target audience, but interested physicians from any specialty could participate. Exclusion criteria included self-reported specialties of medical student, consumer/other, health business/administration, media/press, pharmacist, nurse, nursing student, administration/

Table 1. Study Design

Study Elements	Components Included for Assessments
Pretest before each activity	Stage of change, decisional balance, self-efficacy
1–14 CME activities	Included behavior change statements
Test repeated as a post-assessment after each activity	Stage of change, decisional balance, self-efficacy
Analysis	Comparison of pre- versus posttest results for each participant

Table 2. Physician and Rheumatologist Participation in Internet CME Curriculum Activities*

Educational Activity	Activity Format	Number of Behavior Change Messages Included	Physician, n Full Case (Imputed)	Rheumatologist, % Full Case (Imputed)
Latest Evidence on Biologic Therapy for RA: Weighing the Risks and Benefits	Interactive clinical review	13	1568 (990)	37.8 (42.3)
Rhematoid Arthritis: Next-Generation Biologic Therapies	Interactive clinical review	15	2766 (826)	19.5 (27.7)
Update on RA Management—New Therapeutic Options and Monitoring Approaches	Roundtable expert discussion	20	759 (557)	30.0 (28.3)
Marrying Rheumatoid Arthritis Pathophysiology to Treatment Mechanism of Action	Roundtable expert discussion	11	453 (202)	41.6 (53.6)
Understanding the Scientific Principles behind TNF Failure and Cycling	Roundtable expert discussion	23	286 (90)	33.7 (55.8)
Clinical Challenges in RA Management: Addressing Treatment Failure	Roundtable expert discussion	22	381 (150)	34.6 (44.2)
Addressing the Cardiovascular Risk in Rheumatoid Arthritis	Roundtable expert discussion	14	492 (157)	24.1 (36.1)
Rheumatoid Arthritis: Beyond Joint Inflammation to Treat Nonarticular Symptoms	Clinical case study	23	1017 (480)	26.1 (32.2)

*Formats of the internet continuing medical education (CME) activities are as follows: Interactive clinical review is a text-based CME article with interactive polling questions throughout the program showing immediate feedback in comparison with peers; roundtable expert discussion is a video webcast discussion among three faculty with a moderator with downloadable slides and transcript; clinical case study is a text-based presentation of two cases with interactive questions and answers showing immediate feedback in comparison with peers; conference coverage is a text or video based, multi-article activity summarizing presentations at annual clinical meetings. RA indicates rheumatoid arthritis; TNF, tumor necrosis factor.

management, faculty/teaching, public/community health, quality management, and risk management/utilization review.

Physicians were invited, but not required, to complete a pretest to assess current clinical practice. Immediately following the activity but prior to completion of the CME posttest (required for CME credit), participants were invited, but not required, to complete the same test items as a post-assessment. All responses were date stamped and captured electronically and were associated with a unique identification number to maintain anonymity.

Measures

The desired performance was defined through a rigorous, iterative, qualitative, and quantitative measurement development process conducted in 2008 and repeated in 2009 (n = 397 physician participants). It was based on the input of five expert faculty and an extensive literature review [28-30]. Details of this methodology are provided elsewhere [15].

The final definition of the desired performance was:

> Individualized early and aggressive treatment for RA includes:
>
> - Understanding RA and its systemic manifestations, the therapeutic targets of action, safety, and efficacy of biologic agents
> - Considering biologic agents for RA
> - Using objective patient and physician tools to recognize suboptimal response to therapy; prescribe appropriate therapy; and monitor disease progression, response to treatment, and quality of life
> - Collaborating closely with the patient and other medical practitioners to manage comorbid conditions such as cardiovascular disease

Stage of Change

Best practices were presented to physicians who were asked as a pre-activity assessment: "Assume that the four bulleted principles above DEFINE an evidence-based approach. Are you using these principles consistently to select individualized early and aggressive treatment regimens for rheumatoid arthritis?" Response options (corresponding stage of change) were:

- NO, and I do NOT intend to in the next 6 months (Precontemplation)
- NO, but I intend to in the next 6 months (Contemplation)
- NO, but I intend to in the next 30 days (Preparation)
- YES, I am and have been for LESS than 6 months (Action)
- YES, I am and have been for MORE than 6 months (Maintenance)

Decisional balance questions assessed the importance of six items (three pros [α = .84], three cons [α = .70]) in physicians' decisions about whether or not to adopt an evidence-based, individualized, early, and aggressive treatment approach for RA. A five-point scale was used (1 = not important, 5 = extremely important). A sample

pro item read, "This approach to RA treatment leads to better outcomes."

