This is an Open Access document downloaded from ORCA, Cardiff University's institutional repository: https://orca.cardiff.ac.uk/id/eprint/160187/

This is the author’s version of a work that was submitted to / accepted for publication.

Citation for final published version:

Publishers page: https://doi.org/10.3399/BJGP.2022.0616

Please note:
Changes made as a result of publishing processes such as copy-editing, formatting and page numbers may not be reflected in this version. For the definitive version of this publication, please refer to the published source. You are advised to consult the publisher’s version if you wish to cite this paper.

This version is being made available in accordance with publisher policies. See http://orca.cf.ac.uk/policies.html for usage policies. Copyright and moral rights for publications made available in ORCA are retained by the copyright holders.
Title:
The burden of acute eye conditions on different healthcare providers: a retrospective population-based study

Author list:
Anna Rawlings, PhD¹
Research Officer / Senior Data Scientist; ORCID ID 0000-0003-3929-474X

Angharad Hobby, PhD²,⁶
Research Associate & Senior Lecturer; ORCID ID 0000-0002-6007-2685

Barbara Ryan, PhD²
Professor; ORCID ID 0000-0003-3722-8757

Andrew Carson-Stevens, PhD³
Clinical Professor of Patient Safety and Quality Improvement; ORCID ID 0000-0002-7580-7699

Rachel North, PhD²,³
Professor of Optometry; ORCID ID 0000-0002-6657-5099

Mathew Smith, PhD⁴
Reader

Sioned Gwy, MBBCh³
Honorary Research Fellow

Nik Sheen, PhD⁵
Eye Care Transformation Lead; ORCID ID 0000-0003-2746-8626

Jennifer H. Acton, PhD²*
Senior Lecturer; ORCID ID 0000-0002-0347-7651

Affiliations
¹ Swansea University Medical School
² School of Optometry and Vision Sciences, Cardiff University
³ PRIME Centre Wales, Division of Population Medicine, School of Medicine, Cardiff University
⁴ School of Pharmacy and Pharmaceutical Sciences, Cardiff University
⁵ Health and Education Improvement Wales (HEIW)
⁶ University of the West of England Bristol

*Corresponding author
actonj@cardiff.ac.uk

Manuscript word count: 2,811

Keywords
eye, primary health care, optometry, pharmacy, general practice, emergency medicine
Abstract

**Background:** The demand for acute eyecare exponentially outstrips capacity. Public awareness of community eyecare services is lacking.

**Aim:** We primarily aimed to quantify the burden of acute eyecare on different healthcare service providers in a national population through prescribing and medicines provision by GPs, optometrists and pharmacists and provision of care by Accident and Emergency (A&E) services. We further aimed to characterise some of the drivers of this burden.

**Design & Setting:** Retrospective data-linkage study set in Wales, UK.

**Method:** Analysis of datasets from the Secure Anonymised Information Linkage Databank (GP and A&E), the ‘Eye Health Examination Wales’ service (optometry) and the ‘Common Ailments Scheme’ (pharmacy) during 2017-2018.

**Results:** We identified 65.4 episodes of care per 1,000 people per year, a GP prescribing rate of 0.9% and an A&E attendance rate of 0.6%. Optometrists and pharmacists managed 51.8% and 0.6% of all episodes respectively. Older females and infants of both sexes were more likely to use GP prescribing services, while adolescent and middle-aged males were more likely to visit A&E. GP prescribing burden was driven partially by economic deprivation, access to services and health score. Season, day of the week and time of day were predictors of burden in GP and A&E.

**Conclusion:** Acute eyecare continues to place considerable burden on GP and A&E services in Wales, particularly in urban areas with greater economic deprivation and lower overall health. This is likely to increase with a rapidly ageing population. With ongoing pathway development to better utilise optometry and pharmacy and improved public awareness, there may be scope to change this trajectory.

