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Heterogeneity of reasons for attendance in high users of emergency departments and its relationship to future attendance.

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Abstract

Background

Emergency care services globally are under increasing pressure through rising demand. High users of services are known to have complex health needs and use a disproportionate amount of resources. We hypothesized that heterogeneity of individual patients' reason for attendance at emergency departments could be used to characterise patients and their likelihood of future attendance.

Method

We analysed an anonymized dataset of all emergency department (ED) visits over the course of 2014 in Yorkshire, United Kingdom. We identified 15986 patients who had five or more emergency department encounters at any ED in the calendar year. Presenting complaint was categorized into one of 14 categories based on the Emergency Care Data Set (ECDS). We calculated measures of heterogeneity (count of ECDS categories and entropy of categories) and examined their relationship to total number of ED visits and to patient characteristics. We also examined the predictive value of these and other features on future attendance.

Results

Most frequent attenders attended with more than one presenting complaint type. Heterogeneity increased with number of attendances, but heterogeneity adjusted for number of attendances did not vary substantially with patient age or sex. Heterogeneity was associated with the presence of one or more contacts for a mental health problem. For a given number of attendances, greater heterogeneity of presenting complaint was associated with a lower probability of further attendance.

Conclusions

Heterogeneity of presenting complaint can be quantified and analysed for emergency department use and is only weakly associated with age. This suggests it reflects more than the number of medical conditions.

What this paper adds

What is already known on this subject

Recognising and dealing with users of the Emergency Department is a ubiquitous problem

High users are a diverse group and few methods are available to predict which high users will continue to attend.

We hypothesised that attending for multiple different reasons may be a predictor of future high use

What this study adds

Attending for multiple reasons was only weakly related to age (suggesting it was not strongly related to multiple illnesses).

Attending for multiple reasons did not predict further attendance in high users.

Background

Emergency department (ED) care is under increasing pressure both in the UK and internationally due to growing numbers of patients presenting to emergency departments¹. One aspect of this which has attracted attention is the issue of high users of EDs². There is no single definition of high use, and in different studies it varies between 3-12 or more attendances in a single year³. However, regardless of the definition, high users make up a disproportionate amount of attendances. UK based studies show 3-4% of emergency department patients are high users and account for 8-12% of all attendances^{4 5}.

The literature suggests that high users are a diverse group of individuals, often with complex health needs. Previous studies have found high users are more likely to be male⁶, older⁷ and to suffer from mental health or substance misuse problems.^{4 8 9} Several studies have shown that high users are more likely to suffer from chronic health problems^{10 11}, more likely to be admitted and more likely to have a poorer outcome during a hospital stay¹¹. Several studies have indicated that high use is also associated with the presence of functional¹² or “medically unexplained” symptoms¹³⁻¹⁵. Patients with functional symptoms commonly have multiple symptoms in multiple body systems¹² for which they seek medical attention¹⁶. and the presence of multiple reasons for attendance may be a pointer to this.

We hypothesized that heterogeneity of the reason for attendance¹⁷ may be informative in understanding high users. First, it may indicate the presence of multiple medical comorbidities; second, it may indicate a tendency to experience and consult for multiple different physical symptoms as is seen in many patients with functional disorders^{12 14 15}; or third it may indicate a lower threshold for consulting due to anxiety or concurrent mental distress. As such it may have value both as a marker of risk for further attendance and as an indicator that attention should focus beyond the immediate presenting complaint and onto the patient’s wider condition and context.

In this study, we aimed to measure the heterogeneity of presenting complaints among high users of ED care, to describe its association with patient characteristics and to examine whether it was predictive of further ED usage.

Methods

Study Design

Cross sectional analysis using routinely collected ED data.

Ethics and permissions

Ethical approval for use of the dataset in this research was gained from the NHS Research Ethics Committee (REC reference 14/YH/1139). The NHS Health Research Authority Confidentiality Advisory Group also approved the research (CAG REC reference 14/CAG/1015).

