

# Research on Non-alcoholic Fatty Liver Disease From Indian Subcontinent: A Bibliometric Analysis of Publications During 2001–2022



Raju Vaishya<sup>\*</sup>, Brij M. Gupta<sup>†</sup>, Mallikarjun M. Kappi<sup>‡</sup>, Anoop Misra<sup>§,||,¶</sup>, Mohammad S. Kuchay<sup>#</sup>, Abhishek Vaish<sup>\*</sup>

<sup>\*</sup>Department of Orthopaedics and Joint Replacement Surgery, Indraprastha Apollo Hospitals, Sarita Vihar, New Delhi, 110076, India, <sup>†</sup>Formerly with CSIR-NISTADS, New Delhi, 110012, India, <sup>‡</sup>Government First Grade College, Jagalur, 577528, Karnataka, India, <sup>§</sup>Fortis-C-Doc Centre of Excellence for Diabetes, Metabolic Diseases and Endocrinology, New Delhi, India, <sup>||</sup>National Diabetes, Obesity and Cholesterol Foundation (N-DOC), SDA, New Delhi, India, <sup>¶</sup>Diabetes Foundation, India and <sup>#</sup>Division of Endocrinology & Diabetes, Medanta-The Medicity, Gurugram, India

**Introduction:** The non-alcoholic fatty liver disease (NAFLD) is common in the Indian Subcontinent. We aimed to examine the bibliometric characteristics of the publications arising from the countries of the Indian Subcontinent on NAFLD, over the last two decades. **Methods:** Publications on NAFLD from Indian Subcontinent during the period of 2001–2022 were retrieved from the Scopus database. Various important bibliometric parameters were studied from the retrieved publications and were exported to MS-Excel for analysis. VOSviewer software was used for analyzing co-author collaborative networks and keyword co-occurrence networks. **Results:** There is a rising trend of publications, especially in the last decade, with an average annual growth of 28.95% and an absolute growth of 526.21% between 2013 and 2022, compared to 2001–2012. From Indian Subcontinent's authors, 1053 papers were indexed in Scopus, with the majority (81.3%) being from India. Indian Subcontinent holds 13<sup>th</sup> rank globally with 3.43% share of global output. External funding was received for 15.76% publications and 24.59% papers were prepared with international collaboration, and these received much higher citations per paper. Research output is low, only 3.43% of global share. Regional research cooperation among countries of Indian subcontinent is also poor. Further, only 3.61% of papers were highly cited. **Conclusion:** Despite a high prevalence of NAFLD in Indian Subcontinent, the research output is low and of low impact. Further, the research collaboration between these Indian Subcontinent needs improvement. (J CLIN EXP HEPATOL 2024;14:101271)

The non-alcoholic fatty liver disease (NAFLD) is an umbrella term which encompasses a spectrum of liver abnormalities, ranging from (i) simple fatty liver (steatosis), (ii) non-alcoholic steatohepatitis (NASH), (iii) fibrosis, and (iv) cirrhosis. NAFLD is also a strong risk factor for hepatocellular carcinoma (HCC).<sup>1–3</sup>

**Keywords:** non-alcoholic fatty liver disease, Indian Subcontinent, research, bibliometrics, liver

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Address for correspondence: Dr. Raju Vaishya, Department of Orthopaedics and Joint Replacement Surgery, Indraprastha Apollo Hospitals, Sarita Vihar, New Delhi, 110076, India. Tel.: +91 9810123331.

E-mail: [raju.vaishya@gmail.com](mailto:raju.vaishya@gmail.com)

**Abbreviations:** AIIMSND: All India Institute of Medical Sciences, New Delhi; CLD: Chronic Liver Disease; CMC: Christian Medical College; CPP: Citations Per Paper; CSIR: Council of Scientific & Industrial Research; DBT: Department of Biotechnology, India; DST: Department of Science & Technology, India; ESLD: End-stage Liver Disease; HCC: Hepatocellular Carcinoma; ICP: International Collaborative Papers; IL & BS, ND: Institute of Liver & Biliary Sciences, New Delhi; IPGIMER: Institute of Post Graduate Medical Education & Research; MAFLD: Metabolic (dysfunction) Associated Fatty Liver Disease; MetD: Metabolic Disease; NAFLD: Non-alcoholic fatty liver disease; NASH: Non-alcoholic Steatohepatitis; NIDDKD: The National Institute of Diabetes and Digestive and Kidney Diseases; NIH: National Institute of Health; PGIMER: Postgraduate Institute of Medical Education & Research; RCI: Relative Citation Index; SGPIMS: Sanjay Gandhi Postgraduate Institute of Medical Sciences

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The global prevalence of NAFLD is estimated to increase by 21% by 2030, from 83.1 million in 2015 to 100.9 million, while prevalence of fibrotic NASH will increase by 63% from 16.52 million to 27.0 million cases. Importantly, there would be around 178% rise in liver-related mortality in the same time period.<sup>4</sup> Globally, about<sup>3–15</sup> per cent of the obese patients with NASH progress to cirrhosis and about 4–27 per cent of NASH with cirrhosis patients transform to HCC. This indicates that NAFLD will become the leading cause of end-stage liver disease, an indication for liver transplantation.<sup>5</sup> In patients with NAFLD, the annual incidence of HCC is 1.8 cases per 1000 person-years with an overall mortality rate of 5.3 deaths per 1000 person-years.<sup>6</sup>

Recent NAFLD studies, based on hepatic imaging (Ultrasound/Computed Tomography), a quarter of the general population in Asia has NAFLD.<sup>7</sup> In the general population of Indian Subcontinent (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka) shows percentage of 25.2% with high heterogeneity. The prevalence was similar among men and women, and the pooled overall prevalence of NAFLD in the non-obese population was 11.7%, and for obese population, it was 43.4%.<sup>7</sup> The pooled overall prevalence of NAFLD

in patients with metabolic diseases (MetD)—like type 2 diabetes (T2D) [relative risk (RR)-2.03 (1.56–2.63)], dyslipidemia [RR-1.68 (1.51–1.88)], obesity [RR-2.56 (1.86–3.51)], central obesity [RR-2.51 (1.69–3.72)], and metabolic syndrome [RR-2.86 (1.79–4.57)] was much higher at 55.1% with high heterogeneity.<sup>7</sup> Due to an increased prevalence of MetD, in the recent past, it is likely that the incidence of NAFLD would also rise significantly in future, both in the developing and the developed countries.<sup>8</sup>

Epidemiological studies in India show that the prevalence of NAFLD ranges from 9% to 32% of the general population with a higher prevalence in those with overweight or obesity and those with prediabetes and T2D. Although differences in diagnostic techniques for NAFLD may partly account for the wide variations in reported prevalence, a rural–urban divide and geographical variation are evident.<sup>9</sup> A population-based Indian study from West Bengal showed a prevalence rate of 8.7% in predominantly non-obese populations from rural areas.<sup>1</sup> NAFLD has been reported in 40%–80% of people who have T2D and in 30%–90% of people who are obese.<sup>10</sup> Studies also suggest that people with NAFLD have a greater chance of developing cardiovascular disease, which is the most common cause of death in NAFLD.<sup>9</sup>

