Original Article

Relationship between Corneal Biomechanical Properties among Pregnant Women in a Tertiary Hospital in Nigeria

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Abstract

Objective: In Nigeria, many pregnant women as well as health-care providers are unaware of the effect of pregnancy on the eye. The present study investigated the changes in central corneal thickness (CCT), corneal sensitivity (CS), and intraocular pressure (IOP) among pregnant women in a tertiary hospital in Nigeria and the relationship between them. **Materials and Methods:** A prospective longitudinal study was used. One hundred and thirty-four pregnant women attending the Obstetric Clinic of the University of Nigeria Teaching Hospital, Enugu, were consecutively recruited in their second trimester for the study. Changes in CCT, CS, and IOP were monitored at the second and third trimesters and 6-week postpartum. Data obtained were analyzed using Statistical Package for the Social Sciences version 20. The effect of duration of pregnancy on these variables was determined using simple linear regression and further analysis was done using Bonferroni's *post hoc* test. **Results:** The women were aged 18–48 years, with a mean age of 30.81(±5.49) years and majority of them (61.2%) were multigravida. The duration of pregnancy varied inversely and significantly with CS ($P < 0.05$) and IOP ($P < 0.000$) with the least values recorded in the third trimester, while it varied directly and also significantly with CCT ($P < 0.000$) with the highest value obtained in the third trimester. A negative correlation that was significant only in third trimester was found between CCT and IOP ($P < 0.02$) and CS ($P < 0.03$).
Conclusion: There was a progressive increase in CCT with a corresponding decrease in CS and IOP across the trimesters of pregnancy, but these changes reversed 6-week postpartum.

Keywords: *Central corneal thickness, cornea sensitivity, intraocular pressure, pregnancy*

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Introduction

The interplay between hormonal, metabolic, hemodynamic, vascular, and immunological factors invariably affects the ocular system during pregnancy and causes changes which may be more commonly transient but occasionally permanent.[1] Their effects could be mild enough to be overlooked or severe enough to cause distress during the stages of pregnancy.[2] Hormonal changes are among the most prominent systemic changes in pregnancy.[3] The immune system is suppressed, leaving the pregnant woman more susceptible to serious immunological disorders.[3] The ocular changes during pregnancy could be classified as physiological, pathological (associated with the development of new ocular conditions), or modification of preexisting ocular conditions.[1] Physiological changes reported during pregnancy include reduced corneal sensitivity (CS),[4] increase in corneal curvature, most often linked to contact lens intolerance as well as tear film instability,[5] and decreased or transient loss of accommodation. Others include reduced intraocular

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pressure (IOP) in women with normal eyes and those with ocular hypertension.[6]

In Nigeria, there is a paucity of information on ocular changes during pregnancy; this lack of awareness exists even among health-care providers. The present study investigated some physiological changes in the eye such as central corneal thickness (CCT), CS and IOP, and the relationship between them during pregnancy. Since some of these physiological changes reverse after delivery, knowledge of their existence and nature will help avoid unnecessary treatment and allay anxiety.

Materials and Methods

The study adopted a prospective longitudinal design. Pregnant women attending the Obstetric Clinic of University of Nigeria Teaching Hospital, Ituku-Ozalla, Enugu, were recruited for the study.

Inclusion criteria

Normal pregnant women with no ocular pathologies in their second trimesters of pregnancy with known last menstrual period (LMP), confirmed with ultrasound scan, who voluntarily give their consent to be part of the study. The Second trimester was chosen because in a pilot study carried out in a secondary health-care facility in Enugu metropolis that lasted for 3 months, only one pregnant woman presented in her first trimester, the rest presented in second trimester. The study was also extended to 6-week postpartum when all physiological changes are expected to resolve, thus they acted as their own control.

Exclusion criteria

Patients with systemic comorbidities such as diabetes and hypertension, those with ocular pathologies such as glaucoma and past ocular surgeries such as glaucoma surgeries and cornea refractive surgeries, those using any topical medications 3 months before recruitment, and those refused to give their consent were excluded from the study.