Patient and public involvement

Patients were not directly involved in the planning or execution of this research which involved routinely collected healthcare data. Three public members of the Sheffield Emergency Care Forum commented on the final manuscript.

Data collection

The study used data collected as part of the NIHR Collaboration for Leadership in Applied Research and Care (CLAHRC) Yorkshire and Humber (Y&H) to form the CUREd database CUREd database¹⁸. This involved a retrospective cross-sectional database linking routine NHS health data from a number of UEC providers within a single geographical region in England (Yorkshire and Humber) which is now part of the The region has a population of 5.5 million people with a mixture of urban (large and small), suburban and rural settings and as such is representative of the UK. At the time of data collection, the region included 13 acute hospital trusts with 19 type 1 EDs (consultant-led, with multi-specialty 24-hour services and full resuscitation facilities). The Y&H region is served by a single ambulance service (Yorkshire Ambulance Service, YAS).

Hospital data relating to ED attendances was extracted by the acute trusts from their ED administration systems. Data was linked at the patient level in order to identify and code attendances for the same patient at different EDs. All data were pseudonymised before use. We used data for new attendances and unplanned re-attendances for adults aged 18 years and over which occurred during the calendar year 2014.

Data management

Data items collected and used in this analysis included: age, sex, date of attendance, presenting complaint, and diagnosis. Coding of presenting complaint varied between EDs: some reported patient complaints verbatim, while others collected them in categories. For this analysis we chose to use categories relating to the Emergency Care Dataset¹⁹. This contains 14 categories of presenting complaint; Cardiovascular, Respiratory, Gastrointestinal, Neurological, Skin, Head and Neck, Eye, Orthopaedics/Trauma, Genitourinary, Obstetrics/Gynaecology, Environmental, Mental Health, Substance misuse, General/minor. Due to the sometimes brief details given for presenting complaint, it was impossible to satisfactorily separate mental health and substance misuse encounters, so these were merged together as a single mental health/substance misuse category. These 13 categories formed the basis of our set of Presenting Complaint Categories. We created extensive lookup tables of words and phrases within the presenting complaints field and used them to recode each presenting complaint to one of the categories. We were able to recode 99% of the data into one of the 13 categories, the remaining 1% of encounters (a mix of blank, unclear or very infrequently occurring terms) were placed in an additional “other” category.

Definition of high use

We used a cut-off number of attendances of five within the 12 month period for inclusion in this analysis. There is no standard definition for high use of emergency departments. While several recent studies have used a cut-off of four or more attendances³, we chose five as this was the threshold used in a recent study of GP Out of Hours service attendance which used a similar approach to analysis¹⁷. The data contained some instances where patients had multiple encounters on the same day. Where the reason for encounter was the same we used only the first encounter^{17 20}. Where the reasons for encounter were different we included all encounters.

Estimation of heterogeneity of presenting complaint

We used two measures of heterogeneity of reason for encounter, both of which are based on the presenting complaint category. The first was count of categories and the second was Shannon entropy of categories. Count of categories was defined as the number of different categories present in a sequence of consultations. Shannon entropy extends this by describing the unpredictability of the distribution of categories (if most consultations are in one category

it is quite likely the next one will be in that category too; if consultations are spread across several categories, it is harder to predict what the next one will be).. These measures which are widely used for instance in ecology have previously been used in a study of Primary Care Out of Hours services ¹⁷. Figure 1 illustrates the relationship between these, using the example of patients with 8 ED attendances for up to 4 categories of presenting complaint (indicated by the letters *A,B,C&D*). Shannon entropy increases when the attendances are more evenly distributed between presenting complaints categories and decreases when one or two presenting complaints account for most of the attendances. Both the count and the entropy of presenting complaint categories are strongly related to the total number of attendances and must be interpreted in the light of that.

FIGURE 1 ABOUT HERE

Statistical analysis

Association of measures of heterogeneity with patient characteristics

We plotted the relationship between count of presenting complaint categories, the entropy of presenting complaint categories and the total number of contacts by age, sex, and whether patients had any encounters for a mental health problem. We then examined the relationships between either the count or entropy of presenting complaint categories with age, sex and mental health contact using univariable linear regression, followed by multiple linear regression. Because of the large number of individuals in the data, we entered all variables into multiple regression models and model fit was estimated by Aikake Information Criterion (AIC).

