A multidisciplinary endocrinologist-led shared medical appointment (SMA) model showed statistically significant reductions in A1C from baseline over 3 years that were not significantly different from appointments with endocrinologists or primary care providers alone within a resource-poor population. Similarly, the SMA model achieved clinical outcomes on par with endocrinologist-only visits with the added benefit of improving endocrine provider productivity and specialty access for patients. Greater patient engagement with the SMA model was associated with significantly lower A1C.

The burden of diabetes disproportionately affects medically underserved racial and ethnic minorities (1). This vulnerable patient population has a diabetes prevalence rate two times higher than that of the general population, worse glycemic control, and more diabetes-related complications, including cardiovascular disease (2,3). Disparities in diabetes care among racial and ethnic minorities can be attributed to factors such as reduced access to care and greater challenges to receiving high-quality care (4).

Quality diabetes care requires a patient-centered, coordinated approach by a multidisciplinary team of health care professionals (5). Previous studies have shown that a shared medical appointment (SMA) model led by primary care providers (PCPs) or nonphysician health care providers improves diabetes-related clinical outcomes and reduces hospital and emergency department utilization (6–12). None of these studies evaluated endocrinologist-led SMAs, and few have applied SMAs to underserved racial and ethnic minorities. For medically and socially complex cases, SMAs led by endocrinologists improve access to diabetes specialists and may lead to better clinical outcomes (13).

To address challenges related to endocrine access and quality of care in an underserved population, the Cooper University Hospital’s Urban Health Institute (UHI) in Camden, NJ, initiated an innovative, multidisciplinary, endocrinologist-led diabetes SMA model in July 2013. The goals of the SMA model were to improve diabetes clinical outcomes and target social determinants of health (SDOH) related to access and social support. This study evaluated the impact of the multidisciplinary, endocrinologist-led SMA model on diabetes-related clinical outcomes compared with diabetes management by an individual endocrinologist or a PCP alone. We hypothesized that patients attending endocrinologist-led SMAs would have greater improvements and better control of A1C, blood pressure, and lipids than patients attending individual endocrinologist or PCP visits alone.

**Research Design and Methods**

**Setting**

The endocrinologist-led diabetes SMA model took place at the UHI, which serves vulnerable, underserved patients, including those insured by Medicaid or Medicare and living within the five zip codes of Camden, NJ. The population of the city of Camden includes a large proportion of underserved racial and ethnic minorities (48% black and 47% Hispanic/Latino residents), with about 40% of its population living in poverty (14,15). The same endocrinologist sees patients in the diabetes SMA and in individual visits. All data were abstracted from electronic medical records,
and the Cooper University Hospital institutional review board approved the protocol.

Study Design and Participants

This was a 3-year retrospective cohort study comparing diabetes-related clinical outcomes in patients with diabetes attending endocrinologist-led diabetes SMAs with two control groups: 1) patients managed by the endocrinologist alone who were not seen in SMAs ("endocrine-only") and 2) patients managed by a PCP who were not being seen in either the SMA or endocrine-only groups ("PCP-only"). Patients seen by multiple providers were only included in one group (e.g., patients being managed by the PCP and SMA were included in the SMA group; patients being managed by both the PCP and endocrinologist were included in the endocrine-only group).

The study included patients with type 1 or type 2 diabetes who attended at least one SMA, individual endocrinologist visit, or PCP visit at the UHI between July 2013 and July 2016. To address the potential of confounding by indication, we only included patients with a baseline A1C ≥8%. The study enrollment date of July 2013 corresponded to the start of the endocrinologist-led SMA model.

Description of the Interventions

The SMA model provided medical management and interactive education by a multidisciplinary care team, including an endocrinologist, a clinical pharmacist, licensed practical nurses (LPNs), and occasionally endocrinology fellows and health professions students (medicine and pharmacy). SMA visits were conducted in English or Spanish one afternoon per week encompassing four 1-hour visits with different groups of patients each hour. Follow-up SMA visits occurred between 1 and 6 months after initial sessions, depending on A1C control, presence of diabetes-related complications (e.g., frequent hypoglycemia), or patient scheduling preferences. Patients in the control groups attended traditional one-on-one visits with the endocrinologist or a PCP. The PCPs were internal medicine physicians or nurse practitioners. Visits for the individual endocrinologist and PCPs were typically in 15- and 45-minute blocks for follow-up and new visits, respectively.

