



The state of medical physics in Brazil demonstrated by research groups publications: an analytical example of bibliometrics used to investigate a scientific field

O estado da física médica no Brasil por meio das publicações de grupos de pesquisa: um exemplo analítico do uso da bibliometria para investigar um campo científico

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RESUMO

Este artigo aborda a condição de construção paradoxal do campo da Física Médica (FM) no Brasil através da análise de sua produção científica. Portanto, o objetivo é levantar o estado da arte da FM brasileira e a metodologia foi baseada em ferramentas de *webscrapping* e análise quantitativa e qualitativa para coletar e analisar dados em bancos de dados públicos e abertos que são referência em divulgação e comunicação tecnocientífica. Os resultados apontam para o fato de que as áreas da medicina e da física produziram em sua sobreposição um campo cujo conhecimento não necessariamente contribui para a consolidação de um suposto campo ou área independente da FM.

Palavras-chave: Física Médica; Educação Superior; Grupos de Pesquisa; Bibliometria.

ABSTRACT

This paper addresses the paradoxical construction condition of the Medical Physics (MP) field in Brazil through an analysis of scientific production. Therefore, the objective is to understand the state of art of Brazilian MP and the methodology was based on webscrapping and quantitative and qualitative analysis tools to collect and analyze data in public and open database that are reference in dissemination and technoscientific communication. The results point to the fact that the areas of medicine and physics produced in their overlap a field whose knowledge does not necessarily contribute to the consolidation of a supposed field or area independent of MP.

Keywords: Medical Physics; Higher Education; Research Groups, Bibliometrics.

INTRODUCTION

For almost thirty years, the disciplinary field of Medical Physics (MP) in Brazil has been training professionals, legitimizing their respective scientific and professional scenario. At least this has been the expectation of many people, especially those involved in the training process. There are, however, unsolved questions and evidences that medical physicists still experience perplexities as to their place of both

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action and speech in the field where today the monopoly of discourse belongs to the physician. Physicists without specific training and not acting in this dimension/territory of interlocution and interaction with the field of health. Our hypothesis is that its promotion becomes impracticable due to the perennial irresolution between its spokespersons and the non-consolidation of Medical Physics in the scientific areas' classification, leading to a deficit of production within this scope, not generating a claim on this possible interdiscipline.

Brazilian science historically goes hand in hand with public universities, despite the lack of investment in science and technology (S&T) (CHAIMOVICH, 2000). This panorama experienced a kind of renovation in the decade of 2000 with the increase of investments in the expansion of public higher education. And it was in this context that the first undergraduate courses in Medical Physics were created and received their first class of students.

In a scenario as plural as that of Brazilian science, criteria for the identification of areas and subareas become necessary in order to better manage the distribution of the resources of public development agencies. Thus, these agencies have a mechanism of classification of the areas of scientific knowledge in the form of a set of terms organized in a tree of knowledge format in which it considers all fields of research, scientific, and technological production in Brazil (“Árvore do conhecimento - Plataforma Lattes - CNPq” n.d.). In the case of Medical Physics, it should be remembered that its limits and borders seem to deal with a certain imprecision, since their respective researches and productions are sometimes found in the shadow of areas already consolidated, such as physics and medicine. While medical physics does not constitute itself as an area or discipline, it is not at the base of the National Council for Scientific and Technological Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq) circumscribed in any of these two already consolidated. The diagnosis presented here in this paper presents a way to elucidate this asymmetry and to problematize it in the face of the Brazilian S&T scenario.

In order to complement the proposed theoretical-conceptual approach, where Bourdieu with his sociology of the scientific field is constituted as the basis for epistemological reflection of the disciplinary field in formation, already formed and in struggle for legitimation, it seems that his idea of "field" is fundamental (2004, p. 68).

The field notion also destroys all kind of common oppositions, beginning by an opposition between consensus and conflict, and, although ends with the naively idealistic view of the scientific world as a solidarity community or “kingdom of the purposes” (in the sense of Kant), opposes to the very partial view of the scientific life as “war”, *bellum omnium contra omnes*¹, that the own scientists sometimes evoke (when, for example, characterize some of them as “murderers”): the scientists have in common characteristics that, in certain aspects, join them and, in other aspects, separate them, divide them, opposes them – purposes, for example, even the more noble, as to find the truth or fight the error – also all that determines and allows the competition, as the common culture, which also is a gun in scientific struggles. The researchers, like the artists and the writers, are united by the struggles that oppose them, and the own alliances that can unite

¹ From Latin: "Bellum omnium contra omnes"

them always have something to do with the positions that they occupy in these struggles.

