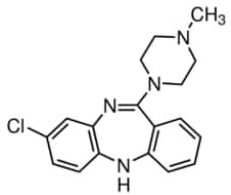
69 CONGRESO NACIONAL
SOCIEDAD ESPAÑOLA DE FARMACIA HOSPITALARIA

A CORUÑA
17-19 OCT 24

FARMACIA 360°
ABRAZANDO LA EXCELENCIA · CUIDANDO EN TODAS LAS DIRECCIONES ·

Clozapine –
A unique drug

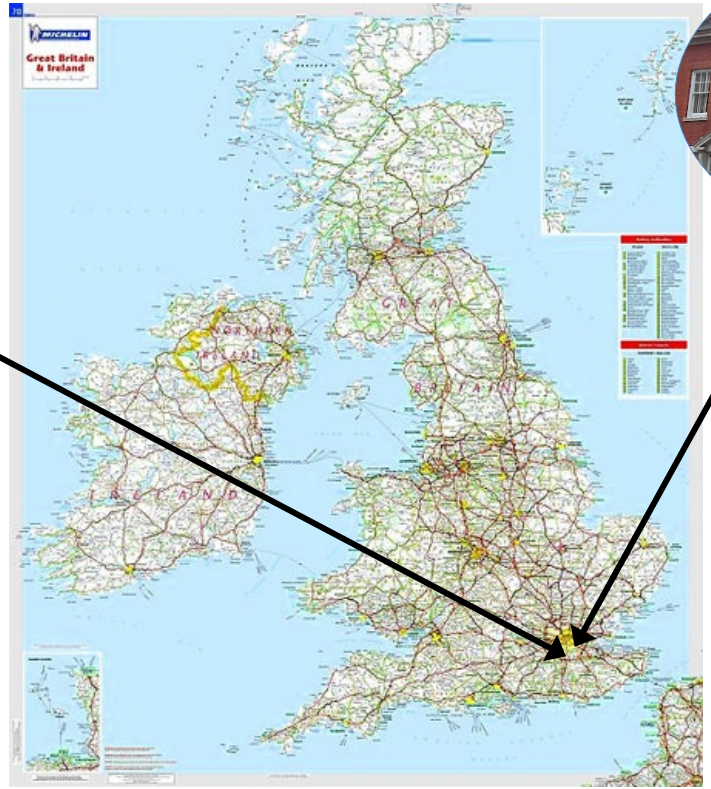
Professor David Taylor



sefh
Sociedad Española de Farmacia Hospitalaria

Bethlem (Bedlam) Hospital 1676

Bethlem Hospital



Maudsley Hospital

1.4m population

1000 beds

60,000 out-patients

1600 people on clozapine

Clozapine


Where I come in
1958
1971
1975
1990
2023
Synthesised
First RCT
Withdrawn
Reintroduced

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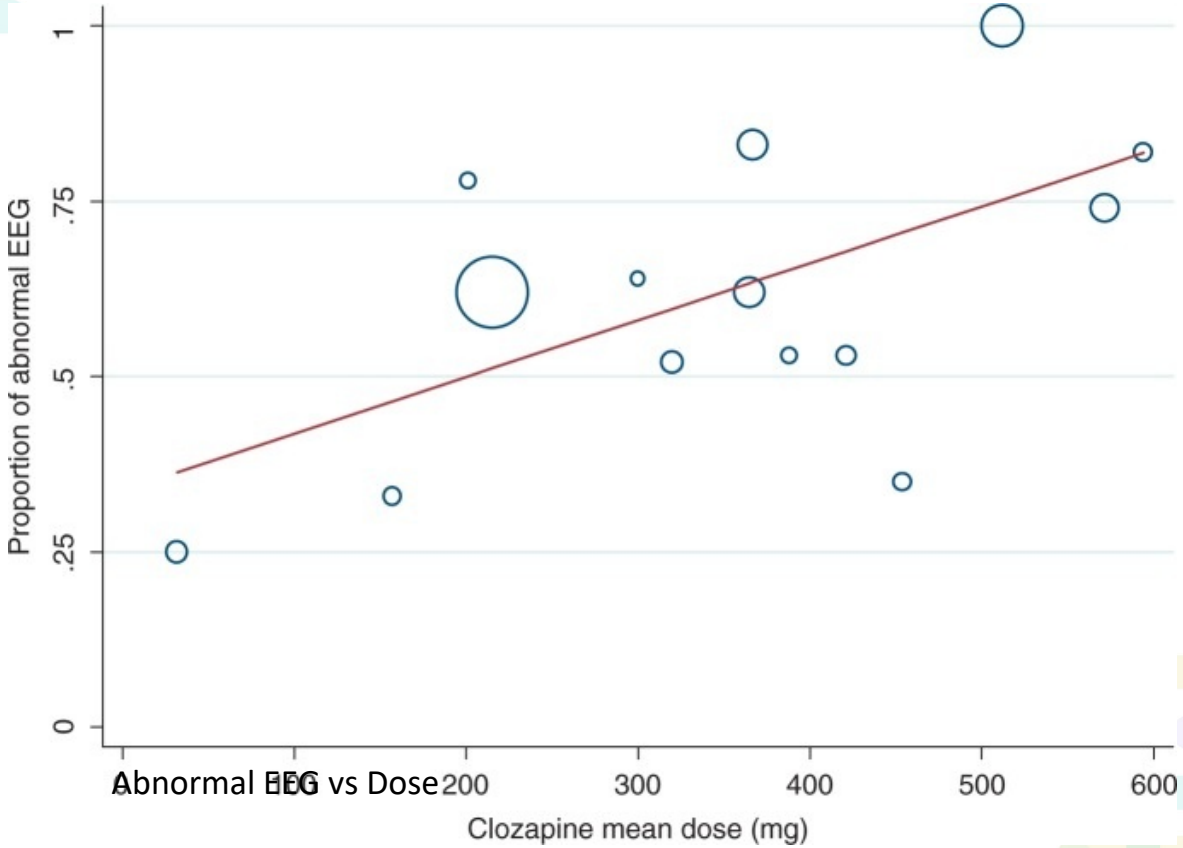
A CORUÑA 17-19 OCT 24

Clozapine-related EEG changes and seizures: dose and plasma-level relationships

Seema Varma, Delia Bishara, Frank M. C. Besag and David Taylor

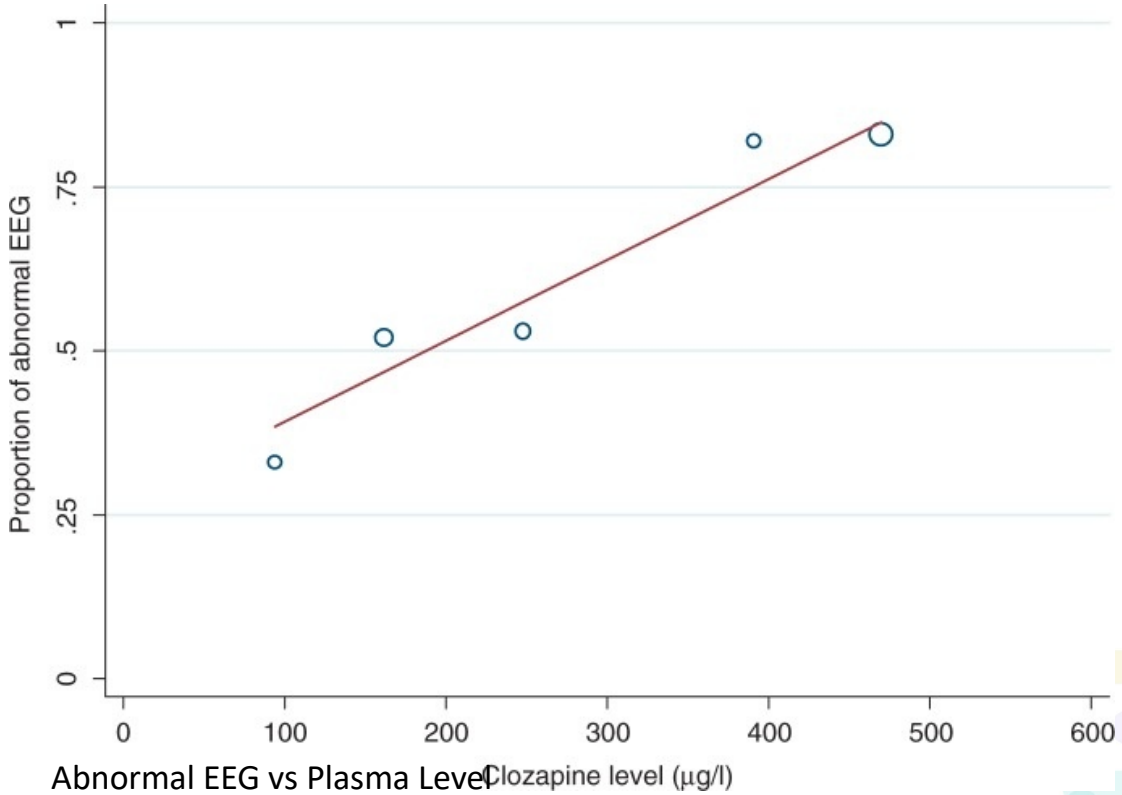
Ther Adv Psychopharmacol

(2011) 1(2) 47–66



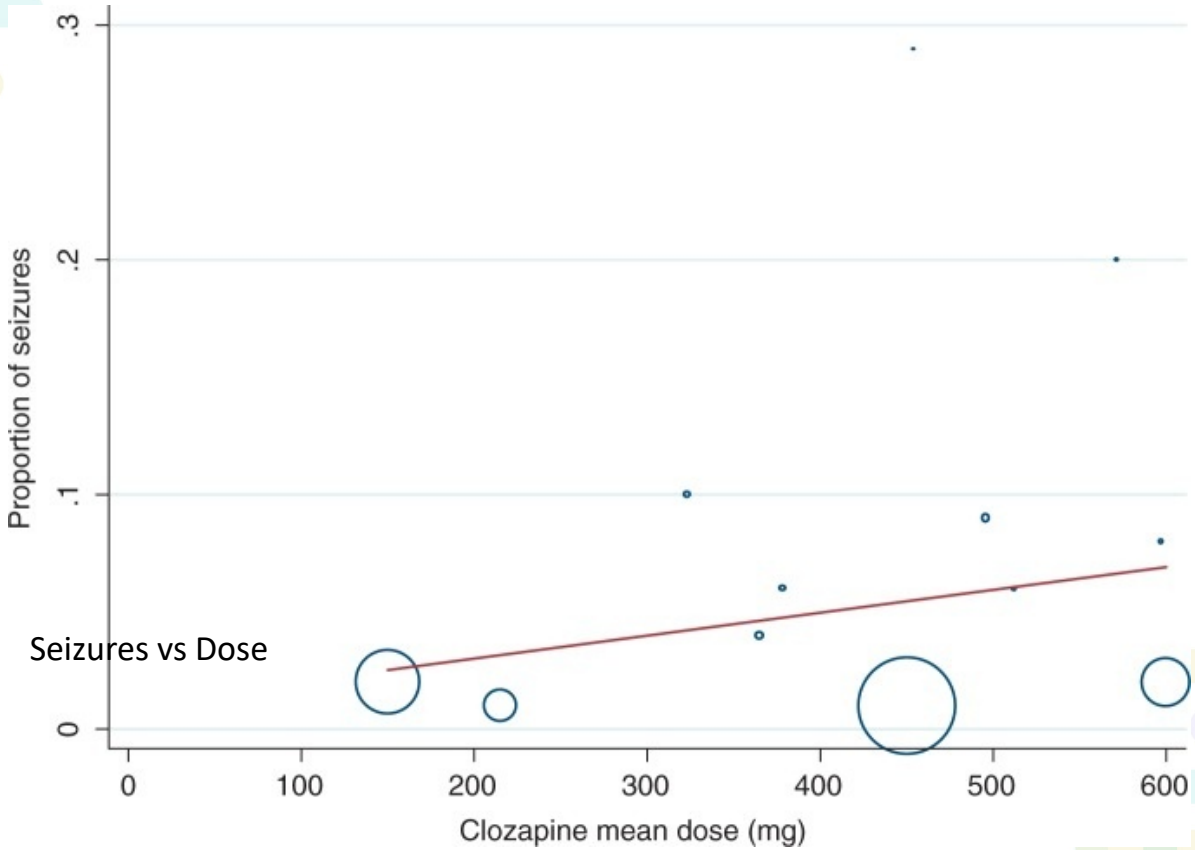
Abnormal EEG vs Dose

Ther Adv Psychopharmacol
(2011) 1(2) 47–66



Abnormal EEG vs Plasma Level

Ther Adv Psychopharmacol
(2011) 1(2) 47–66



Seizures vs Dose

Ther Adv Psychopharmacol
(2011) 1(2) 47–66

Short Report

Incident infection during the first year of treatment – A comparison of clozapine and paliperidone palmitate long-acting injection

Shubhra Mace[1,2], Olubanke Dzahini[1,2], Victoria Cornelius[3], Hadar Langerman[2], Ebenezer Oloyede[1] and David Taylor[1,2]

Journal of Psychopharmacology
1–6

DOI: 10.1177/02698811211058973
journals.sagepub.com/home/jop

Abstract

Background: To examine the risk of infection in patients prescribed clozapine compared with patients prescribed paliperidone palmitate long-acting injection (PPLAI).

Method: A retrospective, 1-year, cohort study conducted on events occurring in eligible patients beginning treatment for the first time with clozapine or PPLAI between June 2017 and June 2019 in a UK mental health trust providing in-patient and out-patient services.

Results: The study included 64 patients starting clozapine and 120 patients starting PPLAI. Incidence of infection was greater in clozapine starters than in PPLAI starters (28% vs 6%; $p = 0.001$; adjusted odds ratio 5.82 (95% confidence interval (CI) – 2.15–15.76, $p = 0.001$). Infectious episodes in clozapine patients were not related to changes in neutrophil counts. Incident infection in the clozapine group was highest in the first 3 months of treatment. The most commonly reported infection in the clozapine group was chest infection; however, the majority of infections were non-chest-related.

Conclusion: Patients starting clozapine showed a substantially increased likelihood of infection compared with patients starting PPLAI.

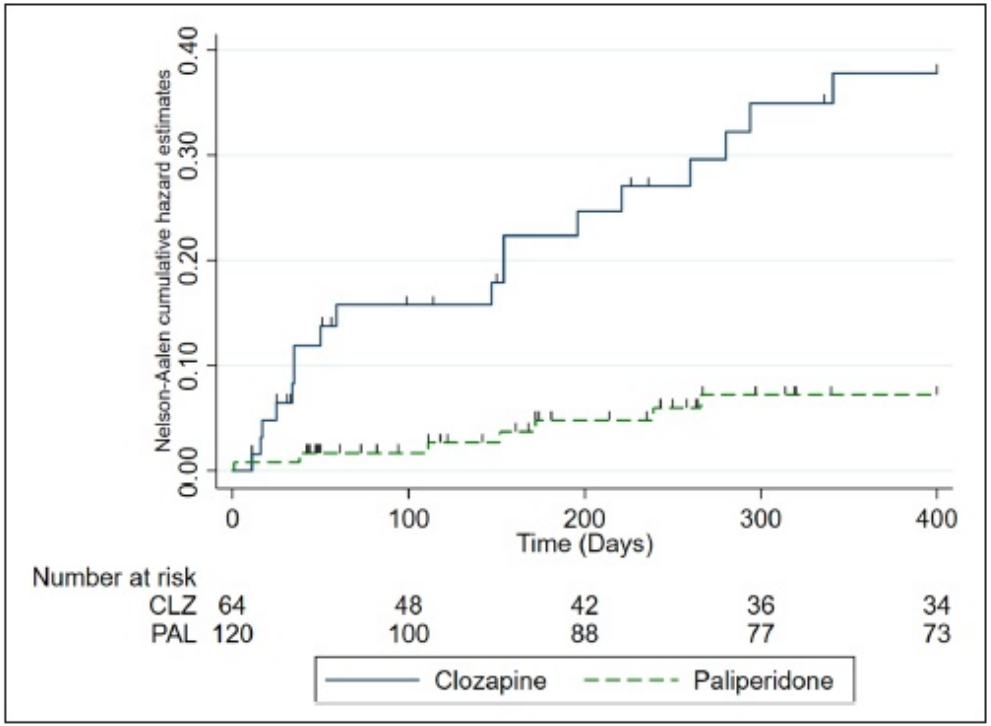


Figure 1. The cumulative incidence of infection over time (days) in both groups.

