

1 **Taking the strain? Impact of glaucoma on patient's informal caregivers**

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16

17 **Summary**

18 **What was known before**

- 19 • Chronic open angle glaucoma (COAG) can cause difficulties with activities of daily living such as driving  
20 and mobility.
- 21 • Other chronic eye diseases, for example, age related macular degeneration lead to an increase in  
22 reliance on family support networks; this is termed informal caregiving.

23 **What this study adds**

- 24 • The first to estimate caregiver strain in a sample of COAG caregivers using a validated instrument.
- 25 • Informal caregiver strain is negligible in most patients consecutively sampled from a glaucoma clinic in  
26 England.
- 27 • ICG strain becomes inflated in patients with advanced visual field (VF) loss in COAG.
- 28 • ICG strain increases moderately with worsening VF's but in our sample some of this could be explained  
29 by worse general health.

30 **Abstract**

31 **Purpose:** To estimate informal caregiver (ICG) strain in people from a glaucoma clinic.

32 **Methods:** Patients with glaucoma were consecutively identified from a single clinic in England for a cross-  
33 sectional postal survey. The sample was deliberately enriched with a number of patients designated as  
34 having advanced glaucoma (visual field [VF] mean deviation worse than -12 dB in both eyes). Patients were  
35 asked to identify an ICG who recorded a Modified Caregiver Strain Index (MCSI), a validated 13 item  
36 instrument scored on a scale of 0-26. Previous research has indicated mean MCSI to be >10 in Multiple  
37 Sclerosis and Parkinson's disease. All participants gave a self-reported measure of general health (EQ5D).

38 **Results:** Responses from 105 patients (43% of those invited) were analysed; only 38 of the 105 named an  
39 ICG. Mean (95% confidence interval [CI]) MCSI was 2.4 (1.3, 3.6) and only three ICGs recorded a MCSI > 7.  
40 The percentage of patients with an ICG was much higher in patients with advanced VF loss (82%; 9/11)  
41 when compared to those with non-advanced VF loss (31%; 29/94; p=0.001). Mean (standard deviation)  
42 MCSI was considerably inflated in the advanced patients (5.6 [4.9] vs 1.5 [2.2] for non-advanced; p=0.040).  
43 Worsening VF and poorer self-reported general health (EQ5D) of the patient were associated with  
44 worsening MCSI.

45 **Conclusion:** ICG strain, as measured by MCSI, for patients with non-advanced glaucoma is negligible,  
46 compared to other chronic disease. ICG strain increases moderately with worsening VFs but this could be  
47 partly explained by worse general health in our sample of patients.

49 **Introduction**

50 Chronic Open Angle Glaucoma (COAG) can cause slow, irreversible damage to the visual field (VF). COAG,  
51 like many other chronic conditions affecting older adults, does not limit lifespan but can make life more  
52 challenging. For example, patients can report significant problems with activities of daily living, such as  
53 driving, reading and mobility as their VF worsens [1, 2]. Such difficulties may lead to a reliance on a spouse,  
54 partner, close friend or family member for support [3, 4]. A person caring for someone with a chronic or  
55 disabling condition, but not in a formal capacity, can be termed an informal caregiver.

56 Informal caregiving, much like the condition that the patient is experiencing, can be a complex issue  
57 incorporating physical, psychological, financial and emotional changes [5]. When these experiences are  
58 negative, it is termed caregiver strain [6]. For example, informal caregivers have been shown to experience  
59 exhaustion, problems with wellbeing and reduced levels of self-esteem [7]. Informal caregiver (ICG) strain is  
60 most likely to affect women and those who do not have adequate social support [8, 9]. Conversely, ICGs who  
61 are psychologically well adjusted, have good social support and implement proactive coping strategies are  
62 less likely to suffer from caregiver strain [6]. ICGs often do not report their caregiver status to healthcare  
63 professionals and as such may not receive appropriate support [10].

64 ICG strain is well studied in conditions like cancer [11] and mental illness [12] where burden of care is often  
65 significant. More recently, ICG strain in long-term conditions has received attention. For example, ICG strain  
66 in Parkinson's disease (PD) and Multiple Sclerosis (MS), was found to be significant when measured  
67 quantitatively using a modified version of the Caregiver Strain Index (MCSI) [6]. The same may be true for  
68 long-term chronic eye conditions. For example, ICG strain has recently been described in people with age-  
69 related macular degeneration (AMD) especially as the condition leads to visual impairment [13, 14, 15, 16,  
70 17]. Moreover, specific aspects of ICG strain for AMD like that associated with frequent treatment visits to  
71 clinic have been flagged [14, 16]. There has also been an effort to assess ICG strain in paediatric glaucoma

72 patients [18, 19]. However, there has been no attempt to quantify ICG strain in adult COAG and this is the  
73 main idea presented in this paper.

