ABSTRACT

Objective. To evaluate a community-based, not-for-profit medical group’s effectiveness with diabetic management while using an electronic medical record and financial incentives. Design. Descriptive retrospective study over 2 years with published reference standards. Methods. There were 5,316 diabetic patients in the medical group (MG) compared with 5,069 diabetic patients reported in the literature (CT). The main outcome measures included serum hemoglobin A1C (HbA1C), total (TC), low density lipoprotein (LDL-C) and high density lipoprotein (HDL-C) cholesterol, and clinic measures of systolic (SBP) and diastolic blood pressure. We determined a mean 10-year composite multivariable cardiovascular risk score based upon these parameters. Results. The mean MG serum HbA1C (7.10±0.02; 8.18±0.23%), TC (193.2±0.64; 218.3±6.09 mg/dl), LDL-C (109.2±0.52; 137.8±4.24 mg/dl), and SBP (132.8±0.25; 141.6±2.36 mmHg) were below those for the CT (p<0.001). The MG mean overall coronary heart disease risk of 14.9±1.4% over 10 years was below that for the CT group of 22.7±2.3%, representing a 34.7±4.4% reduction (p<0.0002). The electronic medical record and the use of a financial award may have contributed to these results. Conclusion. Improvement of cardiovascular risk variables can be achieved in the primary care setting. Electronic tools and incentives may facilitate this improvement. (Int J Circumpolar Health 2005;64(1):26-37.)

Keywords: Diabetic, cardiovascular, multivariable, community, medical group
INTRODUCTION

Only 54% of the providers in the United States meet the quality indicators for diabetic care (1) and, in general, only 65% reach well-known goals for hypertension and 49% for cholesterol management. Diabetic patients presenting for elective cardiac catheterization have similar poor control of cardiovascular risk factors (2). Particular populations living in circumpolar regions, such as the Alaska Natives, have a high risk for cardiovascular disease (3) and diabetes (4). Additionally, those peoples who live in both temperate and high latitude regions are at risk for winter increases in the incidence of hypertension, stroke and myocardial infarction (5). The clinical benefits for diabetic patients can be dramatic with improved attention to multiple risk factors (6). When patients improve glycemic control, lipid management, blood pressure regulation, and add aspirin therapy and other factors, they can be shown to dramatically reduce the risk of myocardial infarction, stroke, nephropathy and retinopathy (6-8). The improved outcomes are now recognized for both type 2 and type 1 diabetics (7), and these goals are rapidly becoming the new standard of international care for diabetic patients. The importance of this issue reaches even greater significance with the lifetime risk of diabetes in the United States now exceeding 30% for all children born in 2000 (9).

Many factors contribute when patients do not reach optimal goals for end-organ risk reduction management. Some of these limitations include patient compliance, insurance cost, medication cost, and lifestyle habits. However, reminders for patients and providers (10,11) have been highlighted as a principal tool for improving the success in reaching treatment goals. Electronic medical records and electronic databases have been suggested by some authors as the tools that may both improve clinical outcomes (1) and reduce medical errors (12). With intensive intervention, cardiovascular risk reduction can result in substantially improved outcomes; however, the cost associated with this intensive management can be extreme (6, 13). Offering provider incentives for delivering quality was reviewed recently (14). Many groups are now beginning to develop provider and institutional incentives to improve the quality of healthcare (15-17).

The Medical Group (MG) reported here had both an electronic medical record that can provide patient-specific reminders for diabetic target goals and an incentive program for rewarding achievement of diabetic care targets by our primary care providers. By comparing our 5,316 diabetic patients to diabetics treated with conventional therapy (CT) as a reference group, we can review the effectiveness of medical management. This comparison can be extended to predictions about the cardiovascular risk of these patients with regard to myocardial infarction rate, death rate, and end-organ damage (8, 18-21).

