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ORIGINAL ARTICLE

Adequate health literacy is associated with adherence to continuous positive airway pressure in adults with obstructive sleep apnea

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Abstract

Study Objectives: Obstructive sleep apnea (OSA) is a chronic disease with significant health implications and adequate adherence to continuous positive airway pressure (CPAP) is essential for effective treatment. In many chronic diseases, health literacy has been found to predict treatment adherence and outcomes. In this study, the aim was to determine the health literacy of a sleep clinic population and evaluate the association between health literacy and CPAP adherence.

Methods: A prospective cohort study was undertaken, recruiting 104 consecutive patients with a variety of sleep diagnoses. The Short Form Rapid Estimate of Adult Literacy in Medicine (REALM-SF), a validated questionnaire, was administered to measure health literacy. In a sub-group of 91 patients prescribed CPAP for OSA, CPAP usage was measured, with adequate usage defined as greater than 4 h/night CPAP therapy.

Statement of Significance

Health literacy is a measurable factor that is defined as "The cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand and use information in ways which promote and maintain health" (Nutbeam D. Defining, measuring and improving health literacy. *Health Eval Promot*. 2015;42:450–456). To date, only two studies have evaluated the relationship between health literacy and continuous positive airway pressure (CPAP) adherence, despite a large body of evidence in other chronic diseases linking low health literacy to worse treatment adherence and disease outcomes. This study showed that low health literacy is associated with a twofold increased risk for inadequate CPAP usage. Health literacy may be an under-recognized and potentially modifiable factor for patients with OSA who require treatment with CPAP.

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Results: Seventy-one percent of the sleep clinic cohort was found to have adequate health literacy, as measured by the REALM-SF. In those prescribed CPAP for OSA, inadequate health literacy was associated with a twofold increased risk for inadequate CPAP usage (adjusted odds ratio [OR] 2.9, 95% CI: 1.1 to 8.22, $p = 0.045$). There was a 1.7 h/night difference in median CPAP usage comparing those with adequate to inadequate health literacy (4.6 h vs. 6.3 h/night).

Conclusions: The majority of this sleep disorders cohort had adequate health literacy as measured by the REALM-SF questionnaire. However, inadequate health literacy appears to be an independent predictor of treatment adherence and may represent a modifiable risk factor of poor treatment outcomes in OSA.

Key words: CPAP usage; CPAP adherence; CPAP compliance; health literacy; obstructive sleep apnea

Background

Obstructive sleep apnea (OSA) is a prevalent sleep disorder associated with significant health and financial implications [1, 2]. The treatment of choice for the majority of symptomatic OSA patients is continuous positive airway pressure (CPAP) [3]. The minimum duration of CPAP per night to achieve symptomatic improvements in day time sleepiness [4] and neurocognitive performance [5] is 4 h per night; however, in severe OSA, CPAP duration over 6.5 h per night is required to normalize obstructive events [6]. Adherence to CPAP therapy of more than 4 h a night remains low (ranging from 40% to 60% [7]). Of the patient demographic factors that predict adequate CPAP adherence, socioeconomic deprivation has been shown to predict poor usage [8]. In other chronic disease, socio-economic status (SES) and treatment adherence have been linked through the concept of health literacy [9].

The World Health Organization defines health literacy as "The cognitive and social skills which determine the motivation and ability of individuals to gain access to, understand and use information in ways which promote and maintain health" [10]. In the USA it is estimated that only a third of adults have basic health literacy [11] and similarly only approximately 40% of adult Australians have adequate health literacy sufficient to comprehend patient educational material [12]. Low individual health literacy is associated with higher rates of hospitalization and emergency care, as well as higher rates of adverse outcomes generally [13]. Several validated tools for assessing health literacy exist in the literature. Two commonly utilized questionnaires are the Short Test of Functional Health Literacy in Adults (takes 10 min to administer) and the Short Form Rapid Estimate of Adult Literacy in Medicine (REALM-SF; takes 3 min to administer) and have been validated across a variety of patient populations [14]. These tools are not disease specific, but rather correlated with literacy, numeracy and compression skills and thresholds below which individuals have difficulty with health educational material.

