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Clinical relevance Following COVID-19 lockdown, uptake of slit lamp enabled live teleophthalmology increased. Its use contributed to a reduction of referrals escalated to secondary care during-lockdown (avoided: 64% pre-lockdown vs 86% during-lockdown).

Background Live teleophthalmology using video conferencing allows real-time, three-way consultation between secondary care, community providers and patients, improving interpretation of slit lamp finding and potentially reducing referrals to secondary care. NHS Forth Valley implemented live teleophthalmology in March 2019. In March 2020, the COVID-19 pandemic created urgency to deliver ophthalmic care while minimising the risk of contracting or spreading the disease. We aim to compare uptake and two outcomes (number of avoided secondary care referrals; pattern of presenting conditions) of live teleophthalmology consultations in NHS Forth Valley before and during COVID-19 national lockdown.

Methods An NHS secure video conferencing platform connected optometrists' video slit lamp, or an iPad mounted on a slit lamp and viewing through the eyepieces, to a secondary care ophthalmologist via a virtual live clinic / waiting area. Data about avoiding a secondary care referral were extracted from a post-consultation ophthalmologist survey for 14 months of data. Pre- and during-lockdown intervals were before/after March 23rd 2020, when routine eyecare appointments were suspended. Numbers of avoided referrals to secondary care and patterns of presenting condition were compared for pre- and during-lockdown periods.

Results The COVID-19 pandemic markedly increased use of live teleophthalmology in NHS Forth Valley. Surveys were completed for 164 of 250 (66%) teleophthalmology consultations over the study period. Data from 154 surveys were analysed, 78 and 76 for the pre- and during-lockdown periods respectively. Significantly more during-lockdown (86%) than pre-lockdown (64%; difference 21%, 95% CI 8–34%, $p=0.001$) surveys indicated that referrals to secondary care were avoided.

Conclusion Survey data from ophthalmologists suggest significantly fewer escalations to secondary care due to teleophthalmology use.

Background

Teleophthalmology is the remote provision of ophthalmic care by telecommunication technologies. Asynchronous 'store-and-forward' technologies¹ are beneficial in some settings² but are less useful for real-time decisions in primary care. Live teleophthalmology using video conferencing allows three-way consultation between the community optometrist, the patient and the secondary care ophthalmologist, reduces uncertainty around slit lamp signs, and limits unwarranted referrals to secondary care³. Experience with live teleophthalmology is limited. Surveys are commonly used to assess telemedicine, and anonymous data collection captures individual experiences confidentially without jeopardizing the clinical relationship⁴.

Traditional model of care in Scotland

Uniquely in the National Health Service (NHS) Scotland, the 2006 General Ophthalmic Service (GOS) contract provides for primary care and management of patients by optometrists who can initiate treatment, diagnose, and refer to secondary ophthalmic care⁵. Publicly funded through taxation, it aims to improve patient care, retain patients in the community where possible, and reduce escalations to secondary care. Referrals to secondary care are made by clinician judgment rather than following set criteria.

NHS Forth Valley serves a population of ~300,000 in central Scotland and implemented live teleophthalmology in March 2019 to connect optometrists directly to secondary care.

COVID-19

An infectious respiratory coronavirus disease, COVID-19, was declared a global pandemic on March 11th, 2020. Worldwide, measures were taken to prevent its spread. The first case of COVID-19 was detected in Scotland on March 2nd, 2020. The Scottish government enforced 'lockdown' on March 23rd 2020⁶ and routine community eyecare services were suspended as mandated by government⁷ and recommended by professional bodies, with non-face-to-face methods encouraged^{8,9}. The COVID-19 pandemic therefore created urgency to deliver ophthalmic care while

minimising the risk of contracting or spreading the disease¹⁰. Community funding changed⁷, with suspension of the traditional GOS contract reimbursement model and introduction of monthly payments matching average monthly income across the 2019/20 financial year. Most community optometrists provided only advice from closed premises. A few triaged, remotely managed, or diverted patients to Emergency Eye Treatment Centres within Forth Valley. These centres were re-purposed community optometric practices conducting only emergency or essential eye care to the community. They effectively became extensions of secondary care within the community, funded centrally as part of the National Health Service.

In this paper, we compare the uptake and two outcomes (number of avoided escalations to secondary care (outpatient); nature of conditions where escalation was or was not avoided) of live teleophthalmology in NHS Forth Valley before and after COVID-19 lockdown.