There are several factors which have contributed to rising obesity, T2D and NAFLD in the Indian population. Interestingly, risk factors may be similar in all Indian Subcontinent countries. Misra *et al.* reported the probable reasons for India's "epidemic" of diet-related non-communicable diseases (DR-NCDs) and transition in nutrition over the past three decades, a decreasing intake of coarse cereals, pulses, fruits, and vegetables and an increasing intake of meat products and salt (coupled with declining levels of physical activity); all these resulted in escalating levels of obesity, atherogenic dyslipidemia, subclinical inflammation, metabolic syndrome, T2D, and coronary heart disease.<sup>11</sup> Economic transition, industrialization, urbanization, and globalization, reduced physical activity, and increased sedentary behavior are also responsible for these conditions.<sup>12</sup> A recent review emphasizes a tendency toward consumption of calorie-dense foods, which may result in micronutrient deficiencies and development of T2D and related MetD.<sup>13</sup> During the COVID-19 pandemic, a deterioration of dietary habits (especially during the lockdown period) had a major impact by worsening NCDs, and hence, it was emphasized to maintain a correct lifestyle during COVID-19 pandemic by doing regular exercise and consuming balanced and nutritious foods.<sup>14</sup> With the increasing prevalence, and research articles regarding NAFLD during the past two decades, it is important to review NAFLD research from Indian Subcontinent countries, particularly India.

By utilizing bibliographical features of the NAFLD publications, the study aimed to study the current publications

trends and research impact, key research areas and their focus using significant keywords, the strength of research collaboration and available funding, leading organizations and authors and their collaborative linkages, the leading channels of communications and characteristics of Highly Cited Papers (HCPs).

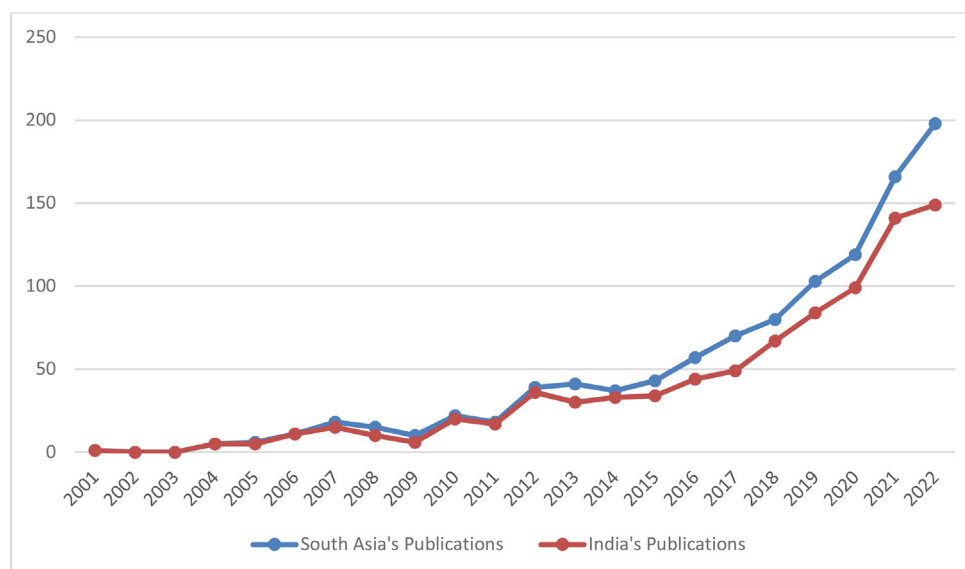
## MATERIAL AND METHODS

Ethics committee approval was not required since it is a study derived from the published literature. From the 30,707 global studies indexed in the Scopus database on NAFLD during 2001–2022, only 1053 were identified involving at least one author from the Indian Subcontinent. We used a comprehensively search strategy in Scopus database for identification of publications from Indian Subcontinent's on this topic. We used keywords related to "non-alcoholic fatty liver" or "non-alcoholic steatohepatitis" in the keyword tag and the keywords "India or Pakistan, Bangladesh or Nepal or Sri Lanka" in affiliation country tag, joined by Boolean operators. The search strategy used in this study is presented below

((AFFILCOUNTRY (India) AND KEY (nonalcoholic AND steatohepatitis)) OR (AFFILCOUNTRY (India) AND KEY (nonalcoholic AND fatty AND liver))) OR (((AFFILCOUNTRY (SRI LANKA) AND KEY (non-alcoholic AND steatohepatitis)) OR (AFFILCOUNTRY (SRI LANKA) AND KEY (non-alcoholic AND fatty AND liver))) OR ((AFFILCOUNTRY (NEPAL) AND KEY (nonalcoholic AND steatohepatitis)) OR (AFFILCOUNTRY (NEPAL) AND KEY (nonalcoholic AND fatty AND liver))) OR ((AFFILCOUNTRY (BANGLADESH) AND KEY (nonalcoholic AND steatohepatitis)) OR (AFFILCOUNTRY (BANGLADESH) AND KEY (nonalcoholic AND fatty AND liver))) OR ((AFFILCOUNTRY (PAKISTAN) AND KEY (nonalcoholic AND steatohepatitis)) OR (AFFILCOUNTRY (PAKISTAN) AND KEY (nonalcoholic AND fatty AND liver)))) AND (LIMIT-TO (SUBJAREA, "MED") AND (EXCLUDE (PUBYEAR, 2023))).

The search was carried out on October 1, 2022 and was not restricted by document, source, or language types. The data were searched by author #3, and the adjudicator in case of any doubt related to the suitability of the articles by the authors #1,2. Indian Subcontinent's publication output obtained on this topic was subjected to further analysis on organizations, authors, journals, keywords, using additional features provided in Scopus database. The MS-Excel, VOSviewer and Bibliometrix R software packages were used for bibliometric analysis, for evaluating and visualizing the collaborative interactions among most organizations, authors, journals and for studying the co-occurrence of keywords.

All types of documents, including articles, reviews, letters, editorials, notes, short surveys, book chapters, and conference papers, are included in this study.



**Figure 1** The trend of publications from India and other Select Indian Subcontinent countries on non-alcoholic fatty liver disease: 2001–2022. X-axis shows number and Y-axis shows year.

