Bibliometric study on Dutch university medical centers 2004-2015/2016

Research report to the Deans of Medical Sciences (DMW) in the Netherlands

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Contents

Executive summary

In this report we describe the landscape of Dutch academic medical research1, by studying the output of the eight Dutch University medical centers (UMCs). With increased welfare comes the wish for an increasing well-being. The eight UMCs play an important role in Dutch society, as they produce important new knowledge in the fight against major diseases, such as cancer, cardiovascular diseases and various neurological diseases. By studying the scientific publications as produced by the UMCs, a bibliometric analysis on the impact of these publications in their field produces insights into the successfulness of the eight UMCs in a worldwide context.

It is often said that all Dutch science is at a plateau, with some extra-ordinary peaks. Dutch academic medical research creates such a plateau, with some of the UMCs and their specializations standing out in that landscape. In this study we analyze the output of the eight UMCs with advanced bibliometric techniques. While output and impact measures show that the Dutch UMCs perform very strongly as compared to international standards, the research profiles show the break-down into specializations within the fields in medical science. As stated above, some of the major fields are visible in the profiles of all Dutch UMCs (cardiovascular, oncology, and neurosciences), while below these major fields, each UMC displays a certain degree of specialization. Remarkable is that in the fields shown in the profiles, in most cases the scientific impact is high to very high, corroborating the overall, high impact of Dutch UMCs.

The Dutch UMCs are publishing in journals with a strong position in the research fields to which these journals belong. This is shown in the profiles displaying the fields, using the journal impact indicator to illustrate the position of the Dutch UMCs. Their success is also very clear in the analyses showing journal impact levels from another perspective. The impact of the Dutch UMCs when publishing in general medicine journals such the New England Journal of Medicine, the JAMA and the Lancet is sky-high and stands out among their publications.

In an ever increasing global network of science, the Dutch UMCs are very well internationally connected. While international cooperation is covering an increasing share of the output of the UMCs, with high impact scores, the UMCs are publishing a substantial part of their output as single institute. Even though this part of their output is independent of any cooperating party, the impact level remains substantial, indicative of the scientific power of the individual houses. The analysis that displays academic leadership, focusing on primary authorships is a further underlining of the strong position of the eight Dutch UMCs in the global network of biomedical research.

[1] Medical research (medical science) comprises (bio)medical-, medical-, clinical-, health- and health organization research (science).

1. Introduction

In this report, we describe a bibliometric study conducted on the research performed within the Dutch university medical centers. The study consists of two separate parts, of which the first part is presented in this report. The current part of the study is based on a comparison on the output in journals covered by Clarivate Analytics in their Web of Science (WoS), on the overall level of UMCs in the Netherlands. The second part of the study consists of a lower-level analysis of the organizational structure within each UMC. The findings from that part of the study will be reported confidentially to each UMC separately.

The present report relates to the publication output of the university medical centers at Dutch universities. The UMCs supplied publication lists to CWTS, which were matched with the CWTS in-house bibliometric data-system. The bibliometric analysis is covering the period 2004-2015/2016 for all eight UMCs. This study is an update of the study conducted in 2016, for the update CWTS was supplied with the year 2015 as an additional year to the data collected for the previous studies.

We considered only papers classified in the WoS as normal articles and reviews, published in source serials processed for the WoS database. Other document types, such as letters, meeting abstracts, 'editorials', 'editorial material', corrections, comments, and book reviews were not included. Also, papers in non-WoS source journals are not counted. A few journals are only partially processed for the WoS. Here, only papers processed for the WoS were included.

The changes made in the report in comparison to last year's study relate to:

1) aligning the study with the SEP protocol periodization, that is take a six year period as starting point, as the six year cycle is central in the SEP protocol (for an explanation of the functioning of the SEP, please visit the VSNU website http://www.vsnu.nl/files/documenten/Domeinen/Onderzoek/SEP2015-2021.pdf).
2) a change in the way normalization in calculating impact measures is implemented. As we discovered that journal category based normalization did not work as well as we expected it to do, CWTS developed a system that is based upon a more granular composition of science, ending up in some 4.000 micro clusters. For a more in-depth explanation of the functioning of MNCS, see Appendix C (pages 52-54).
3) ***Letters*** are excluded as document type in this bibliometric study, due to the heterogeneous character of the document type, leading to the question how to deal with those publications best.

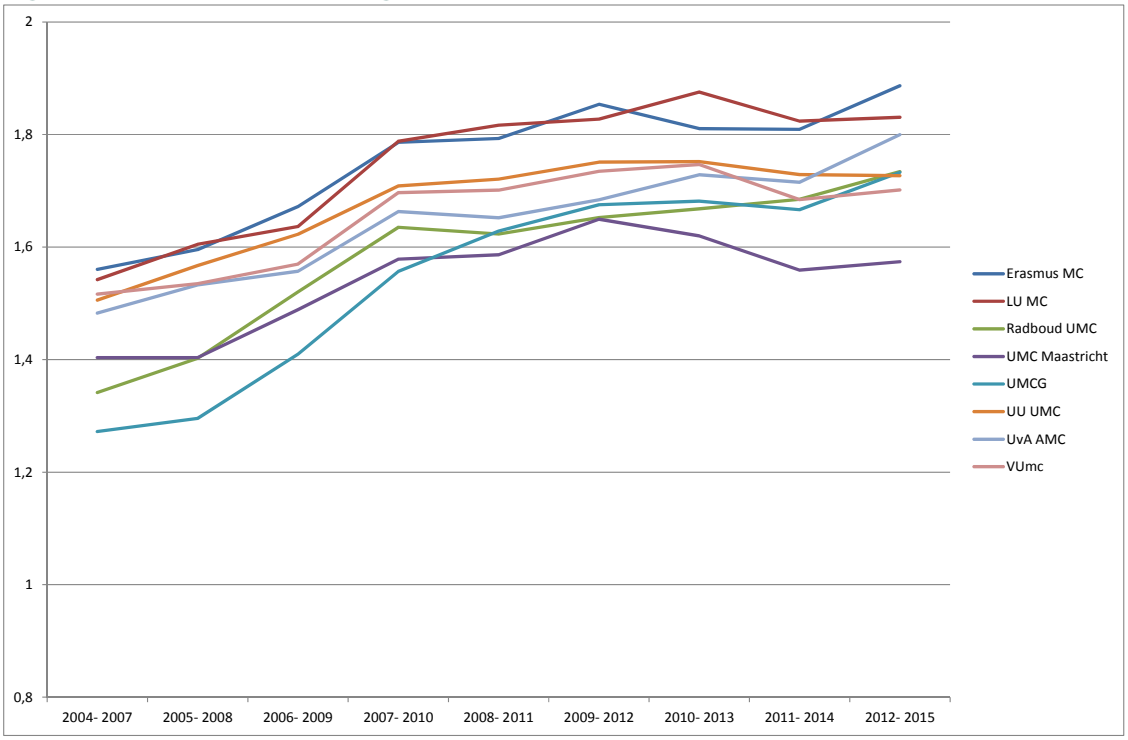
2. Results

2.1 The average impact of Dutch UMCs (MNCS)

In **Figure 1,** the overall bibliometric impact scores (based on MNCS values)for the eight UMCs in the Netherlands are shown for the periods 2004-2015/2016. For the underlying bibliometric data underlying the analysis, we refer to Appendix A (pages 39-44).

For a full explanation on the methodological aspects of bibliometric analysis, and in particular citation impact measurement, we refer to Appendix C, paragraph 2, pages 52-54.

Figure 1: Trend in the average impact of Dutch UMCs (MNCS), 2004-2015/2016

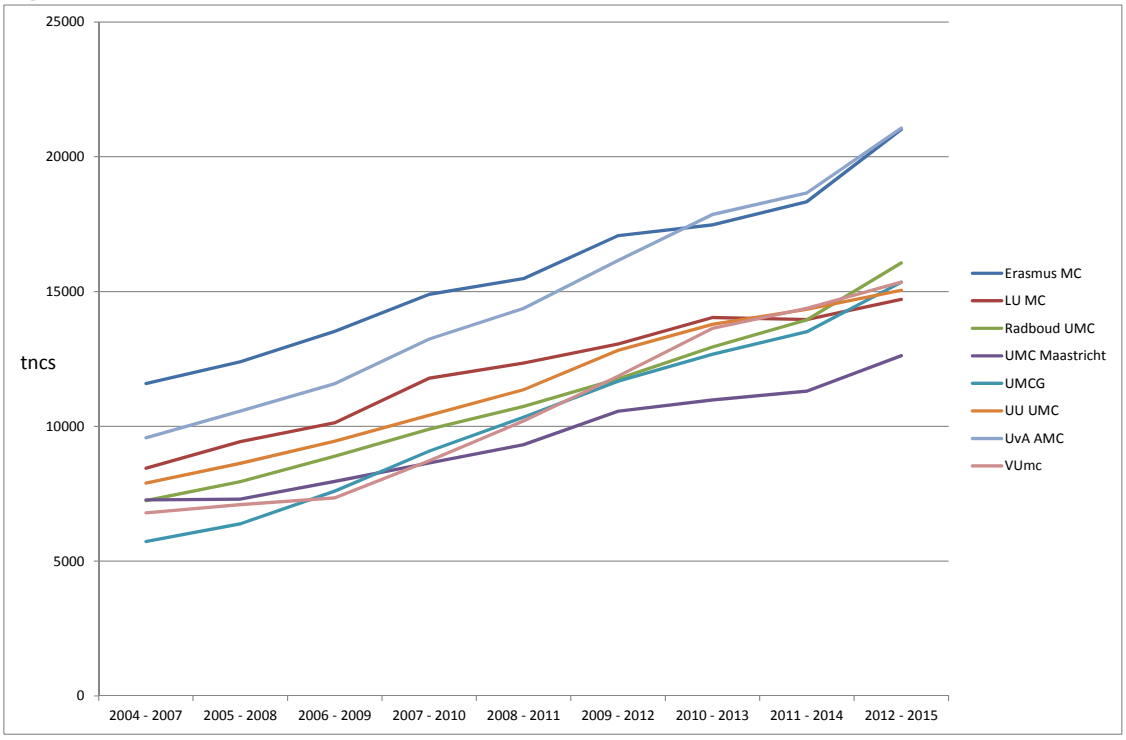


2.2 The Brute force indicator for Dutch UMCs (P * MNCS values)

In this section, the focus is on what is called the 'brute force' of a research organization, analog to the ranking of universities (see http://www.LeidenRanking.com the rankings of universities). 'Brute force' is the product of the total number of publications in a period (***P***, multiplied by the field-normalized impact score ***MNCS***. The advantage of this indicator is found in the combination of two indicators that normally describe two different aspects or dimensions of scientific performance.

Figure 2 contains the trend in Brute Force scores for the eight Dutch UMCs.

*Figure 2: Trend in the Brute Force of Dutch UMCS (P*MNCS), 2004-2015/2016*



2.3 Research profiles (using MNCS to display overall impact)

In the research profiles for the eight UMCs, displayed in **Figures 3 to 10** describing the period 2010-2015/2016, the output per UMC is displayed to the 1% level of the output (UMCs were invited to list up to five additional fields in the profile that are below the 1% threshold). Per UMC, the total share displayed in the profile with respect to the total output is indicated. We have produced the profiles for the last six year period 2010-2015/2016. This six year period is also shown in the tables (see Appendix A, pages 39-44), and is now also introduced in the profiles, as it shows the most recent situation of the performance per UMC.

While reading and using the profiles, it is important to keep in mind that these profiles display information of the output and impact per UMC across fields, particularly focused on the comparison between UMCs. These profiles **do not** provide information on the

level of organizational units within every single UMC, as there exists in this analysis no organic link between the units producing papers, and the fields these papers belong to. For that particular information, every UMC has its own internal analysis. So the output and impact in for example *Immunology* can be compared between UMCs, but does not allow any kind of conclusion of the level of units involved in immunological research within every UMC.
In general, around 80% of the output of the UMCs is displayed in the research profiles.

In **Figure 11**, the research profile for the period 2010-2015/2016 for the combined output of UMCs is displayed.
Please note that for the overall UMC profile, no additional fields were selected and/or displayed.

Figure 3: Percentage of publications and normalized impact per field
Erasmus MC (2010-2015/2016)

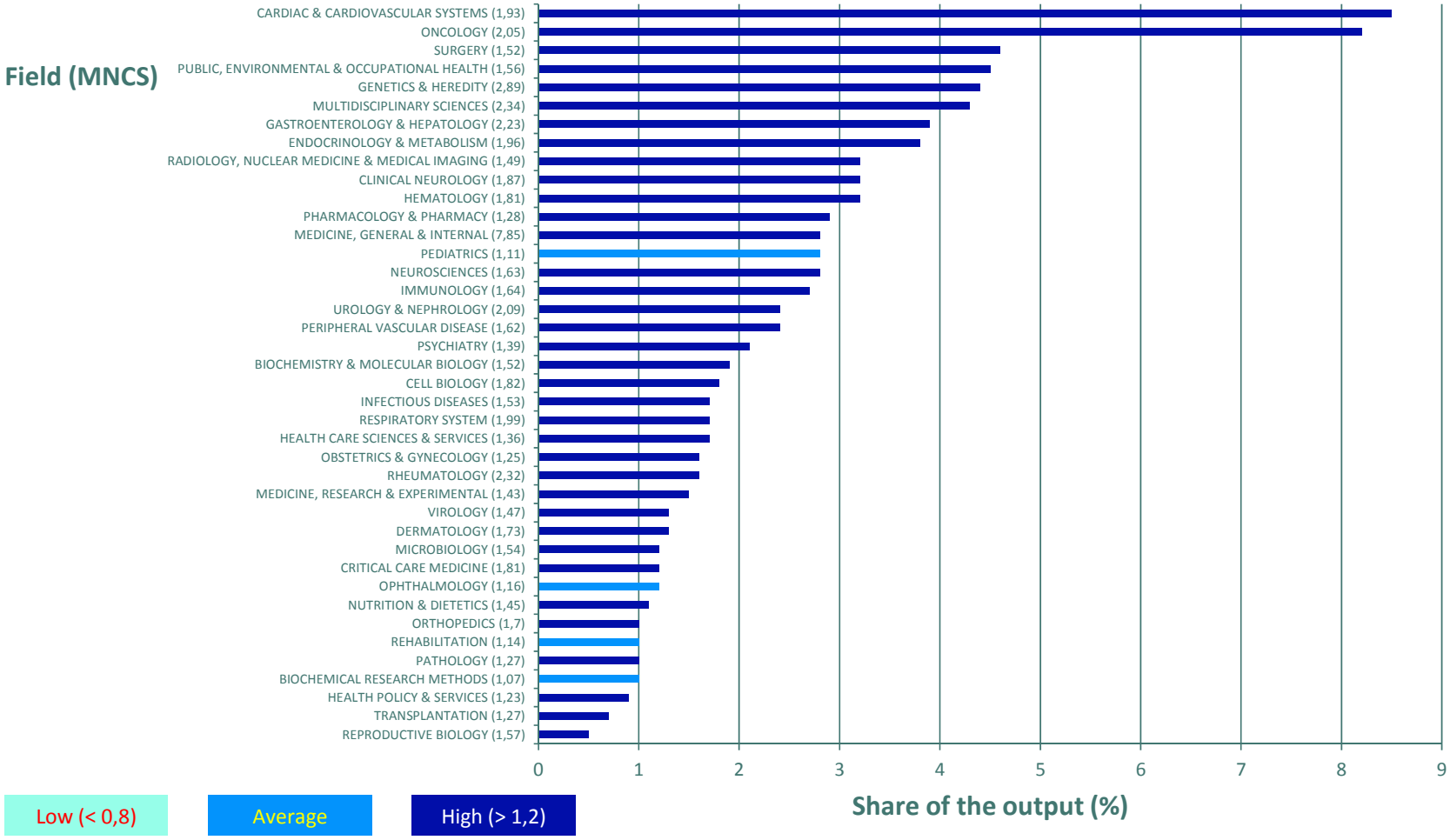


Figure 4: Percentage of publications and normalized impact per field
LU MC (2010-2015/2016)

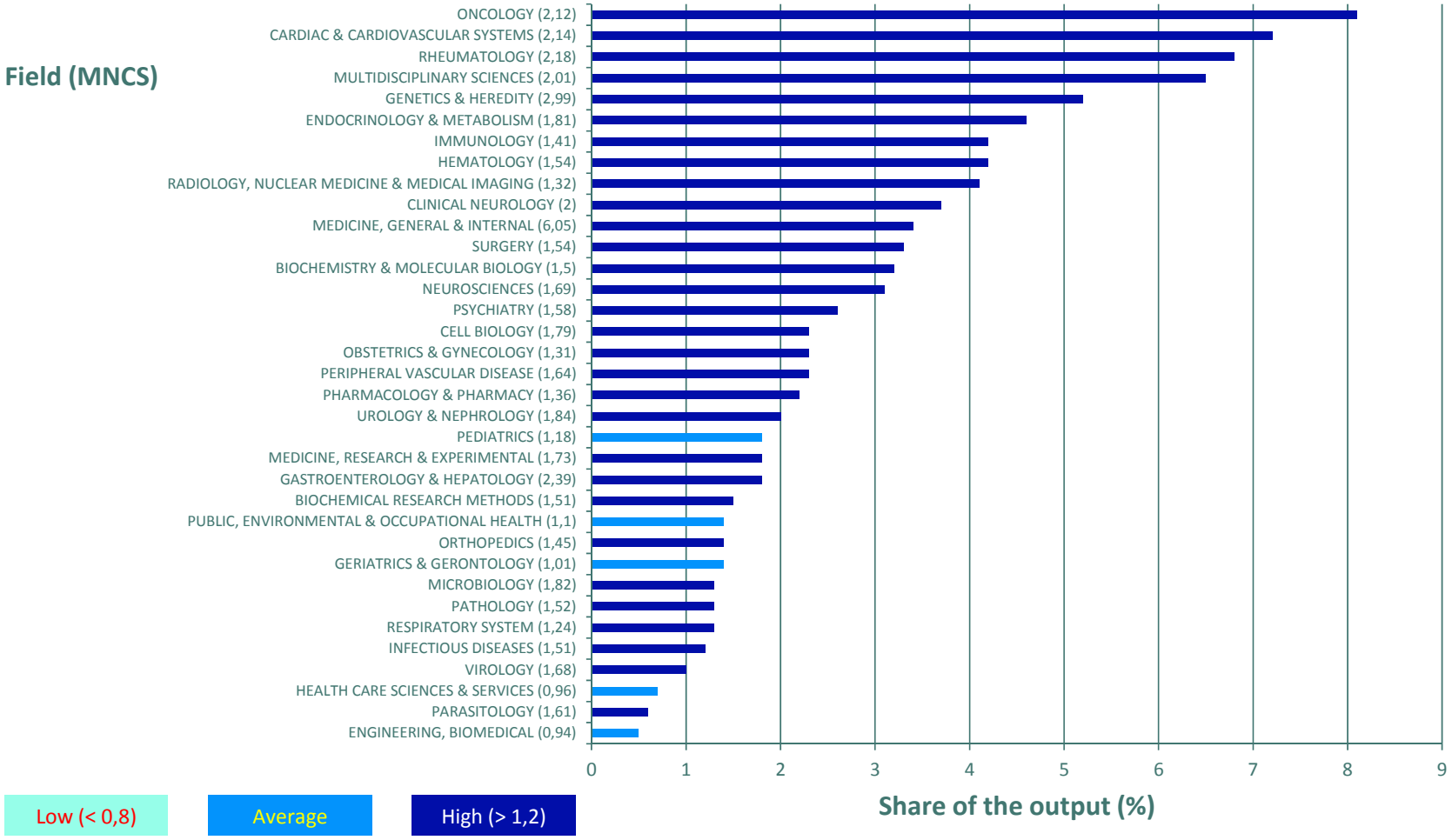


Figure 5: Percentage of publications and normalized impact per field
Radboud UMC (2010-2015/2016)

