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Age makes a difference: Symptoms in pediatric supraventricular tachycardia

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Abstract

Background: Supraventricular tachycardia is a group of rhythm disturbances that affect 1 in 300-1200 Australian children annually. The differentiation of supraventricular tachycardia (SVT) symptoms and age of onset according to their subtype is not well understood in the pediatric population. Most studies rely on ECG criteria only to characterize the subtype of the SVT, which is not applicable to all subtypes. The purpose of this study was to identify the symptoms and ages of onset of SVT subtypes, and to analyze whether ethnicity or severity correlated with the SVT subtype confirmed in an invasive Electrophysiology (EP) study.

Methods: A retrospective analysis and prospective survey evaluated 364 patients who underwent an EP study at The Royal Children's Hospital, Melbourne between 2009 and 2015. Age of onset, symptoms, and ethnicity were collected by phone survey or medical records in addition to EP study diagnostic data, medication status, and follow-up information about their symptom status following EP procedure. Patients were grouped according to their SVT subtype. Data analysis was performed using chi-squared, Fisher's exact, and ANOVA statistical tests to determine associations between SVT substrates.

Results: Two hundred and thirty-three suitable cases of SVT were identified (131 men, 102 women) aged between 0 and 18 years. Atrioventricular Reentrant Tachycardia (AVRT) (n = 153) was the most common SVT subtype, followed by Atrioventricular Nodal Reentrant Tachycardia (AVNRT) (n = 55), Atrial Tachycardia (AT) (n = 17), and other SVT subtypes (n = 8) which included Atrial Fibrillation, Atrial Flutter, and Junctional Tachycardia. There was a male predominance in all subtypes, except for AVNRT. AVNRT patients had palpitations, dyspnoea, dizziness, and anxiety more than any other group, AVRT patients complained of vomiting most and patients with AT had the most fatigue. The mean age of symptom onset varied among groups, being earlier in AVRT, later in AVNRT with a significant difference between AVRT with unidirectional retrograde accessory pathway (URAP) and AVNRT subtypes ($P < 0.01$).

Conclusion: Some specific symptoms were strong discriminators between different SVT subtypes. Ethnicity did not have strong correlations with SVT subtype incidence. This study was able to show clinical differences among children with SVT

due to AVRT (URAP) compared to AVNRT, allowing the prognosis and intended management of pediatric SVT to be anticipated by less invasive means.

KEYWORDS
age of onset, children, ethnicity, Supraventricular tachycardia, symptoms

1 | INTRODUCTION

Supraventricular tachycardia (SVT) is a group of rhythm disturbances which are relatively common within the pediatric population with an incidence of 1:250 to 1:1000 in otherwise healthy children.[1-5] With respect to the Australian population census in 2011, this incidence corresponds to approximately 5500-23 000 Australian children suffering from SVT, or 300-1200 per annum, making it a significant condition impacting on the Australian healthcare system.[6]

Electrophysiology (EP) studies are a diagnostic tool with therapeutic potential for clinicians investigating the etiology of a recorded SVT.[1] With electrophysiology, the clinician has the ability to map the electrical conduction system of the patient's heart and identify aberrant pathways that can be treated with radiofrequency (RF) or cryoablation techniques during the EP study. This technology has revolutionised the way in which clinicians can manage SVT in the pediatric population.

The symptoms of SVT in the pediatric population have previously been described[2,3,7]; however, correlation between specific symptomatology and SVT subtypes has not previously been studied extensively. Ko et al[8] have described the age of SVT symptom onset, but not the relationship between age and SVT subtype. Correlations between ethnicity and pediatric SVT incidence are yet to be conducted in Australia and have only been studied in overseas populations.[9,10] In this study, we focussed on a subtype-based analysis of symptoms, age of onset, and ethnicity with patients whose SVT diagnosis had been confirmed by EP study. SVT that is caused by either an Atrioventricular Reentrant Tachycardia (AVRT) with unidirectional retrograde accessory pathway (URAP) or an Atrioventricular Nodal Reentrant Tachycardia (AVNRT) is often indistinguishable on ECG, making the children diagnosed with these SVT subtypes of particular interest in this study. There are theoretical methods to differentiate AVNRT and AVRT (URAP); however, in practical terms, they are very difficult to use in children consistently. The rate of tachycardia in infants and children as well as the quality of ECGs while in tachycardia present challenges in detecting the subtle differences that can aid in differentiating between these substrates.

