

# Development of a Natural Language Processing Model to Identify Patients with Cognitive Impairment Associated with Schizophrenia from a Real-World Dataset

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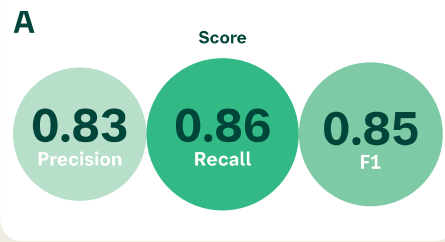
## Introduction

- CONTEXT**
  - CIAS is common in people with schizophrenia, and characterised by deficits in cognitive functions (e.g. speed of processing, verbal learning, working memory, reasoning/problem solving and social cognition)<sup>1,2</sup>
  - Commonly associated with challenges in functioning, CIAS may manifest as difficulties with activities of daily living (e.g. employment, social relationships and living independently)<sup>3-4</sup>
  - NLP is a branch of AI involved in the development of automated computational processing of human (i.e. natural) language.<sup>5</sup> It can be used to extract information from unstructured or free-text clinical notes in EHRs (e.g. diagnoses and symptoms), and is used increasingly in medicine<sup>6-7</sup>
- UNMET NEED**
  - Although previously considered for inclusion in diagnosis reference manuals (e.g. DSM-5),<sup>8</sup> there remains no standardised diagnostic code for CIAS
- RATIONALE**
  - Improved strategies to identify CIAS may benefit both patients and clinicians, and have the potential to provide data that are more representative of CIAS prevalence in the real world

## Key Conclusions

- NLP models can be used to identify patients with CIAS from EHRs, providing a high level of precision and recall across all 5 cognitive domains

Figure 1. Performance metrics for (A) named-entity recognition model and (B) contextual classifier model



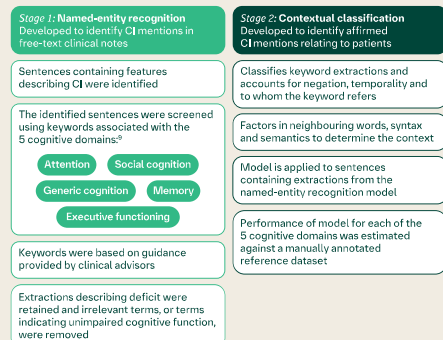
Cognitive domain	Point estimate (95% confidence interval)
Attention	Precision: 0.91 (0.86, 0.95)
	Recall: 0.86 (0.81, 0.91)
	F1: 0.88 (0.83, 0.93)
Executive function	Precision: 0.89 (0.85, 0.93)
	Recall: 0.86 (0.80, 0.91)
	F1: 0.87 (0.82, 0.91)
Generic cognition	Precision: 0.88 (0.83, 0.92)
	Recall: 0.83 (0.77, 0.89)
	F1: 0.84 (0.79, 0.89)
Memory	Precision: 0.88 (0.83, 0.92)
	Recall: 0.83 (0.77, 0.88)
	F1: 0.84 (0.79, 0.89)
Social cognition	Precision: 0.92 (0.88, 0.96)
	Recall: 0.83 (0.77, 0.89)
	F1: 0.87 (0.81, 0.91)

## Aim

To identify and validate the presence of CIAS from EHR data using NLP models applied to free-text clinical notes

## Methods

Figure 2. Two stages of AI-based NLP model development



## Dataset

- Akviva Health dataset:** real-world longitudinal, de-identified, anonymised patient records from ~4.6 million patients using mental healthcare services in England and Wales
- Patient data inclusion criteria:** ≥18 years old at diagnosis, with a first schizophrenia diagnosis (per ICD-10 code F20) and clinical notes available within the study period (1 January 2005–31 December 2023)
- Patient data exclusion criteria:** diagnosis of dementia, mild CI or intellectual disability

## NLP model validation

- Precision and recall performance metrics for the named-entity recognition model were determined from a sample of 500 sentences. The F1 score, which is a metric that balances precision and recall values of false positives and false negatives, was also determined<sup>10</sup>
- Performance metrics for the contextual classifier model were derived from the annotation of 180 sentences per each of the 5 cognitive domains, with 95% confidence intervals estimated using bootstrapping with 10,000 iterations
- The models were also validated using analysis of patients' maximum scores on the HoNOS item 4 score (cognitive problems), which is a clinician-recorded outcome measure that includes assessment of cognitive functioning. Probability of between-group difference was assessed by T-test, and eta-squared was calculated as a measure of effect size

## Study outcomes

- NLP model performance metrics**
- Identification of patients with and without CIAS at any point during the study period, reported descriptively**
- Mention of cognitive problems in each cognitive domain in patients with CIAS, reported descriptively**
- NLP cognitive impairment score, derived from the number of cognitive domains in which patient impairment was recorded over the study period**
- HoNOS item 4 (cognitive problems) scores in patients with and without CIAS**