We report the risk of developing cardiovascular disease in diabetic patients treated in a fee-for-service, community-based medical group and compare these to the risks from published groups of conventionally-treated diabetic patients. These population risk scores are calculated using standard measures of glycemic, cholesterol, and blood pressure control.
METHODS

The electronic medical records were searched for diabetic patients (18-75 yrs) by using ICD-9-CM diagnostic codes (250.00-250.93). There were 5,316 individual diabetic patients registered with the MultiCare Medical Group between October 1, 2001 and September 30, 2002 who were eligible for the study. By using data fields for extraction, we retrieved values for the hemoglobin A1C (HbA1C), serum total (TC), low density lipoprotein (LDL-C) and high density lipoprotein (HDL-C) cholesterol, systolic and diastolic blood pressure, body weight, height, age and gender. Both type 1 (5.9%) and type 2 (94.1%) diabetics were used, but gestational diabetic patients were excluded from analysis (7). Patients were deidentified for analysis, and the study was approved by our Institutional Review Board.

Inclusion and exclusion criteria were used based upon the one-year period 2001-2002, diagnosis, patient age (18-75yr), and number of clinic visits to the Medical Group (at least 1 visit) at the end of the period of evaluation. A one-year period of data collection for HbA1C and blood pressure and a two-year period of data collection for lipid management were used in order to be consistent with the national recommendations at the time for monitoring of these parameters. The values for all parameters were selected as the last evaluation obtained prior to 30 September, 2002. The care was provided by a primary care provider who was a current member of the Medical Group. The provider description included 32% Internists, 64% Family Physicians, and 4% Primary Care Advanced Nurse Practitioners. The MultiCare Medical Group is part of an integrated not-for-profit, community-based healthcare delivery system, MultiCare Health System (MHS), Tacoma, WA. The medical group payment is composed of 18.5% government insurance, 2.24% self pay, less than 1% managed care and charity care, and the remainder in commercial payment. The cardiovascular risk and demographic parameters were reviewed again for a follow-up period between October 1, 2002 and September 30, 2003 to determine the stability of the values since the end of the initial study period. The serum values for the MG patients were measured by the MHS clinical laboratory in the course of managing care, and the LDL-C was calculated. To convert cholesterol to millimoles per liter, multiply by 0.02586. The values reported here for the MG were stable in the one-year follow-up period with slight, but not significant, further reductions in TC, LDL-C, HbA1C, and blood pressure control.

The combined effects of using multiple interventions can be predicted using published tools (19,21). These tools are supported by the Framingham Heart Study data (18) and the UK Prospective Diabetes Study group (UKPDS) data (8), respectively. The demographics of the UKPDS patients are included in our CT group and they are similar to the MG demographics; we therefore chose to use this newly-revised analysis tool, which includes glycemic control (21). The conventional treatment (CT) subjects have a mean age and gender ratio which are similar to our patients (Table I). Thus, whatever inherent differences exist within the model regarding the weighting of age, gender, and duration of diabetes, these will be similar between groups. The multifactorial tool (21) was used...
to determine overall cardiovascular risk for standardized groups using mean and 95% CI data to generate models of high and low risk for the following categories of male smokers, female smokers, male nonsmokers and female nonsmokers. The high-risk analysis consisted of the high 95% CI measures for HbA1C, TC, SBP, and the low measure for HDL-C; by contrast, the low-risk analysis consisted of the opposite 95% CI favorable values. The mean risk was determined using the mean values for these parameters in the same four gender and smoking preference standardized patient types. The mean age of the populations and 8.06 years duration of diabetic disease was used in all calculations for a Caucasian population risk assessment. The ethnic distribution for our population was Caucasian (86.1%), African American (8.4%), Hispanic/Latino (1.5%), American Indian (0.3%), Asian (1.7%), Multiracial (0.1%), Pacific Islander (0.5%), and other (1.5%) with data available for 53.4% reporting ethnicity. The duration of diabetes was used as a standard normalization because of the presence of this reported value for the CT group. To compare the overall cardiovascular risk score, these patient types were then analyzed with an ANOVA. Because the presence of smoking has such a substantial weight upon cardiovascular risk, we elected to analyze this separately and equally for both groups. In order to model the individual populations for the more specific risk of smoking, we weighted the risk parameters according to accepted ratios of gender-specific smoking trends in the US (Figure 1). These average rates of smoking in the United States are 25.7% for men and 21.0% for women, as published by National Center Health Statistics (22). We understand that some of the CT group are not from the United States and that these data may not directly apply; however, we felt that using the same weighting for smoking allowed a more accurate comparison of the parameters originally chosen for the study.

We verified our main conclusions with a complete analysis using a second and less powerful multivariable risk model (19). These results are not presented here but they showed similar statistically-significant benefit of risk reduction in the MG compared with the CT patients.