Sample size determination

The minimum sample size was calculated using the method of comparison of 2 means described by Kirkwood and Sterne.[7]

$$\frac{(u+v)^2\left(\sigma^2_1+\sigma^2_0\right)}{(\mu_1-\mu_0)^2}$$

u = one-sided percentage point of the normal distribution corresponding to 100% – the power, e.g., if power = 90%, u = 1.28.

v = percentage point of the normal distribution corresponding to the (two-sided) significance level, e.g., if significance level = 5%, v = 1.96.

$\mu_1-\mu_0$ = difference between 2 means in a previous study.[8]

σ_1, σ_0 = standard deviations (σ_1-SD for mean 1, σ_0-SD for mean 0).

$$\frac{(u+v)^2\left(\sigma^2_1+\sigma^2_0\right)}{(\mu_1-\mu_0)^2}=\frac{(1.28+1.96)^2\times\left(2.08^2+2.07^2\right)}{(12.42-13.31)^2}$$

$$=\frac{(3.24)^2\times(4.32+4.28)}{(-0.89)^2}$$

$$=\frac{10.5\times 8.6}{0.792}$$

$$=114$$

Ten percent of this number shall be added in case of attrition, thus giving a total of 127 pregnant women.

A total of 134 pregnant women were recruited and followed up to 6 weeks after delivery when physiological changes in pregnancy must have reverted to the normal prepregnancy state. Past medical and ocular history, family, and social history were obtained using interviewer-administered questionnaire and review of systems were also carried out. The gestational age was assessed from the LMP and verified using ultrasound. An informal approach within the privacy of an examination room to encourage full participation without embarrassment of the participant was adopted. A general examination of the participants was carried out to detect comorbidities. Ocular examination such as visual acuity (VA), pen torch, slit lamp, and posterior segment examinations was carried out to rule out ocular pathologies.

Visual acuity assessment

Unaided VA was measured for the right eye, and then, the left eye in that order using the Snellen's chart and tumbling Ɛ chart at 6 m in a well-illuminated room. This was followed with a pinhole test in those with VA <6/9. The near VA was carried out on each participant using LogMAR near acuity chart at a distance of 40 cm. The VA was retested with the participant's existing refraction where applicable and all obtained data recorded. If the participant read all the letters in a row of the acuity chart, that line was taken as the actual VA. This procedure was carried out at each of the three visits.

Pen torch examination

A pen torch was shone into the participant's eye from arm's length. The pupillary reaction was observed using the swinging-flashlight test. The head loupe was used for further examination where necessary.

Slit-lamp examination

A slit-lamp examination in a dimly lit room was used to examine the cornea, anterior chamber for flares, cells, anterior chamber depth, and iris.

This was done by varying illumination techniques to get a general view of the anterior segment and adnexa (diffuse illumination). Conjunctival vessels were clearly observed (direct illumination), anterior chamber (conical beam), and iris (retroillumination).

Researcher and research assistant carried out a careful assessment of the anterior segment and adnexa.

Posterior segment examination

This was carried out by the researcher using the direct ophthalmoscopes. A dilated fundoscopy was done. The eye was dilated by instilling dilating drops in the conjunctival sac with an interval of 5 min, and after 30 min, the eye was observed with a pen torch to ascertain dilatation. The slit-lamp beam was adjusted to a width of about ¼ of its full round diameter and the illumination set at an angle coaxial with the slit-lamp viewing system. The magnification and light intensity were adjusted to the lowest setting and the light beam centered to pass directly through the pupil. Magnification was increased where necessary. The examination was carried out in both the eyes, one at a time.

Patients with no ocular comorbidities were now subjected to the following tests of biomechanical properties.

Pachymetry

CCT was measured by the researcher using the Reichert Ipac pachymeter. The participant was properly sited and given a target. The pachymeter was advanced toward the central cornea. It was held at that position for a few seconds till a beep was heard. The test was repeated three times. The average was recorded as the value. This test was done at the three visits.

Corneal sensitivity

This was tested using the Cochet–Bonnet esthesiometer. The participant was given a target. This test was done before the application of any anesthesia. The filament was extended to its full length (60 mm) and retracted incrementally by 5 mm steps until participant was able to feel its contact. The test was repeated in 4 quadrants and the fellow cornea compared. Results were recorded at each visit. The mean filament length from three stimulus applications that produced a positive response from the participant was considered to be the CS threshold.

