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An overview of the most cited studies in health research

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An overview of the most cited studies in health research

Abstract

Many important contributions have been published in health research over the last years. Objective: This article aims to identify the most influential articles between 1990 and 2014 according to the total number of citations. Methods: A bibliometric analysis is conducted using the Web of Science (WoS) database which is usually regarded as the most influential one. The work divides health in nine categories: Environmental and Occupational Health, Epidemiology, Health Informatics, Engineering and Technology, Health Management and Economics, Health Policy and Services, Health Promotion and Health Behavior, Medicine, Primary Care, and Public Health. The focus is between 1990 and 2014 although it also considers a general overview of highly cited articles published before this period. Results: The results show that a small group of journals have published most of the highly cited papers in health including Environmental Health Perspectives, Medical Care, Social Science and Medicine, American Journal of Epidemiology and the Journal of Clinical Epidemiology. Discussion: In general, the categories of Public Health and Epidemiology are the leading ones in publishing the most cited papers.

Keywords: Health; highly cited articles; bibliometrics; Web of Science.

1. Introduction

The number of citations is considered an important indicator of academic performance and quality of the research output. Among the most cited papers in the world, we find the work published by Lowry, Rosenbrought, Farr and Randall in 1951 titled "Protein measurement with the Folin phenol reagent" with more than 305,000 citations, which is followed by the papers written by Laemmli in 1970 with close to 213,000 citations, and by Bradford in 1976 with more than 155,000 citations (Van Noorden et al., 2014). These three papers focused on research about protein biochemistry, but How have health research citations performed?, Which are the most cited papers in this field?, and Are there specific areas in health research (as in biochemistry) where papers are most cited?

In order to answer all of these questions we conducted a bibliometric study of health research citations. Bibliometric studies are understood as quantitative analysis of articles and their references (citations and co-citations) (Pritchard, 1969), and allows us to have an overall picture of the output in scientific research. For this study, the scope of analysis of health research has been expanded from previous bibliometric studies in the area (Anonymous, 2015a), identifying and quantifying the scholarly publications and their citations in the field and subfield approaches of public health, environmental and occupational health, health management and economics, health promotion and health behavior, epidemiology, health policy and services, medicine, health informatics, engineering and technology and primary care.

Citation analysis and bibliometrics have been examined before in health research but not to the extent in which we are studying it. For example, there are citation analysis of bibliometric trends in a single journal (Derek, 2009a), bibliometric studies of citations in a specific area of health research (Derek, 2009b; Hsu, 2014) or in a specific health topic (Hunt, 2012; Wagstaff and Culyer, 2012; Zyoud, 2014), just to name a few. These types of studies about frequently cited articles are relevant in order to determine the papers and authors that have been more significant to the health care fields and subfields. In this paper, our main goal is to produce an overview of the health research citations in the world for a time frame of twenty-five years from 1990 to 2014. Findings from this research may assist the research evaluation process and track its

evolution over time, increasing the visibility of health research and demonstrating valuable works through their citations.

2. Methods

Bibliometrics is one of the most common approaches for classifying bibliographic material (Bar-Illan, 2008; Broadus, 1987). The Web of Science (WoS) is one of the most popular databases for classifying the bibliographic material because it indexes those journals that are widely regarded as the leading ones. WoS divides science in 251 research categories. Four of them are related to health: Health Care Sciences & Services, Health Policy & Services, Primary Health Care, and Public, Environmental & Occupational Health. These categories include 363 journals (Anonymous, 2015a). In order to classify health research in a deeper way, this study considers nine categories for health and assigns each of the 363 journals into one of the categories. The categories studied are:

- Environmental and Occupational Health
- Epidemiology
- Health Informatics, Engineering and Technology
- Health Management and Economics
- Health Policy and Services
- Health Promotion and Health Behavior
- Medicine
- Primary Care
- Public Health

In order to rank the articles, this study considers the total number of citations received inside the WoS database (Anonymous, 2015b). Note that the papers also receive citations from other sources outside WoS but this work focuses strictly on this database due to its influence and recognition all over the World. Moreover, other indicators could also be taken into account when measuring the importance of the papers because each research topic may be affected by a wide range of particularities (Anonymous, 2015c). This

study also considers the citations per year (Anonymous, 2015d) because the age of an article may also significantly influence the ranking in the list. Since the results are divided by categories, a final column that considers the global position of each paper among the 200 most cited in health is also considered. Note that those that do not reach the Top 200 are marked with a dash in this column.

The analysis considers the most cited articles between 1990 and 2014. This time period is representative of the most influential contributions of the last years. However, in order to obtain a more general perspective, a final table with the most cited studies before 1990 is also presented. Thus, the reader can see the most cited papers in health research from a wide range of perspectives. Note that the results were collected between March and August 2015.

3. Results

This section presents the main bibliometric results found in WoS for the most cited papers of each field and subfield of health research from 1990 to 2014. Each table contains the 20 most cited papers of each category (see the Supplementary material for the top 50 list of highly cited papers by category). Although there are many aspects that can indicate the value of a paper, the number of citations represents their recognition in the scientific community.

3.1. Environmental and Occupational Health

Table 1 presents the top 20 positions for the environmental and occupational health category. The first position in the category is held by an article written by Günter Oberdörster, Eva Oberdörster, and Jan Oberdörster titled "Nanotoxicology: An emerging discipline evolving from studies of ultra fine particles" and published in *Environmental Health Perspectives*. This article pointed out that a careful evaluation of exposure is critical to proper risk assessment of nanosized particles. This paper takes a high position in the T200 ranking, reaching a 9th place. It also has 325 citations per year, the highest ratio in the category. The work done by the Oberdörster family is followed by two other papers studying chemical effects in wildlife and humans, which are "Developmental effects of endocrine_disrupting chemicals in wildlife and humans"

and "Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife". These two articles are in the 13th and 16th positions of the T200 respectively.

This category has 24 articles included in the T200 rank, equivalent to the 12% of the most cited papers in all fields of health.

