


Research Article

The Most Cited Articles in Neuroimaging for Depression: A Bibliometric Analysis of the Top 100 Most Highly Cited Articles Between 1992 and 2020

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Abstract

Objectives: The goal of this study was to assess the current state and trends in neuroimaging for depression over the last four decades, using bibliometric analysis to give researchers fresh ideas for the future study area.

Methods: The Web of Science Core Collection was used to pull papers about neuroimaging for depression published between 1992 and 2021. We utilized the included articles to look at data on neuroimaging and depression publications, countries, institutions, cited journals, cited authors, cited references, keywords, and citation bursts.

Results: From 1992 to 2021, 5153 publications were pulled. In these last four decades, we selected the most prestigious journals, countries, institutions, and authors in neuroimaging modalities in depression. The keyword "major depression disorder" came in first for research discoveries with the most elevated citation burst. "Neuroimaging," "depression," "bipolar," "unipolar," and "anxiety" were the five hot themes in neuroimaging on depression.

Conclusions: The findings of this bibliometric analysis provide insight into current research patterns in neuroimaging for depression, as well as the present status and trends of the last four decades, which may aid investigators in determining the field's current status hotspots, and frontier tendencies.

Keywords: Neuroimaging; Depression; Bibliometric Analysis; Web of Science

Introduction

Major depression or depression is a common illness that severely limits psychosocial functioning and diminishes the quality of life around the world [1]. In 2008, the World Health Organization (WHO) ranked major depression as the common cause of death worldwide and projected that the disease will rank first by 2030.[2] The global prevalence of major depressive illness is estimated at around 4.7 %, with a 3% yearly incidence rate.[3] Depression affects 50% of all psychiatric outpatients and 12% of all inpatients, significantly influencing the quality of life.[4] Every year, about 5.8% of males and 9.5 % of females experience depression episodes [5]. According to the WHO, depression is the fourth major cause of disability worldwide [6]. With thousands of studies published, neuroimaging has become one of the most fundamental approaches to understanding depression. On the other hand, quantitative studies on neuroimaging in depressive patients are still limited. It is challenging for medical students, junior residents, and new researchers

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to determine essential study areas and future directions in this profession.

Bibliometric methods have widely been utilized to evaluate the impact of research outputs and analyze books and papers [7]. This form of research identifies the countries, institutions, and authors who have made the most significant contributions to science [8]. Highly cited papers' subjects, study designs, and levels of evidence-based medicine may affect clinical practice and future research [9]. The citation rate of an article usually correlates with the researchers' desire to use such a paper in their research. As a result, bibliometric analysis can describe the current state of a disease or study subject and provide ideas and recommendations for future research [10].

Very few medical majors have used rank analysis to find the most significant publications in their field.[11-14] There have been no studies to select the most influential papers on neuroimaging in depression. As a result, we used a bibliometric analysis approach to quantitatively sort out the knowledge system in the field of depression in neuroimaging by analyzing each article individually for aspects such as publication year, affiliation and country of the first author, study design, study purpose, citation count, yearly citation, imaging modality, journals, and journals' impact factor (IF).

Materials and Methods

Our research retrospective analyzes already published literature exempted from institutional review board approval.

Data Acquisition

All included publications were retrieved and obtained from the Web of Science Core Collection (<https://www.webofscience.com/wos/woscc/advanced-search>) (Clarivate 30 Thomson Place, 36T3 Boston, DE 02210) in this study on December 5, 2021. The true findings were limited to English language research articles. The search terms were listed: 1# TS= (("depression" or "major depression disorders" or "MDD" or "major depression" or "anxiety" or "anxiety depression" or "vascular depression" or "mood disorders" or "bipolar disorder" or "unipolar disorder" or "unipolar depression" or "UD" or "bipolar depression" or "BD") 2# TS= ("neuroimaging" or "neuroradiology" or "brain imaging" or "computed tomography" or "brain CT" or "head CT" or "magnetic resonance imaging" or "MR imaging" or "MRI" or "functional magnetic resonance imaging" or "fMRI" or "structural magnetic resonance imaging" or "sMRI" or "diffusional kurtosis imaging" or "DKI" or "diffusion-weighted imaging" or "DWI" or "diffusion tensor imaging" or "DTI" or "MR perfusion" or "magnetic resonance perfusion" or "PWI" or "perfusion weighted imaging" or "ASL" or "arterial spin labelling" or "dynamic susceptibility contrast enhanced" or "DSC "or "magnetic resonance spectroscopy"

or "MRS" or "positron emission tomography" or "PET" or "single photon emission computed tomography" or "SPECT" or "sonography" or "network" or "connect" or "sonography" or "ultrasound" or "Doppler" and "infant" or "child" or "pediatric" or "toddler" or "baby" or "kid" or "neonate" or "newborn" or "adolescent" or "teenager" or "juvenile" or "teen" or "adult" or "Offspring"). Indexes = Science Citation Index Expanded (SCIE), Social Sciences Citation Index (SSCI), and Arts and Humanities Citation Index (A&HCI) from the Web of Science Core collection. Sources of Emergence Proceedings Citation Index Science; ESCI; Conference Proceedings Citation Index Social Science (CPCI-S) & Humanities (CPCI-SSH); Science Book Citation Index (BKCI-S); Book Citation Index for the Social Sciences and Humanities (BKCI-SSH); timespan = 1992–2021, 1# AND 2#. Articles that took advantage of those neuroimaging modalities to explore the diagnosis, management outcomes and mechanism of depression were included. Conference abstracts, case reports, and nonhuman studies were excluded.

Screening of the Most Highly Cited Original Research Articles

We utilized the included original articles for the sake of bibliometric analysis. Numerous variations distinguished the names of the major authors who appear in the report. The findings revealed annual publication trends. It was also checked for references and institutions. The current neuroimaging management for depression was put to the test through analysis of visualization. In descending order of yearly citations (the total citation count divided by the year difference between publication year and 2021), the top 100 articles were chosen.

Data Analysis

The included utilized articles were extended between 1992–2020; for the most highly cited literature included in the final study analysis, the following data were collected: publication year, contributing affiliation and country of the first author, study design, study purposes, total citations, yearly citations, imaging modality, publication journal and journal's IF. For descriptive analysis, the numbers and proportion of the literature were provided.

