License to Drive: Type 1 Diabetes Management and Obtaining a Learner’s Permit in Maryland and Virginia

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Type 1 diabetes is one of the most commonly diagnosed chronic illnesses of childhood, with a prevalence of 1 out of every 400–600 children.1 Successful management of type 1 diabetes requires adolescents to engage in a number of daily tasks, including frequent self-monitoring of blood glucose (SMBG), insulin administration, carbohydrate counting, and prevention of hyperglycemia and hypoglycemia.2 Consistent adherence to a diabetes care regimen, including frequent SMBG, has been related to improved glycemic control.3,4

Adolescents with type 1 diabetes demonstrate poorer adherence to treatment regimens compared to other age-groups, and there are limited data on specific methods to improve adherence among adolescents.5,6

Driving is one of the most anticipated privileges for many adolescents. For adolescents diagnosed with type 1 diabetes, additional steps may need to be taken to obtain a driver’s license.5,6 At present, at least 23 states require drivers to disclose a diagnosis of type 1 diabetes.7 Some states require physician approval only when a driver has a history of seizure or unconsciousness, whereas 11 states require the signature of a physician for all patients with type 1 diabetes before obtaining a learner’s permit or license.9 The impact of state driving laws on type 1 diabetes management behaviors is not well understood, and no research to date has explored the relationship between state requirements for physician endorsement of drivers and type 1 diabetes management.

In general, adolescents are less experienced drivers and engage in greater risk-taking behaviors when driving compared to adults.10,11 Acute complications related to poor type 1 diabetes management may exacerbate unsafe driving behavior in adolescents.

Few studies have directly examined driving behavior in adolescents with type 1 diabetes. In a survey of 72 parents, 31% reported that their adolescent had been in a collision in the past year, and 29% reported that their adolescent experienced at least one moderately disruptive hypoglycemic event while driving.12 Limited research suggests that adults with type 1 diabetes also are at greater risk for automobile accidents, particularly when there is a history of severe hypoglycemia and infrequent SMBG.13,14

To reduce the risk of accidents, drivers are encouraged to perform SMBG before driving and treat glucose excursions as needed, even for short trips.7 However, research suggests that as few as 15% of adults routinely perform SMBG before driving.15,16

As a large tertiary diabetes care center in the mid-Atlantic, our practice is uniquely poised to evaluate associations among state-directed driver’s license requirements, physician involvement, and type 1 diabetes control. We routinely see adolescent patients in the Washington, D.C., metro area, including patients from Maryland and Northern Virginia.

When adolescents with type 1 diabetes apply for a learner’s permit to drive in Maryland, they must have a physician-signed medical clearance.
Results will provide preliminary information about adolescent management of type 1 diabetes in each state and will be used to determine the value of pursuing this research question in a larger representative sample.

Study Methods

Study participants
Participants included 45 adolescents with type 1 diabetes receiving care at a pediatric diabetes center. Purposive sampling was used to identify eligible participants. To minimize physician differences, all participants were seen by the same medical provider for at least 1 year between the ages of 15 and 16 years. All patients seen by this provider in a 2-year period were reviewed, and 74 patients between the ages of 16 and 17 years with a confirmed residence in Maryland or Virginia met criteria for initial chart review.

In Maryland, the minimum age requirement is 15 years and 9 months to obtain a learner’s permit to drive, whereas in Virginia, the minimum is 15 years and 6 months of age. All patients needed to be routinely seen for standard medical visits for type 1 diabetes (at least one visit every 4 months) for at least 6 months before and after reaching the age of eligibility for a learner’s permit and have data on SMBG frequency (via an SMBG meter download in the clinic or at home) and A1C values available for a minimum of two clinic visits.

Clinic letters generated by the physician after each medical appointment were reviewed to ensure that patients were of driving age and planning to obtain a learner’s permit. All clinic letters list specific recommendations that were discussed and documented with the patient in the medical visit; patients and/or parent(s) also sign the ambulatory treatment record during the clinic visit to endorse understanding of the recommendations provided. For patients in Maryland, physician letters needed to include a specific documented recommendation of the requirements for carrying out SMBG at least 4 times/day for at least 6 months before the legal learner’s permit age.

After excluding ineligible patients and those with incomplete data \( (n = 29) \), 45 patients from Maryland \( (n = 26) \) and Virginia \( (n = 19) \) were included in the analyses.