How this fits in

The demand for acute eyecare is high, and new eyecare pathways delivered by optometrists and pharmacists are promising, yet the burden of acute eyecare all acute eyecare providers is unknown. This is the first study to collate data at a national level and describes attendance and prescribing rates in Wales. Optometrists and GPs managed the greatest burden, but significant A&E attendances remain. Improving public awareness of the allied healthcare services for acute eye conditions may help to relieve current pressures.
Introduction

The demand for urgent eyecare exceeds capacity(1,2), but continues to increase(3). Eye-related attendances to UK accident and emergency (A&E) departments rose from 1.9% in 2014 to 3.8% in 2015(4), and a nationally-representative sample in the US, rose from 740,000 in 2007 to 932,000 in 2015(5). More recently, the burden on eyecare services has been further complicated by the COVID-19 pandemic(6,7).

Eye-related issues account for 1-2% of all general practitioner (GP) consultations(8,9). Conjunctivitis is the most common ocular disorder presenting to GPs(10,11). Yet, many GPs are not confident in the management of red eye conditions(12).

Public awareness as to where to seek help for eye conditions is lacking(13,14). Whilst many ocular problems are acute, a high proportion are not sight- or life-threatening. Non-emergency conditions comprised 44% of all eye-related US emergency department visits(15). In the UK, 30% and 37% attending specialist ocular(16) and general A&E(17), respectively, could have been managed in the community. Effective optometrist-led enhanced eyecare(4,18–21) and pharmacist-led minor conditions schemes(22,23) could reduce the burden on hospital and GP services(24).

The study primarily aimed to quantify the burden of acute eyecare on different healthcare service providers in a national population, including the quantification of burden on GP, optometry and pharmacy prescribing/medicines provision and on A&E services. A secondary aim was to understand some of the drivers of increasing burden. We established several hypotheses which are illustrated in Fig 1.
Methods

Study design and data sources

This was a cross-sectional study of patients presenting to GP, A&E, community pharmacy or optometry services in Wales for acute eyecare. Anonymised patient and consultation data, demographic data and socio-economic data were acquired from the Secure Anonymised Information Linkage (SAIL) Databank(25,26), the ‘Eye Health Examination Wales’ service and the ‘Common Ailments Scheme’. Study flow chart is presented in Fig 1 showing data sources used in this study (Supplementary Information gives detailed description of data sources).

We took the 2,660,925 people registered to a SAIL GP practice at any point between 1st July 2017 and 30th June 2018 (study period), equating to 85.1% of the mid-2017 whole-Wales population(27). We considered two sub-sets of this population: our study population comprised all individuals who had interacted with a SAIL GP or Welsh A&E unit for acute eye care during the study period; the general population comprised all individuals who were issued a prescription by a SAIL GP or attended a Welsh A&E unit for any reason, including for acute eyecare, during the study period.

Licensed medicines for acute eye conditions can be prescribed by a GP, Independent Prescriber (IP) optometrist, or another prescriber, and a sub-set of these can be supplied by UK entry-level optometrists. GP and A&E datasets were selected based on coded medicines/items associated with acute eyecare (Supplementary Information provides a description of the coding processes). The final code lists were deposited in the SAIL Databank Concept Library(28)(concepts C2913&C2914)(29).

The Welsh Government’s measurement of deprivation is the Welsh Index of Multiple Deprivation (WIMD; Supplementary Information provides a detailed description of WIMD). The following deprivation information was captured for each individual based on their residential address on the date of their first eligible event in the study: overall deprivation score; access to services (ATS) domain score in quintiles (ATS levels 1-5, level 1 being the most deprived); and health domain score.
Publicly available metrics for the ATS and health domains for each individual consisted of i) average public and private travel times to GPs and pharmacies for each residential area (minutes) and ii) the rate of chronic and limiting conditions for each residential area, respectively. Supplementary Information provides the calculation of age.

**Incidence and prescribing rates**

We calculated rate of incidence of acute eye episodes per 1,000 persons registered to SAIL GPs within the study period. The rate of eligible GP-issued prescriptions was calculated from the total number of prescriptions issued for all conditions by SAIL GPs during the same period.

**Statistical analysis**

We used data visualisation to understand proportional changes in burden over temporal, demographic and socio-economic ranges and statistical models to investigate whether these changes were statistically significant and to understand some of the drivers underpinning them. We report on models of best fit as assessed by likelihood ratio tests (lmtest(30)) and with the greatest predictive power assessed by comparison of McFadden’s pseudo-$R^2$ (DescTools(31)).