Up to 14 patients were scheduled every hour in the SMA, with an average show rate of 6–8 patients/hour. During the visit, patients 1) had their vital signs taken; 2) reviewed their glycemic control, blood pressure, and lipids with a clinical pharmacist or LPN; 3) created and reviewed an individual diabetes plan with the clinical pharmacist/LPN and endocrinologist; and 4) participated in a 15- to 20-minute group discussion. The discussion was facilitated by the endocrinologist and focused on education and problem-solving strategies to enhance diabetes self-management. A curriculum of educational topics, including meal planning, hypoglycemia prevention and management, and medication adherence was reviewed throughout the year. Additionally, while vitals were being obtained, a team member facilitated a discussion with patients to gather questions and concerns that were then discussed by the endocrinologist during the education component. The group education was designed to be interactive, allowing participants to share their successes and failures and receive advice and support from their peers. Additional details of the SMA model have been published previously (13).

There was no certified diabetes educator (CDE) or registered dietitian integrated at the urban SMA practice site. Although our SMA provided diabetes education, it was not a substitute for diabetes self-management education and support (DSMES). SMA participants in need of more advanced self-management support were referred to DSMES classes. Lack of transportation to the suburban education program and lack of insurance coverage by Medicaid were barriers to DSMES for many patients.

Outcome Measures

The primary outcome was change in A1C. Secondary outcomes included changes in systolic blood pressure (SBP), diastolic blood pressure (DBP), and LDL cholesterol. Dichotomous secondary outcomes were control of A1C (<8%), SBP (<140 mmHg), DBP (<90 mmHg), and LDL cholesterol (<<100 mg/dL) and prescribing of moderate- or high-intensity statin therapy.

Control thresholds were based on the most up-to-date treatment guidelines during the study period. Controlled diabetes was defined as A1C <8% (instead of <7%) based on performance metrics used by the National Quality Forum and the less stringent definition of glycemic control in the American Diabetes Association (ADA) treatment guidelines (5,16). Blood pressure targets were set at <140/90 mmHg as recommended by the ADA guidelines (5). Based on the 2013 American College of Cardiology (ACC)/American Heart Association (AHA) guidelines for the treatment of blood cholesterol (17), the authors identified whether patients with type 1 or type 2 diabetes aged 40–75 years were actively prescribed a moderate- to high-intensity statin within 90 days of their last visit in year 1, 2, and 3. Given that other practice guidelines still target LDL cholesterol goals, changes in LDL cholesterol and control of LDL cholesterol were evaluated as secondary outcomes (18). Appropriate moderate-intensity statin therapy medication
and dosing was defined according to the 2013 ACC/AHA guidelines (17).

**Data Analysis**

Baseline patient characteristics were compared using ANOVA tests for continuous variables and χ² tests for categorical variables. Changes in A1C were calculated comparing years 1, 2, and 3 with the baseline value from the first appointment between July 2013 and July 2016 (“index visit”). The baseline A1C was defined as the value within 6 months before to 1 month after the index visit. The “post” value was defined as the last recorded value in years 1, 2, and 3 (±30 days). The index visit for a patient could occur at any time in the 3-year study period. Therefore, not all patients may have been followed long enough to have year 2 or 3 visits or laboratory values. To be included in the analysis of change, patients needed to have at least two measurements of an outcome variable at least 3 months apart.

