

Original Article

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The data that support the findings of this study are available on request from the corresponding author.

Author Contributions

Conceptualization – T.P., P.M., L.D., N.L.; Data curation – P.M., R.S., A.P., V.N., V.I., M.J., K.M.; Formal analysis – P.M., R.S., T.P.; Funding acquisition – L.D., N.L., T.P., R.S.; Investigation – P.M., R.S., A.P., V.N., V.I., M.J., K.M., T.P.; Methodology – P.M., R.S.; Project administration – T.P., L.D., N.L.; Software – R.S.; resources – R.S., A.P., V.N., V.I., M.J., K.M.; Supervision – L.D., N.L., T.P.; Validation – P.M., T.P.; Visualization – P.M., R.S.; Writing – original draft – P.M., T.P.; Writing – review and editing – P.M., R.S., A.P., V.N., V.I., M.J., K.M., L.D., N.L., T.P.

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Evaluating award-winning doctoral theses to reveal PhD research landscape: A case study of the Faculty of Medicine, University of Belgrade

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Declaration of Interests

The authors have no conflicts of interest to declare.

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Abstract

Background: Doctoral programmes are an important pillar of medical education, and although many universities award the best theses, the criteria for selection of awardees and the topics of their doctoral theses are seldom analysed.

Objectives: To analyse the landscape of doctoral research through assessing the temporal trends in the criteria related to recognising the best theses.

Methods: A total of 55 award-winning doctoral theses, from those submitted to the Faculty of Medicine, University of Belgrade, over 7 years (2016–2022), were examined, focusing on the number of awardees, publications based on the theses, research subfields, and keywords.

Results: The awardees comprised 36 women (65%) and 19 men (35%). The number of award-winning theses per year in clinical medicine and public health increased over the years ($P < .05$ for both the fields). The awardees had published a total of 134 articles based on their theses before the thesis defence, and half of these were published in open-access journals. The journals that each published at least 4 of these articles were *PLOS One*, *Experimental and Molecular Pathology*, and *Oxidative Medicine and Cellular Longevity*. The cumulative impact factor of these publications showed no significant increase ($P > .05$). The subfields that accounted for at least 5 of the publications were molecular medicine (13 publications) among the basic or translational fields, cardiology (5) among clinical medicine, and epidemiology (7) among public health. Mapping the co-occurrence of keywords from all the dissertations identified some research hotspots, which included cancer, oxidative stress, Parkinsonism, risk factors, genetic polymorphisms, and biomarkers.

Conclusion: The increasing number of award-winning theses reflects the rising quality of doctoral research and the growing motivation of candidates to choose indexed journals as outlets for papers based on the theses. This approach can serve as a basis for strategic evaluation of the practices for evaluating PhD theses and for identifying strong and weak spots in the research landscape of medical schools to guide future doctoral research and the competitiveness of doctoral programmes.

Keywords:

doctoral programmes, evaluating theses, identifying research hot spots, medical education

Introduction

Doctoral programmes are an important pillar of medical education. Awarding a doctoral (PhD) thesis refers to the act where a candidate for a PhD degree receives it following “the approval from an assessment committee that has evaluated the thesis and the oral defence.”¹ However, many universities also offer awards to the best theses or dissertations to honour the most important scholarly contributions of doctoral candidates at those universities over a specified period. Such awards recognise excellence in research and are presented to one or more individuals, depending on the institution.

Following the labelling recommendations by the Organization for PhD Education in Biomedicine and Health Sciences in the European System (ORPHEUS), the Faculty of Medicine, University of Belgrade (FMUB) – the largest public medical faculty in Serbia – implemented the annual practice of awarding the most successful among the PhD theses. In addition to a positive assessment from thesis evaluation committees in terms of the originality of research, methodological rigour, and the potential scientific impact of the results, as well as the quality of the oral defence, a quantitative threshold was set for the award, namely the cumulative impact factor (IF, as awarded by Clarivate Analytics and published in *Journal Citation Reports*) of the dissertation-related published papers should be 5 or more. In other words, the sum of the IFs of the journals in which a candidate has published papers based on the work done for the PhD thesis – taking the IF of each journal for the year of publication or for either of the 2 previous years, whichever was higher (in line with the national regulations for the evaluation of scientific work) – should be 5 or more. The rationale for setting the quantitative threshold was to upscale research activities and international recognition and

the relevance of the theses through promoting the publication of thesis-based research results in peer reviewed, internationally recognized journals, which is in agreement with *Best Practices in Doctoral Education*, published by ORPHEUS.¹ At the FMUB, the names of awardees who defended their theses in the previous academic year are officially announced on the annual PhD Day, which is organised in September each year. On that day, the awardees are invited to give short presentations on their doctoral work in front of other PhD candidates, interested researchers, and guests. After that, they receive the award certificates from the Vice Dean for Research and PhD Studies as the final part of the programme of the PhD Day. Given that the responsibility for a PhD project is shared jointly by the candidate and the supervisor(s), the FMUB has also been awarding PhD supervisors of the awardee candidates to incentivise the supervisors as well as to recognise the most successful supervisors. The supervisors also receive the certificates on the PhD Day.

The practice of recognizing the best thesis may enhance the quality of doctoral research work and encourage further research by doctoral candidates. Although many universities award the best theses, practices related to bestowing such awards and the topics of the award-winning theses are seldom analysed, particularly with reference to trends over time and outcomes of the awards. No studies have evaluated or re-evaluated the criteria for giving such awards either. Moreover, the peculiarities and impacts of honouring the best theses in various socio-economic, geographical, and political contexts have not been addressed. That is why it is particularly important to examine these aspects in the context of a developing country.