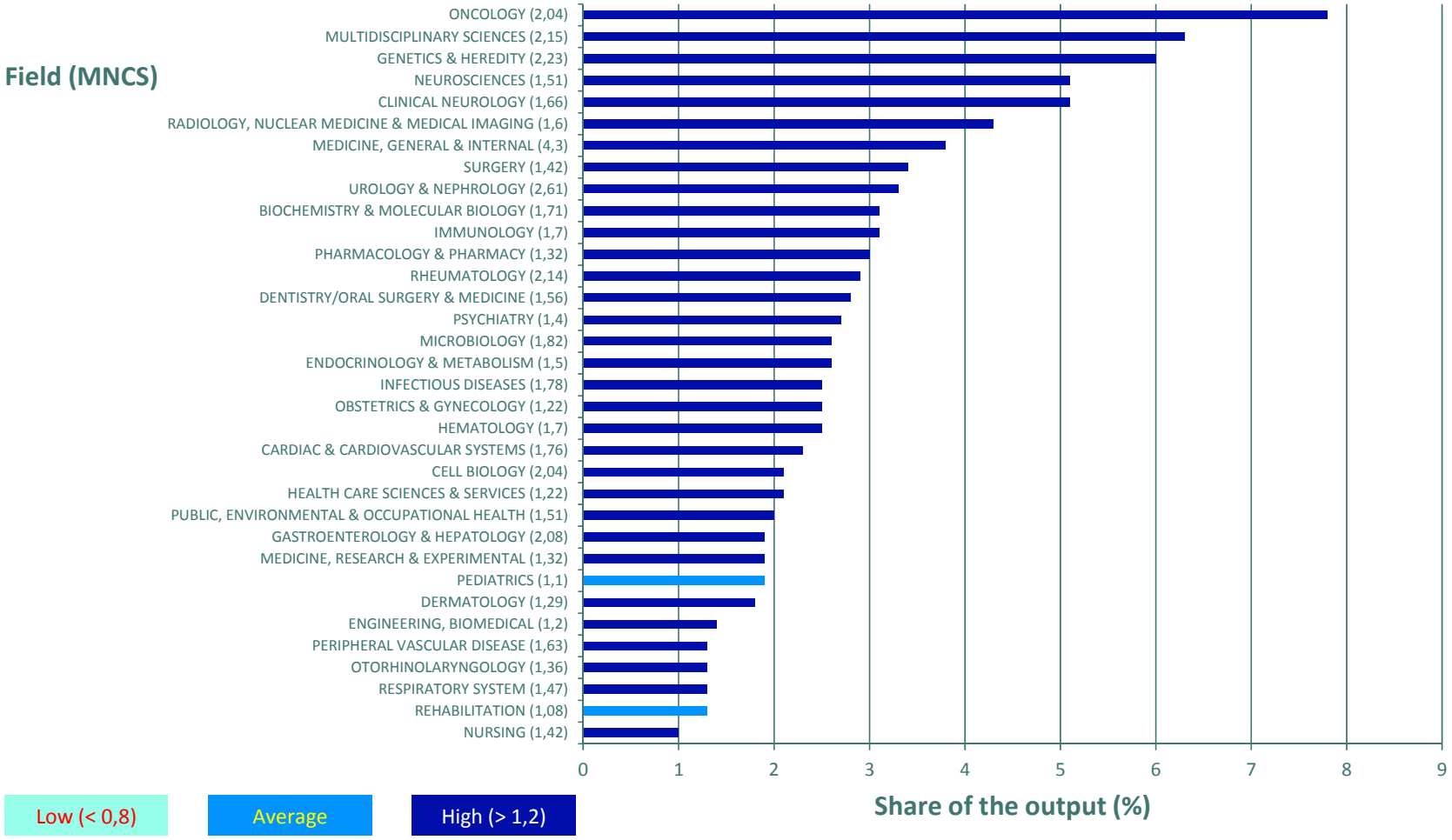


Figure 6: Percentage of publications and normalized impact per field
UMC Maastricht (2010-2015/2016)

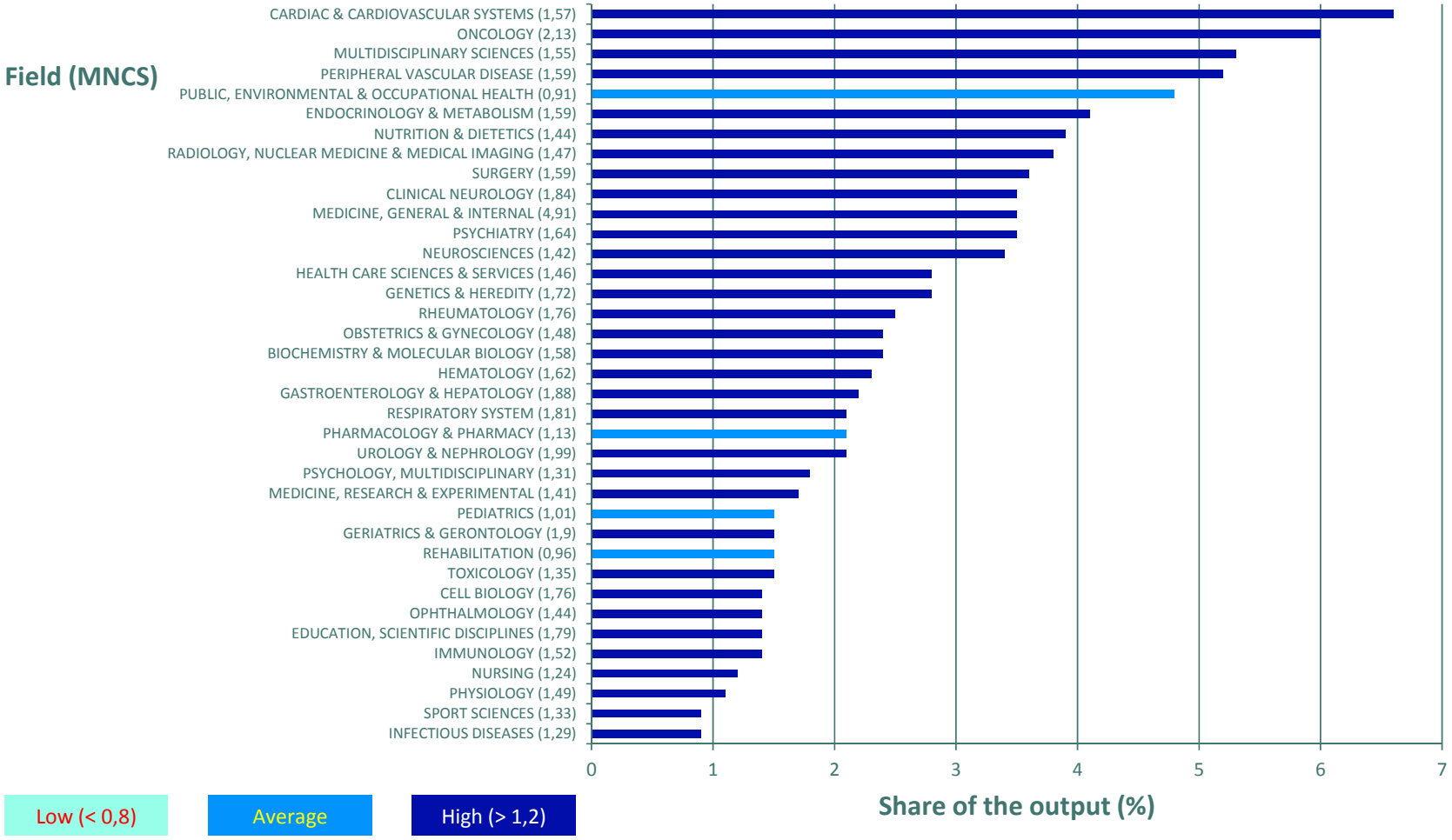


Figure 7: Percentage of publications and normalized impact per field
UMCG (2010-2015/2016)

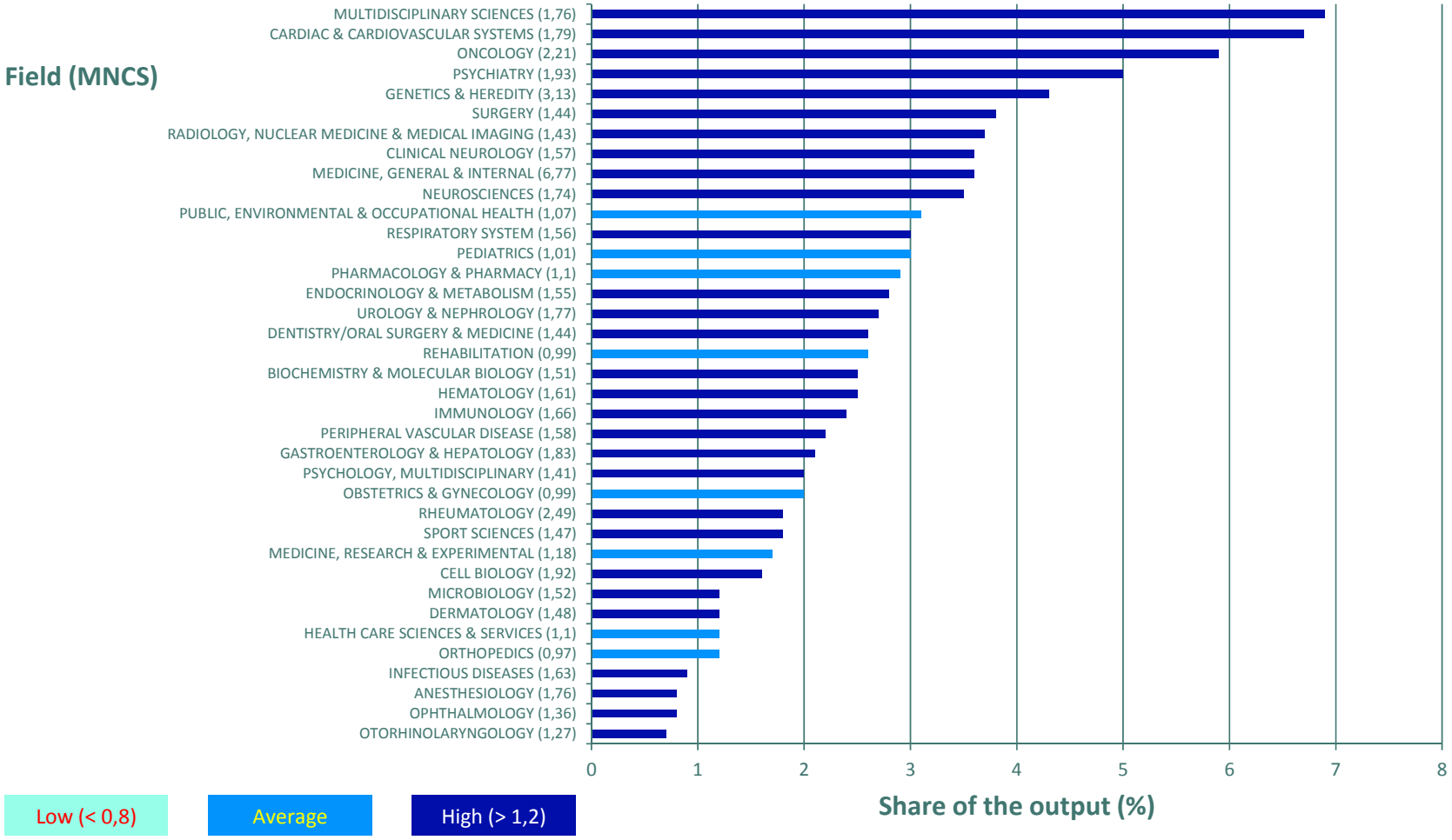


Figure 8: Percentage of publications and normalized impact per field
UU UMC (2010-2015/2016)

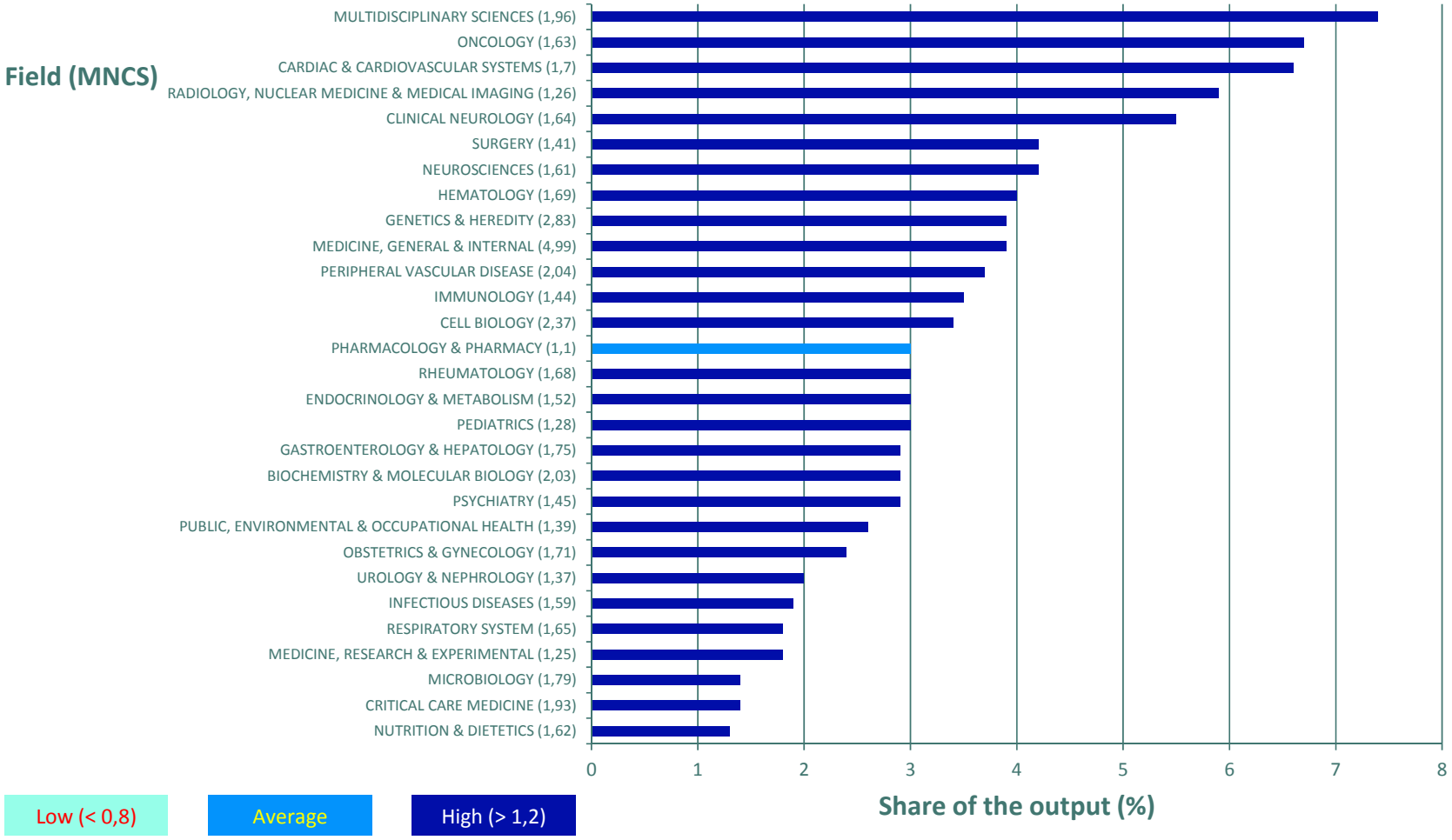


Figure 9: Percentage of publications and normalized impact per field
UvA AMC (2010-2015/2016)

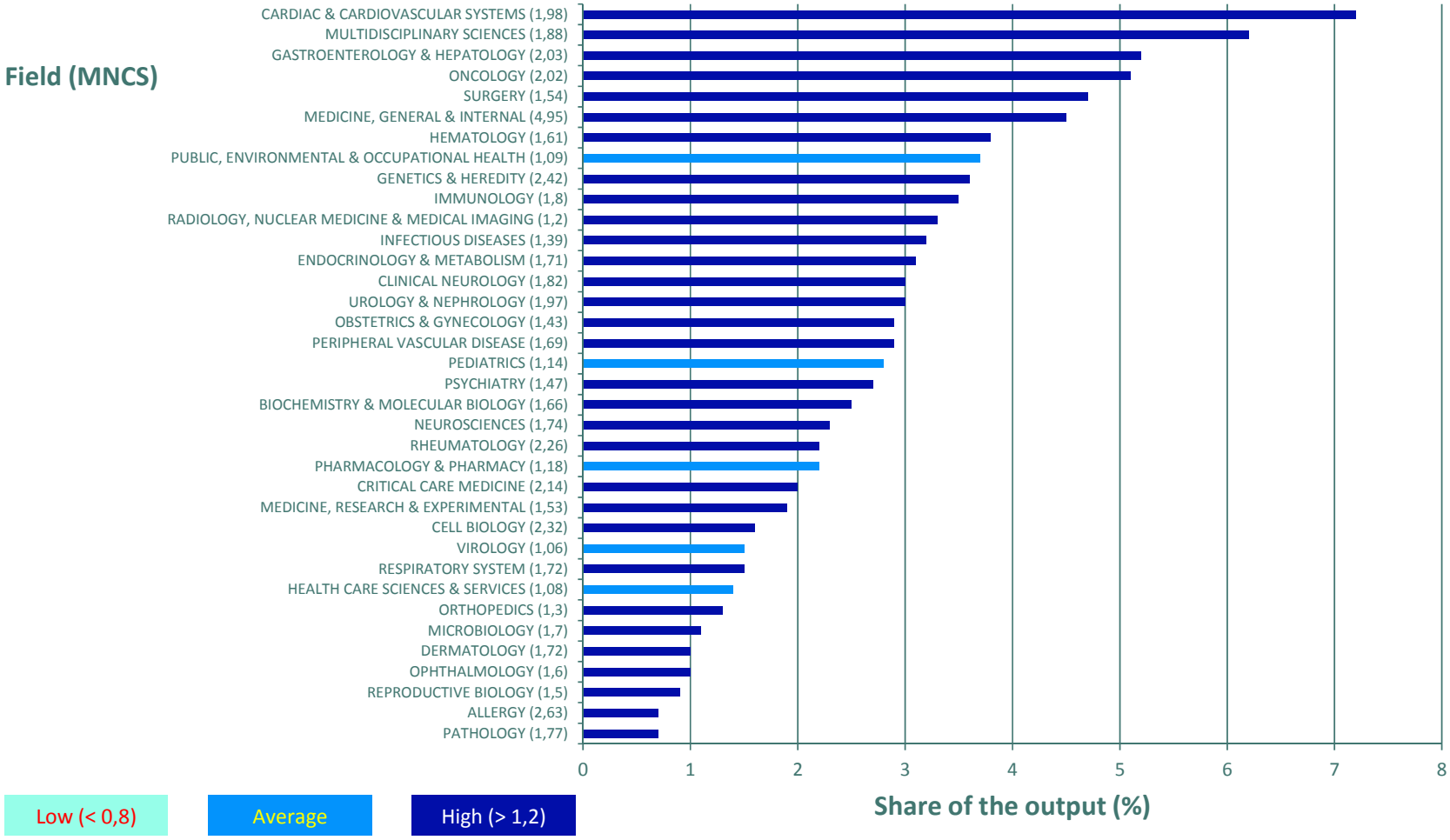


Figure 10: Percentage of publications and normalized impact per field VUmc (2010-2015/2016)