Paired sample t tests were used to compare changes in the primary outcome (A1C) from baseline to years 1, 2, and 3 in each group. To compare differences in A1C changes between the SMA, endocrine-only, and PCP-only groups, separate multivariable linear regression models compared year 1, 2, and 3 changes. The following covariates were included in primary outcome analyses of A1C changes: age, sex, race, insurance type, baseline insulin use, baseline value of outcome, and number of clinic visits. Secondary analyses calculated and compared changes in SBP, DBP, and LDL cholesterol between the SMA group and the control groups similarly but did not include baseline insulin use in the regression models. A subgroup analysis of only the SMA group was performed to compare change in A1C based on number of SMA visits attended. The three categories of SMA visit attendance were 1) one to two visits (reference group), 2) three to four visits, and 3) five or more visits. Dichotomous variables (i.e., control of A1C, SBP, DBP, and LDL cholesterol or on appropriate statin) were analyzed using multivariable logistic regression models that included parallel covariates as above. Control of A1C, SBP, DBP, and LDL cholesterol was based on the last recorded measure in years 1, 2, and 3. All statistical tests were two-sided, and P ≤0.05 was deemed statistically significant. All analyses were conducted using Stata 14 (StataCorp, College Station, TX).

Based on the available sample size in each group at year 1, we had sufficient power (80%) to detect a mean difference in A1C of 0.5% between the SMA and control groups. For the paired sample t test evaluation of pre-/post-A1C changes, we had sufficient power (80%) to detect mean A1C changes of 0.5, 1.2, and 0.7% for the SMA, endocrine-only, and PCP-only groups, respectively.

**Results**

The SMA group included 279 patients, 68 were in the endocrinologist-only group, and 195 were in the PCP-only group. Baseline A1C, blood pressure, and LDL cholesterol levels were similar across all groups (Table 1). SMA and control groups differed in race, insurance type, visit frequency, and insulin use. The SMA group had more patients who were Hispanic compared with the endocrine-only group (56.6 vs. 44.1%) and fewer African-American patients compared with the PCP-only group (36.2 vs. 43.6%). The PCP-only group had more patients covered by Medicaid (50.8 vs. 45.5%) but fewer covered by Medicare (38.5 vs. 42.3%) compared with the SMA group. SMA patients had more clinic visits per patient per year than endocrine-only patients (2.4 vs. 1.4). Compared with PCP-only patients, more patients in the SMA group were on a regimen consisting of any insulin (88.8 vs. 68.6%) or a multiple-dose regimen (46.3 vs. 28.5%).

Changes in A1C, SBP, DBP, and LDL cholesterol and the number of patients included in each analysis are shown in Table 2. Both the SMA and PCP-only groups had persistent, statistically significant reductions in A1C of ~1% during the 3-year study period (P <0.05).

SMA patients had greater reductions in A1C that were not statistically significant compared with endocrine-only patients from baseline to year 1 (±0.3%, P = 0.52) and year 2 (~0.2%, P = 0.74) (Table 3). Compared with PCP-only patients, SMA patients had less change in A1C at year 1 (~0.2%, P = 0.69) and year 2 (~0.2%, P = 0.66) and a greater change in A1C that was not statistically significant at year 3 (~0.2%, P = 0.71). There were too few A1C readings available in the endocrine-only group at year 3 to conduct meaningful statistical analyses. There were no differences in the proportion of patients achieving control of A1C in any follow-up year.

Compared with PCP-only patients, SMA patients had greater reductions in SBP that were not statistically significant at year 2 (~7.8 mmHg, P = 0.32). There were no significant differences in DBP between groups at year 1 and year 2. There were too few blood pressure values available in the endocrine-only group at year 2 and in any group at year 3 to make statistical comparisons. The proportion of patients achieving control of SBP or DBP was not significantly different in any follow-up year.

SMA patients had greater reductions in LDL cholesterol that were not statistically significant compared with
endocrine-only patients (−11.0 mg/dL, \( P = 0.30 \)) at year 1. Compared with PCP-only patients, SMA patients had greater reductions in LDL cholesterol, but again these were not statistically significant at year 1 (−13.0 mg/dL, \( P = 0.16 \)) and year 2 (−8.4 mg/dL, \( P = 0.52 \)). There were too few LDL cholesterol values available to make comparisons between SMA and endocrine-only patients at year 2 and between any group at year 3. There were no significant differences in the proportion of patients achieving control of LDL cholesterol in any follow-up year. For statin prescribing (Table 4), SMA patients were 2.1 times more likely to be on a moderate- or high-intensity statin compared with endocrine-only patients (95% CI 1.1–4.3, \( P = 0.03 \)). SMA patients were less likely to be on a moderate- or high-intensity statin compared with PCP-only patients (odds ratio [OR] 0.6, 95% CI 0.3–1.0, \( P = 0.06 \)).