74 We estimate ICG strain in people in a glaucoma clinic in England. We do this with a cross-sectional study  
75 using a widely used and well validated standardised instrument (MCSI) [20]. We primarily aim to compare  
76 values from this index to values from other chronic conditions where ICG strain has been investigated using  
77 the same measure, specifically those described in Peters et al. (2013) [6]. We test a secondary hypothesis  
78 that measures of worsening VF in COAG are associated with worsening ICG strain as measured by MCSI.

## 79 **Materials and Methods**

80 We designed a cross-sectional study involving patients recruited from the glaucoma clinic of Hinchingsbrooke  
81 Hospital (part of North West Anglia NHS Foundation Trust). The study was approved by the NHS Research  
82 and Ethics committee of the East of Scotland (17/ES/0044 ref number: 216487) and adhered to the tenets  
83 of the Declaration of Helsinki. Patient participants were selected consecutively from an Electronic Medical  
84 Record (EMR) (Medisoft, Leeds, UK) by the study coordinator (PT) and the clinic's main glaucoma consultant  
85 (LC). To be eligible, patients (>40 years) had to be currently treated for a diagnosis of COAG with visual field  
86 (VF) loss in at least one eye. COAG suspects and patients with ocular hypertension were excluded.  
87 Participants were only included if they had no other ocular disease (except for uncomplicated cataract  
88 extraction) and a corrected binocular visual acuity (VA) of better than LogMAR 0.3 (6/12) at their last clinic  
89 visit. Patients were selected consecutively from the date they last attended clinic, and this had to be within  
90 6 months of the data extraction. Names and addresses were recorded along with age (years) and a measure  
91 of VF loss in both eyes (mean deviation; MD) from their last clinic visit as acquired using a Humphrey Field  
92 Analyser (Carl Zeiss Meditec, Dublin, CA). The EMR also has a field for the number of significant non-ocular  
93 co-morbidities and this number was recorded too.

94 We aimed to select a total of 250 patients representing a population of people with COAG being treated in  
95 a clinic in England (see data analysis; sample size). We deliberately aimed to include 50 patients (some  
96 selected non-consecutively) designated as having advanced COAG defined as MD worse than -12 dB in both  
97 eyes. This measure for advanced VF loss has been widely used before in, for example, health economic  
98 evaluations of COAG and coincides with a high-likelihood that the patient does not satisfy the VF component  
99 for legal fitness to drive [21, 22].

100 A questionnaire pack, including a participant information document, was posted to the address of selected  
101 participants. Due to the postal nature of the survey, participants were asked to complete a statement of  
102 implied consent. The patient information document asked participants to identify an informal caregiver (if

103 applicable) with the following question: *'Can you identify someone who is an informal caregiver for your*  
104 *glaucoma? This might be a spouse, a partner, a relative or friend who helps you with any aspect related to*  
105 *your glaucoma.'*

106 The questionnaire pack included two sections printed on different coloured paper, one for the patient and  
107 one for their potential informal caregiver (ICG). The patient section had demographic questions and a  
108 validated instrument (EQ5D) to measure self-reported general health. EQ5D is commonly used by NICE (The  
109 National Institute for Health and Care Excellence) for health economic evaluations for clinical interventions.  
110 We used EQ5D-5L in which items are scored from 1 (no problems) to 5 (severe problems) on the five domains  
111 of mobility, self-care, usual activities, pain/discomfort and anxiety/depression. An EQ5D index score was  
112 generated in a standard way with 1 representing full health (a score of 1 on all five items), and on the basis  
113 of a so-called UK tariff (applicable to our participants), a worst health state of -0.594 [23].

114 If an ICG was identified by the patient, then they completed a separate section of the questionnaire with its  
115 own consent statement; this included demographic questions, the EQ5D and MCSI questionnaires [20]. MCSI  
116 has been widely used with more than 200 citations in the literature. MCSI estimates levels of ICG strain in  
117 terms of financial, physical, psychological, social, and personal strain using 13 items, each of which is scored  
118 'yes, regularly', 'yes, sometimes' or 'no'. Scores range from 0 ('no' on all items) to 26 ('yes, regularly' on all  
119 items).