The Indian Subcontinent countries included in this study were India, Pakistan, Bangladesh, Nepal, and Sri Lanka, as other three countries of this region (Afghanistan, Bhutan, and Maldives) have made very small contributions. We have divided the above 5 countries in two groups: “India” and four “Select Indian Subcontinent countries” (Pakistan, Bangladesh, Nepal, and Sri Lanka). Since India’s contribution is much higher than the combined output of other four other Indian Subcontinent countries, we separated it as a single country for comparison with the “Select Indian Subcontinent countries” in this study for analysis and presentation. Any bibliometric study on the Indian Subcontinent generally highlights the core contribution and major players (organizations, authors, journals and keywords) in any field. India being the dominating country in publication output is, therefore, likely to be highlighted. In this study, we shall highlight the contribution of both the groups together and independently in overall Indian Subcontinent output.

## RESULTS

### Publications From Indian Subcontinent

The publications output on NAFLD from Indian subcontinent consisted of 1053 papers, of which India contributed 856 papers (81.3%) and “Select Indian Subcontinent” 219 (18.7%) papers. There has been a progressive increase in the number of publications from the Indian Subcontinent (Figure 1). The Indian Subcontinent’s (i) annual contribution increased from 1 in 2001 to 192 papers in 2022, registering the 28.95% annual

average growth rate and (ii) cumulative contribution increased from 145 during 2001–12 to 908 papers during 2013–22, registering 526.21% absolute growth (Supplement 1). Within Indian Subcontinent, (i) India’s contribution increased from 5 in 2004 to 192 papers in 2022, registering annual growth rate of 18.28% and (ii) “Select Indian Subcontinent” countries contribution increased from 3 in 2007 to 48 papers in 2022, registering average growth of 51.62%. Within the “Select Indian Subcontinent” countries output (219 papers), Pakistan contributed 142 papers, followed by Sri Lanka (43 papers), Bangladesh (36 papers), and Nepal (15 papers).

The publications share from the Indian Subcontinent in relation to global output increased from 2.42% during 2001–2012 to 3.74% during 2013–2022, thus achieving 13<sup>th</sup> global rank during 2001–22. The 1053 papers on NAFLD from the Indian Subcontinent received 24,695 citations, averaging 23.458 citations per paper (CPP, Table 1). Among Indian Subcontinent, India’s and “Select Indian Subcontinent” (856 and 219) papers received 22,465 and 4947 citations, respectively, averaging 26.44 and 22.55 CPP.

External funding support was received for 15.76% (166) publications from global funding agencies and these together received 8060 citations averaging 48.55 CPP. Among Indian Subcontinent, share of nationally funded publications from India and “Select Indian Subcontinent” were 16.70% (143) and 15.52% (34) and they registered 40.50 CPP and 62.79 CPP, respectively. The largest funding support (along with their output) in Indian Subcontinent’s output came from Indian Council of Medical Research (22 papers), followed by National Institute of

Health (NIH), USA (16 papers), Department of biotechnology (DBT), India (16 papers), National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK), USA (14 papers), Council for Scientific & Industrial Research (CSIR), India and Science & Engineering Board, India (10 papers each), Department of Science & Technology (DST), India and Gilead Sciences (9 papers each), National Health & Medical Research Council and Pfizer (7 papers each), etc.

Of the 1053 papers on NAFLD, 24.59% (259) were written with international collaboration registering 14,509 citations, and averaging 56.02 CPP. The share of international collaborative papers (ICPs) of India and Select Indian Subcontinent countries were 23.83% (204) and 36.53% (80) and these ICPs registered 64.63 CPP and 50.91 CPP, respectively.

The largest international participation (52.12% share) in the Indian Subcontinent's output came from the USA, followed by U.K. (19.69% share), Japan (19.31% share), and China (17.37% share). Among 259 ICPs from the Indian Subcontinent, the share of bilateral and multilateral collaborative papers was 54.05% (140) and 45.95% (119), respectively. Among 1053 papers, the majority of 63.82% appeared as research articles, followed by 20.99% as reviews. The major focus of papers on NAFLD was on adults, middle-aged, and aged (87.56%). The majority of papers were clinical studies (43.49%), followed by paper based on pathophysiology (10.92%) and epidemiology (9.88%).

Controlled studies accounted for the largest share ( $n = 348$  and 33.05%) of papers, followed by cross-sectional studies ( $n = 120$  and 10.40%), follow-up studies ( $n = 111$  and 10.54%), prospective studies ( $n = 99$  and 9.40%), retrospective studies ( $n = 77$  and 7.31%), cohort studies or analysis ( $n = 66$  and 6.27%), observational studies ( $n = 57$  and 5.41%), comparative studies ( $n = 55$  and 5.22%), procedures ( $n = 48$  and 4.56%), case-control studies ( $n = 46$  and 4.37%),

case reports ( $n = 42$  and 3.99%), randomized control trials (RCTs) ( $n = 27$  and 2.56%), and other clinical trials ( $n = 26$  and 2.47%).

Among the non-invasive imaging techniques used, nuclear magnetic resonance was used in 59 papers (11.21%), followed by transient elastography ( $n = 53$  and 10.07%), computer-assisted tomography ( $n = 49$  and 9.31%), ultrasonography ( $n = 27$  and 5.13%), magnetic resonance imaging ( $n = 7$  and 1.33%), and proton magnetic resonance ( $n = 5$  and 0.95%), etc.

### Most Productive and Most Impactful Research Organizations

In all 544 organizations participated in Indian Subcontinent's NAFLD research, 423 organizations contributed 1–5 papers each, 91 organizations 6–10 papers each, 27 organizations 11–50 papers each, 2 organizations 51–100 papers each, and 1 organization 112 papers. The top 50 organizations contributed 5 to 112 papers each and together contributed 798 papers and 29,402 citations, accounting for 75.78% and more than 100.0% share in Indian Subcontinent's total publications and citations.

On further analysis, it was observed that:

- (A) 14 organizations contributed more than group average productivity (15.96) of all 50 organizations, with Postgraduate Institute of Medical Education & Research (PGIMER), Chandigarh (10.64%), All India Institute of Medical Sciences (AIIMS), ND and Institute of Liver & Biliary Diseases (IL&BS), ND (7.03% each) being at the top (Table 2).
- (B) 18 organizations registered CPP and relative citation index (RCI) more than their group average (36.84 and 1.58): University of Delhi (156.5 and 6.69), G.B. Pant Hospital, Delhi (118.29 and 5.06), and Indraprastha Apollo Hospital, New Delhi (87.2 and 3.73) were the leading institutions (Table 2).

**Table 1** Statistics on Total Papers, Total Citations and Citations Per Paper From Indian Subcontinent.

Region/Selected key word based on countries	Publications/Citations	2001–2012	2013–2022	2001–2022
India	Total papers	126	730	856
	Total citations	5426	17,039	22,465
	Citations per paper	43.06	23.34	26.44
Select Indian Subcontinent <sup>a</sup>	Total papers	20	199	219
	Total citations	1192	3755	4947
	Citations per paper	59.60	18.87	22.59
Indian Subcontinent <sup>b</sup>	Total papers	145	908	1053
	Total citations	5784	18,911	24,695
	Citations per paper	39.89	20.83	23.45

<sup>a</sup>Select Indian Subcontinent includes four countries, namely Pakistan, Bangladesh, Nepal, and Sri Lanka.

