Characteristics of Malaysian highly cited papers

A. Noorhidawati[1], M.K. Yanti Idaya Aspura[1], M.N. Zahila[2] and A. Abrizah[1,3]
[1]Department of Library and Information Science,
Faculty of Computer Science and Information Technology,
University of Malaya, Kuala Lumpur, MALAYSIA
[2] Library, International Islamic University of Malaysia,
Kuala Lumpur, MALAYSIA
[3]Malaysian Citation Centre,
Ministry of Higher Education, Putrajaya, MALAYSIA
e-mail: noorhidawati@um.edu.my (corresponding author); yanti@um.edu.my;
zahila@iium.edu.my; abrizah@um.edu.my

ABSTRACT

Highly cited papers serve as a proxy for excellence. In this paper, we identify Malaysia's highly-cited papers and explore the characteristics of these papers. The research question posed is "What characterizes Malaysian highly cited papers?" This study adopts the definition by Thomson Reuters Essential Science Indicator, i.e. the highly cited papers are papers that received enough citations to be placed in the top 1 percent of the academic field of each 22 subject areas based on a highly cited threshold for the field and publication year. As a small scientific nation, Malaysia has a rather limited number of papers being highly cited, and we observed nine characteristics of highly cited papers based on 708 datasets obtained from the Web of Science. Malaysian highly cited papers are largely represented by articles, but reviews have higher impact. Typically, these papers have a low self-cited index and they are published in the First Quartile of the science discipline publications. The papers are mainly the outcome of national funded research; involve multiple co-authorship and international collaboration; affiliated to Malaysian research universities and Malaysian authors often play a dominant role as first or reprint authors. Partnership with scientists from Iran, Australia and UK may increase markedly the possibility of a Malaysian paper becoming highly cited. This investigation has shown that these are the characteristics of Malaysian highly cited papers, but to what extent can these be used as indicators need further investigation and discussions among the scientific community.

Keywords: Highly cited papers; Citation analysis; Bibliometrics; Research evaluation; Research quality.

INTRODUCTION

The importance of scientific excellence has been widely documented in the existing scientometrics literature (Aksnes 2003; Aksnes and Sivertsen 2004; Fu et al. 2011; Miyairi and Chang 2012), but no standardized method of evaluating research influence has been universally accepted. It is generally agreed that scholars' influence on research can be measured by a common indicator, i.e. the number of citations they have (Aksnes 2003). However, when aggregated citation indicators are used to assess the scientific performance of a nation, the underlying citation distributions are seldom analysed (Aksnes and Sivertsen 2004. Citations are the references researchers append to their papers to explicitly show earlier works on which they have relied on to conduct their own investigations. As described in Eugene Garfield's reasons for citing a paper, the citations in scientific papers create a record of influence (Garfield 1955). Tracking citations and understanding their trends in

context is a key to evaluating the impact of research. Not only can the influence of an individual research paper be traced through its citations in other papers, but the influence of a body of research in a specific domain can be determined. Ultimately, the scientific impact of a paper depends on the number of papers citing it, the scientific impact of the citing papers, and the role it plays in the citing papers (Fang 2015).

The more science policy focuses on research influence, the more researchers and institutions are confronted with evaluations based on citations. Using highly cited papers as indicators in research assessment has been an emerging interest since June 2014, when Thomson Reuters published a list of 3,215 highly cited researchers (available at http://highlycited.com/), based on the number of the top 1 percent most highly cited papers per author in the years 2002-2012. The percentile ranks were normalized using the 22 broad categories for journals in the Essential Science Indicator (ESI) as reference sets. Bornmann et al. (2013) indicated that the list has been appropriately used to identify excellent papers, because it indicates the ranks of papers in their categories as defined in ESI or the Web of Science (WoS).

Studies characterizing highly cited papers have become quite widespread in many disciplines and the need is arising as countries, funding agencies and universities are trying to gauge research performance and identify top researchers and research impact. To understand these characteristics, the common approach used is the bibliometric method. Most-cited papers with a significant influence, especially in medicine and health sciences, have been investigated in bibliometric literature (Baltussen and Kindler 2004; Paladugu et al. 2002; Ponce and Lozano 2010; Shadgan et al. 2010). Several studies on highly cited papers at the macro level (detailed in Table 1) highlight the general characteristics of these papers. These studies are based on the data in WoS and selected using the definition of highly cited set by ESI.