In this reflexive exercise, still questioning the existence or not of this "non-place" of medical physics, we chose to study the formation of medical physicists to understand why the scenario is presented in this way. And understanding their questions and their singularities (with their gaze starting from the formation), we would have elements to understand the disputes and/or violence (symbolic, in the Bourdieu sense) that are given or not in the academic environment and, thus, to realize what Bourdieu calls praxiology of the professional field.

To be considered with scholarships for academic research or technological development, or other resources offered by public development agencies (and ultimately to enable the production of scientific knowledge), it is necessary (among many bureaucratic procedures) to choose an area of knowledge that characterizes the proposed work to peer appreciation, in the respective chosen area. In this sense, it is shown here that classification is a necessary action to maintain knowledge (since it locates and guides practices in and around it) and, in this sense, the problem arises: where is medical physics?

The term 'Medical Physics' does not appear in any table with the breakdown of areas of knowledge of any scientific agency². In the Coordination of Improvement of Higher Level Personnel (CAPES), for example, it is considered a subarea, although it appears in some searches as a specialty (MINISTÉRIO DA EDUCAÇÃO (MEC), 2001). In this scope, project evaluators can, therefore, be listed, by means of a system that ignores the existence of medical physics, from diverse areas and specialties; some with little or no familiarity with the praxis of medical physics.

The *International Labour Organization* (ILO) updated in 2012, the *International Standard Classification of Occupations* (ISCO-08) (INTERNATIONAL LABOUR ORGANIZATION, 2012), providing a system of classification and aggregation of occupational information obtained through census and statistical surveys, and administrative records. In this update, it was added that "(...) medical physicists are considered an integral part of the health workforce alongside the occupations classified in the main subgroup 22, Health Professionals (...)" (INTERNATIONAL ORGANIZATION FOR MEDICAL PHYSICS (IOMP), 2008). What may seem a mere question of nomenclature, made it possible to create residency courses in medical physics (MINISTÉRIO DA SAÚDE, 2013) (a lato sensu postgraduate course), according to the medical residencies, with pre-established hours of work, common basic cycle and uniform remuneration throughout the national territory. Proving therefore that the classification is determinant in the actions in relation to what is classified changing conduits.

The definition of "non-place" is a concept proposed by Marc Augé (2010) to designate a space incapable of forming any kind of identity, that is, any space that serves only as a transition. Such contextualization applies to our questioning in this work on the "non-place" that Medical Physics occupies as a field. Since to be recognized as such it needs to have productions in the area (generating scientific knowledge), training professionals and their members need to recognize each other as peers. There are, in

² Faperj – general index of areas in <<http://www.faperj.br/?id=50.4.7>>; CNPq – table of areas of knowledge in <<http://www.cnpq.br/documents/10157/186158/TabeladeAreasdoConhecimento.pdf>> and CAPES - table of areas of knowledge / evaluation in <<http://www.capes.gov.br/avaliacao/instrumentos-de-apoio/tabela-de-areas-do-conhecimento-avaliacao>>

Brazil, isolated groups that already fulfill these three conditions, but they are very few or exist in little cohesive form. Without an effective place of knowledge production with peer recognition, the field of medical physics tends to merge with others or even to be extinguished (SCHNEIDER, 2015).

The central question of this discussion is that the demarcation of the field of medical physics, necessary for the transition from this "non-place" to a "place", will be defined, mainly, by the production of the exclusive knowledge of this field and by its aegis, in practice.

MATERIALS AND METHODS

For this work, a quantitative-qualitative analysis of the Lattes curricula³ of the participants of the research groups registered in the directory of Brazilian research groups (Lattes - CNPq) with the term 'Medical Physics' in the name of the group was done. Thus, the information accessed therein is certified by the research and teaching institutions, giving validity to the data collected during this research.

Here, medical physics was marked as a field, but the imprecision of its definition as an area/field/specialty in these sought-after locations shows that the guidelines of the survey and information become central to a critical analysis of its real condition in the scientific, academic, and educational worlds.