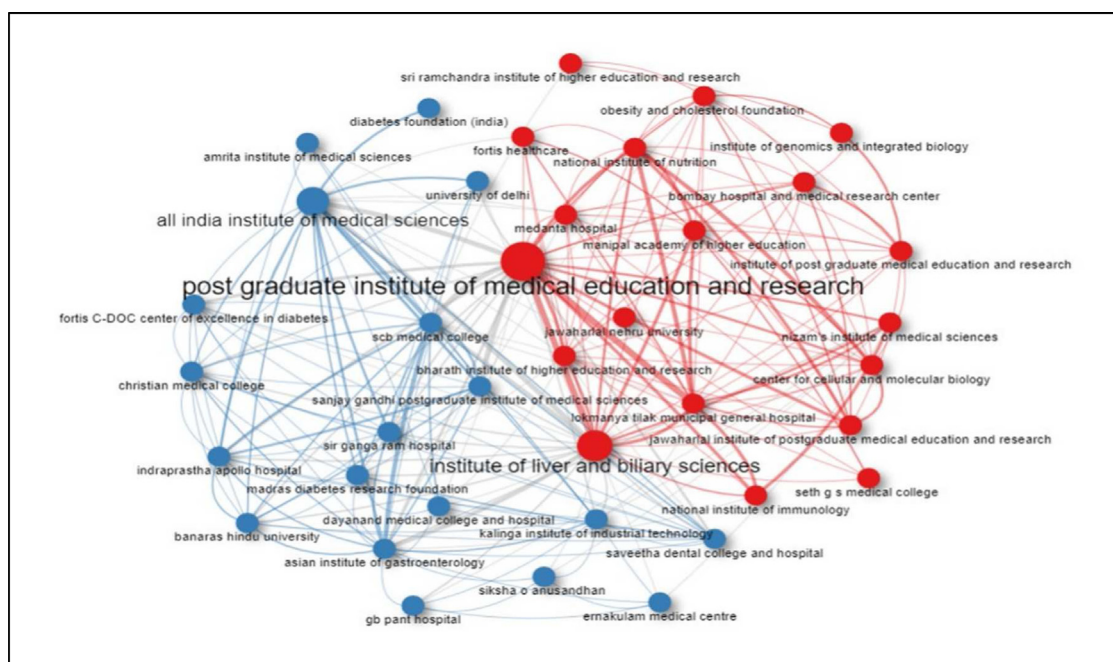
<sup>b</sup>Indian Subcontinent includes five countries, namely India, Pakistan, Bangladesh, Nepal, and Sri Lanka.



**Table 2 Bibliometric Profile of Top 10 Most Productive and 10 Most Impactful Organizations From India and Select Indian Subcontinent Countries.**

10 Most productive organizations											
India						Select Indian Subcontinent					
S.No	Name	TP	TC	CPP	RCI	S.No	Name	TP	TC	CPP	RCI
1	Postgraduate Institute of Medical Education & Research, Chandigarh	112	5206	46.48	1.78	1	University of Kelaniya, Sri Lanka	27	794	29.41	1.30
2	All India Institute of Medical Sciences, New Delhi	74	1510	20.41	0.78	2	Bangabandhu Sheikh Mujib Medical University, Bangladesh	19	633	33.32	1.48
3	Institute of Liver and Biliary Sciences, New Delhi	74	4111	55.55	2.12	3	The Aga Khan University Hospital, Pakistan	19	236	12.42	0.55
4	Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow	35	1469	41.97	1.60	4	Dow University of Health Sciences, Pakistan	16	131	8.19	0.36
5	Medanta - The Medicity, Gurugram	27	1021	37.81	1.45	5	The Aga Khan University, Pakistan	15	1291	86.07	3.82
6	Sir Ganga Ram Hospital, Delhi	24	662	27.58	1.05	6	Ziauddin Medical University, Pakistan	8	356	44.50	1.97
7	Asian Institute of Gastroenterology, Hyderabad	23	747	32.48	1.24	7	University of Colombo, Sri Lanka	8	258	32.25	1.43
8	Institute of Post-Graduate Medical Education, Kolkata	20	1004	50.20	1.92	8	Khyber Medical College, Pakistan	5	6	1.20	0.05
9	Srirama Chandra Bhanja Medical College and Hospital, Cuttack	17	306	18.00	0.69	9	King Edward Medical College, Lahore, Pakistan	5	12	2.40	0.11
10	Kalinga Institute of Industrial Technology, Bhubaneswar	16	388	24.25	0.93	10	National University of Medical Sciences, Pakistan	5	52	10.40	0.46
10 Most Impactful Organizations											
1	University of Delhi, Delhi	6	939	156.5	6.67	1	Foundation Nepal Sitapaila Height, Nepal	2	329	164.50	7.29
2	Gobind Ballabh Pant Hospital, Delhi	14	1656	118.29	4.52	2	University of Punjab, Pakistan	3	389	129.67	5.75
3	Indraprastha Apollo Hospital, New Delhi	10	872	87.20	3.33	3	Sir Salimullah Medical College, Bangladesh	3	300	100.00	4.43
4	Medanta Institute of Digestive & Hepatobiliary Sciences, Gurugram	8	492	61.50	2.35	4	The Aga Khan University, Pakistan	15	1291	86.07	3.82
5	Institute of Liver and Biliary Sciences, New Delhi	74	4111	55.55	2.12	5	Ziauddin Medical University, Pakistan	8	356	44.50	1.97
6	Siksha O Anusandhan, Bhubaneshwar	7	361	51.57	1.97	6	National University of Sciences and Technology, Pakistan	3	120	40.00	1.77
7	Institute of Post Graduate Medical Education and Research, Kolkata	20	1004	50.20	1.92	7	Bangabandhu Sheikh Mujib Medical University, Bangladesh	19	633	33.32	1.48
8	Bombay Hospital & Medical Research Center, Mumbai	10	467	46.70	1.79	8	University of Columbo, Sri Lanka	8	258	32.25	1.43
9	Postgraduate Institute of Medical Education & Research, Chandigarh	112	5206	46.48	1.78	9	University of Kelaniya, Sri Lanka	27	794	29.41	1.30
10	Sanjay Gandhi Postgraduate Institute of Medical Sciences, Lucknow	35	1469	41.97	1.60	10	University of Veterinary & Animal Science, Lahore	4	95	23.75	1.05

CPP= Citations Per Paper, RCI=Relative Citation Index, TC = Total Citations, TP = Total Papers.



**Figure 2** Network collaborative linkages map of top 50 organizations with research publications in NAFLD in India. NAFLD, non-alcoholic fatty liver disease.