Study design
We conducted a retrospective cohort study using medical chart data from the electronic medical record system Clinipro (NuMedics, Tigard, Ore.) and used by the Child and Adolescent Diabetes Program at Children’s National Medical Center. The Clinipro database contains clinical data for all patients with type 1 diabetes at this site. Data on SMBG frequency and glycemic control (A1C) were collected via retrospective chart review from 6 months before the eligible age for a learner’s permit (baseline) through the following year (6 months after obtaining a learner’s permit).

All SMBG data were collected via glucose meter downloads. The majority of glucose meters were downloaded at the medical visit into Clinipro. In a small number of cases, the family downloaded the glucose meter at home and brought data printouts to the clinic. Daily SMBG frequency is based on the most recent 30 days of SMBG data at each time point.

The study was approved by the Institutional Review Board at the primary author’s institution. All data were de-identified to protect patient health information.

Statistical analyses
Means and standard deviations (SDs) were generated for target variables. Independent samples t-tests were used to investigate differences over time for SMBG frequency and A1C. Pearson correlations were conducted to evaluate the relationship between SMBG frequency and A1C. A repeated-measures analysis of variance (rANOVA) was conducted to discern differences in the frequency of SMBG before and after obtaining a learner’s permit, by state of residence.

Study Results
At baseline, participants had a mean age of 15.21 years (SD 0.27 years) and had been diagnosed with type 1 diabetes. Patients were of driving age and planning to obtain a learner’s permit. All clinic letters list specific recommendations that were discussed and documented with the patient in the medical visit; patients and/or parent(s) also sign the ambulatory treatment record during the clinic visit to endorse understanding of the recommendations provided. For patients in Maryland, physician letters needed to include a specific documented recommendation of the requirements for carrying out SMBG at least 4 times/day for at least 6 months before the legal learner’s permit age.

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diabetes for an average of 6.07 years (SD 4.10 years). The sample was primarily female (64%) and white (85%). At the baseline of 6 months before qualifying for a learner’s permit, mean frequency of SMBG was 3.73 checks/day (SD 1.69, median 3.63, range 1.0–8.0) and mean A1C was 8.52% (SD 1.28, median 8.30, range 6.0–11.9%). Frequency of SMBG and A1C were significantly correlated ($r = –0.40, P < 0.01$).

Frequency of SMBG and A1C did not vary by state of residence.

Six months after obtaining a learner’s permit to drive, mean frequency of SMBG was 3.91 checks/day (SD 1.65, median 3.90, range 1.00–8.00) and mean A1C was 8.87% (SD 1.53, median 8.70, range 6.6–13.4%). Frequency of SMBG and A1C remained significantly correlated ($r = –0.34, P < 0.05$).

Using a paired-samples $t$-test, frequency of SMBG did not significantly increase from baseline to 6 months after obtaining a learner’s permit in the total sample ($t(43) = –0.72, P = 0.47$). Neither adolescents from Maryland ($t(25) = –0.19, P = 0.84$) nor Virginia ($t(25) = –0.83, P = 0.42$) significantly increased daily SMBG frequency from baseline to 6 months after obtaining a learner’s permit. A1C significantly increased over the 1-year period ($t(43) = –2.18, P < 0.05$), and did not vary by state ($t(43) = 0.05, P = 0.96$). Table 1 provides additional details.

An rANOVA was conducted to look at change over time in SMBG by state across the 6-month periods before and after obtaining a learner’s permit. Results confirm that state of residence and time did not significantly affect SMBG frequency [$F(2, 43) = 0.31, P = 0.58$]. With a small feasibility sample, significant results may be masked by the small sample size. Thus, individual cases were examined to determine change in SMBG frequency by state. Five adolescents in Maryland (12%) and four adolescents in Virginia (21%) did not meet the recommended level of SMBG frequency at either time point. Five adolescents in Maryland (19%) and nine adolescents in Virginia (47%) consistently performed an average of ≥4 checks/day across the study period. Tables 2 and 3 offer more details.

**Discussion**

The purpose of this retrospective study was to evaluate changes in SMBG frequency and A1C during the time when adolescents obtained their learner’s permit. During this same time period, three adolescents in Maryland (12%) and four adolescents in Virginia (21%) also evidenced decreases in their mean SMBG frequency to <4 checks/day after obtaining a learner’s permit. Additionally, 13 adolescents in Maryland (50%) and four adolescents in Virginia (21%) did not meet the recommended level of SMBG frequency at either time point. Five adolescents in Maryland (19%) and nine adolescents in Virginia (47%) consistently performed an average of ≥4 checks/day across the study period.