Table 1 - Most cited articles in Environmental and Occupational Health

R	Journal	TC	Title	Author	Year	C/Y	T200
1	EHP	2924	Nanotoxicology: An emerging discipline evolving from studies of ultrafine particles	Oberdorster, G; Oberdorster, E; Oberdorster, J	2005	325	9
2	EHP	2197	Developmental effects of endocrine-disrupting chemicals in wildlife and humans	Colborn, T; Saal, FSV; Soto, AM	1993	105	13
3	EHP	2100	Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife	Van Den Berg, M; Birnbaum, L; Bosveld, ATC; et al.	1998	131	16
4	EHP	1845	Pharmaceuticals and personal care products in the environment: Agents of subtle change?	Daughton, CG; Ternes, TA	1999	123	21
5	AJIM	1498	Development of an upper extremity outcome measure: The dash (disabilities of the arm, shoulder, and head)	Hudak, PL; Amadio, PC; Bombardier, C; et al.	1996	83	29
6	EHP	1298	The e-screen assay as a tool to identify estrogens : An update on estrogenic environmental-pollutants	Soto, AM; Sonnenschein, C; Chung, KL; et al	1995	68	40
7	EHP	1046	Male reproductive health and environmental xenoestrogens	Toppari, J; Larsen, JC; Christiansen, P; et al.	1996	58	64
8	EHP	977	Vitellogenesis as a biomarker for estrogenic contamination of the aquatic environment	Sumpter, JP; Jobling, S	1995	51	73
9	EHP	951	A toxicologic review of quantum dots: Toxicity depends on physicochemical and environmental factors	Hardman, R	2006	119	82
10	EHP	910	Critical periods of vulnerability for the developing nervous system: Evidence from humans and animal models	Rice, D; Barone, S	2000	65	93
11	EHP	883	Para-Nonyl-Phenol : An estrogenic xenobiotic released from modified polystyrene	Soto, AM; Justicia, H; Wray, JW; et al.	1991	38	101
12	EHP	859	A variety of environmentally persistent chemicals, including some phthalate plasticizers, are weakly estrogenic	Jobling, S; Reynolds, T; White, R; et al.	1995	45	109
13	EHP	833	Manufactured nanomaterials (Fullerenes, C-60) induce oxidative stress in the brain of juvenile largemouth bass	Oberdorster, E	2004	83	114
14	EHP	830	Ultrafine particulate pollutants induce oxidative stress and mitochondrial damage	Li, N; Sioutas, C; Cho, A; et al.	2003	75	116
15	EHP	763	Brominated Flame Retardants: Cause For Concern?	Birnbaum, LS; Staskal, DF	2004	76	132
16	EHP	734	Developmental abnormalities of the gonad and abnormal sex-hormone concentrations in juvenile alligators from contaminated and control lakes in Florida	Guillette, LJ; Gross, TS; Masson, GR; et al.	1994	37	148
17	EHP	726	Decrease in anogenital distance among male infants with prenatal phthalate exposure	Swan, SH; Main, KM; Liu, F; et al.	2005	81	149
18	EHP	705	Low-Level environmental lead exposure and children's intellectual function: An international pooled analysis	Lanphear, BP; Hornung, R; Khoury, J; et al.	2005	78	163
19	EHP	697	Association of fine particulate matter from different sources with daily mortality in six US cities	Laden, F; Neas, LM; Dockery, DW; et al.	2000	50	166
20	SJWEH	682	Psychosocial factors at work and musculoskeletal disease	Bongers, PM; Dewinter, CR; Kompier, Maj; et al.	1993	32	177

Abbreviations: R = Rank; TC = Total citations; C/Y = Cites per year; T200 = Global ranking among the 200 most cited in all fields of health between 1990 and 2014; EHP = Environmental Health Perspectives; AJIM = American J. Industrial Medicine; SJWEH = Scandinavian Journal of Work Environment & Health.

3.2. Epidemiology

Table 2 includes the most cited articles from the Epidemiology category. The paper "Quantifying heterogeneity in a meta-analysis" from Higgins and Thompson has the first place in the category, with a very high C/Y rate of 499 citations per year and being located in the second position of the T200 ranking. In this paper authors propose three statistics that can be used to measure the impact of heterogeneity on a meta-analysis.

Under this category, there are also other three articles that are in the first 10 positions of the T200, which are "Adapting a clinical comorbidity index for use with ICD-9-cm administrative databases", "Multivariate prognostic models: Issues in developing models, evaluating assumptions and adequacy, and measuring and reducing errors", and "Measuring agreement in method comparison studies" located in the 4th, 8th, and 10th position respectively. It is remarkable that all the articles in this category belong to the ranking of the 200 most cited in all fields of health between 1990 and 2014. This proves the importance of this discipline in health research.

Table 2 - Most cited articles in Epidemiology

R	Journal	TC	Title	Author	Year	C/Y	T200
1	SM	5985	Quantifying heterogeneity in a meta-analysis	Higgins, JPT; Thompson, SG	2002	499	2
2	JCE	3762	Adapting a clinical comorbidity index for use with ICD-9-cm administrative databases	Deyo, RA; Cherkin, DC; Ciol, MA	1992	171	4
3	SM	2963	Multivariable prognostic models: Issues in developing models, evaluating assumptions and adequacy, and measuring and reducing errors	Harrell, FE; Lee, KL; Mark, DB	1996	165	8
4	SMMR	2870	Measuring agreement in method comparison studies	Bland, JM; Altman, DG	1999	191	10
5	SM	2160	Propensity score methods for bias reduction in the comparison of a treatment to a non-randomized control group	D'Agostino, RB	1998	135	14
6	SM	2028	Evaluating the added predictive ability of a new marker: From area under the roc curve to reclassification and beyond	Pencina, MJ; D'Agostino, RB, Sr.; D'Agostino, RB, Jr.; et al.	2008	338	17
7	JCE	1763	Cross-cultural adaptation of health-related quality-of-life measures - literature-review and proposed guidelines	Guillemin, F; Bombardier, C; Beaton, D	1993	84	23
8	AJE	1445	A modified Poisson regression approach to prospective studies with binary data	Zou, GY	2004	145	30
9	SM	1432	Two-sided confidence intervals for the single proportion: Comparison of seven methods	Newcombe, RG	1998	90	31
10	JECH	1403	The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions	Downs, SH; Black, N	1998	88	32
11	JCE	1380	A simulation study of the number of events per variable in logistic regression analysis	Peduzzi, P; Concato, J; Kemper, E; et al.	1996	77	33
12	ER	1354	The epidemiology of infections caused by escherichia-coli O157-H7, other enterohemorrhagic escherichia-coli, and the associated hemolytic uremic syndrome	Griffin, PM; Tauxe, RV	1991	59	36

Table 2 - Most cited articles in Epidemiology (continue)