Few attempts have been made to utilize these tools to assess the level of health literacy amongst the OSA population, or to evaluate whether poor health literacy is a risk factor for OSA and/or a predictor of treatment adherence. Li *et al.* [15] evaluated men aged over 40 years in an Australian chronic disease screening cohort, and found adequate health literacy amongst 75.3% of previously diagnosed and 68% previously undiagnosed OSA. The authors do note, however, that the cohort was better educated and reported better health than the general population. Thus, the results may not be representative of a general sleep clinic population. Adherence to therapy in other chronic diseases such as HIV, asthma, and diabetes has been strongly linked to an individual's level of health literacy [16]. The relationship between CPAP adherence and health literacy has been evaluated in only two trials, in which health literacy was a secondary outcome; one found a nonsignificant trend toward poor adherence with low health literacy, and the other found no significant relationship [8, 17]. The present study aimed to measure health literacy in a cohort of incident and prevalent patients treated in a tertiary hospital sleep clinic. We hypothesized that the proportion of patients with adequate health literacy in a sleep clinic population would be lower than the 75% previously described nonclinical population. A secondary aim of this study was to evaluate the association between health literacy and CPAP adherence, independent of SES.

METHODS

Study participants

Following approval of Metro South Human Research and Ethics Committee (HREC 2018/QPAH/98), participants were recruited from a public sleep disorders outpatient clinic in Brisbane, Australia over a 4-month period, 2018–2019. Inclusion criteria included age ≥18 years, no past medical history consistent with cognitive impairment and any sleep diagnosis was permitted. All incident and prevalent patients of the service were approached to participate. Exclusion criteria were age less than 18 years, those unable to provide informed consent and inability to read or write in English. Demographic data, anthropomorphic, years of education, socioeconomic decile (index of relative socio-economic advantage and disadvantage, index of economic resources (IER) and index of education and occupation (IEO) [18]) were recorded. The three measures of SES recorded, capture varied aspects of relative advantage and/or disadvantage from post code census data. The "index of relative socio-economic advantage and disadvantage" (IRSAD) is a composite calculated from a locations proportion of residents with low-income, labor intensive jobs, disability or chronic disease, one parent families, rent under $AUD215 per week and unemployed status [18]. Lower IRSAD decile indicates greater disadvantage and lack of advantage. IER incorporates financial measures of SES and is calculated as a composite of factors such as proportion of high versus low-income households and rent versus home ownership [18]. IEO reflects educational level of a local community and occupational advantage [18].

The CONSORT statement of patient recruitment is shown in Figure 1, indicating the number of "eligible and recruited," "potentially eligible but not assessed," "ineligible," and patients whom specifically "declined recruitment," as there were a number of patients eligible but not screened due to clinical workload.

OSA was defined as per American Association of Sleep Medicine testing criteria [19] and all other sleep diagnosis

according to Sleep Physician assessment using the ICSD-3 definitions [20].

Health literacy assessment

Health literacy was assessed using the REALM-SF, which involves the patient reading and pronouncing seven English medical words arranged in ascending order of difficulty. Points are given for correctly pronounced words within a 3-minute timeframe. Correct responses of 4–6 words correspond to a seventh to eighth grade reading level, 1–3 words correspond to fourth to sixth grade level, and a score of 0 indicates literacy of third grade and below [5]. Inadequate health literacy was defined as an REALM-SF score less than or equal to 6 [21]. The primary endpoint of the study was the proportion of patients with REALM-SF > 6. Staff administering the REALM-SF assessment were blinded to the sleep and socioeconomic outcomes of the patients they were assessing. Clinicians treating the sleep disorders were blinded to the REALM-SF outcome.

CPAP adherence in OSA subgroup

In patients with OSA on CPAP, a prespecified subgroup analysis was planned to evaluate therapy usage as a secondary outcome measure. Objective CPAP usage was downloaded from the CPAP device and recorded as mean hours of usage per day. For incident patients, CPAP usage was determined at the next clinic follow up, which was at the 2-month post REALM-SF assessment visit. For prevalent CPAP patients, usage was obtained from download of the machine on the same day health literacy assessment. All patients commencing CPAP therapy had in-laboratory education from sleep scientific staff at the time of CPAP titration study. This includes a standard two-page educational brochure that explains the rational for CPAP therapy and troubleshooting. Adequate CPAP usage was defined as ≥4 h/night adequate usage, and <4 h/night inadequate.

