Impact of elective hospital admissions on glycaemic control in adolescents with poorly controlled type 1 diabetes

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Abstract

Aim. – Different treatment strategies have been used to manage adolescents with poorly controlled type 1 diabetes. We investigated whether a brief elective hospital admission improves haemoglobin A1c (HbA1c) over 12 months.

Methods. – We studied a retrospective cohort of adolescents with poorly controlled type 1 diabetes attending a tertiary care pediatric diabetes clinic in Montreal, Canada, between January 2005 and December 2010. Hospitalized adolescents (admitted group) were matched with controls (non-admitted group) for age and baseline HbA1c. HbA1c values at baseline, 6 and 12 months were obtained from the clinic database.

Results. – Thirty patients aged 11 to 17 years with a first elective admission for poor metabolic control were paired with 30 non-admitted patients. At baseline, HbA1c was 12.2 ± 1.6% in admitted and 12.0 ± 1.2% in non-admitted patients. There were no clinically important differences in potential confounders between groups. There was no improvement in the primary outcome as assessed by the change in HbA1c at 12 months in the admitted group (−1.3 ± 2.3%) compared with the non-admitted group (−2.1 ± 1.7%) (P = 0.078). No improvement in intermediary measures of glycaemic control was observed (HbA1c at 6 months or change at 6 months). After 12 months, HbA1c values were higher in the admitted group (10.9 ± 1.9%) versus the non-admitted group (9.9 ± 1.4%) (P = 0.016).

Conclusion. – Elective hospital admission for adolescents with poorly controlled type 1 diabetes does not seem to be an effective strategy to improve HbA1c over 12 months.

Keywords: Diabetes mellitus; Type 1; Adolescent; Hospitalisation; HbA1c

Résumé

L’impact d’hospitalisations élecitives sur le contrôle glyémique d’adolescents ayant un diabète de type 1 mal contrôlé.

Objectif. – Différentes stratégies sont utilisées pour la prise en charge d’adolescents ayant un diabète de type 1 mal contrôlé. Nous avons examiné l’impact d’une hospitalisation élecitive sur l’évolution de l’hémoglobine glyquée (HbA1c) pendant une période de 12 mois.

 Méthodes. – Nous avons conduit une étude de cohorte rétrospective d’adolescents ayant un diabète de type 1 mal contrôlé suivis à une clinique pédiatrique de diabète à Montréal, Canada, entre janvier 2005 et décembre 2010. Les adolescents hospitalisés (groupe admis) ont été comparés à des adolescents suivis en externe (groupe non admis) selon l’âge et la valeur initiale d’HbA1c.

 Résultats. – Trente adolescents (11–17 ans) ayant été hospitalisés pour un mauvais contrôle métabolique ont été jumelés avec 30 adolescents non admis. Les valeurs d’HbA1c initiales étaient de 12,2 ± 1,6 % chez les patients hospitalisés et 12,0 ± 1,2 % chez les patients non hospitalisés. Aucune différence clinique importante ne fut observée au niveau de facteurs confondants potentiels. Il n’y eut aucune différence significative de la réduction d’HbA1c mesurée à 12 mois dans le groupe admis (−1,3 ± 2,3 %) par rapport au groupe non admis (−2,1 ± 1,7 %) (P = 0,078). L’HbA1c à six mois et la différence entre les valeurs d’HbA1c à six mois étaient comparables entre les groupes. Après 12 mois, l’HbA1c était plus élevée dans le groupe admis (10,9 ± 1,9 %) par rapport au groupe non admis (9,9 ± 1,4 %) (P = 0,016).

 Conclusion. – L’hospitalisation élecitive d’adolescents ayant un diabète mal contrôlé ne semble pas être une stratégie efficace pour améliorer le contrôle glyémique à moyen terme.