Clozapine - patient perceptions

Taylor et al (2000) Psych Bull, 24: 450-452

N = 570/1284

85% on clozapine for >6 months

	Yes	No
Feel better on clozapine	86.1%	12.5%
Advantages > disadvantages	87.0%	6.5%
Prefer clozapine to previous T_x	88.6%	6.5%

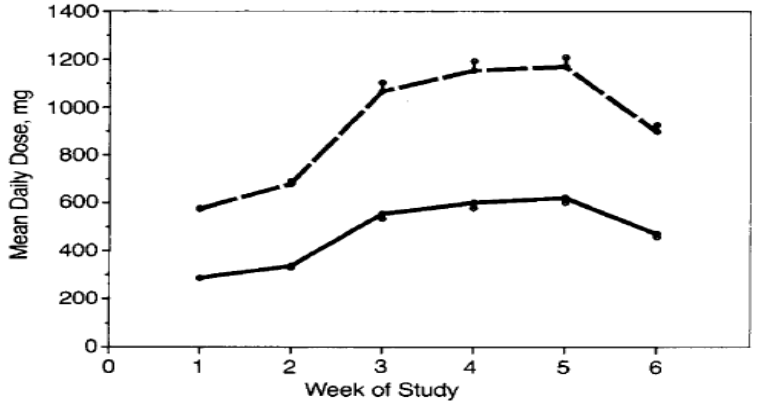


Fig 1.—Mean daily doses of clozapine (solid line) and chlorpromazine (broken line) during double-blind phase of study (period 4). For clozapine, at week 1, n = 126; week 2, n = 126; week 3, n = 122; week 4, n = 120; week 5, n = 119; and week 6, n = 116. For chlorpromazine, at week 1, n = 141; week 2, n = 140; week 3, n = 137; week 4, n = 133; week 5, n = 128; and week 6, n = 125.

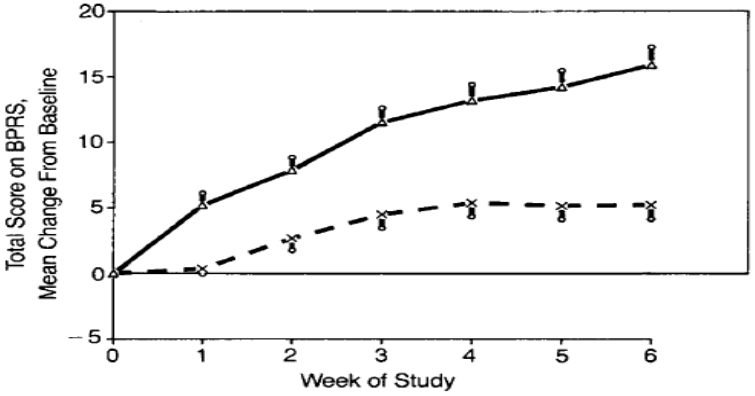


Fig 2.—Mean change from baseline in total score on Brief Psychiatric Rating Scale (BPRS) for patients treated with clozapine (solid line, n = 126) or chlorpromazine and benztropine mesylate (broken line, n = 139). $P<.001$ during each week of study.

Table 6.—No. of Patients Whose Condition Improved*

Drug	No. (%) of Patients Whose Condition Improved	All Others, No. (%)	Total, No. (%)
Clozapine	38 (30)	88 (70)	**126 (100)**
Chlorpromazine	5 (4)	136 (96)	**141 (100)**
Total	**43** (16)	**224** (84)	**267 (100)**

*The categorization is based on the last evaluation completed for each patient. $P<.001$ by two-tailed Fisher's exact test.

Kane J, Honigfeld G, Singer J et al. Clozapine for the treatment-resistant schizophrenic. A double-blind comparison with chlorpromazine. *Arch Gen Psychiatry*. 1988; 45: 789-796

Lieberman JA, Phillips M, Gu H, et al.
Atypical and conventional antipsychotic drugs in treatment-naive first-episode schizophrenia: a 52-week randomized trial of clozapine vs chlorpromazine. Neuropsychopharmacology 2003; **28**:995-1003.

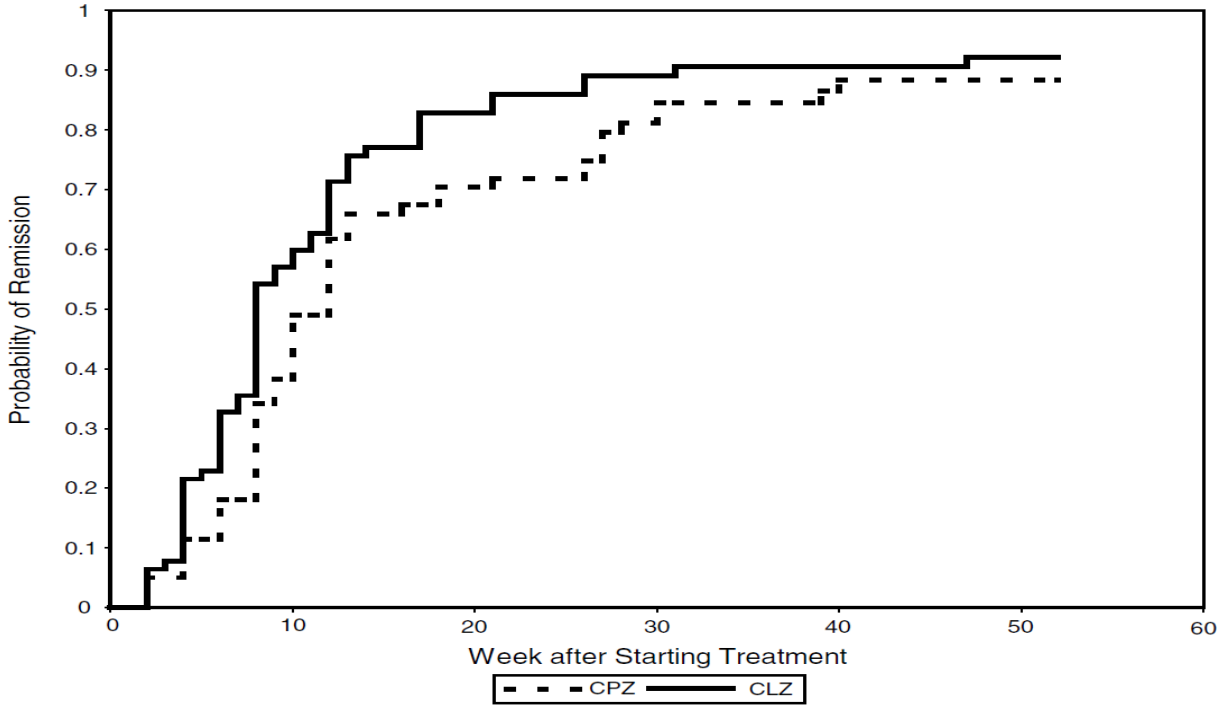
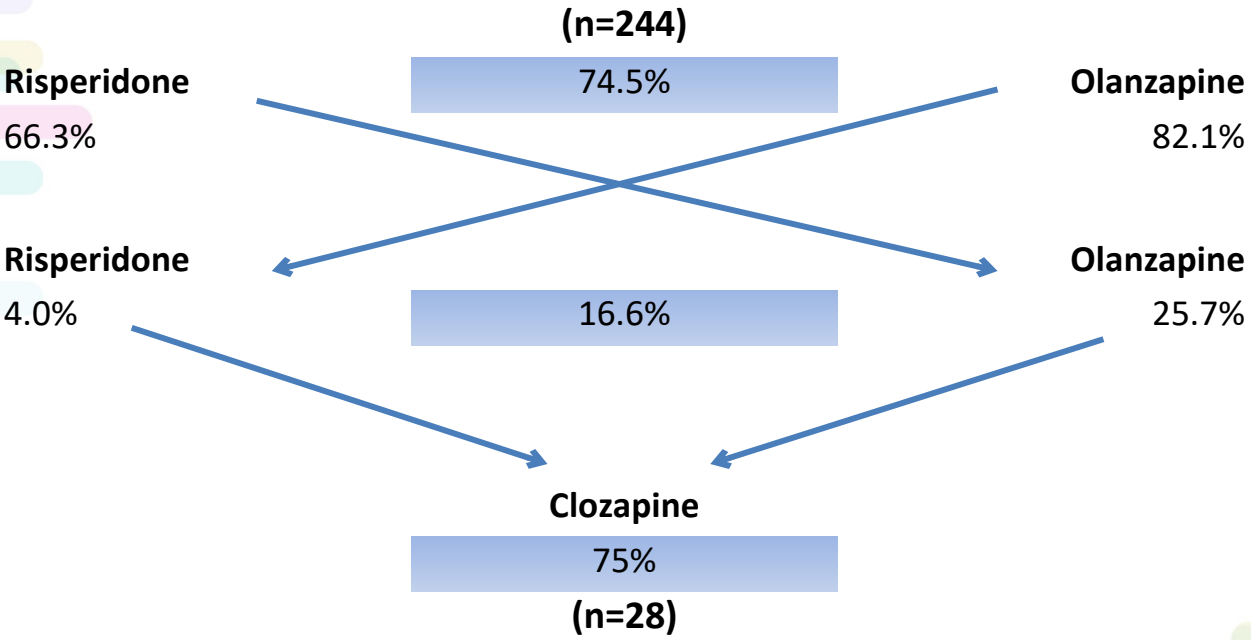


Figure 2 Kaplan–Meier remission survival plots for time to first remission for CPZ (broken line) and CLZ (solid line) groups. The median time to remission in the CLZ group was 8 and 12 weeks in the CPZ group.

Agid O et al, J Clin Psychiatry 2011, 72: 1439-1444

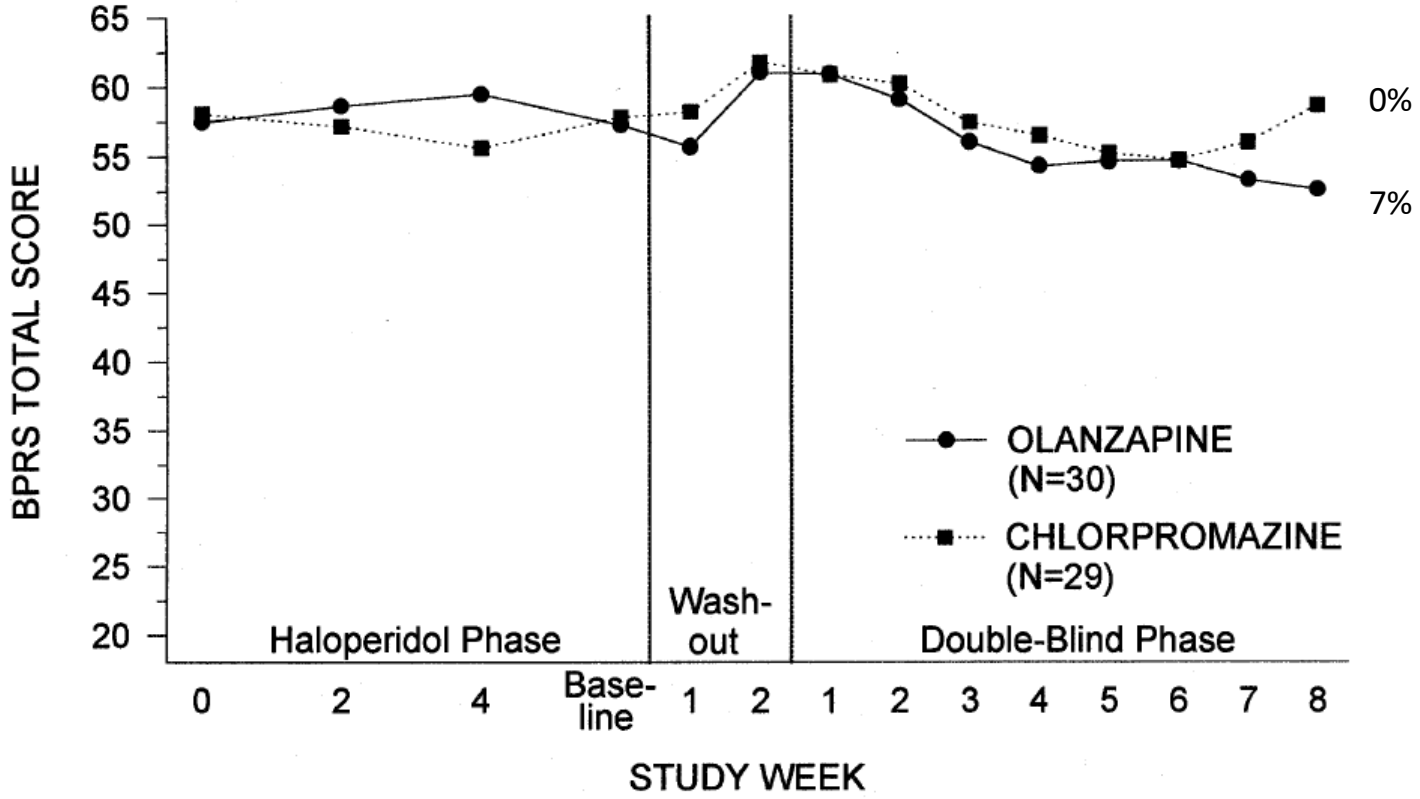


Olanzapine Compared With Chlorpromazine in Treatment-Resistant Schizophrenia

Am J Psychiatry 1998; 155:914–920

Robert R. Conley, M.D., Carol A. Tamminga, M.D., John J. Bartko, Ph.D., Charles Richardson, M.D., Michael Peszke, M.D., Jami Lingle, Pharm.D., Judith Hegerty, M.D., Raymond Love, Pharm.D., Cathy Gounaris, B.A., and Sandra Zaremba, R.N.

FIGURE 1. BPRS Total Scores of 59 Schizophrenic Patients Who Completed a Trial of Olanzapine or Chlorpromazine After Lack of Response to Treatment With Haloperidol



Olanzapine non-responders → Clozapine → 41% Responders

Conley RR, Schulz SC, Baker RW, Collins JF, Bell JA. Clozapine efficacy in schizophrenic nonresponders. Psychopharmacol Bull. 1988;24(2):269-74.