Self-efficacy items assessed physicians' confidence that they could implement these best practices even in five difficult situations (α = .87) (e.g., if there is a lack of long-term safety data on new biologics). Items were responded to on a five-point scale (1 = not at all confident, 5 = extremely confident).

Knowledge was assessed using nine multiple choice questions with four to five response options and a single correct answer.

Behavior change statements addressed pros, countering cons, increasing self-efficacy, or providing information on the importance of the performance change to include in the educational content. The faculty members were provided with suggested TTM-based behavior change statements to include in CME. After each CME activity was finalized, an audit was conducted by two independent reviewers with extensive expertise in the TTM to tally the number of TTM-based behavior change statements included.

Data Analysis

Data were merged from eight of the 13 CME activities of the curriculum that included both pre- and posttest measures. Five of the activities lacked pretest data. Data were analyzed using both complete case data and data estimated by multiple imputation (MI) for participants who entered responses to the pretest but did not complete the entire posttest. Complete datasets were analyzed using t tests and analyses of variance (ANOVAs).

MI, the state-of-the-art for missing value replacement, uses a simulation technique to replace each missing value with a set of plausible values, resulting in multiple complete datasets that differ only in the imputed values [31-33]. Tests of significance take into account the uncertainty introduced by the missing data and the uncertainty in the imputed values, so they yield more accurate estimates of confidence intervals and significance levels than other missing data approaches [31]. For the current study, 10 datasets were imputed for the intervention and control groups using multivariate imputation by chained equations (MICE) [34] implemented by R package MICE version 1.10 [35]. The imputation models included a large number of variables related to outcomes being imputed and to missingness. The 10 complete datasets were analyzed separately using complete data methodology and the results pooled to yield final estimates of the outcomes. Thus, MI was used to estimate missing data for the TTM constructs for pre- and posttests, resulting in a unique sample of participants with complete pre- and posttest data for each activity.

Pretest responses to participants' first activity were compared to their posttest responses for their final activity. Data for each individual were linked. The number of activities in which each physician participated and knowledge were examined by learners' stage of change. Analyses were conducted among those participating in one, two, or three or more activities, given the small sample that completed four or more activities.

Correlations of number of behavior change statements included in each activity to difference scores in behavior change variables were examined. Difference scores were calculated by subtracting the pretest score for each activity from the posttest score for that activity. Separate logistic regressions were also conducted to examine the relationship between highly correlated behavior change variables and the likelihood of progression on the readiness to change continuum or progression to action/maintenance. Stage progression was defined as movement forward of at least one stage on the TTM stage-of-change continuum (e.g., from Precontemplation to Contemplation). Difference scores were categorized as (0) stable or decreasing from pretest to posttest and (1) increasing from pretest to posttest.

RESULTS

Knowledge

Sample size ranged from 309 to 3134 CME participants in the complete case analyses and 95 to 1060 for the imputed data (Table 2). The number of CME activities completed by participants is shown in Table 3. An ANOVA on the complete case data indicated that physician post-activity knowledge varied significantly based on number of activities completed; $F(2, 3053) = 6.70$, $P < .01$, $n^2 = .004$. Those who completed 3 or more CME activities had a higher percent correct on the posttest than did those completing fewer activities. The difference among rheumatologists was not significant; $F(2, 476) = 1.84$, $P > .05$, $n^2 = .008$. ANOVAs on the imputed data also indicated that physician post-activity knowledge varied significantly based on number of activities in which physicians participated; $F(2, 425.14) = 7.10$, $P < .001$, $n^2 = .03$ (Figure 1).

Table 3. Number of CME Activities Completed by Physicians and Rheumatologists*

Number of Activities	Frequency	Complete Case, %	Imputed Data, %
Overall physician sample			
1	3962	68.5	69.3
2	1052	18.2	17.0
3 or more	766	13.3	13.7
Rheumatologist sample			
1	735	55.7	52.0
2	285	21.6	23.0
3 or more	299	22.7	25.0

*Physician participant number in 1, 2, and 3 or more continuing medical education (CME) activities in the CME curriculum with full case data and imputed data are shown.