Aksnes's (2003) study of 297 Norway's highly cited papers identified typical characteristics such as they are authored by a large number of scientists and involve extensive international collaboration as quality dynamics. Similar studies conducted in China (Fu et al. 2011), Taiwan (Miyairi and Chang 2012) and Russia (Pislyakov and Shukshina 2014) substantiate the widely accepted view that international collaboration is almost a requirement for publishing highly cited papers. About 47 percent of all China ESI papers have collaboration with the group of eight (G8) highly industrialized nations, especially the United States (Fu et al. 2011). Taiwan's international collaboration in its production of highly cited papers remain relatively stable with USA with the highest number of collaboration, followed by China, Japan and Germany. However, Taiwan has increasingly collaborated with European countries whose output of highly cited papers is relatively high and increasing, rather than with its neighbouring countries in Asia (Miyairi and Chang 2012). Partnership with USA, German, UK, and French scientists increases markedly the probability of a Russian paper becoming highly cited. It is notable that although more than 90 percent of Russian highly cited papers involve international collaboration, Russian institutions often do not play a dominant role. (Pislyakov and Shukshina 2014). This shows that international and large number of co-authorship typically increases visibility of papers and proves to be profitable in terms of citations (Pislyakov and Shukshina 2014). Additionally, Chen, Arsenault, and Larivière (2015) reported the top 1 percent most cited papers exhibit higher levels of interdisciplinarity, implying that interdisciplinary research plays an important role in creating major scientific discoveries and generating high impact knowledge.

Table 1: General Characteristic of Highly Cited Paper at the Macro Level

No	Author	Country	General Characteristics
1	Aksnes (2003)	Norway	i. Highly cited papers are typically authored by a large number of scientist ii. Highly cited papers do typically involve international collaboration iii. Highly cited papers are mainly present in high impact journal iv. Review articles are over-represented among highly cited papers v. Highly cited papers are mainly cited by foreign scientist vi. The self-citations is very low for highly cited papers
2.	Pislyakov and Shukshina (2014)	Russia	i. Highly cited papers mainly involved international collaboration ii. Highly cited papers often have co-author(s) from at least one foreign institution iii. Highly cited papers resulted from bilateral collaboration iv. Highly cited papers distribution was dominated by science field (physics)
3.	Fu et. al (2014)	China	i. Highly cited papers were international collaboration ii. Highly cited papers were published by many authors iii. First and co-responding authors of highly cited papers includes international authors iv. Sciences (chemistry and physics) were the most productive fields in the highly cited papers
4.	Miyairi and Chang (2016)	Taiwan	i. Highly cited papers involve international collaboration ii. Highly cited papers distribution has strong domination in science fields (engineering, clinical medicine, physics)

Highly cited papers from the periphery world have received little attention in the literature. Malaysia's research excellence from the perspective of highly cited papers which represents "useful indicators for identifying world-class research" (Tijssen, Van Leeuwen and Visser 2002) is timely. Prior studies are restricted to Malaysia's overall scientific performance (Prathap and Ratnavelu 2015); performance in specific fields such as computer science (Bakri and Willett 2011), engineering (Tahira, Alias and Aryati 2015), medicine (Sanni et al. 2013) and health sciences (Zainal and Zainab 2011); performance of Malaysian journals (Abrizah et al. 2013); performance of Malaysian research reflected in Malaysia's WoS-indexed papers (Abrizah and Wee 2011; Ale Ebrahim et al. 2015), and Malaysia's international collaboration (Davarpanah 2009; Glänzel, Schubert and Czerwon 1999; Kumar and Jan 2013; Yu et al. 2013) or between Malaysia and particular countries (Alatas 2000; Arunachalam and Garg 1986; Kumar and Jan 2014; Nguyen and Pham 2001). In the case of Malaysia, acknowledging highly cited papers to denote research excellence is particularly appropriate, as it gives even more correct and interpretable results than the analysis of the entire national output. Malaysia's progress can be seen in the outstanding increase of scientific publications output between 2006 and 2016 and the production of papers that honour the 14 Malaysian researchers as the most influential in their respective fields, designated by Clarivate Analytics as highly cited papers (King 2016). However, it is not clear what one is measuring using highly cited papers

and how this measure relates to world-class research. How different are highly cited papers from ordinary cited papers? It has been shown that highly cited papers are the results of international collaboration and multi-authorship (Aksnes 2003; Fu et al. 2011; Glänzel and Schubert 1995; Miyairi and Chang 2012; Persson 2010; Pislyakov and Shukshina 2014; Tijssen, Van Leeuwen and Visser 2002). Do these characteristics holfd true for Malaysian highly cited papers? To what extent do Malaysian authors dominate or are dominated in such a collaborative and multi-authorship works? Therefore, the objective of this investigation is to identify the characteristics of Malaysian highly cited papers. The research question posed is "What characterizes Malaysian highly cited papers?" It should be noted that the objective and research question of the study are exploratory and descriptive in nature. Identification of these characteristics may play a key role in determining highly cited Malaysian papers.