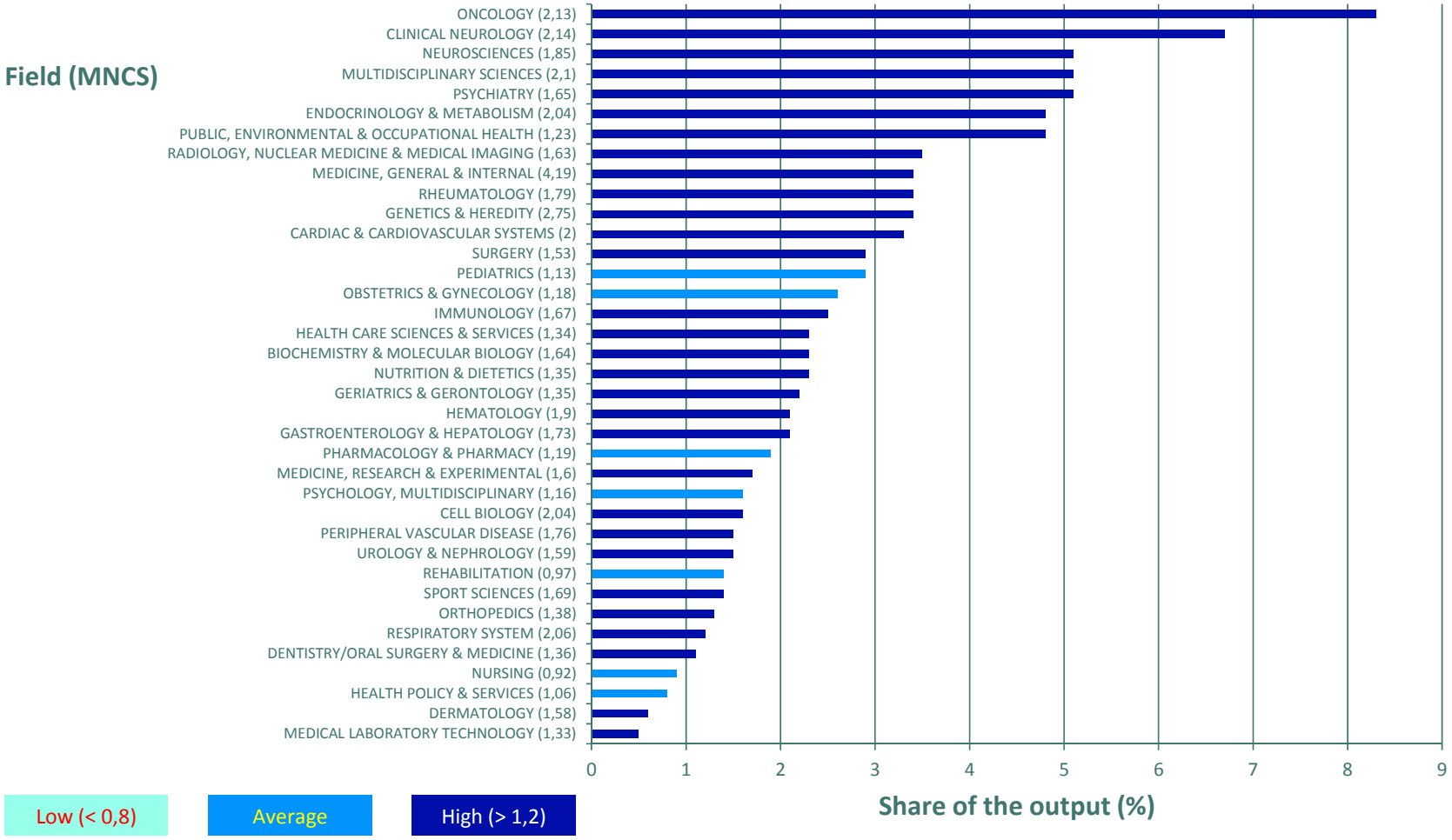
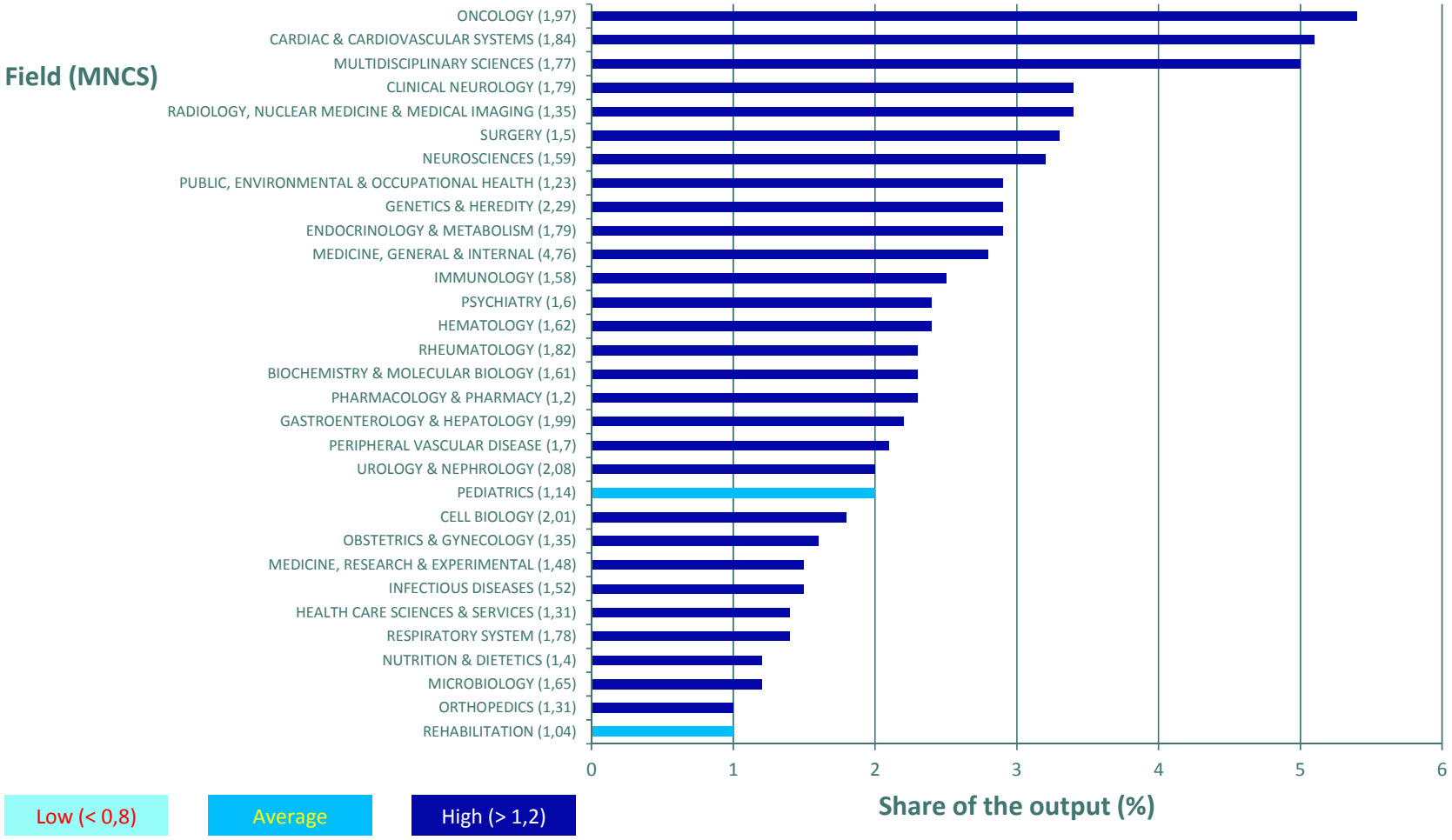


Figure 11: Percentage of publications and normalized impact per field
All UMCs together (2010-2015/2016)



2.4 Analysis of the publication strategy: profiles with MNJS values

In this section, we focus on the journals (and their impact position) in which the output was published across the fields in which the UMCs were active in. These profiles are similar to the research profiles, with this difference that the ***MNJS*** is now used to indicate the impact in the field, not as an indicator of the field impact, but rather as an indicator of the journal impact position in the field. The period analyzed is the period 2010-2015/2016.

Figures 12 through 19 contain such profiles for the eight UMCs, while **Figure 20** contains similar information for the UMCs overall journal selection.

Figure 12: Percentage of publications and journal-to-field impact Erasmus MC (2010-2015/2016)

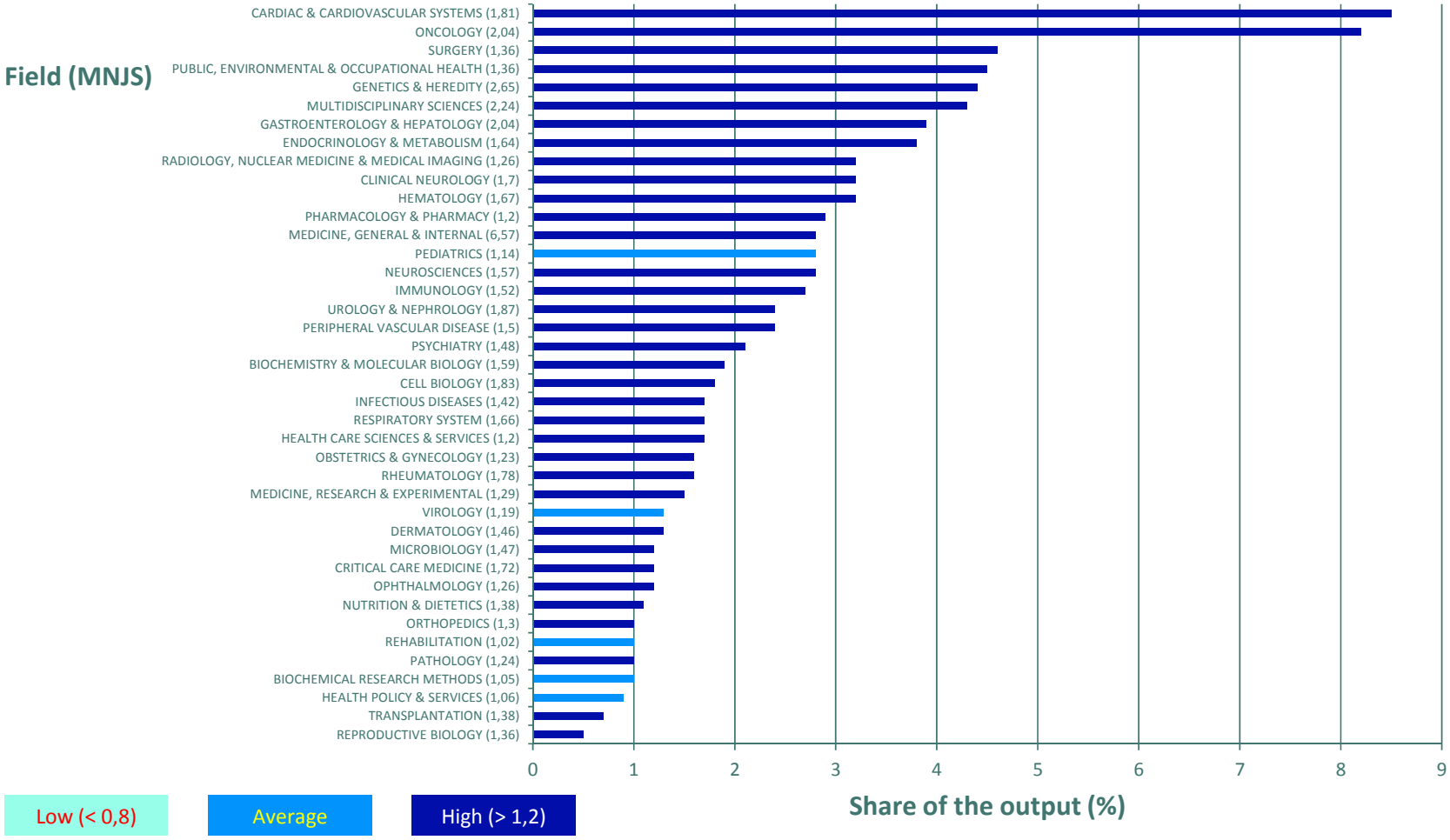


Figure 13: Percentage of publications and journal-to-field impact
LU MC (2010-2015/2016)

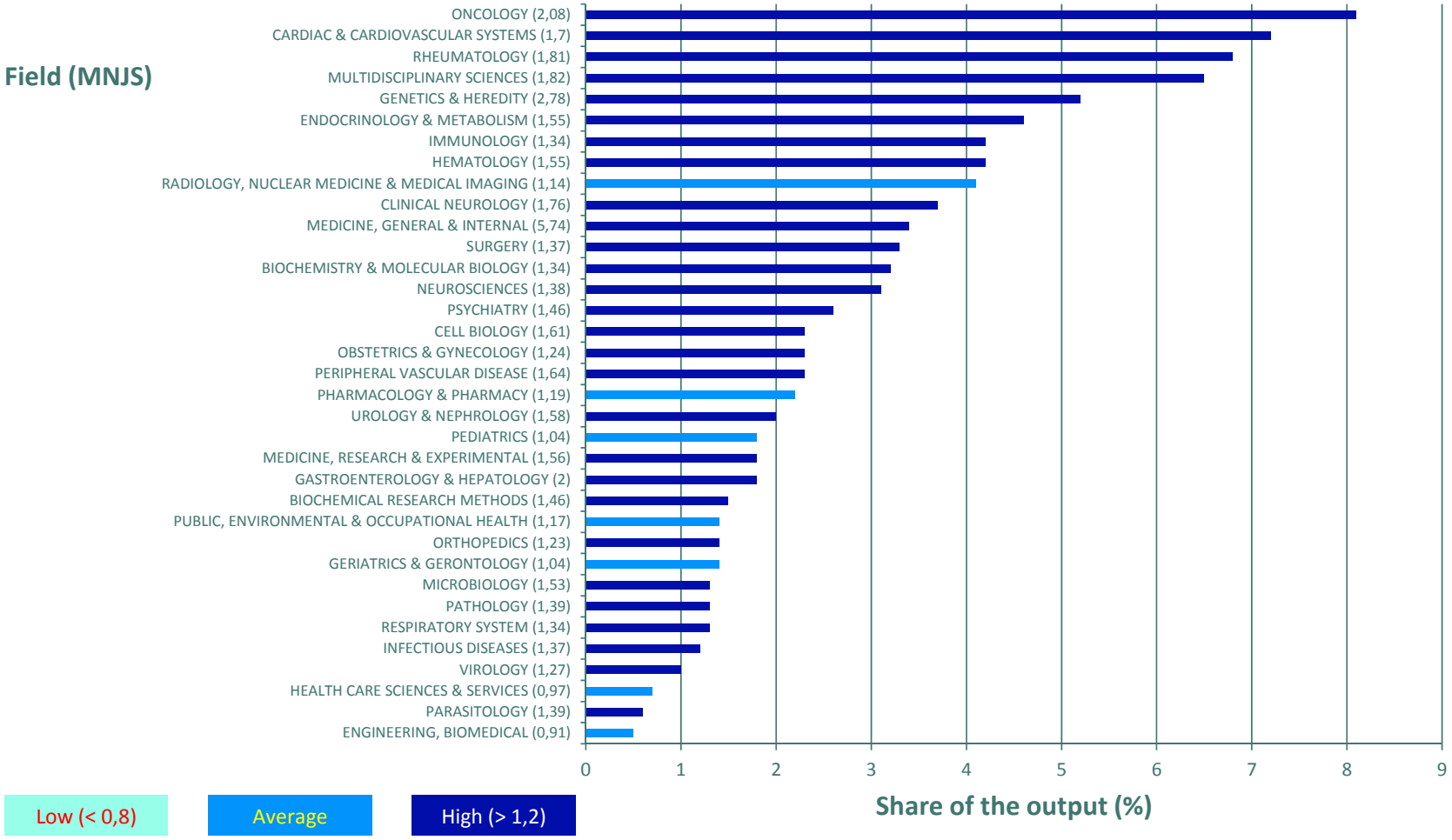


Figure 14: Percentage of publications and journal-to-field impact Radboud UMC (2010-2015/2016)

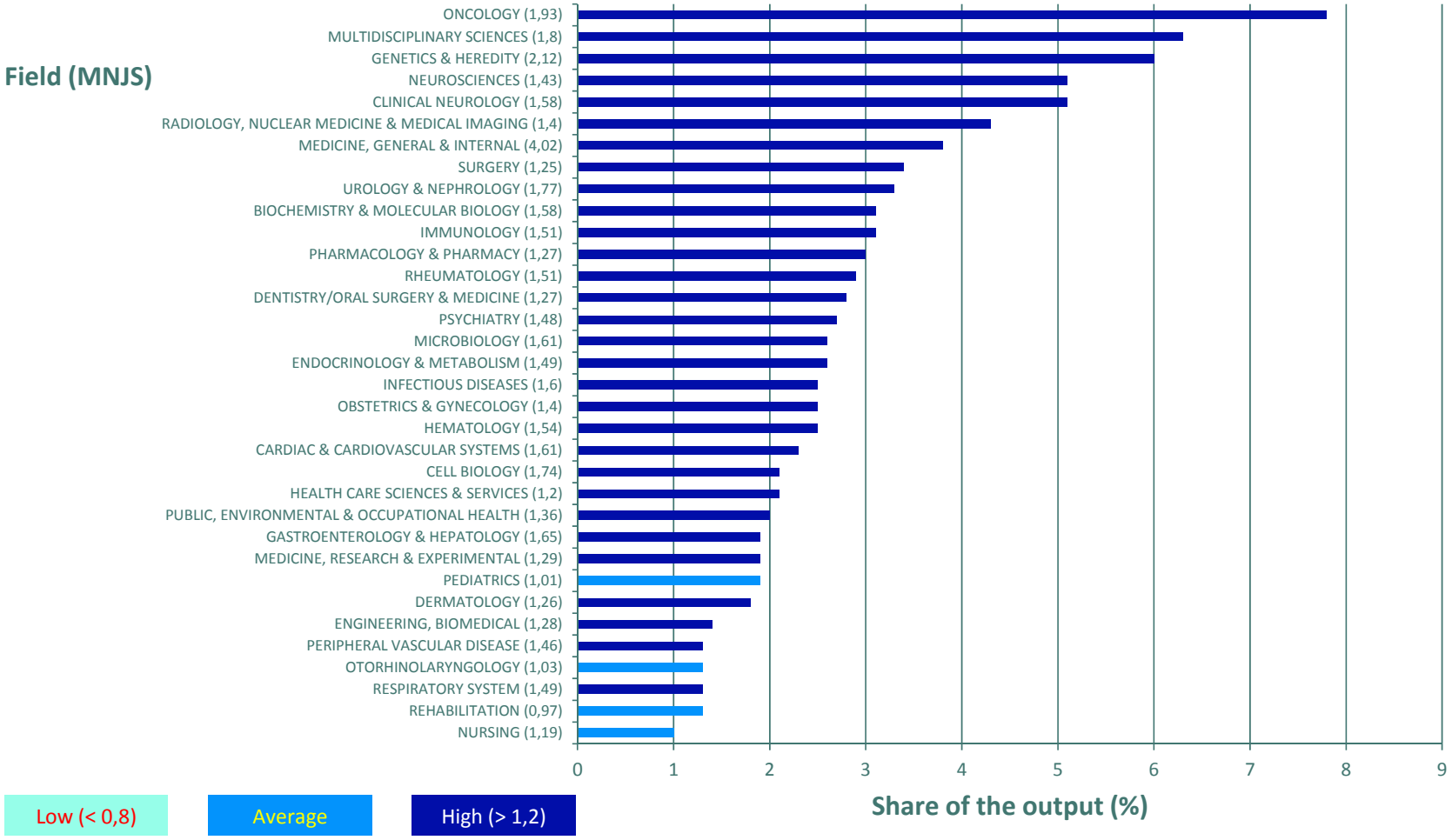


Figure 15: Percentage of publications and journal-to-field impact UMC Maastricht (2010-2015/2016)