Chance of response in TRS

- Clozapine 60%
- Olanzapine 7%
- Everything else 0-5%

Chance of response in TRS

- ~~Clozapine 60%~~
- Olanzapine 7%
- Everything else 0-5%

sefh Sociedad Española de Farmacia Hospitalaria

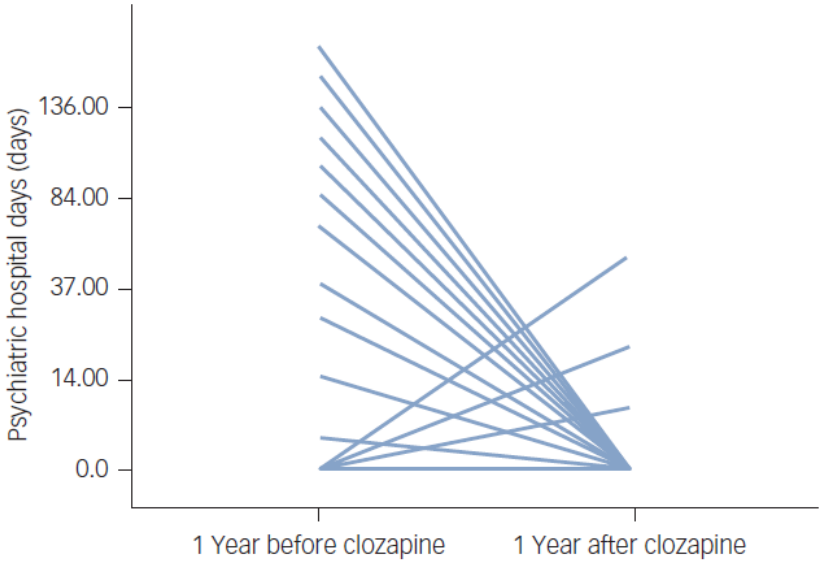
BJPsych

The British Journal of Psychiatry (2022)
Page 1 of 8. doi: 10.1192/bjp.2022.47

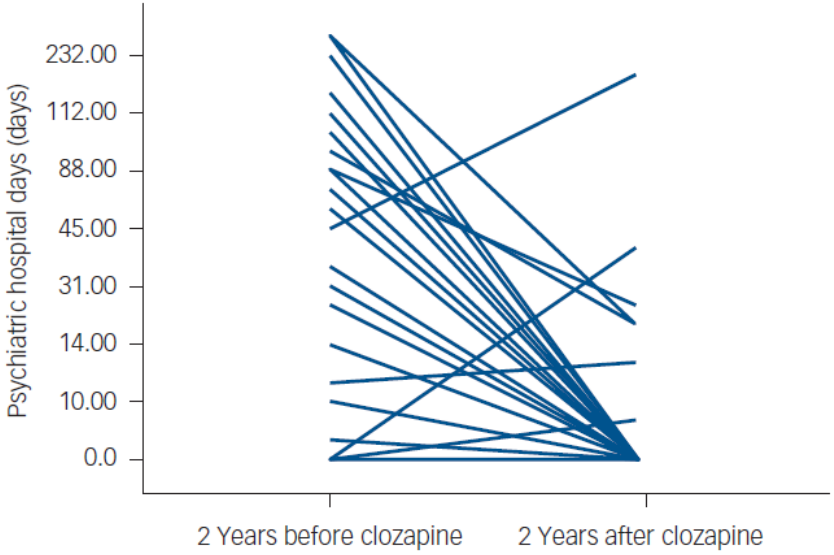
Real-world clinical and cost-effectiveness of community clozapine initiation: mirror cohort study

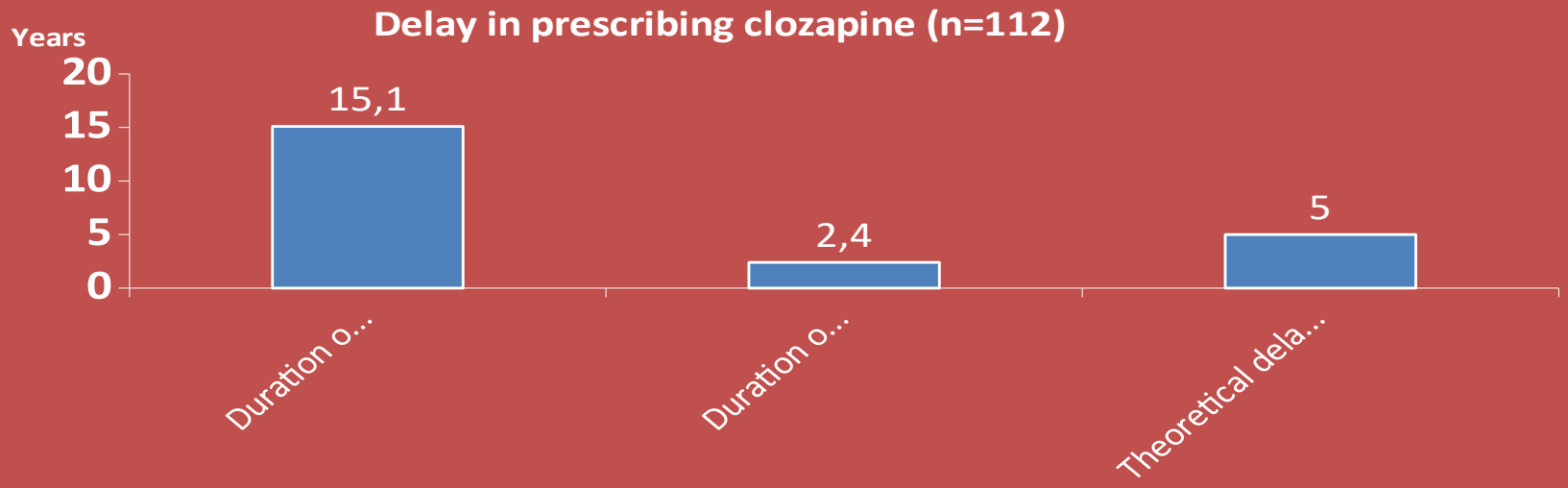
Emma Butler, Toby Pillinger, Kirsten Brown, Faith Borgan, Alice Bowen, Katherine Beck, Enrico D'Ambrosio, Lisa Donaldson, Sameer Jauhar, Stephen Kaar, Tiago Reis Marques, Robert A. McCutcheon, Maria Rogdaki, Fiona Gaughran, James MacCabe, Rosalind Ramsay, David Taylor, Paul McCrone, Alice Egerton and Oliver D. Howes

(e)


Psychiatric hospital days (days)
136.00
84.00
37.00
14.00
0.0
1 Year before clozapine
1 Year after clozapine

(f)


Psychiatric hospital days (days)
232.00
112.00
88.00
45.00
31.00
14.00
10.00
0.0
2 Years before clozapine
2 Years after clozapine



Prior antipsychotic prescribing in patients currently receiving clozapine - a case note review

Taylor D, Young C, Paton C. (2003) ***Journal of Clinical Psychiatry****, 64, 30-38*

Adherence to treatment guidelines in clinical practice: study of antipsychotic treatment prior to clozapine initiation†

Oliver D. Howes,* Francis Vergunst,* Siobhan Gee, Philip McGuire, Shitij Kapur and David Taylor

Background
Clozapine is the only antipsychotic drug licensed for treatment-resistant schizophrenia but its use is often delayed. Since previous studies, national guidelines on the use of clozapine and other antipsychotics have been disseminated to clinicians.

Aims
To determine the theoretical delay to clozapine initiation and to quantify the prior use of antipsychotic polypharmacy and high-dose antipsychotic treatment.

Method
Clinico-demographic data were extracted from the treatment records of all patients commencing clozapine in our centre between 2006 and 2010.

Results
Complete records were available for 149 patients. The mean theoretical delay in initiating clozapine was 47.7 months (s.d. = 49.7). Before commencing clozapine, antipsychotic polypharmacy and high-dose treatment was evident in 36.2 and 34.2% of patients respectively. Theoretical delay was related to illness duration ($\beta = 0.7$, $P < 0.001$) but did not differ by gender or ethnicity.

Conclusions
Substantial delays to clozapine initiation remain and antipsychotic polypharmacy and high doses are commonly used prior to clozapine, despite treatment guidelines.

Declaration of interest
D.T. has received consultancies fees, lecturing honoraria and/or research funding from AstraZeneca, Janssen-Cilag, Servier, Sanofi-Aventis, Lundbeck, Bristol-Myers Squibb (BMS), Novartis, Eli Lilly and Wyeth. O.D.H. has been a speaker at meetings organised by and/or received investigator-initiated charitable research funding from Astra-Zeneca, BMS, Eli Lilly, and Jansenn-Cilag. S.K. has received grant support from AstraZeneca and GSK, and has served as consultant and/or speaker for AstraZeneca, Bioline, BMS-Otsuka, Eli Lilly, Janssen (J&J), Lundbeck, NeuroSearch, Pfizer, Roche, Servier and Solvay Wyeth.

Reasons for delaying clozapine

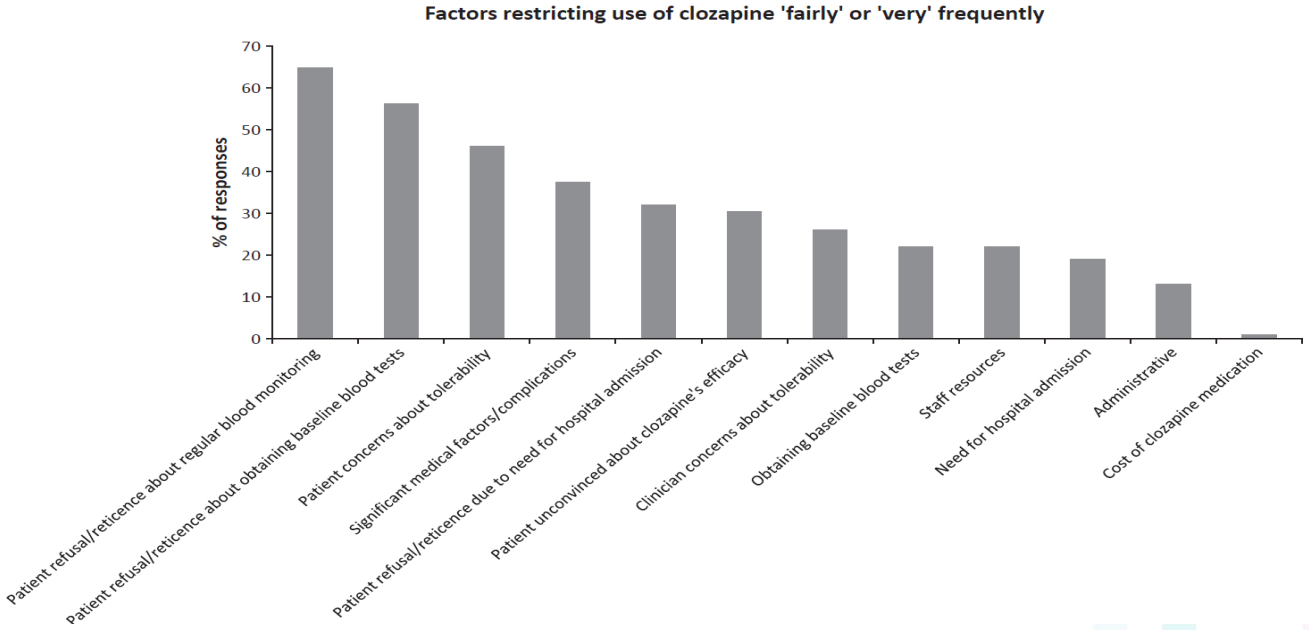
Acta Psychiatr Scand 2014: 130: 16–24

DOI: 10.1111/acps.12193

ACTA PSYCHIATRICA SCANDINAVICA

S. Gee[1,2], F. Vergunst[3,4], O. Howes[3], D. Taylor[1,2]

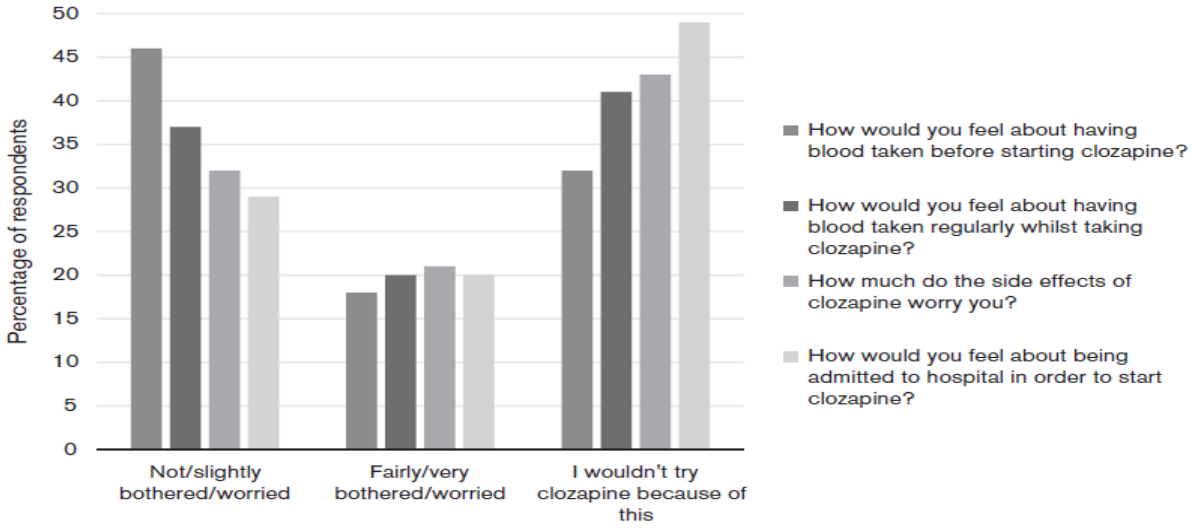
Practitioner attitudes to clozapine initiation



International Clinical Psychopharmacology 2017, 32:337–342

Patient attitudes to clozapine initiation

Siobhan H. Gee[a], Sukhwinder S. Shergill[b] and David M. Taylor[c]



Responses to questionnaire, shown as percentage of responses for each question.

Acta Psychiatr Scand 2017: 1–15
DOI: 10.1111/acps.12742

ACTA PSYCHIATRICA SCANDINAVICA

International trends in clozapine use: a study in 17 countries

Bachmann CJ, Aagaard L, Bernardo M, Brandt L, Cartabia M, Clavenna A, Coma Fusté A, Furu K, Garuolienė K, Hoffmann F, Hollingworth S, Huybrechts KF, Kalverdijk LJ, Kawakami K, Kieler H, Kinoshita T, López SC, Machado-Alba JE, Machado-Duque ME, Mahesri M, Nishtala PS, Piovani D, Reutfors J, Saastamoinen LK, Sato I, Schuiling-Veninga CCM, Shyu Y-C, Siskind D, Skurtveit S, Verdoux H, Wang L-J, Zara Yahni C, Zoëga H, Taylor D. International trends in clozapine use: a study in 17 countries.

Objective: There is some evidence that clozapine is significantly underutilised. Also, clozapine use is thought to vary by country, but so far no international study has assessed trends in clozapine prescribing. Therefore, this study aimed to assess clozapine use trends on an international scale, using standardised criteria for data analysis.
Method: A repeated cross-sectional design was applied to data extracts (2005–2014) from 17 countries worldwide.
Results: In 2014, overall clozapine use prevalence was greatest in Finland (189.2/100 000 persons) and in New Zealand (116.3/100 000), and lowest in the Japanese cohort (0.6/100 000), and in the privately insured US cohort (14.0/100 000). From 2005 to 2014, clozapine use increased in almost all studied countries (relative increase: 7.8–197.2%). In most countries, clozapine use was highest in 40–59-year-olds (range: 0.6/100 000 (Japan) to 344.8/100 000 (Finland)). In youths (10–19 years), clozapine use was highest in Finland (24.7/100 000) and in the publicly insured US cohort (15.5/100 000).
Conclusion: While clozapine use has increased in most studied countries over recent years, clozapine is still underutilised in many countries, with clozapine utilisation patterns differing significantly between countries. Future research should address the implementation of interventions designed to facilitate increased clozapine utilisation.

C. J. Bachmann[1], L. Aagaard[2], M. Bernardo[3], L. Brandt[4], M. Cartabia[5], A. Clavenna[5], A. Coma Fusté[6], K. Furu[7], K. Garuolienė[8,9], F. Hoffmann[10], S. Hollingworth[11], K. F. Huybrechts[12], L. J. Kalverdijk[13], K. Kawakami[14], H. Kieler[4], T. Kinoshita[14], S. C. López[15], J. E. Machado-Alba[15], M. E. Machado-Duque[15], M. Mahesri[12], P. S. Nishtala[16], D. Piovani[5], J. Reutfors[4], L. K. Saastamoinen[17], I. Sato[14], C. C. M. Schuiling-Veninga[18], Y.-C. Shyu[19,20,21], D. Siskind[22], S. Skurtveit[7], H. Verdoux[23], L.-J. Wang[24], C. Zara Yahni[6], H. Zoëga[25], D. Taylor[26,27]

[1]Freelance Researcher, Marburg, Germany, [2]Life Science Team, Bech-Bruun Law Firm, Copenhagen, Denmark, [3]Barcelona Clinic Schizophrenia Unit, Neuroscience Institute, and Hospital Clinic, Department of Medicine, Barcelona University, and Institut d'Investigacions Biomèdiques August Pi i Sunyer (IDIBAPS), and Centro de Investigación Biomédica en Red de Salud Mental (CIBERSAM), Barcelona, Spain, [4]Centre for Pharmacoepidemiology, Department of Medicine, Solna, Karolinska Institutet, Karolinska University Hospital, Stockholm, Sweden, [5]Pharmacoepidemiology Unit, Department of Public Health, IRCCS Istituto di Ricerche Farmacologiche 'Mario Negri', Milan, Italy, [6]Pharmacy Department of Barcelona Health Region, Catalan Health Service (CatSalut), Barcelona, Spain, [7]Division of Mental and Physical Health, Norwegian Institute of Public Health, Oslo, Norway, [8]Medicines Reimbursement Department, National Health Insurance Fund of the Republic of Lithuania, [9]Faculty of Medicine, Department of Pathology, Forensic Medicine and Pharmacology, Vilnius University, Vilnius, Lithuania, [10]Department of Health Services Research, Carl von Ossietzky University Oldenburg, Oldenburg, Germany, [11]School of Pharmacy, University of Queensland, Woolloongabba, Qld, Australia, [12]Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA, [13]University of Groningen, University Medical Center Groningen, Department of Psychiatry, the Netherlands, [14]Department of Pharmacoepidemiology and Clinical Research Management, Graduate School of Medicine and Public Health, Kyoto University, Kyoto, Japan, [15]Grupo de Investigación en Farmacoepidemiología y