2 | METHODS

The Royal Children's Hospital, Melbourne is a tertiary pediatric referral center for children with arrhythmias living in Victoria, South Australia and Tasmania, conducting an average of 85 EP studies each year. A single-center retrospective data analysis of 419 pediatric EP studies occurring between 2009 and December 2015 were undertaken. We identified 364 individual patients, of whom 233 were suitable for analysis in this study, with patient demographics shown in Figure 1. Inclusion criteria were having SVT confirmed by EP study, being 18 years of age or less at the time of EP study and having a follow-up period of at least 3 months. Patients were excluded from the study if SVT was not induced at EP, if the reason for EP was not SVT or if there were underlying structural heart defects (see Figure S1). Nine patients were excluded from subgroup analysis as they had multiple SVT types identified at EP study and so could not be clearly categorized to a single SVT subtype. The classification of tachycardia and the indication for ablation were performed in accordance with the current guidelines for ablation in children.[11] Most patients underwent elective ablation due to breakthrough episodes or minor side effects on medication.

A prospective survey was conducted via phone by a single examiner using a standardized template. In nearly all cases, this was performed with the parent, as they tend to recall all events of their children better than the children themselves and are able to describe their observations as well as symptoms of their children. Medical records were reviewed to obtain patient epidemiology, symptoms experienced prior to EP study, and clinical condition following the procedure. The resolution of symptoms was surveyed on a scale from no improvement to very good. Medication status and EP study details were also recorded. Data analysis was undertaken using a SOFA statistics program version 1.4.6 and STATA version 14.1. Chi-squared and Fisher's exact tests were performed to analyze associations between symptoms and SVT subtypes, and ANOVA tests were used to determine the association of age of symptom onset among the different SVT subtypes. The P values for every combination of groups were performed and a 95% confidence interval was determined for the percentage difference in incidence between two groups when there was a significant result from initial analysis. A chi-squared goodness of fit test was used to compare participant ethnicity to Australian population census data. Statistical significance where $P < 0.05$ and $P < 0.01$ was annotated by * and **, respectively. Descriptive analysis of collected data was also performed. Ethics was approved through the Royal Children's Hospital board of ethics prior to the commencement of the study and informed consent was obtained.

3 | RESULTS

3.1 | Age of Symptom Onset

Symptoms of AVRT were present by a mean age of 6 years and 1 month (SD 5.1, CI 5.3-6.9), AVNRT by 9 years (SD 3.9, CI 8.0-10.0),