R	Journal	TC	Title	Author	Year	C/Y	T200
13	SM	1319	Extracting summary statistics to perform meta-analyses of the published literature for survival endpoints	Parmar, MKB; Torri, V; Stewart, L	1998	82	38
14	SM	1250	Estimation of failure probabilities in the presence of competing risks: New representations of old estimators	Gooley, TA; Leisenring, W; Crowley, J; et al.	1999	83	44
15	JCE	1209	Response rates to mail surveys published in medical journals	Asch, DA; Jedrzejewski, MK; Christakis, NA	1997	71	46
16	JCE	1184	Validation of a combined comorbidity index	Charlson, M; Szatrowski, TP; Peterson, J; et al.	1994	59	48
17	AJE	1145	Reproducibility and validity of an expanded self-administered semiquantitative food frequency questionnaire among male health-professionals	Rimm, EB; Giovannucci, EL; Stampfer, MJ; et al.	1992	52	50
18	JCE	1128	Quality criteria were proposed for measurement properties of health status questionnaires	Terwee, CB; Bot, SDM; De Boer, MR; et al.	2007	161	54
19	AJE	1120	Association of coronary heart disease incidence with carotid arterial wall thickness and major risk factors: The atherosclerosis risk in communities (ARIC) study, 1987-1993	Chambless, LE; Heiss, G; Folsom, AR; et al.	1997	66	55
20	E	1118	Marginal structural models and causal inference in epidemiology	Robins, JM; Hernan, MA; Brumback, B	2000	80	57

Abbreviations: R = Rank; TC = Total citations; C/Y = Cites per year; T200 = Global ranking among the 200 most cited in all fields of health between 1990 and 2014; SM = Statistics in Medicine; JCE = Journal of Clinical Epidemiology; SMMR = Statistical Methods in Medical Research; JCE = Journal of Clinical Epidemiology; AJE = American Journal of Epidemiology; JECH = Journal of Epidemiology and Community Health; ER = Epidemiology Review; E = Epidemiology.

3.3. Health Management and Economics

This category contains the most cited paper in all fields and subfields of health research, which is titled "The MOS 36-item short-form health survey (SF-36). I. Conceptual framework and item selection". This article was the result of the Medical Outcome Study (MOS) to explain variations in patient outcomes. They developed a 36-item short form to survey health status, which nowadays is widely utilized by health care organizations. The authors of this paper, Ware and Sherbourne, have 700 citations per year for this work. Ware has also other 4 papers as first author or coauthor in the first 4 positions of the Health Management and Economics category, and 3 of them in the first 10 positions of the T200 ranking.

The articles in the second and third place of this category, and at the same time in the 3rd and 6th positions of the T200 are both works related to a short-form health survey, their titles are "A 12-item short-form health survey: Construction of scales and preliminary tests of reliability and validity" and "The MOS 36-item short-form health survey (SF-36). 2. Psychometric and clinical-tests of validity in measuring physical and mental-health constructs".

It is worth to note that 22 out of the 50 most cited articles of this category have a position in the T200 ranking. This confirms the significance of this category in health research.

Table 3 - Most cited articles in Health Management and Economics

R	Journal	TC	Title	Author	Year	C/Y	T200
1	MC	15406	The MOS 36-item short-form health survey (SF-36) .1. conceptual-framework and item selection	Ware, JE; Sherbourne, CD	1992	700	1
2	MC	5254	A 12-item short-form health survey : Construction of scales and preliminary tests of reliability and validity	Ware, JE; Kosinski, M; Keller, SD	1996	292	3
3	MC	3359	The MOS 36-item short-form health survey (SF-36) .2. psychometric and clinical-tests of validity in measuring physical and mental-health constructs	McHorney, CA; Ware, JE; Raczek, AE	1993	160	6
4	MC	2427	The MOS 36-item short-form health survey (SF-36) .3. tests of data quality, scaling assumptions, and reliability across diverse patient groups	McHorney, CA; Ware, JE; Lu, JFR; et al.	1994	121	12
5	MC	1994	Comorbidity measures for use with administrative data	Elixhauser, A; Steiner, C; Harris, DR; et al.	1998	125	18
6	MC	1672	Modeling valuations for EuroQol health states	Dolan, P	1997	98	25
7	JHE	1516	The price of innovation: New estimates of drug development costs	Dimasi, JA; Hansen, RW; Grabowski, HG	2003	138	28
8	MC	1298	Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data	Quan, HD; Sundararajan, V; Halfon, P; et al	2005	144	39
9	MC	1219	PedsQL (TM) 4.0: reliability and validity of the pediatric quality of life inventory (TM) version 4.0 generic core scales in healthy and patient populations	Varni, JW; Seid, M; Kurtin, PS	2001	94	45
10	MDM	1201	Markov-models in medical decision-making : A practical guide	Sonnenberg, FA; Beck, JR	1993	57	47
11	MC	1.135	Interpretation of changes in health-related quality of life :The remarkable universality of half a standard deviation	Norman, GR; Sloan, JA; Wyrwich, KW	2003	103	51
12	JHE	1.096	The estimation of a preference-based measure of health from the SF-36	Brazier, J; Roberts, J; Deverill, M	2002	91	59
13	MC	868	Evidence suggesting that a chronic disease self-management program can improve health status while reducing hospitalization : A randomized trial	Lorig, KR; Sobel, DS; Stewart, AL; et al.	1999	58	104
14	MC	854	The PedsQL (TM): Measurement model for the pediatric quality of life inventory	Varni, JW; Seid, M; Rode, CA	1999	57	110
15	RA	769	500 lifesaving interventions and their cost-effectiveness	Tengs, TO; Adams, ME; Pliskin, JS; et al.	1995	40	131
16	MC	736	The patient health questionnaire-2 : Validity of a two-item depression screener	Kroenke, K; Spitzer, RL; Williams, JBW	2003	67	144
17	MC	723	Incidence and types of adverse events and negligent care in Utah and Colorado	Thomas, EJ; Studdert, DM; Burstin, HR; et al.	2000	52	151
18	JHE	707	Estimating log models: to transform or not to transform?	Manning, WG; Mullahy, J	2001	54	156
19	RA	716	Risk as analysis and risk as feelings: Some thoughts about affect, reason, risk, and rationality	Slovic, P; Finucane, ML; Peters, E; et al	2004	72	155
20	MC	698	Variations in patients' adherence to medical recommendations : A quantitative review of 50 years of research	Dimatteo, MR	2004	70	165

Abbreviations: R = Rank; TC = Total citations; C/Y = Cites per year; T200 = Global ranking among the 200 most cited in all fields of health between 1990 and 2014; MC = Medical Care; JHE = Journal of Health Economics; MDM = Medical Decision Making; RA = Risk Analysis.

3.4. Health Informatics, Engineering and Technology

The top 10 articles of the category Health Informatics, Engineering and Technology are shown in Table 4.