Results

Among the 182,551 published articles, 5153 were identified based on the inclusion and exclusion criteria. Based on their ranking number of yearly citations, 100 articles were recorded as the most highly cited articles. For collaboration analyses, 501 original articles were obtained. The number of studies published each year in the last four decades is listed in (table 1). Although the count of studies fluctuated from 1992 to 2020, the overall trend remained and ranked.

The Top 100 Most Highly Cited Articles

The top 100 most highly cited original research articles are revealed in Table 1. The yearly citation counts ranged from 14.29 to 147.00 per year (median: 80.67). The total citation counts were between 19 and 1883 (median: 951 times). Based on different study purposes, the articles were sorted out into three subdivisions: studies related to the mechanisms of depression (78 articles, 78%), those related to the prognosis of depression (13 articles, 13%), and those related to the diagnosis of depression (9 articles, 9%). According to the classification, we analyzed the publication year, contributing affiliation and country of the first author, study design, study purposes, total citations, yearly citations, imaging modality, publishing journal, and journal's IF of these articles

Study Designs of the Top 100 Most Highly Cited Articles

Table 2 demonstrates the article counts, study designs, as well as publication years and their distributions among different study aims and medians. Depression case-control studies contained three (03) diagnosis studies, 51 mechanism-related studies, and four (04) prognosis and outcome studies which were reported from 1992-2019 (median: 2005.5). Cross-sectional studies on depression were composed of two (02) diagnoses, 18 mechanism-related, and five (05) prognosis and outcome studies which were reported from 1997-2020 (median: 2008.5). Randomized controlled trial studies on depression consisted of three (03) diagnoses, one (01) mechanism-related study, and three prognosis and outcome studies and were reported from 2000-2017 (median: 2008.5). Multicenter studies related to depression had one (01) diagnosis and four (04) mechanism-related studies (2005-2020, median: 2017). Clinical trial studies related to depression are divided into four (04) mechanism-related studies and one (01) focused on prognosis and outcome studies (1998-2010, median: 2004). For mechanism studies (1992-2020, median: 2006), functional magnetic resonance image (fMRI) assumed an enormous and more effective modality. In addition, subcallosal cingulate gyrus deep brain stimulation received attention for treatment-resistant depression, especially the positron emission tomography (PET) studies. The prognosis evaluating studies (1997-2020, median: 2017) mainly focused on assessing the therapeutic effect through different neuroimaging modalities.

Study Designs

The sample sizes in the studies ranged from 10 to 6503, with median and mean sample sizes of 47.5 and 223.52, respectively. Among the top 100 most highly cited articles, 58% (58/100) were the case-control, and 25% (25/100) were cross-sectional studies. Most depression-related studies used one of these two study designs. Meanwhile, a prospective design was employed in a randomized control trial 7% (7/100)

were three (03) diagnoses, one (01) mechanism, and three (03) therapeutic outcome related studies. For multicenter study representing 5% (5/100), there was one (01) diagnosis and four (04) mechanism-related studies. As for clinical trial studies occupying 5% (5/100) of all studies, there were four (04) mechanisms and one (01) therapeutic outcome-related study. The diagnosis studies are nine (09) included three (03) case-control (3%), two (02) cross-sectional studies (2%), three (03) randomized control trial studies (3%), one (01) multicenter study (1%).

Application of Imaging Modalities in the Top 100 Highly Cited Articles

Figure 1A illustrates the annual publication count distribution of the top 100 highly cited original publications that used single or multiple modalities. Between the years (2009-2015), only four (04) studies were multi-modality studies focused on depression mechanism, while ninety-six studies used single modality (depression diagnosis: n = 09; depression mechanism: n = 74; depression prognosis and therapeutic effect: n = 12). Multiple imaging modalities were used in four (04) of the multi-modality studies. As a result, a single imaging modality could be enough to understand different mechanisms or get a proper diagnosis for depression brain imaging studies.

Figure 1B, according to distinct study aims, presents the yearly article counts of each imaging modality employed in the top 100 highly cited original articles. First, PET (1992) was the first method utilized in depression mechanism research (n = 17), fMRI was the most imaging modality used (45 times), DTI (09 times), and sMRI (31 times). Second, between 2009 and 2015 (4/100 research), multi-modalities were used less frequently in depression mechanism studies, particularly DTI combined with other MR technologies, sMRI and fMRI (sMRI & fMRI) together in one study, and MRS with fMRI.

Authors and Journals of the Top 100 Most Highly Cited Articles

Authors' affiliation

The countries of affiliation of the first author are listed in descending order as follows: United States of America (54, 54%), United Kingdom (10, 10%), Germany (7, 7%), China (6, 6%), Netherlands (5, 5%), Canada (4, 4%), Ireland (3, 3%), France (2, 2%), Australia (2, 2%), Italy (2, 2%), Switzerland (2, 2%), Singapore (2, 2%), Norway (1, 1%).

Among the first authors, most were affiliated with the psychiatry and behavioral sciences (52/100, 52%). A minority of the authors were affiliated with neuropsychology and mental health (14/100, 14%), department of neurosciences (11/100, 11%), radiology (9/100, 9%), neurology, and neurosurgery (3/100, 3%). Other affiliations included the department

Table 1: The Top 100 Most Highly Cited Articles in Depression Ranked by Total Citation