Hierarchical quasi-Poisson generalized linear model (glm) modelled effects of demographics (age and sex) and socio-economic status (WIMD quintiles) on the total number of GP prescribing events per person (total burden). Patient ages were grouped only for the purposes of data visualisation and to protect privacy of patient information.

Hierarchical binomial and multinomial logistic regression (nnet Package(32)) modelled the timings of first prescription issued by GPs and of the first A&E event attended. Temporal predictors were time-of-day, day-of-week and season in which these first events event took place. For each temporal predictor examined in each service provider, likelihood of an event occurring was considered at two levels: total burden wherein all event types were combined (binomial logistic regressions) and individual drug/diagnosis type (multinomial logistic regressions).
Data linkage and cleaning was performed using SQL to query IBM DB2 databases, and analysis and data visualisation using R version 4.1.2

**Results**

**Demographics of primary and secondary acute eyecare provision in Wales**

The general population was 1,923,779 (50.2% females), whilst the total study population receiving acute eyecare via GP and A&E services in that year was 173,494 (60.4% females; Table 1).

The study population using GP services for eyecare (Fig 2e) was dominated by individuals aged \( \geq 25 \) years. Females used these services more than males in all age groups. A&E services (Fig 2f) were used most by those aged 25-64 and all age groups up to 74 years were dominated by males.

Burden of eyecare on GP and A&E services decreased in younger individuals (0-44 years) as deprivation reduced and there was an increase in burden in the oldest age groups (65+) with reduced deprivation, mirroring trends for conditions generally (Fig 2).

**Incidence and prescribing rates**

We identified 173,999 acute eyecare episodes delivered by GP (168,877 episodes) and A&E (5,222) services during the study period. This resulted in an incidence rate of 65.4 episodes of care per 1,000 people per year. There were 300 referrals between GP and A&E services. Supplementary Information provides detailed results on referrals between services.

GPs prescribed a total of 87,973,653 prescriptions within the general population. Of these, 820,693 were related to acute eyecare (Table 2), resulting in a prescribing rate of 0.9% for acute eye conditions for the year. Most eye-related prescriptions were for ocular lubricants (623,250) or anti-allergy or anti-inflammatory drugs (114,766). A total of 766,083 (93.3%) could be supplied by entry-level optometrists while 54,610 (6.7%) prescriptions would require IP qualification. Overall mean GP
episode burden was 3.65 prescribing events per person and 63.1% of episodes comprised a single prescription.

We identified 5,222 eye-related and 905,224 general A&E attendances, respectively, resulting in an A&E annual attendance rate of 0.6% for eye-related causes. Presenting reasons are shown in Table 2b.

Of the 188,960 attendances to the optometry acute eyecare service, 116,868 items were supplied or advised (Fig 3). Of 2,085 attendances to the community pharmacy Common Ailments Scheme, most were females over 45 years.

All four services collectively managed 365,044 acute eyecare episodes, of which optometrists and pharmacists managed 51.8% and 0.6% of cases, respectively. Services collectively issued 939,926 acute eye medications/prescriptions, of which optometrists and pharmacists issued 12.5% and 0.3% respectively.

Effects of demographics and socio-economic status on GP prescribing services

Quasi-Poisson glm on total burden revealed significantly positive associations between patient age and episode burden (adjusted Poisson regression coefficient [adjusted β] 1.76, 95% confidence interval[CI]=1.75, 1.77, p < 0.001; Fig 4e; Supplementary Table S1) and between episode burden and female sex (adjusted β 1.17, 95%CI=1.15, 1.18, p < 0.001).