Among 544 Indian Subcontinent organizations, 442 and 277 participated in the publication output from India and Select Indian Subcontinent. The top 30 organizations individually contributed 7–112 and 2–27 papers and together contributed 610 papers (71.26% share) and 23,333 Citations (more than 100% share) and 197 papers (89.95% share) and 5302 citations (more than 100% share) in overall output of India and Select Indian Subcontinent.

The total link strength (TLS) or collaborative linkages of top 50 organizations individually varied from 1 to 105, with the best three collaborative linkages were of AIIMS-ND (105), followed by PGIMER-Chandigarh (104), and ILBS-ND (84), etc. The one-to-one collaborative linkages among top 50 organizations varied from 1 to 9. The largest number of collaborative linkages depicted by the following institutional pairs is listed in Supplement 2.

Figure 2 presents the collaborative network map of top 50 institutions organizations with 5 or more publications. The 50 organizations were observed to be distributed in 2 clusters shown in two different colors; Cluster 1 (Red and 23 institutions) includes PGIMER, Chandigarh, IL&BS, ND, and Institute of Post Graduate Medical Education & Research (IPGMER), Cluster 2 (Blue and 27 organizations) includes the AIIMS, ND, Amrita Institute of Medical Sciences, Kochi Asian Institute of Gastroenterology, Hyderabad, Banaras Hindu University, Bharath Institute of Higher Education & Research, Center for Cellular & Molecular Biology, Hyderabad Christian Medical College (CMC), Vellore etc.

### Topmost Productive and Most Impactful Authors

In all 1180 authors who were included in Indian Subcontinent's NAFLD research of top 50 organisations, 13 authors contributed more than group average productivity (14.68). The bibliometric profile of top 10 most productive and impactful authors from Indian Subcontinent is presented in Table 3.

The TLS or collaborative linkages of top 50 authors varied from 1 to 190, with the largest collaborative linkages (190) depicted by A.K. Duseja, followed by R.K. Dhiman (176 linkages), and Y.K. Chawla (103 linkages), etc. The author-to-author collaborative linkages, however, varied from 1 to 36, with the largest collaborative linkages (36) depicted by author pair A.K. Duseja–Y.K. Chawla (36 linkages), followed by A.K. Duseja–R.K. Dhiman (32 linkages), A. Duseja–A. Das (20 linkages), etc. From the above, it was observed that the largest collaborative linkages were depicted among authors from the same institute (12 authors from PGIMER-Chandigarh, 8 authors from ILBS-ND, 6 authors from AIIMS-ND, 5 authors from Medanta, 3 authors from Sir Ganga Ram Hospital, 2 authors from Asian Institute of Gastroenterology, etc.) and also across authors from most collaborative organizations.

A network collaborative linkages map of top 50 authors is presented in Figure 3, which depicts their distribution in closed related nine clusters, labeled with various colors, and the same cluster of authors was considered to be similar in

**Table 3 Bibliometric Profile of Top 10 Most Productive and 10 Most Impactful Authors in India and Select South Asian Countries.**

Top 10 Most Productive Authors													
India							Select Indian Subcontinent						
S.No	Name	Affiliation	TP	TC	CPP	RCI	S.No	Name	Affiliation	TP	TC	CPP	RCI
Top 10 Most Productive Authors							Top 10 Most Productive Authors						
1	A. K. Duseja	Postgraduate Institute of Medical Education & Research, Chandigarh	74	2752	37.19	1.41	1	M.S.Niriella	Univ.of Kelaniya, Sri Lanka	13	415	31.92	1.42
2	R.K. Dhiman	Postgraduate Institute of Medical Education & Research, Chandigarh	38	1319	34.71	1.31	2	A.S.Dassanayake	Univ.of Kelaniya, Sri Lanka	12	265	22.08	0.98
3	Y.K. Chawla	Postgraduate Institute of Medical Education & Research, Chandigarh	38	3552	93.47	3.53	3	A.Alam	Bangabandhu Sheikh Mujib Med. Univ., Bangladesh	11	449	40.82	1.81
4	S.K. Sarin	Institute of Liver and Biliary Sciences, New Delhi	35	4699	134.26	5.08	4	H.J.De Silva	Univ. Kelaniya, Sri Lanka	11	157	14.27	0.63
5	Shalimar	All India Institute of Medical Sciences, New Delhi	25	642	25.68	0.97	5	A.Kasturiratne	Univ.of Kelaniya, Sri Lanka	9	237	26.33	1.17
6	S.P. Singh	Srirama Chandra Bhanja Medical College and Hospital, Cuttack	23	349	15.17	0.57	6	A.P.De Silva	Univ. of Kelaniya, Sri Lanka	8	178	22.25	0.99
7	N.S. Choudhary	Medanta Hospital, Gurugram	22	571	25.95	0.98	7	H.J.De Silva	Univ.of Kelaniya, Sri Lanka	8	217	27.13	1.20
8	A. Das	Postgraduate Institute of Medical Education & Research, Chandigarh	17	622	36.59	1.38	8	Z. Abbas	Ziauddin Med.I Univ., Pakistan	6	352	58.67	2.60
9	S.Taneja	Postgraduate Institute of Medical Education & Research, Chandigarh	16	402	25.13	0.95	9	S.Hamid	The Aga Khan Univ., Pakistan	6	146	24.33	1.08
10	R. Maiwall	Medanta, Gurgaon	15	470	31.33	1.34	10	W.Jafri	The Aga Khan Univ. Hospital, Pakistan	6	2266	377.67	16.75
Top 10 Most Impactful Authors							Top 10 Most Impactful Authors						
1	S.K. Sarin	Institute of Liver and Biliary Sciences, New Delhi	35	4699	134.26	3.64	1	W.Jafri	The Aga Khan University Hospital, Pakistan	6	2266	377.67	16.75
2	Y.K. Chawla	Postgraduate Institute of Medical Education & Research, Chandigarh	38	3552	93.47	3.53	2	M. Al Mahtab	Bangabandhu Sheikh Mujib Medical University, Bangladesh	3	361	120.33	5.34
3	A.Chowdhury	Institute of Post-Graduate Medical Education, Kolkata	14	1017	72.64	2.75	3	S.S.Hamid	The Aga Khan University Hospital, Pakistan	4	357	89.25	3.96
4	P.Sakuja	Gobind Ballabh Pant Hospital, Delhi	12	798	66.50	2.51	4	Z. Abbas	Ziauddin Medical University, Pakistan	6	352	58.67	2.60
5	P.N.Rao	Asian Institute of Gastroenterology, Hyderabad	14	586	41.86	1.58	5	A.Alam	Bangabandhu Sheikh Mujib Medical University, Bangladesh	11	449	40.82	1.81
6	A.Rastogi	Institute of Liver and Biliary Sciences, New Delhi	13	532	40.92	1.55	6	M.S.Niriella	University of Kelaniya, Sri Lanka	13	415	31.92	1.42
7	M.S.Kuchay	Medanta Hospital, Gurugram	12	457	38.08	1.44	7	H.J.De Silva	University of Kelaniya, Sri Lanka	8	217	27.13	1.20