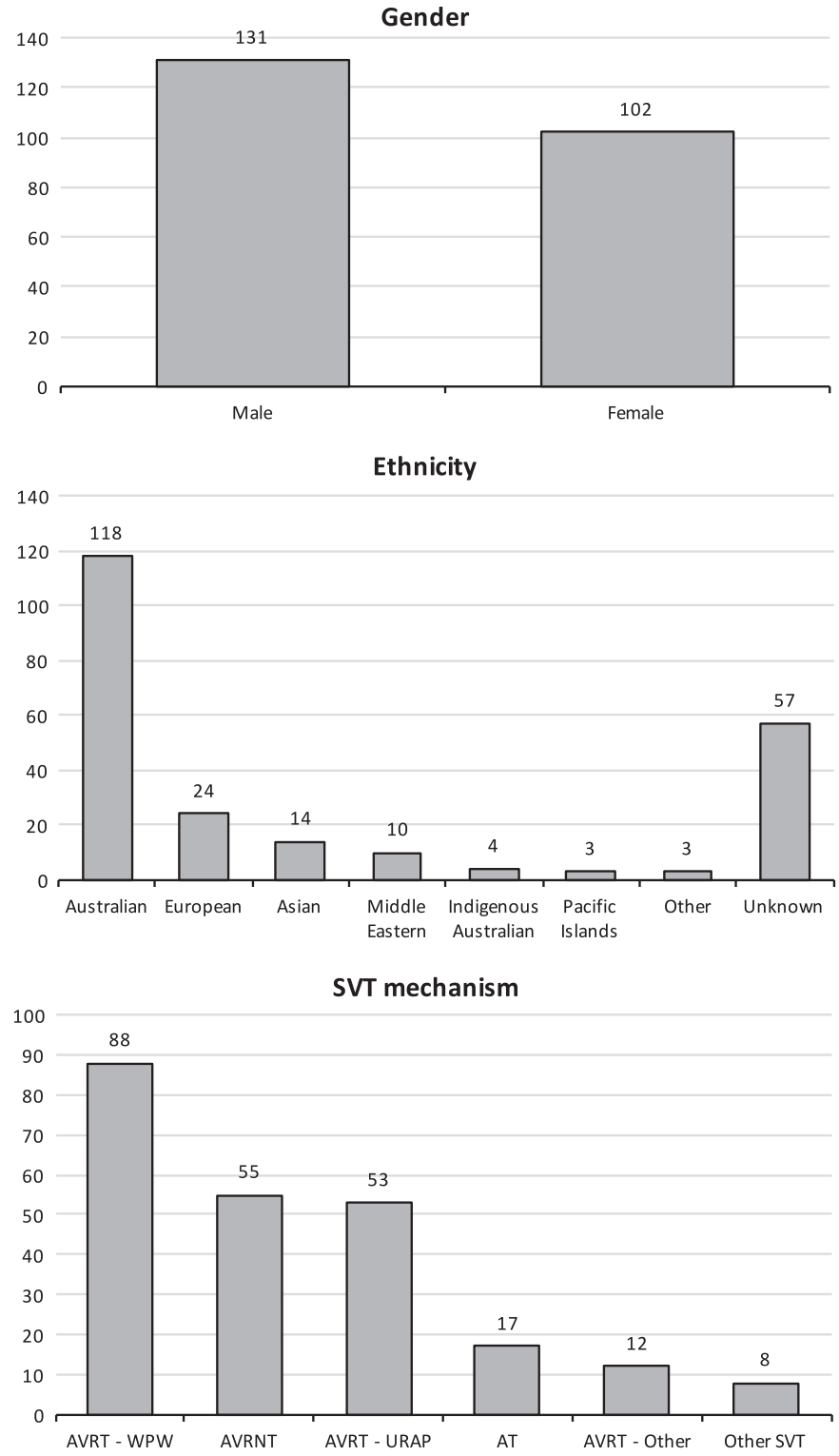

FIGURE 1 Patient demographics (n = 233) describing gender, ethnicity and SVT subtypes included in this study. Neonate 0 - 28 d; Infant 28 d - <1 y; Toddler 1 - <2 y; Pre-School 2 - <5 y; Primary School Age 5 - <10 y; Adolescent 10 - ≤18 y.[17] AT, atrial tachycardia; AVNRT, atrioventricular nodal-reentrant tachycardia; AVRT, atrioventricular reentrant tachycardia; WPW, Wolff-Parkinson-White; URAP, unidirectional retrograde accessory pathway

AT by 6 years and 8 months (SD 4.1, CI 4.9-8.8) and children with other SVT subtypes had symptoms by a mean age of 7 years and 8 months (SD 5.7, CI 3.6-12.0). There was a significant difference between the age of symptom onset between AVRT (URAP) (SD 5.2, CI 4.4-7.2) and AVNRT (SD 3.9, CI 8.0-10.0) subtypes ($P < 0.01$). The majority of patients had symptoms of SVT after the age of five