There are only two articles that entered into the T200 ranking, which are "Guidelines for limiting exposure

to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)" from Ahlbom, Bergqvist, Bernhardt and others, and "Effectiveness and efficiency of guidelines dissemination and implementation strategies" written by Grimshaw, Thomas, MacLennan and others. These two papers are placed in the numbers 19 and 86 of the T200 ranking, with 124 and 94 citations per year respectively.

Table 4 - Most cited articles in Health Informatics, Engineering and Technology

R	Journal	TC	Title	Author	Year	C/Y	T200
1	HP	1987	Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields (up to 300 GHz)	Ahlbom, A; Bergqvist, U; Bernhardt, JH; et al.	1998	124	19
2	HTA	938	Effectiveness and efficiency of guideline dissemination and implementation strategies	Grimshaw, JM; Thomas, RE; MacLennan, G; et al.	2004	94	86
3	JAMIA	630	The impact of computerized physician order entry on medication error prevention	Bates, DW; Teich, JM; Lee, J; et al.	1999	42	-
4	JAMIA	558	Some unintended consequences of information technology in health care: The nature of patient care information system-related errors	Ash, JS; Berg, M; Coiera, E	2004	56	-
5	MIM	522	The unified medical language system	Lindberg, D; Humphreys, BL; McCray, AT	1993	25	-
6	JAMIA	507	An integrated software suite for surface-based analyses of cerebral cortex	Van Essen, DC; Drury, HA; Dickson, J; et al.	2001	39	-
7	IJMI	505	A review of content-based image retrieval systems in medical applications: Clinical benefits and future directions	Muller, H; Michoux, N; Bandon, D; et al.	2004	51	-
8	JMIR	399	The law of attrition	Eysenbach, G	2005	44	-
9	JAMIA	398	Ten commandments for effective clinical decision support: Making the practice of evidence-based medicine a reality	Bates, DW; Kuperman, GJ; Wang, S; et al.	2003	36	-
10	JAMIA	381	Developing optimal search strategies for detecting clinically sound studies in medline	Haynes, RB; Wilczynski, N; McKibbon, KA; et al.	1994	19	-

Abbreviations: R = Rank; TC = Total citations; C/Y = Cites per year; T200 = Global ranking among the 200 most cited in all fields of health between 1990 and 2014; HP = Health Physics; HTA = Health Technology Assessment; JAMIA = Journal of the American Medical Informatics Association; MIM = Methods of Information in Medicine; IJMI = International Journal of Medical Informatics; JMIR = Journal of Medical Internet Research.

3.5. Health Policy and Services

Table 5 presents the top 10 articles in the category Health Policy and Services. The first position in this category goes to the article titled "EuroQOL: The current state of play" written by Richard Brooks, which it is also in the 20th place of the T200 ranking. Although Brook`s paper is very high ranked, it does not have the largest number of citations, this position is occupied by the article entitled "Diffusion of innovations in service organizations: Systematic review and recommendations" with 136 citations per year.

There are 8 articles into the T200 ranking in this category. Therefore this category does not have a big impact compared to other disciplines in health research.

Table 5 - Most cited articles in Health Policy and Services

R	Journal	TC	Title	Author	Year	C/Y	T200
1	HP	1910	EuroQOL: The current state of play	Brooks, R	1996	106	20
2	MQ	1355	Diffusion of innovations in service organizations: Systematic review and recommendations	Greenhalgh, T; Robert, G; MacFarlane, F; et al.	2004	136	34
3	MQ	1033	Organizing care for patients with chronic illness	Wagner, EH; Austin, BT; Vonkorff, M	1996	57	65
4	HA	961	Improving chronic illness care: Translating evidence into action	Wagner, EH; Austin, BT; Davis, C; et al.	2001	74	77
5	MQ	898	Contribution of primary care to health systems and health	Starfield, B; Shi, LY; Macinko, J	2005	100	95
6	QLR	825	Assessing health status and quality-of-life instruments: Attributes and review criteria	Aaronson, N; Alonso, J; Burnam, A; et al.	2002	69	117
7	QLR	682	The world health organization's WHOQOL-bref quality of life assessment: Psychometric properties and results of the international field trial - a report from the WHOQOL group	Skevington, SM; Lotfy, M; O'Connell, KA	2004	68	176
8	QLR	673	Individual-patient monitoring in clinical-practice : Are available health-status surveys adequate	Mchorney, CA; Tarlov, AR	1995	35	183
9	HA	589	Annual medical spending attributable to obesity: Payer- and service-specific estimates	Finkelstein, EA; Trogdon, JG; Cohen, JW; et al.	2009	118	-
10	HA	584	Nurses' reports on hospital care in five countries	Aiken, LH; Clarke, SP; Sloane, DM; et al.	2001	45	-

Abbreviations: R = Rank; TC = Total citations; C/Y = Cites per year; T200 = Global ranking among the 200 most cited in all fields of health between 1990 and 2014; HP = Health Policy; MQ = Milbank Quarterly; HA = Health Affairs; QLR = Quality of Life Research.

3.6. Health Promotion and Health Behavior

In the category of Health Promotion and Health Behavior (see Table 6) are 20 articles in the T200, which represents a 10% of it. The article written by Idler and Benyamini, "Self-rated health and mortality: A review of twenty-seven community studies", has the first position in the category and the 7th position of the T200 ranking. The highest number of citations per year is for the article ranked in the 3rd placed of this category "Three approaches to quality content analysis".

Table 6 - Most cited articles in Health Promotion and Health Behavior

R	Journal	TC	Title	Author	Year	C/Y	T200
1	JHSB	3040	Self-rated health and mortality: A review of twenty-seven community studies	Idler, EL; Benyamini, Y	1997	179	7
2	JHSB	2443	Revisiting the behavioral-model and access to medical-care: Does it matter	Andersen, RM	1995	129	11
3	QHR	2019	Three approaches to qualitative content analysis	Hsieh, HF; Shannon, SE	2005	224	15
4	AJPM	1784	Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults : The adverse childhood experiences (ACE) study	Felitti, VJ; Anda, RF; Nordenberg, D; et al.	1998	112	22
5	AJHP	1579	The transtheoretical model of health behavior change	Prochaska, JO; Velicer, WF	1997	93	27
6	PM	1276	Estrogen replacement therapy and coronary heart-disease : A quantitative assessment of the epidemiologic evidence	Stampfer, MJ; Colditz, GA	1991	55	42
7	JHSB	1265	Social conditions as fundamental causes of disease	Link, BG; Phelan, J	1995	67	43
8	HEB	1179	Health promotion by social cognitive means	Bandura, A	2004	118	49
9	AJPM	1012	Screening for depression in well older adults : Evaluation of a short-form of the CES-D	Andresen, EM; Malmgren, JA; Carter, WB; et al.	1994	51	68