120 The questionnaire pack was sent with two stamped-addressed envelopes to ensure that responses could be  
121 returned privately. A 'thank you' note/reminder was sent two weeks later to encourage responses. Data  
122 from the questionnaires was double entered. Median imputation was used for any missing values. Data was  
123 anonymised and stored in a secure location.

## 124

## 125 **Data analysis**

126 Our primary outcome was mean MCSI in the ICGs of the participating patients and a comparison with values  
127 reported from a study by Peters et al. for ICGs for people with MS and PD [6]; these values were 11 and 12  
128 respectively. We aligned our study to the one by Peters et al. because it used MCSI on large numbers of ICGs  
129 for people with chronic conditions. From that study the between person standard deviation (SD) for MCSI  
130 was 6 units. Therefore, a sample-size calculation for a one-sample t-test aiming to demonstrate a difference  
131 of at least 2 units between mean MCSI in our data as compared to ones described in Peters et al. (power and  
132 alpha set at 0.80 and 0.05 respectively) required at least 75 ICG responses. Assuming a response rate of 30%  
133 (Peters et al. had 37%) meant we aimed to post 250 questionnaire packs.

134 Our secondary aims were to compare MCSI between ICGs of patients with and without advanced VF loss,  
135 and then to explore the association between MCSI and worsening COAG as measured by VF loss corrected  
136 for other measures such as, for example, sex, age and self-reported general health (EQ5D). Two-sample t-  
137 tests (assumed unequal variances) were used to compare means and Chi-square tests were used for  
138 categorical values. Associations were explored with Pearson correlation coefficients and a generalised linear  
139 model to correct for covariance. A value of 0.05 was used for statistical significance. Analysis was done in  
140 SPSS Statistics 23 (IBM Corp., Somers, NY) and in R (R Foundation for Statistical Computing, Vienna, Austria).

141 **Results**

142 We sent invitations to 243 patients, falling short of enriching our sample with our target of inviting 50  
143 patients with advanced COAG (n=39); finding eligible patients fulfilling the advanced VF criteria with  
144 preserved VA or not having other ocular pathology was problematic. One-hundred and sixteen (48%)  
145 patients responded. Median (interquartile range [IQR]) time period between a questionnaire pack being  
146 posted and returned was 14 (7, 25) days.

147 Mean (SD) age of the patients who responded (n=116) to the postal survey was 73 (10). Mean (SD) better  
148 eye MD (BEMD) of the patients who responded was -3.7 (6.4). Nine patients returned questionnaires  
149 declining to take part; two other patients were not analysed: on checking data entry of the clinical record  
150 one was found not to satisfy the inclusion criteria for VA and the other had too many missing items to be  
151 analysed meaningfully. This left 105 patients for data analysis.

152 Only 38 (36%) of the 105 patients analysed had an informal caregiver (ICG). These patients represent just  
153 16% of the total of n=243 contacted, a value lower than we anticipated in our sample size calculations (30%)  
154 perhaps reflecting that most people in glaucoma clinics do not consider their condition warrants an ICG. This  
155 in itself is an important finding in relation to the conditions like PD and MS investigated by Peters et al. [6]  
156 because in that study response rates were higher.

157 A participant stating that they had an ICG might be related to whether they are married or have a partner.  
158 For example, in the patients with an ICG, 87% (33/38) self-reported they were married or in a committed  
159 relationship as opposed to being single, divorced, widowed or separated; in contrast this proportion was  
160 60% (40/67) in the patients who did not have an ICG and the difference was statistically significant (p=0.004).  
161 Percentage of male participants with and without an ICG was 47% (18/38) and 55% (37/67) respectively;  
162 these values were not significantly different (p=0.439)

## Caregiver Strain in Glaucoma

163 Our primary outcome for the study was Mean (SD) MCSI; this was 2.4 (3.4) in the 38 ICGs who completed  
164 the questionnaire (95% CI: 1.3, 3.6). This value was overwhelmingly statistically different ( $p < 0.001$ , one-  
165 sample t-test) from the mean value of  $\sim 11$  reported in ICGs for people with MS and PD in Peters et al.  
166 Moreover, nearly one-half ( $n=18$ ; 47%) of our sample of ICG respondents returned a MCSI of zero (indicating  
167 no ICG strain, responding negatively to all 13 items). Furthermore, only three ICGs recorded a MCSI  $> 7$ , a  
168 value that some studies have described as meaningful caregiver strain. Taken together these results suggest  
169 ICG strain in COAG, as measured by MCSI, is negligible for most of the ICGs of glaucoma patients.