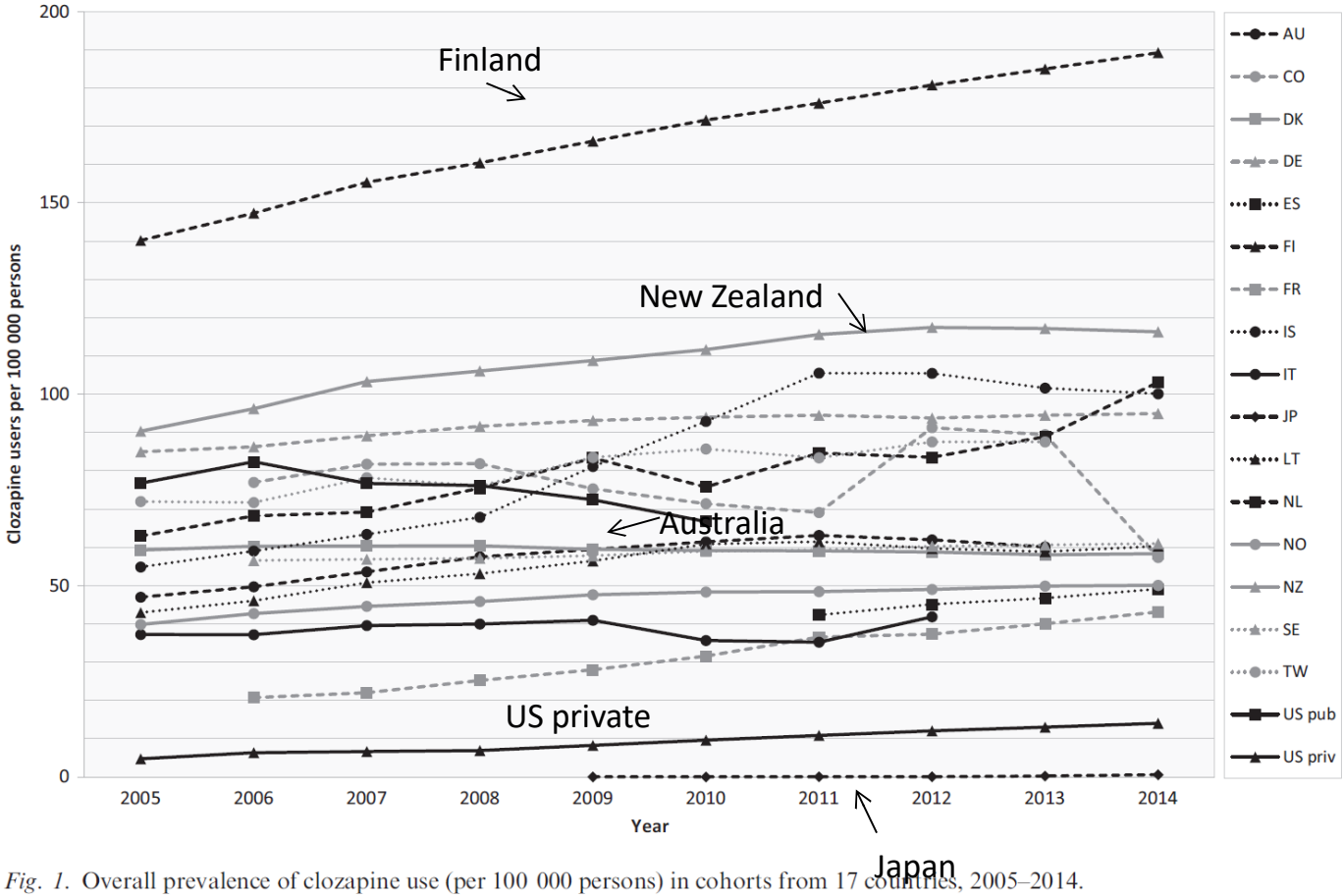


Fig. 1. Overall prevalence of clozapine use (per 100 000 persons) in cohorts from 17 countries, 2005–2014.

DOI: 10.1111/acps.13280

Acta Psychiatrica Scandinavica WILEY

ORIGINAL ARTICLE

An evaluation of the variation and underuse of clozapine in the United Kingdom

Eromona Whiskey[1,2,3] | Alex Barnard[4] | Ebenezer Oloyede[1,2,3] | Olubanke Dzahini[1,2] | David M. Taylor[1,2] | Sukhwinder S. Shergill[3]

Acta Psychiatr Scand. 2021;00:1–9.

Country	Clozapine prescription per 100,000 persons
Finland	189
Netherlands	103
Iceland	100
Germany	95
United Kingdom	69
Sweden	61
Denmark	58
Norway	50
Spain	49
France	43
Italy	42

Acta Psychiatr Scand. 2021;00:1–9.

NHS England Regional Office Name	Key (see map)	Clozapine prescription per 100,000 population	SMI prevalence per 100,000 population	Prescription % per prevalence
NHS England London	12	66.57	1,080.57	6.16%
NHS England North West (Cheshire and Merseyside)	5	62.40	1,039.68	6.00%
NHS England Midlands (North Midlands)	6	39.97	804.63	4.97%
NHS England Midlands (West Midlands)	8	72.60	567.16	12.80%
NHS England North West (Greater Manchester)	4	82.71	1,005.70	8.22%
NHS England North West (Lancashire and South Cumbria)	2	65.34	1,048.19	6.23%
NHS England South East (Hampshire, Isle of Wight and Thames Valley)	11	40.78	548.94	7.43%
NHS England South East (Kent, Surrey and Sussex)	13	41.38	838.70	4.93%
NHS England South West (South West North)	10	35.90	478.79	7.50%
NHS England South West (South West South)	14	43.80	898.01	4.88%
NHS England Midlands (Central Midlands)	7	43.86	816.48	5.37%
NHS England East of England (East)	9	35.26	821.72	4.29%
NHS England North East and Yorkshire (Cumbria and North East)	1	53.58	935.75	5.73%
NHS England North East and Yorkshire (Yorkshire and Humber)	3	37.56	719.60	5.22%

Acta Psychiatr Scand. 2021;00:1–9.

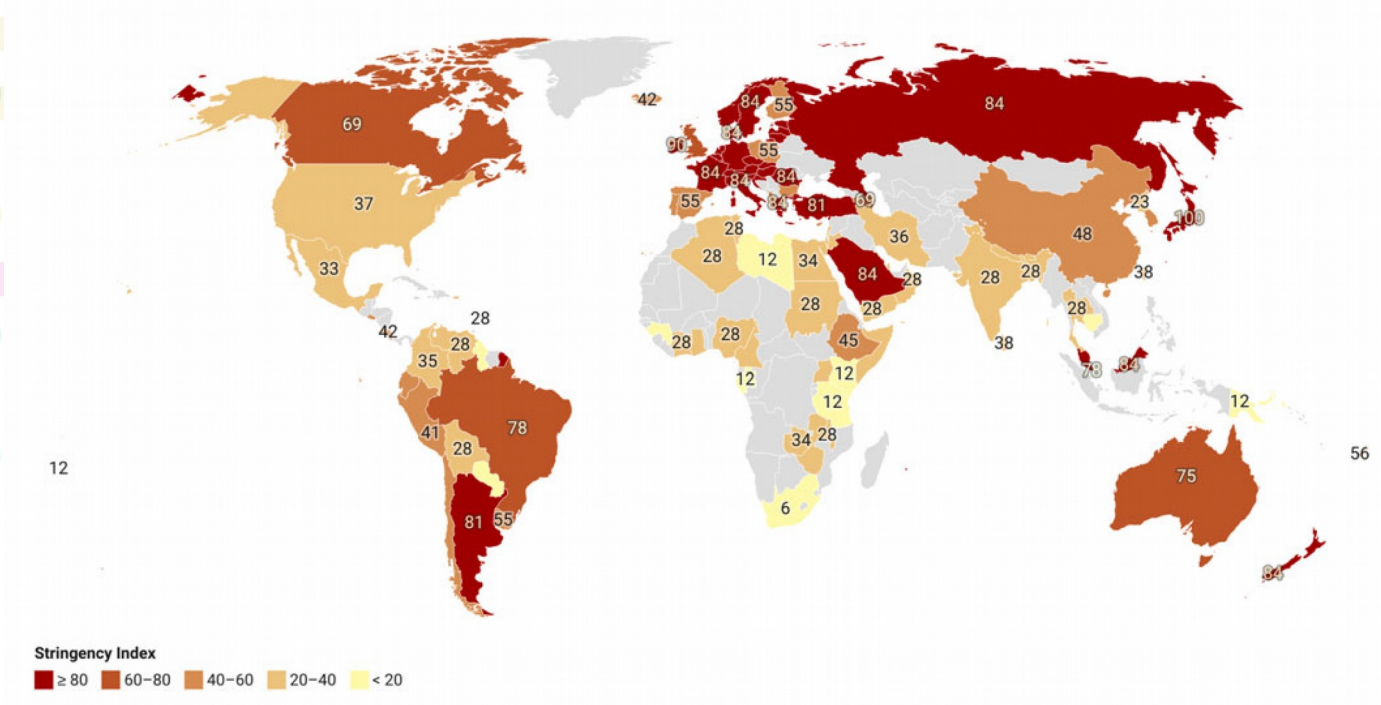
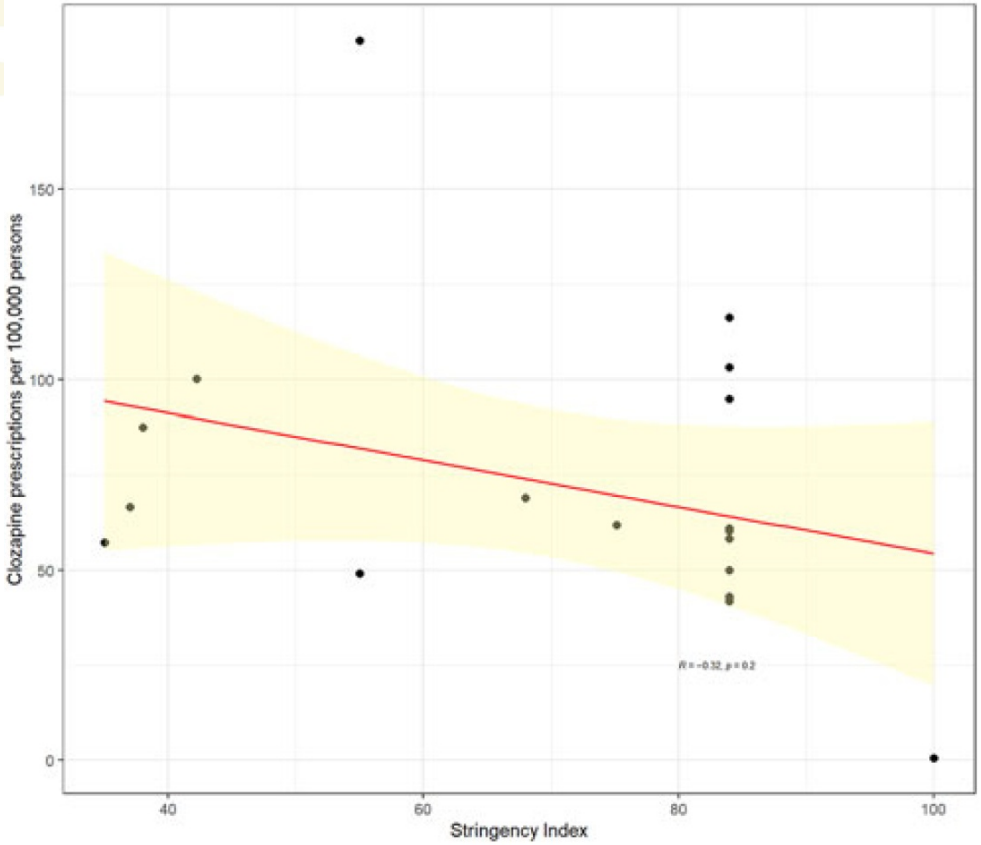


Fig. 1. Choropleth map of clozapine haematological monitoring Stringency Index. Red indicates highest stringency and yellow the lowest stringency. Grey indicates no data.


Clozapine prescriptions per 100,000 persons
150
100
50
0
40
60
80
100
Stringency Index

Asian Journal of Psychiatry 62 (2021) 102742

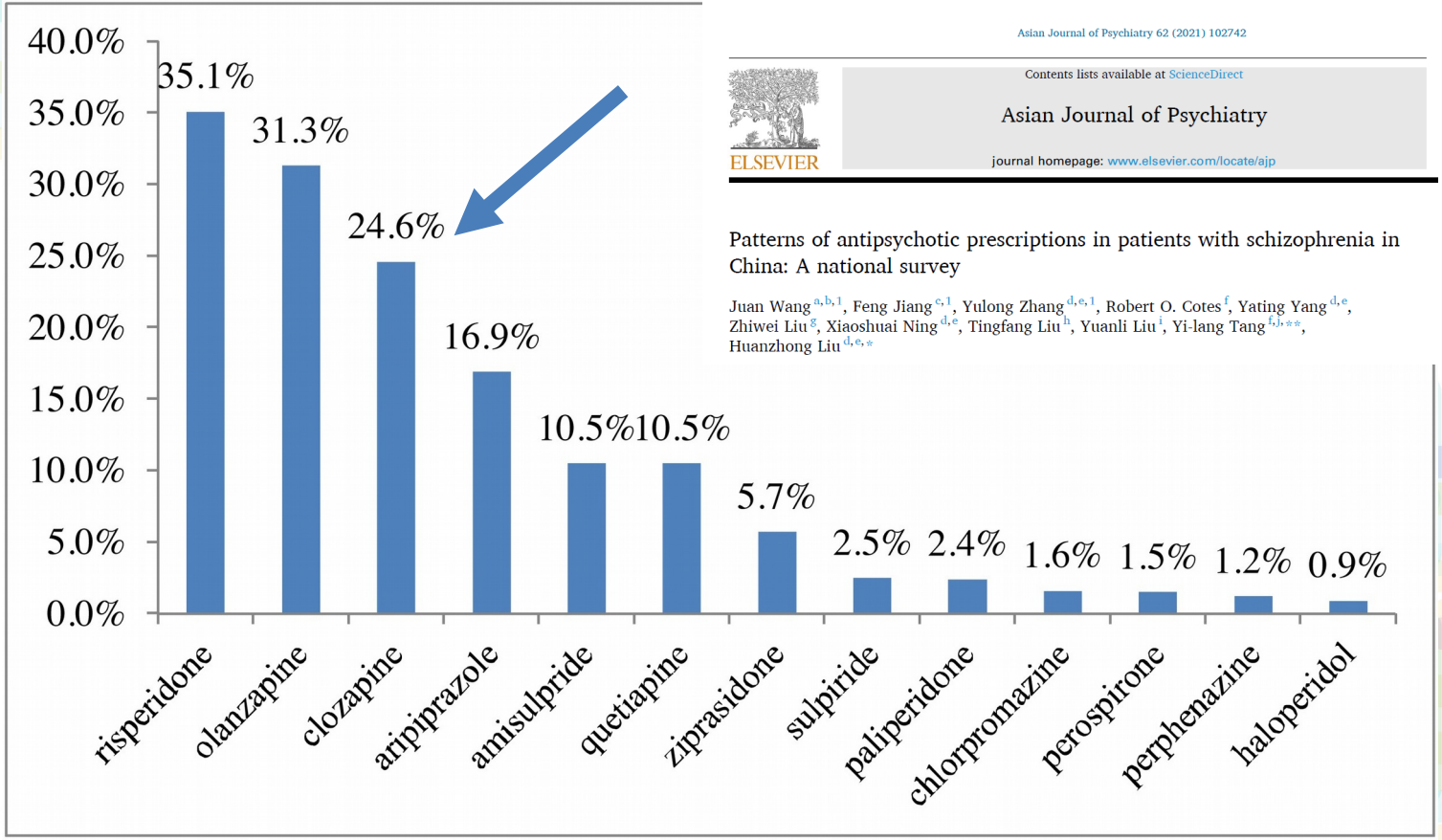
Contents lists available at ScienceDirect

Asian Journal of Psychiatry

journal homepage: www.elsevier.com/locate/ajp

Patterns of antipsychotic prescriptions in patients with schizophrenia in China: A national survey