Table 6 - Most cited articles in Health Promotion and Health Behavior (continue)

R	Journal	TC	Title	Author	Year	C/Y	T200
10	AJPM	990	The theory of planned behavior: A review of its applications to health-related behaviors	Godin, G; Kok, G	1996	55	70
11	PH	930	The revised illness perception questionnaire (IPQ-R)	Moss-Morris, R; Weinman, J; Petrie, KJ; et al.	2002	78	90
12	AJPM	908	Current methods of the US Preventive Services Task Force : A review of the process	Harris, RP; Helfand, M; Woolf, SH; et al.	2001	70	94
13	PM	849	Do obese children become obese adults : A review of the literature	Serdula, MK; Ivery, D; Coates, RJ; et al.	1993	40	111
14	PM	811	Green tea composition, consumption, and polyphenol chemistry	Graham, HN	1992	37	123
15	AJPM	797	The effectiveness of interventions to increase physical activity : A systematic review	Kahn, EB; Ramsey, LT; Brownson, RC; et al.	2002	66	124
16	MT	735	Features and uses of high-fidelity medical simulations that lead to effective learning: A BEME systematic review	Issenberg, SB; McGaghie, WC; Petrusa, ER; et al.	2005	82	146
17	ACPSM	712	Self-reported adherence to antiretroviral medications among participants in HIV clinical trials: The AACTG adherence instruments	Chesney, MA; Ickovics, JR; Chambers, DB; et al.	2000	51	159
18	AJPM	693	Environmental factors associated with adults' participation in physical activity : A review	Humpel, N; Owen, N; Leslie, E	2002	58	168
19	JHSB	684	The prevalence, distribution, and mental health correlates of perceived discrimination in the United States	Kessler, RC; Mickelson, KD; Williams, DR	1999	46	175
20	JCEHP	655	Lost in knowledge translation: Time for a map?	Graham, ID; Logan, J; Harrison, MB; et al.	2006	82	196

Abbreviations: R = Rank; TC = Total citations; C/Y = Cites per year; T200 = Global ranking among the 200 most cited in all fields of health between 1990 and 2014; JHSB = Journal of Health and Social Behavior; QHR = Quality Health Research; AJPM = American Journal of Preventive Medicine; PM = Preventive Medicine; HEB =Health Education and Behavior; PH = Psychology and Health; MT = Medical Teacher; ACPSM = AIDS Care-Psychology and Social-Medical Aspects of AIDS/HIV; JCEHP = Journal of Continuing Education in the Health Professions.

3.7. Medicine

The 10 most cited articles from the Medicine category are presented in Table 7. According to the results, a paper written in 2001 by Kroenke, Spitzer and Williams entitled "The PHQ-9: Validity of a brief depression severity measure" reaches the first position in the category and the highest number of citations per year. This article examined the validity of a new measure of depression severity and is placed number 5 in the T200.

The following papers in the ranking for the Medicine category have lower positions in the T200 ranking and just 7 of them belong to it.

Table 7 - Most cited articles in Medicine

R	Journal	TC	Title	Author	Year	C/Y	T200
1	JGIM	3715	The PHQ-9: Validity of a brief depression severity measure	Kroenke, K; Spitzer, RL; Williams, JBW	2001	286	5
2	AM	934	Problem-based learning :A review of literature on its outcomes and implementation issues	Albanese, MA; Mitchell, S	1993	44	88
3	JMPT	932	The neck disability index : A study of reliability and validity	Vernon, H; Mior, S	1991	41	89
4	AJTMH	737	Identification of single specimens of the anopheles-gambiae complex by the polymerase chain-reaction	Scott, JA; Brogdon, WG; Collins, FH	1993	35	142

Table 7 - Most cited articles in Medicine (continue)

R	Journal	TC	Title	Author	Year	C/Y	T200
5	JGIM	691	Case-finding instruments for depression : Two questions are as good as many	Whooley, MA; Avins, AL; Miranda, J; et al.	1997	41	171
6	JGIM	680	The test of functional health literacy in adults : A new instrument for measuring patients literacy skills	Parker, RM; Baker, DW; Williams, MV; et al.	1995	36	178
7	JPSM	622	Measuring fatigue and other anemia-related symptoms with the functional assessment of cancer therapy (FACT) measurement system	Yellen, SB; Cella, DF; Webster, K; et al.	1997	37	-
8	AM	576	Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains	Ericsson, KA	2004	58	-
9	AJTMH	572	The ears of the hippopotamus: Manifestations, determinants, and estimates of the malaria burden	Breman, JG	2001	44	-
10	AM	571	The psychological basis of problem-based learning: A review of the evidence	Norman, GR; Schmidt, HG	1992	26	-

Abbreviations: R = Rank; TC = Total citations; C/Y = Cites per year; T200 = Global ranking among the 200 most cited in all fields of health between 1990 and 2014; JGIM = Journal of General Internal Medicine; AM = Academic Medicine; JMPT = Journal of Manipulative and Physiological Therapeutics; AJTMH = American Journal of Tropical Medicine and Hygiene; JPSM = Journal of Pain and Symptom Management.

3.8. Primary Care

Among the 10 most cited articles in Primary Care, we find just 2 of them in the T200 ranking. The first position of the ranking is for "Understanding interobserver agreement: the kappa statistic" from Viera and Garret, with 106 citations per year and in the 78th position of the T200. The other article in the T200 ranking is located in the 157th position entitled "The impact of patient-centered care on outcomes", with 51 citations per year. This is a category without a remarkable impact in the most cited papers in health research.