MATERIALS AND METHOD

The bibliometric studies reviewed earlier (Table 1) have shown a uniform pattern for highly cited papers. Although the term highly cited paper may be defined in a number of ways (Aksnes 2003; Aksnes and Sivertsen 2004; Garfield 1955) this study adopts the definition given by ESI, i.e. the highly cited papers are papers that received enough citations to be placed in the top 1 percent of the academic field of each 22 subject areas based on a highly cited threshold for the field and publication year. This is justifiable since the data were collected from WoS Core Collection database. "Malaysia" was used as a keyword for address search and the search was refined using highly cited papers indicated in ESI. Highly cited articles dated from 2006 – 2016 were identified. A 10-year interval was determined because this is the cumulative time period used for ESI to calculate the highly cited papers. This study has included all 22 subject areas from three types of scientific papers, namely article, review and proceeding, and excluded the rest of the paper type. As a result, 708 papers comprising 443 articles, 258 reviews and 7 proceedings, along with the total citation count of 70660, was automatically extracted from WoS into a CSV file. These data were analysed to descriptively report and characterize the Malaysian highly cited papers. Table 2 presents the number of papers and citations based on the year of publication, thus indicating the growth in the number of highly cited papers since 2006.

Table 2: Malaysian Highly Cited Papers and the Citation Impact based on the Year of Publication

Year of Publication	No of Paper	Percentage of Paper	No of Citation
2006	12	1.7	3312
2007	17	2.4	4701
2008	27	3.8	6288
2009	42	5.9	8655
2010	50	7.1	9073
2011	68	9.6	11601
2012	73	10.3	7118
2013	89	12.6	7321
2014	126	17.8	7188
2015	144	20.3	4872
2016	60	8.5	531
Total	**708**	**100.0**	**70660**

RESULTS AND DISCUSSIONS

The following results report and discuss the characteristics of Malaysian highly cited papers in WoS. We have observed 9 characteristics, similar to Aksnes (2003), that influences the direction of this study. The style of analysis is exploratory and findings are presented in themes.

a) Malaysian highly cited papers are more represented by articles, but reviews have more impact

It has been shown that review papers are over-represented among highly cited papers (Aksnes 2003). This characteristic was not found in the current study. Instead Malaysian highly cited papers are mainly represented by articles (62.6 percent). From the 708 papers, 443 are research articles, 258 reviews and 7 proceedings with citations of 38342, 32318, and 845 garnered respectively (Table 3). However, review papers received higher citation impact with an average citation of 125.22 per paper, compared to articles with an average of 86.55 citations per paper.

b) Malaysian highly cited papers are lowly self-cited

Findings indicate that Malaysian highly cited papers are lowly self-cited with the total times cited with self-citations at 610 (0.9 percent), and the total times cited without self-citations at 70895 (99.1 percent). Details are presented in Table 3. Author self-citations account for a relatively large share of all self-citations and studies have shown that poorly cited papers have the highest self-citation share (Aksnes 2003; Davarpanah and Farzaneh 2009). In the case of highly cited papers, the share of self-citation is very low because high citation counts cannot be easily obtained from self-citations and self-citation rates are also taken into consideration as a factor in the journal evaluation process of Web of Science Core Collection citation index (Garfield 1990; Testa 2016).