The study found positive associations between the number of SMA visits attended and greater reductions in A1C levels. Patients who attended five or more SMA visits had statistically significantly greater reductions in A1C at year 2 (−1.8, 95% CI −3.4 to −0.3, \( P = 0.02 \)) and year 3 (−2.0, 95% CI −4.0 to −0.1, \( P = 0.05 \)) compared with patients who attended one to two SMA visits.

Discussion

This study evaluated the impact of a multidisciplinary, endocrinologist-led diabetes SMA model in an underserved population at an urban health institute. Although SMA patients showed statistically significant improvements in A1C from baseline over 3 years, they were not significantly different from those experienced by patients seen by an endocrinologist or PCP alone. However, patients in the SMA model were more likely to be prescribed guideline-recommended moderate- or high-intensity statin therapy than those in the endocrine-only group. Among those in the SMA model, patients who were more engaged (attended five or more SMA visits) had greater reductions in A1C. To our knowledge, this is the first study evaluating clinical outcomes of an endocrinologist-led SMA model in patients with diabetes.

Previous studies of diabetes SMAs led by PCPs or non-physician health care providers have shown variable effects on A1C, blood pressure, and lipids (6–12). In contrast to our findings, meta-analyses have found that SMAs had significantly greater reductions in A1C (−0.5 mg/dL) and SBP (−5.2 mmHg) than usual care (19,20). However, similar to our findings, these meta-analyses have shown greater reductions in LDL cholesterol levels (−6.5 mg/dL) that were
not significant compared with usual care (19,20). Our findings are similar to another evaluation of SMAs in a minority, under-insured population, in which there were no effects on A1C compared with usual care (21).

The results of our study differ from other evaluations of SMAs because this program did not include a CDE to focus on self-care behaviors and self-efficacy. DSMES should be provided to all individuals with diabetes at diagnosis and as needed thereafter as a standard of care (22). The study design reflects the lack of DSMES at the urban clinic site. Patients would have benefited from CDE involvement in the SMA to focus on behavior change; however, New Jersey Medicaid did not cover DSMES until after the study period (23). An important next step to this study would be to add DSMES services to evaluate whether increasing access to specialty care, decreasing wait times for appointments, and providing DSMES to patients enrolled in the SMA model improves diabetes outcomes.

Interestingly, although participation in the SMA was associated with greater statin use than seeing an endocrinologist alone, we saw less statin use in SMA patients compared with PCP-only patients. This is different from existing literature that has reported greater intensification of statin therapy in SMAs compared with usual care with PCPs alone (24). The lack of effect on statin use in SMA versus PCP patients may be explained by the SMA clinic making recommendations rather than directly adding or changing statin medications. A large proportion of PCPs referring patients to the SMA were co-located at the UHI’s academic, multidisciplinary clinic. Primary care and endocrinology have an agreement for the endocrinologist to directly manage blood glucose while only making recommendations for changes to blood pressure and lipid regimens. Direct management of lipids may have led to better outcomes.

Despite this study finding no significant differences in clinical outcomes between the SMA and standard-of-care individual visits, we have previously shown SMA benefits on access to specialty care. The endocrinologist-led SMA reduced loss to follow-up and improved the endocrinologist’s productivity by allowing 2.5 times more patients to be seen per hour of provider time compared with individual endocrinologist visits. The SMA also significantly reduced the number of days until new patients could see the endocrinologist and decreased the time between follow-up visits by about 50% compared with individual endocrinologist visits (25).

SMA patients in this study achieved clinical outcomes similar to those of endocrinologist-only patients (with additional benefits on appropriate statin use) while improving endocrinologist productivity and thus the number of patients who can receive timely, effective specialty care. The endocrinologist-led SMA also provides multidisciplinary diabetes care, significantly increases the amount of education provided at each visit, and enhances access without increasing the number of clinic hours. These are crucial takeaways given the shortage of adult endocrinologists and limited time for comprehensive diabetes care within traditional office visits (26). An endocrinologist-led SMA model that provides similar clinical benefits with enhanced access, provider productivity, and education is an important addition to the diabetes treatment armamentarium.