(Continued on next page)

### Top 10 Most Productive Authors

India		Select Indian Subcontinent											
S.No	Name	Affiliation	TP	TC	CPP	RCI	S.No	Name	Affiliation	TP	TC	CPP	RCI
Top 10 Most Productive Authors													
8	A.Arora	Sir Ganga Ram Hospital, Delhi	13	491	37.77	1.43	8	A.Kasturiratne	University of Kelaniya, Sri Lanka	9	237	26.33	1.17
9	A.K. Duseja	Postgraduate Institute of Medical Education & Research, Chandigarh	74	2752	37.19	1.41	9	S. Hamid	The Aga Khan University, Pakistan	6	146	24.33	1.08
10	A. Das	Postgraduate Institute of Medical Education & Research, Chandigarh	17	622	36.59	1.38	10	A.P. De Silva	University of Kelaniya, Sri Lanka	8	178	22.25	0.99

CPP = Citations per paper; RCI = Relative citation index; TC = Total citations; TP = Total papers.

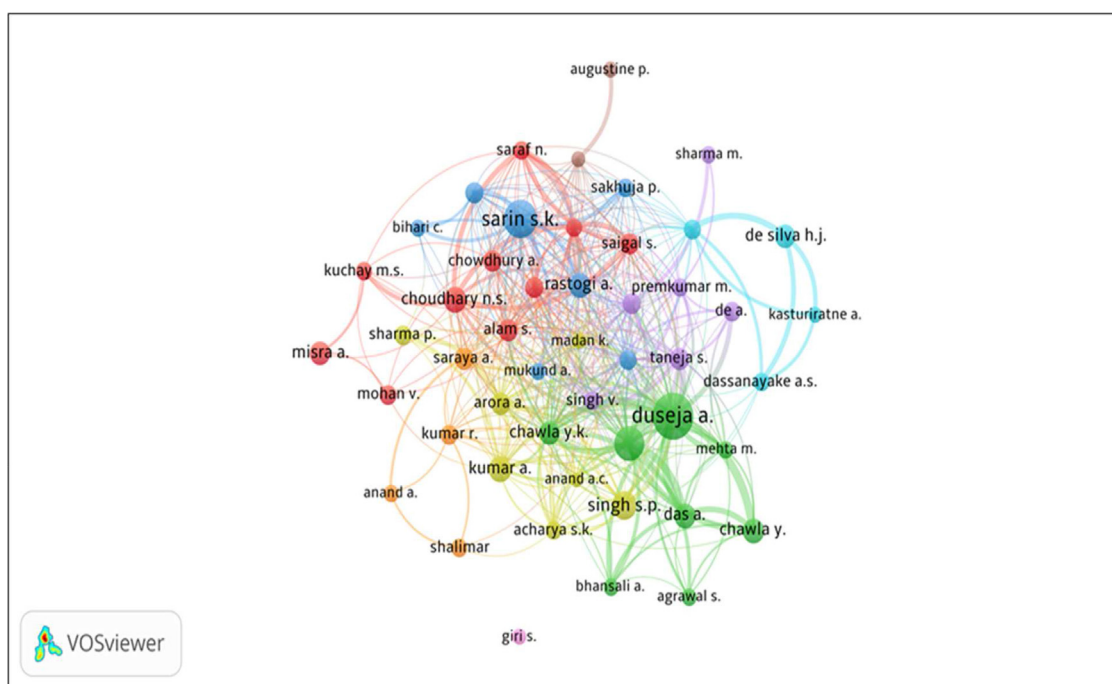
### Significant Keywords

Among 1053 Indian Subcontinent's publications on NAFLD research, 2365 authors' keywords appeared which have frequency of occurrences varying from 1 to 933. From these author keywords, we have identified 50 most significant keywords, with frequency of occurrences ranging from 49 to 933 (Supplement 3). The leading keywords by their frequency of co-occurrence were NAFLD (933), NAFLD (371), obesity (340), liver cirrhosis (289), alanine aminotransferase (279), body mass (248), fatty liver (247), aspartate aminotransferase (238), NASH, (234), diabetes mellitus (217), insulin resistance (199), liver fibrosis (184), triacylglycerol (194), Metabolic Syndrome X (192), etc. (Supplement 3).

## Topmost Productive and Most Impactful Journals

The top 10 most productive journals were (number of papers in parenthesis) *Journal of Clinical & Experimental Hepatology* (105), *Indian Journal of Gastroenterology* (44), *Hepatology* (28), *Diabetes & Metabolic Syndrome. Clinical Research & Review* (India), and *Journal of Gastroenterology & Hepatology (Australia)* (22 each) *Hepatology International* (20), *World Journal of Gastroenterology* (19), *Journal of Hepatology* (18), *Medical Forum Monthly* (18) and *Liver International* (16). The top 10 journals in terms of CPP (given in parenthesis) were: *Journal of Hepatology* (193.33), *Hepatology International* (123.10), *Journal of Gastroenterology & Hepatology (Australia)* (79.68), *Annals of Hepatology* (65.75), *Gastroenterology* (62.50), *Clinical Gastroenterology & Hepatology* (60.85),





**Figure 3** Network collaborative linkages map of top 50 authors with research publications in NAFLD in India. NAFLD, non-alcoholic fatty liver disease.

*Hepatology* (51.96), *Lancet Gastroenterology & Hepatology* (39.13), *Translational Gastroenterology & Hepatology* (32.29) and *Translational Gastroenterology & Hepatology* (28.50).

Of the 1053 papers from Indian Subcontinent, 847 and 219 papers were published in 275 and 112 journals, contributing 440 (51.94% share) and 130 (59.36% share) papers, respectively from India and Select Indian Subcontinent. The top 10 most productive and 10 most impactful journals publishing Indian Subcontinent's research are listed in Supplement 5.

### Highly Cited Papers

Only 38 (3.61%) out of 1053 Indian Subcontinent's papers on NAFLD registered 100 or more citations and are considered here as Highly Cited Papers (HCPs). These together received 11,857 citations, averaging 312.03 CPP. The citation range of these HCPs were 100–185 in 20 papers, 232–388 in 12 papers, 510–834 in 3 papers, and 1083–1271 in 3 papers. These HCPs were published in 22 journals and represented by 111 authors from 51 Indian organizations. Among 38 HCPs, India participated in all 38 papers while Select Indian Subcontinent countries participated in only 5 papers.

The 38 HCPs comprise of 24 articles, 13 reviews, and 1 editorial. Of 38 HCPs, 8 involved the participation of single institution (zero collaborative). The 32 HCPs involved the participation of 2 or more organizations (collaborative), including 4 national collaborations and 26 ICPs.