Association of measures of heterogeneity with total number of contacts

We examined the interaction between count and entropy of presenting complaint category in terms of their association with the total number of contacts in two ways. First, we plotted total number of consultations against count of presenting complaint categories, showing patients with high and low entropy separately. High and low entropy were defined according to the median for each number of presenting complaint categories. Second, we carried out negative binomial regression with total contacts as the outcome variable and all other variables as predictors.

Predictive value of variables for further contact

To assess whether measures of heterogeneity could be clinically useful, we examined whether calculation of the measure after a given number of contacts was predictive of future contact. We used a range of values for the number of contacts (N) between 5 and 15. For each

value of N we identified all patients with at least N contacts and calculated the heterogeneity measures after those N contacts. We then used logistic regression to examine whether the heterogeneity measures predicted having N+1 contacts. We used count and entropy of presenting complaint categories (split at the median into high and low) and attendance with a mental health problem (present or absent) over the first N contacts as predictors. We calculated the odds ratio adjusted for age and sex for each value of N¹⁷.

Sensitivity analysis

During the analysis we found marked variation between EDs in the extent to which presenting complaints were coded. To examine whether this influenced our results we conducted a sensitivity analysis in which we repeated the analysis using only those EDs with many (>200) unique presenting complaints.

Data processing and statistical analysis was carried out using R 3.6.0.

Results

The dataset initially contained 1,272,817 ED encounters by adults aged 18 or over. 47,900 encounters were excluded because there was no linked pseudonymised ID number, leaving 1,224,917 encounters by 805,180 adults. A further 193,204 encounters were excluded: 169,165 (15.2%) without any presenting complaint data; 7340 duplicate encounter records and 26 with incomplete recording of age or sex. This left 1,031,713 encounters by 691,571 individuals. 15,986 (2.3%) of these individuals made five or more attendances over the year, representing 118,501 (11.5%) of eligible encounters and were therefore defined as high users.

The median age of high users was 50 (IQR 31 to 75) and 7778 (48.7%) were male. 3652 high users (22.8%) had one or more contact for a mental health problem. The distribution of contacts per patient was heavily skewed as has been found elsewhere²⁰. High users had a median of 6 contacts (range 5 to 152, IQR 5 to 8) with a median of 3 (IQR 2 to 4) unique encounter categories. 1794 (11.2%) high users had more than 10 encounters and 2395 (15.0%) had 5 or more different presenting complaint categories. Table 1 shows the distribution of different presenting complaint categories per patient by total number of contacts.

Association of measures of heterogeneity with patient characteristics

Figure 2 shows the relationship between the number of unique encounter categories and both the total number of contacts (left hand plots) and entropy of encounter categories (right hand plots). These are split by median age (plots A & B), sex (plots C&D) and whether patients had any encounters for a mental health problem (plots E & F). These show little difference between groups until applied to patients with at least 5 different encounter categories.

Table 2 reports the results of univariable and multiple variable linear regression with either number of presenting complaint categories or entropy of presenting complaint categories as the outcome variable. In light of the very large number of patients in the analysis, the finding of statistically significant differences in groups does not automatically render them clinically meaningful. While the strong association between number and entropy of categories is to be expected, more striking is the small effect of the other variables (mental health consultation history, age, or sex) on these measures of heterogeneity. Individually these accounted for only between <0.1% (sex) and 4-8% (mental health consultation history) of the variance of both number of categories and entropy of categories. The finding that less than 1% of the variance in count and entropy of presenting complaint categories is attributable to age suggests that comorbidity of long term conditions, which is strongly determined by age, is not a major contributor to heterogeneity of presenting complaint.