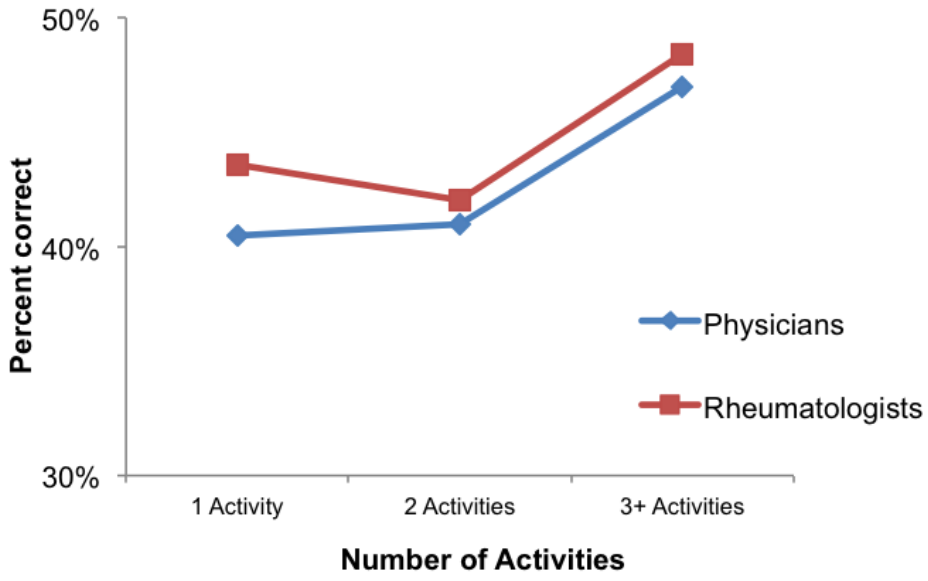

Figure 1. Physician knowledge by number of continuing medical education (CME) activities completed. Percent correct on posttest scores. Physician and rheumatologist knowledge varied based on number of activities completed. Those who completed 3 or more CME activities had a higher percent correct on post-assessments than those completing fewer activities.

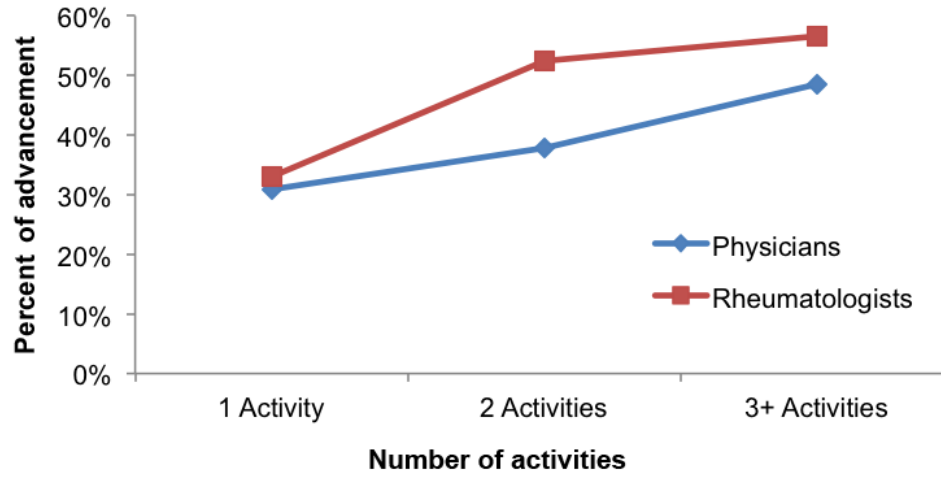

Figure 2. Percent of physicians moving forward at least 1 stage of change for adopting the performance change at continuing medical education (CME) posttest. Physicians and rheumatologists progressing toward a performance change after completing CME varied based on number of activities completed. Those who completed 3 or more CME activities had more stage progress.

Analysis of responses from rheumatologists showed a small effect of number of activities completed on knowledge; F (2, 101.73) = 1.74, $P > .05$, $n^2 = .03$. Rheumatologists completing three or more activities had higher knowledge scores than those completing fewer activities.