METHODS

Following consultation with local NHS Research and Development, this work was classified as an audit of service development and no ethics approval was required. We used a secure NHS video conferencing platform, NHS Near Me¹¹, currently powered by Attend Anywhere (Melbourne, Australia), web-based software designed to connect patients with secondary care.

Digital devices and teleconferencing system

Optometrists used either a video slit lamp (Topcon DC-4, Tokyo, Japan) or an iPad Air 2 (Apple Inc, CA, USA) with a bespoke mount designed (Rhinoceros 3D, Robert McNeel and Associates, USA) and printed (Duplicator i3, Wanhao, China) to align the iPad camera with the eyepieces of slit lamps commonly used in optometry (CSO ITALY SL980-Type 5X), thus effectively emulating a video slit lamp (Figure 1). The optometrist is further from the patient than for non-video slit lamp assessment¹². Video and audio feeds from the optometrist, which could be video slit-lamp, desktop share, or via webcam/mobile devices, could be shared with the ophthalmologist, enabling assessment of lids, motility, retina and optic nerve as well as sight of visual fields, OCT, fundus photography and three-way discussion between patient,

optometrist and ophthalmologist. A shortcut link to an NHS Near Me virtual waiting area was placed on the home screen or desktop for ease of access for optometrists initiating the call. The receiving ophthalmologist used either a dedicated iPhone XR (Apple Inc, CA, USA) or their own device to receive text alerts, and logged in to NHS Near Me to receive the call.

Survey

To gather data about use, consultation quality and outcomes, surveys were developed in liaison with the wider teleophthalmology programme governance, and implemented using an online survey tool (toolol, Helsinki, Fin)¹³. Separate surveys were developed for the patient and optometrist encounter, and for the ophthalmologist. Survey development used an informal Delphi process with a small group of end users; subsequent modifications were based on the programme governance feedback. Only results pertaining to two items from the ophthalmologist survey are considered here: a fuller account of all findings is in preparation. Users were redirected to their survey immediately post-consultation via links embedded in NHS Near Me (Figure 1). Surveys were optional and anonymous, and this was explicitly stated.

Data analysis

Two versions of the survey were used during the 14 month timespan because the survey was modified and shortened as part of ongoing improvements. Survey responses from March 1st 2019 to April 30th 2020 were included in analysis: survey version 1 was used up to December 31st 2019. Version 1 had 18 questions, one of which asked “Has the video consultation avoided a review in secondary care?”, with a single choice of “yes”, “no” or “don’t know”. Version 2 had 15 questions, one of which asked “In comparison with traditional telephone triage, has the video call:”, allowing selection of one or more of five* options, one of which was “avoided a secondary care appointment”.

* Other options comprised: highlighted the need for a further review by an ophthalmologist; increased chances for unnecessary appointments; made no difference; don’t know.

Since the purpose of this study was to estimate the number of avoided escalations to secondary care, we classified all survey version 1 “yes” responses and all survey version 2 “avoided a secondary care appointment” option selected as positive for this outcome. We classified all survey version 1 “no” and “don’t know” responses and all survey version 2 “avoided a secondary care appointment” option not selected as negative for this outcome.

Pre- and during-lockdown intervals used the cut-off date of (Monday) March 23rd 2020, the start of UK ‘lockdown’ and also of suspension of routine community eyecare services⁷. Survey data preceding and succeeding the cut-off date are termed ‘pre-lockdown’ (13 months) and ‘during-lockdown’ (one month) respectively.

One eye subspecialty (lids; peri-orbit; uveitis; anterior segment; posterior segment; trauma; or neuro-ophthalmology) was noted for all consultations. Proportion of each subspeciality was compared pre-and during-lockdown, both for consultations where escalation was avoided, and for those where escalation was not avoided.

Proportions were compared by calculating the 95% confidence interval (CI) of their difference, with a statistically significant difference concluded to be present if this interval excluded zero¹⁴.

Power

These data reflect a retrospective, convenience sample. No prospective hypothesis was tested, so no sample size calculations for adequate power were undertaken.

RESULTS

Two hundred and fifty teleophthalmology calls were made over the study period, 134 pre-lockdown and 116 during-lockdown. For 164 of these (66%), a survey was completed, 83/134 (62%) pre-lockdown and 81/116 (70%) during-lockdown. Ten surveys, five pre-lockdown and five during-lockdown, were excluded from analysis (five operator test calls, three system tests and two connection failures). Data from 154 surveys, each describing a unique consultation, were analysed (78 pre-lockdown and 76 during-lockdown). The earliest 48 responses, pre December 31st 2019, used survey version 1. The most recent 106 responses (January 1st 2020 –

April 30th 2020) used survey version 2. The change in survey version made little difference to the responses regarding referrals (by inspection, Figure 2).