170 Mean (SD) best eye MD in patients with ( $n=38$ ) and without ( $n=67$ ) an ICG was  $-6.9$  (9.1) dB and  $-2.1$  (4.0) dB  
171 respectively; these values are statistically different ( $p=0.004$ ) hinting ICG strain increases with worsening VF  
172 loss. Moreover, percentage of patients with an ICG was much higher in patients with advanced VF loss (82%;  
173 9/11) when compared to those with non-advanced VF loss (31%; 29/94) and this difference was statistically  
174 significant ( $p=0.001$ ). To further highlight this effect of ICG strain being inflated in advanced COAG, Table 1  
175 gives the patient participant and ICG response stratified by our measure of COAG severity. For example, ICG  
176 mean (SD) MCSI was much worse when the patient had advanced VF loss (5.6 [4.9]). The three ICGs with  
177 MCSI  $> 7$  were for patients advanced VF loss too; this is noteworthy. There was no real evidence to suggest  
178 that the sex and age profile, or number of co-morbidities, of the two groups of patients were different. Yet  
179 patients with advanced VF loss, and their ICGs, had worse self-reported general health (EQ5D) compared to  
180 the others in the clinic and their respective ICGs.

181

**TABLE 1**

Comparison between patients with and without advanced VF loss and their respective ICG responses. Means with standard deviations (p-value for two-sample test [unequal variances]) and numbers with percentages (p value for Chi-square test) are given for the measurements and categorical values respectively. (An asterisk denotes statistical significance at  $p < 0.05$ .)

	Patients (n=9) with <b>advanced VF loss</b>	Patients (n=29) with <b>non-advanced loss</b>	p-value
Patient age (years)	78 (9)	72 (7)	0.077
Patient: female	5 (56%)	15 (52%)	0.841
Better eye mean deviation dB	-21.5 (6.1)	-2.4 (3.2)	<0.001*
Worse eye mean deviation dB	-26.5 (4.9)	-6.8 (5.3)	<0.001*
Patient: EQ5D score	0.66 (0.21)	0.87(0.15)	0.018*
Patient: Number of co-morbidities	1.9 (2.8)	1.5 (1.4)	0.690
<b>Modified Care Strain Index (MCSI)</b>	<b>5.6 (4.9)</b>	<b>1.5 (2.2)</b>	<b>0.040*</b>
Informal caregiver (ICG): number of females	5 (56%)	13 (45%)	0.573
Informal caregiver (ICG) : EQ5D score	0.77 (0.07)	0.91 (0.12)	<0.001*

Associations of measured variables with worsening MCSI in the 38 patients with ICGs are shown in Table 2.

Worsening VF and poorer self-reported general health (EQ5D) of the patient were highly associated with

worsening ICG MCSI. This analysis was exploratory because our study was not powered for this. Still, no

other variables had a statistically significant association with MCSI. Given the influence of patient EQ5D we

194 returned to our comparison of mean ICG MCSI between the patients with advanced (n=9) and non-  
 195 advanced VF loss (n=29) using a general linear model (sometimes referred to as ANCOVA). After controlling  
 196 for EQ5D as a covariate the difference in MCSI between the two groups still remained statistically  
 197 significant ( $p=0.035$  vs  $p=0.001$  [unadjusted with equal variances assumed]) but the effect diminished with  
 198 a mean (95% CI) difference in MCSI of 2.7 (0.2, 5.2) reduced from 4.1 (1.8, 6.4) (unadjusted). This analysis  
 199 still suggests having advanced VF loss inflates ICG strain but in our data this is partly explained by the same  
 200 patients having a co-varying worse self-reported general health. Of course, worse general health may or  
 201 may not be related to having advanced VF loss, but this cannot be untangled with our data.

**TABLE 2**

203 Pearson correlation coefficients for different measured variables against MCSI in 38 patients with ICGs. (An  
 204 asterisk denotes statistical significance at  $p<0.05$ .)  
 205  
 206

	Correlation coefficient (r)	p-value
Patient age (years)	+ 0.11	0.499
Better eye mean deviation dB	- 0.46	0.003*
Worse eye mean deviation dB	- 0.62	<0.001*
Patient: EQ5D score	- 0.53	0.001*
Patient: Number of co-morbidities	+ 0.31	0.063
Informal caregiver (ICG) : EQ5D score	- 0.26	0.113

207  
 208 MCSI items (questions) with the 38 ICG's responses are given in Table 3. One third of ICGs have at least  
 209 sometimes made changes in personal plans because of their caregiving. Other relatively more common

210 strains surrounded work adjustments and less time for other family members. MCSI items referring to  
 211 disturbed sleep, physical strain and a feeling of being ‘overwhelmed’ were completely rejected by all but a  
 212 few ICGs.