TTM Stage Progression and Behavior Change

The first behavior change outcome is stage progression for the performance change, optimizing and individualizing treatment for RA as a result of participating in CME activities. Stage progression is measured in two ways: 1) any movement forward to a more advanced stage of change (e.g., movement from Precontemplation to Contemplation), which represents stage progress; and 2) movement from Precontemplation, Contemplation, or Preparation to Action or Maintenance, which represents adoption of the performance improvement. Among physicians with complete case data, 37.5% of those completing three or more CME activities made stage progress versus 26% of those completing a single activity, not reaching statistical significance; $\chi^2(4) = 5.53$, $P > .05$. Analyses of the more well-powered imputed data revealed significant differences. Those participating in three or more activities are more likely to progress forward at least 1 stage of change, a medium effect; F (2, 224.49) = 8.98, $P < .001$, $n^2 = .07$ (Figure 2). As Figure 3 depicts, those participating in three or more activities are also more likely to progress to action or maintenance, a large effect; F (2, 162.35) = 11.77, $P < .001$, $n^2 = .13$. Analyses of the imputed data indicate that rheumatologists participating in three or more CME activities were significantly more likely to make stage progress (F [2, 141.88] = 3.1, $P < .05$, $n^2 = .14$) and to progress to action or maintenance (F [2, 81.91] = 4.97, $P < .01$, $n^2 = .11$) than those participating in fewer activities.

Decisional Balance (Pros and Cons)

The analysis for the physicians overall did not reveal a significant difference on pros from pretest to posttest among those completing a varying number of CME activities; F (2, 1101) = 1.23, $P > .05$, $n^2 = .002$. Because increasing pros is a key intervention strategy for clinicians in precontemplation, differences in pros scores from pretest to posttest were also investigated for this sub-group. Complete case analysis indicated a small effect among physicians in precontemplation at pretest; F (2, 191) = 2.33, $P > .05$, $n^2 = .024$. Those participating in 3 or more activities had larger pros difference scores than those participating in one or two activities. The imputed data analyses revealed similar findings: a small, nonsignificant effect for number of activities among physicians in the overall sample (F [2, 89.41] = .575, $P > .05$, $n^2 = .01$), where the largest pros difference score was between those completing one and two activities (Figure 4). A small effect was also seen among those in precontemplation at pretest of the first activity (F [2, 86.72] = .85, $P > .05$, $n^2 = .019$), for whom the pros difference score was greater for two or three activities than for one activity.

Cons for physicians overall also did not differ significantly among those participating in varying numbers of activities. Subgroup analysis was conducted here as well given the importance of reducing cons for clinicians in contemplation. A small effect was shown for number of activities among those in contemplation at pretest in the complete case analysis; F (2, 243) = 1.2, $P > .05$, $n^2 = .01$. Physicians participating in 3 or more CME activities had the largest drop in cons from pretest of the first activity to posttest of the last activity. The imputed data revealed a small but nonsignificant effect for number of activities completed among physicians in contemplation at pretest; F (2, 49.29) = .73, $P > .05$, $n^2 = .028$. The largest decrease in cons was among physicians participating in three or more CME activities (Figure 5). Neither pros nor

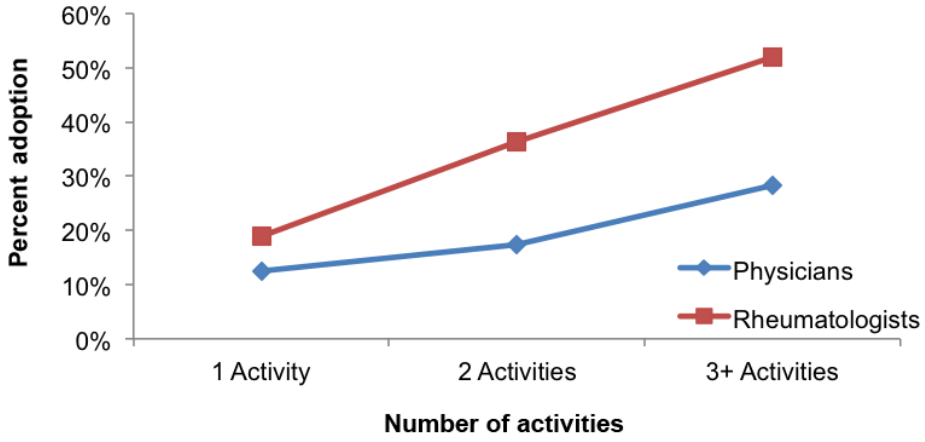

Figure 3. Percent of physicians adopting the performance change at continuing medical education (CME) posttest. Physicians and rheumatologists adopting a performance change after completing CME varied based on number of activities completed. Those who completed 3 or more CME activities were more likely to adopt a desired performance.