Mots clés : Diabète sucré ; Type 1 ; Adolescent ; Hospitalisation ; HbA1c

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1. Introduction

Prevalence of type I diabetes has increased worldwide in the last decades and is one of the most common chronic illnesses of childhood and adolescence in Canada [1]. Persisting hyperglycaemia secondary to diabetes can be associated with important vascular complications. The Diabetes Control and Complications Trial (DCCT) showed a reduction in these long-term complications with improved glycaemic control [2]. Similar results were observed when the cohort of adolescents was analyzed separately [3]. However, even if the adolescents randomized to the intensive insulin regimen needed more support than in the adult group, their mean haemoglobin A1c (HbA1c) level was approximately 1% higher than the adults [3]. As a matter of fact, adolescence is a period of important social, physiologic and psychological changes, which may result in reduced adherence to insulin therapy and deterioration of metabolic control [4].

Diabetes is primarily managed in the ambulatory setting and education is the corner stone of the management. Routine care of adolescents with type I diabetes typically rely on periodic meetings with health care professionals [5]. However, patients with inadequate metabolic control often require additional interventions and different management strategies have been studied over the years. Home-based, family-based or outpatient programs that increase education and psychological support have been developed [6,7]. Even if these programs have shown to improve metabolic control, they are usually expensive and time-consuming and the positive effect is not sustained after the interventions have been withdrawn [8]. Other groups have studied the effects of regular telephone calls from a pediatric diabetes educator. Again, they typically failed to achieve a significant improvement in HbA1c [9–11].

Rates of hospital admissions for children and adolescents with type I diabetes are known to be higher than those of the non-diabetic population [12,13]. This has a large impact on health care costs in youth with diabetes [14]. Hospitalizations are usually due to intercurrent illnesses, diabetic ketoacidosis or severe hypoglycaemia. As well, in our setting, patients with poorly controlled diabetes are sometimes admitted on an elective basis for education and insulin dose adjustments [15,16].

Up to now, there is little information about the best way to manage adolescents with poorly controlled type I diabetes in order to improve their long-term glycaemic control and ultimately prevent complications. The purpose of our study was to evaluate the sustained effects on metabolic control of brief elective hospital admissions in this population. We compared the change in HbA1c over 12 months of hospitalized adolescents aged 11–17 years with HbA1c greater or equal to 10% to a similar group of non-admitted adolescents followed as outpatients, controlling for age and baseline HbA1c. We hypothesized that hospitalized patients with poorly controlled diabetes would have improved glycaemic control than matched non-admitted patients over a period of 1 year.

2. Material and methods

2.1. Subjects

We conducted a retrospective cohort study at a tertiary care paediatric hospital to evaluate whether elective hospitalization improves glycaemic control in adolescents with poorly controlled type I diabetes. All data for demographics, treatment modality and HbA1c values were retrieved from a retrospective review of the electronic database of a diabetes clinic at a tertiary pediatric healthcare centre in Montreal, Canada (Montreal Children’s Hospital). This is the primary record keeping system for documenting all patient communication with the diabetes team, which are recorded scrupulously for medico-legal reasons [17]. Missing information was collected through patients’ hospital charts. All adolescents that attended the diabetes clinic of the Montreal Children’s hospital from January 2005 to December 2010 were identified and screened for this study. Patient eligibility criteria for both groups included age 11 to 17 years; type I diabetes; duration of diabetes more than 1 year; HbA1c greater or equal to 10% on two consecutive occasions approximately 3 months apart and HbA1c data available 6 (5–7) months and 12 (11–13) months after the baseline HbA1c. Patients were excluded if they were known to suffer from major psychiatric illness (including eating disorders and depressive disorders) or other significant chronic medical conditions.

The selection procedure for inclusion into the hospitalized cohort (admitted group) was as follows: patients must have had one first elective hospital admission during the study period for which the main reason was identified in the hospital discharge summary as poor control of diabetes. Adolescents admitted for acute decompensation of their diabetes (severe hypoglycaemia or diabetic ketoacidosis) were excluded. The study protocol received institutional review board approval and the requirement for patient consent was waived.