Statistical analysis

Sample size of 120 participants was estimated based on our centers known average usage of 5.6 h (±2) to observe a 1-hour difference in CPAP assuming power of 80%. However, due to clinic workload requirements during the study window, only 107 participants could be recruited; missing data from three eligible participants were excluded from the analysis. Normality was assessed using the Shapiro-Wilks test. For categorical variables, Pearson's chi-square or Fisher's exact test was performed. Non-normally distributed data were compared with Mann–Whitney U-test and Kruskal–Wallis. Linear regression analysis was performed to investigate risk factors predefined of interest for adequate CPAP adherence (age, sex, SES, Epworth Sleepiness Scale, OSA severity).

To assess whether recruitment bias was present, a gap analysis was performed on the demographic data of clinic attendees that were not included in the study, but whom would have otherwise met the enrolment criteria for the study. Comparisons were made with *t*-test, Mann–Whitney U or Kruskal–Wallis tests where appropriate. Analysis was performed using R version 4.02.2 (2020-06-22). A $p < 0.05$ was considered statistically significant.

RESULTS

Two hundred and one patients met the eligibility criteria and full a complete data set was available for 104 participants. Ninety-one of these patients were recommended for CPAP therapy. Demographics of the cohort are shown in Table 1. The cohort had an almost equal proportion of men and women who predominantly had severe OSA; only three had no sleep disorder breathing. Comparisons were made between eligible patients who were and were not enrolled, as shown in Supplement Table S1. There were no significant differences between these groups according to age, sex, education levels, or socioeconomic factors. There was, however, a trend towards more university-educated patients in the sampled population compared with un-sampled.

Health literacy

Health literacy as measured by REALM-SF was found to be adequate in 71 (71%) of patients. Higher REALM-SF health literacy was associated with increased years of education (β 0.36, 95% CI: 0.11 to 0.61, $p = 0.05$) and higher SES postcode-decile (β 0.49, 95% CI: 0.15 to 0.83, $p = 0.005$). In this cohort, adequate health literacy was more common in women ($p = 0.05$), shown in Table 2. There was no significant difference in adequate health literacy between incident (74%) and prevalence (67%) CPAP users, $p = 0.49$.

CPAP adherence

Patients with inadequate health literacy had significantly reduced CPAP usage (4.6 h per night, IQR 0.4–7.0), compared to patients with adequate health literacy (6.3 h per night, IQR 4.3–7.6) $p = 0.02$, shown in Figure 2 and Table 3; unadjusted OR 3.03 (95%

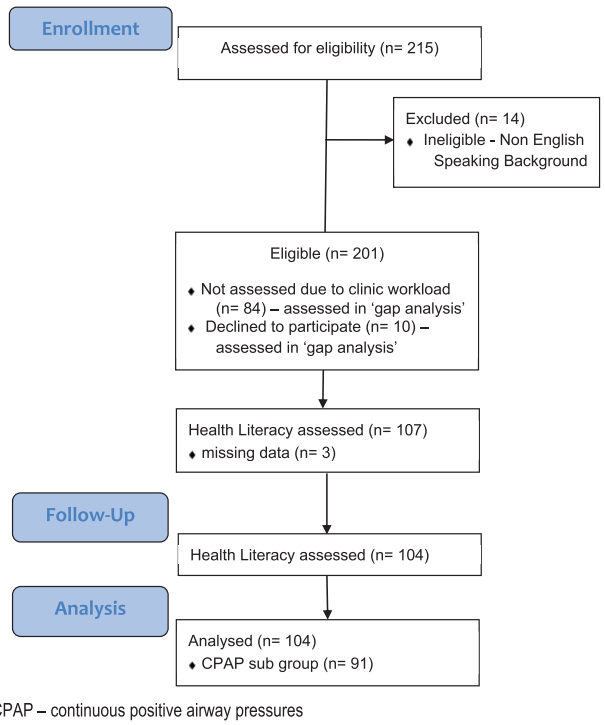

Figure 1. CONSORT statement of included participants.