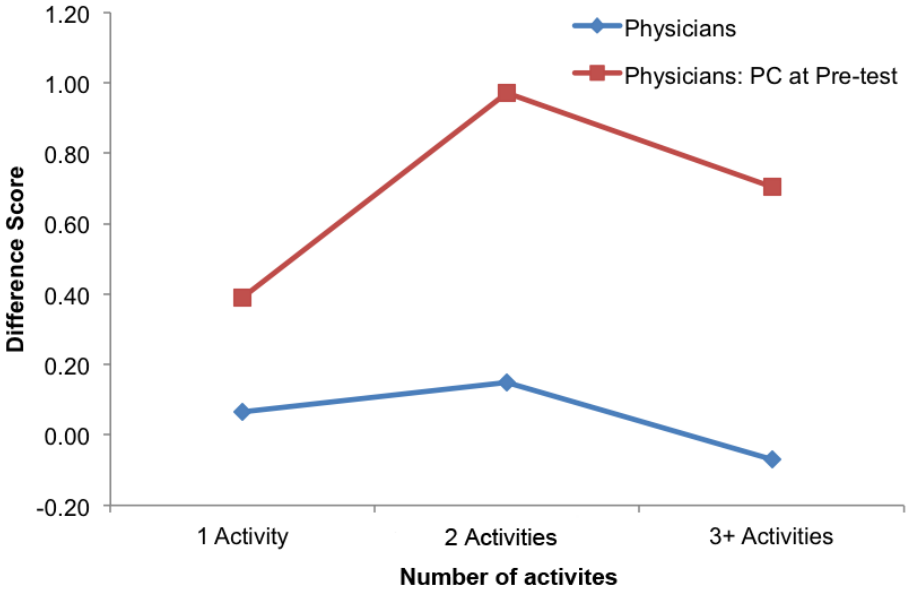

Figure 4. Difference scores on pros of adopting the performance improvement by number of activities completed. Physicians in the overall sample and physicians in precontemplation at pretest who complete 2 or 3 activities have larger increases in pros than those who complete a single activity.

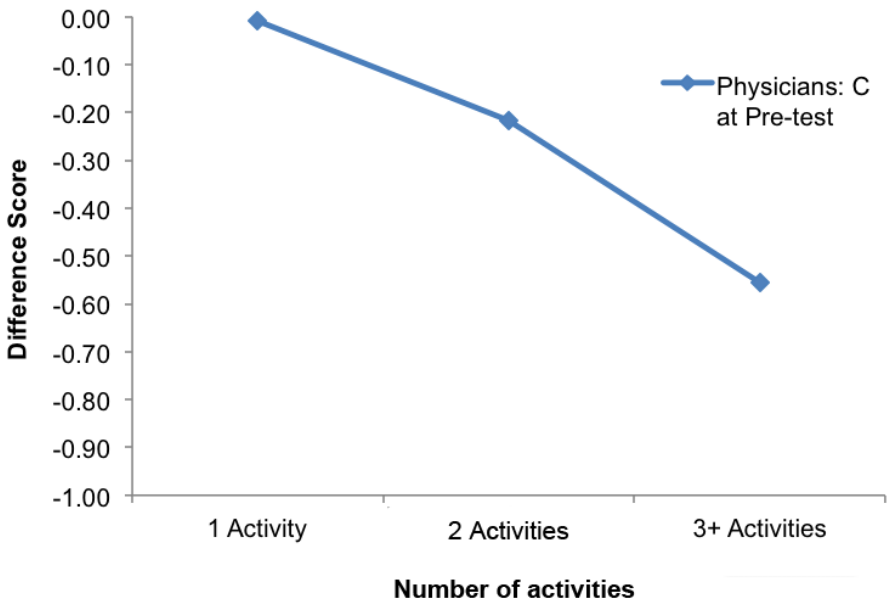

Figure 5. Difference scores on cons of adopting the performance improvement by number of activities completed. Physicians in the contemplation stage at pre-test who complete 3 or more activities have larger decreases in cons than those who complete fewer activities.