Association of measures of heterogeneity with total number of contacts

Figure 3 shows the relationship between count and entropy of presenting complaint categories and total contacts. It indicates that for each number of categories, patients with high entropy (more even distribution of attendances among the categories) have a lower overall number of contacts, than those with low entropy (most attendances for the same reason). The negative binomial regression confirmed these findings after adjustment for age, sex and having had any contact for a mental health condition.

Predictive value of variables for further contact

While figure 3 considers the association between count and entropy of presenting complaint in relation to total contacts, Table 3 considers whether this information is useful in predicting, after a limited number of contacts, whether a patient is likely to consult again. It shows the probability of one or more additional contacts, after each given number of contacts, expressed

as an odds ratio comparing those with an above-median or below-median value of a variable. The three variables shown are count and entropy of presenting complaint categories (comparing above-median value to median or less), and whether one or more attendance had been for a mental health problem (compared to no mental health problem). After each number of attendances (between 5 and 10), patients with higher levels of both measures of heterogeneity were less likely to reattend. For example after 7 attendances the odds ratio for an eighth attendance for a patient with a high rather than low entropy of presenting complaint category was 0.8 (95% confidence interval 0.72-0.90). In contrast a patient with at least one mental health presenting complaint was more likely to reattend than a patient with no mental health presenting complaints: odds ratio 1.57 (1.37-1.80)

Sensitivity analysis

The sensitivity analysis which was limited to EDs with >200 presenting complaints (8 EDs, 6605 high users, 49017 attendances) found no material differences in the results from the full analysis (data not shown), suggesting that the absence of major effects of heterogeneity on future attendance were not simply due to insufficient granularity of coding.

Discussion

Summary of principal findings

This is the first study to quantify and examine the heterogeneity of presenting complaints in frequent attenders at emergency departments. Despite the known increase in multimorbidity with age there was little increase in heterogeneity of presenting complaint with age. While higher heterogeneity was associated with total number of attendances, it was associated with a lower probability of future attendance after any given number of attendances.

Strengths and limitations

The main strength of this study is the use of a very large, population-wide dataset involving multiple different EDs. By examining associations across a range of thresholds for frequent attendance we were able to demonstrate that our initial assumptions have not affected our results. The main limitation was the inconsistency of recording presenting complaint between EDs. Some used a very wide range of statements – which we subsequently mapped to categories – while others used very few categories. Particularly in these low category number services we found examples of unhelpful coding (for instance weakness due to a stroke being

coded as musculoskeletal). However, the sensitivity analysis which was restricted to departments with many different recorded presenting complaints found no material differences in the findings. Our choice of 13 categories mirrored that in a study of a GP Out of Hours service.¹⁷ The use of presenting complaint from ED data which was not linked to other medical records meant we were unable to include any measure of actual multimorbidity. This means we could not disentangle the effects on attendance of concern about multiple symptoms from the presence of multiple diseases. The data also did not include information about individual patients' socioeconomic status.

Comparison with other studies

While this is the first study examining heterogeneity of presenting complaint in the ED, the findings are similar to those described in a study of users of a GP Out of Hours services¹⁷ which used the same approach. In both studies, there was little increase in heterogeneity with age. Neither study was able to triangulate heterogeneity of presenting complaint against documented multimorbidity.

Implications for practice and further research

This study demonstrates that heterogeneity of presenting complaint in high users of EDs is common and measurable. The weak association of heterogeneity with age suggests that while heterogeneity is likely in part driven by the number of medical conditions an individual has – which strongly increases with age - this is unlikely to be the whole explanation. An alternative explanation for high heterogeneity, is due to different illness perceptions²¹, greater experience of multiple symptoms^{14 15}, or a lower threshold for attendance (whatever the presenting complaint)²², rather than to the experience of more illnesses of such a severity as to require emergency medical care. While this might indicate an unrecognised mental health problem such as anxiety or high emotional distress, greater heterogeneity of reasons for attendance was less predictive of future attendance than explicitly presenting with one or more mental health problems. As the ECDS coding system becomes widely used, it should be possible to automate the sequence generation, which was labour intensive for this study, and use artificial intelligence approaches to identify additional signals in attendance data which are predictive of particularly high future attendance. These could be used to flag patients as at particularly high risk of reattendance and trigger active case management²³ particularly where mental health problems appear significant²⁴. Patient and public feedback was supportive of this

interpretation of the data, with one forum member emphasising also the patient safety issue of atypical presentation of serious illness as a rare but important element of multi-symptom attendance.