Juan Wang [a,b,1], Feng Jiang [c,1], Yulong Zhang [d,e,1], Robert O. Cotes [f], Yating Yang [d,e], Zhiwei Liu [g], Xiaoshuai Ning [d,e], Tingfang Liu [h], Yuanli Liu [i], Yi-lang Tang [f,j,**], Huanzhong Liu [d,e,*]



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Patterns of antipsychotic prescriptions in patients with schizophrenia in China: A national survey

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Making clozapine use easier

Therapeutic Advances in Psychopharmacology *Original Research*

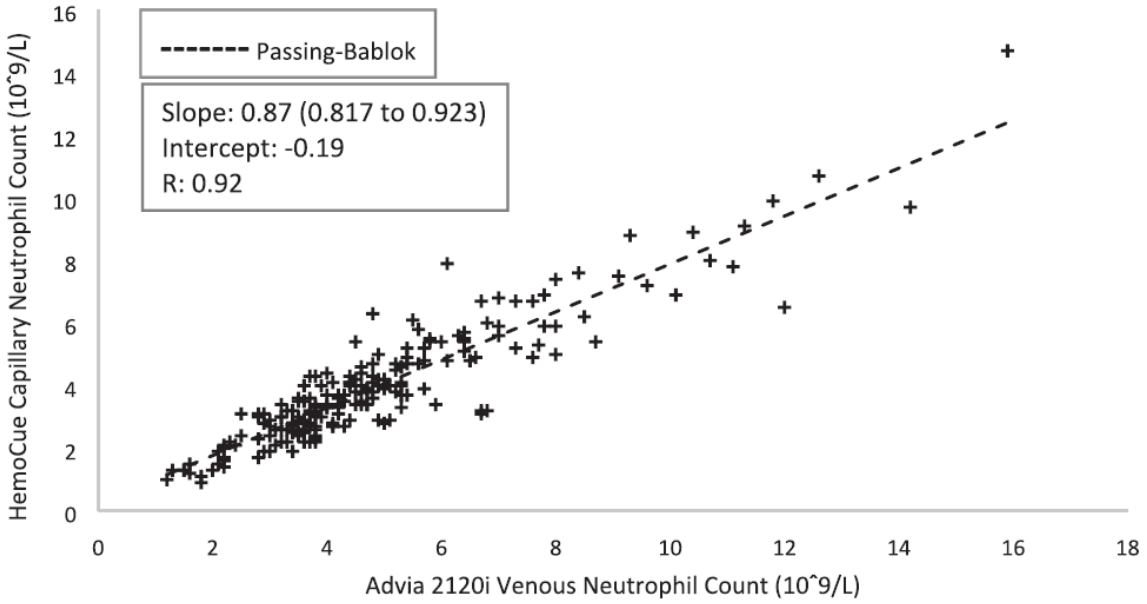
Using a fingerstick test for haematological monitoring in patients treated with clozapine

Matthew Atkins, Philip McGuire, Bhirundra Balgobin, Pravinkumar Patel and David Taylor

Ther Adv Psychopharmacol

2021, Vol. 11: 1–6

DOI: 10.1177/20451253211000865


Passing-Bablok
Slope: 0.87 (0.817 to 0.923)
Intercept: -0.19
R: 0.92
HemoCue Capillary Neutrophil Count (10^9/L)
Advia 2120i Venous Neutrophil Count (10^9/L)
0
2
4
6
8
10
12
14
16
18

Journal of Psychiatric Research 157 (2023) 66–71

Contents lists available at ScienceDirect

Journal of Psychiatric Research

journal homepage: www.elsevier.com/locate/jpsychires

Haematological point of care testing for clozapine monitoring

Matthew Atkins [a,b,*], Philip McGuire [b], Bhirundra Balgobin [d], Neville Desouza [a], David Taylor [a,c]

HemoScreen

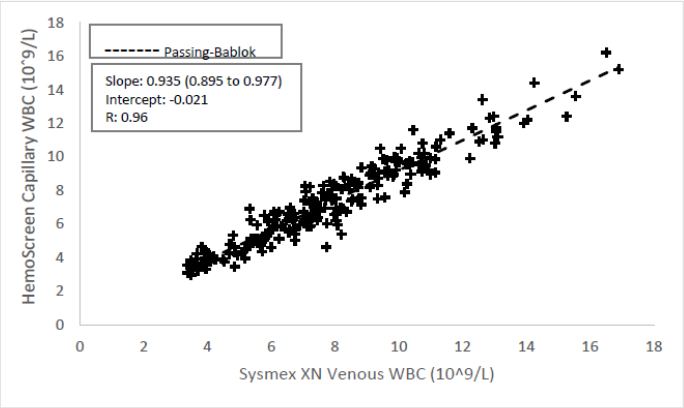


Fig. 1. HemoScreen® WBC (capillary whole blood) versus. Sysmex XN (venous whole blood) WBC counts. (N = 226).

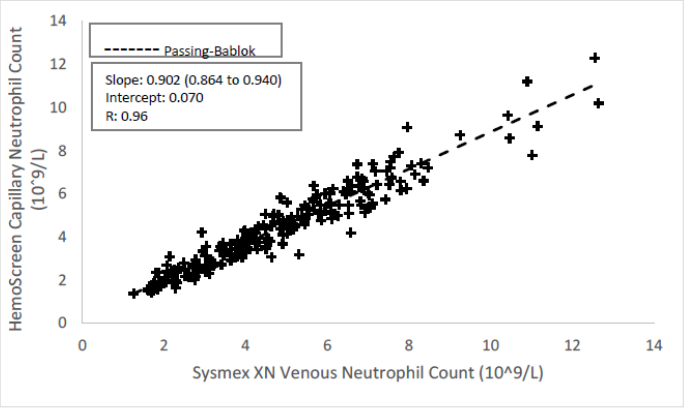


Fig. 2. HemoScreen® Neutrophil (capillary whole blood) versus Sysmex XN (venous whole blood) Neutrophil counts. (N = 226).

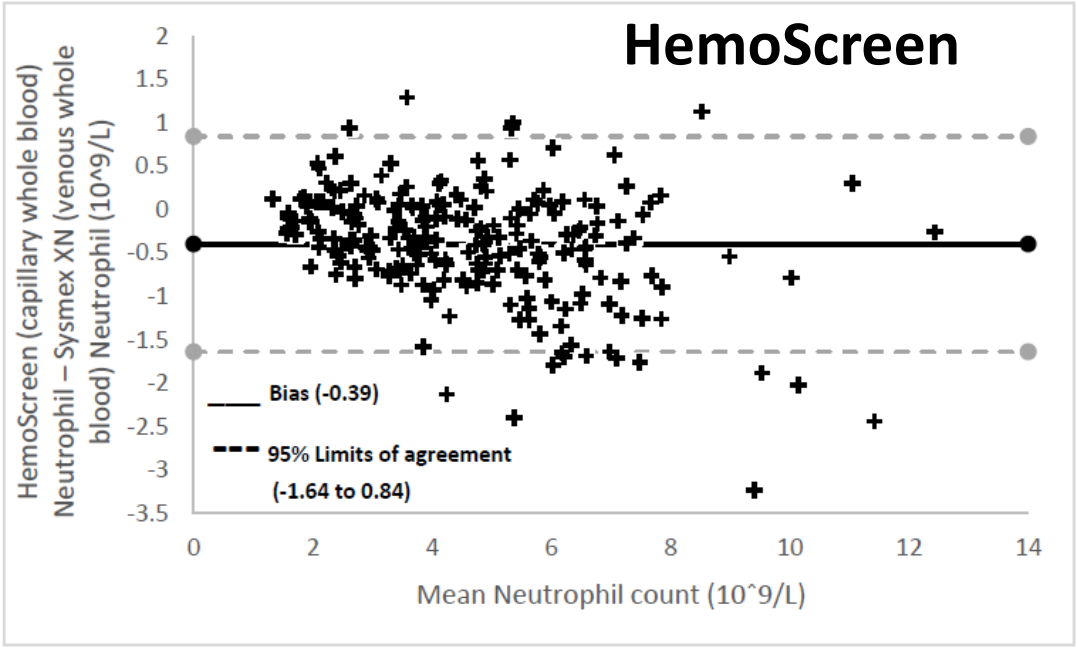


Fig. 8. Bland-Altman plot for the difference between HemoScreen capillary whole blood neutrophil count and Sysmex XN venous whole blood neutrophil count against the mean of both methods. (N = 226).

Original Paper

Point-of-care measurement of clozapine concentration using a finger-stick blood sample

David Taylor[1,2], Matthew Atkins[2,3], Robert Harland[4], Irina Baburina[5], James H MacCabe[6], Salvatore J Salamone[5] and Philip McGuire[6]

Journal of Psychopharmacology
2021, Vol. 35(3) 279–283

DOI: 10.1177/0269881121991567
journals.sagepub.com/home/jop
SAGE

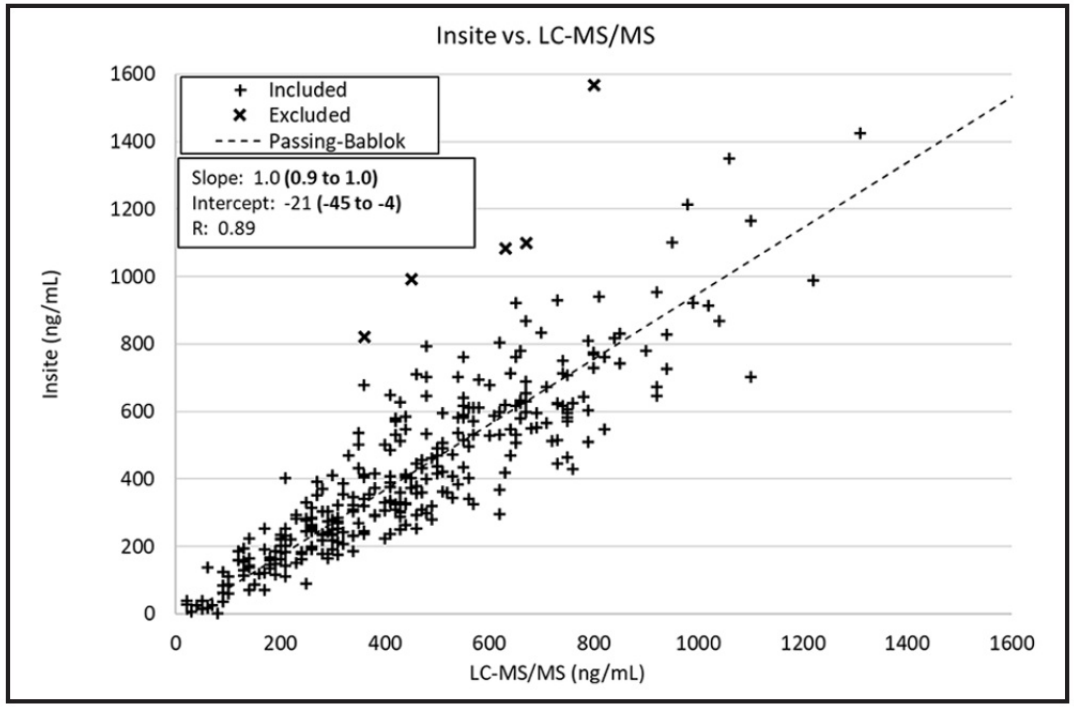


Figure 1. Insite point-of-care testing (capillary whole blood) versus liquid chromatography with tandem mass spectrometry (plasma) concentrations measured. (Excluded (×) $N=5$; Included (+) $N=304$).

Psychiatry Research Communications 2 (2022) 100070

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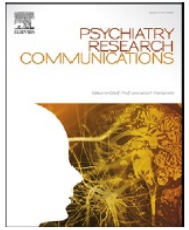


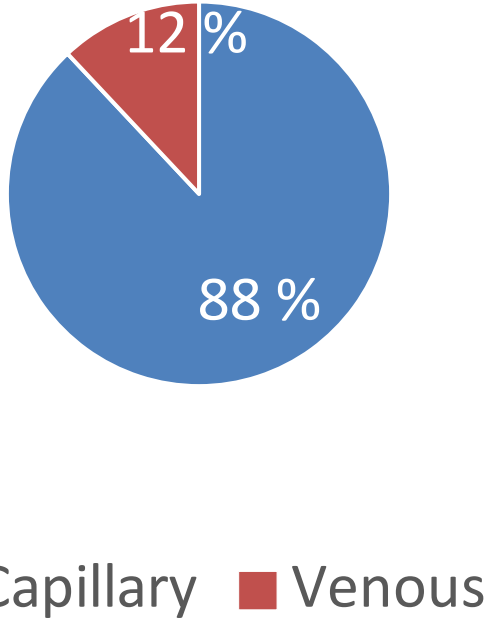
Acceptability of point of care testing for antipsychotic medication levels in schizophrenia

Matthew Atkins [a,b,*], David Taylor [a,b], Robert Harland [a,c], Aaron Brewer [a,c], Sophie Williams [e], Edward Chesney [a,c], Philip McGuire [c,d]

Table 1
Patient sample.

Patients being treated with clozapine	(n = 84)
Male/Female	55/29
Age (years)	47 (21–75)
Duration of clozapine treatment (months)	144 (12–192)
Patients being treated with aripiprazole **(n=22)**	11/11
Male/Female	
Age (years)	30 (20–63)
Duration of aripiprazole treatment (months)	15 months (2 - 36)

Patient preference



BJPsych | The British Journal of Psychiatry (2020)
217, 506–513. doi: 10.1192/bjp.2020.115

A retrospective study of intramuscular clozapine prescription for treatment initiation and maintenance in treatment-resistant psychosis

Cecilia Casetta, Ebenezer Oloyede, Eromona Whiskey, David Michael Taylor, Fiona Gaughran, Sukhi S. Shergill, Juliana Onwumere, Aviv Segev, Olubanke Dzahini, Sophie E. Legge and James Hunter MacCabe

sefh
Sociedad Española de Farmacia Hospitalaria

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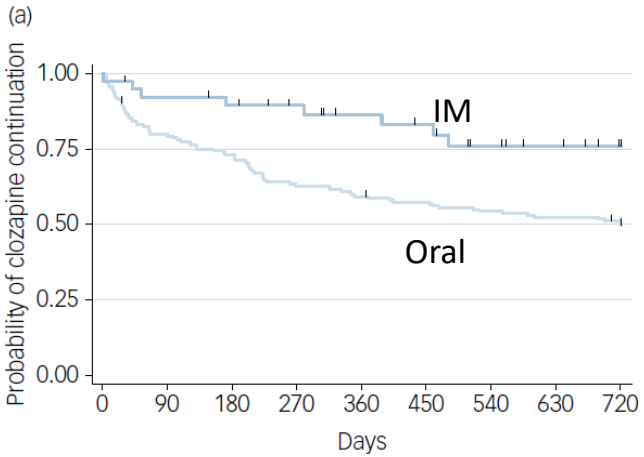
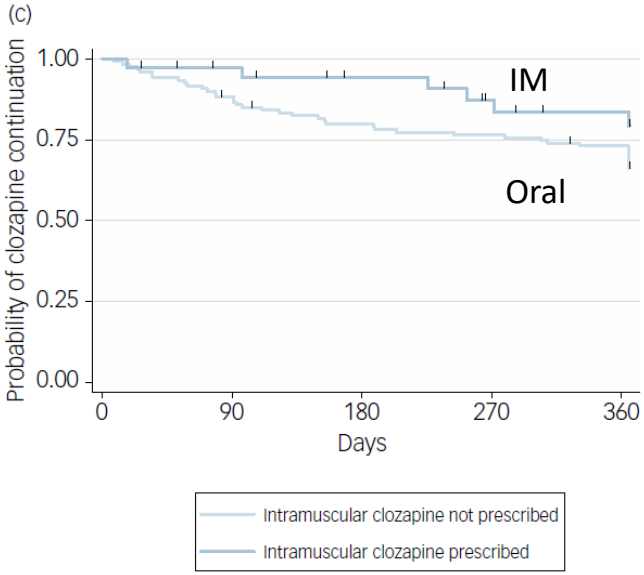


Discontinuation after Rx



Discontinuation after discharge

CNS Drugs
https://doi.org/10.1007/s40263-022-00900-w

CURRENT OPINION

Alternative Routes of Administration of Clozapine

Siobhan Gee[1] · David Taylor[1,2]

Clozapine genetic testing

Response

Three variants have been reliably shown to predict therapeutic outcome with clozapine [Gressier et al, 2016]