CT data were obtained from two large (8, 23) trials as well as from two smaller groups of diabetic patients with cardiovascular risk intervention (2, 6). The definition of conventional therapy is the therapy that was in place at the time that the baseline data were obtained in the smaller studies. For the larger studies it is defined as the therapy that was in place for the group without specific intervention. The total number of patients used for the conventional analysis and the demographics of this pooled group are listed in Table I.

Since 1999, a Quality Improvement Program has been in place which awards a financial incentive of 5% of the production salary if certain criteria in the program are satisfactorily met. For our primary care providers, specific diabetic care guidelines have been included in the evaluation for scoring of this Quality Improvement Program. Providers are reviewed annually for their effectiveness in reaching diabetic targets, and the awards are published and given annually.

The individual risk factor parameters for each patient are sorted according to their primary care provider. These data are then re-
turned to the primary care provider in an electronic format and are used in the clinical care and improvement in risk reduction. Therefore, each patient who was part of the study group received benefit of the feedback of these data, and patients with multiple high-risk variables were targeted for interventions. These interventions included calling patients to the clinic for therapeutic modifications, recommending treatment changes over the telephone or during regular visits, and making referrals to dietary, diabetic education sessions, and specialty consultations.

Analysis was carried out using a multifactorial model of risk categorization (UKPDS risk engine v2.0) (21). Comparisons between the medical group and conventional therapy groups were by ANOVA, linear regression and, when appropriate, the Student’s two-tailed t-test for population analysis using GraphPad Software Inc. (GraphPad.com) tools and Microsoft Excel, Microsoft Corporation, Redmond, WA. The standard error of the mean (SEM) is listed, and significance was accepted as p<0.05 unless otherwise stated.

RESULTS

The 5,316 MG patients had a mean age of 56.5±0.2 yr with an approximately equal male and female distribution, and the 5,096 CT patients had a mean age of 57.7±0.1 yr with 60% male patients. The MG patients had a slightly higher BMI and slightly lower proportion of male patients (Table I)(p<0.05).

Table I.
The demographic data for the Medical Group (MG) and conventional therapy (CT) group are shown. The Body Mass Index is calculated from a subgroup of the patients who had a height measurement in the time frame of the study representing 20% of the MMG patients. The number of patients who had values available for the measurements are listed in parentheses.

| Variable         | Medical Group | Conventional Therapy |
|------------------|---------------|----------------------|
| N                | 5316          | 5096                 |
| Gender (M/F) (%) | 49.4/50.6 (n=5316) | 60.0/40.0 (n=4701)   |
| Age (yr)         | 56.5±0.2 (n=5316) | 57.7±0.4 (n=5069)    |
| BMI (kg/m²)      | 34.1±0.2 (n=1066) | 28.5±0.2 (n=4701)    |

*** p<0.05

Table II.
The mean and ±SE, (95% Confidence Interval) values are provided for hemoglobin A1C (HbA1C), systolic blood pressure, diastolic blood pressure, serum total, low and high density lipoprotein cholesterol for both the medical group (MG) and conventional therapy (CT). To convert cholesterol to millimoles per liter, multiply by 0.02586. The CT group values are pooled from literature sources (2,3,5,20) as described in the methods.

| Variable                      | Medical Group             | Conventional Therapy         |
|-------------------------------|---------------------------|-------------------------------|
| Hemoglobin A1C (%)             | 7.10±0.02 (7.06-7.15)     | 8.18±0.23 (7.72-8.63)        |
| Systolic Blood Pressure (mm Hg) | 132.8±0.25 (132.3-133.3)  | 141.6±2.36 (137.0-146.3)    |
| Diastolic Blood Pressure (mm Hg) | 76.9±0.15 (76.6-77.2)    | 80.3±1.14 (78.1-82.6)      |
| Total Cholesterol (mg/dl)      | 193.2±0.64 (191.9-194.5)  | 218.3±6.09 (206.4-230.2)    |
| Low Density Lipoprotein (mg/dl) | 109.3±0.52 (108.2-110.2)  | 137.8±4.24 (129.5-146.1)   |
| High Density Lipoprotein (mg/dl) | 44.8±0.20 (44.4-45.2)    | 41.6±0.55 (40.6-42.5)       |

* p<0.001 compared with conventional treatment
The mean values for the MG HbA1C, systolic and diastolic blood pressure, and both TC and LDL-C, are all below the comparable CT values (p<0.0001) (Table II). The HDL-C values were slightly higher in the MG compared with the CT values (p<0.0001).