Conclusion

Heterogeneity of presenting complaint can be quantified and analysed for emergency department use and is only weakly associated with age. This suggests it reflects more than the number of medical conditions and should alert clinicians to the possibility of underlying functional somatic disorders or mental disorders.

Contributorship

CB had the original idea for the study and all authors were involved in design. TS, SM and CO’K provided the data and RH and CB carried out the analysis. RH wrote the first draft of the paper which was edited and reviewed by all authors.

Funder Statement

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Table 1: Number of presenting complaint categories by total number of attendances per individual patient

Attendances	5		6-7		8-10		11-14		15-20		21-30		31+		All Patients
	N	%	N	%	N	%	N	%	N	%	N	%	N	%	
1	473	7.1%	262	5.0%	79	3.4%	25	2.7%	4	0.8%	1	0.4%	1	0.7%	845
2	1878	28.3%	1055	20.1%	312	13.6%	88	9.3%	44	9.3%	8	3.3%	3	2.2%	3388
3	2690	40.5%	1887	36.0%	618	26.9%	177	18.8%	57	12.0%	32	13.2%	7	5.2%	5468
4	1342	20.2%	1401	26.7%	704	30.6%	289	30.6%	103	21.7%	35	14.4%	16	11.9%	3890
5	260	3.9%	559	10.7%	430	18.7%	218	23.1%	127	26.8%	54	22.2%	27	20.1%	1675
6	0		82	1.6%	128	5.6%	96	10.2%	86	18.1%	59	24.3%	36	26.9%	487
7	0		2		28	1.2%	42	4.5%	31	6.5%	31	12.8%	24	17.9%	158
8	0		0		2	0.1%	6	0.6%	13	2.7%	18	7.4%	9	6.7%	48
9	0		0		0		2	0.2%	9	1.9%	3	1.2%	7	5.2%	21
10	0		0		0		0		0		2	0.8%	3	2.2%	5
12	0		0		0		0		0		0		1	0.7%	1
TOTAL	6643		5248		2301		943		474		243		134		15986

Table 2 Results of linear regression (univariable and multiple variable) for two measures of heterogeneity of presenting complaint category

Outcome	Shannon entropy			Number of unique PCC		
	coefficient	95% CI	R ²	coefficient	95% CI	R ²
Univariable regression						
Predictor						
Number of unique PCC	0.434	0.431 to 0.437	0.852	-	-	
Shannon entropy	-	-		1.963	1.95 to 1.976	0.852
Total number of contacts	0.018	0.017 to 0.02	0.028	0.092	0.089 to 0.095	0.157
Any mental health contact	0.309	0.288 to 0.33	0.048	0.855	0.81 to 0.899	0.082
Age (decade)	-0.007	-0.011 to -0.003	0.001	-0.034	-0.042 to -0.026	0.004
Sex (male)	-0.021	-0.039 to -0.002	<.001	-0.021	-0.06 to 0.018	<.001
Multiple variable regression						
Number of unique PCC	0.479	0.477 to 0.482		-	-	
Shannon entropy	-	-		1.861	1.851 to 1.871	
Total number of contacts	-0.025	-0.026 to -0.025		0.056	0.055 to 0.057	
Any mental health contact	0.004	0.002 to 0.005		-0.005	-0.008 to -0.003	
Age (decade)	-0.017	-0.024 to -0.009		0.1	0.085 to 0.115	
Sex (male)	-0.001	-0.007 to 0.005		-0.008	-0.019 to 0.004	
Total R ²			0.899			0.913

Table 3 Prediction of probability of further attendance for each number of attendances