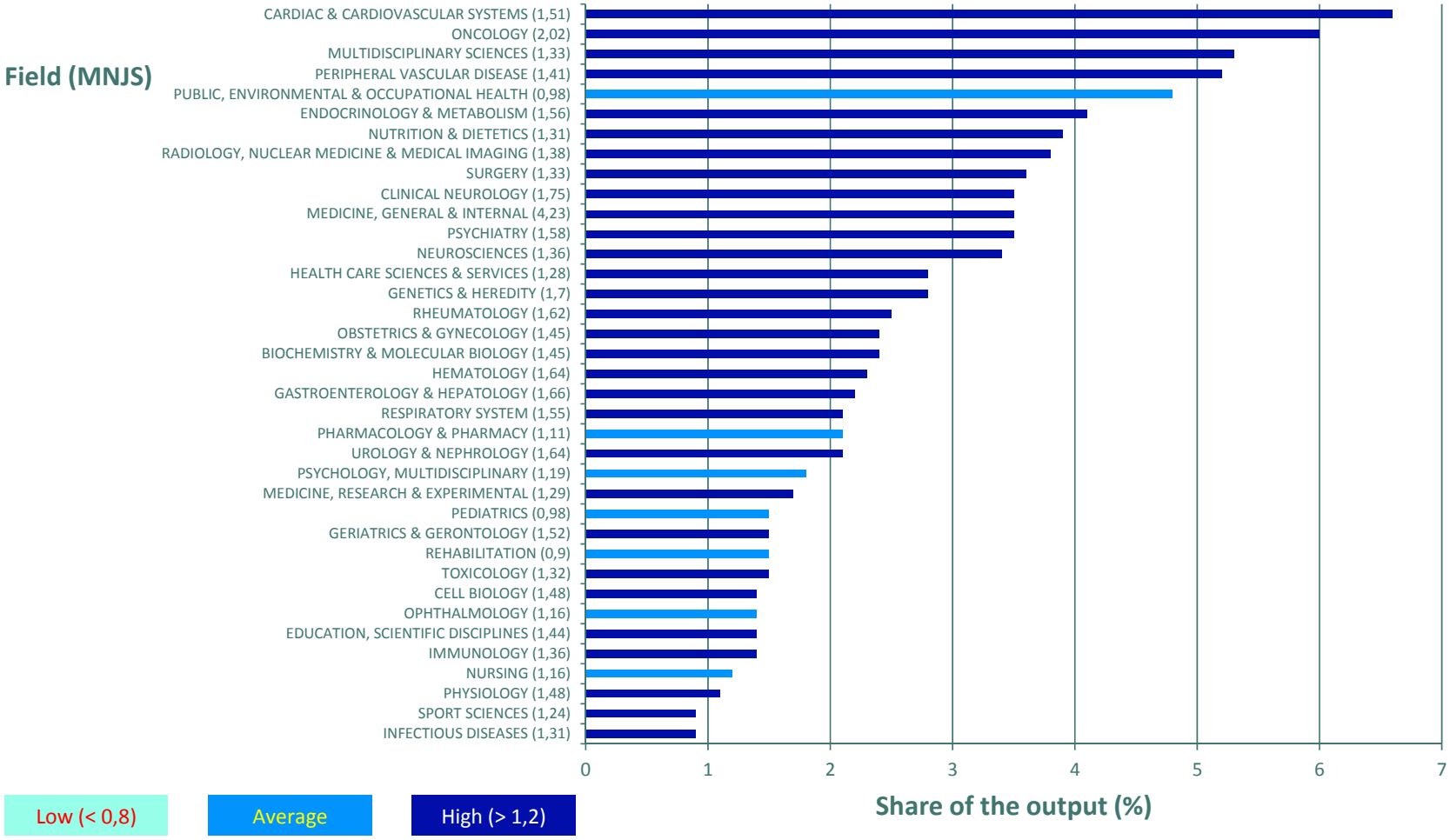


Figure 16: Percentage of publications and journal-to-field impact UMCG (2010-2015/2016)

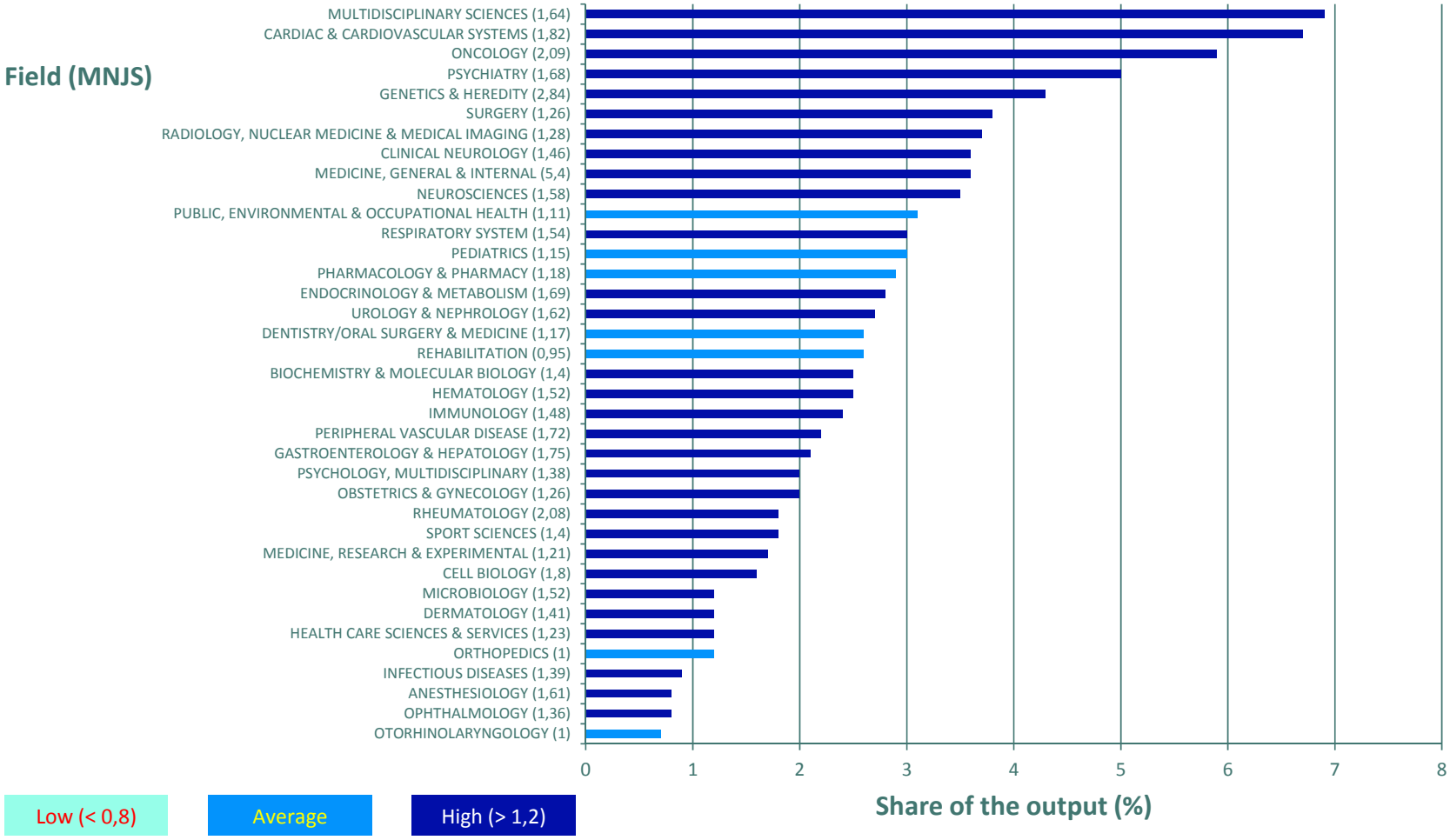


Figure 17: Percentage of publications and journal-to-field impact
UU UMC (2010-2015/2016)

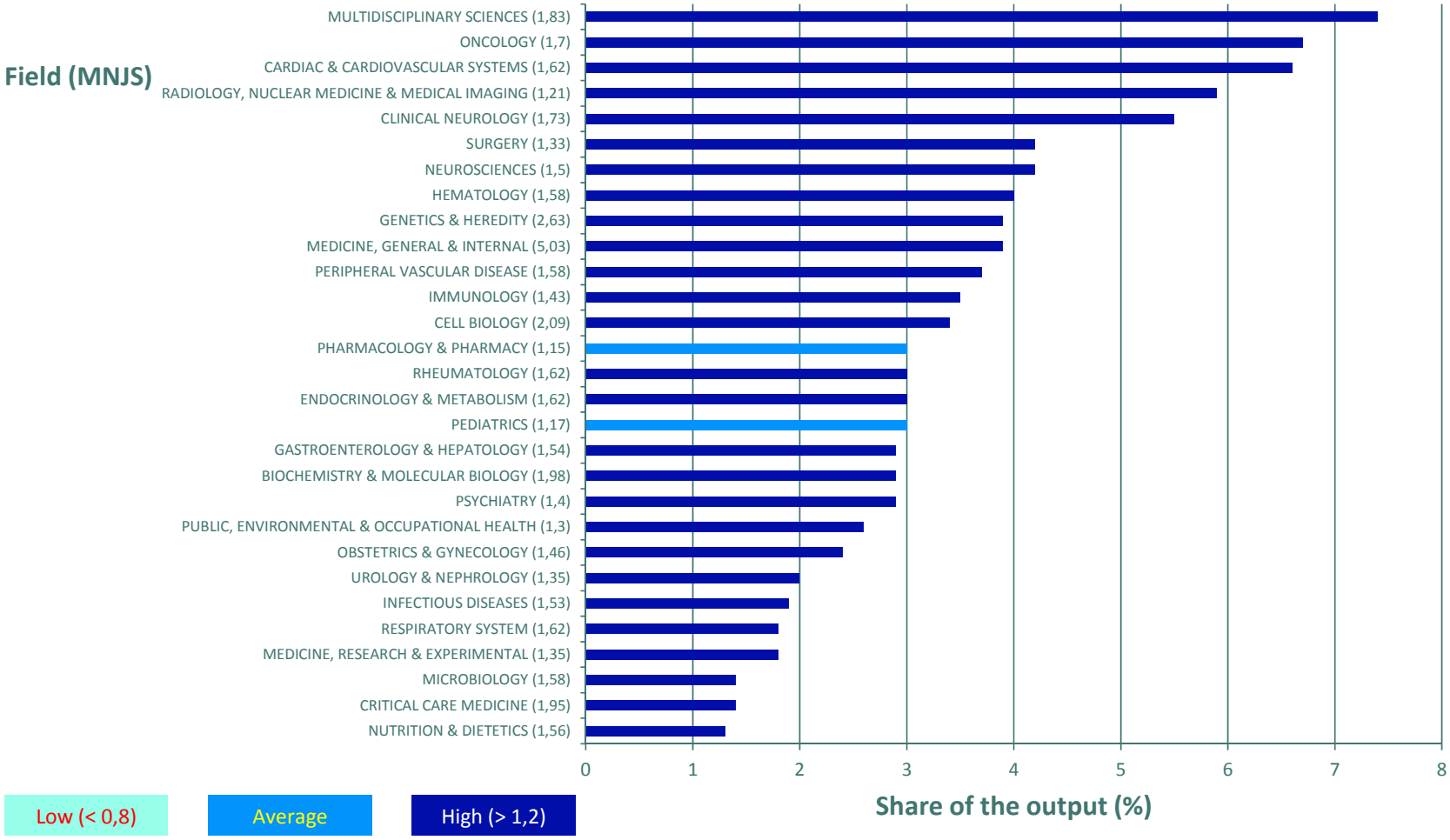


Figure 18: Percentage of publications and journal-to-field impact UvA AMC (2010-2015/2016)

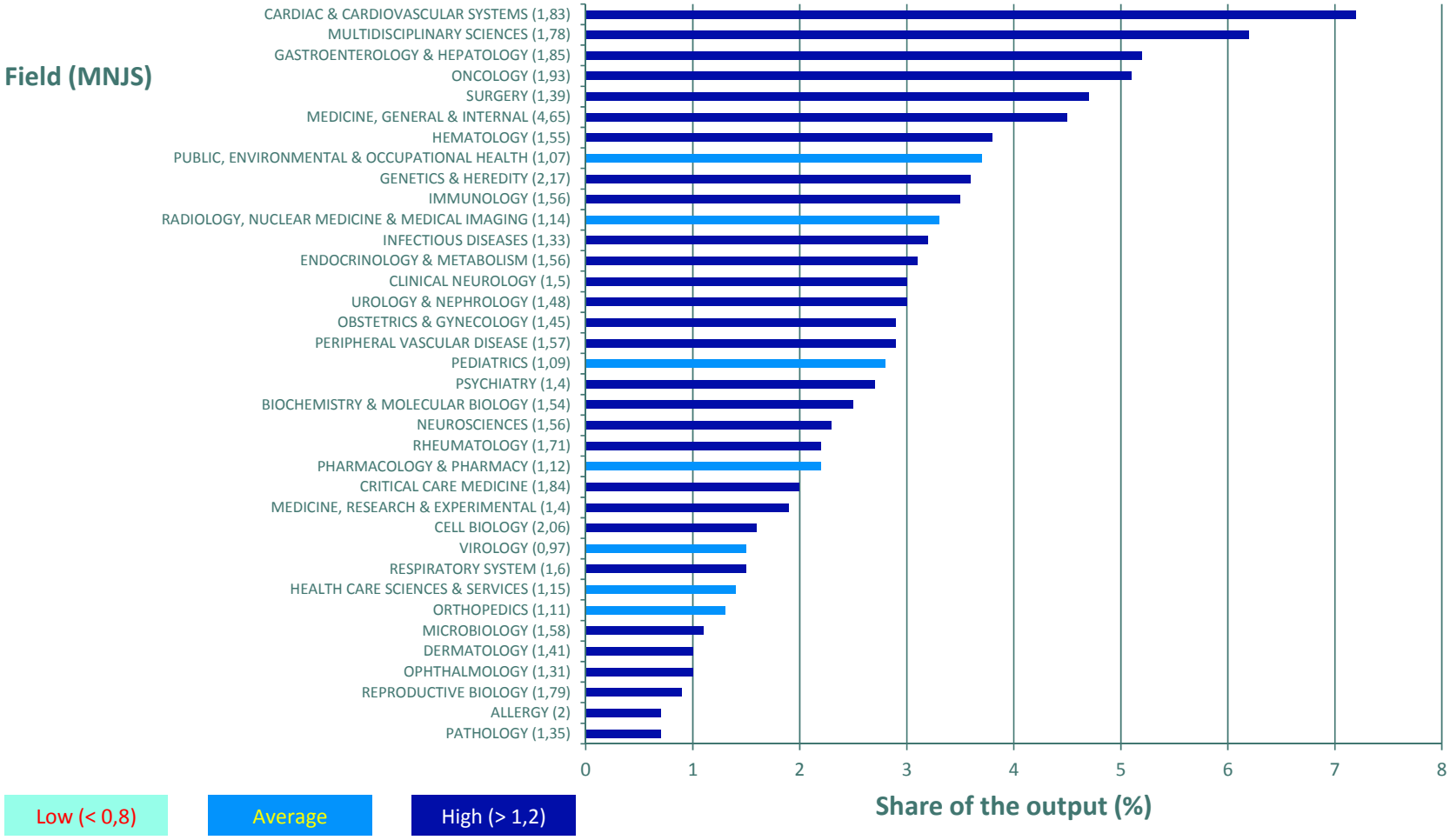


Figure 19: Percentage of publications and journal-to-field impact VUmc (2010-2015/2016)

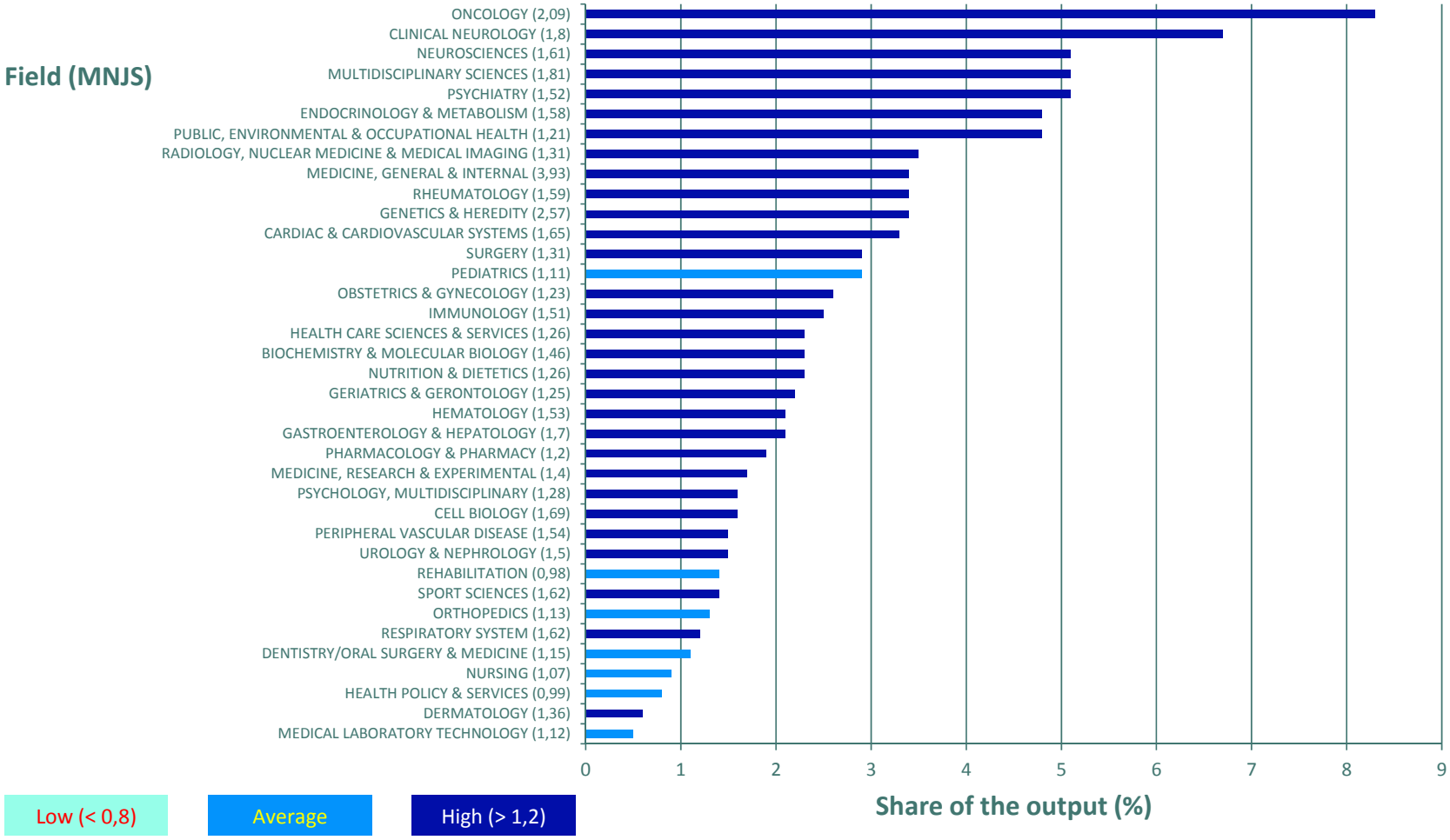
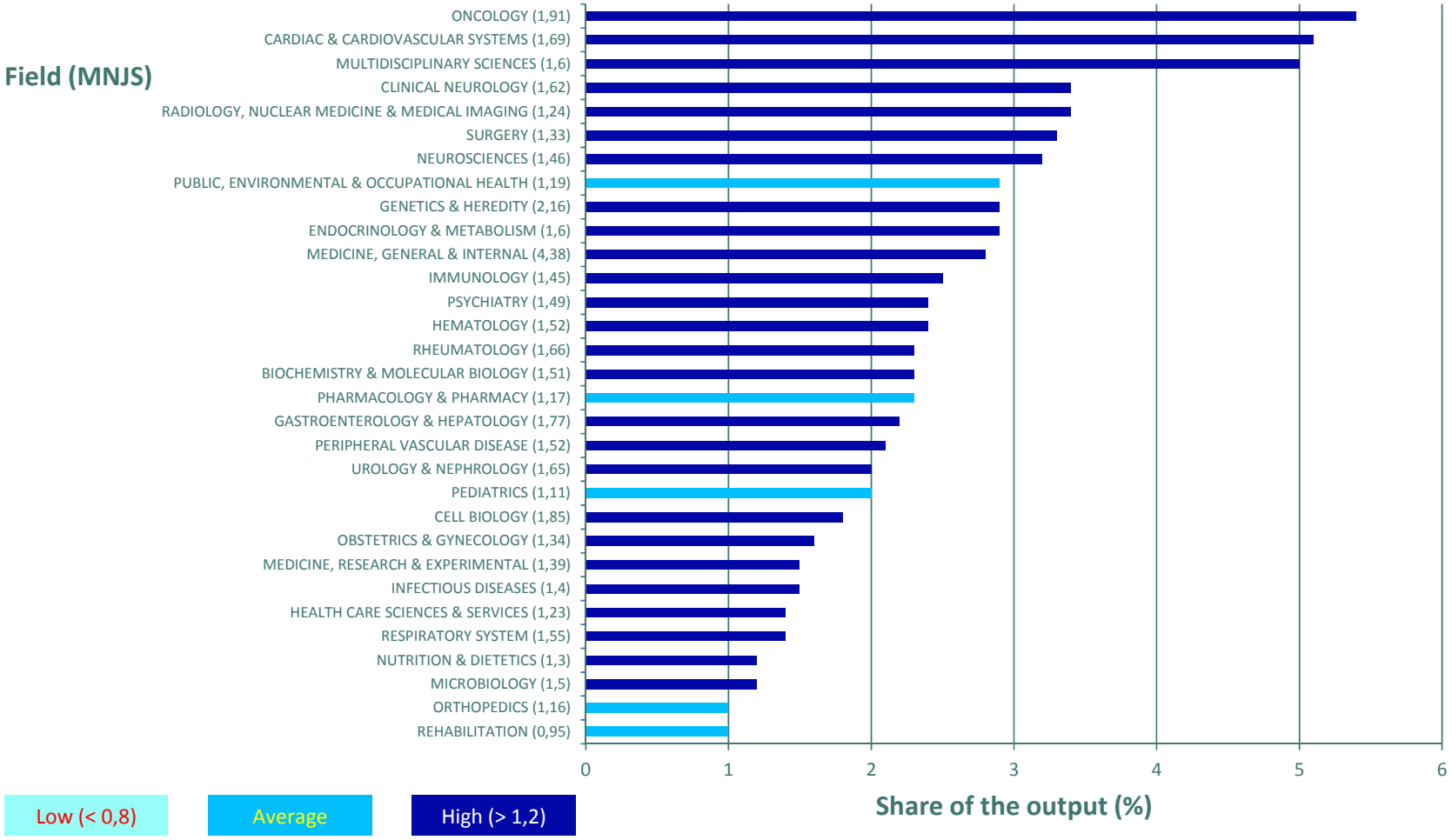