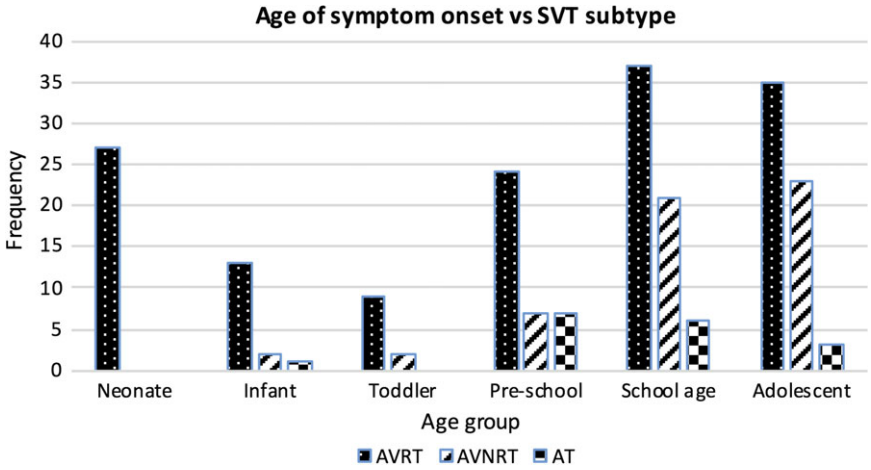

FIGURE 2 Histogram showing relative frequencies of age of symptom onset according to SVT subtype in children aged 0 to 18 (n = 217). For abbreviation and defenitions see Figure 1

TABLE 1 Probability of AVRT (URAP) vs AVNRT by age group

Age group	AVRT (URAP) patients (n = 53)	AVNRT patients(n = 55)	Total patients in the age group	Probability of AVRT (URAP) pathway	Probability of AVNRT pathway
Neonate	8	0	8	1.00	0.00
Infant	5	2	7	0.71	0.29
Toddler	8	2	10	0.80	0.20
Pre-School	7	7	14	0.50	0.50
School Age	12	21	33	0.36	0.64
Adolescent	13	23	36	0.36	0.64

Table 1 shows the probability of a child having SVT due to an AVRT (URAP) pathway or AVNRT according to a defined age group. Neonate 0 - 28 d, Infant 28 d - <1 y, Toddler 1 - <2 y, Preschool 2 - <5 y, Primary School Age 5 - <10 y, Adolescent 10 - ≤18 y.[17]

(63.4%) while 36.6% of patients reported symptoms before the age of five. A histogram representing the age of symptom onset is shown in Figure 2, with the probability of a child of a particular age having SVT due to either an AVRT (URAP) or an AVNRT shown in Table 1. The mean ages of symptom onset with centile ranges are represented in Figure 3. The 50th centile for age of symptom onset of AVRT was 5 years of age, AVNRT was 10 years of age, AT was 6 years of age, and other SVT subtypes was 9 years of age. The mean age at the time of the EP study was 11.5 years. The older a child was when they first presented with symptoms, the shorter the interval of time between symptom onset and age of first EP study, when compared to younger children.

3.2 | Symptoms

When analyzing for difference in symptoms by SVT type, patients were allocated to subgroups according to diagnosis at EP study. These subgroups were AT, AVNRT, AVRT, and other SVT. Further subgroup analysis of AVRT was performed, looking at baseline conduction properties, that is, antegrade conduction (Wolff-Parkinson-White pattern on ECG), unidirectional retrograde accessory pathways, and other pathways which included Persistent Junctional Reciprocating Tachycardia (PJRT) and atriofascicular conduction pathways. The frequency of symptoms experienced by children with a diagnosis of AVRT (URAP) compared to AVNRT is illustrated in Figure 4, with the percentage of children experiencing each symptom within the SVT subtype shown. AVNRT patients had palpitations, dyspnoea, dizziness, and anxiety more than any other group. Palpitations were most common in AVNRT compared to AVRT combined ($P < 0.01$), AT ($P < 0.01$), and other SVT subclasses ($P < 0.01$). Patients with AVRT complained of vomiting most, whereas patients with AT had the most fatigue. Among all types of SVT, there were no statistically significant differences between the incidence of diaphoresis, chest pain, syncope, pallor, or headaches in patients of any groups.

3.3 | Preliminary Diagnosis and Medication Status

When Wolff-Parkinson-White (WPW) pattern was recognized on ECG prior to EP study, 97.5% of patients were confirmed to have an antegrade conducting accessory pathway at EP study. AVRT (URAP) and AVNRT subtypes of SVT are difficult to accurately differentiate on ECG from one another and were diagnosed as re-entrant tachycardia or SVT in 98.1% of cases. Of the 233 included patients, 209 underwent ablation at EP study. Following ablation, 198 (94.7%) patients no longer required antiarrhythmic medication to control