For the processing of the data collected for analysis, we used ScriptLattes (MENA-CHALCO; JUNIOR, 2013), a free software tool designed for extraction and automatic compilation of bibliographic, technical and artistic productions, orientations, research projects, prizes and titles, that generates collaborative graphs from a set of researchers registered on the Lattes platform (MENA-CHALCO; JUNIOR; MARCONDES, 2009).

The active research groups registered in the directory of Brazilian research groups (Lattes - CNPq)⁴, certified by the institution of origin, were studied. Eight groups were found that fulfilled these inclusion criteria, according to the table below.

Table 1 - List of research groups that contain the term 'medical physics' in their name.

INSTITUTION	GROUP	PREDOMINANT AREA	LEADERS UNDERGRAD COURSE
Universidade de São Paulo	Dosimetria das radiações e física médica (group 1)	Exact and Earth Sciences	Physics
Universidade Estadual de Campinas	Engenharia biomédica e física médica (group 2)	Engineering	Computer Science and Electrical Engineering

³ The Lattes Platform is an information system (integrated data-base, web-based query interface, etc.) maintained by the Brazilian Government to manage information on science, technology, and innovation related to individual researchers and institutions working in Brazil (MENA-CHALCO; JUNIOR; MARCONDES, 2009).

⁴ In: < <http://lattes.cnpq.br/web/dgp> > Access in January 26 2018.

Universidade Federal de Sergipe	Física médica (group 3)	Exact and Sciences	Earth	Physics
Universidade do Estado do Rio de Janeiro	Física médica (group 4)	Biological Sciences		Physics
Universidade Federal do Sul e Sudeste do Pará	Física médica aplicada (group 5)	Exact and Sciences	Earth	Physics
Universidade Estadual do Sudoeste da Bahia	Física médica e nuclear aplicada (group 6)	Exact and Sciences	Earth	Physics
Universidade Estadual de Santa Cruz	Núcleo de física médica e ambiental (group 7)	Health Sciences		Physics
Comissão Nacional de Energia Nuclear	Pesquisa em física médica (group 8)	Engineering		Physics

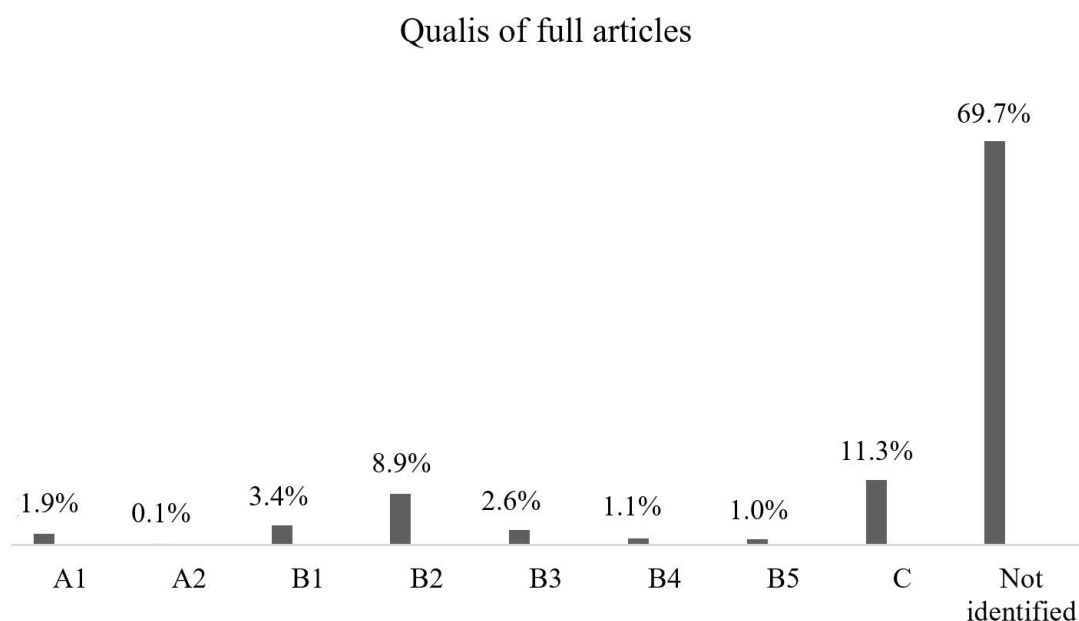
RESULTS

In the period from 2007 to 2017, researchers from the groups cited in Table 1 (111 individuals in total) generated 4864 bibliographic productions distributed between full articles published in journals (1183), published/edited books (37), chapters of published books (134), articles in newspapers/journals (60), complete papers published in congressional proceedings (610), expanded abstracts published in congressional proceedings (242), abstracts published in congressional proceedings (1152), articles accepted for publication (23), presentations of work (1335) and other types of bibliographic production (88). It is noted that the distribution between work presentations (27.4%), complete articles published in journals (24.3%) and abstracts published in congressional proceedings (23.7%) are more balanced, perhaps showing a certain preference for disclosure of their results in congresses.