Intraocular pressure

This was taken with the Perkins handheld tonometer (MK2). IOP s were taken at a particular time range (8–11 am) to avoid diurnal variation errors in IOP. The eye was anesthetized. Fluorescein strip was placed in the conjunctival sac. After few seconds, it was removed. The Perkins was held so that the thumb rested on the milled wheel controlling the spring. The light was switched on by turning the thumb wheel. The forehead rest was rightly positioned. Tonometer was held obliquely with handle away from the nose. The scale was set at one. Prism cone was placed on cornea without touching the eyelid. The semicircles were viewed and adjusted through the viewing lens until the inner margins coincide. Reading was noted and multiplied by ten. Reading was taken three times and an average taken. The test was repeated on the other eye.

Statistical analysis

The data were collected, cleaned, coded, and presented as means ± SD and analyzed using statistical package for the social sciences version 20 (IBM, USA). A simple linear regression analysis was used to determine the influence of the duration of pregnancy on the corneal biomechanical properties (CCT, CS, and IOP) and also the relationship between these parameters. Further analysis was done using Bonferroni's *post hoc* test. $P < 0.05$ was considered statistically significant.

Results

The participants were aged 18–35 years and majority of them had tertiary education. The distribution of the participants according to their sociodemographic and clinical characteristics is shown in Table 1.

The majority of the participants were not aware that pregnancy has any effect on the eye. Those who were aware (n = 35) got their information mainly from ophthalmologist 16 (45.7%), internet 7 (20%), and nurses and health workers 5 (14.3%) [Figure 1].

The majority of the pregnant women had no ocular problems before index pregnancy. Among those who had past eye problems, difficulty in seeing far objects and itching were the most common symptoms identified as most disturbing. Most of the participants had never worn eyeglasses before the index pregnancy [Table 2].

The majority of the participants never had an eye check as part of the antenatal examinations for the index pregnancy. For those who noticed eye changes, majority could not relate it to pregnancy. The most frequent symptoms in those that had eye problem during their index pregnancy were itching and blurring of vision [Table 3].

The cornea was least sensitive in both eyes, in most pregnant women, in the third trimester compared to the second trimester and postpartum [Figure 1].

There was an increase in CCT in both eyes above normal range in more women in the third trimester (109; 81.2%) than in the second trimester or postpartum [Figure 2].

Majority of the pregnant women (87; 64.9%) had their IOP reduced below normal in both eyes in the third trimester [Figure 3].

Table 1: Distribution of the pregnant women according to their sociodemographic and clinical characteristics (*n*=134)

Variables	Frequency (%)
Age (years)	
18-35	110 (82.1)
>35	24 (17.9)
Mean±SD	30.81±5.49
Educational level completed	
Primary	1 (0.7)
Secondary	38 (28.4)
Tertiary	95 (70.9)
Occupation	
Civil servants	44 (32.8)
Homemakers	40 (29.8)
Traders	28 (20.9)
Artisans	7 (5.2)
Students	15 (11.2)
Parity	
Primigravida	52 (38.8)
Multigravida	82 (61.2)
Mode of conception	
Normal	132 (98.5)
Assisted reproduction (IVF)	2 (1.5)

IVF=*In vitro* fertilization; SD=Standard deviation

Table 2: Distribution of the pregnant women according to their past ocular history

Variables	Frequency (%)
Ever had eye problems in the past? (*n*=134)	
No	85 (63.4)
Yes	49 (36.6)
Most disturbing symptom for those who had eye problems (*n*=49)	
Difficulty seeing distance objects	16 (32.7)
Difficulty seeing near objects	5 (10.2)
Difficulty reading tiny prints	3 (6.1)
Tearing	5 (10.2)
Itching	13 (26.5)
Redness	7 (14.3)
Primary ocular diagnosis before index pregnancy (*n*=49)	
Allergy	12 (24.5)
Refractive error	22 (44.9)
Conjunctivitis	2 (4.1)
Measles	1 (2.0)
Diabetes	2 (4.1)
Do not know	10 (20.4)

The period of pregnancy affected the values of CS, CCT, and IOP of the participants. Duration of pregnancy varied inversely with CS and IOP with the least values recorded in the third trimester while it varied directly with CCT with the highest value obtained in the third trimester [Table 4].