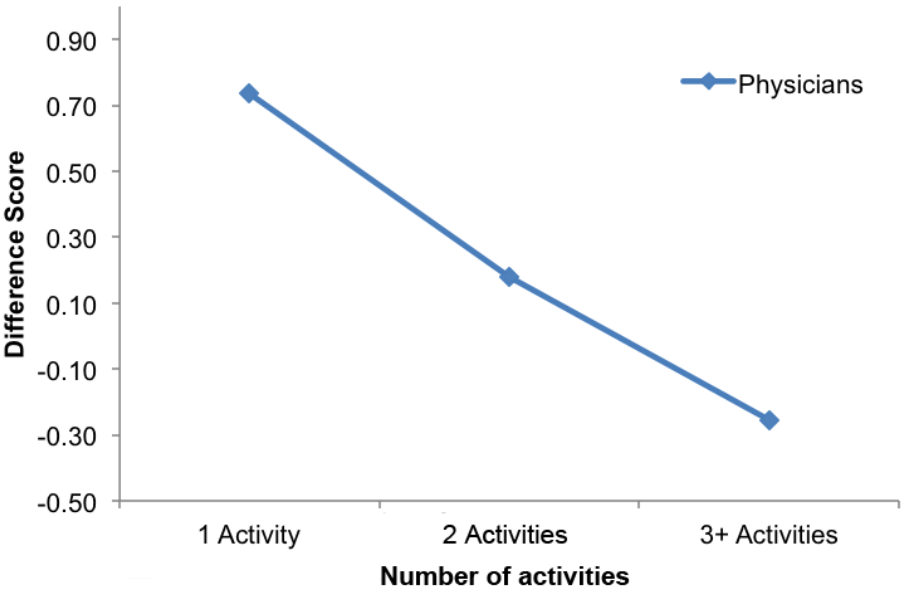

Figure 6. Difference scores on confidence for adopting the performance improvement by number of activities completed. Physicians in the overall sample had the largest increase in confidence after participating in one activity.

cons differed significantly from pretest to posttest among the rheumatologists.

Self-Efficacy

The complete case analyses indicated that level of confidence varied depending on number of CME activities in the overall sample of physicians; F (2, 1187) = 5.56, $P < .01$, $n^2 = .009$ (a small effect). Similar results emerged from the imputed data, with significant differences in the overall sample of physicians; F (2, 74.08) = 8.62, $P < .001$, $n^2 = .19$. As is shown in Figure 6, an unexpected finding was that confidence was highest among those participating in one activity. Rheumatologist data showed no significant differences in confidence based on number of activities completed in the complete case analyses or in the imputed analyses.

Behavior Change Outcomes by Number of Behavior Change Statements

The correlation of number of behavior change statements included in each activity to difference scores on behavior change constructs reveals a pattern of strong relationships. Number of pros messages is not correlated (0.04) in the overall sample with the pros difference score, but among those in pre-action stages, the correlation increases to 0.16. The correlation between number of pros messages and pros difference score among physicians in the pre-contemplation stage at pretest of the first activity increases to 0.48. The strongest correlations were between confidence messages and confidence difference scores. Confidence is the single most sensitive measure of behavior change found in this study. Among the overall sample, number of messages is strongly correlated (0.92, $P <$ .01) with confidence difference scores. The logistic regressions indicate that physicians with increasing self-efficacy scores are, on average, 1.5 times more likely to make stage progression than those who have stable or decreasing self-efficacy scores.

DISCUSSION

This study demonstrates applicability of the TTM to design and evaluation of an Internet CME curriculum of related activities for physicians. Traditional approaches to CME outcome evaluation have relied on a dichotomous outcome framework (i.e., did participants adopt the performance change or not?)—ignoring the continuum of behavior change [5]. The TTM reconceptualizes behavior change as a process that unfolds over time in a series of motivational stages. Employing the stages-of-change framework in CME enables inclusion of behavior change statements matched to the needs of all participants [14-17]. This outcome evaluation demonstrates the impact of a series of 13 related CME activities on the entire population of physician learners.

In this study, participation in multiple CME activities correlated with higher posttest scores related to knowledge. Further, these activities increased adoption of the desired performance and had a significant impact on stage progression toward the performance change. Forty-eight percent of physicians and 56% of rheumatologists moved forward at least one stage of change after participating in three or more activities. These positive outcomes would have been overlooked in a traditional CME outcomes evaluation. Adoption of the performance change and progress toward it are both expected to translate into improved patient care.