CI: 1.17 to 7.8, p = 0.03). Overall, CPAP usage was 6 h per night (IQR 3.22–7.37), with 75/91 (82%) of those patients prescribed CPAP therapy, taking up the treatment. Women did have significantly higher median CPAP usage 6.5 h (IQR 5.21–7.5) compared with men 4.46 h (IQR 0.62–6.9) p = 0.01 (see Supplementary Table S2 for more details). Women did not have significantly higher education, socioeconomic decile and were of similar age to the men prescribed CPAP; however, the women in this cohort had a trend toward worse symptoms (Epworth Sleepiness Scale 10 for women and 8 for men p = 0.05). Incident users of CPAP had lower adherence compared with prevalent users (median CPAP usage 4.4 h IQR 3.1–5.34 vs. 6.3 h IQR 4.9–6.6, p = 0.039). There was a nonsignificant trend toward improved CPAP uptake in those with adequate health literacy (57/64 or 89% patients with adequate health literacy commenced CPAP and 20/27 or 74% with inadequate commenced CPAP p = 0.07).

Adjusting for sex, incident/prevalence, and Epworth Sleepiness Scale, inadequate health literacy was still significantly associated with a twofold increased risk for inadequate CPAP usage (OR 2.9, 95% CI: 1.1 to 8.22, p = 0.04). CPAP adherence was not significantly associated with age, Epworth Sleepiness Scale, Respiratory Disturbance Index, years of education, or socioeconomic decile (see Supplementary Table S3 for further details). Female sex was neither a significant mediator (a_1 = 0.19, b_1 = 0.35, c' = 1.67, 95% CI: −0.14 to 0.47), nor moderator (p = 0.42) of the relationship between health literacy and CPAP adherence.

Discussion

In this study, health literacy was measured with the REALM-SF questionnaire in a sleep clinic population at a tertiary public hospital and 71% were found to have adequate health literacy. Of those 91 patients prescribed CPAP therapy, adherence to CPAP was 1.7 h per night greater in those with adequate health literacy, compared to those with inadequate health literacy. This study has found that inadequate health literacy puts patients with OSA at a more than twofold risk of inadequate CPAP usage.

The data surrounding CPAP adherence and baseline disease and patient demographics in the literature are inconsistent. Comparable with other series, CPAP adherence in this cohort was not associated with Apnea Hypopnea Index, Epworth Sleepiness Scale, socioeconomic factors, nor years of education. Sex was a significant influence on our cohort on adherence, with females 3.5 times more likely to have CPAP usage > 4 h per night than men. This difference in CPAP usage in this cohort aberrant compared to many other series [22, 23] and is not explained by common confounders (age, SES, years of education), however may be explained by higher Epworth Sleepiness Scale in the females of this cohort, compared with men. Epworth Sleepiness Scale consistently is a predictor for adherence, with baseline severe symptoms and large improvements in sleepiness in the first months predicting long term response [22]. In our cohort, there was a large variance in Epworth Sleepiness Scale and inadequate sample size is the likely explanation for this difference compared with larger previously published series. This cohort had high CPAP long-term usage compared with many other published series; however the data are in keeping with the 10-year average CPAP usage from the clinic [24, 25]. The in-laboratory CPAP educational and on-call troubleshooting program may be an explanation for this. Socioeconomic factors as measured by three SES measures were not associated with differences in CPAP usage in this cohort. This is contrasting from findings by Bakker *et al.* [8] in which SES was significantly associated with CPAP adherence and 20% of the variance of CPAP adherence was found to be due to low SES and lower education. Possible explanation for this difference may be the Bakker *et al.* [8] cohort drew from a high proportion First Nations Māori population with unique sociocultural environments.

Psychological factors are more consistently predictive of CPAP adherence in the literature—those individuals with high perceived functional limitation from OSA sleepiness and high self-efficacy to problem solve side effects are likely to adhere to CPAP [26]. Health literacy and self-efficacy appear to be interconnected; health literacy is likely to facilitate the motivation and capacity within the individual to obtain health information, and self-efficacy is likely to facilitate the ability to organize and implement health-promoting activities. Health literacy is thought to be the mediator between disadvantage and poor health outcomes in other chronic disease such as diabetes, however, represents a potentially modifiable risk factor [27]. Health literacy in the current study was higher in women compared to men, this is in keeping with previous national data in this age range [28].