We also searched the Qualis classifications of the researchers' publications of the research groups studied here, as shown in Fig. 1. Qualis is a system used to classify the scientific output of postgraduate programs in relation to articles published in scientific journals. This process was designed to meet the specific needs of the evaluation system and is based on the information provided through a specific application provided on the Sucupira platform (sucupira.capes.gov.br). As a result, it provides a list with the classification of the vehicles used by the graduate programs for the dissemination of their production⁵.

⁵ In <https://sucupira.capes.gov.br/sucupira/public/index.xhtml>

Fig. 1 - Qualis of the full articles published in journals by researchers of the medical physics research groups from 2007 to 2017. Made with Microsoft Excel



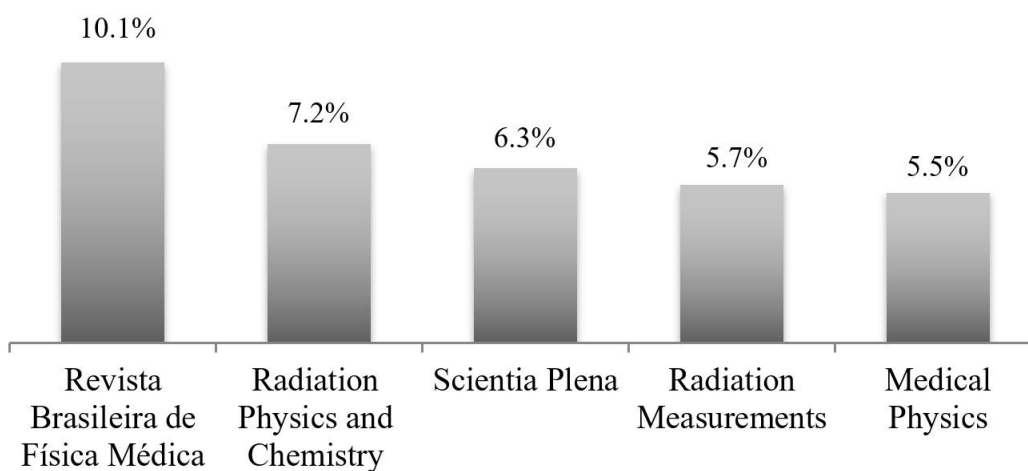
In order to evaluate the publication of the professionals selected by this study, a cut of complete publications in periodicals of medical physics was made to verify if they publish in such magazines. In medical physics journal, the term "medical physics" (not necessarily in Portuguese) in the title or has the words "physical and" medical (or "biomedical" or "medicine") in the title, or those in whose scope publish articles of medical physics. In addition, any material published by a national association of medical physicists is qualified for inclusion. It could be argued that there are other areas that would contemplate this subject, but the criterion mentioned above was used. It is understood that journals that have "medical physics" in their name, in scope or published by associations of this class are unequivocally the most suitable for publications in this field. more adequate to understand a "portrait" or the "state" of scientific production in Medical Physics. For each institution evaluated, publications of the professionals studied in these journals were searched.

We found 1183 articles in journals for all 11 researchers from the selected research groups. Among these, there were 481 (40.7%) articles with themes related to medical physics and only 84 (7.1%) productions published in previously selected journals.

Figure 2 below shows the five scientific journals that have the largest number of complete articles published by this group (only those journals with more than 5% of the publications were plotted). Another important finding observed in the list of publications is that 11% of these were published in medical journals.