Figure 20: Percentage of publications and journal-to-field impact
All UMCs together(2010-2015/2016)



2.5 Impact of Dutch UMCs

In this section, the focus is on various aspects of scientific activity, like single address output, international cooperation, as well as primary authorships. Table 1 below presents the output numbers and share of the respective analysis perspectives against the total output per UMC, in the period 2010-2015.

We start this section with plotting the overall impact scores for the Dutch UMCs, on the indicators MNCS and MNJS, for the period 2010-2015/2016, as these form the reference framework for understanding the results on the exact same indicators on the other dimensions mentioned above.

Single address **(SI)** outputs are the publications from each of the UMCs which are published solely, with only one address attached to it. These publications can be understood as an indication of the scientific performance position of the institute, as this part of the institutional output is produced alone, with no other contributors. International cooperation **(IC)** output is representing those publications per UMC which are forthcoming from international collaboration, practically it means publications that carry two or more country names (irrespective of position in the address by-lines).

Primary authorships **(PA)** are defined as follows: for every single publication from the UMCs, we are capable of establishing which author links to which UMC. We distinguished between first and second authorship (on the front end of the author list), and last and second-before-last authorship, on the tail end of the author list). This has been grouped as primary authorships, and as such formed an entrance on analyzing the outputs of the UMCs.

Table 1: Output types of Dutch UMCs 2010-2015/2016

	p All	p SI	% SI	P IC	% IC	p PA	% PA
Erasmus MC	15589	2808	18%	7782	50%	12011	77%
LU MC	11622	1957	17%	5755	50%	8278	71%
Radboud UMC	12834	2195	17%	6644	52%	9388	73%
UMC Maastricht	11239	1380	12%	6303	56%	8628	77%
UMCG	12273	2214	18%	5698	46%	9234	75%
UU UMC	12276	1936	16%	5586	46%	9519	78%
UvA AMC	16491	2460	15%	8083	49%	12300	75%
VUmc	12608	1464	12%	5987	47%	9270	74%

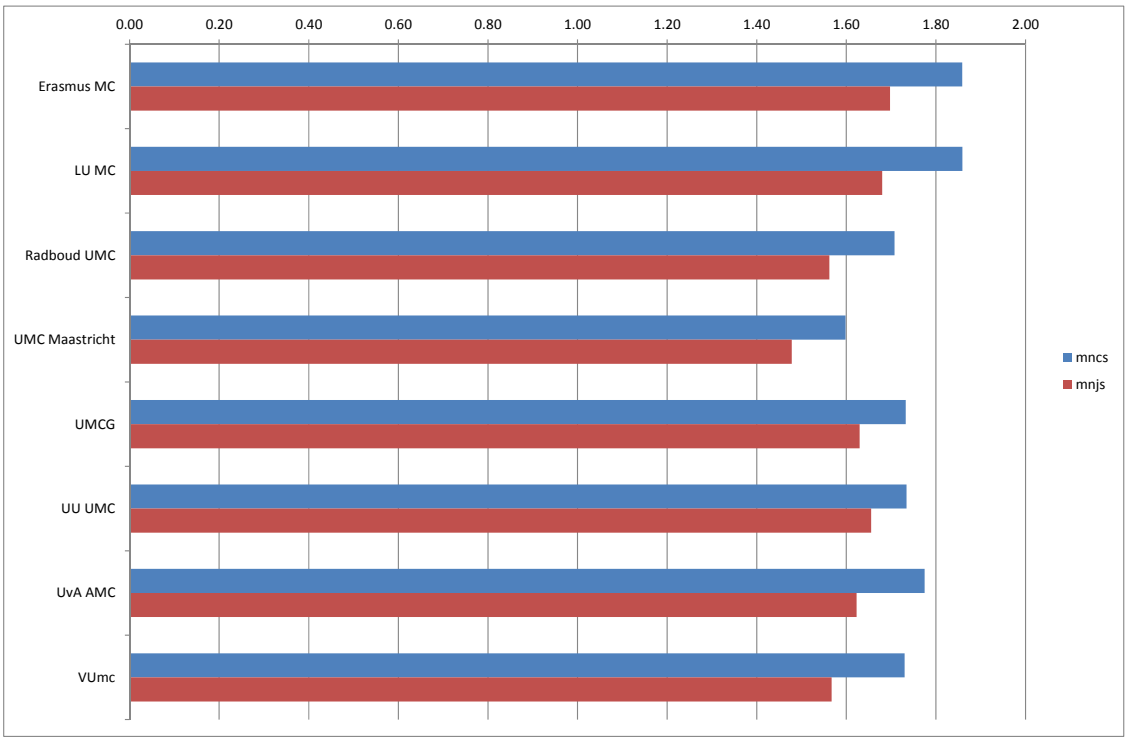


Figure 21: Impact scores related to output of Dutch UMCs, 2010-2015/2016

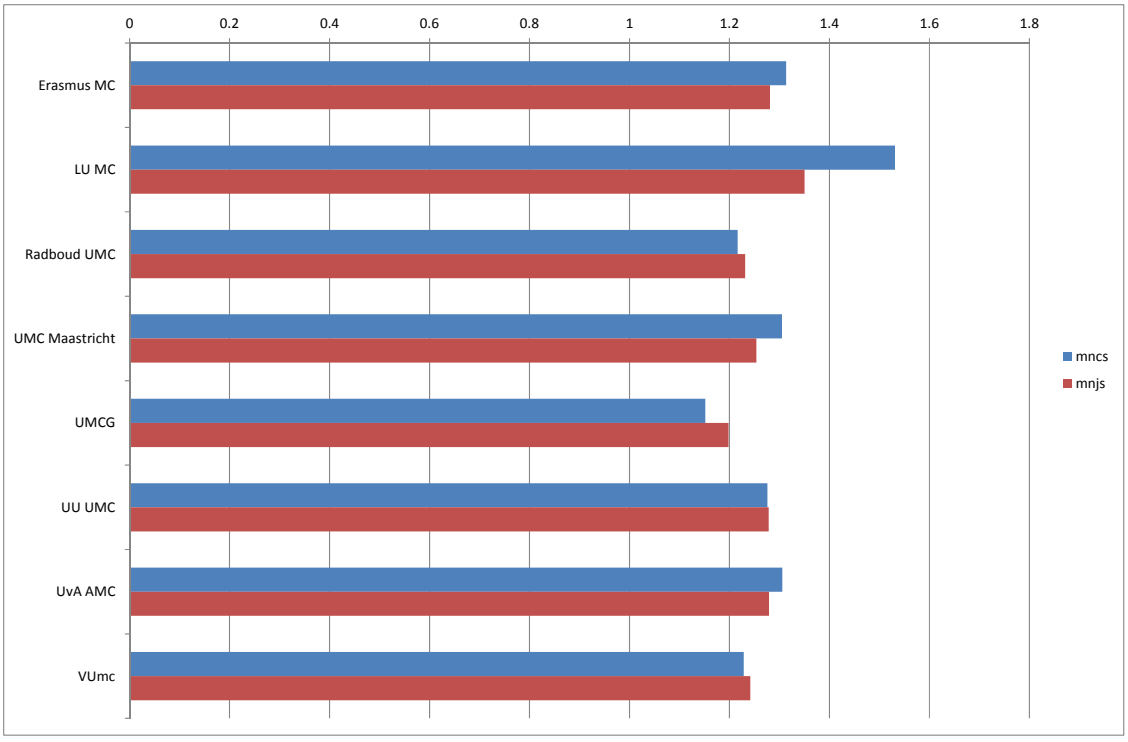


Figure 22: Impact scores related to Single Institute output, 2010-2015/2016

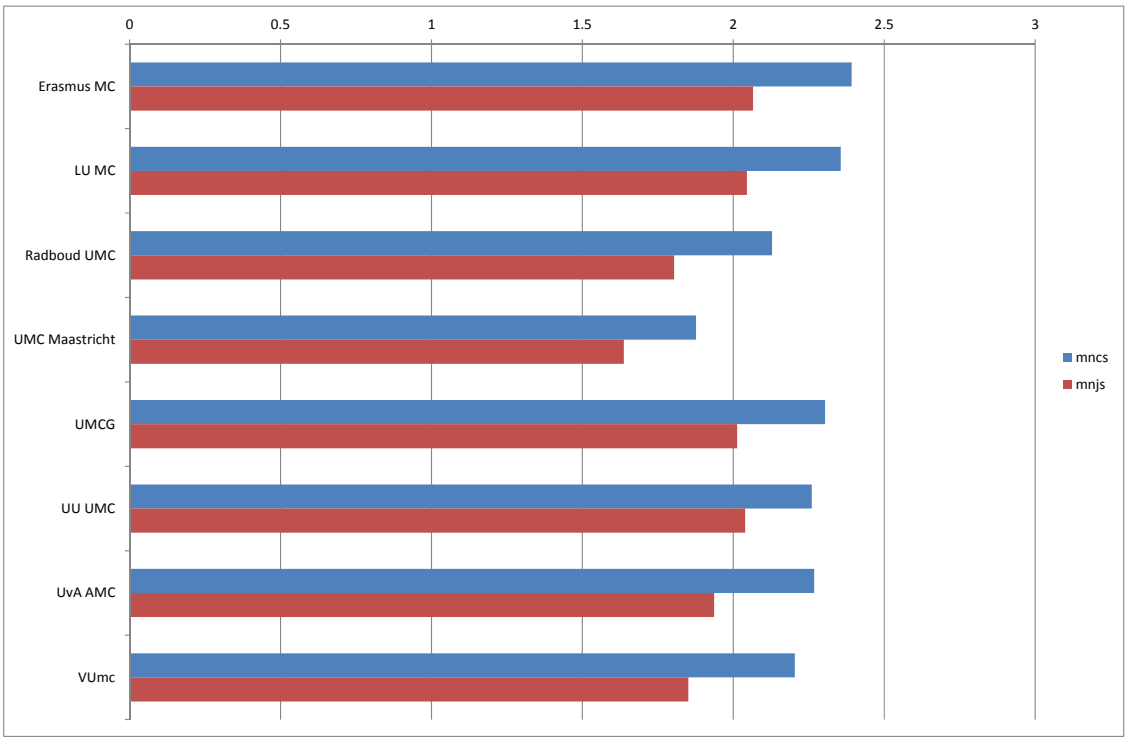


Figure 23: Impact scores related to International Cooperation output, 2010-2015/2016

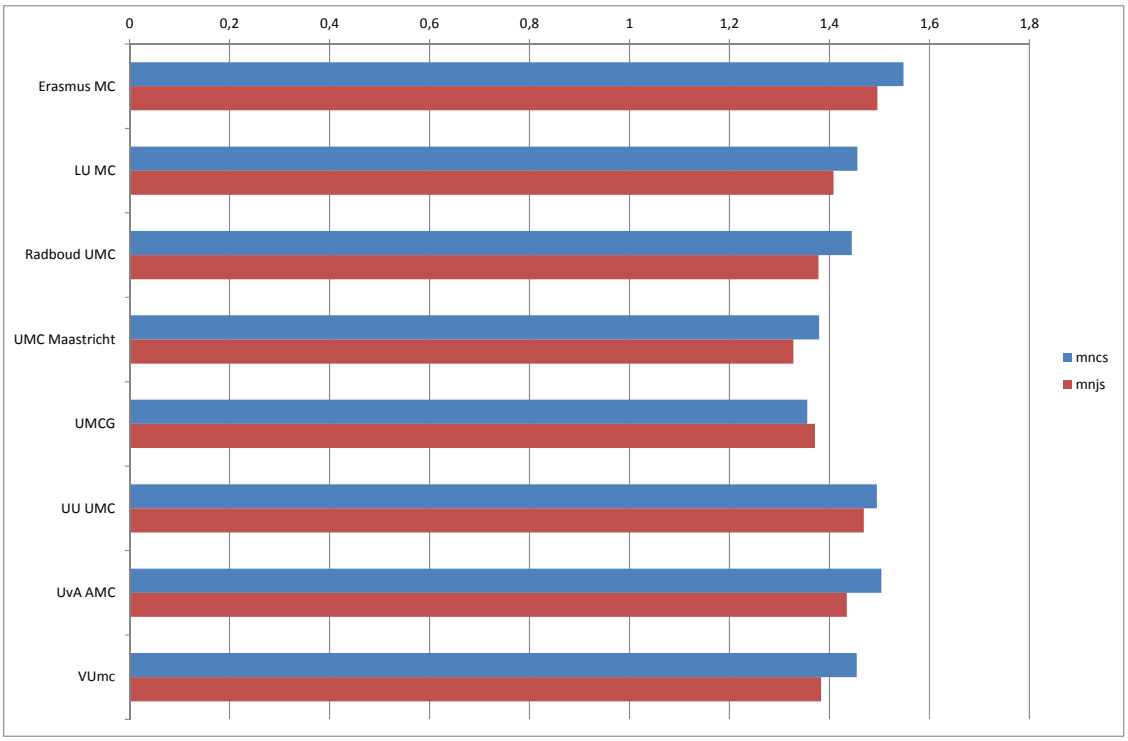


Figure 24: Impact scores related to primary authorships output, 2010-2015/2016

2.6 Analysis of top-research

Per UMC, a break-down into different classes of journal impact is made. While the data in Table A-1 (pages 40-42) show the overall situation, Table 2 (page 33) contains the results of an analysis when the publications from each UMC are analyzed according to the journal-to-field impact classes that the publications can be counted in.

We distinguish five classes, the first class is the set of publications where the JFIS class of the journal is ranging between 0.00 and 0.40 (Class A), the second class is ranging from 0.41 to 0.80 (Class B), the third class is ranging from 0.81 to 1.20 (Class C), the fourth class ranges from 1.21 to 1.60 (Class D), while finally the fifth class contains all publications in journals with a higher JFIS value as 1.61 (Class E).

Figure 25 describes the distribution of absolute numbers of publications over the five journal impact classes. It is important to note that we observe a strong presence of Dutch UMCs in the highest impact class, indicative of the choice for and success in selecting top journals in the fields to which these journals belong.

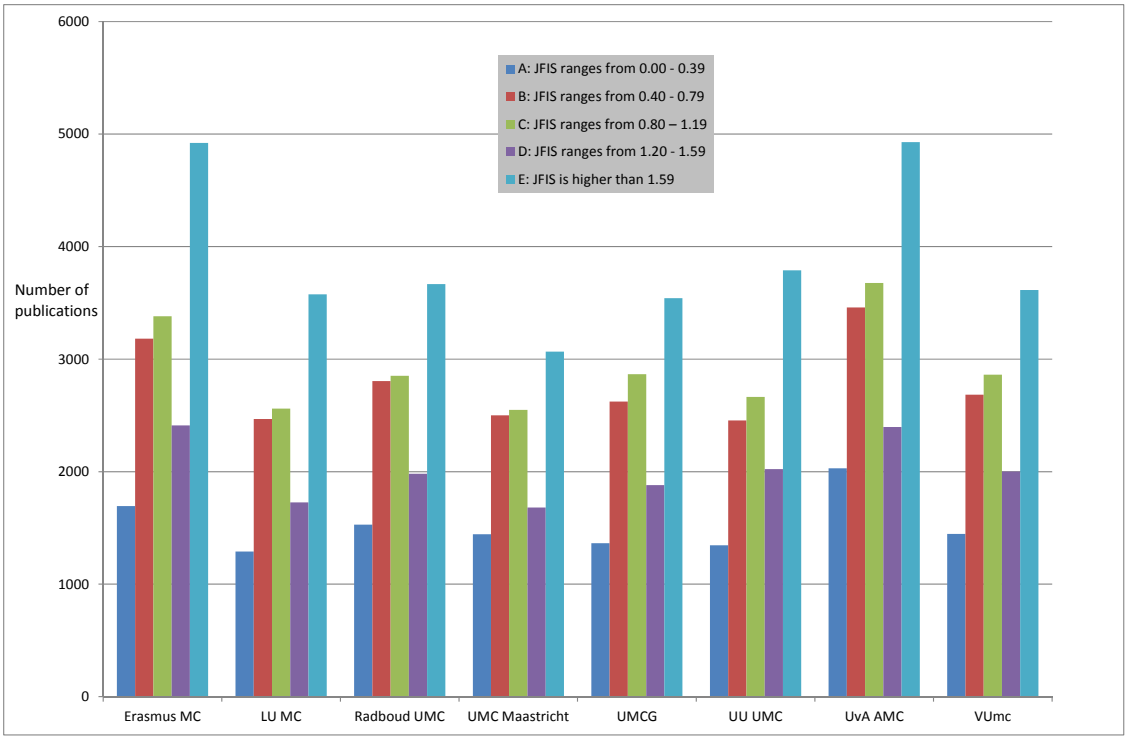


Figure 25: Distribution of output over journal-to-field impact classes (MNJS), 2010-2015/2016

In Figure 26a and 26b, we present the relative distribution of the outputs over these five journal impact classes. While Figure 26a presents the UMCs in alphabetic order, Figure 26b presents the UMCs in descending order of shares in the two top journal impact

classes. This provides a slightly different perspective on the UMC landscape, and the ways the UMCs select and publish high impact journals.