Obtaining a diagnosis of OSA starts with navigating diagnostic testing which may exclude low health literacy patients, due to the complexity of study requirements, particularly in home-based programs. Then, navigating the common complications of CPAP such as mask fit, nasal congestion, aerophagia and

Table 1. Patient demographics

	N	(%)
Number	104	
Males, *n* (%)	50	(48%)
Age, years	59	±14
Body mass index, kg/m^2	38	(32–44)
Years of education, *n* (%)		
Grade 10 or below	38	(36.5%)
Grade 12	7	(6.7%)
Certificate/apprenticeship	40	(38.5%)
University	19	(18.3%)
SES decile by postcode	5	(3–8)
SES decile by resource	5	(3–8)
SES decile by occupation	4	(2–7)
Country of birth, *n* (%)		
Australia	85	(81%)
New Zealand	7	(7%)
UK	4	(4%)
Other	8	(8%)
Epworth Sleepiness Scale	8	(4–13)
RDI, events/hour	27	(16-60)
Sleep diagnosis, *n* (%)		
Mild OSA	21	(20%)
Moderate OSA	28	(27%)
Severe OSA	49	(47%)
Other/ no sleep disorder	6	(6%)
CPAP usage hours	6.0	(3.2–7.4)
CPAP usage > 4 h, *n* (%)	63	(61%)
REALM-SF > 6, *n* (%)	74	(71.2%)

Data are presented as number (percent), mean ± standard deviation or median (interquartile range) where appropriate.
SES, socio-economic status; RDI, respiratory disturbance index; UK, United Kingdom; OSA, obstructive sleep apnea; CPAP, continuous positive airway pressure; REALM-SF, Short Form Rapid Estimate of Adult Literacy in Medicine.

dry mouth [29] often require problem-solving skills with written information in complex device manuals. Furthermore, the majority of sleep unit informational hand-outs are in written form, which is potentially problematic for individuals with low literacy. The higher rates of adequate health literacy seen in this study and Li *et al*. [15] compared with other chronic disease may reflect referral bias, as barriers to sleep disorders services may exclude low health literacy patients from being represented in these sampled populations [15]. It is of concern that nearly 30% of patients were assessed as having low health literacy, which is likely to limit their ability to successfully implement and adhere to recommended OSA treatment.

Behavioral interventions have the strongest evidence in improving CPAP adherence [30]. However, these interventions are labor intensive, with the majority of the interventions reviewed in a recent Cochrane review requiring greater than 2 h of clinician time. Educational interventions to improve CPAP adherence have been shown to improve CPAP adherence, with a mean difference of +0.85 h, however, the quality of evidence is low [30], with a number of the studies demonstrating equivocal results with wide confidence intervals. None of the educational studies have been specifically designed for patients with inadequate health literacy, which may be a factor in the equivocal outcomes. This study points to health literacy as a factor that needs consideration when developing educational approaches to enhance CPAP adherence; clinicians need to incorporate communication strategies specifically designed to address the needs of individuals with low health literacy. From other chronic disease literature, there is evidence that screening for low health literacy, alters clinician's communication style, and increases the likelihood of using pictures, diagrams, and involving family members [31]. Plain language initiative encourages communicators to know the literacy level of their audience, screen for baseline knowledge and increase the use of visuals and videos [32].

Strengths of this study include the prospective design, and the blinding of health literacy assessors and clinicians. The REALM-SF is a well-validated and quick-to-administer measurement of health literacy, taking under 3 min to administer. The test-retest reliability coefficient is 0.99, an interrater reliability of 0.99 and high construct validity, with strong correlations with other measures of literacy [33]. It has been validated in populations similar to the demographics seen in the current study, and is faster to administer than alternatives such as TOFHLA [33]. However, the weaknesses of this measure include potential racial bias, no assessment of numerical literacy, it is not specific for sleep disorders knowledge, nor does it test comprehension [33]. The REALM-SF is not a based on a conceptual framework of health literacy and was developed from literacy measures. Other weaknesses of the current study include the lack of inclusion of 94 patients, who were not assessed but would have been eligible. The gap analysis performed is at least reassuring, as there were no significant demographic differences between the sampled and unsampled-eligible populations. The study is not randomized, however, there was blinding of health literacy assessors from those assessing CPAP adherences. While common confounders such as disease severity, SES, and age were considered, marital status and ethnicity were not and those with self-identified insufficient English language skills were excluded. Three patients out of 107 were not included in the analysis due to missing data, which is a potential weakness of the analysis.