Multivariable risk assessments of developing cardiovascular disease over 10 years show a mean risk of 22.7±2.3% in the CT and 14.8±1.4% in the MG, representing a 34.7±4.4% reduction of cardiovascular risk in the MG patients (p<0.0002). This risk ranges from the highest category of the male patient who smokes and has unfavorable parameters of 37.1% in CT and 22.1% in MG patients to the lowest risk category of a female patient who does not smoke and has all favorable parameters of 12.1% in CT and 8.8% in MG patients (Table III). The mean change score in cardiovascular risk for these categories is −7.9±1.0% (range: −3.3 to −15.0%) over 10 years (p<0.0002).

**Table III.**
The risk of developing cardiovascular disease over 10 years for several standardized patient categories. The high risk uses the unfavorable HbA1C, cholesterol and blood pressure measures at the 95% CI while the low risk measures uses the favorable HbA1C, cholesterol and blood pressure measures at the 95% CI assuming that all variable are present. The MG and CT groups are different (***p<0.0002) and the MG has a mean reduction in cardiovascular risk over all categories of 34.7±4.4% compared with the CT patients. The abbreviations are the same as for Table II.

| Patient Category         | Medical Group | Conventional Therapy | Difference |
|--------------------------|---------------|----------------------|------------|
| Male Smoker Mean Risk    | 21.7%         | 32.4%                | 10.7%      |
| Male Smoker High Risk    | 22.1%         | 37.1%                | 15.0%      |
| Male Smoker Low Risk     | 21.1%         | 28.1%                | 7.0%       |
| Female Smoker Mean Risk  | 12.0%         | 18.6%                | 6.6%       |
| Female Smoker High Risk  | 12.3%         | 21.6%                | 9.3%       |
| Female Smoker Low Risk   | 11.7%         | 15.9%                | 4.2%       |
| Male Non-Smoker Mean Risk| 16.6%         | 25.2%                | 8.6%       |
| Male Non-Smoker High Risk| 16.9%         | 29.0%                | 12.1%      |
| Male Non-Smoker Low Risk | 16.1%         | 21.7%                | 5.6%       |
| Female Non-Smoker Mean Risk| 9.1%        | 14.1%                | 5.0%       |
| Female Non-Smoker High Risk | 9.3%       | 16.5%                | 7.2%       |
| Female Non-Smoker Low Risk | 8.8%       | 12.1%                | 3.3%       |
| Mean (±SEM)              | 14.8±1.4%     | 22.7±2.3%            | 7.9±1.0%***|

*** p<0.0002
A cardiovascular risk score was determined and weighted for smoking rates in the United States for men and women. When this weighting was included, the mean male cardiovascular risk over 10 years continued to be lower in men (17.8±1.5%) and women (9.8±0.8%) of the MG compared with men (27.6±2.5%) and women (16.5±1.4%) of the CT group (p<0.007) (Figure 1).

DISCUSSION

We report our experience in Tacoma, WA, USA (47°15’ N, 122°30’ W) while managing major cardiovascular risk factors for diabetic patients. Both the risk of diabetes and cardiovascular disease are high in circumpolar native populations (3-5). Our population is geographically near Alaskan native populations such as in Kodiak, AK, USA (57°45’ N, 152°29’ W). We think the observations presented here are relevant to those who deliver community based medicine in many circumpolar regions. As a medical group operating within a not-for-profit, community-based, integrated, healthcare system, our diabetic population has mean values for HbA1C, total and LDL cholesterol and blood pressure control that are more favorable than similar populations reported in the literature (2,6,8,23). All of these modifiable MG parameter values are below, or within, 10% of the American Diabetic Association 2004 target goals (24). The medical group patients have an overall cardiovascular risk of 14.8±1.4%, while those patients treated with conventional therapy have a 22.7±2.3% risk. Compared with conventional therapy, this represents a 34.7±4.4% reduction in overall cardiovascular risk over 10 years (p<0.0002) observed in the medical group patients. We cannot determine from this report the precise causes for the difference; however, we speculate that the electronic medical record and financial incentives may play a role.