Table 8 - Most cited articles in Primary Care

R	Journal	TC	Title	Author	Year	C/Y	T200
1	FM	957	Understanding interobserver agreement: The kappa statistic	Viera, AJ; Garrett, JM	2005	106	78
2	JFP	713	The impact of patient-centered care on outcomes	Stewart, M; Brown, JB; Donner, A; et al.	2000	51	157
3	BJGP	485	Motivational interviewing: A systematic review and meta-analysis	Rubak, S; Sandboek, A; Lauritzen, T; et al.	2005	54	-
4	JFP	412	Linking primary care performance to outcomes of care	Safran, DG; Taira, DA; Rogers, WH; et al.	1998	26	-
5	AFM	362	Quick assessment of literacy in primary care: The newest vital sign	Weiss, BD; Mays, MZ; Martz, W; et al.	2005	40	-
6	FP	320	Sampling for qualitative research	Marshall, MN	1996	18	-
7	JFP	315	Competing demands of primary-care : A model for the delivery of clinical preventive services	Jaen, CR; Stange, KC; Nutting, PA	1994	16	-
8	FM	293	Brief questions to identify patients with inadequate health literacy	Chew, LD; Bradley, KA; Boyko, EJ	2004	29	-
9	JFP	290	The relationship of physician medical interview style to patient satisfaction	Bertakis, KD; Roter, D; Putnam, SM	1991	13	-
10	AFM	284	Prevalence of multimorbidity among adults seen in family practice	Fortin, M; Bravo, G; Hudon, C; et al.	2005	32	-

Abbreviations: R = Rank; TC = Total citations; C/Y = Cites per year; T200 = Global ranking among the 200 most cited in all fields of health between 1990 and 2014; FM = Family Medicine; JFP = Journal of Family Practice; BJGP = British Journal of General Practice; AFM = Annals of Family Medicine; FP = Family Practice.

3.9. Public Health

The Public Health category presents 15 articles in the first 100 positions of the T200 (see Table 9), and 38 out of the 50 articles considered in this category are in the T200 ranking. The first article in the category describes the development and evaluation of a social support survey from the MOS, the title of the article is "The MOS social support survey" and have close to 75 citations per year and occupies the position 24 in the T200. The highest number of citations per year goes for the paper located in the second place of the category "Global data on visual impairment in the year 2002", which is in the 26th position of the T200.

Table 9 - Most cited articles in Public Health

R	Journal	TC	Title	Autor	Year	C/Y	T200
1	SSM	1714	The MOS social support survey	Sherbourne, CD; Stewart, al.	1991	74,52	24
2	BWHO	1618	Global data on visual impairment in the year 2002	Resnikoff, S; Pascolini, D; Etya'Ale, D; et al.	2004	161,8	26
3	SSM	1354	The disablement process	Verbrugge, LM; Jette, AM.	1994	67,70	35
4	ARPH	1322	Review of community-based research: Assessing partnership approaches to improve public health	Israel, BA; Schulz, AJ; Parker, EA; et al.	1998	82,63	37
5	ARPH	1284	Acute respiratory effects of particulate Air-Pollution	Dockery, DW; Pope, CA	1994	64,20	41
6	AJPH	1133	Social capital, income inequality, and mortality	Kawachi, I; Kennedy, BP; Lochner, K; et al.	1997	66,65	52
7	SSM	1133	The structure and properties of the sense of coherence scale	Antonovsky, A	1993	53,95	53
8	SSM	1119	The World Health organization quality of life assessment (WHOQOL): Position paper from the World Health organization	Kuyken, W; Orley, J; Power, M; et al.	1995	58,89	56
9	SSM	1058	Shared decision-making in the medical encounter: What does it mean? (or it takes at least two to tango)	Charles, C; Gafni, A; Whelan, T	1997	62,24	61
10	ARPH	1048	Measuring social class in us public health research: Concepts, methodologies, and guidelines	Krieger, N; Williams, DR; Moss, NE	1997	61,65	63
11	AJPH	970	The validity of self-reported smoking - a review and metaanalysis	Patrick, DL; Cheadle, A; Thompson, DC; et al.	1994	48,50	74
12	AJPH	964	Overcoming the absence of socioeconomic data in medical records : Validation and application of a census-based methodology	Krieger, N	1992	43,82	76
13	AJPH	937	Projections of Alzheimer's disease in the United States and the public health impact of delaying disease onset	Brookmeyer, R; Gray, S; Kawas, C	1998	58,56	87
14	SSM	923	From social integration to health: Durkheim in the new millennium	Berkman, LF; Glass, T; Brissette, I; et al.	2000	65,93	91
15	SSM	888	Constructions of masculinity and their influence on men's Well-Being: A theory of gender and health	Courtenay, WH	2000	63,43	99
16	SSM	867	Doctor-Patient communication :A review of the literature	Ong, LML; Dehaes, JCJM; Hoos, AM; et al.	1995	45,63	105
17	AJPH	861	Evaluating the public health impact of health promotion interventions: The re-aim framework	Glasgow, RE; Vogt, TM; Boles, SM	1999	57,40	108
18	PHR	836	Estimating health Care-Associated infections and deaths in US hospitals, 2002	Klevens, RM; Edwards, JR; Richards, CL, Jr.; et al.	2007	119,43	112
19	BWHO	821	Burden of major musculoskeletal conditions	Woolf, AD; Pfleger, B	2003	74,64	119
20	BWHO	820	Development of a who growth reference for school-aged children and adolescents	De Onis, M; Onyango, AW; Borghi, E; et al.	2007	117,14	118

Abbreviations: R = Rank; TC = Total citations; C/Y = Cites per year; T200 = Global ranking among the 200 most cited in all fields of health between 1990 and 2014; SSM = Social Science and Medicine, BWHO = Bulletin of the World Health Organization; ARPH = Annual Review of Public Health; AJPH = American Journal of Public Health.

3.10. Most cited articles in health research published before 1990

To complement our study, we have incorporated the most cited articles in health research before 1990 in Table 10. The first position is for an article written in 1987 by Charlson, Pompei, Ales and others, about comorbidity and entitled "A new method of classifying prognostic comorbidity in longitudinal studies-development and validation", it has 446 citations per year. The second position is for "A global measure of perceived stress" with 150 citations per year, and followed by the article "CDC definitions for nosocomial infections, 1988" with 138 citations per year.

It is worth to notice the evolution in health research because most of the most cited papers before 1990 belonged to the Medicine category, which has no longer the same impact on citations today.