We observed a significantly negative association between episode burden and overall deprivation score, i.e. episode burden was lowest in more affluent Lower layer Super Output Areas (LSOAs; adjusted β 0.94, 95%CI=0.92, 0.95, p < 0.001). In contrast we observed a significantly positive association between episode burden and ATS domain scores, i.e. episode burden was highest in more highly provisioned connected LSOAs (adjusted β 1.07, 95%CI=1.05, 1.09, p < 0.001). We found no association between episode burden and rates of chronic conditions or limiting illnesses in a patient’s LSOA.
Effect of seasonality on likelihood of GP prescribing events

Following data visualisation we observed that burden was greatest in summer (52.3%; n=83,919) and lowest in winter (14.4%; n=23,109; Fig 4b). Prescribing of ocular lubricants in summer was particularly high (52.0%; n=48,687). The proportion of anti-allergy and anti-inflammatory drugs issued was greatest during the spring months (29.6%; n=7,232). The majority (62.4%; n=14,419) of prescriptions issued in winter were antimicrobials, however, similar counts of antimicrobials were prescribed in summer (n=13,470; 16.1%) and winter.

Logistic regression on total burden by season revealed increased likelihoods of a prescription being issued in spring (adjusted odds ratio [aOR] 1.51, 95%CI=0.38, 0.45, p < 0.001), summer (aOR=1.63, 95%CI=0.46, 0.52, p < 0.001) and winter (aOR=1.45, 95%CI=0.33, 0.41, p < 0.001) compared with autumn (n=28,968), despite overall burden being lower in both spring and winter (Supplementary Table S2).

Logistic regression on burden of individual drug types by season revealed that in summer, the likelihood of anti-allergy (aOR=7.94, 95%CI=1.69, 2.43, p < 0.001), ocular lubricants (aOR=5.16, 95%CI=1.25, 1.99, p < 0.001), physical intervention (aOR=3.44, 95%CI=0.78, 1.68, p < 0.001) and antimicrobial (aOR=1.48, 95%CI=0.01, 0.75, p = 0.003) prescriptions being issued were highly significantly elevated over items classed as other. In spring, the likelihood of anti-allergy prescription being issued increased (aOR=2.01, 95%CI=0.37, 1.10, p < 0.001) and that of ocular lubricants decreased (aOR=0.56, 95%CI=-0.91, -0.19, p = 0.001) significantly. In winter, the likelihood of antimicrobial prescriptions being issued increased (aOR=1.59, 95%CI=0.24, 0.95, p = 0.011) significantly.

Effect of day-of-the-week on GP prescribing events

Logistic regression on total burden revealed that prescribing burden was greatest on Mondays (n=38,737; aOR =1.31, 95%CI=0.19, 0.35, p < 0.001; Fig 4a; Supplementary Table S3) and lowest on Thursdays (n=27,991; reference condition in logistic regression) with a modest increase on Fridays.
During the week, the proportional burden of each prescribing class remained consistent (Fig 4a). At the weekends, ocular lubricants and physical treatments accounted for a greater proportion of prescriptions issued (Fig 4a).

Effect of day-of-the week on A&E events

Following data visualisation we observed that A&E burden was greater on Saturdays (n=742) and Sundays (n=724) than on weekdays (Fig 4c). We observed modest increases in burden as a result of ophthalmic conditions and conditions classed as ‘other’ (serious and non-serious) towards the beginning and end of the week, with minima occurring mid-week. The reverse was true for foreign body trauma.

Logistic regression on total burden revealed that differences in likelihood of any event taking place between days were insignificant (Supplementary Table S4). Logistic regression on burden of individual drug types revealed that foreign body occurrences were significantly less likely to occur on all days compared with Thursdays. Allergy diagnoses were less likely to occur on Mondays (aOR<0.01, 95%CI=-1.93, 1.31, p < 0.001).