2.2. Procedures

At our centre from 2005 to 2010, seven pediatric endocrinologists were regularly practicing in the diabetes clinic. No formal consensus existed among the group on the management of adolescents with poorly controlled type I diabetes and ultimate decisions were the responsibility of the treating physician. One of the strategies consisted of admitting patients to the hospital for a few days in order to make insulin dose adjustments and to emphasize the need for proper diabetes management at home. During their hospitalization, patients had daily meetings with diabetes educators, dieticians, social workers and physicians. On average, the hospital stay was 4 days (1–7 days, median 3 days). Only one patient was admitted for 24 hours and had to be discharged early due to hospital bed shortage. The following weeks after discharge, patients were seen more intensively as outpatients with numerous phone calls and clinic visits. On the other hand, physicians sometimes decided not to admit patients with uncontrolled diabetes. They preferred them to have a close outpatient follow-up with regular phone calls or emails with different health care professionals from the diabetes team. These
patients also benefited from more frequent clinic visits (every 1 to 4 weeks) for 1 to 6 months. It is noteworthy that certain adolescents were supposed to be managed as inpatients according to their physician’s clinical decision, but were managed as outpatients instead because of lack of bed availability.

2.3. Measurements

We used the change in HbA1c at 12 months as our primary outcome to assess the effect of hospitalization on glycaemic control. Secondary outcomes included the change in HbA1c at 6 months and HbA1c values at 6 and 12 months. Glycaemic control was assessed using glycated haemoglobin A1c (HbA1c), measured with three point-of-care analyzers Bayer DCA 2000+. The instruments had an analytical error up to 0.7% and were calibrated prior to each visit at the Diabetes Clinic. Usually patients had HbA1c levels measured every 3 months or more often if needed according to their physician’s clinical judgment. For the purpose of our study we obtained HbA1c values at baseline, 6 and 12 months.

We matched admitted and non-admitted patients 1:1 by age category and baseline HbA1c. Age (in years [y]) was calculated at the time of collection of baseline HbA1c. The age categories were 11 to 14 y and above 14 to 17 y. Baseline HbA1c for the admitted group was defined as the HbA1c value at the time of hospitalization (7 days prior to day of admission). For the non-admitted group, baseline HbA1c was considered to be the first HbA1c matched and used for the study. To be matched together, a difference of less than 1.0% between baseline HbA1c levels was required.

In addition to age and HbA1c, we also collected data on other potential confounders at baseline: gender, insulin regimen, insulin dose (U/kg/day), duration of diabetes, socioeconomic status, ethnicity (non-Hispanic white versus others) and physician (MD1 to MD7). Insulin regimens were divided into BID injections, multiple daily injections (TID and QID injections) and continuous subcutaneous insulin infusion (CSII). Duration of diabetes was calculated from time of diagnosis to the date of collection of baseline HbA1c. Given that socioeconomic status may influence adherence to treatment, we chose to explore whether the groups differed in their socioeconomic status as assessed by area-based deprivation indices [18]. These composite indices (material and social) are based on socially homogenous neighbourhoods of 400 to 700 inhabitants and have been validated in Canada as measures of socioeconomic status that impact on health outcomes, with higher percentiles indicating more disadvantage. The ‘Material Deprivation Index’ represents a measure of unemployment rates, mean household income and educational achievement. The ‘Social Deprivation Index’ reflects number of single parent households, number of divorced, separated or widowed households, and number of people living alone. Number of contacts with the family were all recorded in the clinic database and allowed us to compare number of contacts after an admission or during an outpatient follow-up.

2.4. Data analysis

Data are presented as means ± SD for continuous variables and as proportions (%) for categorical variables. Group comparisons between admitted and matched non-admitted patients are presented as 95% confidence intervals of the difference and were tested using paired t-test for the primary outcome (change in HbA1c at 12 months). The same approach was used for secondary outcomes; change in HbA1c at 6 months and HbA1c values at 6 and 12 months. Statistical analyses were done using SPSS (IBM SPSS Statistics, Version 20, IBM Corporation, Somers, NY) and open source R software. Statistical significance was defined as \( P < 0.05 \).

3. Results

A total of 35 patients were found to have had a first elective admission in our centre for poorly controlled diabetes. Among those, two had type 2 diabetes, two did not have subsequent HbA1c values at 6 or 12 months and one was diagnosed with a major depressive disorder. Therefore, 30 patients were included in the admitted group.