Of the consultations, 50/78 (64.1%) surveyed pre-lockdown said a referral to secondary care had been avoided versus 65/76 (85.5%) surveyed during-lockdown (Figure 2), a statistically significant increased proportion (difference of 21%, 95% CI of difference 8–34%, $p=0.001$). As Figure 2 illustrates, management change seems to have started earlier than our cut-off, in early-to-mid March 2020, likely due to patients and healthcare workers becoming aware of COVID-19 and impending restrictions.

The pattern of eye subspecialty involved showed that the great majority of consultations concerned anterior or posterior segment (Figure 3). No surveys reported a case of trauma. Subspecialty where escalation was avoided (Figure 3a and 3b; total $N=115$) was predominantly anterior or posterior segment ($N=101$, 91%), with a few cases ($N=14$, ≤ 5 for any one subspecialty) presenting with lid, neuro-ophthalmology, peri-orbit or uveitis problems.

Where numbers were sufficient for statistical comparison, there were no differences in subspecialty pre- and during-lockdown: anterior segment 25/50 vs 35/65 (difference of 4%, 95% CI of difference -14–21%, $p=0.34$); posterior segment 16/50 vs 25/65 (difference of 6%, 95% CI of difference -11–23%, $p=0.24$). Subspecialty where escalation was not avoided (Figure 3c and 3d; $N=39$) was again mostly anterior or posterior segment ($N=27$, 69%) but these formed a smaller majority than was the case for avoided escalations. Therefore, lid, peri-orbital, neuro-ophthalmology and uveitis presentations ($N=12/39$) formed a relatively greater proportion of cases where escalation was not avoided than the same conditions where escalation was avoided ($N=12/39$ vs $14/115$, difference of 19%, 95% CI of difference 4–35%, $p=0.004$). This suggests slightly more scope for avoiding escalation to secondary care for patients presenting with anterior or posterior segment problems than those presenting with lid, peri-orbital, uveitis or neuro-ophthalmological conditions. For data pertaining to cases where escalation was not avoided, numbers per condition are small ($N=0–14$), precluding statistical

comparison, but visual comparison of Figure 3c with Figure 3d suggests similar distribution of subspecialties pre- and during-lockdown.

DISCUSSION

The COVID-19 pandemic has changed ways of working in NHS Forth Valley, with increased use of live teleophthalmology: the month of April 2020 saw approximately the same number of live teleophthalmology consultations (N=86) as the preceding four months (N=88, Dec 2019 to March 2020 inclusive).

The main finding of this study is a significant increase (21%) in avoided referrals observed with live teleophthalmology calls, suggesting it could be an important tool in delivering at least two of the aims of the GOS contract by retaining patients in the community and by improving the suitability of referrals to secondary care. It is likely that the patient-optometrist-ophthalmologist triad became highly motivated from March 2020 onwards to avoid secondary referrals for the new reason of minimising risk of viral spread by social distancing, as well as for existing motivation to provide appropriate and person-centred care without unduly burdening limited healthcare resources. Teleophthalmology can, in principle, protect patients and healthcare workers, and serve public health interests by avoiding unnecessary review in secondary care. Our data additionally suggest more scope for avoiding escalation to secondary care for patients presenting with anterior or posterior segment problems than those presenting with lid, peri-orbital, uveitis or neuro-ophthalmological conditions. The pattern of conditions either avoiding or not avoiding escalation to secondary care appeared similar pre- and during-lockdown.

The technology supporting the referral pathway did not change pre- / during-lockdown in this prospective audit. The drop in number of escalations to hospital likely reflects multiple changes in perspectives during a lockdown, including a significant change in approach to patient care, as the new risk of contracting or spreading COVID-19 significantly altered the construct of patient safety.

Limitations

The major limitation of this study is that it is a retrospective analysis of data from surveys which were not designed as a research tool to measure changes in referral to secondary care as a primary outcome. In addition, the question regarding secondary referrals changed in wording and in response type between the two survey versions, as part of ongoing improvement. An imperfect classification process was then used in an attempt to equate the two question versions. For survey version 1, “don’t know” (n=4/48) was classified as a negative result, which may have underestimated the avoided referral proportion. For survey version 2, it was possible to select further options alongside “avoided a secondary care appointment”: however, only 7/106 surveys had further options selected. Slightly fewer pre-lockdown teleophthalmology consultations resulted in a survey completion than during-lockdown (62 vs 70%), so the increase in ‘avoided referrals’ may partially reflect increased reporting.