Likelihood of A&E events occurring out-of-hours

We observed an increase in burden on A&E services and the likelihood of an attendance out-of-hours (n=2,601; aOR=1.30, 95%CI=0.12, 0.41, p < 0.001; Supplementary Table S5) compared with attendances taking place between 6am-6pm Monday-Friday (n=2,225; Fig 4d). We also observed that females are more likely to use A&E services out-of-hours (aOR=1.36, 95%CI=1.21, 1.54), p < 0.001. The likelihood of an out-of-hours visit was lower for allergies (aOR=0.02, 95%CI=-5.66, -1.81, p < 0.001) and for conditions classed as ‘other, serious’ (adjusted OR=0.45, 95%CI=-1.17, -0.40, p < 0.001) than for other, non-serious cases.
The majority of items issued by optometrists were ocular lubricants \((n=76,680, \, 65.6\%); \text{Fig} \, 3c\), mostly to older age groups. Chloramphenicol \((n=25,539, \, 21.9\\%)) and anti-allergy drops \((n=8,781, \, 7.5\\%)) were mostly supplied to younger age groups. This age-related trend was also observed for items issued by pharmacies \((\text{Fig} \, 3e\)), who by contrast, issued chloramphenicol \((n=1,925)\) more than ocular lubricants \((n=420)\).

Logistic regressions on individual diagnosis types and drug types revealed statistically significant but negligible effects of age on items issued by optometrists \(\text{(Supplementary Table S6)}\). Similarly logistic regression on prescribing by pharmacies revealed a statistically significant but negligible increase in the issuing of ocular lubricants over chloramphenicol with increased age \((\text{aOR} \, = \, 0.98, \, 95\%\text{CI} \, = \, 0.97, \, 0.99, \, p \, = \, 0.004; \text{Supplementary Table S7)}\).

**Discussion**

**Summary**

This national-level population-based study characterises the burden on acute eyecare services across four distinct healthcare services. Optometrists and GPs managed the greatest burden of acute eye cases, with fewer attendances and medicines provision recorded in A&E and pharmacy, respectively.

An incidence rate of 65.4 episodes of care per 1,000 people per year attending GP and A&E services was found. The prescribing rate for GP services was 0.9\%. Although lower than previously reported UK rates\(4,9,33\), this may be explained in part by the well-established Welsh optometrist-led acute eye service, in which patients may attend same day acute eye appointments via community-based enhanced optometric services. The A&E attendance was 0.6\%, identical to that previously reported in the US\(34\).
Comparison with existing literature

The age and sex distribution in those attending GP and A&E services for acute eyecare represents a unique population relative to that for all conditions. Older females and infants of both sexes were more likely to use GP services, while adolescent and middle-aged males were more likely to visit A&E. This pattern agrees with previous findings in general A&E(15,35) and GP services(36,37).

A strong relationship between age and episode burden (no. prescriptions issued by GPs and attendances to A&E; adjusted $\beta$ 1.76, $p < 0.001$) was notable. Such relationships may be expected, since the burden on health services is greater amongst older adults(38) and dry eye symptoms increase with age(39,40). The older population in Wales is increasing rapidly. An increase in 24% of over 75s expected over the next decade(41), thus the burden reported here is likely to increase in the future.

GPs prescribed anti-allergy and anti-inflammatory drugs more frequently in spring/summer, consistent with the symptoms of ocular allergy which typically occur during these months(42). The type of prescription did not vary with days-of-the week for both GP and A&E services, nor did it vary for ‘out-of-hours’ A&E services compared to daytime hours. This is consistent with reported prescribing of antibacterial eye drops by GPs(43) and antibiotics by dentists(44).

Ocular lubricants and antimicrobial drugs accounted for 43% and 33% of all acute eye-related GP prescriptions, respectively. Similarly, optometrists mainly issued ocular lubricants (66%) and chloramphenicol (22%). Yet pharmacists issued fewer ocular lubricants (18%) relative to chloramphenicol (82%). This may reflect the availability of ocular lubricants for purchase in the pharmacy without a consultation with the pharmacist, unlike chloramphenicol. Ocular lubricants can be issued for both acute (e.g. viral conjunctivitis) and chronic (e.g. recurrent corneal erosions) conditions, but are frequently prescribed for dry eye disease, a chronic disorder which often presents with acute symptoms(45). These commonly prescribed items support literature from the UK(46) and Canada(47). In Wales, 47% of people reported seeking help from their GP for eye pain...
and redness(14). Yet, GP trainees find management of eye conditions challenging(48) and there is
evidence of over-prescribing of antibiotics by GPs(49). Conversely, optometrists are well-placed to
manage such conditions in primary care, given their specialist equipment and training.