Using the same source population as the admitted group, 95 adolescents followed as outpatients were identified as having poor glycaemic control. Twenty-eight were excluded for missing subsequent HbA1c data in the following year, three had significant comorbidities and four were admitted electively prior to the study time period; for a total of 60 patients meeting all eligible criteria to be part of the non-admitted group. From the 60 eligible non-admitted patients, 30 patients were able to be matched 1:1 by age category and baseline HbA1c to patients of the hospitalized group.

Baseline characteristics are shown in Table 1. At baseline, no clinically important differences in potential confounders were observed between the admitted and non-admitted groups. Regarding changes in insulin regimen during the one-year follow-up, no clinically important differences were observed. At 12 months, 13 (43.3%) in the admitted group compared to 10 (33.3%) in the non-admitted group received BID injections. The proportion receiving MDI injections were also similar between the admitted (17 [56.7%]) and non-admitted groups (20 [66.7%]).

HbA1c results are presented in Table 2. At baseline, paired t-tests showed that there was no significant difference in the mean HbA1c in admitted (12.2 ± 1.6%) versus non-admitted patients (12.0 ± 1.2%) (\( P = 0.069 \)). We observed no improvement in the primary outcome, as measured by the change in HbA1c at 12 months in hospitalized patients (−1.3 ± 2.3%) compared with non-admitted patients (−2.1 ± 1.7%) (\( P = 0.078 \)). The same pattern was seen for the intermediary measure; that is no difference in the change in HbA1c at 6 months between hospitalized (−1.8 ± 2.3%) and non-admitted patients (−1.9 ± 1.7%) (\( P = 0.852 \)). Although the mean HbA1c values decreased from baseline in both groups 6 and 12 months after the intervention, HbA1c values at 6 months did not differ between groups (admitted group: 10.4 ± 2.1%; non-admitted group: 10.1 ± 1.3%) (\( P = 0.532 \)). However, at 12 months, HbA1c values differed

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were four patients in the admitted group (13.3%) versus seven patients of the control group (23.3%) who achieved this goal.

4. Discussion

To our knowledge, the current observational study is the first to investigate the impact of elective admissions for poor control of diabetes in adolescents with type 1 diabetes. Importantly, we observed that brief hospitalization does not seem to improve glycaemic control in this population.

There was no improvement in glycaemic control based on the primary outcome, change in HbA1c at 12 months for hospitalized adolescents in comparison to matched non-admitted adolescents. Intermediary measures of metabolic control (HbA1c at 6 months or change in HbA1c at 6 months) did not differ between groups. Surprisingly, the HbA1c value at 12 months was higher in the hospitalized group versus the non-admitted group, suggesting lesser improvement with hospitalization. Although the observed direction of association is opposite to what we had expected, this difference might be considered clinically significant as the DCCT showed that a reduction in HbA1c of 0.5% is significant enough to decrease the risk of long-term complications [2].

In each group, we witnessed a decrease in HbA1c at 6 months and 12 months when compared to initial values. The improvement in HbA1c could be explained by effectiveness of care. Alternatively, we might be experiencing regression towards the mean since the initial reason for the admission was the concern over a high HbA1c value.

Overall, HbA1c levels were stable at the 12-month assessment compared to the 6-month assessment in both groups. It seems that medical management strategies used in our clinic avoided the frequently seen rebound effect from short-term interventions. However, although we observed a decline in HbA1c levels throughout the study period, neither group was ever close to achieve target goals for HbA1c in adolescents as established by the International Society for Pediatric Diabetes (ISPAD) [19], the American Diabetes Association (ADA) [20] or the Canadian Diabetes Association (CDA). The lowest mean HbA1c level was found at 12 months in the non-admitted group (9.9 ± 1.4%) and was well above the recommended goals of the different organizations (ISPAD < 7.5% for all age groups; ADA < 8% for 6–12 y and < 7.5% for 13–19 y; CDA < 8% for 6–12 y and ≤ 7% for 13–18 y). Similarly, only a small proportion of patients in both group managed to obtain HbA1c levels less than 9% during