S.No	Articles Title	First Author	Journal Name	Impact Factor (2020)	Brain Imaging Modalities	Publication Year	No. of Annual Citation	No. of Total Citation	The rank of Total Citation
1	Resting-state connectivity biomarkers define neurophysiological subtypes of depression	Drysdale, Andrew T	NATURE MEDICINE	53.44	fMRI-RS	2017	147	588	16
2	Resting-state functional connectivity in major depression: Abnormally increased contributions from subgenual cingulate cortex and thalamus	Greicius, Michael D	BIOLOGICAL PSYCHIATRY	13.382	fMRI-RS	2007	95.57	1338	2
3	Subgenual prefrontal cortex abnormalities in mood disorders	Drevets, WC	NATURE	49.96	PET	1997	78.46	1883	1
4	Resting-state functional MRI in depression unmasks increased connectivity between networks via the dorsal nexus	Sheline, Yvette I	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	11.2	fMRI-RS	2010	60.09	661	11
5	Cortical abnormalities in bipolar disorder: an MRI analysis of 6503 individuals from the ENIGMA Bipolar Disorder Working Group	Hibar, D. P	MOLECULAR PSYCHIATRY	15.99	sMRI	2018	58.33	175	66
6	Hippocampal volume reduction in major depression	Bremner, JD	AMERICAN JOURNAL OF PSYCHIATRY	18.11	sMRI	2000	53.19	1117	3
7	Failure to regulate: Counterproductive recruitment of top-down prefrontal-subcortical circuitry in major depression	Johnstone, Tom	JOURNAL OF NEUROSCIENCE	6.167	fMRI-TB	2007	47.29	662	10
8	Identifying major depression using whole-brain functional connectivity: a multivariate pattern analysis	Zeng, Ling-Li	BRAIN	13.3	fMRI-RS	2012	46.33	417	27
9	Untreated depression and hippocampal volume loss	Sheline, YI	AMERICAN JOURNAL OF PSYCHIATRY	18.11	sMRI	2003	45.56	820	7
10	Depression duration but not age predicts hippocampal volume loss in medically healthy women with recurrent major depression	Sheline, YI	JOURNAL OF NEUROSCIENCE	6.167	sMRI	1999	45.45	1000	4
11	Subcallosal cingulate gyrus deep brain stimulation for treatment-resistant depression	Lozano, Andres M	BIOLOGICAL PSYCHIATRY	13.382	PET	2008	43.62	567	18
12	Increased amygdala response to masked emotional faces in depressed subjects resolves with antidepressant treatment: An fMRI study	Sheline, YI	BIOLOGICAL PSYCHIATRY	13.382	fMRI-RS	2001	42	840	6
13	Increased amygdala and decreased dorsolateral prefrontal BOLD responses in unipolar depression: Related and independent features	Siegle, Greg J	BIOLOGICAL PSYCHIATRY	13.382	fMRI-BOLD	2007	41.57	582	17

14	Efficacy of Transcranial Magnetic Stimulation Targets for Depression Is Related to Intrinsic Functional Connectivity with the Subgenual Cingulate	Fox, Michael D	BIOLOGICAL PSYCHIATRY	13.382	fMRI-RS	2012	41.22	371	30
15	Modulation of cortical-limbic pathways in major depression - Treatment-specific effects of cognitive behavior therapy	Goldapple, K	ARCHIVES OF GENERAL PSYCHIATRY	14.48	fMRI-RS	2004	40.53	689	9
16	Nucleus Accumbens Deep Brain Stimulation Decreases Ratings of Depression and Anxiety in Treatment-Resistant Depression	Bewernick, Bettina H	BIOLOGICAL PSYCHIATRY	13.382	PET	2010	40.45	445	25
17	Evidence of a Dissociation Pattern in Resting-State Default Mode Network Connectivity in First-Episode, Treatment-Naive Major Depression Patients	Zhu, Xueling	BIOLOGICAL PSYCHIATRY	13.382	fMRI-RS	2012	39.67	357	33
18	Subcortical volumetric abnormalities in bipolar disorder	Hibar, D. P	MOLECULAR PSYCHIATRY	15.99	sMRI	2016	35.2	176	65
19	Default Mode Network Mechanisms of Transcranial Magnetic Stimulation in Depression	Liston, Conor	BIOLOGICAL PSYCHIATRY	13.382	fMRI-RS	2014	35	245	46
20	Toward a Neuroimaging Treatment Selection Biomarker for Major Depressive Disorder	McGrath, Callie L	JAMA PSYCHIATRY	21.6	PET	2013	34.25	274	42
21	Inflammation is associated with decreased functional connectivity within corticostriatal reward circuitry in depression	Felger, J. C	MOLECULAR PSYCHIATRY	15.99	fMRI-RS	2016	34.2	171	70
22	Attenuation of the neural response to sad faces in major depression by antidepressant treatment - A prospective, event-related functional magnetic resonance imaging study	Fu, CHY	ARCHIVES OF GENERAL PSYCHIATRY	14.48	fMRI-ER	2004	33.24	565	19
23	A FUNCTIONAL ANATOMICAL STUDY OF UNIPOLAR DEPRESSION	DREVETS, WC	JOURNAL OF NEUROSCIENCE	6.167	PET	1992	33.1	960	5
24	Activity and connectivity of brain mood regulating circuit in depression: A functional magnetic resonance study	Anand, A	BIOLOGICAL PSYCHIATRY	13.382	fMRI-RS	2005	32.88	526	21
25	Cingulate function in depression: A potential predictor of treatment response	Mayberg, HS	NEUROREPORT	1.343 (2016)	PET	1997	32.83	788	8
26	Can't shake that feeling: Assessment of sustained event-related fMRI amygdala activity in response to emotional information in depressed individuals	Siegle, GJ	BIOLOGICAL PSYCHIATRY	13.382	fMRI-ER	2002	32.42	616	13