Participation in multiple, related CME activities had a more favorable impact on physician pros and cons TTM scores. An unexpected finding was that confidence was highest among those physicians participating in only 1 activity. Approximately 2700 of the participants who completed three or more activities (more than 60%) selected a final activity that highlighted at least two difficult situations from clinical practice. However, the activity did not provide guidance for how to practice the change in performance in those situations. In other words, the faculty potentially inadvertently lowered clinician participant's confidence. This finding underscores the importance of including statements to boost self-efficacy (e.g., faculty explaining how to handle situations in which it is difficult to adopt the change in performance).

The study demonstrated the importance of including behavior change statements for physicians in all stages of change. Inclusion of more behavior change statements per CME activity correlated with larger difference scores on crucial TTM behavior change variables. The predictive power of increases in confidence on adopting the desired performance further highlights the need to include more messages to increase physicians' levels of confidence. Confidence is a crucial behavior change variable that influences stage progress and prevents regression out of the maintenance stage. The highest correlations among pros difference scores and pros messages were among physicians in the precontemplation stage. This is consistent with meta-analyses on decisional balance that have demonstrated that pros are lowest in precontemplation [11, 35]. In CME activities, increasing pros in precontemplation is one of the most important behavior change variables to facilitate movement to the contemplation stage.

Strengths of this study include the large sample size, diversity of CME activities, and sequencing of the activities in a curriculum. Additional strengths are use of both complete case and imputed data and inclusion of a guiding theory of behavior change in the implementation and evaluation of CME. The study adds to the literature that supports the application of the TTM to CME [8]. Limitations include potential bias of self-reported data not independently evaluated with chart records or patient outcomes.

In conclusion, this longitudinal curriculum provided a unique opportunity to evaluate the effect of multiple CME activities on readiness to adopt the desired performance and progress toward it. Future studies should examine correlations of self-reported stage to clinical performance and patient outcomes.

DISCLOSURE

The CME activities and outcomes study were supported by an independent educational grant from Genentech.

REFERENCES

1. Rowe JW. Pay-for-performance and accountability: related themes in improving health care. Ann Intern Med. 2006;145:695-699.
2. Pelletier S. PI CME. Medical Meetings. Available at: http://meetingsnet.com/medicalmeetings/cme_rules_regs/1201-medical-education-continuous-performance-improvement. Accessed June 28, 2012.
3. Moore DE Jr, Green JS, Gallis HA. Achieving desired results and improved outcomes: integrating planning and assessment throughout learning activities. J Contin Educ Health Prof. 2009;29:1-15.
4. Castel OC, Ezra V, Alperin M, et al. Can outcome-based continuing medical education improve performance of immigrant physicians? J Contin Educ Health Prof. 2011;31:34-42.
5. Parker K, Parikh SV. Applying Prochaska's model of change to needs assessment, programme planning and outcome measurement. J Eval Clin Pract. 2001;7:365-371.
6. Cohen SJ, Halvorson HW, Gosselink CA. Changing physician behavior to improve disease prevention. Prev Med. 1994;23:284-291.
7. Casebeer LL, Strasser SM, Spettell CM, et al. Designing tailored Web-based instruction to improve practicing physicians' preventive practices. J Med Internet Res. 2003;5:e20.
8. Shirazi M, Zeinaloo AA, Parikh SV, et al. Effects on readiness to change of an educational intervention on depressive disorders for general physicians in primary care based on a modified Prochaska model—a randomized controlled study. Fam Pract. 2008;25:98-104.
9. Young JM, Ward J. Can distance learning improve smoking cessation advice in family practice? A randomized trial. J Contin Educ Health Prof. 2002;22:84-93.
10. Prochaska JO, Velicer WF, Rossi JS, et al. Stages of change and decisional balance