Our study also found that patients who attended more SMA visits had greater reductions in A1C compared with

### TABLE 2 Changes in A1C, SBP, DBP, and LDL Cholesterol From Baseline to Years 1, 2, and 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>SMA (n)</th>
<th>Endocrine-Only (n)</th>
<th>PCP-Only (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A1C, %</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 1 (SD)</td>
<td>-1.3 (2.5)</td>
<td>178</td>
<td>-0.7 (2.3)</td>
</tr>
<tr>
<td>Year 2 (SD)</td>
<td>-1.2 (2.5)</td>
<td>108</td>
<td>-0.7 (3.4)</td>
</tr>
<tr>
<td>Year 3 (SD)</td>
<td>-1.0 (2.6)</td>
<td>51</td>
<td>-0.7 (2.1)</td>
</tr>
<tr>
<td><strong>SBP, mmHg</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 1 (SD)</td>
<td>0.2 (24.5)</td>
<td>177</td>
<td>4.2 (21.2)</td>
</tr>
<tr>
<td>Year 2 (SD)</td>
<td>-3.7 (21.2)</td>
<td>25</td>
<td>-0.7 (21.2)</td>
</tr>
<tr>
<td><strong>DBP, mmHg</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 1 (SD)</td>
<td>-0.7 (13.4)</td>
<td>177</td>
<td>1.4 (13.4)</td>
</tr>
<tr>
<td>Year 2 (SD)</td>
<td>0.5 (12.6)</td>
<td>25</td>
<td>-0.7 (13.4)</td>
</tr>
<tr>
<td><strong>LDL cholesterol, mg/dL</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 1 (SD)</td>
<td>-15.0 (32.9)</td>
<td>53</td>
<td>-2.3 (30.5)</td>
</tr>
<tr>
<td>Year 2 (SD)</td>
<td>-9.8 (33.2)</td>
<td>31</td>
<td>-0.7 (30.5)</td>
</tr>
</tbody>
</table>

Bold values represent statistically significant changes (P ≤0.05) from baseline based on a paired sample t test (analysis conducted for primary outcome only). *Sample size too small for meaningful comparison.
those who attended fewer visits. We cannot exclude the possibility that clinic attendance was just a marker for other positive adherence-related behaviors such as medication adherence and glucose self-monitoring rather than the intervention inspiring these behaviors (27). Nevertheless, missed appointments are extremely common in our high-risk, urban population and may be an important symptom of other barriers to care, including absence of social support, unemployment, unstable housing, and lack of transportation. These barriers may affect patients’ ability to adhere to treatment plans and achieve better outcomes.

Our study had several limitations. First, this was a retrospective cohort study using preexisting electronic records. This design posed difficulties with regard to variability in missing data and medical visits. Missing data lowered the sample size for analysis of the primary outcome, causing the study to have limited power. We chose not to impute missing values given that the probability of missingness was related to the outcome of interest (i.e., patients with missing data may be more likely to have worse A1C control). This decision restricted us from conducting a longitudinal analysis to evaluate A1C trends over multiple visits. Second, this study is subject to confounding by indication, in which diabetes disease severity may predict enrollment in the SMA model. Patients referred to an endocrinologist usually represent more complex cases of diabetes compared with PCP-only patients. Although we limited the sample set to patients with a baseline A1C $\geq 8\%$, other reasons remain. For example, endocrinologists generally do not see newly diagnosed patients with diabetes, who are more likely to have greater initial decreases in A1C. This may have contributed to larger reductions in A1C in the PCP-only group. Third, we were unable to account for unmeasured covariates, including certain disease-related factors (e.g., duration of diabetes) and SDOH (e.g., social support, neighborhood environment, and food insecurity), which are known to affect diabetes health outcomes in patients with low socioeconomic status (SES) (28–30). Finally, the SMA group included patients also treated by PCPs and potentially by the individual endocrinologist. For example, patients in the