HTR2A rs6313C CC carriers less likely to respond than T carriers
CC 146/272 response, CT/TT 366/596 response (54% vs 62%)

HTR2A rs6314 C allele more likely to respond than T allele
C allele response 685/1215, T allele 55/127 (56% vs 43%)

HTR3A rs1062613 C allele less likely to respond than T allele
C allele response 528/841, T allele 134/185 (63% vs 72%)

Response

Variant	Test result		
HTR2A_rs6313	CC	CT	TT
HTR2A_rs6314	CC	CT	TT
HTR3A_rs1062613	CC	CT	TT

27 permutations

Estimated chance of response (%)
95% confidence intervals (%)

Eg permutation 4

Chance of response - 20% (8-51%)

NB true value increasingly unlikely as we approach extremes of CIs

Agranulocytosis

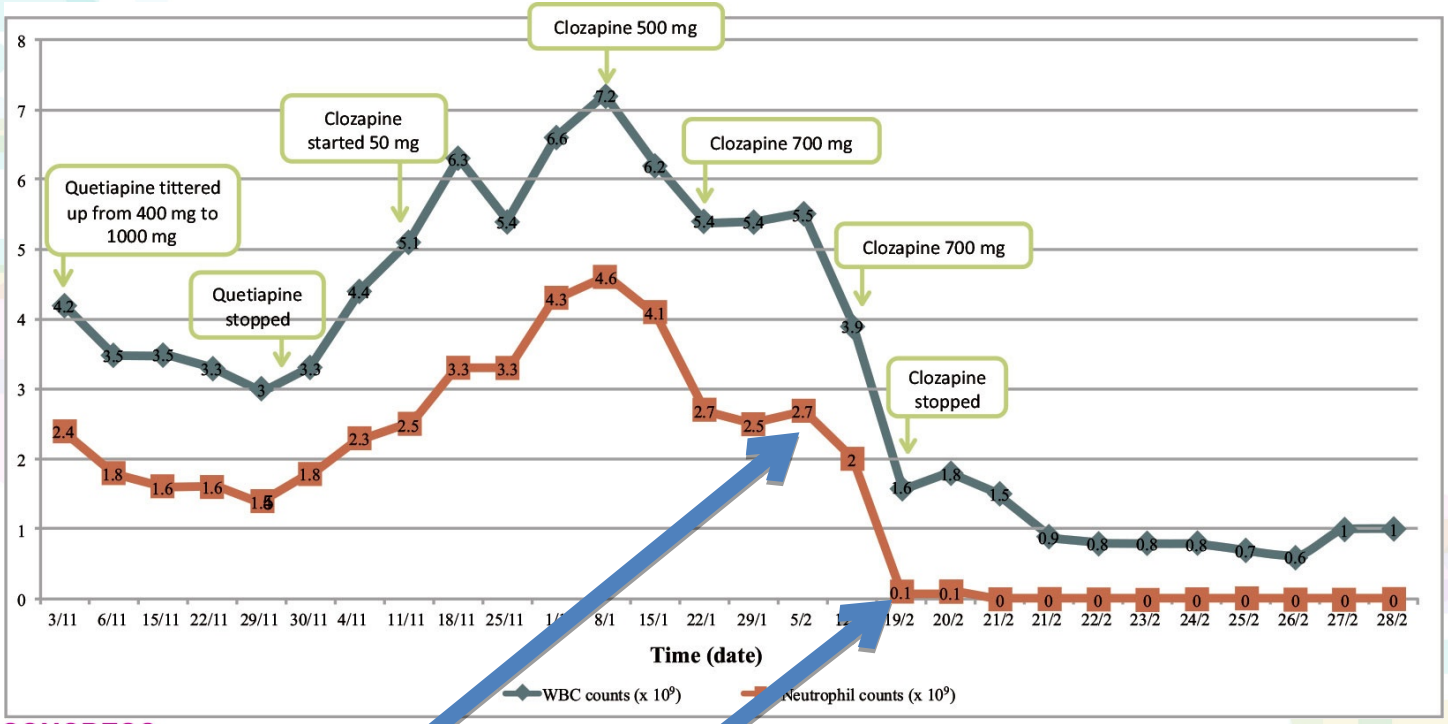
Risk of agranulocytosis

(A – granulocyte – osis)

- Risk of agranulocytosis – 0.4% (1 in 250)
- Risk of fatal agranulocytosis – 0.05% (1 in 2000)

Li X-H et al (2020). The prevalence of agranulocytosis and related death in clozapine-treated patients: a comprehensive meta-analysis of observational studies. Psychological Medicine 50, 583–594.

Almaghrebi A et al Current Drug Safety Volume 14 , Issue 1 , 2019



Last count > 2.5

Neutrophil nadir 12 days later

(Time from 2.0 to 0.1 = 7 days)

Agranulocytosis

Four genetic variants are reliably associated with altered risk of (threshold-based) agranulocytosis.

HLA-DQB1 Sequence variant 6672G>C (REC 21G) confers 1,175% higher risk of agranulocytosis than general population. Sensitivity 21.5%, specificity 98.4% (Athanasiou et al, 2011).
Positive predictive value 5.1%, negative predictive value 99.7%

HLA-DQB1 DQB1*0502 allele associated with agranulocytosis in 5/7 studies (eg. Dettling et al, Yunis et al). Effect size variable.

HLA-B*59:01 Presence of allele highly predictive of agranulocytosis but is rare in East Asian populations and almost absent in Caucasians. Sensitivity 31.8%, specificity 95.3% (Saito et al, 2015). PPV 6.4%, NPV 99.3%

HLA DBQ1/HLA-B Single amino acid changes HLA DBQ1 126Q and HLA-B 158 associated with increased risk of agranulocytosis. Overall 39 of 95 cases had one or both alleles; 175 of 206 controls had neither allele.
Sensitivity 41.0%, specificity 85.0% (Girardin et al, 2019; Goldstein et al 2015) (36% and 89% figures given by Legge and Walters).

The HLA-DQB1 variants and the HLA-B variants are in linkage disequilibrium [Legge et al] and are likely to convey the same association signal. Variants in LD are inherited together

Agranulocytosis

High risk variant	**6-20%**
No high risk variant	**0.4/0.3%**

Agranulocytosis

Best sensitivity **54%**

SnNOUT: a highly Sensitive test if Negative, rules OUT agranulocytosis

Best specificity **99%**

SpPIN: a highly Specific test if Positive, rules IN agranulocytosis

Konte B, et al. HLA-DQB1 6672G>C (rs113332494) is associated with clozapine-induced neutropenia and agranulocytosis in individuals of European ancestry. Transl Psychiatry. 2021 Apr 12;11(1):214. doi: 10.1038/s41398-021-01322-w.

Agranulocytosis – HLA variants

Konte B, et al. Transl Psychiatry. 2021 Apr 12;11(1):214.

Best sensitivity **54%** (only half of cases have the variant)

Best specificity **99%** (a high proportion of the people with agranulocytosis) the variant get

Explanations:

There is more than one genetic cause of agranulocytosis

The defined phenotype is polluted (not everybody with ‘clozapine-induced agranulocytosis’ has clozapine-induced agranulocytosis)

Clozapine -

What is and what is not clozapine-associated agranulocytosis

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Schizophrenia

ARTICLE OPEN

Check for updates

Distinctive pattern of neutrophil count change in clozapine-associated, life-threatening agranulocytosis

David Taylor[1,2]✉, Kalliopi Vallianatou[2], Eromona Whiskey[1,2,3], Olubanke Dzahini[1,2] and James MacCabe[3,4]

The wider use of clozapine is limited by the risk of agranulocytosis and the associated requirement for monitoring of neutrophil counts. We searched local electronic patient records for cases of agranulocytosis occurring during clozapine treatment during the period 2007–2020. We found 23 episodes recorded as agranulocytosis in clozapine patients. Of these, nine met pre-defined criteria and were considered episodes of life-threatening agranulocytosis (LTA). These episodes of clozapine-induced LTA exhibited a distinct pattern of continuous and rapid neutrophil count decline to zero or near zero. Mean time for neutrophils to fall from ANC > 2 to ANC $<0.5 \times 10^9$/L was 8.4 days (range 2–15 days). Each event was also characterised by a prolonged nadir and delayed recovery (range 4–16 days). Non-LTA episodes were, in contrast, brief and benign. We conclude that an important proportion of cases of agranulocytosis identified in people prescribed clozapine are not life-threatening and may not even be clozapine-related. Monitoring schemes should aim to identify true clozapine-induced LTA as opposed to threshold-defined nominal agranulocytosis.

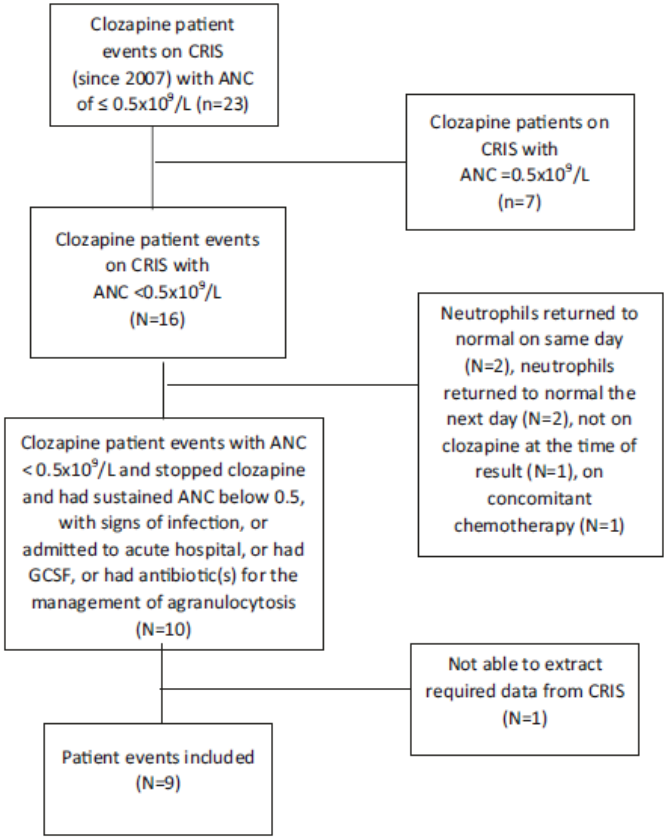


Fig. 1 Case selection.

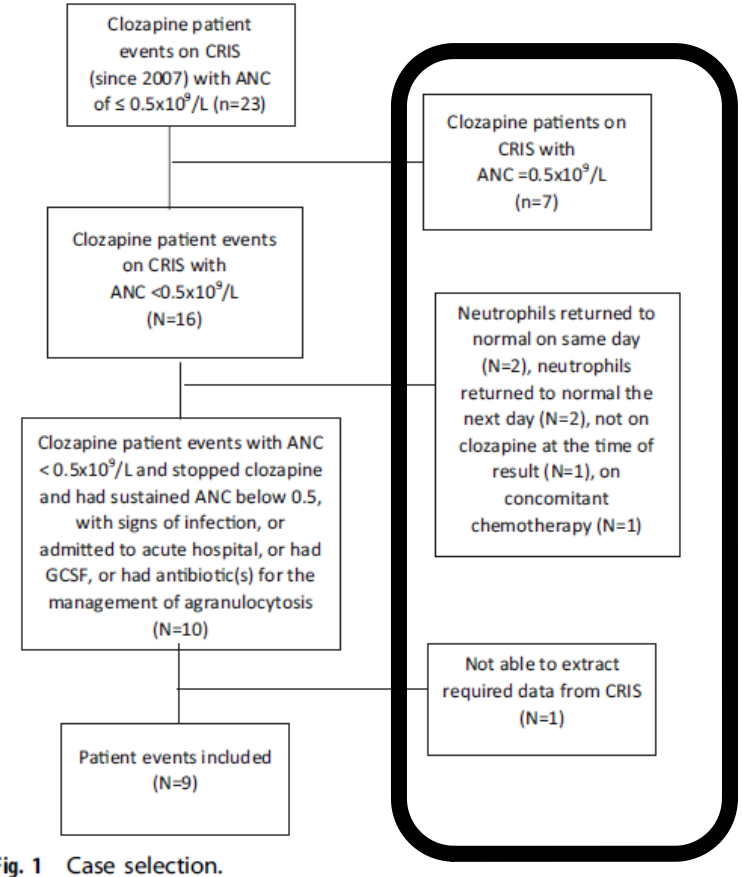
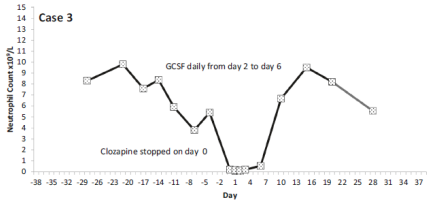
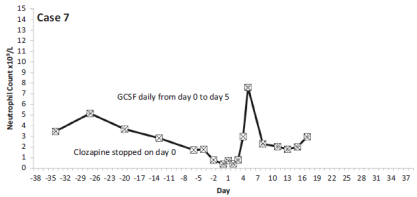
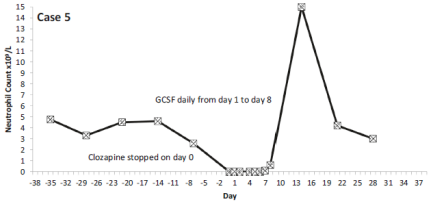


Fig. 1 Case selection.

We will come back to these


Case 3
GCSF daily from day 2 to day 6
Clozapine stopped on day 0
Neutrophil Count x10⁹/L
Day


Case 7
GCSF daily from day 0 to day 5
Clozapine stopped on day 0
Neutrophil Count x10⁹/L
Day


Case 5
GCSF daily from day 1 to day 8
Clozapine stopped on day 0
Neutrophil Count x10⁹/L
Day

Original Paper

Severe neutropenia unrelated to clozapine in patients receiving clozapine

David Taylor[1,2], Kalliopi Vallianatou[1,2], Shreyans Gandhi[3], Cecilia Casetta[4,5], Oliver Howes[4,6] and James MacCabe[4,5]

Journal of Psychopharmacology
2024, Vol. 38(7) 624–635

DOI: 10.1177/02698811241262767
journals.sagepub.com/home/jop

Table 1. Patient details.

Number	Sex	Age range	Duration of clozapine	BEN status	Concurrent medication	Clozapine restarted?	Clozapine-induced neutropenia?	Life-threatening?	Likely cause
1	F	50–60	2 years	No	Lamotrigine,[a] hyoscine, amisulpride, levothyroxine	Yes	No	No: ANC <0.5 for 1 day	Anomalous result, Possible laboratory error
2	M	50–60	18 years	No	Doxycycline, sodium valproate[a]	Never stopped	No	No: ANC <0.5 for 1 day	Anomalous result, Possible laboratory error
3	M	30–40	4 weeks	Yes	Fluoxetine,[a] lamotrigine,[a] amlodipine, lurasidone, promethazine	Yes, but later stopped	No	No: ANC never <0.5	Unknown
4	M	20–30	2 weeks	Yes	Quetiapine[a]	Yes, when BEN diagnosed	No	No: ANC <0.5 for 1 day	Anomalous result, Possible laboratory error
5	M	20–30	8 weeks	No	Nil	Not on clozapine	No	No: ANC <0.5 for 2 days	Unknown
6	M	40–50	9 months	No	Amisulpride, omeprazole[a]	No	Possible	No: ANC <0.5 for 3 days	Clozapine?
7	F	60–70	8 weeks	No	Sodium valproate[a]	No	Possible	No: ANC <0.5 for 1 day	Clozapine?
8	M	60–70	4 weeks	No	Sodium valproate,[a] amlodipine, ranitidine,[a] simvastatin, procyclidine	No - myocarditis	Possible	No: ANC <0.5 for 1 day	Clozapine?
9	M	60–70	20 years	No	Nil	Yes	No	Yes: ANC <0.5 for 12 days	Cancer chemotherapy
10	M	50–60	14 years	No	Hyoscine	Never stopped	No	No: ANC <0.5 for 1 day	Cancer chemotherapy
11	M	50–60	16 years	No	Nil	Yes	No	No: ANC never <0.5	Cancer chemotherapy
12	M	50–60	6 weeks	No	Ramipril,[a] clopidogrel[a]	No	Possible	No: ANC never <0.5	Clozapine?
13	M	50–60	9 weeks	No	Ramipril,[a] valproate semisodium,[a] hyoscine	No	Possible	No: ANC never <0.5	Clozapine?