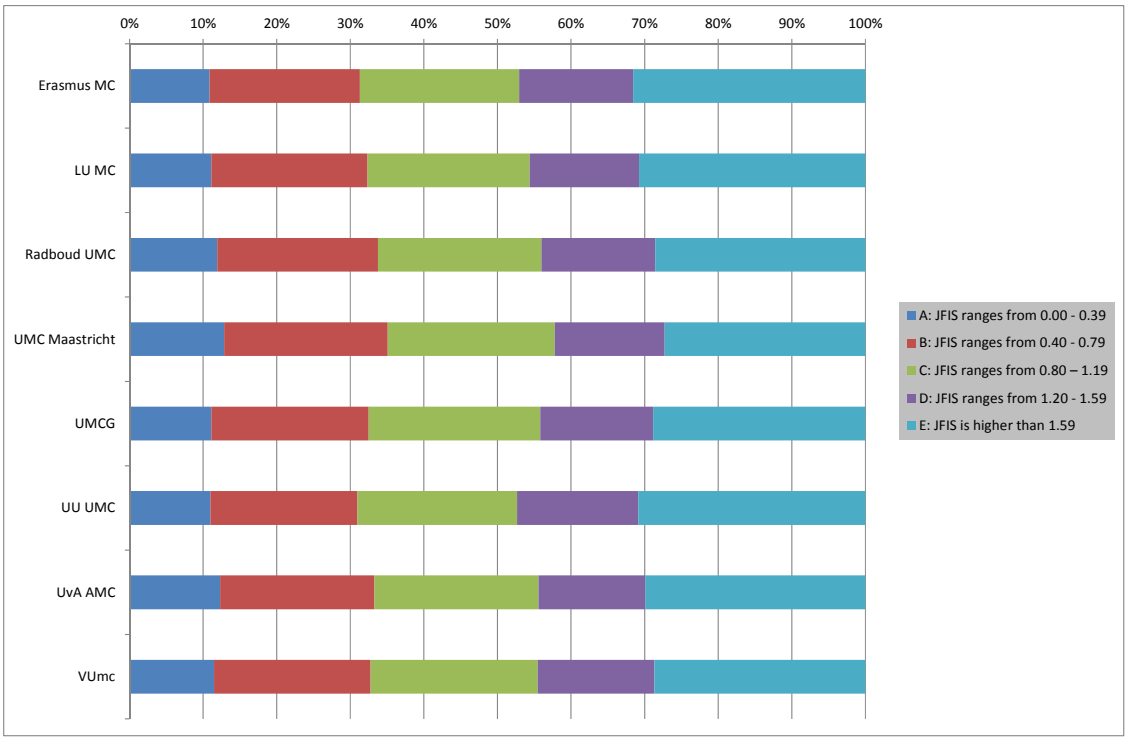


Figure 26a: Relative distribution of output over journal-to-field impact classes (MNJS), 2010-2015/2016

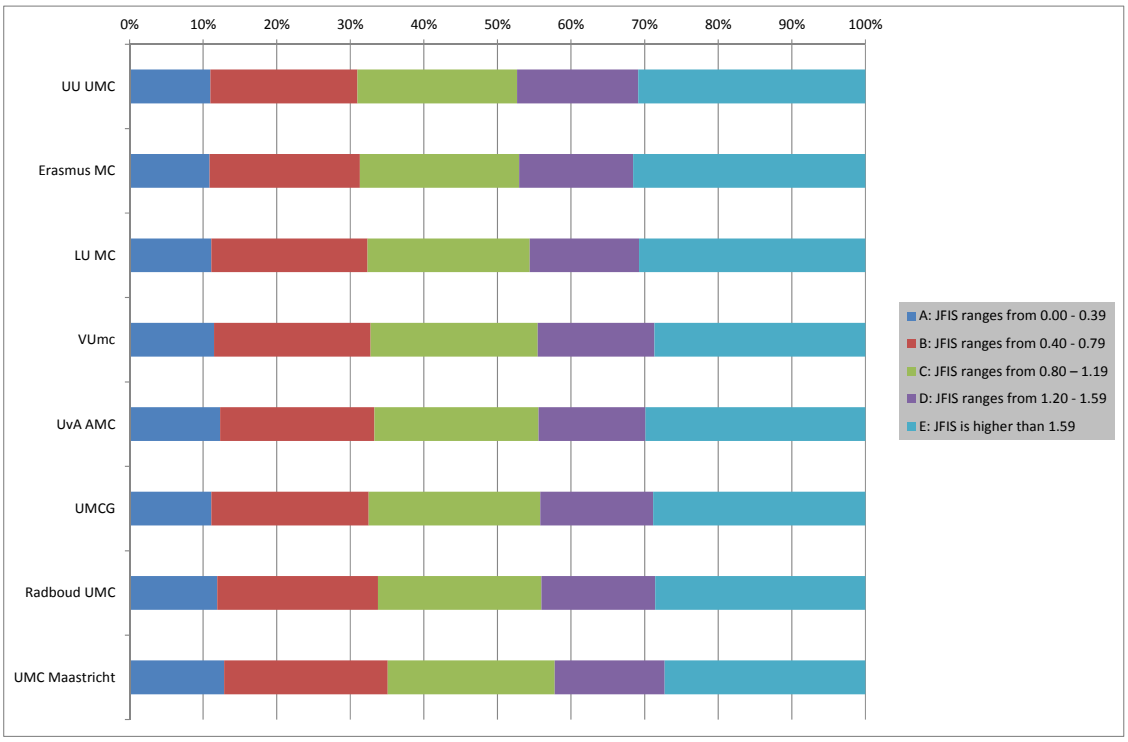


Figure 26b: Relative distribution of output over journal-to-field impact classes (by descending highest share in the two classes MNJS > 1.20), 2010-2015/2016

In **Figures 27** and **28**, we present the actual MNCS and MNJS values attached to the outputs in the five journal impact classes. These coincide, as might be expected, with the definition of the separate classes, however, the last class E, which is not limited on the upper end, displays quite high scores on both impact measures, indicative of the strong performance of the Dutch UMCs in particular that upper end of the journal landscapes of the fields in which the UMCs publish their findings.

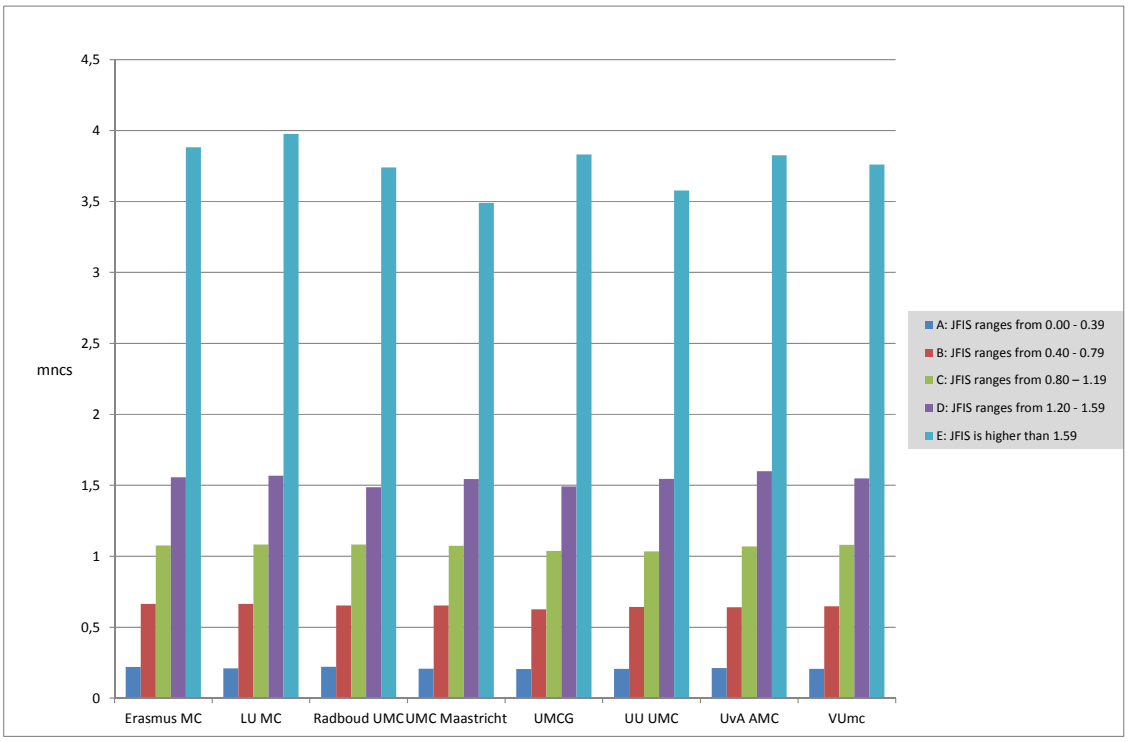


Figure 27: Impact level (MNCS) of output over journal-to-field impact classes, 2010-2015/2016

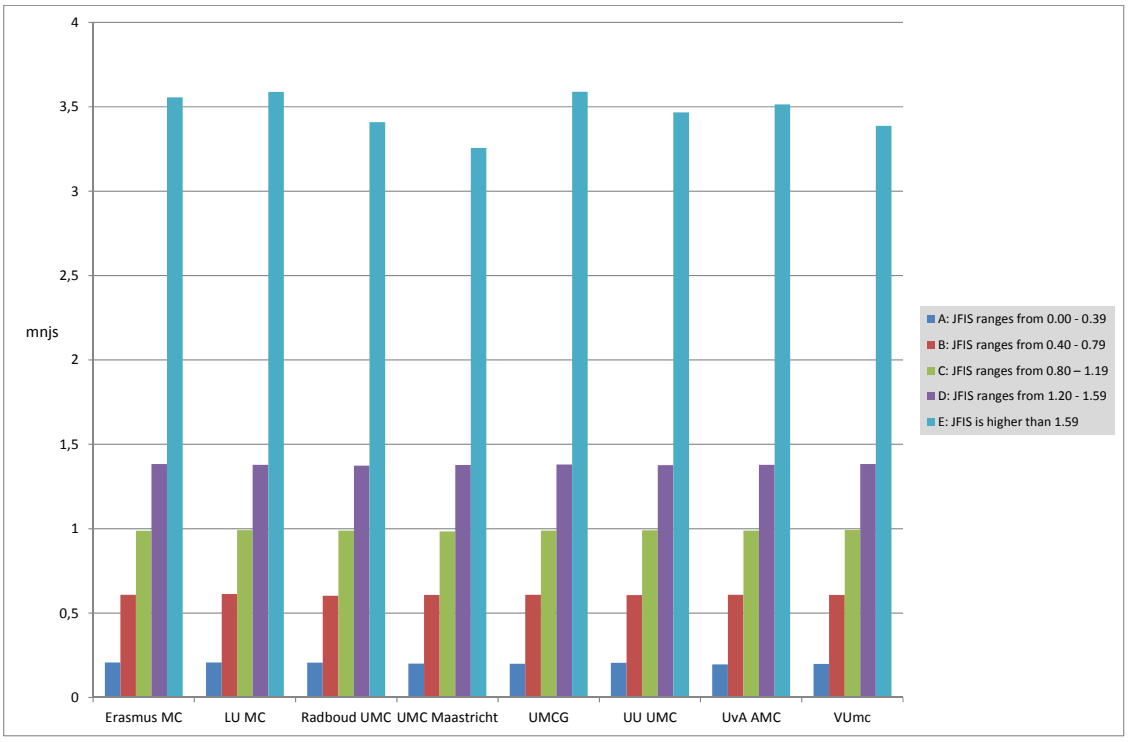


Figure 28: Impact level (MNJS) of output over journal-to-field impact classes, 2010-2015/2016

Table 2: Distribution of output of Dutch UMCs over journal impact classes, 2010-2015/2016

	JFIS-Class	p	tcs	mcs	mncs	mnjs	tncs	Top 10%c	% uncited
Erasmus MC	A	1694	3850	2,27	0,22	0,21	372,31	0%	31%
Erasmus MC	B	3182	20707	6,51	0,66	0,61	2113,33	2%	9%
Erasmus MC	C	3381	33859	10,01	1,08	0,99	3639,66	8%	6%
Erasmus MC	D	2411	32094	13,31	1,56	1,38	3750,49	17%	4%
Erasmus MC	E	4921	176322	35,83	3,88	3,56	19102,14	52%	2%
LU MC	A	1291	3053	2,36	0,21	0,21	270,38	0%	30%
LU MC	B	2468	17117	6,94	0,67	0,61	1641,28	2%	8%
LU MC	C	2560	27754	10,84	1,08	0,99	2769,93	8%	6%
LU MC	D	1727	25038	14,50	1,57	1,38	2707,98	19%	4%
LU MC	E	3576	146443	40,95	3,98	3,59	14216,27	52%	2%
Radboud UMC	A	1530	3440	2,25	0,22	0,21	338,40	0%	31%
Radboud UMC	B	2804	17643	6,29	0,65	0,60	1829,87	2%	10%
Radboud UMC	C	2851	27843	9,77	1,08	0,99	3085,84	8%	7%
Radboud UMC	D	1982	25213	12,72	1,49	1,37	2946,38	0,17	5%
Radboud UMC	E	3667	123134	33,58	3,74	3,41	13713,77	0,50	2%
UMC Maastricht	A	1443	2950	2,04	0,21	0,20	299,87	0%	36%
UMC Maastricht	B	2500	15194	6,08	0,65	0,61	1630,98	2%	10%
UMC Maastricht	C	2550	24484	9,60	1,07	0,98	2736,78	8%	7%
UMC Maastricht	D	1680	21928	13,05	1,54	1,38	2594,93	16%	5%
UMC Maastricht	E	3066	97010	31,64	3,49	3,26	10701,73	48%	3%
UMCG	A	1364	3036	2,23	0,21	0,20	280,97	0%	35%
UMCG	B	2622	15399	5,87	0,63	0,61	1639,75	1%	11%
UMCG	C	2866	27695	9,66	1,04	0,99	2972,57	8%	7%
UMCG	D	1880	22442	11,94	1,49	1,38	2806,43	17%	4%
UMCG	E	3541	119694	33,80	3,83	3,59	13568,20	50%	2%
UU UMC	A	1345	3167	2,35	0,21	0,20	278,08	0%	31%
UU UMC	B	2455	16683	6,80	0,64	0,61	1578,09	2%	9%
UU UMC	C	2665	28017	10,51	1,03	0,99	2756,62	7%	6%
UU UMC	D	2023	29448	14,56	1,55	1,38	3127,37	18%	4%
UU UMC	E	3788	132143	34,88	3,58	3,47	13549,53	50%	2%
UvA AMC	A	2030	4632	2,28	0,21	0,20	431,21	0%	32%
UvA AMC	B	3459	20608	5,96	0,64	0,61	2214,35	1%	9%
UvA AMC	C	3677	35413	9,63	1,07	0,99	3932,22	8%	6%
UvA AMC	D	2396	33863	14,13	1,60	1,38	3834,18	18%	5%
UvA AMC	E	4929	168236	34,13	3,83	3,51	18857,13	52%	2%
VUmc	A	1446	3014	2,08	0,21	0,20	297,99	0%	33%
VUmc	B	2685	17020	6,34	0,65	0,61	1739,24	2%	10%
VUmc	C	2862	29687	10,37	1,08	0,99	3089,43	8%	6%
VUmc	D	2001	28013	14,00	1,55	1,38	3097,88	18%	5%
VUmc	E	3614	135170	37,40	3,76	3,39	13591,28	50%	2%

A clear difference between publishing in top medical journals and top multidisciplinary research journals is shown in **Figures 29** and **30**. The figures also show that there is a clear difference in the way these publications are received, citation wise, in particular for the papers published in the general medicine category. In the figures, the overall average impact per UMC is indicated by the red bars, while the blue bars indicate the average impact of the two sets of publications based on a selection of high profile journals. The percentages in the z-axis indicate the share of the output of the UMCs are covered by both sets of selected journal publications.

In **Figure 29**, the results are shown with respect to publications in four general medicine journals, with a multidisciplinary medical content, **The Lancet, JAMA, the New England Journal of Medicine**, and the **BMJ-British Medical Journal**.
The graph compares the average impact of all output (mcs All) with the average impact of the respective UMCs in these four general medicine top journals (mcs GMJ). Next to this, the share of the output in these four journals as share of the total output of the respective UMCs is expressed as a percentage of the total output.

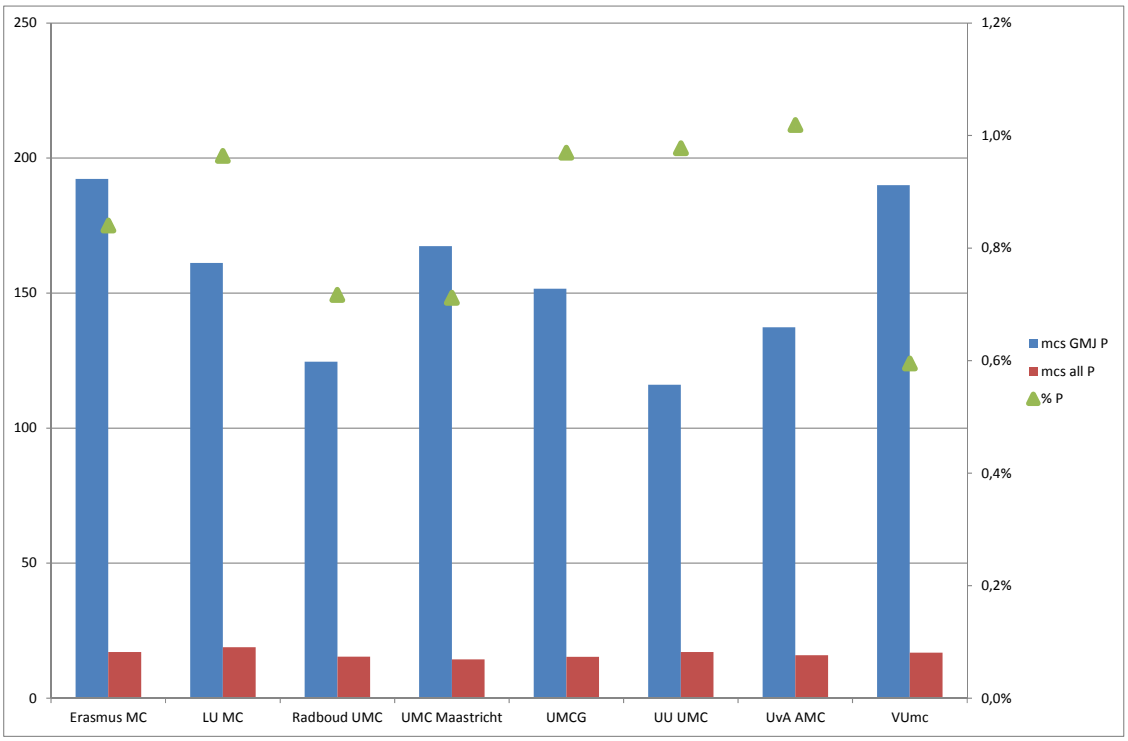


Figure 29: Comparing mean citation score (mcs All) and output shares in four general medicine top journals (mcs GMJ), 2010-2015/2016

Figure 30 contains a similar analysis, in this case focusing on four general multidisciplinary journals: **Science**, **Nature**, and **PLOS-One** and the **Proceedings of the**

National Academy of Sciences of the USA. As in Figure 29, in Figure 30 we present the average impact (mcs MDJ) in these four journals with that of the total output of the respective UMCs (mcs All), again in combination with the percentage of the total output that appeared in these four multidisciplinary top journals.