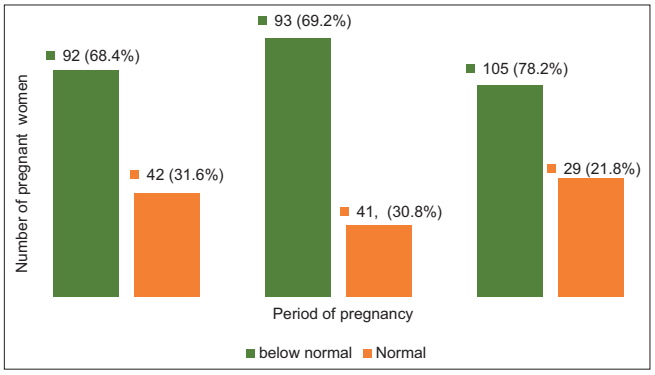

Figure 1: Distribution of pregnant women according to their corneal sensitivity.

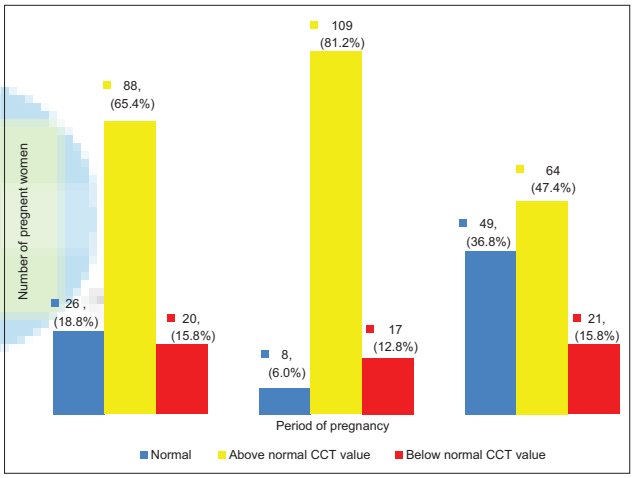

Figure 2: Distribution of pregnant women according to changes in central corneal thickness.

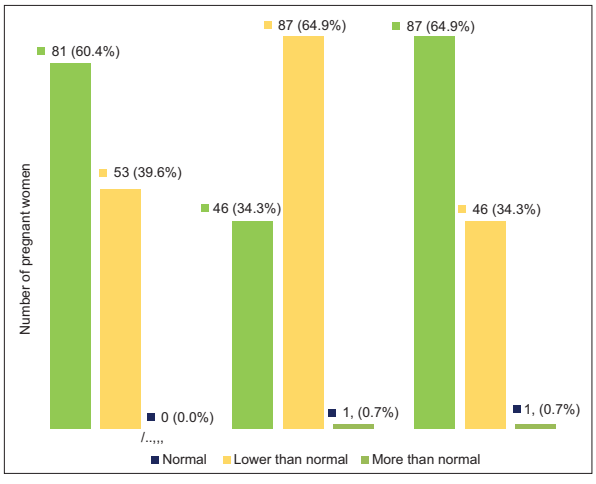

Figure 3: Distribution of pregnant women according to their changes in IOP.

Table 3: Distribution of the pregnant women according to their contemporary ocular history in the index pregnancy

Variables	Frequency (%)
Had any eye check since index pregnancy (*n*=134)	
No	129 (96.3)
Yes	5 (3.7)
Ever had eye problems since index pregnancy (*n*=134)	
No	109 (81.3)
Yes	25 (18.7)
Patients most disturbing symptoms (*n*=25)	
Itching	10 (40.0)
Blurring of vision	7 (28.0)
Redness	3 (12.0)
Drooping of eyelids	1 (4.0)
Primary diagnosis	
Allergy	1 (4.0)
Conjunctivitis	1 (4.0)
Glaucoma	1 (4.0)
Ptosis	1 (4.0)
Short-sightedness	1 (4.0)
Do not know	20 (76.0)
Main reason perceived to be the cause of the eye changes	
Pregnancy	3 (12.0)
Contact with infected persons	1 (4.0)
Do not know	21 (84.0)

Table 4: Central corneal thickness, corneal sensitivity, and intraocular pressure in the 2nd/3rd trimesters and postpartum period among the pregnant women