Among 32 HCPs, the USA contributed the largest number of publications (13), followed by Japan (11), China and

Hong Kong (9 each), Italy (7), Australia, Singapore, South Korea, Spain, Turkey and the U.K. (6 each), Indonesia and Malaysia (5 each), France and Germany (4 each), Egypt and Pakistan (3 each), etc.

Among 38 HCPs, 51 organizations and 111 authors from the Indian Subcontinent participated in 38 HCPs. Among 11 organizations, the largest contribution (6), were made by PGIMER, Chandigarh, followed by ILBS, ND (5), G.B. Pant Hospital, New Delhi and SGPGIMS, Lucknow (4 each), St. John's Medical College, Bangalore and The Aga Khan University Hospital (3 each), AIIMS, New Delhi, Bombay Hospital & Medical Research Center, IPGIMER-Kolkata, Jagjivanram Hospital, Mumbai, Medanta, Gurgaon, Sir Ganga Ram Hospital, University of Kelaniya, Sri Lanka, University of Punjab, Lahore, Pakistan, and Indraprastha Apollo Hospital, New Delhi (2 each), etc.

Among authors, S.K. Sarin contributed the largest number of papers (7) in 38 HCPs, followed by A.K. Duseja and Y.K. Chawla (6 papers each), B. Sharma (3 papers), H. Devarbhavi, P. Sukhuja, S.K. Satapathy, V. Malhotra, R.K. Dhiman, R.A. Sinha, A. Saraya and D.N. Amarapurkar (2 papers each), etc.

The 22 journals participated in 38 HCPs, with the largest number of publications (7) contributed by, *Journal of Gastroenterology & Hepatology* (Australia), followed by *Journal of Hepatology* (4), *Hepatology International* and *Hepatology* (3 each), *Clinical Gastroenterology & Hepatology*, *Metabolism: Clinical & Experimental* and *Gastroenterology* (2 each), and other journals (1 each).

Full citations of the top 10 HCPs have been included in the bibliography,<sup>22–31</sup> in the decreasing order of number of citations received by them, ranging from (1173- Ref. #22, to 295 citations-Ref.<sup>31</sup>). It is interesting to note that only 9 out of 10 of these HCPs were ICPs, and only one was solely from an Indian institute of Kolkata.<sup>30</sup>

### **Regional Cooperation in Indian Subcontinent**

Only 22 (8.49%) of the 259 ICPs from the Indian Subcontinent involved the participation of one or more of the five Indian Subcontinent countries. Among 22 ICPs, India participated in all 22 papers, Pakistan in 18, Bangladesh in 8, and Nepal & Sri Lanka in 6 papers each. Among 22 ICPs, 1 was published in 2010 and 21 were published during 2016–2022.

The 22 ICPs have received 2708 citations, averaging 123.09. Of the 22 ICPs, only 8 were externally funded. Among 22 ICPs, 20 involved multilateral collaboration and 2 bilateral collaborations. The leading foreign countries participating in 20 multilateral ICPs were China and USA (13 papers), Japan, Malaysia, Turkey and Egypt (11 papers), Hong Kong and Indonesia (10 papers each), Australia and Singapore (9 papers each).

The leading Indian Subcontinent organizations along with their collaborative linkages within Indian Subcontinent, participating in these 22 ICPs were PGIMER, Chandigarh (10 papers, 17 linkages), Aga Khan University Hospital (9 papers, 19 linkages), Aga Khan University (8 papers, 16 linkages), Bangabandhu Sheikh Mujib Medical University (5 papers; 18 linkages), IL&BS, ND (5 papers, 13 linkages), SGPGIMS, Lucknow (4 papers, 12 linkages), G.B. Pant Hospital, New Delhi (3 papers, 12 linkages) and AIG, Hyderabad (3 papers, 7 linkages), St John's Medical College, Bangalore (2 papers, 7 linkages), CMC, Vellore (2 papers, 8 linkages), Kalinga Institute of Industrial Technology (KIIT), Bhubaneswar, International Centre for Diarrhoeal Disease Research (ICDDR), Bangladesh, University of Kelaniya (2 papers, 7 linkages), Foundation Nepal, Sitapaila (2 papers, 7 linkages). There is a moderate collaboration among these Indian Subcontinent organizations, with the collaborative linkages varying from 1 to 8.

The leading Indian Subcontinent authors participating in 22 ICPs (along with their collaborating linkages within the Indian Subcontinent) were A.K. Duseja and S.K. Sarin (6 paper each), W. Jafri (6 papers), Y.K. Chawla and S.S. Hamid (4 papers each), M. Al Mahtab and S. Hamid (2 papers), R.K. Dhiman, A.K. Duseja, A. Goel, P. Jain, S. Rahman, S. Alam, and Z. Abbas (2 papers each). There is a moderate collaboration among these Indian Subcontinent organizations, with the collaborative linkages varying from 1 to 8.

The 22 ICPs were published in 16 journals, with 4 papers in Hepatology International, 2 papers each in Clinical Gastroenterology & Hepatology and Lancet Gastroenterology & Hepatology, and 1 paper each in 13 other journals.

## **DISCUSSION**

A few bibliometric studies are available on various aspects of NAFLD and related sub-fields mainly at global level. Among the specific studies on this topic, Zhang *et al.* (15) examined the global publications trends and the research hotspots of NAFLD using Web of Science (WOS) database during 1986–2013. This publication covered 6356 articles, which were published in 994 different journals covering 93 Science Citation Index (SCI) subject categories. Bibliometric results suggest that the obvious rapid growth of the articles in recent years appears to be associated with the 'epidemic' of NAFLD and its cofactors such as metabolic syndrome. Among the research hotspots of NAFLD, insulin resistance, a common factor in the metabolic syndrome, might play a major role in the pathogenesis research of NAFLD. Trifan *et al.*<sup>16</sup> presented a bibliometric analysis of global literature (6632 articles from 1355 journals) on NASH during 1980–2018 using the Scopus database. The study focused on literature growth and identified the key countries, authors and journals involved in research in this area. Zhang *et al.*<sup>17</sup> identified and examined the top 100 cited articles in NAFLD covered in SCI during 1965–2015, with a citation ranging of 227–2151 times since publication. These authors evaluated their bibliometric parameters including times cited, publication year, journals, subject categories, and the highly related concepts of NAFLD. Further, these authors studied the distribution of leading countries and institutes as well as the research hotspots of NAFLD. Feng *et al.*<sup>18</sup> examined 1685 global publications on the status and trends of research on transient elastography in NAFLD, a technique widely used during 1997–2021, using WOS database. These authors studied the research performance of countries, institutions, and authors and identified significant keywords and their co-occurrences using mapping software.