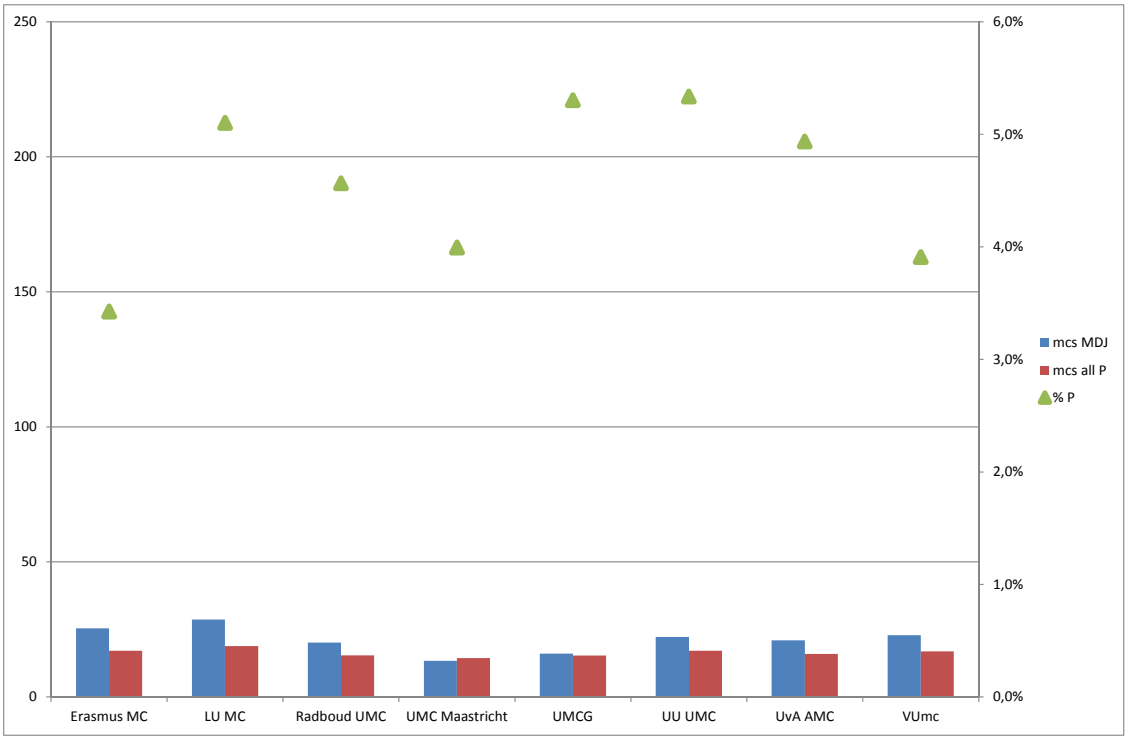


Figure 30: Comparing mean citation score (mcs All) and output shares in four general multidisciplinary top journals (mcs MDJ), 2010-2015/2016

It is important to stress the very high generated by publishing in those four general medicine journals. Average impact scores are exceptional are compared to the multidisciplinary journals, as well as to the overall impact of the Dutch UMCs.

A third bibliometric approach of scientific top research or excellence is shown in Table 3 and **Figure 31**. As indicated before, the top paper analysis can be extended to other parts of the total publication set, and accordingly, other parts of the distribution of impact over publications. Here we present the presence of Dutch UMCs among respectively the top-50%, top-20%, the top-10%, the top-5%, the top-2% and the top-1% most highly cited publications in the fields these centers are active in. In Table 3, we present the output that relates to the actual numbers of publications per UMC within the various sub-sets of the total distribution most highly cited publications in the fields these centers are active in, while **Figure 31** displays these relative outcomes for the eight Dutch UMCs graphically.

Table 2: Overview of the presence of Dutch UMCs in the top-x most highly cited publications, 2010-2015/2016

	p 2010-2015	P in Top 1%	PP(top 1%)	P in Top 2%	PP(top 2%)	P in Top 5%	PP(top 5%)	P in Top 10%	PP(top 10%)	P in Top 20%	PP(top 20%)	P in Top 50%	PP(top 50%)
Erasmus MC	15589,00	467,50	3%	817,41	5%	1852,33	12%	3306,80	21%	5767,05	37%	11014,39	71%
LU MC	11622,00	374,24	3%	639,69	6%	1367,46	12%	2411,29	21%	4169,92	36%	8077,56	70%
Radboud UMC	12834,00	354,57	3%	597,68	5%	1350,92	11%	2494,73	19%	4376,79	34%	8679,99	68%
UMC Maastricht	11239,00	276,80	2%	493,58	4%	1071,90	10%	2009,27	18%	3681,11	33%	7470,00	66%
UMCG	12273,00	348,63	3%	602,37	5%	1336,66	11%	2368,40	19%	4171,72	34%	8301,52	68%
UU UMC	12276,00	344,46	3%	591,17	5%	1393,31	11%	2491,88	20%	4383,07	36%	8549,18	70%
UvA AMC	16491,00	490,63	3%	873,87	5%	1885,62	11%	3355,26	20%	5796,60	35%	11176,63	68%
VUmc	12608,00	340,77	3%	620,16	5%	1372,11	11%	2451,63	19%	4376,47	35%	8674,11	69%

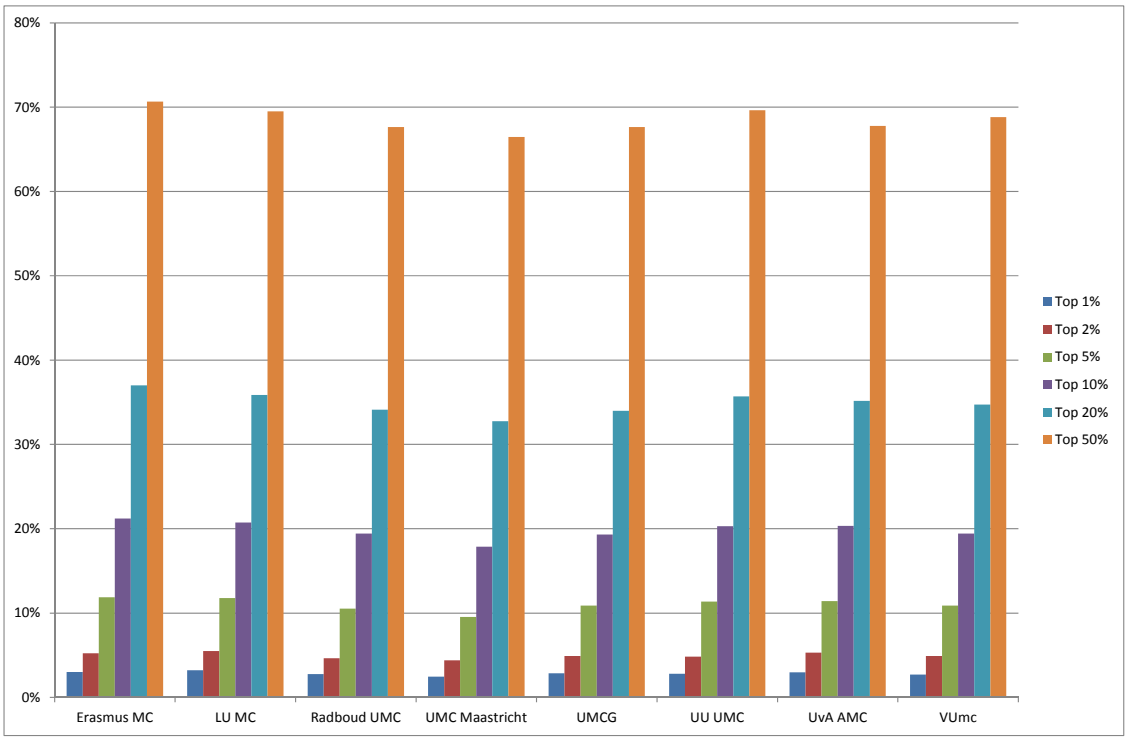


Figure 31: Presence of the Dutch UMCs in Top-50% / Top-20% / Top-10% / Top-5% / Top-2% and Top-1% most highly cited publications worldwide, 2010-2015/2016

Appendix A: Tables underlying the results in the report

Table A-1: Bibliometric statistics of Dutch UMCs, 2004-2015/2016

Erasmus MC								
period	p	tcs	mcs	mncs	mnjs	tncs	Top 10%c	% uncited
2004 - 2015	27207	763536	28,06	1,77	1,61	48240,18	20%	5%
2010 - 2015	15589	266832	17,12	1,86	1,70	28977,93	21%	8%
2004 - 2007	7430	82391	11,09	1,56	1,47	11592,24	18%	12%
2005 - 2008	7769	87257	11,23	1,60	1,49	12396,51	18%	12%
2006 - 2009	8089	92665	11,46	1,67	1,54	13524,01	19%	12%
2007 - 2010	8343	98902	11,85	1,79	1,65	14901,47	20%	10%
2008 - 2011	8636	109481	12,68	1,79	1,65	15483,88	21%	9%
2009 - 2012	9211	119671	12,99	1,85	1,70	17074,29	21%	9%
2010 - 2013	9653	121705	12,61	1,81	1,69	17475,33	21%	10%
2011 - 2014	10136	123878	12,22	1,81	1,65	18337,19	21%	10%
2012 - 2015	11141	143091	12,84	1,89	1,71	21019,64	21%	10%
LU MC								
period	p	tcs	mcs	mncs	mnjs	tncs	Top 10%c	% uncited
2004 - 2015	20311	577043	28,41	1,76	1,59	35655,26	20%	5%
2010 - 2015	11622	219405	18,88	1,86	1,68	21605,84	21%	7%
2004 - 2007	5479	57166	10,43	1,54	1,41	8448,77	18%	12%
2005 - 2008	5881	62480	10,62	1,60	1,44	9438,75	18%	11%
2006 - 2009	6191	70217	11,34	1,64	1,50	10132,23	18%	11%
2007 - 2010	6590	81149	12,31	1,79	1,62	11784,33	19%	10%
2008 - 2011	6797	85907	12,64	1,82	1,67	12346,99	20%	9%
2009 - 2012	7144	94417	13,22	1,83	1,68	13056,19	21%	10%
2010 - 2013	7485	105621	14,11	1,88	1,69	14037,63	21%	9%
2011 - 2014	7655	98544	12,87	1,82	1,64	13962,77	21%	9%
2012 - 2015	8035	104184	12,97	1,83	1,66	14708,66	20%	10%
Radboud UMC								
period	p	tcs	mcs	mncs	mnjs	tncs	Top 10%c	% uncited
2004 - 2015	21280	499913	23,49	1,60	1,49	33953,62	18%	6%
2010 - 2015	12834	197273	15,37	1,71	1,56	21914,25	19%	9%
2004 - 2007	5404	47119	8,72	1,34	1,33	7249,34	14%	13%
2005 - 2008	5672	53588	9,45	1,40	1,37	7952,68	14%	12%
2006 - 2009	5852	59349	10,14	1,52	1,45	8896,76	16%	11%
2007 - 2010	6051	66211	10,94	1,64	1,53	9895,33	17%	11%

2008 - 2011	6613	74650	11,29	1,62	1,53	10734,10	18%	11%
2009 - 2012	7115	81350	11,43	1,65	1,55	11757,58	19%	11%
2010 - 2013	7762	88906	11,45	1,67	1,56	12946,50	19%	10%
2011 - 2014	8279	92839	11,21	1,68	1,56	13949,89	19%	10%
2012 - 2015	9263	103948	11,22	1,73	1,58	16061,15	19%	11%
UMC Maastricht								
period	p	tcs	mcs	mncs	mnjs	tncs	Top 10%c	% uncited
2004 - 2015	19080	462927	24,26	1,55	1,41	29637,41	17%	6%
2010 - 2015	11239	161566	14,38	1,60	1,48	17964,29	18%	10%
2004 - 2007	5183	46620	8,99	1,40	1,27	7273,97	15%	13%
2005 - 2008	5199	49133	9,45	1,40	1,28	7297,57	15%	12%
2006 - 2009	5346	51807	9,69	1,49	1,35	7958,81	16%	12%
2007 - 2010	5477	53549	9,78	1,58	1,41	8644,90	17%	11%
2008 - 2011	5876	57399	9,77	1,59	1,46	9320,64	18%	12%
2009 - 2012	6404	69283	10,82	1,65	1,51	10562,64	18%	12%
2010 - 2013	6779	73743	10,88	1,62	1,50	10981,66	18%	11%
2011 - 2014	7254	75398	10,39	1,56	1,46	11309,03	18%	12%
2012 - 2015	8021	80633	10,05	1,57	1,46	12624,54	18%	13%
UMCG								
period	p	tcs	mcs	mncs	mnjs	tncs	Top 10%c	% uncited
2004 - 2015	19706	439435	22,30	1,60	1,53	31449,97	18%	6%
2010 - 2015	12273	188266	15,34	1,73	1,63	21267,91	19%	9%
2004 - 2007	4501	38198	8,49	1,27	1,25	5725,77	13%	15%
2005 - 2008	4929	41280	8,37	1,30	1,31	6385,42	14%	15%
2006 - 2009	5392	46103	8,55	1,41	1,39	7600,48	16%	13%
2007 - 2010	5837	53857	9,23	1,56	1,50	9086,68	17%	12%
2008 - 2011	6350	64751	10,20	1,63	1,57	10340,17	18%	11%
2009 - 2012	6968	76679	11,00	1,68	1,61	11672,84	19%	11%
2010 - 2013	7536	84889	11,26	1,68	1,62	12673,07	19%	12%
2011 - 2014	8108	87685	10,81	1,67	1,61	13511,72	19%	11%
2012 - 2015	8855	97866	11,05	1,73	1,63	15343,24	19%	12%
UU UMC								
period	p	tcs	mcs	mncs	mnjs	tncs	Top 10%c	% uncited
2004 - 2015	20563	544620	26,49	1,67	1,59	34281,04	19%	5%
2010 - 2015	12276	209458	17,06	1,73	1,66	21289,68	20%	8%

2004 - 2007	5245	52574	10,02	1,51	1,45	7896,74	17%	12%
2005 - 2008	5504	58265	10,59	1,57	1,50	8626,58	17%	10%
2006 - 2009	5824	63201	10,85	1,62	1,54	9451,55	18%	10%
2007 - 2010	6093	69016	11,33	1,71	1,62	10411,01	19%	10%
2008 - 2011	6602	77915	11,80	1,72	1,65	11359,44	19%	9%
2009 - 2012	7320	87300	11,93	1,75	1,66	12817,21	20%	9%
2010 - 2013	7869	97276	12,36	1,75	1,66	13785,84	20%	9%
2011 - 2014	8295	103516	12,48	1,73	1,64	14340,66	21%	9%
2012 - 2015	8716	108895	12,49	1,73	1,65	15050,58	20%	10%
UvA AMC								
period	p	tcs	mcs	mncs	mnjs	tncs	Top 10%c	% uncited
2004 - 2015	26868	648918	24,15	1,68	1,54	45074,13	19%	6%
2010 - 2015	16491	262752	15,93	1,77	1,62	29269,09	20%	8%
2004 - 2007	6460	62677	9,70	1,48	1,38	9578,12	16%	13%
2005 - 2008	6894	68260	9,90	1,53	1,43	10566,84	17%	13%
2006 - 2009	7441	75791	10,19	1,56	1,46	11585,46	17%	13%
2007 - 2010	7962	84946	10,67	1,66	1,53	13240,74	18%	12%
2008 - 2011	8704	93793	10,78	1,65	1,54	14379,07	19%	12%
2009 - 2012	9593	104389	10,88	1,68	1,57	16154,18	20%	11%
2010 - 2013	10332	119782	11,59	1,73	1,60	17860,35	20%	11%
2011 - 2014	10881	123977	11,39	1,72	1,59	18661,76	20%	11%
2012 - 2015	11704	137354	11,74	1,80	1,65	21066,06	21%	11%
VUmc								
period	p	tcs	mcs	mncs	mnjs	tncs	Top 10%c	% uncited
2004 - 2015	19501	516462	26,48	1,68	1,52	32693,96	19%	6%
2010 - 2015	12608	212904	16,89	1,73	1,57	21815,81	19%	9%
2004 - 2007	4479	48751	10,88	1,52	1,39	6791,68	17%	11%
2005 - 2008	4626	50942	11,01	1,53	1,42	7100,25	17%	11%
2006 - 2009	4683	52516	11,21	1,57	1,46	7351,62	18%	10%
2007 - 2010	5143	57390	11,16	1,70	1,57	8726,65	19%	10%
2008 - 2011	5998	67473	11,25	1,70	1,59	10203,02	20%	12%
2009 - 2012	6838	82127	12,01	1,73	1,59	11862,06	20%	11%
2010 - 2013	7806	98439	12,61	1,75	1,60	13636,19	20%	10%
2011 - 2014	8535	100429	11,77	1,68	1,53	14375,02	20%	11%
2012 - 2015	9024	103803	11,50	1,70	1,54	15353,25	19%	11%

Table A-2: Bibliometric statistics of Dutch UMCs, 2010-2015/2016

	p	tcs	mcs	mncs	mnjs	tncs	Top 10%c	% uncited
Erasmus MC	15589	266832	17,12	1,86	1,70	28977,93	21%	8%
LU MC	11622	219405	18,88	1,86	1,68	21605,84	21%	7%
Radboud UMC	12834	197273	15,37	1,71	1,56	21914,25	19%	9%
UMC Maastricht	11239	161566	14,38	1,60	1,48	17964,29	18%	10%
UMCG	12273	188266	15,34	1,73	1,63	21267,91	19%	9%
UU UMC	12276	209458	17,06	1,73	1,66	21289,68	20%	8%
UvA AMC	16491	262752	15,93	1,77	1,62	29269,09	20%	8%
VUmc	12608	212904	16,89	1,73	1,57	21815,81	19%	9%

Table A-3: Bibliometric statistics of Dutch UMCs, Single Institute output, 2010-2015/2016

	p	tcs	mcs	mncs	mnjs	tncs	Top 10%c	% uncited
Erasmus MC	2808	33655	11,99	1,31	1,28	3688,57	15%	9%
LU MC	1957	33504	17,12	1,53	1,35	2996,38	15%	8%
Radboud UMC	2195	25345	11,55	1,22	1,23	2670,22	13%	9%
UMC Maastricht	1380	15592	11,30	1,30	1,25	1800,73	15%	11%
UMCG	2214	21406	9,67	1,15	1,20	2549,95	13%	10%
UU UMC	1936	23483	12,13	1,28	1,28	2470,04	14%	10%
UvA AMC	2460	27832	11,31	1,31	1,28	3212,45	15%	10%
VUmc	1464	18027	12,31	1,23	1,24	1798,74	13%	11%

Table A-4: Bibliometric statistics of Dutch UMCs, International Cooperation output, 2010-2015/2016

	p	tcs	mcs	mncs	mnjs	tncs	Top 10%c	% uncited
Erasmus MC	7782	176095	22,63	2,39	2,06	18616,21	27%	6%
LU MC	5755	138059	23,99	2,36	2,05	13558,76	26%	6%
Radboud UMC	6644	129654	19,51	2,13	1,80	14140,82	25%	7%
UMC Maastricht	6303	108201	17,17	1,88	1,64	11829,15	21%	9%
UMCG	5698	117501	20,62	2,30	2,01	13128,51	26%	8%
UU UMC	5586	127949	22,91	2,26	2,04	12623,55	27%	6%
UvA AMC	8083	168838	20,89	2,27	1,94	18332,11	26%	7%
VUmc	5987	134873	22,53	2,20	1,85	13191,33	25%	7%

Table A-5: Bibliometric statistics of Dutch UMCs, primary authorship output, 2010-2015/2016

	p	tcs	mcs	mncs	mnjs	tncs	pp_top_perc	pp_uncited
Erasmus MC	12011	170800	14,22	1,55	1,50	18595,83	18%	8%
LU MC	8278	116064	14,02	1,46	1,41	12050,33	17%	8%
Radboud UMC	9388	124420	13,25	1,44	1,38	13565,12	17%	9%
UMC Maastricht	8628	106881	12,39	1,38	1,33	11902,07	16%	10%
UMCG	9234	111333	12,06	1,36	1,37	12517,75	15%	10%
UU UMC	9519	139150	14,62	1,50	1,47	14232,16	17%	8%
UvA AMC	12300	163746	13,31	1,50	1,43	18499,44	18%	9%
VUmc	9270	123873	13,36	1,45	1,38	13483,32	17%	9%

Appendix B: Overview of the bibliometric indicators of CWTS

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Overview of bibliometric indicators

P	Number of papers (normal articles, letters, and reviews) published in journals processed for the Web of Science (WoS).
TCS	Number of citations recorded in WoS journals to all papers involved. Self-citations are excluded.
MCS	Average number of citations per publication, or citation per publication ratio. Self-citations are excluded.
MNCS	The impact of a research unit's articles, compared to the world citation average in the subfields in which the research unit is active.
TNCS	The output multiplied by the average normalized impact, an indication of the volume/impact of a unit (referred to as '*Brute Force*' indicator).
MNJS	The impact of the journals in which a research unit has published (the research unit's journal selection), compared to the world citation average in the subfields covered by these journals.
PP(uncited)	Percentage of articles not cited during the time period considered.
%Self Cit *	Percentage of self-citations. A self-citation is defined as a citation in which the citing and the cited paper have at least one author in common (first author or co-author). Percentages of self-citations are relatively stable over time, and based on our many years of experience in conducting these type of bibliometric studies, normally tend to fluctuate between 20-40%, within a four/five year period.
PP(top 10%)	The share of the number of papers that are among the 10% most frequently cited of all similar papers in the period 2004-2015/20156
Int Cov*	This indicates the degree to which a unit refers themselves to the literature covered in the WoS. The reference behavior of a unit thus indicates whether the journal literature is important for the scholarly communication in a field, and as such can be interpreted as indicator of the applicability of bibliometrics in an assessment context. As we have seen form previous analyses, in the biomedical and life sciences domain this internal coverage tends to be quite high (above 90%), which indicates that this type of bibliometric studies can be relatively of importance in informing peers assessing research performance in this domain.