	Mean±SD
CCT (µm)	
2nd trimester	562.38±34.81
3rd trimester	568.42±38.80
Postpartum	542.61±43.19
CS (mm)	
2nd trimester	56.59±4.26
3rd trimester	55.53±3.98
Postpartum	58.40±4.90
IOP (mmHg)	
2nd trimester	13.51±3.00
3rd trimester	11.73±3.12
Postpartum	13.78±2.96

IOP=Intraocular pressure; CS=Corneal sensitivity; CCT=Central corneal thickness; SD=Standard deviation

A simple linear regression with the period of pregnancy as the independent variable showed that it significantly reduced CS ($P < 0.05$) and IOP ($P < 0.000$) but significantly increased CCT ($P < 0.000$) [Table 5].

An inverse relationship was found between CCT and IOP, i.e., an increase in CCT was associated with a decrease in IOP; this association was statistically significant ($P < 0.02$) in the third trimester [Table 6].

An increase in CCT was associated with a decrease in cornea sensitivity which was statistically significant ($P < 0.05$) in the third trimester [Table 7].

Table 5: The effect of period of pregnancy on corneal sensitivity, central corneal thickness, and intraocular pressure

Parameter	Estimate (SE)	*P*
CS R^2=0.008*		
b_0 (Intercept)	64.571 (3.676)	0.000
b_1 (Period of pregnancy)	−3.356 (1.703)	0.050
CCT R^2=0.048*		
b_0 (Intercept)	531.442 (6.736)	0.000
b_1 (Period of pregnancy)	14.216 (3.119)	0.000
IOP R^2=0.051*		
b_0 (Intercept)	14.805 (0.413)	0.000
b_1 (Period of pregnancy)	−0.897 (0.190)	0.000

*Significant $P<0.05$. R^2=Regression coefficients; b_1=Coefficient of the independent; b_0=Intercept/constant; SE=Standard error; IOP=Intraocular pressure; CS=Corneal sensitivity; CCT=Central corneal thickness

Table 6: Relationship between central corneal thickness and intraocular pressure across the 2nd and 3rd trimesters and postpartum

CCT	IOP		
	Both eyes		
	2nd trimester	3rd trimester	Postpartum
Adjusted R^2	0.008	−0.032*	−0.005
P	0.945	0.022	0.547

Simple linear regression analysis was used with IOP as the dependent variable and CCT the independent variable. *$P<0.05$ significant. CCT=Central corneal thickness; IOP=Intraocular pressure; R^2=Regression coefficients

Table 7: Relationship between central corneal thickness and corneal sensitivity across 2nd/3rd trimesters and postpartum

CCT	CS		
	Both eyes		
	2nd trimester	3rd trimester	Postpartum
R^2	0.010	−0.038*	−0.003
P	0.144	0.035	0.248
P	0.144	0.035	0.248

Simple linear regression with CS as dependent and CCT the independent variable. *$P<0.05$ significant

Discussion

Several studies carried out in other countries have shown that pregnancy affects the eye.[1,9] The present study investigated some physiological changes in the eye during pregnancy and 6-week postpartum in an

attempt to establish baseline values in our environment and ensure better eye care for pregnant women.

The demographic characteristics of the participants in the present study were similar to those reported in the previous studies done in Iran[9] and Malaysia.[10] The mean age of their study populations were similar to that of the present study. This differed from a study carried out in Northern Nigeria by Muhammad and Emmanual[11] where the mean age of the survey population was 23.67 ± 6.11 years. This difference could be attributed to sociocultural factors as the latter study was carried out in Northern Nigeria where girls marry at an early age in contrast to this study area (Eastern Nigeria) where most girls prefer to marry after their university education. In the present study, the majority of the participants had tertiary education which is similar to a study done in Iran[9] where 77.5% of the pregnant women had tertiary education.