### Table 1. SMBG and A1C at Baseline and 6 Months After Obtaining a Learner’s Permit, by State of Residence

<table>
<thead>
<tr>
<th></th>
<th>Maryland ($n = 26$)</th>
<th>Virginia ($n = 19$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>6 Months After Obtaining Learner’s Permit</td>
</tr>
<tr>
<td>Daily SMBG checks*</td>
<td>3.44 (1.64)</td>
<td>3.52 (1.42)**</td>
</tr>
<tr>
<td>A1C (%)*</td>
<td>8.42 (1.23)</td>
<td>8.88 (1.55)**</td>
</tr>
</tbody>
</table>

*Mean (SD).

**Nonsignificant change from baseline to 6 months after obtaining learner’s permit.

### Table 2. SMBG Frequency at Baseline and 6 Months After Obtaining a Learner’s Permit in Individual Cases by State of Residence

<table>
<thead>
<tr>
<th></th>
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<th>Virginia ($n = 19$)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>6 Months After Obtaining Learner’s Permit</td>
</tr>
<tr>
<td>Number of adolescents meeting baseline recommendation for SMBG frequency of ≥4 checks per day ($n [%]$)</td>
<td>8 (31)</td>
<td>10 (38)*</td>
</tr>
</tbody>
</table>

*Nonsignificant change from baseline to 6 months after obtaining a learner’s permit.
We hypothesized that adolescents in Maryland would increase their frequency of SMBG across the study period because a physician’s signature is required to obtain a learner’s permit, and our practice requires adolescents to demonstrate a minimum of 4 checks/day to obtain this endorsement. Adolescents in Virginia were hypothesized to evidence no change in SMBG frequency because no physician approval is required to obtain a learner’s permit.

In our sample, our primary hypothesis was not supported, and no significant changes in SMBG frequency were observed during the 1-year period in either group of adolescents. Examination of individual cases revealed that five of adolescents in Maryland (19%) and two adolescents in Virginia (12.5%) increased SMBG frequency from ≤4 checks/day to ≥4 checks/day over the study period. Overall, 6 months after obtaining a learner’s permit, 38% of adolescents in Maryland and 58% of adolescents in Virginia were performing SMBG ≥4 times/day.

These results are consistent with other studies involving clinic-based samples of adolescents with type 1 diabetes that have typically found that up to 40% of adolescents meet SMBG frequency targets. Thus, our results support the established literature and suggest that some adolescents are not meeting physician requirements for optimal monitoring of glucose levels.4,17

A1C significantly increased during the same period that SMBG frequency did not significantly decrease, suggesting that at least one aspect of type 1 diabetes self-care (SMBG) was maintained even as A1C worsened. Although our data did not indicate a reason why A1C worsened over time, other studies with adolescents have evidenced a general worsening of A1C across adolescence, in part because of decreased self-care, disturbed eating, mood concerns, and hormonal fluctuations.18,19

This study is the first to evaluate adolescent type 1 diabetes management behaviors in relation to obtaining a learner’s permit. Little is known about how requirements for obtaining a driver’s license are enforced. Furthermore, physician involvement in the approval of a driver’s license varies significantly by state. The privilege of driving may be particularly salient for youth with diabetes, and comprehensive education related to driving safety is needed for this age-group.7,11

We had hypothesized that the desire to obtain a driver’s license may motivate teens to engage in appropriate self-care behaviors and maintain or increase their SMBG frequency. However, in this sample, approximately half of the youths were not meeting minimum standards for SMBG frequency at the time of learner’s permit acquisition.