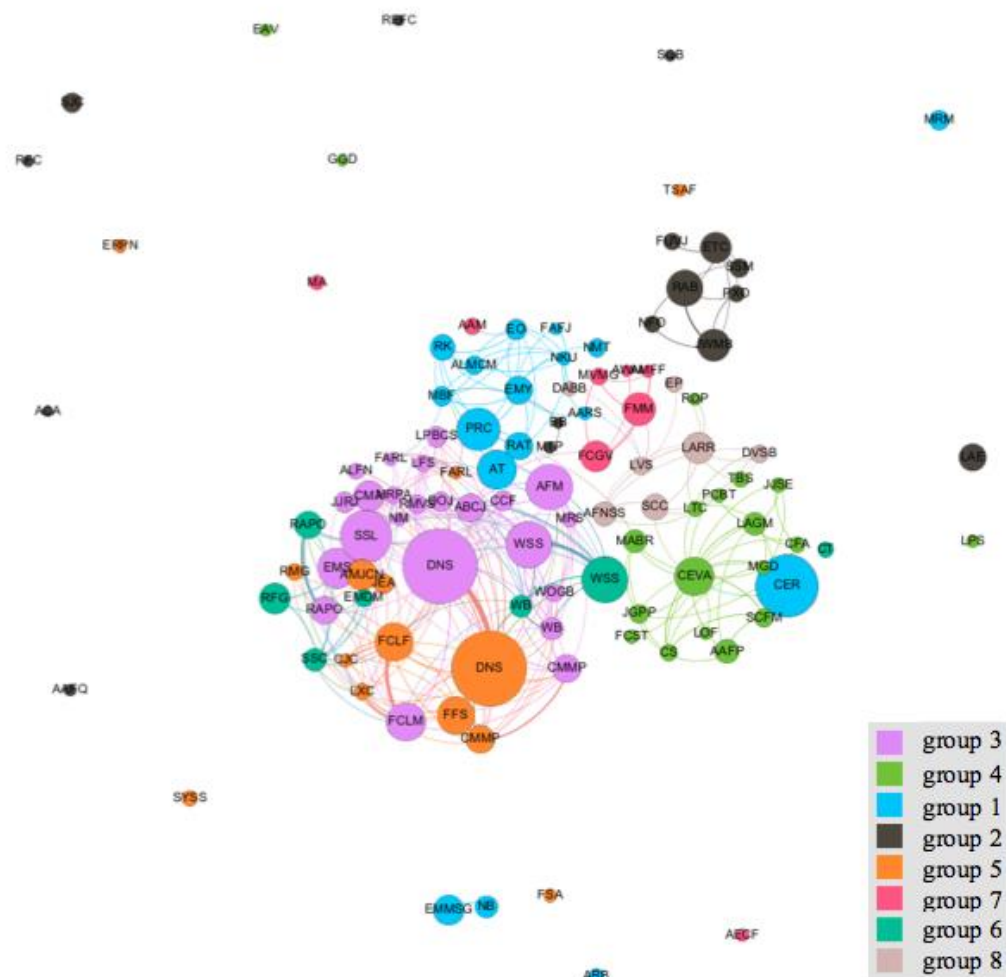
Fig. 2 - Percentage of publications of the research groups in the five most frequent journals. Made with Microsoft Excel

Percentage of research group publications in the most frequent journals



Another important indicator in the production of knowledge within a field is the interaction between its members. We evaluated this interaction through co-authored publications among group members. The objective was to verify if the medical physics groups interact with each other by publishing together, and the result is presented in Fig. 3. To plot this graph, we used Gephi software (version 0.9.2) (BASTIAN; HEYMANN; JACOMY, 2009) and the distribution algorithm was Force Atlas 2 (JACOMY et al., 2014).

Fig. 3 - Graph of collaboration between researchers of the research groups listed in Table 1 (letters represent the initials of the researchers' names). Made with Gephi