27	Evidence from functional magnetic resonance imaging of crossmodal binding in the human heteromodal cortex	Calvert, GA	CURRENT BIOLOGY	10.83	fMRI-RS	2000	31.43	660	12
28	Elevated Translocator Protein in Anterior Cingulate in Major Depression and a Role for Inflammation in Suicidal Thinking: A Positron Emission Tomography Study	Holmes, Sophie E	BIOLOGICAL PSYCHIATRY	13.382	PET	2018	29	87	93
29	Childhood trauma associated with smaller hippocampal volume in women with major depression	Vythilingam, M	AMERICAN JOURNAL OF PSYCHIATRY	18.11	sMRI	2002	27.95	531	20
30	Dynamic connectivity states estimated from resting fMRI Identify differences among Schizophrenia, bipolar disorder, and healthy control subjects	Rashid, Barnaly	FRONTIERS IN HUMAN NEUROSCIENCE	3.169	fMRI-RS	2014	26.86	188	58
31	Dynamic Resting-State Functional Connectivity in Major Depression	Kaiser, Roselinde H	NEUROPSYCHOPHARMACOLOGY	7.853	fMRI-RS	2016	26.6	133	81
32	Functional Connectivity of the Subcallosal Cingulate Cortex And Differential Outcomes to Treatment With Cognitive-Behavioral Therapy or Antidepressant Medication for Major Depressive Disorder	Dunlop, Boadie W	AMERICAN JOURNAL OF PSYCHIATRY	18.11	fMRI-RS	2017	25.25	101	88
33	White matter disturbances in major depressive disorder: a coordinated analysis across 20 international cohorts in the ENIGMA MDD working group	van Velzen, Laura S	MOLECULAR PSYCHIATRY	15.99	DTI	2020	25	25	99
34	Changes in regional brain glucose metabolism measured with positron emission tomography after paroxetine treatment of major depression	Kennedy, SH	AMERICAN JOURNAL OF PSYCHIATRY	18.11	PET	2001	24.8	496	23
35	MRI-defined vascular depression	Krishnan, KRR	AMERICAN JOURNAL OF PSYCHIATRY	18.11	sMRI	1997	24.54	589	15
36	Brain serotonin(1A) receptor binding measured by positron emission tomography with [C-11]WAY-100635 - Effects of depression and antidepressant treatment	Sargent, PA	ARCHIVES OF GENERAL PSYCHIATRY	14.48	PET	2000	24.38	512	22
37	Subcortical and ventral prefrontal cortical neural responses to facial expressions distinguish patients with bipolar disorder and major depression	Lawrence, NS	BIOLOGICAL PSYCHIATRY	13.382	fMRI-RS	2004	24.12	410	28
38	Randomized Clinical Trial of Real-Time fMRI Amygdala Neurofeedback for Major Depressive Disorder: Effectson Symptoms and Autobiographical Memory Recall	Young, Kymberly D	AMERICAN JOURNAL OF PSYCHIATRY	18.11	real-time functional MRI	2017	23.75	95	91

39	Imbalance between left and right dorsolateral prefrontal cortex in major depression is linked to negative emotional judgment: An fMRI study in severe major depressive disorder	Grimm, Simone	BIOLOGICAL PSYCHIATRY	13.382	fMRI-ER	2008	22.31	290	41
40	Anhedonia and Reward-Circuit Connectivity Distinguish Nonresponders from Responders to Dorsomedial Prefrontal Repetitive Transcranial Magnetic Stimulation in Major Depression	Downar, Jonathan	BIOLOGICAL PSYCHIATRY	13.382	sMRI	2014	22.29	156	73
41	Illness Progression, Recent Stress, and Morphometry of Hippocampal Subfields and Medial Prefrontal Cortex in Major Depression	Treadway, Michael T	BIOLOGICAL PSYCHIATRY	13.382	sMRI	2015	22	132	82
42	Lower synaptic density is associated with depression severity and network alterations	Holmes, Sophie E	NATURE COMMUNICATIONS	14.92	PET	2019	22	44	96
43	Use of fMRI to predict recovery from unipolar depression with cognitive behavior therapy	Siegle, GJ	AMERICAN JOURNAL OF PSYCHIATRY	18.11	fMRI-ER	2006	21.07	316	39
44	PET imaging of serotonin 1A receptor binding in depression	Drevets, WC	BIOLOGICAL PSYCHIATRY	13.382	PET	1999	21	462	24
45	Brain Morphometric Biomarkers Distinguishing Unipolar and Bipolar Depression A Voxel-Based Morphometry-Pattern Classification Approach	Redlich, Ronny	JAMA PSYCHIATRY	21.6	sMRI	2014	20.86	146	77
46	THE ANATOMY OF MELANCHOLIA - FOCAL ABNORMALITIES OF CEREBRAL BLOOD-FLOW IN MAJOR DEPRESSION	BENCH, CJ	PSYCHOLOGICAL MEDICINE	7.723	PET	1992	20.34	590	14
47	Structural brain magnetic resonance imaging of limbic and thalamic volumes in pediatric bipolar disorder	Frazier, JA	AMERICAN JOURNAL OF PSYCHIATRY	18.11	sMRI	2005	20.31	325	37
48	Resting state corticolimbic connectivity abnormalities in unmedicated bipolar disorder and unipolar depression	Anand, Amit	PSYCHIATRY RESEARCH-NEUROIMAGING	18.11	fMRI-RS	2009	20.25	243	47
49	Regional Brain Volume in Depression and Anxiety Disorders	van Tol, Marie-Jose	ARCHIVES OF GENERAL PSYCHIATRY	14.48	sMRI	2010	20	220	49
50	Cognitive control and brain resources in major depression: An fMRI study using the n-back task	Harvey, PO	NEUROIMAGE	6.556	fMRI-TB	2005	19.88	318	38
51	Hippocampal changes in patients with a first episode of major depression	Frodl, T	AMERICAN JOURNAL OF PSYCHIATRY	18.11	sMRI	2002	19.74	375	29