[a]Drugs known to be associated with agranulocytosis (Malik et al., 2018; Rattay and Benndorf, 2021).
ANC: absolute neutrophil count; BEN: benign ethnic neutropenia.

Defining agranulocytosis caused by clozapine

- Agranulocytosis
  - Below $0.5x10^9/l$
  - Two consecutive counts

'Pattern-based' or Taylor criteria

- Caused by clozapine
  - Neutrophils usually fall to zero
  - No recovery until GCSF
  - No other cause

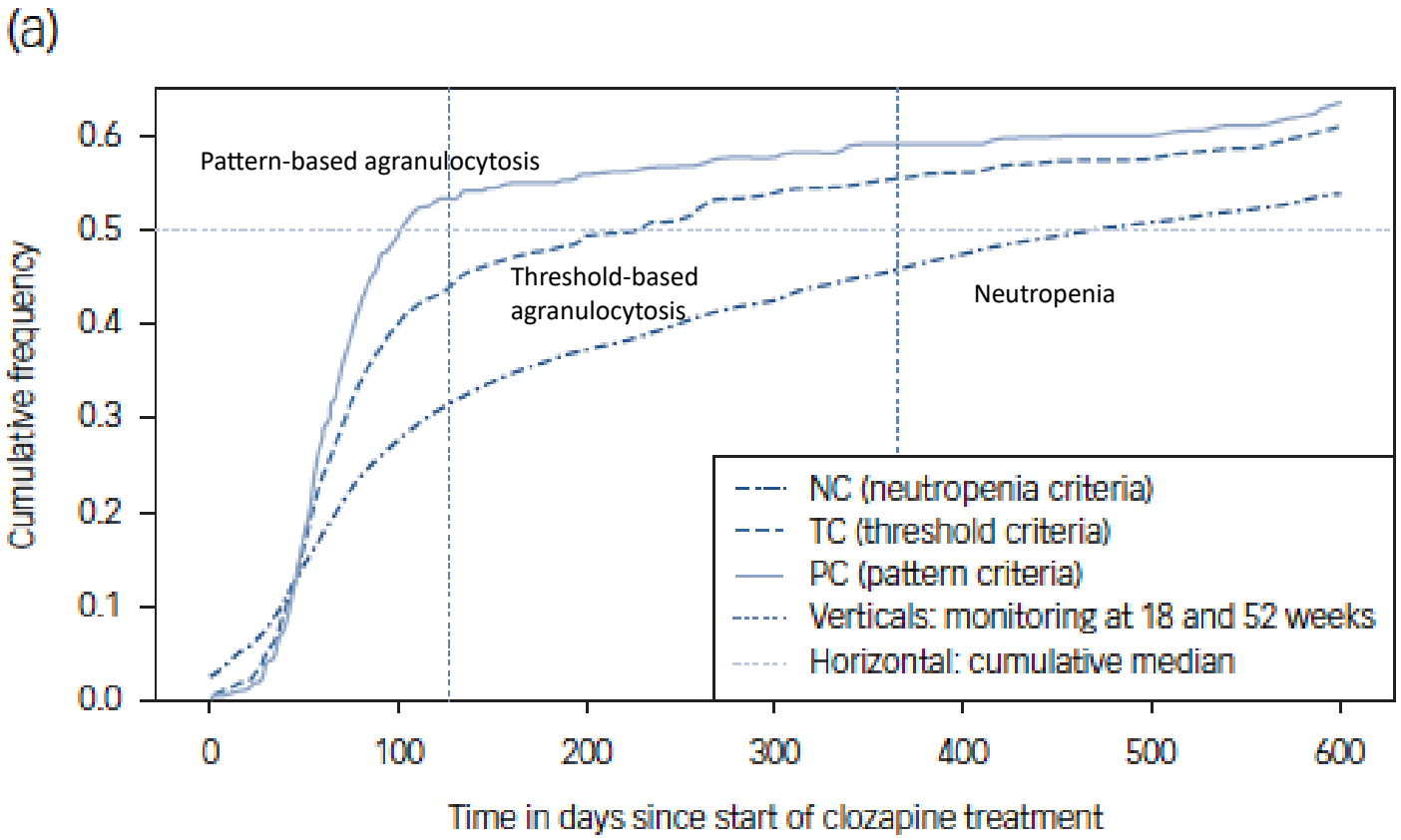
  - Chemo, laboratory error

What difference does it make?

Using pattern-based criteria vs threshold-based criteria

- Of the 3029 patients registered on the CNRD with 283 726 blood measurements, 593 (**19.6%)** had threshold-based agranulocytosis and 348 (**11.4%)** pattern-based agranulocytosis.
- In the total sample (75 533), the prevalence of threshold-based agranulocytosis was **0.8%** and **0.5%** for pattern-based agranulocytosis
- Prevalence rates for PB agranulocytosis were greatest for White (18%) and male individuals (13%), and lowest for Black individuals (**0.1%**).
- The proportion of people with pattern-based agranulocytosis without passing through neutropenia was **70%**.

Oloyede E, Bachmann CJ, Dzahini O, Lopez Alcaraz JM, Singh SD, Vallianatu K, Funk B, Whiskey E, Taylor D. Identifying clinically relevant agranulocytosis in people registered on the UK clozapine Central Non-Rechallenge Database: retrospective cohort study. Br J Psychiatry. 2024 Aug 16:1-8.



Oloyede E, Bachmann CJ, Dzahini O, Lopez Alcaraz JM, Singh SD, Vallianatu K, Funk B, Whiskey E, Taylor D. Identifying clinically relevant agranulocytosis in people registered on the UK clozapine Central Non-Rechallenge Database: retrospective cohort study. Br J Psychiatry. 2024 Aug 16:1-8.

TLDR –

The risk of clozapine-induced agranulocytosis is about half of that previously reported

TLDR –

The risk of clozapine-induced agranulocytosis is about half of that previously reported

Oh, and (as an aside) all the genetic linkage studies need to be redone…

TLDR –

The risk of clozapine-induced agranulocytosis is about half of that previously reported

Oh, and (as another aside) black people are least likely to have agranulocytosis

BEN and misdiagnosis of neutropenia

Schizophrenia Bulletin
doi:10.1093/schbul/sbab006

There Is Life After the UK Clozapine Central Non-Rechallenge Database

Ebenezer Oloyede[1,2], Cecilia Casetta[2,3], Olubanke Dzahini[1,4], Aviv Segev[2,5], Fiona Gaughran[2,3], Sukhi Shergill[2,3], Alek Mijovic[6], Marinka Helthuis[7], Eromona Whiskey[1,2,3,8], James Hunter MacCabe[†,2,3,8], and David Taylor[†,1,4]

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Success on re-Exposure

- 62 pts re-exposed
- 3 recorded further ‘red’ result and were discontinued
- 59/62 (95%) successfully re-exposed and remained on clozapine
- Mean time to diagnosis of BEN – 10 years

Relaxation of the criteria for entry to the UK Clozapine Central Non-Rechallenge Database: a modelling study

Ebenezer Oloyede, Eromona Whiskey*, Cecilia Casetta, Olubanke Dzahini, Danielle Dunnett, Shreyans Gandhi, Fiona Gaughran, Sukhi Shergill, Philip McGuire, James H MacCabe†, David Taylor†*

Summary

Background Clozapine is uniquely effective in treatment-resistant psychosis. In the UK, patients must discontinue clozapine indefinitely if they are placed on the Central Non-Rechallenge Database (CNRD) after their haematological parameters fall below particular thresholds. Under exceptional circumstances, patients can be rechallenged on clozapine under an off-licence agreement. In the USA in 2015, restrictive practice was discontinued to allow greater flexibility for clozapine maintenance. The absolute neutrophil count leading to treatment interruption was lowered from less than $1{\cdot}5\times10^9$/L to less than $1{\cdot}0\times10^9$/L and platelet and white cell count monitoring were ceased. We aimed to investigate the implications of a similar policy change on clozapine use in the UK.

Methods This was a modelling study of all patients registered on the UK CNRD. First, we determined the proportion of patients placed on the database in the UK who would have had to discontinue clozapine treatment under the US Food and Drug Administration (FDA) criteria. Second, we compared the haematological characteristics of patients who did or did not meet FDA criteria for discontinuing clozapine, including the time to registration from clozapine initiation and the proportion of cases of severe neutropenia at registration. Third, we investigated the success rates of clozapine re-challenge for patients that had been placed on the CNRD. Successful rechallenge was defined as no recurrence of CNRD registration.

Findings Between May 2, 2002 and March 1, 2021, 3731 patients were placed on the CNRD, with a mean age of 47 years (SD 15), including 1420 (38%) women and 2311 (62%) men, of whom 3089 (83%) were White, 360 (10%) were Black, 190 (5%) were Asian, and 92 (2%) were classified as other. 566 (15%) of 3731 patients met the equivalent criteria for clozapine discontinuation under the FDA guidelines. The median time to CNRD registration from clozapine initiation was 1·6 years (IQR 0·2–4·9). Data for 519 rechallenged patients were examined; 419 (81%) were successful. Clozapine rechallenge success rates were broadly similar between individuals who did not meet the US CNRD registration criteria (36 [78%] of 46) and those who did meet the criteria (383 [81%] of 473).

Interpretation Implementing the revised FDA monitoring criteria in the UK would substantially reduce clozapine discontinuation for haematological reasons, which would greatly improve the mental health outcomes of these patients without having a major effect on their physical health.

Funding None.

Lancet Psychiatry 2022

Published Online
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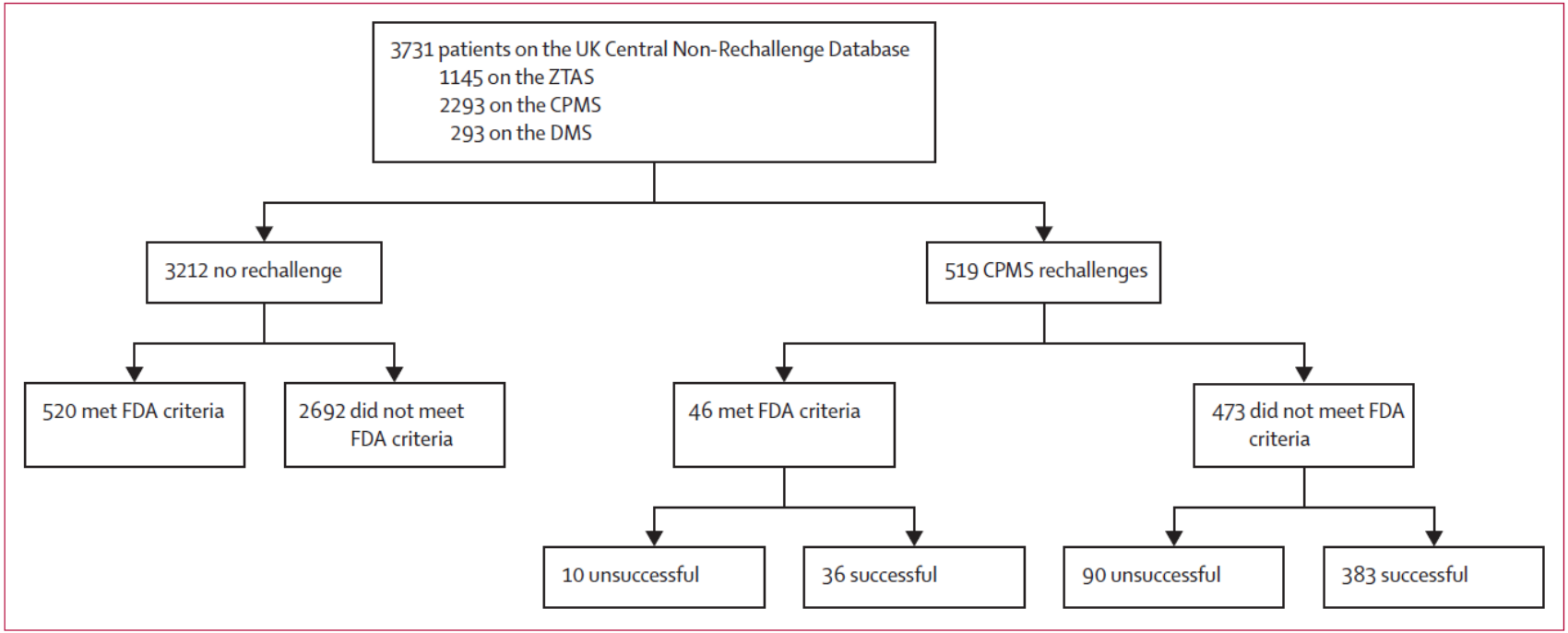
https://doi.org/10.1016/S2215-0366(22)00188-2

*Joint first authors

†Joint last authors

Pharmacy Department (E Oloyede MPharm, E Whiskey PhD, O Dzahini MSc, Prof D Taylor PhD) **and National Psychosis Service** (E Whiskey, C Casetta MD, Prof F Gaughran MD, Prof J H MacCabe PhD), **South London and Maudsley NHS Foundation Trust, London, UK; Department of Psychosis Studies, Institute of Psychiatry, Psychology and Neuroscience, King's College London, London, UK** (E Oloyede, C Casetta, D Dunnett MSc, Prof F Gaughran, Prof S Shergill PhD, Prof P McGuire PhD, Prof J H MacCabe); **Institute of Pharmaceutical Science, King's College, London, UK** (E Whiskey, O Dzahini, Prof D Taylor); **NIHR Biomedical Research Centre for Mental Health South London and Maudsley NHS, London, UK** (Prof F Gaughran, Prof J H MacCabe); **Kings College Hospital London NHS Foundation Trust, London, UK** (S Gandhi MD)



419/519 (81%) successful rechallenge

Oloyede *et al. BMC Psychiatry* (2021) 21:502
https://doi.org/10.1186/s12888-021-03514-6

BMC Psychiatry

RESEARCH Open Access

Benign ethnic neutropenia: an analysis of prevalence, timing and identification accuracy in two large inner-city NHS hospitals

Ebenezer Oloyede[1,2*], Olubanke Dzahini[1,3], Nigel Barnes[4], Aleksandar Mijovic[5], Shreyans Gandhi[5], Sara Stuart-Smith[5], Theo de Witte[6], David Taylor[1,3†] and Eromona Whiskey[1,2,3†]

Table 3 Treatment stage of BEN diagnosis

Stage of BEN Identification	SLaM ($n = 89$) n (%)	BSMHFT[a] ($n = 17$) n (%)	Total ($n = 106$) n (%)
At Initiation	27 (30)	6 (35)	33 (32)
After Below Threshold Haematological Reaction	45 (51)	11 (65)	56 (52)
On Re-challenge	17 (19)	0 (0)	17 (16)