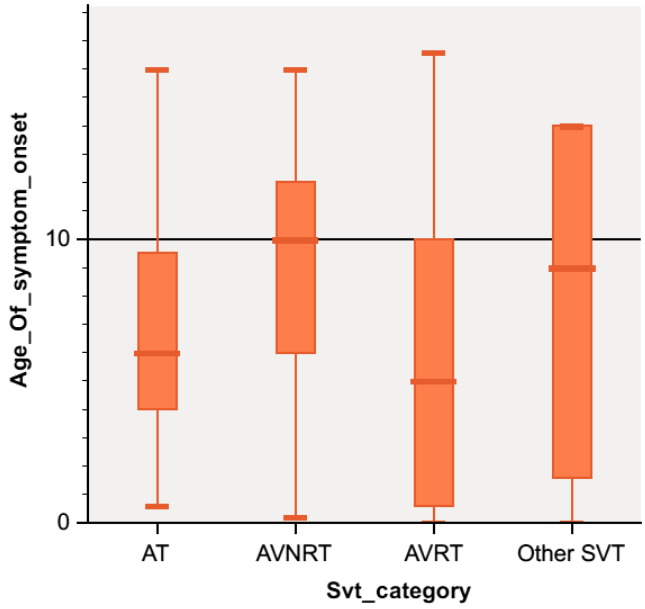

FIGURE 3 Age of symptom onset according to SVT subtype for patients aged between 0-18 y (n = 224). For abbreviation and defenitions see Figure 1

symptoms while 11 (5.3%) patients required antiarrhythmic medications to control symptoms of arrhythmia post ablation.

4 | DISCUSSION

Differentiating symptoms of distinct SVT mechanisms were identified among the children within this study, as well as differences in the age of onset of individual SVT subclasses. When analyzing the incidence of arrhythmias across the study population, there were no differences in the ethnicity of patients.

We found some symptoms that could differentiate patients clinically by SVT subtype. Literature published by Moak et al, Kantoch et al, and Schlechte et al has described the symptoms of pediatric SVT according to age group, although have yet to describe which symptoms are more common according to SVT subtype.[2,3,7] When analyzing symptoms that were significantly different in one group compared to all other groups, the presence of vomiting was the best discriminator for patients with SVT due to AVRT pathways although given the different age at presentation, we cannot exclude that vomiting may be an age-specific feature. Palpitations, dizziness, dyspnoea, and anxiety differentiated patients with AVNRT, while fatigue differentiated patients with AT from any other SVT subtype. Fatigue may be more common in AT due to its more subacute presentation. Andersen et al noted that palpitations were the most common reported symptom among patients of all SVT subtypes, similar to our findings. In our group, patients with AVNRT had significantly more palpitations reporting than other SVT subtypes.[12] We found that there was no significant difference between SVT subtypes for symptoms including diaphoresis, chest pain, syncope, pallor, and headaches. Clinically, reference to an observable symptom set, which could predict an SVT substrate prior to invasive testing, may assist clinicians in determining the urgency and prognosis of the SVT substrate their patient is presenting with.

The age of symptom onset differed among patients diagnosed with different SVT subtypes. Onset of symptoms of AVRT was present at a younger age on average and onset of AVNRT symptoms was present at an older age compared to other SVT subtypes, which are consistent with literature published by Ko et al, Anand et al, Porter et al, and Ludomirsky et al.[8,10,13,14] Children over the age of five were more likely to report symptoms rather than they be purely observed by a carer, reflecting their advancing age, and the development of expressive language.