Table 3: Citation Count of Highly Cited Papers (n=708)

Type of Papers	No of Papers (Percentage)	Times Cited	Times Cited without Self-citations	Average Citations Per Paper
Article	443 (62.6)	38342	37963	86.55
Review	258 (36.4)	32318	32088	125.26
Proceeding	7 (1.0)	845	844	120.71
Total	**708 (100.0)**	**71505**	**70895**	**331.51**

c) Malaysian highly cited papers are mainly published in the First Quartile

Based on the findings, it has been descriptively demonstrated that scientific papers that are most cited tends to be published in high impact journals denoted by their impact factor. Because impact factor is incomparable across different research disciplines, Field-normalized Journal Impact Factor (JIF) has been used (Leydesdorff and Bornmann 2011; Moed 2010), and the JIF Quartile is the commonly used one to evaluate an entity's (e.g., a country's, institution's, research group's or individual's) publications distribution among journals of different fields. To analyse what is the real proportion of Malaysian highly cited papers allocated in the top journals, we identified the JIF Quartile of the 708 papers from the Journal Citation Report (JCR). As can be seen from Table 4, a very high percentage of Malaysian highly cited papers (79 percent) appear in journals that are ranked in the first

quartile. In contrast, a very low percentage (less than 1 percent) appears in the category of journals cited below average (Quartile 4). Our analysis shows that Malaysian highly cited papers are predominantly published in high impact journals. However, other studies have reported that in order to be highly cited, it is not necessary to be published in high impact journals (Aksnes 2003; Martín-Martín et al. 2016; Meho and Yang 2007).

Table 4: Quartile Journal Ranking of Highly Cited Papers

Journal Quartile	No of Papers	Percentage	No of Citations	Citation Percentage
Quartile 1 (Q1)	559	79.0	60070	85.0
Quartile 2 (Q2)	111	15.7	8559	12.1
Quartile 3 (Q3)	26	3.7	1047	1.5
Quartile 4 (Q4)	5	0.7	701	1.0
NA	7	1.0	283	0.4
Total	**708**	**100**	**70660**	**100**

d) Malaysian highly cited papers are from the sciences

The subject of a paper to be cited has been argued to be an important factor in explaining frequent citations. However, knowledge on this issue appears to be limited. We are interested to know to what extent a particular subject field characterizes Malaysian highly cited papers. The 708 highly cited papers were categorized according to 184 WoS categories, which we re-categorized into five broad subjects based on the Malaysian Citation Centre (MCC) (http://www.myjurnal.my/public/about.php) classification (as shown in Table 5). Our analysis shows that Malaysian highly cited papers are predominantly from the Sciences (98.7 percent, 420 papers) and only one percent (9 papers) from the Social Sciences. Engineering & Technology has the highest contribution to Malaysian highly cited papers, followed by Science, and Medical & Health Sciences. Table 6 details the top 20 specific subject categories in which Malaysian research is highly cited. The highest category is Green and Sustainable Science and Technology; Energy and Fuels, with a total of 14.4 percent (102 papers), followed by Medicine, General and Internal, and Engineering, Environmental; Engineering, Civil; Environmental Sciences, with 4.7 percent (33 papers) respectively. This shows that Malaysian highly cited papers do not exhibit a high level of interdisciplinarity, thus implying a low level of interdisciplinary research.

Table 5: Broad Subjects and No of Papers

Subjects	No of Papers	Percentage
Engineering & Technology	368	52.0
Science	216	30.5
Medical & Health Sciences	115	16.2
Social Sciences	9	1.3
Arts & Humanities	0	0.0
Total	**708**	**100.0**

Table 6: Top 20 Subject Category of Highly Cited Papers

No	Specific Subject Category (WOS)	Broad Subject (MCC)	No of Papers	Citation
1	Green and Sustainable Science and Technology; Energy and Fuels	Engineering and Technology	102	8271
2	Medicine, General and Internal	Medical and Health Sciences	33	6769
3	Engineering, Environmental; Engineering, Civil; Environmental Sciences	Engineering and Technology	33	5702
4	Thermodynamics; Energy and Fuels; Mechanics; Physics, Nuclear	Engineering and Technology	29	1117
5	Engineering, Environmental; Engineering, Chemical	Engineering and Technology	28	3412
6	Physics, Particles and Fields	Sciences	21	1013
7	Multidisciplinary Sciences	Sciences	17	1925
8	Thermodynamics; Energy and Fuels	Engineering and Technology	15	1162
9	Chemistry, Physical; Electrochemistry; Energy and Fuels	Sciences	12	1332
10	Genetics and Heredity	Medical and Health Sciences	12	904
11	Energy and Fuels; Engineering, Chemical	Engineering and Technology	12	821
12	Green and Sustainable Science and Technology; Engineering, Environmental; Environmental Sciences	Engineering and Technology	12	511
13	Astronomy and Astrophysics; Physics, Nuclear; Physics, Particles and Fields	Sciences	12	454
14	Chemistry, Applied; Food Science and Technology; Nutrition and Dietetics	Sciences	11	1603
15	Engineering, Chemical; Water Resources	Engineering and Technology	11	1169
16	Food Science and Technology	Medical and Health Sciences	11	585
17	Astronomy and Astrophysics; Physics, Particles and Fields	Sciences	9	421
18	Gastroenterology and Hepatology	Sciences	8	1309
19	Mathematics, Applied	Sciences	7	455
20	Chemistry, Applied; Chemistry, Organic; Polymer Science	Sciences	6	932