213 **TABLE 3**

214  
 215 The 13 items from the Modified Care Strain index questionnaire ranked by the frequency of responses by  
 216 the informal caregivers (ICGs). The top and bottom item in the table represent the item cited as the most  
 217 common and least common strain experienced by the ICGs respectively. The numbers are rounded whole  
 218 percent of the n=38 ICGS.  
 219

	<b>Not at all</b>	<b>Sometimes</b>	<b>Regularly</b>
There have been changes in personal plans because of my caregiving	<b>66</b>	31	3
There have been work adjustments because of my caregiving	<b>76</b>	16	8
Caregiving is confining/restricting	<b>74</b>	26	0
There have been other demands on my time (e.g. other family members need me) which I have been unable to deal with	<b>76</b>	24	0
It is upsetting to find the person I care for has changed so much from his/her former self	<b>79</b>	18	3
There have been family adjustments because of my caregiving	<b>82</b>	18	0
Caregiving is inconvenient	<b>84</b>	16	0
There have been emotional adjustments because of my caregiving	<b>87</b>	10	3
My caregiving is a financial strain	<b>87</b>	13	0
Some behaviour is upsetting (the person I care for has upsetting behaviours)	<b>89</b>	8	3
My sleep is disturbed by my caregiving	<b>89</b>	11	0

## Caregiver Strain in Glaucoma

Caregiving is a physical strain	<b>92</b>	<b>8</b>	<b>0</b>
I feel completely overwhelmed by my caregiving	<b>92</b>	<b>8</b>	<b>0</b>

220

221 Some other results from our sample of participants are worth noting. Nearly all patients (98%; 103/105)  
222 were Caucasian and 38% (40/105) self-reported being educated to degree level or higher. In our sample of  
223 38 ICGs there were roughly equal numbers of men (n=18) and women (n=20); mean (SD) MCSI was similar  
224 (p=0.606) for men (2.1[3.6]) and women (2.7 [3.4]) too.

**Discussion**

We used a cross-sectional postal survey to illicit a measure of ICG strain for glaucoma patients in a single clinic in England. Patients were selected consecutively but the sample was enriched with a number of patients with advanced VF loss. Only 36% of patients who responded felt they had an ICG and in these, caregiver strain as measured by a standardised instrument (MCSI) was negligible. Although, in a subset of patients with advanced VF loss in both eyes, but preserved VA and no other ocular comorbidity, the ICGs response on MCSI was considerably inflated.

Results from this study represent new knowledge about ICG strain in glaucoma patients. Our data might be useful for clinicians and practitioners who may not have considered ICG in COAG before. A raised awareness is useful because there is evidence that ICGs who are given adequate support do not experience as much strain [10]. Moreover, our data might be useful for targeting patients who need extra support and also health economic models for glaucoma care [24].

Comparing MCSI values between different conditions seems attractive but is fraught with issues because of the different sampling and methodology used in different studies. For example, MCSI (not the modified version) >7 has been reported in 36% of ICGs of people recovering from hip fracture surgery [25], 15% of ICGs of people with adult cancer [26] and 24% of ICGs of people with mild relapsing-remitting MS [27]. In contrast we only had three ICGs with MCSI >7; this could be reported as 3/105 (3%) of people who were contacted/replied, or 3/38 (8%) of ICGs analysed or 3/9 (33%) of the people with advanced COAG; these different figures illustrate how sampling can affect results. We aligned our results to Peters et al. [6] but even their study had different methodology to ours. Still, for our primary outcome, mean MCSI for ICGs of patients in glaucoma clinics was considerably lower than values estimated by Peters et al. for MS and PD.

Greater ICG strain being related to worse VFs is another novel finding of our study; the association was true in the least and most affected eye. Mean MCSI was three times larger in our sample of patients with

248 advanced VF loss compared to other patients in the clinic; this co-varied by the patients self-reported general  
249 health (EQ5D) but the effect remained after statistically correcting for this. This result is unsurprising because  
250 studies have indicated a rapid decline in vision related quality of life in COAG as both eyes progress to end  
251 stage VF loss [28, 29] and this likely reflects the greater help these people need. Of course, our findings add  
252 to the evidence that halting VF progression is a clinical imperative, not just for the patient but also for the  
253 wellbeing of the ICG of a patient. A longitudinal study would be needed to explore how ICG strain increases  
254 as COAG progresses in an individual and this could untangle the effect from worsening of general health.