Each of the key cardiovascular risk parameters in the MG are more favorable than similar measures in the CT group. When these differences are used to calculate the weighted cardiovascular risk for the two groups, they differ by a mean absolute value of −7.9±1.0% (p<0.0002). This absolute difference between the groups ranges from the high risk categories of −15.0% to −3.3% in the lowest risk categories. All categories show an improved risk score. Additionally, when the data are weighted with a similar and representative smoking rate, the gender-specific differences continue to remain significant (p<0.007) (Figure 1). When adding this gender-specific smoking weight for the population, the male risk in the MG is reduced by 38.4% and the female risk by 40.4% below the CT group (p<0.006).

The continued high risk of cardiovascular disease in Alaska Natives is not declining with the same rate as cardiovascular disease in the other states of the United States (3). Even though Eskimos had a prevalence of diabetes in 1985 of 8.8/1000 which was lower than the general population in the United States (24.7/1000) in that year, there is a wide range of the prevalence of diabetes in Alaska. This diabetic frequency in Alaska Natives is influenced directly by Caucasian cultural involvement and genetics as seen in the Aleutian Islands and the peoples classi-
fied generally as "Aleuts". Generally the "Aleuts" had a prevalence rate for diabetes of between 69.2 and 20.0/1000 depending upon the subgroup. Those who are on the Alaska Peninsula and Kodiak Island have an intermediate prevalence of diabetes (24.4/1000) which is similar to residents in the other states including Washington as measured in 1985 (4). Therefore, because of the geographic proximity, and social, economic, and Euro-American cultural influences of the Seattle region upon Alaska residents, this report is relevant to Alaska Natives who have increasing risk from diabetes. The information and methodology provided in this report regarding relative risk calculations and diabetic management in community hospitals by primary care providers may have special importance for Alaska residents and other circumpolar populations. It may be especially relevant to those living in Kodiak, AK who have similar prevalence rates of diabetes as other parts of the United States and a cardiovascular disease rate that is not declining (3).

Many components may contribute to overall cardiovascular risk reduction in diabetic patients as recently described by Hurst and Lee (25). Smoking cessation, aspirin therapy, and beta-blocking medication administration are three major factors that were not evaluated in the present investigation. The emphasis of our report is to highlight major cardiovascular risk parameters that can be retrieved accurately from an electronic medical record and that, with intervention, can be quickly and effectively improved. Serum HDL cholesterol concentration is reported here and used in the risk calculation, but it is under substantial genetic influence and less altered by standard intervention. Future modifications of the electronic medical record will have improved reporting for smoking cessation and medication administration, but we felt that with the present version of our record, these values lacked the accuracy for reporting a group mean or median value.

A recently revised (20) multivariable-adjusted risk calculator tool (21) was used to develop a mean weighted risk for our population of patients. Although designed for individual providers to predict multivariant coronary risk in their patients without overt coronary disease, we used this to predict the risk of a population by using the mean values and 95% confidence intervals of the input variables. The UKPDS cohort population from which the tool was developed is similar to the MG and CT populations in age and gender distribution (8). Physicians and patients understand the tool and commonly use it or a similar one published by Wilson, et al. (18,19), or the National Cholesterol Education Program (NCEP)(26) to calculate individual risk scores. The older Joint National Committee (JNC-V) blood pressure risk categories are used in the model by Wilson, et al. (18) which also does not quantify glycemic control with specific hemoglobin HbA1C values, both of which weaken the risk evaluation. We completely analyzed our data using the tool by Wilson, et al. (19) as well as with the UKPDS tool (21), obtaining similar results. We report the UKPDS measures because they specifically weigh glycemic control individually with regard to cardiovascular risk category. We feel that
feedback to providers who are now using these measurements is meaningful, and reporting the risk helps stimulate individual patient-risk calculation and reduction. Comparison to the mean of their own medical group and other standard and conventional treatments facilitates peer-group change.

In order to develop a composite risk score, we have made several assumptions. We have initially weighted all risk categories and gender selections equally for comparison between groups. The 95% confidence intervals of the parameters were used to show population overlap and high and low risk categories.