e) Malaysian highly cited papers are outcomes of national funded research

Funding has been viewed in the literature as one of the determinants of research activities. Funding agencies do not only focus on how the money is spent, but also on the impact of new and important discoveries in improving life. The research community suggests that a highly cited paper is an outcome of funded research (Patsopoulos 2006; Paul-Hus, Desrochers and Costas 2016).

Information about funding was obtained from the acknowledgement section of each paper. From Table 6 we can conclude that most of the highly cited papers are outcomes of funded research with a total of 435 papers (61.4 percent), of which 35 percent (248 papers) acknowledged more than one funder and 26.4 percent (187 papers) indicated a single funder. About 38.6 percent (273 papers) did not acknowledge any specific grant

from any funding agency. Table 7 also shows that the majority of the highly cited papers are in fact outcomes of national funded research (62.1 percent). A total of 164 papers acknowledged both the Ministry of Higher Education (MOHE) Malaysia and University of Malaya (UM) as the funding agencies, and these papers are mainly in Engineering & Technology, with a total citation of 3277, of which 89 papers are outcome of the High Impact Research (HIR) grant funded by MOHE and UM.

Table 7: Research Funder Acknowledged in Highly Cited Papers (n=708)

Funders	No of Papers	Percentage	Citations
Single funder	187	26.4	16787
More than one funder	248	35.0	21044
No funding information	273	38.6	32829
Total	**708**	**100**	**70660**
National funder only	270	62.1	20753
International funder only	117	26.9	13286
Collaborative funding	48	11.0	3792
Total	**435**	**100.0**	**37831**

* Collaborative funding includes international and local funders

f) Malaysian highly cited papers are typically authored by many

Previous studies have shown that highly cited papers are characterized by an extensive element of co-authorship and co-authored papers serve as a measure of collaborative efforts (Fu et al. 2011; Aksnes 2003; Pislyakov and Shukshina 2014). Malaysian 708 highly cited papers are authored by 7638 authors, indicating an average of 10.8 authors per paper, of which 15.8 percent (1204) are Malaysian-based authors and 83.7 percent (6434) are international authors.

Table 8: Authorship Pattern for Malaysian Highly Cited Papers

Authorship Pattern	No of Papers (Percent)	Malaysian as Reprint Authors (Percent)	Malaysian as First Authors (Percent)
Single author	17 (2.4)	17 (3.9)	17 (3.8)
Two author	88 (12.4)	80 (18.2)	79 (17.5)
Three author	132 (18.6)	114 (25.9)	113 (25.0)
Four author	116 (16.4)	98 (22.3)	104 (23.0)
Five author	75 (10.6)	53 (12.0)	56 (12.4)
Six author	47 (6.6)	33 (7.5)	35 (7.7)
Seven author	36 (5.1)	27 (6.1)	26 (5.8)
Eight author	12 (1.7)	6 (1.4)	6 (1.3)
Nine author	10 (1.4)	7 (1.6)	8 (1.8)
Ten author	9 (1.3)	4 (0.9)	5 (1.1)
Multiple authorship*	121 (17.1)	1 (0.2)	3 (0.7)
Mega authorship**	45 (6.4)	0 (0.0)	0 (0.0)
Total	**708 (100.0)**	**440 (100.0)**	**452 (100.0)**

* 11 to 999 authors
** more than 1000 authors

We observe that Malaysian highly cited papers are typically a result of co-authored work (691, 97.6 percent), and only 17 papers (2.4 percent) are single-authored. Three-authored papers were the dominant authorship pattern (132, 18.6 percent), followed by more than ten-authored paper (121, 17.1 percent) and four-authored paper (116, 16.4 percent). It is interesting to note that mega authorship is evident in 45 papers (6.4 percent), and to be exact, the authorship count of all 45 papers is more than 2000-authored paper, largely from the sciences discipline. Table 5 presents these findings. This clearly indicates that papers with many authors will benefit from a particular mechanism that may increase the citation count. Aksnes (2003) contributes it to potential self-citers and enhanced dissemination through personal communication. However, this might not be so in the context of Malaysian highly cited papers as our earlier findings show low self-citations.