* *Both the* ***% Self citations*** *as well as the* ***Internal Coverage*** *indicators are not further displayed in this report. The main reason for inclusion here is their appearance in the UMC specific reporting, as on lower levels of aggregation these indicators might be more meaningful. On the level of the whole UMC, the self-citation rates are relatively stable, and low, while on that same level the internal coverage indicator is of lesser value, as the WoS database covers biomedical research very well.*

Appendix C: Explanation of the bibliometric indicators of CWTS

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1. Data collection

1.1 Introduction

Bibliometrics is the quantitative study of written products of research. It is assumed that scientific subjects develop at an international research front (Price, 1963). Research results are communicated in publications that are submitted to evaluation by professional colleagues. In the references of their papers, scientists acknowledge relevant publications by others, as they build on previous work. Therefore, the number of times a publication is referred to gives a partial indication of the 'impact' of a publication, its reception and use by scientists at the research front.

In nearly all scientific fields, the scientific journal is by far the most important medium of communication. The Web of Science database (from here on WoS), which consists of the citation indexes known under acronyms such as SCI, SSCI and A&HCI claims to cover the most important 'leading' international journals and serials (such as Annual Reviews) with a well-functioning referee system. In addition, the overall citation rate of journals is considered, as well as their timeliness of publication, and adherence to international editorial conventions. Regularly, a limited number of new journals are added, while other journals are no longer covered. More 'peripheral' journals, often national in scope, are usually not covered by the CI. The WoS counts about 11,000 journals during the last decade.

Both statistical requirements and imperfections in the citation process (for a discussion see Nederhof, 1988) make it desirable to aggregate across individuals, publications, and citations. As scientific (sub)fields differ in publication and citation patterns (as visible in differences in for example length of reference lists, or age of cited literature), it is usually not meaningful to compare directly the raw impact of publications from one (sub)field with those of a different (sub)field. Therefore, in our studies raw impact scores are compared to the impact of similar publications within the same journal, or within the same (sub)field.

We start this final section of the introduction with a few general comments on the use of bibliometric indicators for the assessment of research performance. It is our experience in previous studies on research performance in the natural and life sciences, medicine, the humanities, and in the social and behavioral sciences, that bibliometric indicators provide useful information to a peer review committee evaluating research performance.

These studies revealed a fair correspondence between the results of bibliometric analyses on the one hand, and judgments on scientific quality by peers on the other hand. In our view, a quality judgment on a research unit, department or institute can only be given by peers, based on a detailed insight into content and nature of the research conducted by the group or institute in question. The citation-based indicators applied in this study, measure the impact at the short or middle-long term of research activities at the international research front, as reflected in publication and citation patterns. ***Impact and scientific quality are not necessarily identical concepts***.

Bibliometric indicators cannot be interpreted properly without background knowledge on both the research units that are evaluated, and the subfields in which the research units are active. In fact, in previous studies we have encountered a few cases in which a bibliometric indicator pointed in one direction (e.g., a low impact), while statements by peers or even other indicators pointed in another direction (e.g., a high quality). Analyzing such discrepancies from a bibliometric point of view, specific limitations related to the bibliometric methodology applied in the study in question may be identified. While in most cases such limitations do hardly affect the results or have no effect at all, in exceptional cases the bibliometric outcomes may provide an incomplete or even distorted picture. For instance, the classification of journals into subfields ('journal categories') may be less appropriate for some research units, particularly when they are active in topics of a multidisciplinary nature. Then, in the calculation of the impact compared to the world subfield citation average, this world average may not be representative for the subfield in which such a research group or institute is active. If there are strong indications that the definition of the (sub)field in terms of WOS journal categories is inadequate, then the journal-based world average (***JCSm***) is more appropriate. In particular, this latter case pertains to developing new interdisciplinary fields.

A second limitation concerns the coverage of the Citation Indices (CI). In specific subfields, particularly in applied or technical sciences, the WOS coverage may be less adequate. Consequently, for research units who are active in such technical/applied subfields, the bibliometric results may provide an incomplete picture. A second point concerns non-WOS publications (e.g., articles in journals that are not or no longer covered by CI). For a number of research units, valuable additional information may be obtained by retrieving impact data for non-WOS publications.

Another example of a limitation of bibliometric analysis relates to time delays. It may take several years for a collection of papers to generate a high impact. We have analyzed research units that had generated only a moderate impact at the time. Confronted with the bibliometric results, several peers stated that these research units had recently made important contributions to the field. When we updated the results after a few years, several research units indeed showed a sharply rising impact curve.

We do not wish to imply that all discrepancies between bibliometric indicators and peer judgments are necessarily due to problems or limitations of the bibliometric methods applied. Equally, it would not be appropriate to attribute such discrepancies only to peers expressing incorrect or biased views on the scientific quality of a research unit. Still reasoning from the point of view of the bibliometrician, discrepancies between bibliometric indicators and peer judgments often constitute a research problem in itself and often, a considerable effort is required to examine a discrepancy in sufficient detail.

Nevertheless, also peer review has its disadvantages (van Raan 1996). ***Therefore, the appropriate combination of peer-based qualitative assessment and quantitative, particularly bibliometric indicators appears to be the most successful approach in order to reinforce objectivity, transparency, comparability and reproducibility in the assessment of research performance.***

1.2 Specifics on data collection

The present study relates to the publication output of the UMCs at Dutch universities. The UMCs supplied publication lists to CWTS, which were matched with the CWTS in-house bibliometric data-system. The bibliometric analysis is covering the period 2004-2015/2016 for all eight UMCs. This study is an update of the study conducted in 2015/2016, for the update CWTS was supplied with the year 2015 as an additional year to the data collected for the previous studies.

Actually, the publication data collected in this study are publication years: papers are included for the year in which they were published in the journal, which does not necessarily coincide with the moment the publications are processed for the WoS. While last year's analysis contained an update for three UMCs output from the past, this year the data collection was limited again to the addition of the output of the year 2015.

We considered only papers classified in the WoS as normal articles and reviews, published in source serials processed for the WoS database. Please note that in the

analysis of this year, in comparison with the previous study, letters are excluded. Other document types, such as meeting abstracts, 'editorials', 'editorial material', corrections, comments, and book reviews were also not included (for an analysis of letters in particular biomedical journals, see van Leeuwen et al, 2007, and for a discussion on editorials in bibliometric analysis, see van Leeuwen et al, 2013). Also, papers in non-WoS source journals are not counted. A few journals are only partially processed for the WoS. Here, only papers processed for the WoS were included.

A statement needs to be made on a specific type of articles in the WoS database. This concerns the articles published in journals, but forthcoming from a scientific conference. These regular journal articles were in 2008 re-classified as proceedings papers, but after a short while, realizing this was an error, this was changed again in to article/proceeding paper. For this study, this does not influence the results, as we still consider these publications as regular journal articles, and are treated as such. In the future, when the CWTS WoS database also contains proceedings publications, a new situation arises, and adequate steps will be taken to handle these new document types correctly (for a report of this issue see Gonzalez-Albo & Bordons, 2011).

1.3 Explanation of the citation impact measurement

In the standard tables, we apply the method in which citation impact is measured for five year maximum in block of publication years of four year maximum. This works as follows: for the first year in a four year block the impact is measured for five years, for the next year in the block we apply a four year citation window, for the third year in the block we apply a three year citation window, and for the last year in the block we apply a two year citation window. As an example, for the publication years 2004-2007, we apply a citation window that stretches the period 2004-2008, with a five year citation window 2004-2008 for the papers of 2004, a four year citation window of 2005-2008 for the 2005 publications, a three year citation window (2006-2008) for the year 2006, and finally a two year citation window (2007-2008) for the 2007 publications. This moves through time like roof tiles, in which the next period overlaps the previous. This approach has several advantages, namely in the first place the full usage of all publication years in the analysis in a similar fashion, which creates a consistent approach, and secondly, the aspect that publications contribute to each block in a different way, maturing in time, and overall creating a more smooth development of research impact measurements. With respect to this latter aspect, we have to stress that due to smaller output numbers, on lower levels of aggregation (such as projects or small teams), these outcomes tend to fluctuate more as compared with output numbers

related to aggregates on higher levels (universities, UMCS, or divisions within UMCS). This approach is also used for the longer periods analyzed in the study (2004-2015/2016 and 2010-2015/2016). In the case of the former period, we measure the full impact of publications from 2004 up and until 2016, that is, covering 13 years, and covering seven years for the 2010 publications. In the case of the latter period, the first year measured is 2010, with a seven year citation window, and the last year is 2015, with a two year citation window (2015-2016).

2. Bibliometric indicators

2.1 Output and impact indicators

We calculated the following indicators. The numbering of the indicators corresponds to the position these indicators have in the data tables.

A *first* statistic gives the total number of papers published by the research unit during the entire period ***(P)***. We considered only papers classified as *normal articles* and *reviews*. Letters, meeting abstracts, corrections, and editorials are *not* included. In a few cases, a paper is published in a journal for which no citation data are available, or that is not assigned to a CI journal category. These papers are not considered in the calculation of the indicators presented in the tables below.

The next indicator gives the total number of citations received, without self-citations (***TCS***). In the calculation of all our impact indicators, we disregard author self-citations. We classify a citation as an author self-citation if the citing publication and the cited publication have at least one author name (i.e., last name and initials) in common. In this way, we ensure that our indicators focus on measuring only the contribution and impact of the work of a researcher on the work of other members of the scientific community. Sometimes self-citations can serve as a mechanism for self-promotion rather than as a mechanism for indicating relevant related work. The impact of the work of a researcher on his own work is therefore ignored. As an indication of the self-citation rate we present the percentage of self-citations ***(% Self Cit***), relative to the total number of citations received (***Self Cit***)).

A next indicator is the average number of citations per publication calculated while self-citations are not included (***MCS)***.

Another indicator is the percentage of articles not cited during the time period considered (***PP(uncited)***), excluding self-citations.

Main indicators

The overall field normalized impact indicator for an institute output is ***MNCS***, the Mean Normalized Citation Score. As this indicator focuses on the broader environment of the group's output, this indicator seems the most suitable indicator of the international position of a research unit. Our mean normalized citation score indicator, denoted by MNCS, provides a more sophisticated alternative to the MCS indicator. The ***MNCS*** indicator is similar to the MCS indicator except that a normalization is being applied to correct for differences in citation characteristics between publications from different scientific fields and between publications of different ages (in the case of a variable-length citation window). To calculate the ***MNCS*** indicator for a unit, we first calculate the normalized citation score of each publication of the unit. The normalized citation score of a publication equals the ratio of the actual and the expected number of citations of the publication, where the expected number of citations is defined as the average number of citations of all publications in WoS belonging to the same field and having the same publication year. The field to which a publication belongs is determined by the micro-clusters to which the publication is attributed (see the Leiden Ranking website for an explanation of this methodological aspect, http://www.leidenranking.com/information/fields).

The ***MNCS*** indicator is obtained by averaging the normalized citation scores of all publications of a unit. If a unit has an ***MNCS*** indicator score of one, this means that on average the actual number of citations of the publications of the unit equals the expected number of citations. In other words, on average the publications of the unit have been cited equally frequently as publications that are similar in terms of field and publication year using the same citation window.

The MNCS (mean normalized citation score) indicator is defined as

$$\mathrm{MNCS} = \frac{1}{n}\left(\frac{c_1}{e_1} + \frac{c_2}{e_2} + \ldots + \frac{c_n}{e_n}\right).$$

An ***MNCS*** indicator score of, for instance, 2 means that on average the publications of a unit have been cited twice as frequently as would be expected based on their field and

publication year. We refer to Waltman, Van Eck, Van Leeuwen, Visser, and Van Raan (2011a and b) for more details on the ***MNCS*** indicator.

A second important indicator, ***MNJS***, is above (below) 1.0 if the citation score of the journal set in which the research unit has published exceeds the citation score of all papers published in the subfield(s) to which the journals belong. In this case, one can conclude that the research unit publishes in journals with a relatively high (low) impact.

2.2 Research profiles: analysis of disciplinary orientation

The disciplinary orientation or research profile of a research center is analyzed by classifying its papers according to scientific (sub-)fields. In the WoS, publications are classified by means of the journal in which they appear into (sub-)field categories such as 'Genetics & heredity', 'Oncology', 'Virology, and so on. These WoS journal subject categories are attached to each publication of a research unit. Subsequently, these publications are aggregated for each WoS subfield, and output and impact indicators are computed separately for these aggregates. The purpose of this procedure is to show how frequently a center has published papers in various subfields of science, what and how the impact of the center is in its main subfield(s) of activity.

If a paper appears in a journal that is classified in more than one subject category, the paper (and its citations) is proportionally distributed over the subject categories. Thus, a paper with 7 citations published in a journal categorized in three subject categories is counted as 0.33 publication with 2.33 citations in each subject category.

As an indication, if the ratio ***MNCS*** is lower than 0.8, the impact is said to be 'low' (graphically indicated by a 'lightest colored' bar), if the ratio is higher than 1.2, the impact is designated as 'high' (graphically indicated by a 'dark colored' bar), while a ratio between 0.8 and 1.2 is called 'average' (subsequently indicated by a 'light colored' bar).

It is important to realize that although the profile display the journal categories used in WoS, the impact computed for such a selection of journals is based on the micro-clusters, as described in the section on how MNCS is calculated. So the output is organized in well-known fields and specialties, while the impact is calculated on more advanced methodology.

Due to ongoing complaints from academics on the way we dealt with the WoS subfield "Multidisciplinary sciences/journals" (which consists of the main multidisciplinary top journals nature, Science, P NAS US and PlosONE, next to many journals of more average impact)), CWTS has decided to solve this is such a way that publications in the journals

in this WoS field are added to the WoS subfields these publications could be attributed to on the basis of the cognitive relations these publications have with the literature around them, based upon citation relations. This means that this WoS field as such becomes very small, setting the field under the 1% threshold for display in the research profiles. However, there is attention for the main journals in the field by a separate analysis described under the top research section of the report.

2.3 Analysis of scientific collaboration

The analysis of the various types of scientific cooperation is based upon a typology of papers, which is based on the addresses attached to the publications. In case of the paper carrying only one address, the publications is automatically labeled as a single institute publication. In case of the appearance of at least two different country names on one publication, the publication is automatically considered an international cooperation. The remaining set of publications, carrying two or more addresses within one country, are considered to be the result of national cooperation.

Any classification such as this one has some drawbacks. For example, the typology applied has the disadvantage that in the case of international cooperation publications, if a paper also carries two addresses from one country, the international dimension is the dominant factor in labeling the publication. Furthermore, in case of publications labeled as national cooperation, it can happen that these are actually two addresses of one and the same main institution, which makes it an intra-mural cooperation. However, the typology has been designed in order to have mutually exclusive classes thus simplifying the analysis of collaboration networks. (the strength of such typology is clearly visible through an analysis of international scientific cooperation links, see van Leeuwen, 2009)

2.4 Journal impact profiles: journal to field impact of Dutch UMCs

In this analysis we have changed the focus to the choice of the journals in which the researchers in the UMCs published their findings. In a similar way of presenting the research profiles, we now indicate the impact per field not by using the field normalized impact indicator ***MNCS***, but apply the ***MNJS***, to indicate the impact level of the journals (in their respective field(s)) in which the researchers have published their output in the period of analysis.

2.5 Top paper analysis

In addition to the ***MNCS*** indicator, we use another important impact indicator. This is the proportion of publications belonging to the top 10%most highly cited, denoted by PP(top 10%). For each publication of a research group, we determine whether it belongs to the top 10% based on its number of citations of all WoS publications in the same field (i.e., the same WoS subject category) and from the same publication year. The PP(top 10%) indicator of a research entity equals the proportion of its publications belonging to this top 10%. If a research group has a PP(top 10%) indicator of 10%, it means that the actual number of top 10% publications of the group equals the expected number. A PP(top 10%) indicator of, for instance, 20% means that a group has twice as many top 10% publications as expected. Of course, the choice to focus on top 10% publications is somewhat arbitrary. Next to the PP(top 10%) indicator, we also calculate PP(top 1%), PP(top 2%), PP(top 5%), or PP(top 20%) and PP(top 50%) indicators. In the main tables, we use the PP(top 10%) indicator. The other PP(top *x*%) indicators are presented as a separate analysis in the study.

2.6 Coverage of a bibliometric analysis

Finally, the indicator ***Int Cov*** shows the degree of the total set of references of a unit referring back to the WoS database, thereby indicating the degree of relevance of that WoS covered literature for the communication processes in the field(s) in which the unit is active. A high score means that many references point directly towards the WoS database, and thus that WoS literature is important for the communication process of the unit. This indicates the relevance of the application of bibliometric techniques in the research assessment of the unit. By inclusion of this indicator in the standard tables, we hope to put the scores in the respective data lines in context (as low scores clearly indicate the extra care one should take in interpreting the results presented in the table).

2.7 Basic elements of bibliometric analysis

All above discussed indicators are important in a bibliometric analysis as they relate to different aspects of publication and citation characteristics. Generally, we consider ***MNCS*** as an important indicator for analyzing research performance. This indicator relates the measured impact of a research group or institute to a worldwide, field-specific reference value. Therefore, it is a powerful internationally standardized impact indicator. This indicator enables us to observe immediately whether the performance of

a research institute/group or institute is significantly far below (indicator value < 0.5), below (indicator value 0.5 - 0.8), about (0.8 - 1.2), above (1.2 - 2.0), or far above (>2.0) the international (western world dominated) impact standard of the field. The higher the aggregation level, the larger the volume in publications and the more difficult it is to have an average impact significantly above the international level. At the 'meso-level' (e.g., a large institute, or faculty, about 500 – 1,000 publications per year), a ***MNCS*** value above 1.2, could be considered that the institute's impact as a whole is significantly above (western-) world average. Therefore, it is important to split up large institutes into smaller groups (e.g. through the specific analysis of the different UMCs). Only this allows a more precise assessment of research performance. Otherwise, excellent work will be 'hidden' within the bulk of a large institute or faculty. We stress that the other indicators provided in the tables, such as PP(uncited) or %Self Cit do contribute to a further understanding of the research performance analysis of units under study. Together these indicators tend to inform the user of bibliometrics on a variety of aspects in research performance analysis.

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