| TABLE 3 Multivariable Analysis Comparing Changes in A1C, SBP, DBP, and LDL Cholesterol Between SMA and Endocrine-Only and PCP-Only Groups |
|-------------------------------------------------|-----------------|-----------------|-----------------|
| SMA Versus Endocrine-Only,* Difference (95% CI) | SMA Versus PCP-Only,* Difference (95% CI) |        |
| A1C, %                                           |                  |                  |
| Baseline to year 1                              | −0.3 (−1.1 to 0.6) | 0.52             | 0.2 (−0.6 to 0.9) | 0.69          |
| Baseline to year 2                              | −0.2 (−1.2 to 0.9) | 0.74             | 0.2 (−0.7 to 1.1) | 0.66          |
| Baseline to year 3                              | −                     | −0.2 (−1.5 to 1.0) | 0.71          |
| SBP, mmHg                                        |                  |                  |
| Baseline to year 1                              | −0.5 (−6.7 to 5.8) | 0.88             | 0.9 (−4.8 to 6.5) | 0.30          |
| Baseline to year 2                              | −                     | −7.8 (−23.3 to 7.7) | 0.32          |
| DBP, mmHg                                        |                  |                  |
| Baseline to year 1                              | −1.4 (−5.0 to 2.1) | 0.43             | −0.73 (−4.0 to 2.5) | 0.66          |
| Baseline to year 2                              | −                     | −0.1 (−9.5 to 9.8) | 0.98          |
| LDL cholesterol, mg/dL                          |                  |                  |
| Baseline to year 1                              | −11.0 (−31.9 to 9.8) | 0.29            | −13.0 (−31.0 to 5.1) | 0.16          |
| Baseline to year 2                              | −                     | −8.4 (−34.2 to 17.4) | 0.52          |

Covariates included in the model: age, sex, race, insurance type, number of clinic visits, baseline A1C (for A1C analysis), baseline insulin use (for analysis of A1C), baseline SBP (for analysis of SBP), baseline DBP (for analysis of DBP), baseline LDL cholesterol (for analysis of LDL cholesterol). *Control group is the reference group. †Sample size for endocrine-only group was too small for statistical comparisons ($n = 4$).

<table>
<thead>
<tr>
<th>TABLE 4 Adjusted ORs for Moderate- or High-Intensity Statin Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA, %</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>Statin use at last visit</td>
</tr>
</tbody>
</table>

Covariates included in the model: age, sex, race, insurance type, and number of clinic visits.
SMA group continued to see their PCP throughout the study. Similarly, patients may have started in the SMA model but switched to endocrinologist-only visits during the study period for various reasons (e.g., declining continued SMA participation). This group spillover may have affected SMA treatment effects in the study.

Conclusion

We found that, although patients enrolled in SMA visits had persistent, statistically significant reductions in A1C from baseline, they were not different from patients who had individual endocrinologist or PCP visits in a resource-poor community in Camden, NJ. However, as our group and others have shown previously, improving access to care in vulnerable populations through SMAs can enhance patient satisfaction and improve specialty provider productivity (25,31). Notably, low-SES patients attending SMA visits were able to achieve clinical outcomes similar to those having one-on-one endocrinologist visits while getting improved access to timely specialty care. This finding is especially important in the era of an endocrinologist shortage.

This study also highlights the importance of improving engagement in SMA care. Particularly in low-SES populations, lack of engagement may be a symptom of unaddressed SDOH, resulting in worse diabetes outcomes. Addressing social needs using a culturally sensitive team-based approach may help patients engage more in care and improve outcomes. Future studies should focus on improving engagement and use a prospective, randomized design with larger patient cohorts to more definitively assess the benefits of an endocrinologist-led SMA on diabetes-related clinical outcomes.

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DUALITY OF INTEREST

No potential conflicts of interest relevant to this article were reported.

AUTHOR CONTRIBUTIONS

V.S.G. planned the study, analyzed data, wrote the manuscript, and reviewed/editied the manuscript. J.A.L. helped plan the study, assisted with data analysis, and reviewed/editied the manuscript. N.M. helped carry out statistical analysis and reviewed/editied the manuscript. K.H.C. assisted with data cleaning and reviewed/editied the manuscript. S.T.K. helped plan the study and reviewed/editied the manuscript. V.S.G. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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