### Table 3. Changes in SMBG Frequency from Baseline to 6 Months After Obtaining a Learner’s Permit, by State of Residence

<table>
<thead>
<tr>
<th></th>
<th>Maryland (n = 26)</th>
<th>Virginia (n = 19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Met SMBG recommendations at baseline and 6 months after obtaining a learner’s permit (n [%])</td>
<td>5 (19)</td>
<td>9 (47)</td>
</tr>
<tr>
<td>Met SMBG recommendations at baseline only (n [%])</td>
<td>3 (12)</td>
<td>4 (21)</td>
</tr>
<tr>
<td>Met SMBG recommendations 6 months after obtaining a learner’s permit only (n [%])</td>
<td>5 (19)</td>
<td>2 (11)</td>
</tr>
<tr>
<td>Did not meet SMBG recommendations at baseline or 6 months after obtaining a learner’s permit (n [%])</td>
<td>13 (50)</td>
<td>4 (21)</td>
</tr>
</tbody>
</table>

Population. Parents play a key role is supporting physician recommendations and state guidelines, and recent research suggests that parental goals for diabetes management are significantly influenced by physician goals.20 Incorporating parents into goal-setting with regard to SMBG frequency and enforcing consistent limits regarding safety behaviors (e.g., performing SMBG before driving) can empower parents and increase parental supervision for daily type 1 diabetes care.21,22

Parent-teen interventions using behavioral contracts regarding driving safety behaviors have successfully decreased risky driving behavior in healthy adolescents and could be applied to adolescents with type 1 diabetes, including contract goals with both parents and physicians.21–23 Incorporating goals for SMBG frequency into behavioral contracts related to specific positive outcomes (e.g., obtaining a learner’s permit) may be an innovative way to promote adolescent adherence.24 Using incentives that have immediate, direct results and affect privileges in which teens are heavily invested (such as driving) may improve adherence and inform novel care innovations.

#### Study limitations

Because this was an exploratory study, there are a number of limitations, including the use of purposive sampling and a relatively small sample size. Additionally, patients from Maryland and Virginia may differ on key unmeasured variables. Future studies should replicate the study procedures in a larger, more diverse sample that incorporates multiple practice locations within both states and assess potential moderators of SMBG frequency and driving behavior, including socioeconomic status and insulin regimen.

Our analysis of application for a learner’s permit is based on age. We reviewed clinic letters to verify that patients were seeking a learner’s permit but were unable to account for possible license rejection or approval by the treating physician or parent. Incorporation of standard documentation related to discussion of driving
and obtaining a learner’s permit would strengthen future studies.

Practice implications
It is important for adolescents with type 1 diabetes to participate in normative developmental milestones (e.g., driving25), but it is also crucial that adolescents learn how to minimize the risks of driving with type 1 diabetes and adequately monitor their blood glucose levels before driving. Driving may be a particularly salient motivator for adolescents, and knowledge of safe driving behaviors and self-care requirements for obtaining a learner’s permit should be included as routine type 1 diabetes care goals.21

Although the requirement of physician endorsement for a license did not appear to differentially affect SMBG behaviors in youths, it is possible that adolescents may benefit from a more structured behavioral intervention involving behavioral contracting coupled with parental reinforcement. Physicians are continually seeking opportunities to improve diabetes management behavior in this vulnerable age range, and obtaining a learner’s permit may provide a unique window of opportunity to effect change by promoting increased SMBG.

Additionally, increasing SMBG frequency has been related to improved A1C in adolescents with type 1 diabetes.4,26 Therefore, although motivation for obtaining a driver’s license may be temporary, an increase in SMBG frequency provides a greater chance of improving glycemic status, decreasing hypoglycemic events, and improving quality of life.27 These benefits may be self-sustaining and continue to serve as an incentive for teens to perform frequent SMBG.

Finally, an interactive dialogue that begins with the teen’s desire to obtain a learner’s permit often leads to further discussion of other high-risk behaviors, including sex, drugs, and alcohol use. Counseling that may not have occurred otherwise with regard to common adolescent risk factors, including hypoglycemia risk and alcohol consumption, may now set in motion further inquiries and lead to safer self-management practices.

Conclusions
Adolescents with type 1 diabetes engage in a number of risky behaviors that can affect their overall health.28 Any efforts to evaluate adolescent health practices and develop novel care innovations that may translate into improved overall safety and better adherence should be encouraged.

Although this exploratory study did not demonstrate the expected results, its results have implications for potential future behavioral interventions in adolescents with type 1 diabetes. Interventions may include setting clear goals for SMBG in relation to driving and using behavioral contracts to link type 1 diabetes behavioral goals to driving. Future prospective, controlled studies in which physicians provide education regarding SMBG requirements before learner’s permit authorization and engage in explicit behavioral contracts to improve driving knowledge and safety are warranted.

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References

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