## Results

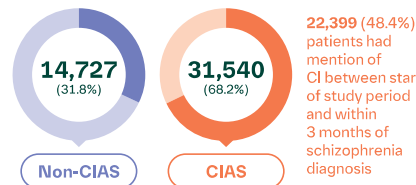
### NLP model performance metrics

- The performance metrics for the named-entity recognition and contextual classifier models are described in Figure 1

### Identification of CIAS

46,267 patients analysed using described NLP models

At any point throughout the study period:



### Cognitive problems

- Cognitive problems were identified in all 5 cognitive domains; prevalence was highest in the domains for attention and executive function (Table 1)

Table 1. Number (%) of patients with mention of CI between study start and within 3 months of schizophrenia diagnosis in patients with ≥1 affirmed mention of cognitive problems in each domain at any time across a patient's EHR

Cognitive domain	Patients with CIAS (N=22,399)
Attention	15,194 (67.8%)
Executive function	14,991 (66.9%)
Social cognition	13,156 (58.7%)
Memory	10,016 (44.7%)
Generic cognition	8,044 (35.9%)

### NLP cognitive impairment score

- In patients identified with CIAS, a quarter had cognitive deficits in only 1 domain (Table 2)

Table 2. Number of domains patients had a record of CI in (max NLP-CI score) and most frequent domains profile in patients with CIAS, n (%)

Max NLP-CI score	Patients with CIAS (N=22,399)	Most prevalent profile
1	5,613 (25.1%)	Executive function
2	4,923 (22.0%)	Attention, social cognition
3	4,674 (20.9%)	Attention, social cognition, executive function
4	4,025 (18.0%)	Attention, social cognition, executive function, generic cognition
5	3,164 (14.1%)	Attention, memory, social cognition, executive function, generic cognition

### Health of the Nation Outcome Scale scores

13,826 patients with HoNOS record

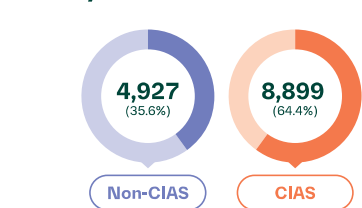
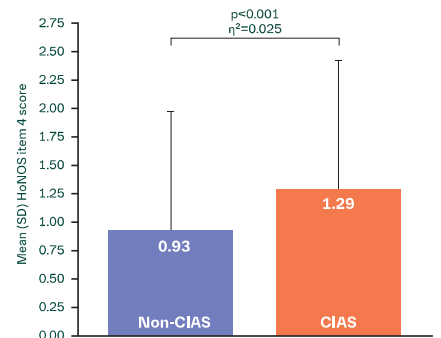


Figure 3. Patients with CIAS had higher mean (SD) HoNOS item 4 (cognitive problems) scores compared with patients without CIAS



## Additional Conclusions

- The use of NLP models to extract information from free text in clinical notes may benefit both physicians and patients through potentially improving diagnosis and early treatment
- Mentions of CI were frequently reported among the study population (68.2% of patients analysed), consistent with previously published studies<sup>11</sup>
- Future studies examining the prevalence of CIAS derived through the use of NLP models would be of interest to reflect real-world prevalence
- For more information on associations between CIAS status and patient characteristics, see poster PS04-3259, 'Determining the Demographic and Health Characteristics of Patients with Cognitive Impairment Associated with Schizophrenia: A Non-interventional Study of Real-World Data'

## Abbreviations

AI, artificial intelligence; CI, cognitive impairment; CIAS, cognitive impairment associated with schizophrenia; DSM-5, Diagnostic and Statistical Manual of Mental Disorders (5th edition); EHR, electronic health record; HoNOS, Health of the Nation Outcome Scale; ICD-10, International Classification of Diseases (10th revision); NLP, natural language processing; SD, standard deviation.

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## Disclosures

TC is an employee of Boehringer Ingelheim Pharmaceuticals, Inc. AW and SSR are employees of Boehringer Ingelheim International GmbH. MF is an employee of Boehringer Ingelheim, Ltd. GF, BP, PK, TF, JR, GR and CU are employees of Akviva Health. RP has participated in Scientific Advisory Boards for Boehringer Ingelheim and Teva. RP has received grant funding from the National Institute for Health and Care Research (NHR301690), the Medical Research Council (MR/S003118/1) and Janssen, and consulting fees from Holmusk, Akviva Health, Columbia Data Analytics, CliniLabs, Social Finance, Boehringer Ingelheim, Bristol Myers Squibb, Supernus, Teva and Orsuka.

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