Attendance number ¹	Patients ²	Presenting complaint categories ³		Any mental health presenting complaint
		Count	Entropy	
		Odds ratio (95%CI)	Odds ratio (95%CI)	Odds ratio (95%CI)
5	15986	0.95 (0.91-0.98)	0.90 (0.84-0.97)	1.57 (1.44-1.72)
6	9343	0.94 (0.90-0.99)	0.88 (0.80-0.96)	1.56 (1.39-1.74)
7	6015	0.89 (0.85-0.94)	0.81 (0.72-0.90)	1.57 (1.37-1.80)
8	4095	0.96 (0.90-1.03)	0.88 (0.77-1.01)	1.40 (1.19-1.64)
9	3001	0.90 (0.84-0.97)	0.82 (0.70-0.97)	1.47 (1.22-1.79)
10	2299	0.88 (0.81-0.96)	0.77 (0.64-0.93)	1.55 (1.25-1.94)
11	1794	0.96 (0.87-1.06)	0.90 (0.73-1.12)	1.37 (1.06-1.77)
12	1450	0.96 (0.86-1.06)	0.98 (0.77-1.25)	1.63 (1.22-2.17)
13	1197	0.86 (0.77-0.97)	0.68 (0.51-0.90)	1.07 (0.77-1.47)
14	994	0.99 (0.87-1.12)	1.06 (0.78-1.44)	1.51 (1.04-2.18)
15	851	0.96 (0.84-1.09)	0.91 (0.66-1.25)	1.23 (0.84-1.79)

¹ This relates to all patients at their nth attendance, not just patients with exactly that number of attendances.

² Patients with at least this number of attendances

³ Odds ratios calculated for high vs low count or entropy based on a median split of the values calculated at each number of attendances.

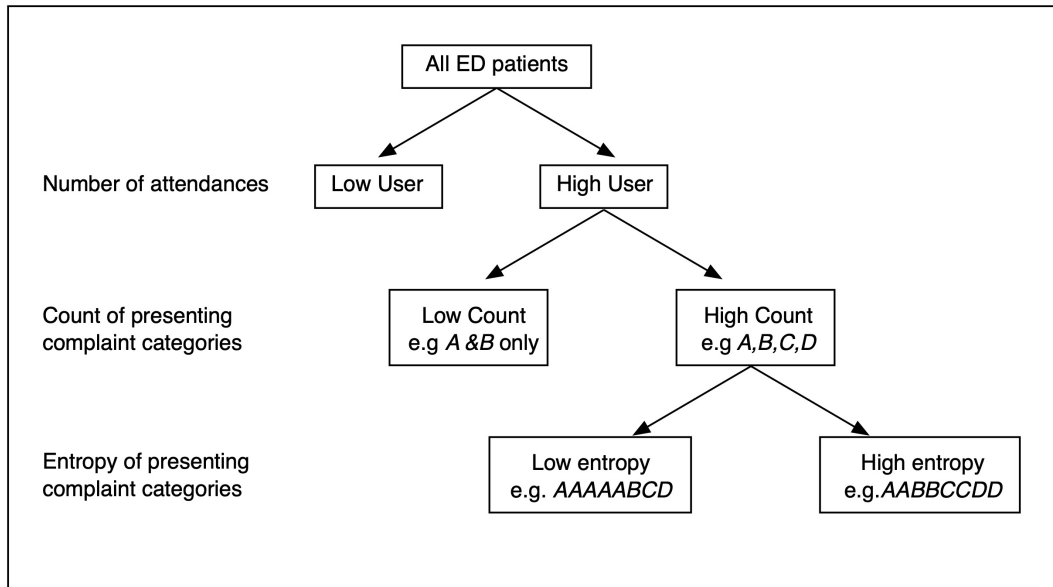


Figure 1 Schematic representation of the relationship between number of attendances, number of presenting complaint categories and entropy of presenting complaint categories. Letters in italics refer to hypothetical presenting complaint categories and are provided as illustration only.