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Patient characteristics at baseline.</th>
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<tbody>
<tr>
<td></td>
<td>Admitted</td>
</tr>
<tr>
<td>n</td>
<td>30</td>
</tr>
<tr>
<td>Age (years)</td>
<td>14.9 ± 1.5</td>
</tr>
<tr>
<td>Baseline HbA1c (%)</td>
<td>12.2 ± 1.6</td>
</tr>
<tr>
<td>Male (%)</td>
<td>17 (57)</td>
</tr>
<tr>
<td>Non-Hispanic white (%)</td>
<td>21 (70.0)</td>
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<tr>
<td>Insulin regimen (%)</td>
<td></td>
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<tr>
<td>BID injections</td>
<td>10 (33.3)</td>
</tr>
<tr>
<td>MDI</td>
<td>20 (66.7)</td>
</tr>
<tr>
<td>CSII</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>Insulin dose (units/kg/day)</td>
<td>1.3 ± 0.4</td>
</tr>
<tr>
<td>Duration of TIDM (years)</td>
<td>6.4 ± 3.6</td>
</tr>
<tr>
<td>Duration of HbA1c ≥ 10% prior to baseline (months)</td>
<td>3.5 (3.0–49.0)</td>
</tr>
<tr>
<td>Average HbA1c in the year prior to baseline (HbA1c) (%)</td>
<td>10.8 ± 1.2</td>
</tr>
<tr>
<td>SES</td>
<td>Material Deprivation Index (centiles)</td>
</tr>
<tr>
<td>Social Deprivation Index (centiles)</td>
<td>26.0 (2–100)</td>
</tr>
<tr>
<td>Physician (%)</td>
<td></td>
</tr>
<tr>
<td>MD 1</td>
<td>3 (10.0)</td>
</tr>
<tr>
<td>MD 2</td>
<td>3 (10.0)</td>
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<tr>
<td>MD 3</td>
<td>6 (20.0)</td>
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<tr>
<td>MD 4</td>
<td>5 (16.7)</td>
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<tr>
<td>MD 5</td>
<td>5 (16.7)</td>
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<tr>
<td>MD 6</td>
<td>3 (10.0)</td>
</tr>
<tr>
<td>MD 7</td>
<td>5 (16.7)</td>
</tr>
</tbody>
</table>

Data are presented as means ± SD, as medians (min-max) or as n (%); HbA1c: haemoglobin A1c; MDI: multiple daily injections (TID or QID injections); CSII: continuous subcutaneous insulin infusion; TIDM: type 1 diabetes; SES: socioeconomic status.

between groups; hospitalized individuals having a higher HbA1c than non-admitted patients (admitted group: 10.9 ± 1.9%; non-admitted group: 9.9 ± 1.4%) (P = 0.016).

At 6 months, a similar proportion of patients had HbA1c levels less than 9% in both groups. Specifically, there were eight patients in the admitted group (26.7%) versus seven in the control group (23.3%) with HbA1c less than 9%. At 12 months, there

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Primary and secondary outcomes.</th>
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<tbody>
<tr>
<td></td>
<td>Admitted n = 30</td>
</tr>
<tr>
<td>Baseline HbA1c (%)</td>
<td>12.2 ± 1.6</td>
</tr>
<tr>
<td>Change at 12 months from baseline (%)</td>
<td>-1.3 ± 2.3</td>
</tr>
<tr>
<td>Change at 6 months from baseline (%)</td>
<td>-1.8 ± 2.3</td>
</tr>
<tr>
<td>HbA1c at 12 months (%)</td>
<td>10.9 ± 1.9</td>
</tr>
<tr>
<td>HbA1c at 6 months (%)</td>
<td>10.4 ± 2.1</td>
</tr>
</tbody>
</table>

All data are presented as means ± SD; CI: confidence interval; HbA1c: Haemoglobin A1c.

* Determined by paired t-test.
follow-up. This suggests that despite intensive inpatient or outpatient care, ideal glycaemic control as defined by world diabetes associations is still a challenge in adolescents with a past history of poor metabolic control. Furthermore, we found no association between outcomes at 6 and 12 months and the amount of follow-up care in both groups (i.e. number of phone calls, emails, fax and clinic visits in the year following the baseline HbA1c).