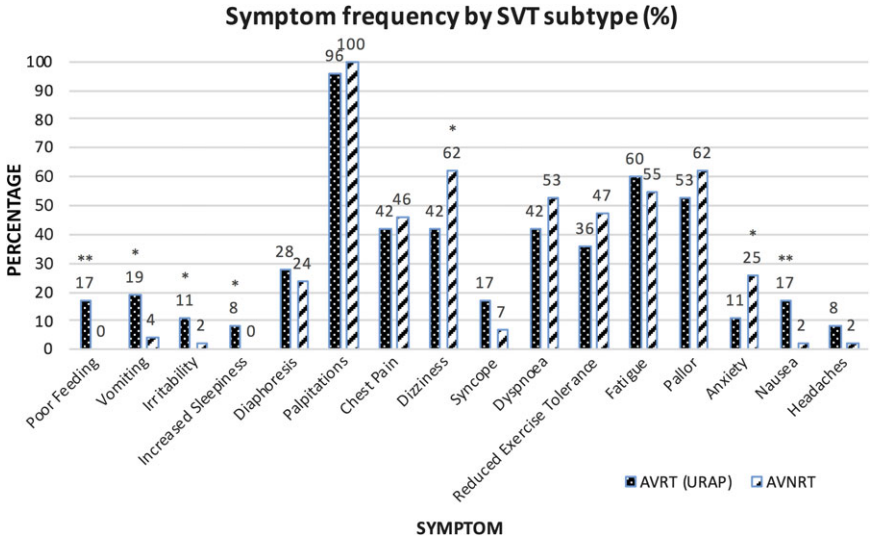

FIGURE 4 Symptoms experienced by patients aged 0-18 y with symptoms of SVT comparing AVRT concealed (URAP) with AVNRT pathway subtypes alone (n = 108). $P < 0.05$ * $P < 0.01$ **. For abbreviation and defenitions see Figure 1

When analyzing children with SVT symptoms by age in years, we found that the likelihood of a 5 year having AVNRT was 9% compared to AVRT, which was 82%. As previously found by Ko et al, AVNRT rarely appears before the age of 2 years and so our findings of fewer patients with poor feeding as a symptom of their SVT when AVNRT was the diagnosis were as expected.[8]

Comparing patients with AVRT (URAP) with AVNRT patients, there was a clear increase in the number of patients aged above 10 years with AVNRT, which was consistent with the findings of Reddy et al.[15] Our findings have allowed us to determine that the likelihood of a child aged between 10 and 12 years having AVNRT is 77% compared to 23% for having SVT caused by an AVRT (URAP) thereby excluding patients with pre-excitation. Similar to the study conducted by Ko et al, we were able to determine the probability of a child of any given age having SVT due to either an AVRT (URAP) or an AVNRT pathway.[8] Ko et al analyzed AVRT patients without subtype distinction, while we looked at AVRT (URAP) compared to AVNRT. Both our study and that conducted by Ko et al identified the age-related trend among AVRT and AVNRT; however, in addition, we were able to determine probabilities within a 1-year age interval, as well as grouped age intervals which were more clinically relevant, making our findings more age specific. Our findings that most patients were below the age of 16 when symptoms first occur are consistent with both Garson et al and Ko et al.[8,16]

There was a higher prevalence of males compared to females in all subtypes of SVT except AVNRT which is consistent with the current literature.[8,10] The ethnicity of participants differed from what was expected when compared to the Australian population, with an over-representation of patients from European, Middle Eastern, and Asian ethnic backgrounds enrolled in our study. Previous studies conducted in the USA had similar findings where the ethnicity of their SVT study participants differed from what was expected in the population.[9,10] This difference in ethnicity of our enrolled patients may relate to an unknown genetic predisposition to SVT among children of different ethnicities, or it may be due to differing cultural attitudes to intervention, and hence provided an ethnically biased patient population for analysis.

4.1 | Study Limitations

This study only included patients who had undergone an EP study and so cannot be generalized to the entire pediatric population who present with symptoms of SVT as only patients whose symptom burden warranted an invasive procedure were analyzed in this study. While this may be seen as a limitation, it is also a strength of our study as all of the children included have a definitive diagnosis of their SVT and so their symptoms are SVT subtype specific. The ethnicity of almost 25% of the patients included in this study was unknown as this information was not recorded in the medical record. Although there was no significant correlation found between ethnicity and SVT subtype, there may have been if there was complete data available for analysis.

5 | CONCLUSION

We found that children with AVRT reported symptoms of SVT on average 3 years earlier than children with AVNRT. Some specific symptoms were strong discriminators between different SVT subtypes. Ethnicity did not have strong correlations with SVT subtype incidence. This study was able to show clinical differences among children with SVT due to AVRT (URAP) compared to AVNRT, allowing the prognosis and intended management of pediatric SVT to be anticipated by less invasive means.

CONFLICT OF INTEREST

The authors have no conflicting interests and have not received financial or nonfinancial support to complete this study.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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