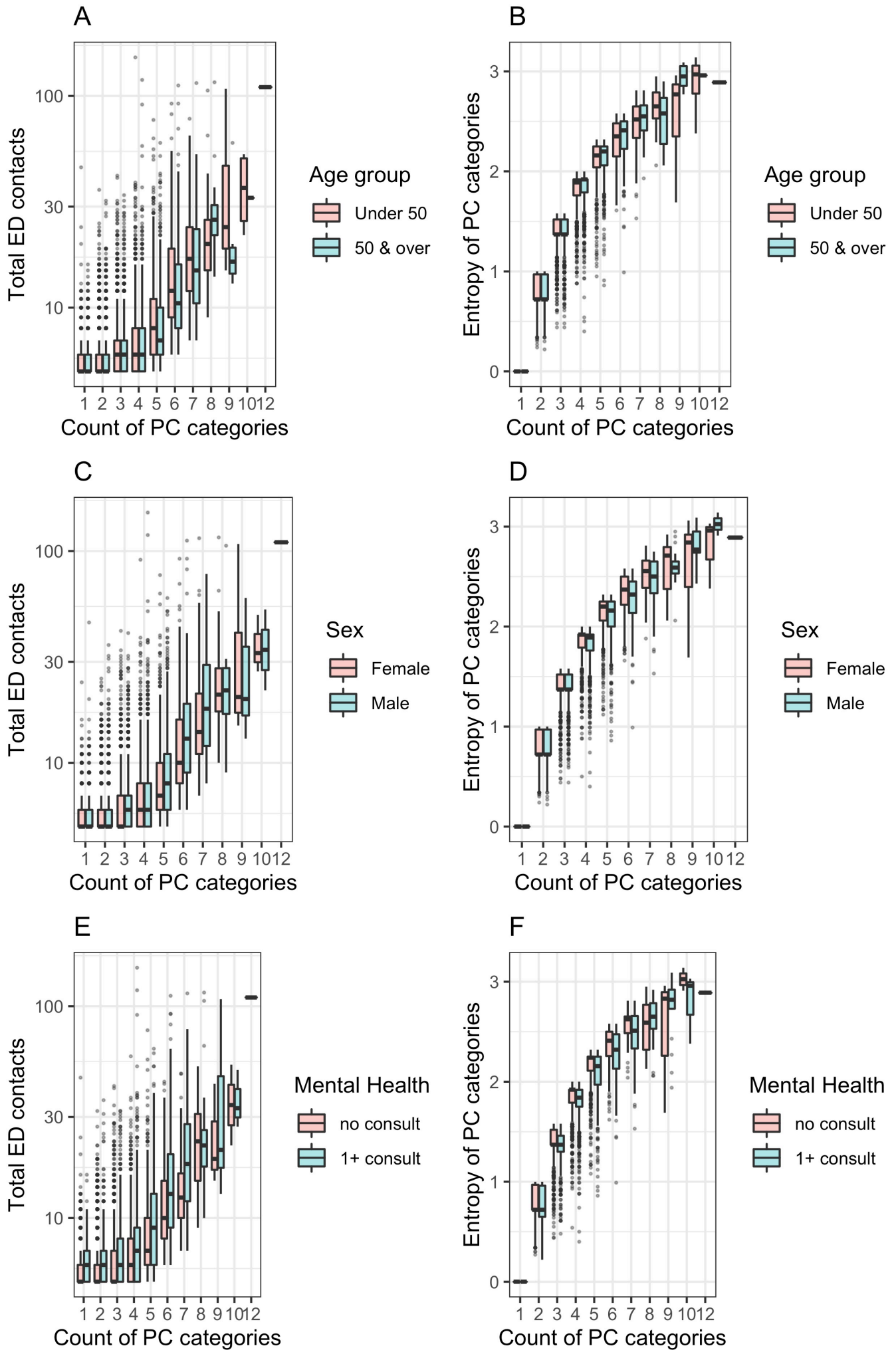


Figure 2 Association of number of unique presenting complaint categories with total ED contacts and entropy of presenting complaint categories
 ED, emergency department; PC, presenting complaint