[a]Missing data: 5 patients

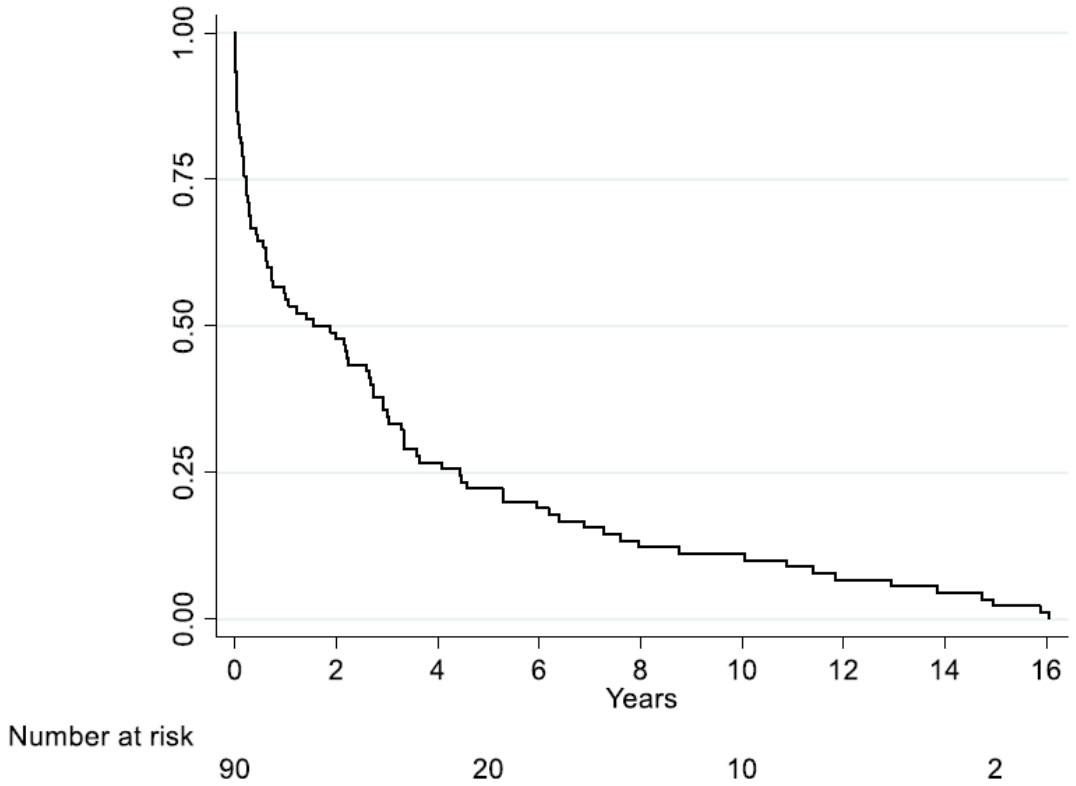


Fig. 1 Kaplan Meier for the time to BEN registration from clozapine initiation

Benign Ethnic Neutropenia

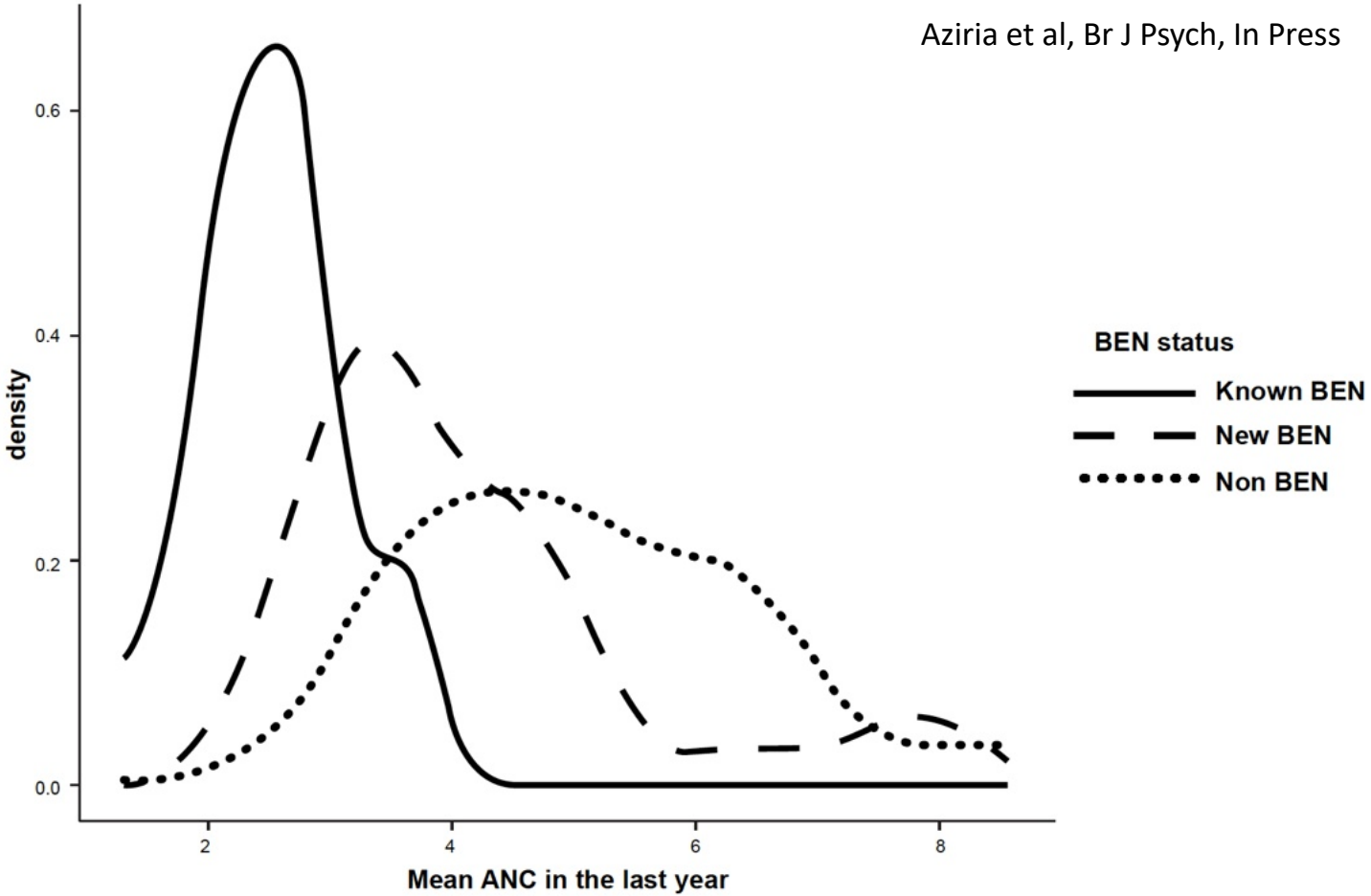
- The absence of the red blood cell Duffy antigen, Fy (a- b-) ('Duffy Null' - SNP rs2814778 at chromosome 1q23.2) is thought to be responsible for BEN.
- "We confirmed that rs2814778 in *DARC* was associated with BEN ($p = 4.09\times10^{-53}$)." (Charles et al, 2018).
- The CC variant of this SNP codes for BEN
- As the Duffy antigen is utilized by the parasite *Plasmodium vivax* to enter the RBC, it has been hypothesized that in West Africa, positive selection for the null allele enabled individuals to be protected against infection and have a survival advantage. (Chang et al *Blood* (2018)).
- SNP rs2814778 at chromosome 1q23.2 may also be responsible for BEN in Yemenite Jews, Bedouin and those of Middle Eastern origin (Reich et al (2009)).

Benign Ethnic Neutropenia
Maudsley Study

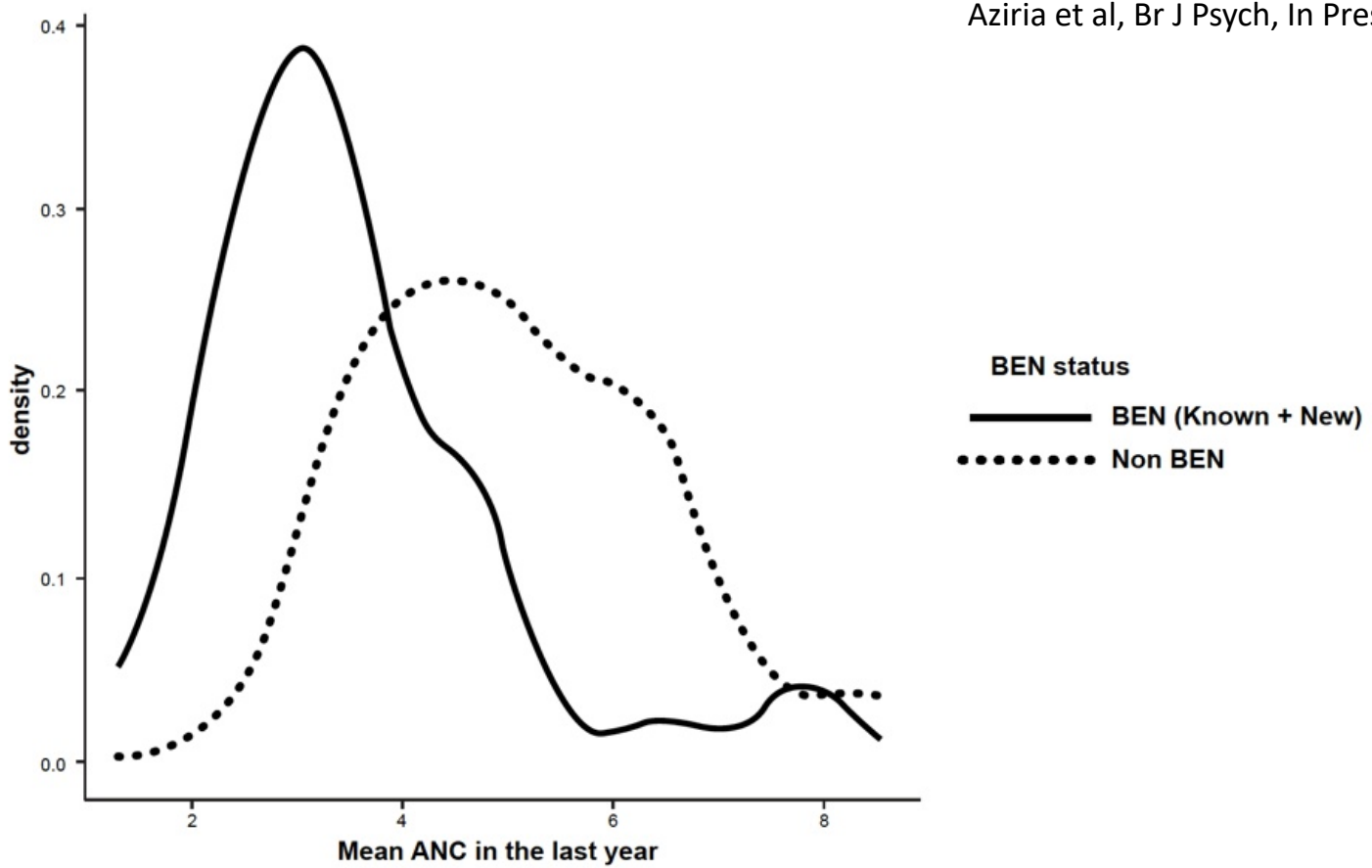
Aziria et al, Br J Psych, In Press

- 108 patients tested at random in clozapine clinic
- 16 previously registered as BEN
- 24 more found to have BEN via genetic test

Aziria et al, Br J Psych, In Press



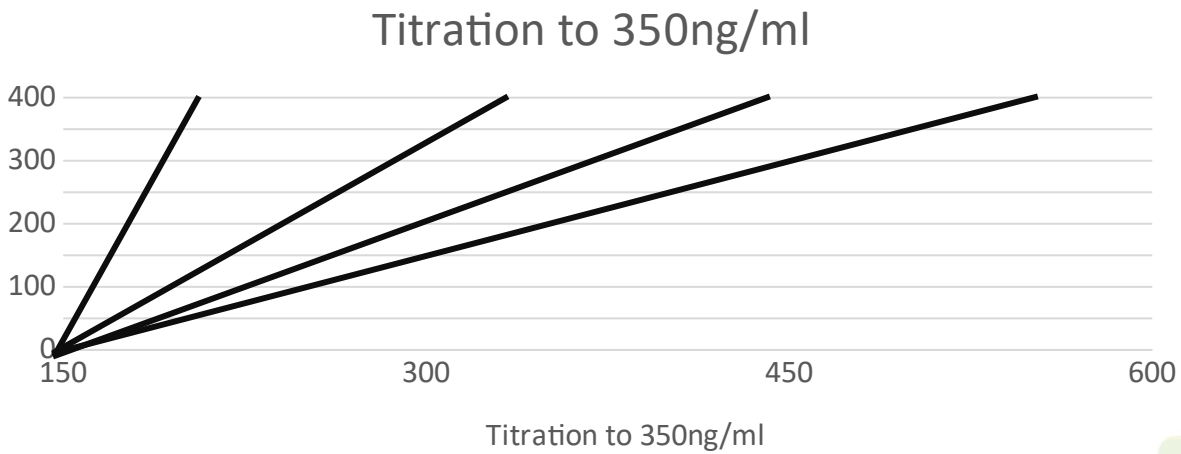
Aziria et al, Br J Psych, In Press



Reducing adverse effects by tailored titration

Speed of titration vs dose needed

Effective speed of titration



metabolism

Cytochrome p4501A2 PM/IM/EM status as normally defined by analysis of CYP1A2*1F/1C/1A/1K

Cytochrome p4503A4 PM/IM/EM status. CYP3A4 is a minor route of clozapine metabolism but metaboliser status affects blood concentration. (Toth et al, 2017)

Cytochrome p4503A5 PM/IM/EM status. CYP3A5 PM status associated with elevated clozapine blood levels (John et al, 2020)

Other non-CYP genetic associations have also been demonstrated.

NFIB rs28379954 ***T>C*** CT carriers have much lower blood concentrations than TT carriers in both smokers and non-smokers (Smith et al, 2020)

Also the **rs2472297** (?CYP1A1) genotype independently predicts clozapine plasm levels. (Pardinas et al, 2019). Levels are highest in C/C

Original Paper

Predicting clozapine dose required to achieve a therapeutic plasma concentration – A comparison of a population algorithm and three algorithms based on gene variant models

David Taylor[1], Caroline Cahill[2], Paul Wallang[2,3], Louise Millard[2], Luis Ramudo Cela[4] and Kieran C Breen[2]

Psychopharm

Journal of Psychopharmacology
1–10

DOI: 10.1177/02698811231199104
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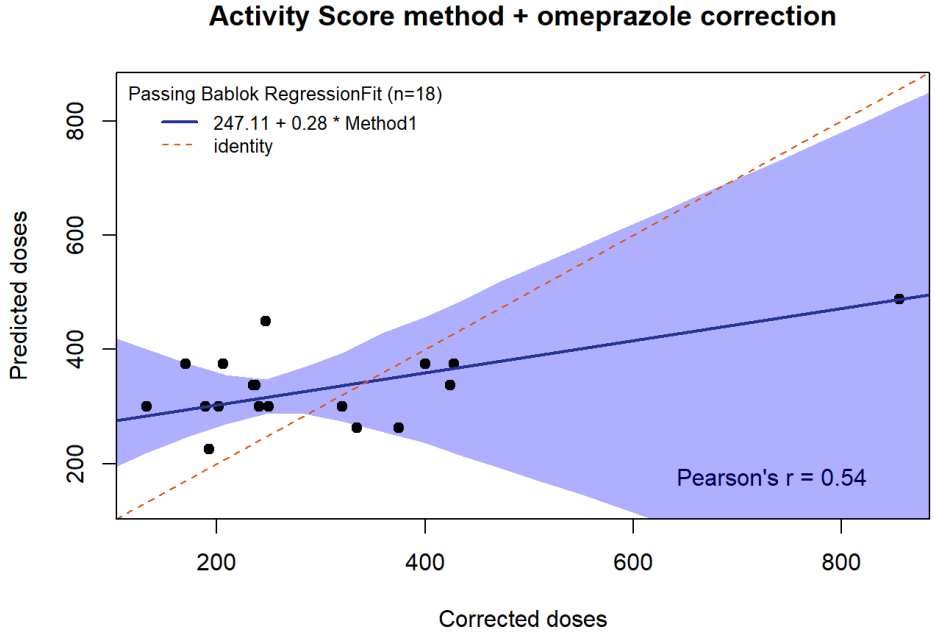

Mean difference between predicted dose and actual dose = 31mg/day

Based on activity of CYP1A2, CYP3A4, CYP3A5 genes, *NFIK* rs28379954

Predicting dose to give 350mg/L (n=18);

Genetic Analysis of Clozapine Metabolism in a Patient With Subtherapeutic Clozapine Plasma Concentrations—The Importance of CYP3A5
A Case Report

Okon-Rocha, Ramudo-Cela, Taylor

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Journal of Clinical Psychopharmacology • Volume 42, Number 6, December 2022 *Letter to the Editors - Case Report*

TABLE 2. Clozapine and Norclozapine Levels During Hospitalization

Treatment Regime-Clozapine Dose Daily	Date	Clozapine Plasma Concentration, mg/L	Norclozapine Plasm Concentration, mg/L
450 mg	17/08/2020	0.25	0.15
550 mg	14/09/2020	0.27	0.11
550 mg + cariprazine 1,5 mg	14/10/2020	0.42	0.19
625 mg + cariprazine 3 mg	02/02/2021	0.36	0.16
725 mg + cariprazine 3 mg	17/03/2021	0.35	0.17
825 mg + cariprazine 3 mg	25/05/2021	0.41	0.20
850 mg + amisulpride 200 mg + cimetidine 800 mg	31/08/2021	0.93	0.41
800 mg + amisulpride 100 mg + cimetidine 400 mg	13/09/2021	0.76	0.33
800 mg + amisulpride 100 mg + cimetidine 400 mg	21/12/2021	0.74	0.36

All samples were taken 10–14 hours after dose.
All samples taken when the patient was in hospital.

Thank you

A CORUÑA
17-19 OCT 24

Gracias por su atención

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SOCIEDAD ESPAÑOLA DE FARMACIA HOSPITALARIA