The study evidences the potential to reduce the burden of acute eyecare services on GPs,
given the changing eyecare pathways in the UK. Of the ~821K prescriptions issued by GPs, 93% were
identified as medicines that could have been supplied by entry-level optometrists while 7%
prescriptions would have required IP qualification. Given that optometry and pharmacy services
include weekend opening hours, there may be potential to reduce the burden of acute eye
attendances to A&E, which is greatest on these days. UK optometry services have responded to
increasing eyecare demand through the shift in some eyecare delivery from hospital to community
settings(24) and through upskilling in areas such as therapeutic prescribing(50), which can reduce
referral to acute hospital services(51).

Episode burden was found to decrease with increased affluence, consistent with prescribing
patterns for antibiotics(52) and general medicines(53) and the greater use of general A&E(35) and
GP(37) services in more deprived areas. Whilst deprivation is thought to be one determinant of
health, it is likely influenced by many complex factors, including social inequalities, e.g., income
inequalities and differences in health behaviour(54,55).

**Strengths and limitations**

This study utilises routinely collected administrative data and is limited by completion and
linkage accuracy, however we observed a low level of missing data from the SAIL databank with
WIMD data missing for 8,833 (5.1%) of individuals. The findings do not represent individuals
obtaining medicines from hospitals, without a prescription, from a pharmacy outside the Common
Ailments Scheme, or through private medical services. Data on sex was not available in the
optometry dataset. It was assumed that each consultation was a separate patient in both optometry
and pharmacy datasets. Any dataset using coded data from healthcare professionals may be liable to coding errors and is not subject to code validation in this study.

**Implications for practice**

Our findings reflect the well-established link between socioeconomic deprivation and poor health, as well as lower levels of health literacy (56–58). Poor health literacy is associated with poorer outcomes in a range of eye conditions (59–61). Interventions improving health literacy in deprived areas have been successful in other health conditions (62–65) and could similarly contribute to appropriate care-seeking behaviour for acute eyecare. For example, behavioural interventions that are community-based and facilitated by trained peer supporters are aimed at improving awareness of conditions and reducing time to symptom presentation. In the context of acute eye care, this could translate to, for example, awareness campaigns to choose optometry first for a red itchy eye. Some patients will continue to present to GP surgeries or A&E departments. Whilst clinical staff report lacking confidence in managing acute eye presentations (12,66), acute ophthalmic triage tools/checklists can facilitate safe and appropriate care (12,66–68). Examples of such tools include the NICE ‘Red Eye’ Clinical Knowledge Summary (https://cks.nice.org.uk/topics/red-eye/) and the BMJ Best Practice Assessment of red eye guidance (https://bestpractice.bmj.com/topics/en-gb/496).

Further exploration of the impact of easier access to ophthalmology specialist advice for community practitioners is warranted. All providers, e.g. reception staff and duty doctors in a GP service, should be aware of the capabilities and capacity of other healthcare providers for managing acute eye problems, and practices should review their procedures for supporting patient care navigation to ensure they attend the most appropriate eye care service within the practice or externally at first contact.

This study presents, for the first time to our knowledge, data combined from four different types of healthcare providers, using national-level population data, to represent the prescribing burden associated with acute eyecare. Acute eyecare continues to place considerable burden on GPs
and A&E, particularly in areas with greater economic deprivation and lower overall health. This is likely to increase with a rapidly ageing population. With ongoing pathway development, including weekend optometry and pharmacy services, community-based IP pharmacists and patient education, there may be scope to change this trajectory. The evidence highlights the imperative to ensure sufficient workforce planning in optometry and pharmacy to reduce the burden on GPs and A&E. Future evaluations of service improvement efforts must examine for unintended consequences on competence that might be created elsewhere in the system (e.g., in general practice).

Additional Information

Funding: School of Optometry and Vision Sciences, Cardiff University, Pump Priming Fund for Public Health Research.

Ethical approval: Ethical approval for the study was granted by the North West - Preston Research Ethics Committee (reference: 19/NW/0481), Integrated Research Application System reference: 254801.

Competing interests: All other authors have declared no competing interests.