Our study population is composed of adolescents with major problems of treatment adherence and subsequent poor metabolic control. Some of these individuals were put on a more simplified insulin regimen (i.e. BID injections) prior to the study period in order to potentially increase treatment compliance. Therefore, the high percentage of adolescents on twice a day injections is specific to this group and does not reflect the usual care of patients in our clinic.

A recent study by Wei et al. [21] showed that adults with poorly controlled type 2 diabetes were less likely to achieve glycaemic targets 12 months after a hospital admission than non-admitted patients, implying that hospitalizations were missed opportunities to increase patients’ long-term metabolic control. However, these patients were admitted for a variety of issues and the focus during their stay might have been put on the management of their acute medical condition rather than on the management of diabetes. In our study, though with a different population, patients were hospitalized specifically for diabetes education. Nevertheless, they did not improve their glycaemic control compared to matched non-admitted patients despite more contacts being recorded in the database following their admission than for the non-admitted group. These results suggest furthermore that hospital admission might not be an appropriate mean to emphasize proper control of diabetes in poorly controlled individuals. We also analyzed different variables within the hospitalized group to try to identify specific subgroups of adolescents that might benefit more from elective hospitalization. Age, gender, duration of diabetes, duration of hospitalization, insulin regimen, ethnicity, and socioeconomic status did not differ between the quintile of patients with the greater reduction in HbA1c over 12 months versus the rest of the group of hospitalized adolescents. In addition, removing the sole patient with an admission of 1 day from the analyses did not alter our results.

While the focus of this study was on glycaemic control changes elicited by the admission, we had the possibility to look at other events that could have followed an admission for poor control, namely diabetic ketoacidosis rates or emergency visits; both of these were not found to be significantly different between the groups.

A number of limitations need to be considered. First, this was a retrospective study where the management of patients depended on physicians’ clinical judgment. Nevertheless, we did not see a significant difference between physicians. Secondly, psychosocial situations could not be thoroughly evaluated and compared between the two study groups. We did not see from our deprivation and social indexes statistically significant differences but it might be possible that pediatric endocrinologists at our centre made their decisions to admit patients based on familial and social difficulties. It is already known that multiple psychological and social factors affect glycaemic control of adolescents with type 1 diabetes [22]. No cost effectiveness analysis was conducted to assess the economic impact of both management strategies even though it appears likely that hospital admissions would be more costly than out-patient follow-ups considering previous studies. It may not be generalizable to all clinics, as the context in other clinics might be quite different in terms of available resources, opportunities to admit or not, and socioeconomic status. Finally, the study may not have been powered to detect smaller differences in the primary outcome. However, we chose not to carry out formal power calculations, given the retrospective cohort design and fixed sample size. Furthermore, we used the change in HbA1c at 12 months as our primary outcome. This approach minimizes the variability in the outcome between subjects and offers increased power than simply comparing HbA1c values at 12 months.

Our study presented several strengths. We explicitly defined the eligibility criteria used for selection of admitted and non-admitted patients. Furthermore, non-admitted patients were selected from the same source population as hospitalized patients. We addressed confounding in the design stage by matching for potentially important confounders (age and HbA1c values). Moreover, we measured other potential confounders that were not included in the initial matching process, due to the small number of available patients. These results suggested comparability between groups, since no clinically important potential imbalances were observed at baseline. Furthermore, to assess the effect of hospitalization on metabolic control, we used objective and specific outcomes, which were measured similarly in both groups and were not likely influenced by knowledge of admission status. Finally, our study looked at longer term impact of hospitalization as many interventions tend to have a short term impact which is not sustained. Follow-up at 12 months was long enough to observe a sustainable effect if one actually existed.

In conclusion, the study indicates that elective hospital admission for adolescents with poorly controlled type 1 diabetes is not, in our context, an effective strategy to improve HbA1c levels at 6 and 12 months. Furthermore, close outpatient follow-up could yield better mid term glycaemic control in the same population. Avoiding admission is likely more cost effective and is not dependent on hospital bed availability. A randomized controlled trial would be required to compare both strategies head to head.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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