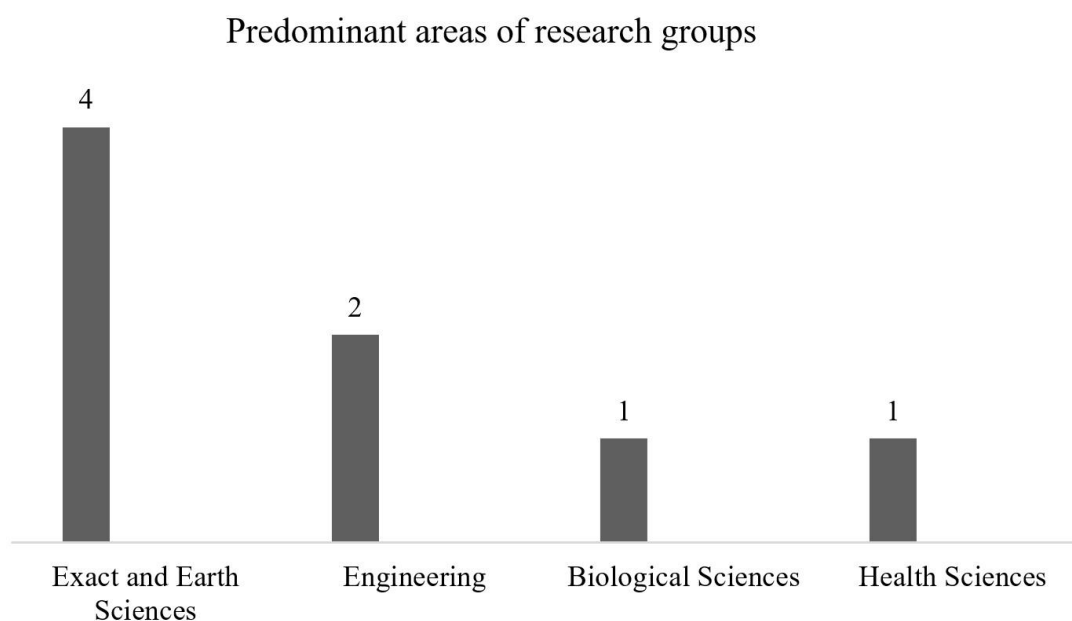


In the previous chart, nodes are the researchers of the groups and are so larger the larger the collaborations of their peers, inside or outside their groups. The colors of the nodes identify which group the researcher belongs to (described in the legend). The larger the node, the greater the bibliographic output of that specific researcher (always comparatively to the whole group). And the node that has no edge corresponds to the researcher who does not publish in co-authoring with any other colleague studied here. The thicker the edge, the greater the collaboration of that author with the node connected to the edge in question.

DISCUSSION

This analysis starts by evaluating the predominant area in which the group was enrolled from table 1. In figure 4, below, there is the distribution of the areas chosen as predominant.

Fig. 4 - Distribution of research groups in the areas chosen as predominant. Made with Microsoft Excel



This result corroborates the hypothesis that when we say that medical physics is in a "non-place". It is noticed that there is no agreement among the researchers of the field in which area this one "fits in", making the maintenance and reproduction of the knowledge among its members difficult.

The distribution between work presentations (27.4%), complete articles published in journals (24.3%) and abstracts published in congressional proceedings (23.7%) is more balanced, perhaps showing a certain preference for dissemination of its results in congresses. However, such forms of dissemination have a very limited scope compared to scientific journals and end up having less legitimacy when not complemented by full papers. In the context of the Brazilian crisis, it can also be inferred that this predilection would be to create partnerships and that the congresses provide a favorable environment for the meeting between peers, unlike printed publications.

Regarding the choice of journals, if a group publishes mostly in journals not indexed in the Qualis system (as shown in Chart 1), it has its scientific capital reduced in the field in which it operates, deteriorating its maintenance and reproduction. For generation of the list of scientific journals indexed by the Qualis system, it is not enough that publications cover topics within that area of knowledge, if no teacher or student of an accredited graduate program has published an article in that journal, there is no sense in including it in the list, since the sole purpose of Qualis Periods is to classify the articles produced by the country's graduate programs (BARRADAS BARATA, 2016). Thus, if most of the complete articles published in journals (Fig. 1) or the programs are performing the CAPES collection in the wrong way, or the teachers/researchers publish in a pulverized way hindering or delaying inclusion in the indexing system. Whatever the alternative, here is an example of how the rescue of information in medical physics, which ultimately means the dissemination of the knowledge produced, is inefficient.

We did the same process of evaluating the production of the members of the selected research groups, verifying how many of their articles were published in

journals included in our clipping. Considering that in the selected groups there are 111 researchers, and that all published in this topic, we have an average of approximately 4 complete articles in journals per researcher in 10 years of clipping.

Analyzing Fig. 3, we can see that the groups that interact most are 3 and 5, but it should be noted that there are researchers in more than one group, giving the false idea of strong interaction between groups, when it is the same person with publications shared between the groups to which they belong. Another important observation is that even if there is interaction, this happens more individually than collectively. That is, there is no policy among the producers of knowledge in the field of medical physics in order to create a permanent collaboration structure for consolidation and strengthening of the field.