Table 10 - Most cited articles in health published before 1990

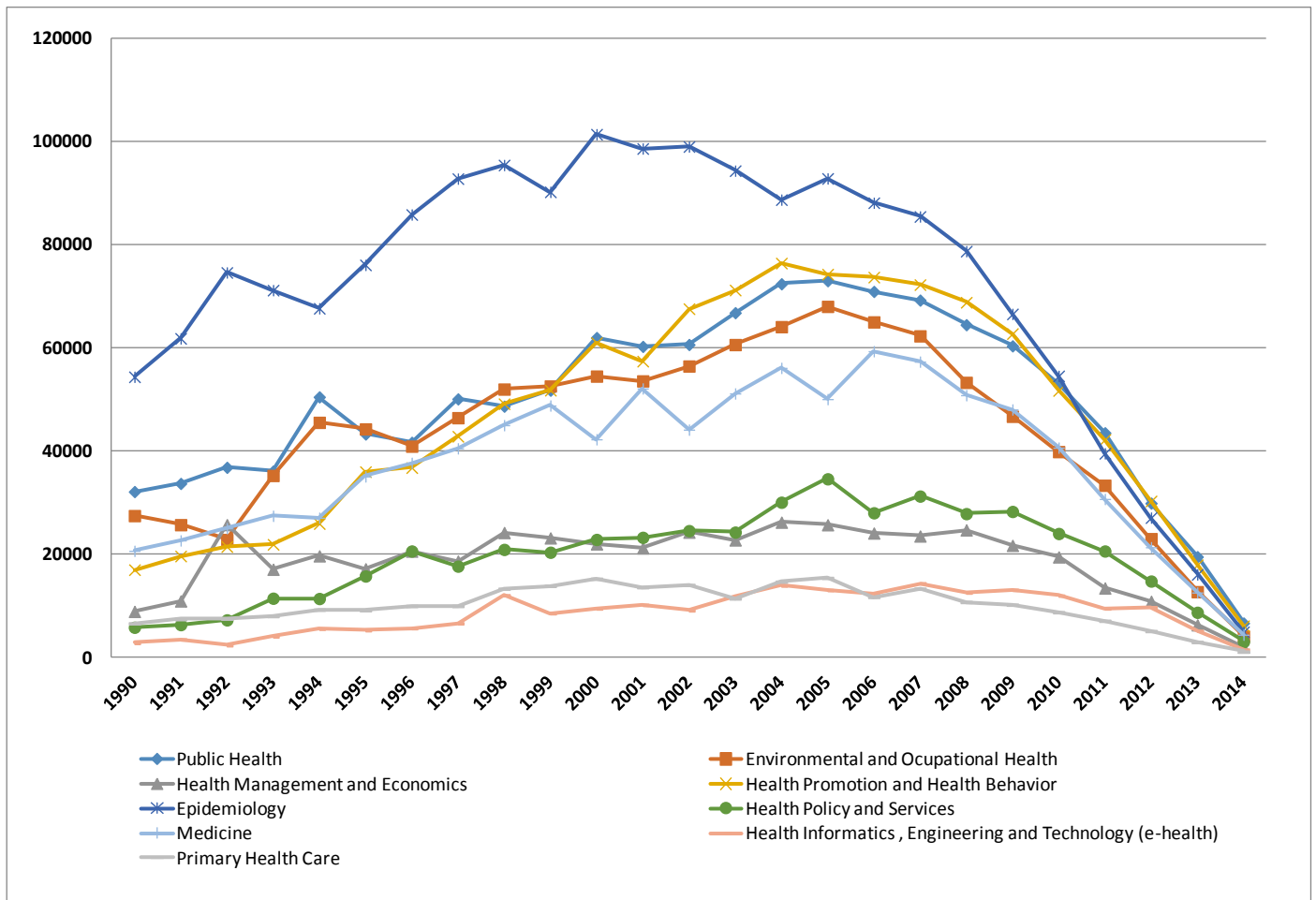
R	Journal	TC	Title	Autor	Year	C/Y
1	JCD	12031	A new method of classifying prognostic comorbidity in longitudinal-studies-development and validation	Charlson, ME; Pompei, P; Ales, KL; et al.	1987	446
2	JHSB	4636	A global measure of perceived stress	Cohen, S; Kamarck, T; Mermelstein, R	1983	150
3	AJIC	3586	CDC definitions for nosocomial infections, 1988	Garner, JS; Jarvis, WR; Emori, TG; et al.	1988	138
4	JHSB	3414	Structure of coping	Pearlin, LI; Schooler, C	1978	95
5	MC	2947	The sickness impact profile: Development and final revision of a health-status	Bergner, M; Bobbitt, RA; Carter, WB; et al.	1981	89
6	AJTMH	2896	Techniques for hemagglutination and hemagglutination-inhibition with arthropodborne viruses	Clarke, DH; Casals, J	1958	52
7	JH	2621	The estimation of the bactericidal power of the blood	Miles, AA; Misra, SS; Irwin, JO	1938	34
8	JHSB	2494	The stress process	Pearlin, LI; Menaghan, EG; Lieberman, MA; et al.	1981	76
9	HEQ	2412	The health belief model : A decade later	Janz, NK; Becker, MH	1984	80
10	AJE	2411	Reproducibility and validity of a semiquantitative food frequency questionnaire	Willett, WC; Sampson, L; Stampfer, MJ; et al.	1985	83
11	JHSB	2379	An analysis of coping in a middle-aged community sample	Folkman, S; Lazarus, RS	1980	70
12	AJE	2315	Social networks, host-resistance, and mortality -9 - year follow-up-study of alameda county residents	Berkman, LF; Syme, SL	1979	66
13	MC	2258	The mos short-form general health survey -reliability and validity in a patient population	Stewart, AL; Hays, RD; Ware, JE	1988	87
14	AJE	1830	Total energy-intake : Implications for epidemiologic analyses	Willett, W; Stampfer, MJ	1986	65
15	AJE	1650	Estimability and estimation in case-referent studies	Miettinen, O	1976	43
16	JOB	1582	The measurement of experienced burnout	Maslach, C; Jackson, SE	1981	48
17	MMFQH	1550	Evaluating quality of medical care	Donabedian, A	1966	32
18	TRSTM	1515	New medium for axenic cultivation of entamoeba-histolytica and other entamoeba	Diamond, LS; Harlow, DR; Cunnick, CC	1978	42
19	HEM	1472	Development of multidimensional health locus of control (MHLC) scales	Wallston, KA; Wallston, BS; Devellis, R	1978	41
20	AJE	1397	A data-based approach to diet questionnaire design and testing	Block, G; Hartman, AM; Dresser, CM; et al.	1986	50

Abbreviations: R = Rank; TC = Total citations; C/Y = Cites per year; T200 = Global ranking among the 200 most cited in all fields of health between 1990 and 2014; JCD = Journal of Chronic Diseases; JHSB = Journal of Health and Social Behavior; AJIC = American Journal of Infection Control; MC = Medical Care; AJTMH = American Journal of Tropical Medicine and Hygiene; JH = Journal of Hygiene; HEQ = Health Education Quarterly; AJE = American Journal of Epidemiology; JOB = Journal of Occupational Behavior; MMFQH = Milbank Memorial Fund Quarterly-Health and Society; TRSTM = Transactions of the Royal Society of Tropical Medicine and Hygiene; HEM = Health Education Monographs.