g) Malaysian highly cited papers have a good number of Malaysian as reprint authors and first authors

Our finding on the collaborative and multi-authored characteristic of Malaysian highly cited papers raised the following sub-research questions: Do Malaysian authors play a major contribution role in Malaysian highly cited paper? The increasing tendency across scientific disciplines to write multi-authored papers makes the sequence of contributors' names important in terms of reflecting the actual contribution and in a posteriori research assessments (Tscharntke et al. 2007). In multi-authored papers, the first author is clearly assigned to the individual making the most contribution to the paper (Bales et al. 2014; Sahu and Panda 2014). The reprint (or corresponding author) in practice, takes the ownership for compliance, pre and post-publication with all journal policies and would be the final decision maker on behalf of all authors for any actions that need to be taken. In the context of Malaysian scholarly publishing, reprint author is now used to indicate seniority and leadership of the research work, and it has been used as an indicator in research assessment. Malaysian highly cited papers have a good number of Malaysian (or Malaysian-based) authors as the first author (452, 63.8 percent) and reprint author (440, 62.1 percent) (Table 8). As Malaysian (or Malaysian based) authors were either first or reprint authors to at least 60 percent of the highly cited papers, it is safe to conclude that Malaysian authors, to a large extent, are major contributors to highly cited papers.

h) Malaysian highly cited papers are mainly affiliated to Malaysian research universities

At the institutional level, the highly cited papers are affiliated to a total of 1492 institutions, with 7.2 percent (108) Malaysian institutions, and 92.8 percent (1384) international-based institutions. This clearly verifies findings from other studies (Fu et al. 2011; Miyairi and Chang 2012; Persson 2010; Pislyakov and Shukshina 2014) that highly cited papers are characterized by an extensive element of international co-authorship. Generally, we find that Malaysian highly cited papers affiliated to Malaysian institutions are from research universities (68.5 percent), followed by research institutes (11.7 percent), private universities (10.9 percent) and other public universities (9.0 percent) (Table 6). The number of citations garnered by research universities is much higher compared to other Malaysian-affiliated institutions. From the total of 708 highly cited papers, about 45.7 percent (268) were affiliated to University of Malaya, followed by 19.9 percent (117) to Universiti Sains Malaysia and 12.6 percent (74) to Universiti Putra Malaysia. The collaboration is mainly with research institutes.

Table 9: Malaysian Affiliated Institutions and Citation

Institution	No of Papers	Percent	No of Citation
Research Universities	587	68.5	54558
Research Institutes	100	11.7	14662
Private Universities	93	10.9	7196
Other Public Universities	77	9.0	7960

i) Malaysian highly cited papers are more internationally collaborative

Our finding on the international co-authorship characteristic of Malaysian highly cited paper raised the following sub-research questions: How do Malaysian highly cited papers characterize in terms of international collaborations? To what extent do Malaysian authors dominate or are dominated in such a collaborative work? What are the key partner countries and their influence on the possibility of a Malaysian paper becoming highly cited? Our analysis shows that the proportion of internationally collaborative papers (co-authored by two or more countries) is 60.6 percent (429). Whereas, the proportion of national inter-institutionally collaborative papers is 6.5 percent (46). A total of 233 papers (32.9 percent) are non-collaborative works.

When a high percentage of the paper involves international collaboration, the notion of Malaysian highly cited papers may become rather problematic. The problem arises in the form of academic authorship responsibility. Aksnes (2003) who studied Norwegian highly cited papers pointed out that "delimitation by countries may be difficult to justify unless corrections are being made for international co-authorship" (p.162). Therefore, to further analyse this, we confine our analysis to those highly cited papers of which Malaysia authors play a major contribution, either as first or reprint authors. We found 66.3 percent (470) of the papers were dominated by Malaysian authors identified as either the first or reprint author. Of this, 40.0 percent (188) are papers with international collaborations and 60.0 percent (282) are national inter-institutional collaborations. Table 10 shows the international collaboration of highly cited papers, with 72.3 percent (136) as result results from a single country collaboration. The largest number of collaborative countries in a single paper is eight.