CONCLUSIONS

All the results pointed out here were considered characteristic of the field of medical physics, almost a fingerprint of its participation in Brazil. Its field (like any other) exists only when there are members that legitimize, maintain and reproduce it. In this way, the central question of this work focused on the people who make up the field. The legislation, certification, training, place or "non-place" occupation of this field depend linearly on its members to maintain and reproduce its status quo.

In fact, such dynamics are not exclusive only to Medical Physics, although there are singularities that explain what we could call the "state of the art" in this reasonably young field and still have problems that suffer from its own recognition in the Brazilian scientific and professional setting. In this way, we recognize that there is also the transit between already consolidated fields (whose actors, professionals and academics have long legitimized them), such as physics and medicine. Because there is no consolidation in the universe of strict productions of medical physics, their respective field becomes vulnerable to fluctuations and oscillations.

With the data analyzed here, we can affirm that medical physics is a field under construction and still occupies a "non-place". This assertion is endorsed by the difficulty of locating such discipline in development agencies, by the few publications in internationally recognized scientific journals such as medical physics, and by the lack of representativeness in the form of departments and lines of research in institutions that train medical physicists, among other questions.

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REFERENCES

AUGÉ, M. **Não-lugares: introdução a uma antropologia da supermodernidade**. Campinas: Papius, 2010.

BARRADAS BARATA, R. DE C. Dez coisas que você deveria saber sobre o Qualis. **Revista Brasileira de Pós-Graduação**, v. 13, n. 30, p. 13–40, abr. 2016.

BASTIAN, M.; HEYMANN, S.; JACOMY, M. **Gephi: an open source software for exploring and manipulating networks**. In: INTERNATIONAL AAAI CONFERENCE ON WEBLOGS AND SOCIAL MEDIA. , 2009. Disponível em:

<<http://www.aaai.org/ocs/index.php/ICWSM/09/paper/view/154>>. Acesso em: 10 jan. 2018

BOURDIEU, P. **Para uma sociologia da ciência**. Lisboa: Edições 70, 2004.

CHAIMOVICH, H. Brasil, ciência, tecnologia: alguns dilemas e desafios. **Estudos Avançados**, v. 14, n. 40, p. 134–143, dez. 2000.

INTERNATIONAL LABOUR ORGANIZATION. **ISCO - International Standard Classification of Occupations**, 2012. Disponível em: <<http://www.ilo.org/public/english/bureau/stat/isco/isco08/>>. Acesso em: 6 ago. 2018

INTERNATIONAL ORGANIZATION FOR MEDICAL PHYSICS (IOMP). **‘Medical Physicist’ Now Included in The International Standard Classification of Occupations (ISCO-08)**. Disponível em: <http://www.iomp.org/sites/default/files/iomp_guidance_on_isco-08.pdf>. Acesso em: 6 ago. 2018.

JACOMY, M. et al. ForceAtlas2, a Continuous Graph Layout Algorithm for Handy Network Visualization Designed for the Gephi Software. **PLoS ONE**, v. 9, n. 6, p. e98679, 10 jun. 2014.

MENA-CHALCO, J. P.; JUNIOR, C. Prospecção de dados acadêmicos de currículos Lattes através de scriptLattes. In: HAYASHI, M. C. P. I.; LETA, J. (Eds.). **Bibliometria e Cientometria: reflexões teóricas e interfaces**. São Carlos: Pedro & João Editores, 2013. p. 109–128.

MENA-CHALCO, J. P.; JUNIOR, C.; MARCONDES, R. ScriptLattes: an open-source knowledge extraction system from the Lattes platform. **Journal of the Brazilian Computer Society**, v. 15, n. 4, p. 31–39, dez. 2009.

MINISTÉRIO DA EDUCAÇÃO (MEC). INFOCAPES. **Boletim Informativo da Capes**, v. vol 9, nº 2 e 3, n. Capes, 2001.

MINISTÉRIO DA SAÚDE. Nota técnica nº 82/2013, de 31 de julho de 2013. Concessão de bolsas pelo Ministério da Saúde para programas de residência em física médica por meio do edital nº 28, de 27 de junho de 2013. . 2013, p. 1.

SCHNEIDER, L. C. Lugar e não-lugar: espaços da complexidade. **Ágora**, v. 17, n. 1, p. 65–74, 30 set. 2015.