Another limitation is the likely different patient populations attending community optometrists in the pre- and during-lockdown periods. From 23rd March 2020, our defined cut-off, community optometrists did no routine eyecare, only emergency and essential eyecare⁷. A small number of the consultations from the pre-lockdown period may have been for patients attending routine appointments, while no routinely-attending patients will have been included in the during-lockdown period. This is likely to bias our findings to slightly under-estimate the reduction in referrals to secondary care.

Finally, it is likely that in the during-lockdown period, and even in the weeks prior to formal lockdown, clinicians may have become more reluctant to escalate patients to secondary care in borderline cases, and this may have introduced a bias to over-estimate the reduction in referrals to secondary care.

Comparison with previous work

This is the first report of a live teleophthalmology system used before and during restrictions imposed because of the COVID-19 pandemic. Several reports of video consultation implementation have been described in ophthalmic service

redevelopment during COVID-19 response processes¹⁵⁻¹⁷. All connect a patient directly to their healthcare provider through video enabled devices, either for assessment of oculoplastic pathology in an outpatient clinic setting¹⁵, or for video consultation in an Accident & Emergency triage setting¹⁶, or for checking visual acuity and video consultation for gross examination of the ocular adnexa¹⁷. None provided the slit-lamp magnification and slit beam view necessary for detailed examination of the eye, or live screenshare of OCT. Moreover, none reported change following COVID-19, which we add to the tele-ophthalmology literature. Our findings mirror and extend those reported in a pre-COVID-19 primary care setting across multiple disciplines, where around 26% of electronic consultations avoided a referral altogether or avoided a referral to the wrong specialty¹⁸.

Conclusions

Teleophthalmology has the potential to retain patients in the community and reduce escalations to secondary care, important public health considerations during the COVID-19 pandemic. Social distancing and other protective measures introduced in response to COVID-19 has added another dimension to ophthalmic decisions when triaging patients, namely public health considerations of risk for the patient, their household and healthcare workers should they be referred to secondary care. The live teleophthalmology system described here allows increased distancing during slit lamp examination, connects optometrists immediately to secondary care providers, reduces referrals to secondary care and therefore reduces travel and inter-personal contacts.

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CONFLICTIONS OF INTEREST

The authors declare that there is no conflict of interest.

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COMPLIANCE WITH ETHICAL STANDARDS

Following consultation with local NHS Research and Development, this work was classified as an audit of a service development and no ethics approval was required. This work was done in accordance with the Declaration of Helsinki 1975.