52	A functional magnetic resonance imaging study of bipolar disorder - State- and trait-related dysfunction in ventral prefrontal cortices	Blumberg, HP	ARCHIVES OF GENERAL PSYCHIATRY	14.48	fMRI-RS	2003	19.67	354	35
53	The Hippocampus in Depression: More Than the Sum of Its Parts? Advanced Hippocampal Substructure Segmentation in Depression	Roddy, Darren W	BIOLOGICAL PSYCHIATRY	13.382	sMRI	2019	19.5	39	97
54	Reduced volume of orbitofrontal cortex in major depression	Bremner, JD	BIOLOGICAL PSYCHIATRY	13.382	sMRI	2002	19.32	367	32
55	Brain magnetic resonance imaging of structural abnormalities in bipolar disorder	Strakowski, SM	ARCHIVES OF GENERAL PSYCHIATRY	14.48	sMRI	1999	19.09	420	26
56	Volume increase in the dentate gyrus after electroconvulsive therapy in depressed patients as measured with 7T	Nuninga, Jasper O	MOLECULAR PSYCHIATRY	15.99	sMRI	2020	19	19	100
57	Amygdala Activation During Emotion Processing of Neutral Faces in Children With Severe Mood Dysregulation Versus ADHD or Bipolar Disorder	Brotman, Melissa Aen	AMERICAN JOURNAL OF PSYCHIATRY	18.11	fMRI-BOLD	2010	18.64	205	52
58	Prenatal maternal depression alters amygdala functional connectivity in 6-month-old infants	Qiu, A	TRANSLATIONAL PSYCHIATRY	6.222	sMRI&fMRI-RS	2015	18.5	111	87
59	Amygdala and nucleus accumbens activation to emotional facial expressions in children and adolescents at risk for major depression	Monk, Christopher S	AMERICAN JOURNAL OF PSYCHIATRY	18.11	fMRI-BOLD	2008	18.46	240	48
60	Regional brain metabolic changes in patients with major depression treated with either paroxetine or interpersonal therapy - Preliminary findings	Brody, AL	ARCHIVES OF GENERAL PSYCHIATRY	14.48	PET	2001	18.45	369	31
61	Abnormal Amygdala Resting-State Functional Connectivity in Adolescent Depression	Cullen, Kathryn R	JAMA PSYCHIATRY	21.6	fMRI-RS	2014	18.14	127	83
62	Resting-State Functional Connectivity in Treatment-Resistant Depression	Lui, Su	AMERICAN JOURNAL OF PSYCHIATRY	18.11	fMRI-RS	2011	18.1	181	62
63	Automatic Mood-Congruent Amygdala Responses to Masked Facial Expressions in Major Depression	Suslow, Thomas	BIOLOGICAL PSYCHIATRY	13.382	fMRI-RS	2010	18	198	55
64	Abnormal Medial Prefrontal Cortex Resting-State Connectivity in Bipolar Disorder and Schizophrenia	Chai, Xiaoqian J	NEUROPSYCHOPHARMACOLOGY	7.853	fMRI-RS	2011	18	180	63

65	Medial reward and lateral non-reward orbitofrontal cortex circuits change in opposite directions in depression	Cheng, Wei	BRAIN	13.3	fMRI-RS	2016	17.6	88	92
66	Real-Time fMRI Neurofeedback Training of Amygdala Activity in Patients with Major Depressive Disorder	Young, Kymberly D	PLOS ONE	3.24	fMRI-RS	2014	17.29	121	85
67	State-dependent changes in hippocampal grey matter in depression	Arnone, D	MOLECULAR PSYCHIATRY	15.99	sMRI	2013	17.25	138	79
68	Human Medial Forebrain Bundle (MFB) and Anterior Thalamic Radiation (ATR): Imaging of Two Major Subcortical Pathways and the Dynamic Balance of Opposite Affects in Understanding Depression	Coenen, Volker A	JOURNAL OF NEUROPSYCHIATRY AND CLINICAL NEUROSCIENCES	2.198	DTI	2012	17.22	155	74
69	Altered serotonin 1A binding in major depression: A [carbonyl-C-11]WAY100635 positron emission tomography study	Parsey, RV	BIOLOGICAL PSYCHIATRY	13.382	PET	2006	16.8	252	44
70	Hippocampal Changes Associated with Early-Life Adversity and Vulnerability to Depression	Rao, Uma	BIOLOGICAL PSYCHIATRY	13.382	sMRI	2010	16.64	183	60
71	Reduced hippocampal volumes and memory loss in patients with early- and late-onset depression	Hickie, I	BRITISH JOURNAL OF PSYCHIATRY	7.233	sMRI	2005	16.63	266	43
72	Abnormal temporal difference reward-learning signals in major depression	Kumar, P	BRAIN	13.3	fMRI-RS	2008	16.38	213	50
73	Can structural MRI aid in clinical classification? A machine learning study in two independent samples of patients with Schizophrenia, bipolar disorder and healthy subjects	Schnack, Hugo G	NEUROIMAGE	6.556	sMRI	2014	16.29	114	86
74	Glucose metabolism in the amygdala in depression: Relationship to diagnostic subtype and plasma cortisol levels	Drevets, WC	PHARMACOLOGY BIOCHEMISTRY AND BEHAVIOR	2.781	PET	2002	16.26	309	40
75	fMRI of alterations in reward selection, anticipation, and feedback in major depressive disorder	Smoski, Moria J	JOURNAL OF AFFECTIVE DISORDERS	4.839	fMRI-RS	2009	16.25	195	56
76	Can voxel based morphometry, manual segmentation and automated segmentation equally detect hippocampal volume differences in acute depression?	Bergouignan, Loretxu	NEUROIMAGE	6.556	sMRI	2009	16.17	194	57

77	Elevated left and reduced right orbitomedial prefrontal fractional anisotropy in adults with bipolar disorder revealed by tract-based spatial statistics	Versace, Amelia	ARCHIVES OF GENERAL PSYCHIATRY	14.48	DTI	2008	16.15	210	51
78	Interaction of childhood stress with hippocampus and prefrontal cortex volume reduction in major depression	Frodl, Thomas	JOURNAL OF PSYCHIATRIC RESEARCH	4.465	sMRI	2010	16.09	177	64
79	In Vivo Hippocampal Subfield Volumes in Schizophrenia and Bipolar Disorder	Haukvik, Unn K	BIOLOGICAL PSYCHIATRY	13.382	sMRI	2015	16	96	90
80	More than just statics: temporal dynamics of intrinsic brain activity predicts the suicidal ideation in depressed patients	Li, Jiao	PSYCHOLOGICAL MEDICINE	7.723	fMRI-RS	2019	16	32	98
81	The Relationship Between Aberrant Neuronal Activation in the Pregenual Anterior Cingulate, Altered Glutamatergic Metabolism, and Anhedonia in Major Depression	Walter, Martin	ARCHIVES OF GENERAL PSYCHIATRY	14.48	fMRI-BOLD & MRS	2009	15.58	187	59
82	Reduced brain serotonin transporter availability in major depression as measured by [¹²³ I]-2 beta-carbomethoxy-3 beta-(4-iodophenyl)tropane and single photon emission computed tomography	Malison, RT	BIOLOGICAL PSYCHIATRY	13.382	SPECT	1998	15.43	355	34
83	Effect of hippocampal and amygdala volumes on clinical outcomes in major depression: a 3-year prospective magnetic resonance imaging study	Frodl, Thomas	JOURNAL OF PSYCHIATRY & NEUROSCIENCE	5.861	sMRI	2008	15.31	199	54
84	Amygdala core nuclei volumes are decreased in recurrent major depression	Sheline, YI; Gado, MH; Price, JL	NEUROREPORT	1.343 (2016)	sMRI	1998	15.26	351	36
85	Prenatal Maternal Depression Associates with Microstructure of Right Amygdala in Neonates at Birth	Rifkin-Graboi, Anne	BIOLOGICAL PSYCHIATRY	13.382	sMRI & DTI	2013	15.25	122	84
86	White matter abnormalities in bipolar disorder and Schizophrenia detected using diffusion tensor magnetic resonance imaging	Sussmann, Jessika E	BIPOLAR DISORDERS	6.744	DTI	2009	15.17	182	61
87	Decreased regional homogeneity in insula and cerebellum: A resting-state fMRI study in patients with major depression and subjects at high risk for major depression	Liu, Zhifen	PSYCHIATRY RESEARCH-NEUROIMAGING	2.964	fMRI-RS	2010	15	165	71