3.11. Comparison between fields

The previous tables have shown the most cited papers in each category. Now, let us look into the total volume of citations obtained by each category. For doing so, Figure 1 presents the number of citations that the articles published in each year have obtained until now (July 2015). The analysis divides the results in the nine categories considered previously.

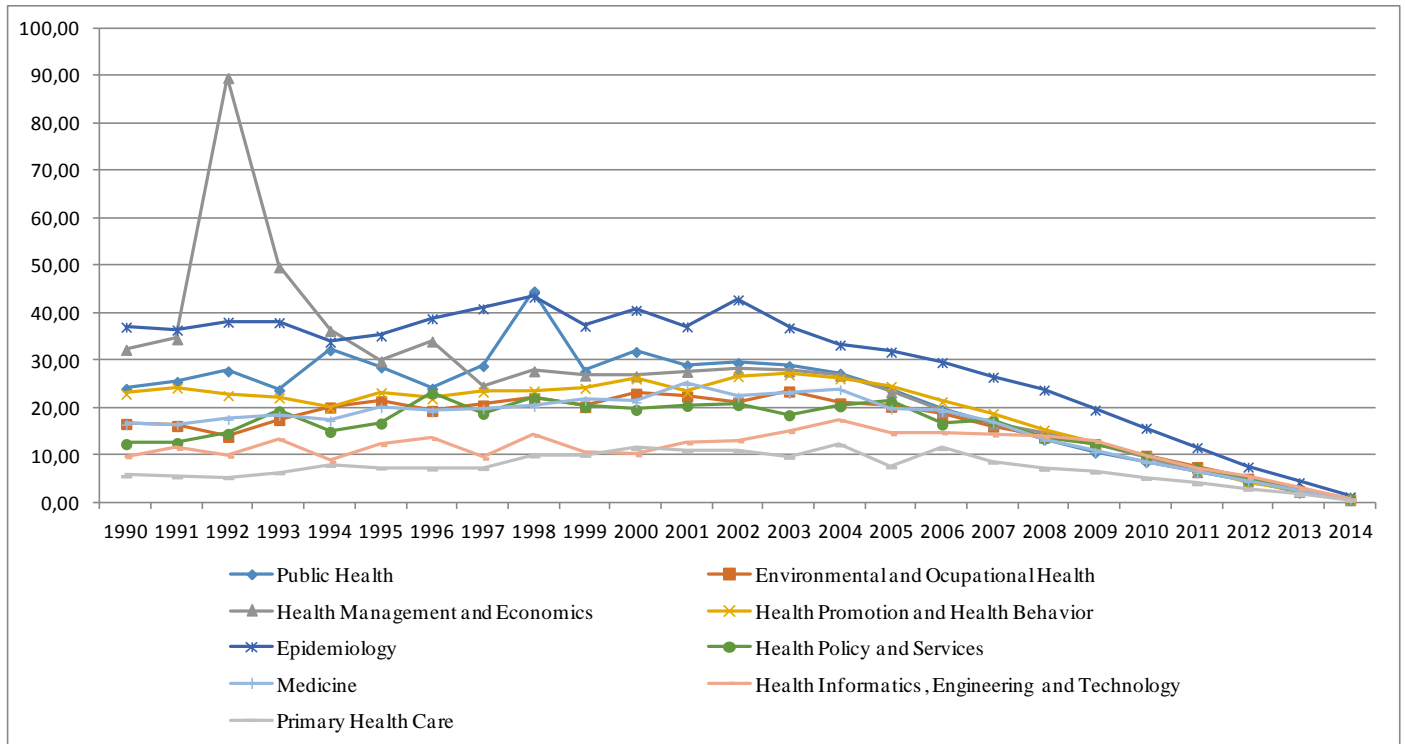
Figure 1 - Annual number of total citations in each category



Epidemiology is the category that has received the highest number of citations which is in accordance with the results seen in the previous tables where Epidemiology is the category with the highest number of highly cited articles. Public Health has also obtained a significant number of citations. Health Promotion and Health Behavior has not received many citations in the nineties but it is growing a lot during the last ten years.

Note that the total number of citations may be conditioned by the number of articles that each category publishes. In order to normalize this issue, let us look into the number of citations per paper obtained by each category on a yearly basis. Figure 2 presents the results.

Figure 2 - Annual number of citations per paper in each category



The papers published in Health Management and Economics in the nineties have received a considerable number of citations. This category did not obtain important results in Figure 1 because it is quite small.

However, Figure 2 shows that this category is also very influential. From a general perspective, Epidemiology also leads the results with this indicator although much closer to Public Health than in Figure 1.

Finally, note that this study has focused on the most cited papers in health research. But other types of analyses could be developed in this direction including the future trends of a field (Yao et al. 2014), health inequalities (Bouchard et al. 2015) and comparison with medical sciences (Gagliardi and Dobrow, 2011). Observe that in the literature some studies have analyzed a country or a region including Europe (Clarke et al. 2007); Latin America (Chinchilla-Rodríguez et al. 2015; Zacca-González et al. 2014); India (Dandona et al. 2009); Africa (Chuang et al. 2011), Australia (Gowland et al. 2012), and many others.

4. Conclusions

This study presents the most cited articles in health research with a focus on the last twenty-five years and according to the results found in WoS. The work divides health research in nine categories instead of the four used by WoS. The reason for doing so is the need of a more specific analysis, especially for the categories with a huge number of journals. Epidemiology is the category that obtains the highest number of citations. Four of his papers are among the Top 10 of the whole field of health research between 1990 and 2014. Public Health also obtains significant results although none of these papers are in the Top 10. Health Management and Economics is a much smaller category but has three papers in the Top 10 including the most cited one which is published in Medical Care. Some other journals that obtain remarkable results among the most cited papers are Environmental Health Perspectives, Journal of Clinical Epidemiology, Social Science and Medicine and the American Journal of Public Health. The American Journal of Epidemiology has published the highest number of highly cited papers before 1990. Currently, all the highly cited articles are published in English. However, note that this analysis focuses on academic articles and included in WoS which is English oriented. Therefore, non-English language articles rarely appear in a significant position under this framework.

This article identifies those articles that are receiving the highest number of citations in health research which indicates the popularity achieved over the last years. Usually, this popularity is linked to the importance of the research developed. However, it is worth mentioning that many other studies with less number of citations may also be very significant. This may occur due to the specific characteristics of the research conducted and other related factors. In any case, the aim of this paper is to identify an important part of the leading papers in the field. Although the focus is given to the last twenty-five years, the results before 1990 are also considered and widely presented in the supplementary material.

Appendix A. Supplementary data

Supplementary data related to this article is available.

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