Given the findings of this study, clinicians and sleep services should consider health literacy as a flag for vulnerable individuals

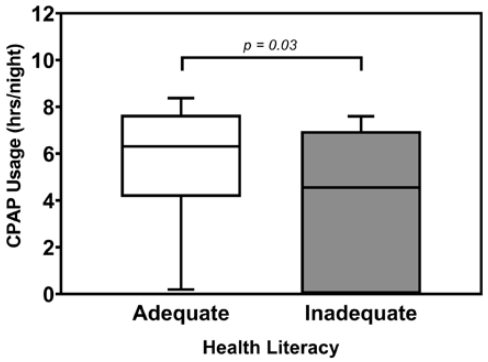

Figure 2. Unadjusted CPAP usage (hours) by health literacy status.

Table 2. Demographics according to level of health literacy (N = 104)

	REALM-SF > 6	REALM-SF ≤ 6	P
Number	74 (71%)	30 (29%)	
Male	31	19	0.05*
Female	43	11	
Age, years	59±13	57±16	0.55
Body mass index, kg/m^2	38 (33–44)	39 (30–44)	0.98
Years of education			
Grade 10 or below	25	13	0.03*
Grade 12	3	4	
Certificate/apprenticeship	28	12	
University	18	1	
Epworth sleepiness scale	8 (4–14)	9 (6.7–12)	0.95
RDI, events/hour	27 (14–61)	37 (15–57)	0.82
SES decile by postcode	6 (3–8)	3 (2–7)	0.02*
SES decile by resource	5.5 (3.75–8)	4 (3–7.25)	0.13
SES decile by occupation decile	5 (2–7.25)	2 (1–4)	0.01*

Data are presented as number, mean ± standard deviation or median (interquartile range) where appropriate.
RDI, respiratory disturbance index; SES, socio-economic status; REALM-SF, Short Form Rapid Estimate of Adult Literacy in Medicine.
*P < 0.05.

Table 3. Health literacy and CPAP outcomes (N = 91)

	REALM-SF > 6	REALM-SF ≤ 6	P
Number	64 (70%)	27 (30%)	
Male	26	16	0.11
Female	38	11	
Age, years	60±12	57±17	0.33
Body Mass Index, kg/m^2	38 (33.75–45)	39 (32–47)	0.95
Epworth sleepiness scale	8.5 (4–14)	8 (7–12)	0.78
RDI, events/hour	30 (17–69)	40 (19–59)	0.68
CPAP usage hours	6.3 (4.3–7.6)	4.6 (0.4–7.0)	0.02*
CPAP usage ≥ 4 h/night	49	14	0.04*
SES decile by postcode	6 (3–8)	3 (2-6)	0.1
SES decile by resource	6 (4–8)	3 (3-7)	0.13
SES decile by occupation	5 (2–7)	2 (1.5-4)	0.01*

Data are presented as either number, mean ± standard deviation or median (interquartile range) where appropriate.
RDI, respiratory disturbance index; SES, socio-economic status; REALM-SF, Short Form Rapid Estimate of Adult Literacy in Medicine.
*P < 0.05.

early in a patient's journey from primary care to CPAP therapy initiation. Primary care should consider being more aware that individuals with poor health literacy may be less likely to engage with sleep service initially and have higher rates of clinic nonattendance. Sleep service may need to target interventions at this more vulnerable population. Moving forward, educational interventions should consider communication techniques for people with inadequate health literacy, to ensure this vulnerable group has maximal opportunity to engage with OSA treatment to improve their health outcomes.

CONCLUSION

Health literacy was adequate in the majority sleep clinic patients in this cohort. In those prescribed CPAP for OSA, poor health literacy was significantly associated with reduced CPAP adherence, independent of age, sex, SES, and years of education. As delivery of sleep medicine moves further into to a direct to consumer or primary care model, screening for health literacy is even more important to ensure that patients with low health literacy are identified, and that appropriate educational and communication strategies are used to enhance treatment adherence.

Supplementary Material

Supplementary material is available at *SLEEP Advances* online.

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Disclosure Statement

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