88	Waiting to win: elevated striatal and orbitofrontal cortical activity during reward anticipation in euthymic bipolar disorder adults	Nusslock, Robin	BIPOLAR DISORDERS	6.744	fMRI-RS	2012	15	135	80
89	Contrasting variability patterns in the default mode and sensorimotor networks balance in bipolar depression and mania	Martino, Matteo	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	11.2	fMRI-RS	2016	14.8	74	95
90	Discriminating Schizophrenia and bipolar disorder by fusing fMRI and DTI in a multimodal CCA plus joint ICA model	Sui, Jing	NEUROIMAGE	6.556	fMRI-RS & DTI	2011	14.7	147	75
91	Reduced Metabotropic Glutamate Receptor 5 Density in Major Depression Determined by [C-11]ABP688 PET and Postmortem Study	Deschwenden, Alexandra	AMERICAN JOURNAL OF PSYCHIATRY	18.11	PET	2011	14.7	147	75
92	Diffusion Tensor Imaging Study of White Matter Fiber Tracts in Pediatric Bipolar Disorder and Attention-Deficit/Hyperactivity Disorder	Pavuluri, Mani N	BIOLOGICAL PSYCHIATRY	13.382	DTI	2009	14.5	174	67
93	Disruption of White Matter Integrity in Bipolar Depression as a Possible Structural Marker of Illness	Benedetti, Francesco	BIOLOGICAL PSYCHIATRY	13.382	DTI	2011	14.5	145	78
94	A functional MRI marker may predict the outcome of electroconvulsive therapy in severe and treatment-resistant depression	van Waarde, J. A	MOLECULAR PSYCHIATRY	15.99	fMRI-RS	2015	14.5	87	93
95	Magnetic resonance imaging analysis of amygdala and other subcortical brain regions in adolescents with bipolar disorder	DelBello, MP	BIPOLAR DISORDERS	6.744	sMRI	2004	14.47	246	45
96	Elevated Amygdala Activity to Sad Facial Expressions: A State Marker of Bipolar but Not Unipolar Depression	Almeida, Jorge R. C	BIOLOGICAL PSYCHIATRY	13.382	sMRI	2010	14.36	158	72
97	Increased Self-Focus in Major Depressive Disorder Is Related to Neural Abnormalities in Subcortical-Cortical Midline Structures	Grimm, Simone	HUMAN BRAIN MAPPING	4.554	fMRI-ER	2009	14.33	172	68
98	A Randomized Trial of rTMS Targeted with MRI Based Neuro-Navigation in Treatment-Resistant Depression	Fitzgerald, Paul B	NEUROPSYCHOPHARMACOLOGY	7.853	sMRI	2009	14.33	172	68
99	Progressive gray matter loss in patients with bipolar disorder	Moorhead, T. William J	BIOLOGICAL PSYCHIATRY	13.382	DTI	2007	14.29	200	53
100	Neuroinflammation in bipolar disorder - A [C-11]-(R)-PK11195 positron emission tomography study	Haarman, Bartholomeus C. M. (Benno)	BRAIN BEHAVIOR AND IMMUNITY	4.554 (2018)	PET	2014	14.29	100	89

Note: sMRI, structural magnetic resonance imaging; fMRI-RS, functional magnetic resonance imaging resting-state; DTI, diffusion tensor imaging; SPECT, single-photon emission computed tomography; PET, positron emission tomography, fMRI-TB= functional magnetic resonance imaging tract-based; fMRI-BOLD=functional magnetic resonance imaging blood-oxygen-level-dependent; fMRI-ER= functional magnetic resonance imaging event related, MRS, magnetic resonance spectroscopy

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of biomedical engineering (3/100, 3%), department of depression and mood disorder (3/100, 3%), department of electrical and computer engineering (3/100, 3%), college of mechatronics and automation (1/100, 1%), and school of mathematical sciences and center for computational systems biology (1/100, 1%).

Journals

The top 100 most highly cited articles were published in 28 international journals. The top three journals that published these articles were Biological Psychiatry (27/100,

27%), American Journal of Psychiatry (14/100, 14%), and Archives of General Psychiatry (9/100, 9%) and representing 50% of all journals. The journals and their recent (IFs) are shown in Table 3. The top three journals in terms of IF were Nature Medicine (53.44), Nature (49.96), and Jama Psychiatry (21.6).