255 ICG strain in another age-related eye condition, AMD, has been explored but making comparison with these  
256 studies is also tricky. For example, a study specifically assessed people on ranibizumab (injection) therapy  
257 for neovascular AMD and found it was associated with significant ICG strain [14]. Other studies have  
258 highlighted ICG strain in AMD but none sampled consecutively from people in clinics nor used MCSI, so it is  
259 difficult to make comparisons [13, 15]. A large multicentre cross-sectional study conducted in Portugal  
260 demonstrated visual impairment, defined as worse than 0.30 logMAR (6/12) in the better seeing eye, incurs  
261 ICG strain [30]. Our results from patients with advanced VF loss add to this knowledge because they had  
262 inflated ICG but, because of our study design, their VA was better than 6/12.

263 There are good explanations for why ICG strain was insignificant in the majority of our sample of patients.  
264 Many of these patients are receiving treatment for a condition that is almost always asymptomatic until  
265 advanced in nature. In addition, patients had relatively preserved VA and no other ocular morbidity. In  
266 addition, although MCSI is widely used it is unlikely to capture specific ICG strain for people with COAG. For  
267 example, it was obvious that some MCSI items (Table 3), like care being physically draining, were rejected.  
268 Analogous to this issue is the debate about items within patient reported outcome measures (PROMs) that  
269 are not glaucoma specific and how they might, for example, be insensitive to glaucoma progression [31, 32].  
270 Investigating the specific aspects of ICG strain in COAG, with a view to the development of a condition  
271 specific measure would be a useful area for future work.

272 We speculate there may be ICG strain in COAG around the different treatments (drops/surgery) and this  
273 could be the subject of future work. Other idiosyncratic ICG strains for COAG might include the psychological  
274 burden of having a potentially blinding condition or loss of visual function that might restrict mobility or  
275 remove a driving licence. We know patients are very concerned about the latter [33] and this would likely  
276 impact on their ICG too. Qualitative analysis of interviews with patients and their ICGs could pinpoint these  
277 strains; this is a subject of further work by our lab. In turn, this research could lead to development of a  
278 simple COAG specific instrument that could be administered in a clinic to detect if there was a 'silent'  
279 developing ICG strain. Others have discussed the importance of identifying a *precipice* when patients lose  
280 self-medicating capability, and this might be identifiable with an appropriate instrument for the ICG [34].

281 Other results from our study are worth discussing. Any postal survey will suffer from non-response. Our main  
282 findings are likely unaffected by this but ICG strain could be a little worse if everyone in the clinic was  
283 captured given the association of MCSI with disease severity. The high number of patients who declared not  
284 to have an ICG is interesting too. This might suggest that patients do not consider their COAG warrants an  
285 ICG. Yet we also found a strong link between having an ICG and being married or having a partner. In turn  
286 this highlights the importance of identifying patients who may be socially isolated or living on their own.  
287 Moreover, in our data we did not observe differences in the sex profile of the ICGs, with men and women  
288 reporting the same level of ICG strain. This contradicts studies where ICG strain has been thought to be  
289 something that affects women more than men [8, 9].

290 Our study had several strengths. We took advantage of a widely used, standardised instrument. In addition,  
291 our sampling was performed consecutively, and we measured other variables allowing for an analysis that  
292 corrected for covariates. At the same time our study has several limitations. We only sampled people from  
293 one centre; the patients were nearly all Caucasian and education levels were relatively high. (Some studies  
294 have indicated that there may be cultural and ethnic differences in the experience of ICG strain [35].) VF  
295 records were extracted from an EMR and, although unlikely, may have changed in the maximum six-month

296 period before a participant responded. Moreover, our study was only cross-sectional, relied on self-report  
297 and could only examine associations. Furthermore, a larger sample and conducting the study across more  
298 centres would have improved the generalisability of our results.

299 In conclusion, our study is novel in assessing ICG strain in patients from a glaucoma clinic. We conclude that  
300 ICG strain in the great majority of these patients is largely negligible but, importantly, it worsens as disease  
301 severity worsens. Patients with advanced VF loss in both eyes have considerably inflated ICG strain although  
302 some of this might be explained by worsening general health in these people too. Further work should be  
303 done to improve our understanding of the specific nuances of ICG in relation to COAG.

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