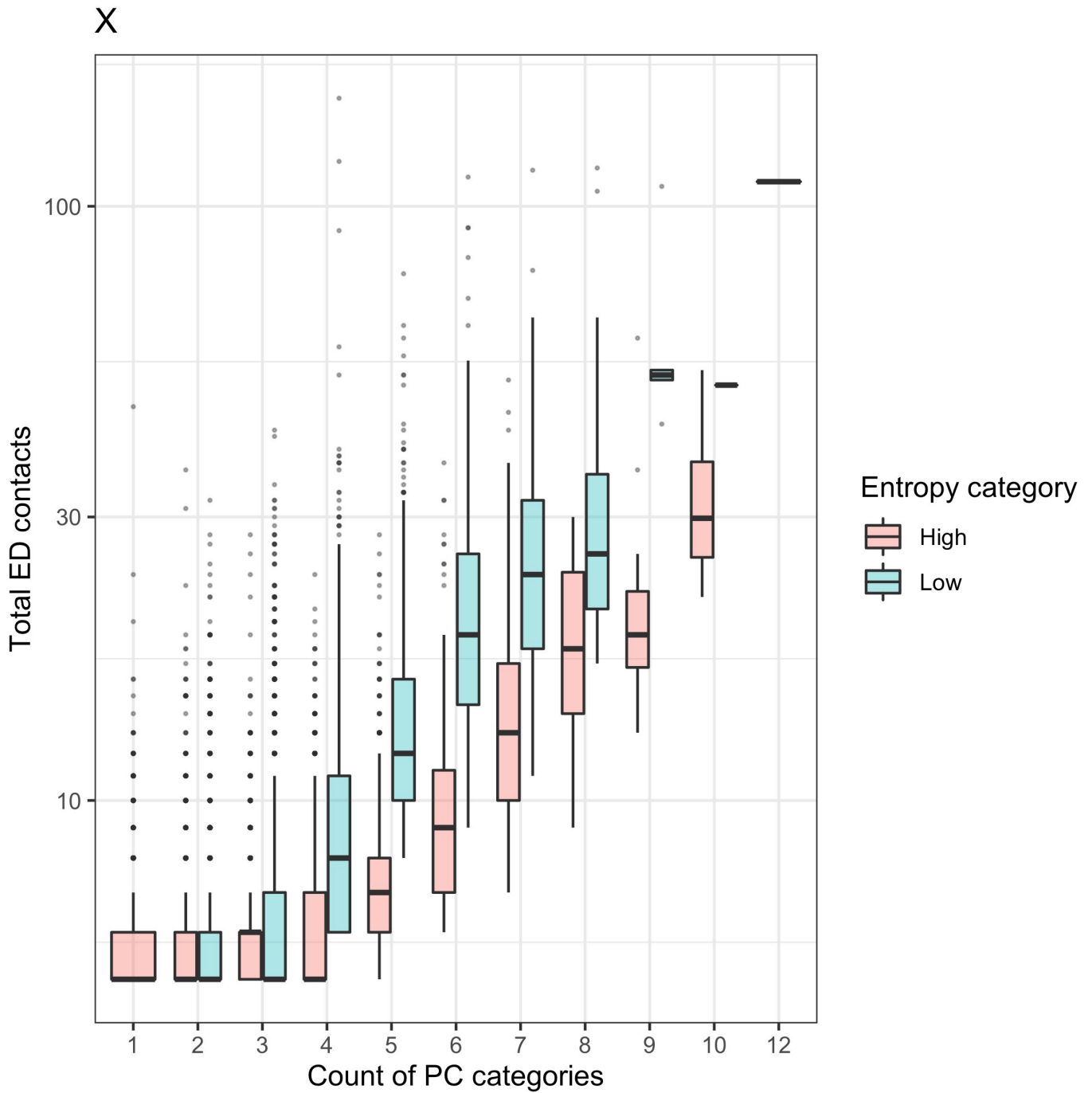


Figure 3 relationship between count and entropy of presenting complaint categories and total contacts over the year. ED, emergency department; PC, presenting complaint

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