Table 10: International Collaboration in Malaysian Highly Cited Papers of which Malaysian Authors are First or Single Authors

No of Collaborative Countries	No of Papers	Percentage	Citation
One	136	72.3	9920
Two	30	16.0	2601
Three	16	8.5	974
Four	5	2.7	416
Eight	1	0.5	33
Total	**188**	**100.0**	**13944**

There are 47 collaborative countries reported from the 188 papers. Table 11 shows the top 20 key country partners that may influence a Malaysian paper to be highly cited. The highest collaboration is with Iran (10.7 percent, 29), followed by Australia (9.2 percent, 25), and UK (7.4 percent, 20). Finding also indicate that Asian countries (Iran, India, Indonesia, Saudi Arabia, Pakistan, Japan, Singapore, South Korea, Turkey, Egypt, Iraq and Bangladesh) as the most collaborative, with an overall total of 146 (53.7 percent) papers. This indicates that Malaysian authors have the tendency to collaborate with their Asian counterparts unlike studies by Fu et al. (2011) and Miyairi and Chang (2012) that reported internationally collaborative highly cited papers from China, Taiwan and Russia were mostly from collaboration with major industrialized countries. It is interesting to note that Malaysia has only two highly cited collaborative papers with China, and one each with Russia and France.

Table 11: International Collaborative Countries

No	International Collaborative Countries	No of Paper (Percentage)	Citation
1	Iran	29 (10.7)	1578
2	Australia	25 (9.2)	2777
3	UK	20 (7.4)	1943
4	India	19 (7.0)	858
5	Indonesia	18 (6.6)	1650
6	USA	17 (6.3)	1267
7	Saudi Arabia	15 (5.5)	729
8	Pakistan	14 (5.1)	836
9	Japan	10 (3.7)	623
10	Canada	9 (3.3)	1033
11	Singapore	9 (3.3)	362
12	South Korea	9 (3.3)	809
13	Turkey	7 (2.6)	279
14	Egypt	6 (2.2)	648
15	Iraq	6 (2.2)	143
16	Netherlands	5 (1.8)	125
17	Nigeria	4 (1.5)	125
18	Bangladesh	4 (1.5)	120
19	Sweden	4 (1.5)	403
20	Germany	3 (1.1)	810

CONCLUSION

This study has systematically identified and characterized Malaysian highly cited papers. The findings reveal the following nine characteristics of Malaysian highly cited papers: (a) represented highly by articles, but reviews have more impact; (b) lowly self-cited; (c) mainly published in the first quartile; (d) from the sciences; (e) outcomes of national funded research; (f) typically authored by many; (g) largely Malaysian as reprint authors and first authors; (h) mainly affiliated to Malaysian research universities; and (i) more internationally

collaborative. This paper has shown that these are characteristics of highly cited papers, but to what extent can these characteristics be used as indicators need further investigation. These characteristics are in line with other studies of highly cited papers (Aksnes 2003; Chen, Arsenault and Larivière 2015; Fu et al. 2011; Miyairi and Chang 2012; Persson 2010; Pislyakov and Shukshina 2014; Tijssen et al. 2002). In addition, our study highlights new findings that highly cited papers are more represented by articles rather than reviews papers, affiliated to research-intensive universities and outcomes of national funded research. Moreover, home-grown researchers dominated as either first or reprint authors in internationally collaborative Malaysian highly cited papers.

We were exposed to some limitations in this paper. As a small scientific nation, Malaysia has a rather limited production of papers being highly cited, and we identified nine characteristics of highly cited papers based on a small pool of dataset. The characteristics may change if the sample of the highly cited papers changed continuously. However, it is notable that the 708 papers represent the highest cited in their respective subject fields in Malaysia from 2006 to 2016. It is concluded that it is important to identify the highly cited and to characterize the overall citation landscape for Malaysia. The results of our study provide various benefits for researchers and practitioners in Malaysia. The results may help early career researchers to strategize their publication practices to collaborate with international researchers for quality dynamics, and publish in high impact journals for visibility dynamics. Using Malaysia's highly cited papers will encourage reinforcing the list of 'characteristics' of highly cited papers found in various literatures from other studies. In the context of Malaysia or national citation indicators, an analysis of the underlying data from this finding for national indicators may be useful in creating awareness towards the existence of articles with great influence on what is characteristically considered an indicator of national performance especially for Malaysian Research Assessment (MyRA)tools. It is hoped that this paper will encourage further discussions among the scientific and national citation indicators community towards further analysis and formal characterization of highly cited papers.

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