We extended the analysis with specific weighting of the smoking risk based upon the U.S current smoking rates for men and women published by the CDC (22) and assumed that these same percentages are similar for diabetic populations. Our review suggests these rates to be similar to those reported by Gegore, et al. (2) for diabetic patients. We have, however, screened a sample of our current diabetic population and determined that within the last 24 months (2001-2003), approximately 9.0% of our diabetic patients were registered as smokers and approximately 10% had stopped smoking. Given these values, we feel that the present estimate of smoking likely overestimates the cardiovascular risk for our population.

Our population has 5.9% type 1 diabetic patients included. However, given the overall similar cardiovascular risk impact upon both type 1 and type 2 diabetic patients as reported recently by Collins, et al. (7), we felt that including type 1 diabetic patients would not substantially alter our projections. Our male (49.4%) and female (50.6%) gender ratio was nearly equal and thus we weighted them equally in the model projections. The CT patients had a slightly higher component of male participants which, when gender weighted equally at 50%, would improve that group’s overall risk assessment and not make the two groups more different. The groups also differed slightly in BMI, with the MG patients having a higher BMI. This difference would theoretically make it a more difficult management problem with hypertension, and both glycemic and lipid control favoring similarity of the groups rather than exaggerating the difference we observe. In order to more specifically correct for the substantial risks of smoking on these populations, we weighted the analysis based on an accepted smoking rate determined in 2003 (22) (Figure 1).

This study is descriptive and therefore cannot determine precisely the cause of the improved glycemic control over the reported literature-based historical controls. Lacking our own group’s historical controls before the interventions, we felt that patients who were demographically similar and recently reported in the literature could represent standard therapy. Those patients would have been similar to our own during a baseline therapy. The UKPDS (8) trial provides not only the tool for multivariable risk calculation but also is weighted heavily in our literature-based control group. This similarity provides further support that the cardiovascular risk we calculate is improved over similar groups treated with conventional means. The difficulty in achieving target goals remains a major regional, national and
international issue as recently reported in 2004 in the Seattle region (27), or in 2003 either generally (1) or for high risk groups receiving intensive management (6). It is also impossible to determine if diabetic care in the Seattle region is somehow special suggesting that our findings are associated with a regional focused improvement rather than any intervention. We would not think that there is regional improvement in diabetic control given the very recent report of poor glycemic control in a sample of patients reported from the Seattle region (27). These patients were outside our treatment population and when managed with conventional treatment had a mean HbA1C of 8% (27).

Unfortunately, we do not have specific cardiovascular outcome data to compare with our predictions. However, when the UKPDS risk information and the Framingham data have been compared with actual outcome data such as recently reported in other cultures, the risk predictions remain robust. The recent improvements in the UKPDS tool (21) by adding specific glycemic control has confirmed the accuracy of the model. We feel that the methodology of reporting the cardiovascular risk is as important as our particular findings. This method of reporting a population risk can be used with mean data from a pooled source by knowing and reporting carefully the variation of the measure and predetermining patient categories of risk. We think that both providers and patients will respond to this type of data presentation where the multiple variables are applied to a clearly understandable and predicted outcome such as risk of heart attack and stoke.

Finally, we cannot determine the specific mechanisms accounting for our results. However, we agree with the suggestion made by the Institute of Medicine that an electronic record will help to improve quality of care, and this likely contributed to our findings. The feedback to providers about the patient-specific cardiovascular risks offered by our electronic medical record combines peer-group competition and informed decision making. Additionally, provider incentives directed at improving quality care can be helpful as reported by Epstein, et al. (14). Our financial reward of 5% of the base production salary would be compared with total healthcare costs of reducing the HbA1C by 1%, or approximately $817 per patient per year (28). In a group of this size, the value has been reported as $4.34 M in Western Washington state (28). Although other estimates of healthcare costs are mixed, most agree that overall hospitalizations and long-term care of complications would be reduced if cardiovascular risk for diabetics was improved. Overall improvement in the quality of diabetic care throughout the United States should help reduce the growing financial burden to our healthcare system (29) with the current diabetic epidemic (9).

CONCLUSION

In conclusion, we report here a community-based medical group where major cardiovascular risk factors for diabetic patients are at or near target values and which are reduced below conventional therapy. These improvements to more favorable parameter mea-
sures would, on average, reduce the overall development of cardiovascular disease by 34.7% over 10 years. The reasons for these results may involve the use of an electronic medical record and financial incentives as used in the medical group.

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