Acknowledgements: None

References


department at the University Hospital of Wales, Cardiff, UK. Clin Exp Optom. 2020;103(6):895–901.


20. Buller AJ. Results of a glaucoma shared care model using the enhanced glaucoma staging
system and disc damage likelihood scale with a novel scoring scheme in New Zealand. Clin


### Tables

<table>
<thead>
<tr>
<th></th>
<th>General population</th>
<th>General pop. with any GP event</th>
<th>General pop. with any A&amp;E event</th>
<th>Study population</th>
<th>Study population with eye-related GP event</th>
<th>Study population with eye-related A&amp;E event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total count</td>
<td>2,660,925</td>
<td>1,923,780</td>
<td>494,848</td>
<td>173,494</td>
<td>169,081</td>
<td>5,088</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>1,325,255</td>
<td>867,310</td>
<td>246,718</td>
<td>68,737</td>
<td>65,776</td>
<td>3,320</td>
</tr>
<tr>
<td>Females</td>
<td>1,335,664</td>
<td>1,056,469</td>
<td>248,130</td>
<td>104,757</td>
<td>103,305</td>
<td>1,768</td>
</tr>
<tr>
<td>Missing</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Deprivation score</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WIMD 1 (most deprived)</td>
<td>506,137</td>
<td>385,821</td>
<td>115,245</td>
<td>34,649</td>
<td>33,557</td>
<td>1,268</td>
</tr>
<tr>
<td>WIMD 2</td>
<td>491,846</td>
<td>376,240</td>
<td>103,187</td>
<td>33,632</td>
<td>32,764</td>
<td>1,007</td>
</tr>
<tr>
<td>WIMD 3</td>
<td>453,482</td>
<td>338,633</td>
<td>85,419</td>
<td>31,449</td>
<td>30,757</td>
<td>784</td>
</tr>
<tr>
<td>WIMD 4</td>
<td>429,544</td>
<td>323,647</td>
<td>75,709</td>
<td>29,980</td>
<td>29,270</td>
<td>802</td>
</tr>
<tr>
<td>WIMD 5 (least deprived)</td>
<td>485,449</td>
<td>365,009</td>
<td>78,375</td>
<td>34,951</td>
<td>34,134</td>
<td>965</td>
</tr>
<tr>
<td>Missing</td>
<td>294,467</td>
<td>134,430</td>
<td>36,913</td>
<td>8,833</td>
<td>8,599</td>
<td>262</td>
</tr>
</tbody>
</table>

*Table 1* Overview of the general and study populations selected for the study broken down by sex and Welsh Index of Multiple Deprivation (WIMD) score. **General population**, all individuals registered to a SAIL GP practice at any time during the study period (85.1% of the mid-2017 whole Wales population); **study population**, individuals within the general population who had an eligible GP prescribing event or A&E event during the study period.
<table>
<thead>
<tr>
<th>Prescription type</th>
<th>A&amp;E eye care patients</th>
<th>A&amp;E eye care events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anti-allergy and anti-inflammatory drugs</td>
<td>114,766</td>
<td>41,347</td>
</tr>
<tr>
<td>Antimicrobial drugs</td>
<td>80,921</td>
<td>62,462</td>
</tr>
<tr>
<td>Ocular lubricants</td>
<td>623,250</td>
<td>81,339</td>
</tr>
<tr>
<td>Physical treatments</td>
<td>1,609</td>
<td>422</td>
</tr>
<tr>
<td>Other</td>
<td>147</td>
<td>146</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,088</strong></td>
<td><strong>5,222</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equivalent prescriber level</th>
<th>A&amp;E eye care patients</th>
<th>A&amp;E eye care events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry level</td>
<td>166,371</td>
<td>766,083</td>
</tr>
<tr>
<td>Independent prescriber</td>
<td>22,480</td>
<td>54,610</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>A&amp;E eye care patients</th>
<th>A&amp;E eye care events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allergy</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Foreign body</td>
<td>1,207</td>
<td>1,241</td>
</tr>
<tr>
<td>Ophthalmic</td>
<td>940</td>
<td>946</td>
</tr>
<tr>
<td>Other – non-serious</td>
<td>2,339</td>
<td>2,377</td>
</tr>
<tr>
<td>Other - serious</td>
<td>635</td>
<td>641</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Treatment</th>
<th>A&amp;E eye care patients</th>
<th>A&amp;E eye care events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandage / support</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Dressing</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Drug administration</td>
<td>564</td>
<td>566</td>
</tr>
<tr>
<td>Guidance / advice only</td>
<td>1,312</td>
<td>1,341</td>
</tr>
<tr>
<td>Incision and drainage</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>No treatment required</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Not stated</td>
<td>2,655</td>
<td>2,685</td>
</tr>
<tr>
<td>Observation</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Removal of foreign body</td>
<td>370</td>
<td>376</td>
</tr>
<tr>
<td>Wound closure</td>
<td>136</td>
<td>137</td>
</tr>
</tbody>
</table>