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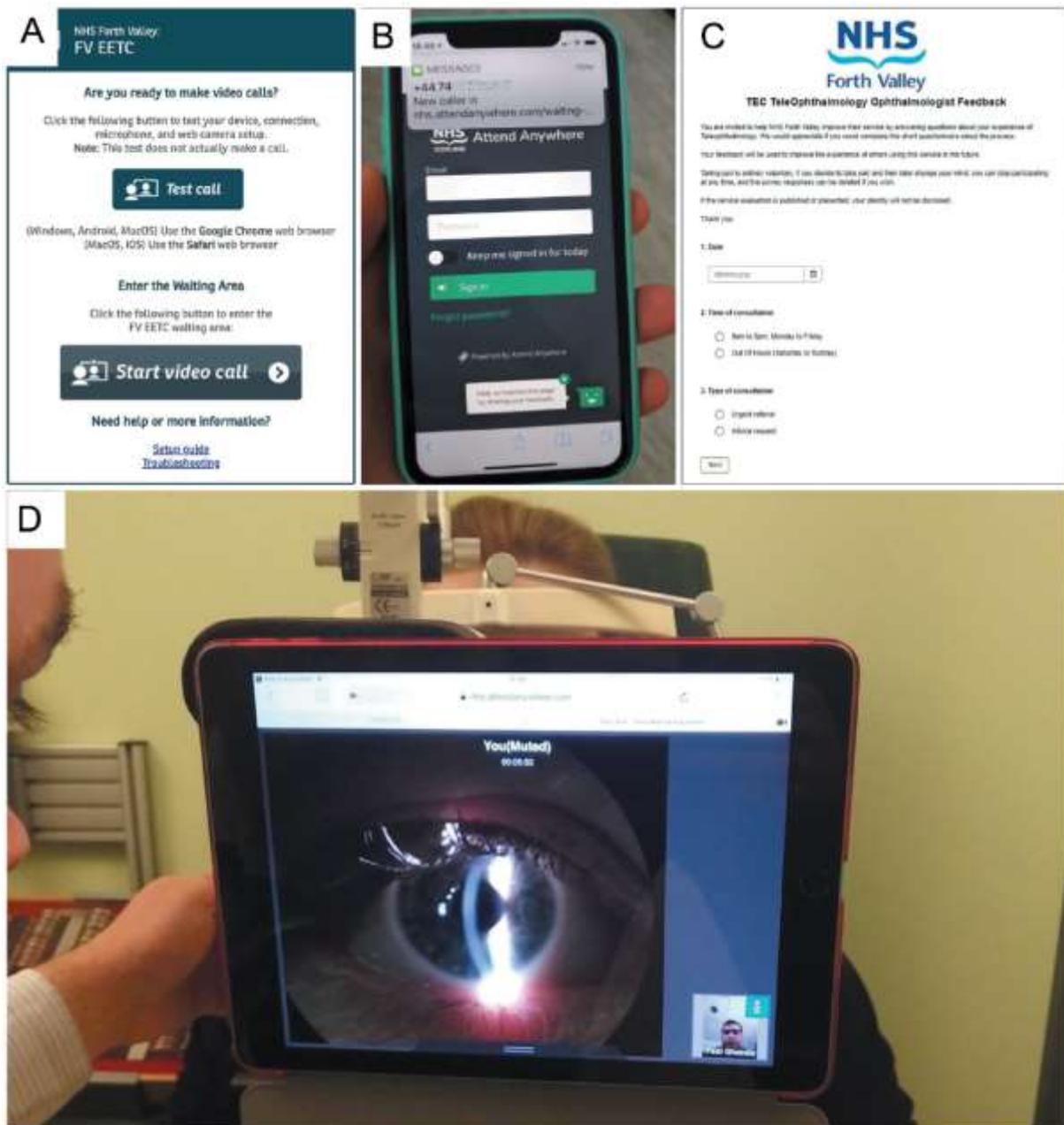


Figure 1. Teleconferencing system. A: NHS Near Me dial-in link as used by community optometrist. B: Text message alerting receiving secondary care ophthalmologist of a call in the waiting area, prompting login to NHS Near Me. C: Webropol online survey pop-up on ending call. D: Optometrist's view of iPad mounted onto slit lamp.

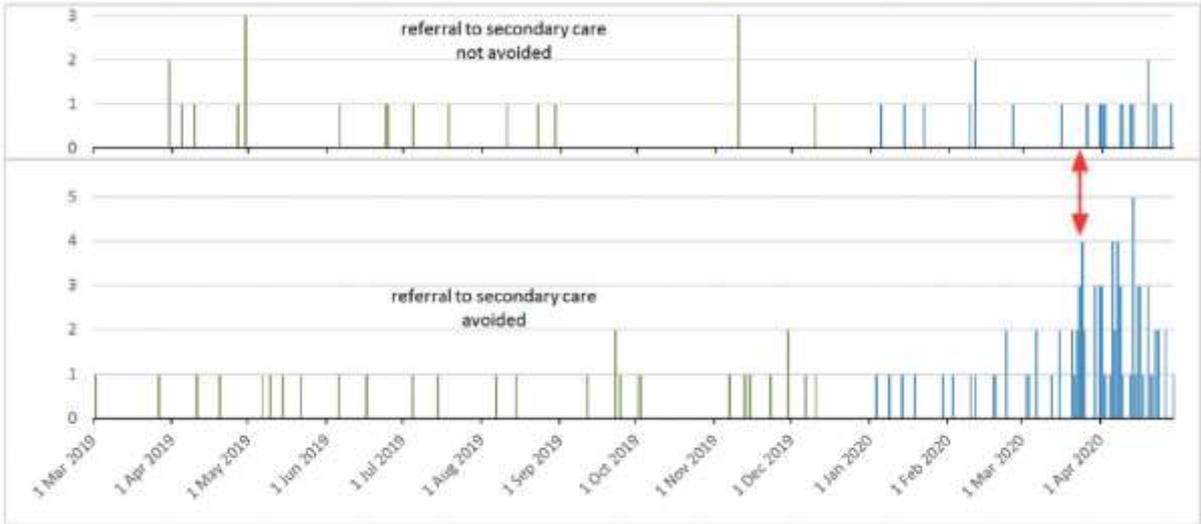


Figure 2. Number of referrals to secondary care not avoided (upper panel) and avoided (lower panel) by date. Green data from survey version 1, blue data from survey version 2. Red arrow indicates transition date (23 March 2020) from pre-lockdown to during-lockdown for data analysis.