Discussion

The characteristics of neuroimaging in exploring the diagnosis, mechanism, and prognosis of depression were reported in this study using a bibliometric analysis of the

Table 2: Depression Study Designs of Highly Cited Articles in Different Study Topics

		Depression diagnosis studies	Depression mechanism studies	Depression prognosis studies	Published year (Median)	Total Articles
Study design	Case control study	3	51	4	1992-2019 (2005.5)	58
	Cross-sectional study	2	18	5	1997-2020 (2008.5)	25
	Randomized Controlled Trial	3	1	3	2000-2017 (2008.5)	7
	Multicenter Study	1	4	-	2005-2020 (2017)	5
	Clinical trial	-	4	1	1998-2010 (2004)	5
	Published year (Median)	2000-2017 (2008.5)	1992-2020 (2006)	1997-2020 (2008.5)	-	-
Total		9	78	13	-	100

Table 3: The Journals (2020) Impact Factor (IF) and Ranking

Journals	No. of Articles (%)	IF (2020)	Rank
BIOLOGICAL PSYCHIATRY	28 (28%)	13.382	8
AMERICAN JOURNAL OF PSYCHIATRY	14 (14%)	18.11	4
ARCHIVES OF GENERAL PSYCHIATRY	9 (9 %)	14.48	7
MOLECULAR PSYCHIATRY	7 (7 %)	15.99	5
NEUROIMAGE	4 (4 %)	6.556	16
BIPOLAR DISORDERS	3 (3 %)	6.744	15
BRAIN	3 (3 %)	13.3	9
JAMA PSYCHIATRY	3 (3 %)	21.6	3
JOURNAL OF NEUROSCIENCE	3 (3 %)	6.167	18
PSYCHOLOGICAL MEDICINE	3 (3 %)	7.723	13
NEUROPSYCHOPHARMACOLOGY	3 (3 %)	7.853	12
NEUROREPORT	2 (2 %)	1.343	28
PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	2 (2 %)	11.2	10
PSYCHIATRY RESEARCH-NEUROIMAGING	2 (2 %)	2.964	25
BRITISH JOURNAL OF PSYCHIATRY	1 (1 %)	7.233	14
CURRENT BIOLOGY	1 (1 %)	10.83	11
FRONTIERS IN HUMAN NEUROSCIENCE	1 (1 %)	3.169	24
HUMAN BRAIN MAPPING	1 (1 %)	4.554	21
JOURNAL OF NEUROPSYCHIATRY AND CLINICAL NEUROSCIENCES	1 (1 %)	2.198	27
JOURNAL OF PSYCHIATRIC RESEARCH	1 (1 %)	4.465	22
JOURNAL OF PSYCHIATRY & NEUROSCIENCE	1 (1 %)	5.861	19

NATURE	1 (1 %)	49.96	2
NATURE COMMUNICATIONS	1 (1 %)	14.92	6
NATURE MEDICINE	1 (1 %)	53.44	1
PHARMACOLOGY BIOCHEMISTRY AND BEHAVIOR	1 (1 %)	2.781	26
PLOS ONE	1 (1 %)	3.24	23
TRANSLATIONAL PSYCHIATRY	1 (1 %)	6.222	17
JOURNAL OF AFFECTIVE DISORDER	1 (1 %)	4.839	20

100 most frequently referenced research publications. The most highly cited articles (78 %) were in depression mechanism-related studies, followed by depression therapeutics outcome-related studies (13 %) using various neuroimaging techniques. Future research directions in this field could include investigating the pathophysiological mechanisms of depression using high-level evidence design and fMRI neuroimaging modalities (63 %). Our findings may be useful to new researchers and students in this field and to established scholars interested in trying new research methods. Meanwhile, our findings can help radiologists and neurologists understand the value of multidisciplinary collaboration between different disciplines in the clinical field of neuroradiology [15].

Since neuroimaging was first used in a depression study in 1992, this study assessed the bibliometric information of the top 25% of articles in order of yearly citation counts in brain imaging for depression [16]. According to our findings, there is still a lack of consensus on the quality of highly cited papers worldwide. According to the Levitt et al. analysis, the top 25% of annual citation counts were chosen as highly cited articles since they covered enough publications in the area while still satisfying the definition of highly cited papers [17]. As a result, we used the same criterion, namely the top 25%. Figure 1 demonstrates that no papers were included before 1992, even though no time constraint was specified for this investigation. Only one article was identified before 1997, with yearly citation counts ranging from 0.10 to 0.97, indicating that these articles did not qualify for the top 25% of the list.

According to one of the most cited papers, structural MRI was the first neuroimaging modality in depression that could find accountable therapeutic outcome.[18] Tissues can be distinguished in sMRI under an external magnetic field due to differences in signal from hydrogen proton. DTI was frequently used as a quantitative tool to study microstructural modification, pathophysiological process, diagnostic biomarkers, and assess the efficacy outcome in depression in the 21st century, with the rapid growth of radiological technology.[19] Nowadays, fMRI examinations provided functional information, metabolic changes were detected by PET and SPECT, and perfusion MR reflected vascular hemodynamic information about depression.[20,21] The

variety of neuroimaging approaches and results emphasize the need for and value of innovative multivariable analytical methods that combine results from multiple modalities to improve diagnostic and mechanistic understanding accuracy, which could be a critical step in neuroimaging's full integration into the clinical realm of depression[22].

Among depression diagnosis investigations, earlier observation research demonstrated the diagnostic efficacy of imaging examination in detecting the biomarker for depressive patients treated with antidepressant medication according to the DSM-IV.[23] Meanwhile, research into image performance and characteristics appeared to aid in understanding the causes of depression and establishing a link between brain anomalies and clinical characteristics. [24] Studies primarily focused on the relevant relationship between structural alterations and other functions, including behavior and cognitive function, after introducing MRI quantitative technology.[25] The focus of recent studies has changed aside from etiology identification and toward methodically summarizing and detecting the relationship between brain abnormalities and potential etiology. [26] Furthermore, recent evidence suggests that depression cases are genetically linked [27]. In depression research, combining molecular genetic approaches with neuroimaging to discover specific brain abnormalities has become a new trend [28].