Table 2 (a) GP prescribing and (b) A&E events in the study and general population. Total patient count is lower than aggregated totals for diagnoses and treatments because total patient count = unique patients and some patients have multiple events within or across sub-groups.
Figure Legends

Figure 1 Study flow chart and hypotheses

Figure 2 GP and A&E dataset showing distribution with age (a-f) and Welsh Index of Multiple Deprivation (g-l). The number of male and female individuals in each of 7 age groups are shown within (a) the general Wales population, (b) the general Wales population who had a GP prescribing event for any condition during the study period, (c) the general Wales population who used A&E services for any reason during the study period, (d) the study population, (e) the study population who had a GP prescribing event for an acute eye condition during the study period, and (f) the study population who used A&E services for an eye-related injury during the study period. The proportion of individuals within each of 7 age groups within WIMD quintiles are shown in (g) the general Wales population, (h) the general Wales population who had a GP prescribing event for any condition during the study period, (i) the general Wales population who used A&E services for any reason during the study period, (j) the study population, (k) the study population who had a GP prescribing event for an acute eye condition during the study period, and (l) the study population who used A&E services for an eye-related injury during the study period. The age groupings are based on those used by the Welsh Government in the derivation of population estimates (https://statswales.gov.wales).

Figure 3 Optometry and pharmacy data. Eye Health Examination Wales (optometry) audit data for the study period showing (a) the number of individuals in each of 7 age groups, (b) the proportion of symptoms recorded per age group by symptom type and (c) the proportion of items issued per age group by drug type. The Common Ailments Scheme (pharmacy) audit data for the study period showing (d) the number of male and female individuals in each of 7 age groups and (e) the proportion of items issued per age group by drug type. The presented categorisations of symptoms and type of drug are consistent with those reported in the audit data for the given service, and therefore differ between services.

Figure 4 Burden of acute eye care conditions over time and effect of predictor variables. Burden of acute eye care conditions on (a) GP prescribing services by week-day classified by drug type, (b) GP prescribing services by season classified by drug type, (c) A&E services by week-day classified by diagnosis type, (d) A&E services by whether the event took place out-of-hours (outside of 6am – 6pm Monday – Friday) or not. To prevent the disclosure of identifying information, physical and ‘other’ treatments have been removed from (a) and allergy diagnoses have been removed from (c) and (d). Effect sizes of demographic and socio-economic predictor variables on episode burden of acute eye conditions, measured as the number of prescriptions issued, calculated through quasi-Poisson GLM. \( \text{Exp}(est) = \text{exponentiated Poisson regression coefficient (} \beta \text{) indicating the unit change in the outcome (number of prescriptions) with each unit or level change in each predictor, should all other predictors be held constant (} \text{e}) \). Error bars in (e) show the 95% confidence intervals. WIMD levels 2-5 = Welsh Index of Multiple Deprivation quintiles contrasted against the most deprived areas (level 1); Chronic conditions = rate of chronic conditions measured within the Welsh Index of Multiple Deprivation; Limiting illness = rate of limiting illnesses measured within the Welsh Index of Multiple Deprivation; ATS levels 2-5 = Access to Services domain quintiles contrasted against the most deprived areas (level 1). The presented categorisations of drug and diagnosis type are consistent with those reported in the audit data for the given service, and therefore differ between services.