In spite of the educational status of the participants in the present study, they booked in their second trimester. Other previous studies done in Shagamu,[12] Lagos,[13] Ibadan,[14] and Benin[15] reported a similar habit among pregnant women in Nigeria, but studies in other countries such as Iran[9] and India[16] reported that pregnant women booked in their first trimester. The lack of early booking by the most Nigerian pregnant women could be due to lack of awareness on the right time to book and its importance,[9] sociocultural factors such as financial constraints, ignorance, or misconception about antenatal care and fear of possible consequences that may follow making the pregnancy public.[10]

The present study has shown that the duration of pregnancy has a significant effect on corneal biomechanical properties; highest effects were observed in the third trimester. This could be attributed to hormonal changes during pregnancy which peak during the third trimester.[9] There was an increase in CCT among the participants from the second to the third trimester which decreased in the postpartum period. The increase may be due to fluid retention caused by hormonal changes. Hormonal changes that occur during pregnancy were reported to peak in the third trimester.[9,17] The increase in CCT observed in the present study is similar to reports from other previous studies which also reported increase in CCT among pregnant women,[16,17] but differs from the study by Park *et al*.[5] where no change was observed; this could possibly be attributed to the small sample size of participants in the later study. The consequence of this change in CCT would be a possible intolerance to contact lens in these pregnant women.

A decrease in CS was observed among the participants in this study. A previous study by Millodot[18] also reported decreased CS during pregnancy. This results in patients' lack of awareness of the presence of foreign bodies or trauma to the eye, the sequelae being possible damage to the eye. Reduced CS in these pregnant women may be as a result of fluid retention, a view supported by the increased CCT observed. CS correlated inversely with the increase in CCT in this study; increase in CCT caused a corresponding decrease in CS which was significant in the third trimester.

A progressive decrease in IOP was observed among the participants in this study across the trimesters. This is similar to findings from several other studies where IOP was reported to fall during pregnancy.[3,6,19] The decrease in IOP could be due to an increase in the hormonal level of progesterone and estrogen which lead to dilatation of the circulatory system vessels and reduction in aqueous humor production.[20] A woman's progesterone level begins to increase at approximately 20 weeks of gestation and continues to increase until the end of the third trimester.[21] In addition, estrogen levels first increase at 9 weeks and peak at 31–35 weeks of gestation.[19] Another considered mechanism could be the result of relaxin which causes relaxation of the pelvic ligament in pregnancy; this effect is believed to be extended to the corneoscleral envelope to produce decreased ocular rigidity and cause a reduction in IOP.[20] Pilas-Pomykalska *et al*.[20] reported 19.8% decrease in IOP during pregnancy which agreed with our findings. A contradicting study by Qureshi[6] indicated that this reduction in IOP could be falsely low and was as a result of reduced corneoscleral rigidity.

Twin gestation was observed to cause a further reduction in IOP in this study; this is similar to reports from a previous study by Saylik and Saylık[22] who attributed the decrease to exaggeration of physiologic adaptation in multiple pregnancies which involves every organ system. They reported that the number of fetuses might be associated with the intensity or degree of exaggeration; they attributed these changes to a greater increase in serum levels of progesterone, estrogen, b-human chorionic gonadotropin, cortisol, and alpha-fetoprotein in multiple pregnancies. The result from this study may not be conclusive enough since only three of the pregnant women had twin gestation. Further studies may be required to investigate the effect of twin gestation on IOP.

An inverse relationship was observed between CCT and IOP in the present study, an increase in CCT was associated with a decrease in IOP. This is similar to findings in other previous studies.[17,23] A study in India[17]

observed that a 3.13% increase in CCT was associated with a 9.33% decrease in IOP which was similar to the results of this study.

The result from this study has shown that the duration of pregnancy significantly affected the course of CCT, CS, and IOP; CCT increased with duration while CS and IOP reduced as pregnancy progressed. Our results agree with that from a previous study by Wang *et al*.[23] which reported a significant reduction in IOP and increase in CCT in the second and the third trimesters of pregnancy. These workers reported that changes in IOP negatively correlated with progesterone, estrogen, and relaxin levels, and changes in the CCT positively correlated with the levels of the three female hormones. They suggested that the three hormones may induce a decrease in the IOP and an increase in the CCT.

Conclusion

The lack of awareness on ocular changes in pregnancy is alarming in our area. In this study, pregnancy caused significant changes in CCT, CS, and IOP in the study population. There was a progressive increase in CCT with a corresponding decrease in CS and IOP across the trimesters. These changes are physiological and reversed 6 weeks after delivery. Knowledge of their existence will prevent unnecessary interventions during pregnancy.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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