There are over 300 million people worldwide that suffer from depression.[29] Patients with early-onset depression are more likely to experience neurobehavioral disorders, and the functional brain abnormalities are particularly susceptible to negative outcomes. [30] However, due to a lack of effective means to track these changes, changes in the structure and function of depression remain poorly understood. These alterations have been clarified due to recent rapid advances in MRI technology. According to the most cited articles, fMRI was the first MR imaging method to locate the responsible focus in the pathophysiology of depression [31]. The focus of the study has recently switched from partial brain tissue volume measurements to a systematic examination of changes in total brain oxygen consumption and metabolic activity linked with neuropsychology using fMRI. The first study describing mechanism studies was published in 1997, according to the current review Neuroimaging in Depression [32]. Currently, functional information is obtained through

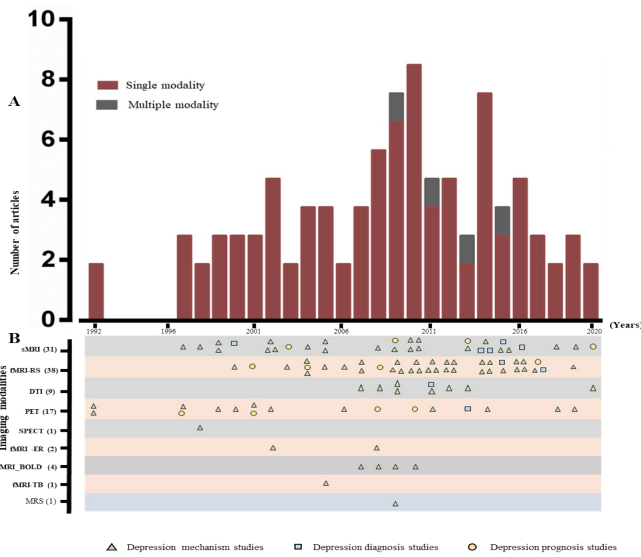


Figure 1: The Distribution of Imaging Modality and Study Topics. (A) Yearly total count distribution and increasing trend of top 100 highly cited articles using single or multi-modality. (B) The number of articles per imaging modality in the top 100 highly cited articles about depression diagnosis studies, depression mechanism studies, and depression prognosis studies. Different topic studies are displayed in different colors and show different application trends within years. sMRI: Structural magnetic resonance imaging; DTI: Diffusion tensor imaging; fMRI-RS: Functional magnetic resonance imaging resting-state; fMRI-TB: Functional magnetic resonance imaging tract-based; fMRI-BOLD: Functional magnetic resonance imaging blood-oxygen-level-dependent; fMRI-ER: functional magnetic resonance imaging event-related; SPECT: Single-Photon Emission Computed Tomography; PET: Positron Emission Tomography; MRS: Magnetic resonance spectroscopy.

fMRI tests, metabolic changes are evaluated through PET and SPECT findings, and vascular hemodynamic data are reflected through perfusion imaging (PI). Such numerous imaging techniques can thus provide information on depression's macro-structural alterations and functional and micromolecular information. Our findings show that the use of fMRI in pathophysiology and mechanism investigations is on the rise, with the increase being especially noticeable in recent years. Consequently, we believe that using fMRI to assess depression pathogenesis will be a major future research hotspot.

In the study of depression processes, fMRI is widely used. The majority of this research focused on drug-resistant depression, a topic that has sparked significant concern.[31] Many studies have investigated the functional connectivity network to learn more about the pathophysiological mechanisms of depression and, as a result, the causes of cognitive dysfunction. [33] It has been suggested that changes in default-mode function are linked to cognitive decline.[33] However, very few studies have taken advantage of fMRI modalities that can provide quantitative information

on brain function.[15] The use of fMRI modalities to research the pathophysiology of depression may be on-trend. Our findings support a previous finding that neuroimaging research is a major focus in depression studies [13]. The top 100 most cited original articles had at least four decades of yearly citations, showing a high technical activity level. Recently, new imaging techniques have increased, as seen by historical trends in neuroimaging modalities. The diversity of neuroimaging tests utilized for PET imaging and the various disorder-related tasks evaluated in the fMRI studies demonstrate how adaptable various imaging modalities may be. These findings reflect the field's ongoing efforts to expand the area of research.

A study on pharmacotherapy was the top-ranked publication on the topic of depression. Sidney H et al. produced the top-ranked article on depression in 2001, a comparative study of major depressive disorder. At the time of the study, none of the patients had a concomitant DSM-IV diagnosis, and none was taking any extra psychiatric medication. Medical stability was also essential for the participants [21]. In depression, drug resistance is invariably accompanied by hippocampal neuronal loss, decreased dentate gyrus neurogenesis, and glial cell loss [34].

We also reported that the most cited articles on depression were published in Biological Psychiatry, which is perhaps related to the fact that the scope of the journal related to the pathophysiology and mechanism of the disease among the depression-specific articles belong to the American journal of psychiatry and archives of general psychiatry, which are of vital significance in shaping the landscape of depression mechanism, diagnosis, and management. Other high IF journals in the top 100 also provide several important journals, such as Nature Medicine, Nature, Jama Psychiatry, and the American Journal of Psychiatry. These prestigious journals tend to be cited more frequently in original articles and have had a high impact in recent years because the number of references allowed in most journals is limited.

Moreover, we found that about half of the 100 top-cited articles on depression originated from institutions in the United States of America, followed by the United Kingdom, Germany, China, Netherlands, Canada, Ireland, France, Australia, Italy, and Switzerland, Singapore, and Norway. Although most studies on depression using neuroimaging are from developed countries, the low-income and middle-income countries still have a similar prevalence of depression (59%) as that in high-income countries (55%), indicating that major depressive disorder is neither a simple consequence of modern-day lifestyle in developed countries nor a result of poverty [35].

The distribution of depressive patients among countries is almost equal, with an increasing trend in developing countries. Therefore, developing countries need a forward-

thinking economy and a strong healthcare system. There are some limitations to this study. First, this bibliometric analysis was conducted using the Web of Science All Databases; the results may not apply to all depression articles found in other databases, such as Google Scholar. Second, the amount of citations is heavily influenced by the passage of time. Third, the rate of self-citation may have an impact on the outcomes. However, the number of yearly citations for the top 100 most referenced publications was limited; therefore, the results were unaffected.

Conclusion

In conclusion, this study provided useful information for future research collaborations between researchers and institutions and identified hot topics and trends in depression research. Although neuroimaging appears to be useful in understanding the pathophysiology of depression, additional research is needed. Hence, further research is needed, including high-quality randomized controlled trials that follow defined guidelines and have a minimal risk of bias.

Conflict of Interest

The authors declare that no commercial or financial relationships could be construed as a potential conflict of interest during the research.

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