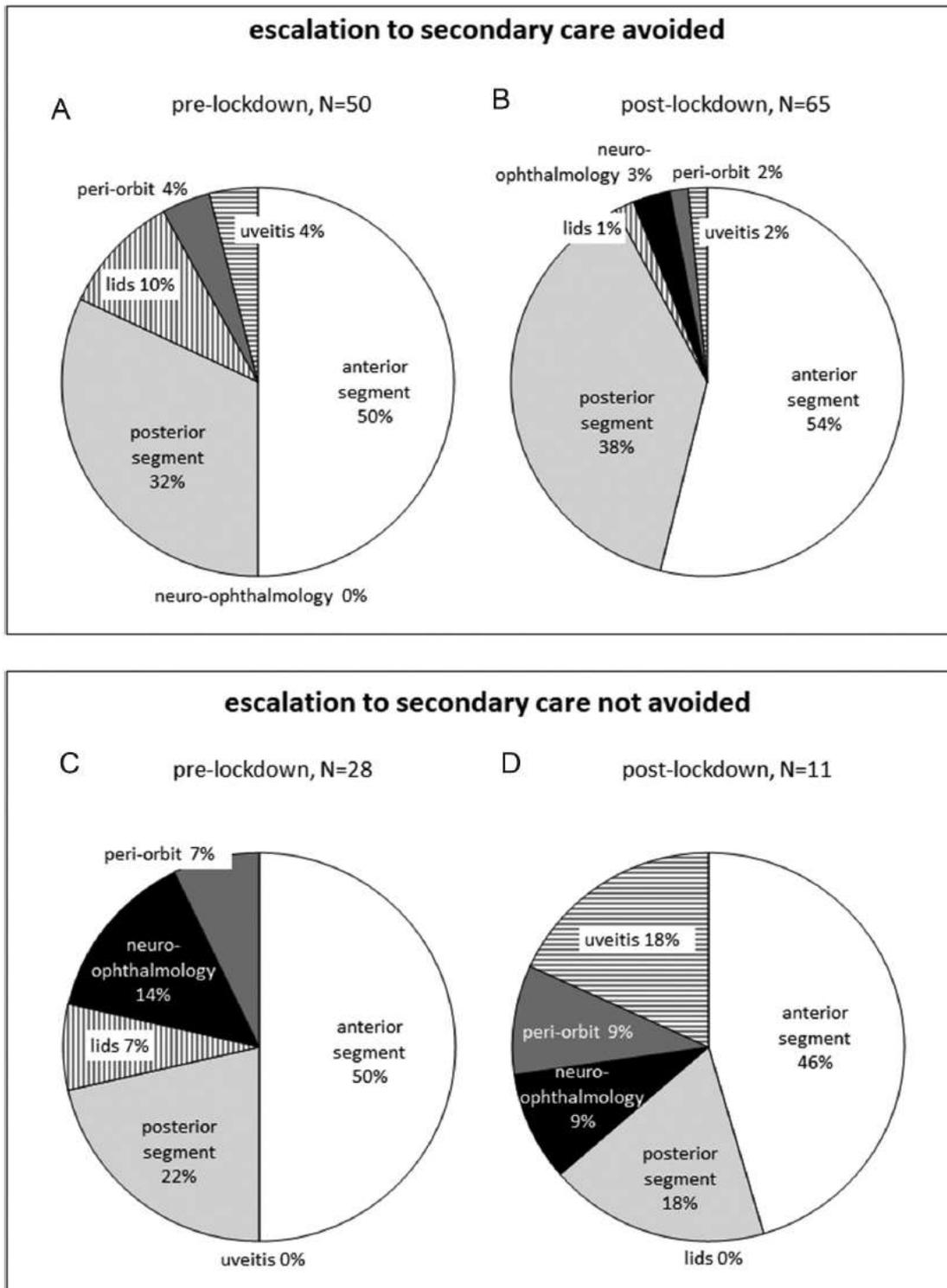


Figure 3. Pattern of presenting conditions by eye subspecialty where escalation to secondary care was avoided A, B or not avoided C, D. Left hand charts A, C: illustrate pre-lockdown presenting conditions, right hand charts B, D: illustrate during-lockdown presenting conditions.