Among the related studies, Gupta *et al.*<sup>19</sup> analyzed Indian publication on liver disorder research during 2003–2012 using Scopus database on several parameters, including contribution and citation impact of the most productive countries, India's overall contribution, its growth pattern, citation impact, the share of international collaboration, identification of the significant participating countries in India's international collaboration, contribution and impact of different types of liver disorders, productivity and impact of leading Indian institutions and authors, and pattern of communication of Indian output in most productive journals. Hao *et al.*<sup>20</sup> examined global literature (5257 articles) on liver disease caused by alcohol during 2009–2019 networks of co-cited references representing the literature of liver disease caused by alcohol are constructed and visualized. Structure and temporal dynamics are identified in terms of the most active topical areas and cited references. Using bibliographic coupling analysis and clustering analysis, the authors identified

major and young research clusters in the field. Dai *et al.*<sup>21</sup> examined the publications on liver fibrosis for the last 20 years till April 16, 2022. The study covered 15,237 records, involving 72,686 authors from 200 institutions in 134 countries. The study identified research trends and delineated research hotspots, using bibliometric methods and mapped co-author links using knowledge mapping software.

Despite a reported high pooled incidence of NAFLD of 25.2%,<sup>9</sup> the publications on this topic from the Indian Subcontinent comprise only 3.43% of the global publications, during 2001–2022, and accounts for 13<sup>th</sup> global ranking. We found that only 15.76% of the publications from the Indian Subcontinent were externally funded and 24.59% were involved in international collaboration. It is crucial to note that the publications that received external funding and those which participated in internal collaboration received much higher CPP than the average (48.55 *vs.* 23.45, and 56.02 *vs.* 24.49 respectively). The funding support to India's research came from both national (Indian Council of Medical Research, Department of Science and Technology, Government of India, Council of Scientific and Industrial Research and University Grant Commission) agencies, foreign agencies mainly from USA (NIDDKD and NIH) and multinational drug firms (Gilead Sciences and Pfizer). Among Indian Subcontinent's ICP, USA made the largest contribution (52.12% share), followed by U.K, Japan, China and Australia (with contribution varying from 16.61% to 19.69%). Among the Indian Subcontinent's ICPs, the share of bilateral and multilateral collaborative papers was 54.05% and 45.95%, respectively.

From the 2365 author's keywords appearing in 1053 Indian Subcontinent's publications, 50 significant keywords were selected which represent important concepts in their field and their co-occurrence occurrences throw some light on current areas of research. However, when co-occurrence analysis of these 50 keywords was carried out, they were found to be clustered in four cluster groups (having 11–5 keywords), represented by different colors. The keyword clusters represent new advances in this field over the past decade and help scholars to figure out the hot spots more effectively which is used to explain the distribution of keywords according to their contents. This bibliometric study found that the majority of Indian Subcontinent's 1053 papers (81.3%) were contributed by Indian organizations, with PGIMER-Chandigarh being the leader (112 papers), followed by AIIMS-ND and IL&BS-ND (74 papers each). However, the most impactful organizations in terms of CPP and RCI were from University of Delhi, G.B. Pant Hospital, Delhi, and Indraprastha Apollo Hospital, Delhi. The most productive authors from the Indian Subcontinent were AK Duseja (70 papers), RK Dhiman (38 papers) and SK Sarin (35 papers), and the most impactful authors were YK Chawla, SK Sarin, and A Chowdhury.

The most productive journals to publish Indian Subcontinent's papers were *Journal of Clinical & Experimental Hepatology* (99 papers), *Indian Journal of Gastroenterology* (37 papers), and *Hepatology* (28 papers). However, the most impactful journals in terms of CPP were *Journal of Hepatology* (201.2), *Hepatology International* (150.73), *Journal of Gastroenterology & Hepatology Australia* (80.11). Only 38 (3.61%) of Indian Subcontinent's publications registered 100 or more citations, and these together received 11,857 citations, averaging 312.03 CPP.

The Indian Subcontinent's organizations were involved in a comparatively higher level of collaboration across most productive institutions. Similarly, very high collaborative linkages were observed within authors from the same institute and moderate collaborative linkages were observed among authors across Indian Subcontinent organizations. The regional collaboration among the Indian Subcontinent is extremely weak, although they faced similar problems. There is an urgent need to increase regional collaboration and cooperation between researchers and policy makers in addressing the common issues facing Indian Subcontinent countries and to enhance the quality of research and publications related to NAFLD.

Since the incidence of NAFLD is increasing at an alarming rate in Indian Subcontinent and a more focused approach (like preventive health check-up) is required in these resource-constraint countries, so that early and necessary measures can be undertaken to minimize the NAFLD related morbidity and mortality in the community.<sup>32</sup> Our study points out that so far there has been much less research done on NAFLD from the Indian Subcontinent and therefore it needs to be strengthened.

There is a need to make Indian Subcontinent's research more focused and it is important to identify national priorities *vis-a-vis* global priorities in NAFLD research, with the major support should come from national funding agencies. Since a very small percentage (3.61%) of Indian Subcontinent's publication output registered 100 or more citations, there it is important to increase research output and improve the research quality of publications. We believe that the recommendations from the research from high income countries (HIC) may not entirely applicable or suitable to the patients of low middle-income countries like from Indian Subcontinent, similar to other NCDs like T2D.<sup>33,34</sup> Hence, it is mandatory that significantly more resource allocation and encouragement is required from the Funding agencies, Governments, and Institutions to enhance the research and publications from the Indian Subcontinent, and their findings and recommendations can then be applied effectively to the patients from these countries.

There are a few limitations in the present study. First, only one Scopus database was searched for analysis. Other databases such as WOS, Dimension, PubMed, and so on could have been used to make this search comprehensive.



But, the use of multiple databases involves a lot of problems in standardizing the data as most have their own formats and extent of information covered. Since most bibliometric studies involve one database, as a result, we restricted the present study to one database. Although the bibliometric indicators provide valuable information, these may be taken out of context and applied without a full knowledge about the bibliometric research, on which they are based.<sup>35</sup>

Overall, despite a high prevalence of NAFLD in Indian Subcontinent, the research output on this medical problem is low, with 3.43% global share. The regional cooperation and research collaboration between the Indian Subcontinent countries is also poor. India has led the list of publications with 81.3% contributions. Further, HCPs from Indian Subcontinent are low (3.61%). More regional and international collaboration and external funding is required to enhance the number and quality of research and publication.

## CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

RV: Conceptualization, Literature search, Manuscript writing and editing, Final check & Approval.

BMG: Conceptualization, Literature search, Manuscript writing and editing, Final check & Approval.

MK: Literature search, Manuscript writing and editing, Final check & Approval.

AM: Conceptualization, Literature search, Manuscript writing and editing, Final check & Approval.

SK: Literature search, Manuscript writing and editing, Final check & Approval.

AV: Literature search, Manuscript writing and editing, Final check & Approval.

## CONFLICTS OF INTEREST

The authors have none to declare.

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## SUPPLEMENTARY DATA

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jceh.2023.08.007>.