for 12 problem behaviors. Health Psychol. 1994;13:39-46.
11. Hall KL, Rossi JS. Meta-analytic examination of the strong and weak principles across 48 health behaviors. Prev Med. 2008;46:266-274.
12. DiClemente CC, Prochaska JO, Fairhurst SK, Velicer WF, Velasquez MM, Rossi JS. The process of smoking cessation: an analysis of precontemplation, contemplation, and preparation stages of change. J Consult Clin Psychol. 1991;59:295-304.
13. Prochaska JO, DiClemente CC, Velicer WF, Rossi JS. Standardized, individualized, interactive, and personalized self-help programs for smoking cessation. Health Psychol. 1993;12:399-405.
14. Johnson SS, Driskell MM, Johnson JL, et al. Transtheoretical model intervention for adherence to lipid-lowering drugs. Dis Manag. 2006;9:102-114.
15. Johnson SS, Paiva AL, Cummins CO, et al. Transtheoretical model-based multiple behavior intervention for weight management: effectiveness on a population basis. Prev Med. 2008;46:238-246.
16. Evers KE, Prochaska JO, Johnson JL, Mauriello LM, Padula JA, Prochaska, JM. A randomized clinical trial of a population- and transtheoretical model-based stress-management intervention. Health Psychol. 2006;25:521-529.
17. Shirazi M, Lonka K, Parikh SV, et al. A tailored educational intervention improves doctor's performance in managing depression: a randomized controlled trial. J Eval Clin Pract. 2011 Aug 30. doi: 10.1111/j.1365-2753.2011.01761.x.
18. Riemsma RP, Pattenden J, Bridle C, et al. Systematic review of the effectiveness of stage based interventions to promote smoking cessation. BMJ. 2003;326:1175-1177.
19. Bridle C, Riemsma RP, Pattenden J, et al. Systematic review of the effectiveness of health behavior interventions based on the transtheoretical model. Psychol Health. 2005;20:283-301.
20. Aveyard P, Massey L, Parsons A, Manaseki S, Griffin C. The effect of Transtheoretical Model based interventions on smoking cessation. Soc Sci Med. 2009;68:397-403.
21. Noar SM, Benac CN, Harris MS. Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions. Psychol Bull. 2007;133:673-693.
22. Norcross JC, Krebs PM, Prochaska JO. Stages of change. J Clin Psychol. 2011;67:143-154.
23. Hutchison AJ, Breckon JD, Johnston LH. Physical activity behavior change interventions based on the transtheoretical model: a systematic review. Health Educ Behav. 2009;36:829-845.
24. Spencer L, Pagell F, Hallion ME, Adams TB. Applying the transtheoretical model to tobacco cessation and prevention: a review of literature. Am J Health Promot. 2002;17:7-71.
25. Prochaska JO. Flaws in the theory or flaws in the study: a commentary on "The effect of Transtheoretical Model based interventions on smoking cessation". Soc Sci Med. 2009;68:404-406.
26. Aherne M, Lamble W, Davis P. Continuing medical education, needs assessment, and program development: theoretical constructs. J Contin Educ Health Prof. 2001;21:6-14.
27. Price DW, Xu S, McClure D. Effect of CME on primary care and OB/GYN treatment of breast masses. J Contin Educ Health Prof. 2005;25:240-247.
28. Donahue KE, Gartlehner G, Jonas DE, et al. Comparative Effectiveness of Drug Therapy for Rheumatoid Arthritis and Psoriatic Arthritis in Adults. Comparative Effectiveness Review No. 11. Rockville, MD: Agency for Healthcare Research and Quality; 2007.
29. Chou R, Bianco T, Robinson S, et al. Choosing Medications for Rheumatoid Arthritis: Physician's Guide. Comparative Effectiveness Review No. 11. Rockville, MD: Agency for Healthcare Research and Quality; 2007.
30. Saag KG, Tegn GG, Patkar NM, et al. American College of Rheumatology 2008 recommendations for the use of nonbiologic and biologic disease-modifying antirheumatic drugs in rheumatoid arthritis. Arthritis Rheum. 2008;59:762-784.
31. Rubin DB. Multiple Imputation for Nonresponse in Surveys. New York: John Wiley & Sons, Inc; 1987.
32. Harel O, Zhou XH. Multiple imputation: review of theory, implementation and software. Stat Med. 2007;26:3057-3077.
33. Schafer JL, Graham JW. Missing data: our view of the state of the art. Psychol Methods. 2002;7:147-177.
34. van Buuren S, Oudshoorn CGM. Multivariate imputation by chained equations (MICE), V1.0 User's Manual. Report PG/VGZ/00.038. Available at: http://web.inter.nl.net/users/S.van.Buuren/mi/docs/Manual.pdf. Accessed July 29, 2012.
35. Prochaska JO, Velicer WF, Fava JL, Rossi JS, Tsoh JY. Evaluating a population-based recruitment approach and a stage-based expert system intervention for smoking cessation. Addict Behav. 2001;26:583-602.