It is against this background that the present study sought to evaluate the outcomes, over

7 years, of this practice of awarding the best theses at the FMUB. More specifically, the study had two objectives: (1) to evaluate the quantitative criteria for selecting the theses for the awards at the FMUB and to identify any trends over the period of the study and (2) to evaluate the current landscape of doctoral research and to identify the hotspots of such research at the FMUB by analysing the scientific field or subfields, topics, and keywords related to the award-winning theses.

Methods

Data collection

We extracted data on all award-winning theses from the electronic records of the Department for PhD studies, FMUB. For each such thesis, the following information was collected: candidate's name, age, and sex; number of PhD supervisors; name(s), sex, academic title(s), and scientific field(s) of PhD supervisor(s); academic year of thesis defence; scientific field and subfield of the thesis; cumulative IF of papers based on the thesis and published in journals indexed in the *Web of Science Core Collection: Science Citation Index Expanded*; and English versions of the title of the thesis, its abstract, and keywords.

Data analysis and visualization

We grouped the theses by their topics into three main medical fields – basic or translational, clinical, and public health – and into subfields (PhD programmes or modules, such as cardiology, epidemiology, and skeletal biology) to identify the leading programmes and the most popular topics for doctoral research at the FMUB. Beyond such simple categorisation into scientific fields and subfields, a word cloud of the keywords was generated using a freely available online word-cloud generator (<https://www.jasondavies.com/wordcloud/>) to visualise the number of occurrences of

each keyword from the entire collection of keywords from the chosen theses.

To analyse the co-occurrence of the frequently used keywords, VOSViewer (<https://www.vosviewer.com/>) was employed to generate term co-occurrence network maps based on the titles, abstracts, and keywords, which were manually inserted into VOSViewer. Only those keywords that occurred at least 10 times and non-binary relationships were used for the analysis. Each keyword was represented as a sphere, its size being proportional to its frequency of occurrence. The spheres were interconnected by lines that indicated their interrelationships. Different colours of the spheres represented different clusters of the keywords. This visualisation offered a way to analyse the interrelationships between the keywords in semantic terms and to advance the understanding of the hot topics featured in the selected theses.

Ethics approval

The study was approved by the Institutional Review Board of Faculty of Medicine Belgrade (no 70/IV-8).

Statistical analysis

Microsoft Excel 2019 was used for data tabulation and descriptive analysis. The categorical variables were presented as frequencies (percentages), and the numeric variables, as means (standard deviation [SD]) or median with 25th and 75th percentiles. To ascertain temporal trends in the number of theses and the cumulative IF over the entire period of the study, linear regression analysis and the χ^2 test was used. The differences in age between the sexes were analysed using the Student's *t*-test, and differences in the number of publications and their cumulative IF between the sexes were analysed using the Mann–Whitney test. SPSS ver. 17 was used for statistical analysis and set the significance level at 0.05.

Results

General information and temporal trends in awarding

During the 7-year (2016–2022) period, a total of 55 candidates, comprising 36 (65%) women and 19 (35%) men, won awards for their theses. The two sexes showed no significant differences in age, number of papers based on the theses and published before the thesis defence, and the cumulative IF of these papers (Table 1).

Of the total theses, 28 (51%) were placed in the category of basic or translational medicine; 15 (27%) in clinical medicine; and 12 (22%) in public health medicine (Table 1). A descriptive analysis of this distribution showed some variation between sexes: for

example, women outnumbered men in molecular medicine, whereas the field of surgery was represented exclusively by men. The most frequent subfields were molecular medicine (13 theses) in the basic or translational medicine category, cardiology (5 theses) in clinical medicine, and epidemiology (7 theses) in public health medicine. The number of awardees per year did not change significantly in basic or translational medicine ($y = 3.769 + 0.058x$, $P = .867$), but increased significantly in clinical medicine ($y = 1.750 + 1.313x$, $P = .018$) and in public health medicine ($y = 2.235 + 1.029x$, $P = .014$).

All the theses were written in the form of a monograph; of these, 7 (13%) were written and defended in English, and the rest, in Serbian. All 55 candidates were based in Serbia.

Table 1. Demographics, cumulative impact factor, and field of study of awardees

	Men	Women	Total	P
Sex (N, %)	19 (34.5%)	36 (65.5%)	55 (100%)	.570
Age, years (mean ± SD)	35.5 ± 4.3	35.5 ± 5.3	35.5 ± 4.9	.985
Number of thesis-based papers published before defence (median, 25th–75th percentile)	2 (2–3)	2 (2–3)	2 (2–3)	.902
Cumulative IF of papers (median, 25th–75th percentile)	7.8 (5.6–9.1)	6.3 (5.4–8.6)	6.5 (5.6–8.6)	.296
Field of study				
<i>Basic or translational medicine</i>				
Skeletal biology	0	1	1	
Tumour biology and oxidative diseases	0	1	1	
Physiological sciences	4	2	6	
Medical pharmacology	0	3	3	
Molecular medicine	2	11	13	
Neurosciences	1	3	4	
<i>Clinical medicine</i>				
Human reproduction and perinatology	1	1	2	
Cardiology	3	2	5	
Neurology	0	2	2	
Radiology and nuclear medicine	1	1	2	
Reconstructive surgery	3	0	3	
Inflammation and autoimmunity	0	1	1	
<i>Public-health medicine</i>				
Epidemiology	3	4	7	
Public health	1	2	3	
Biomedical informatics	0	2	2	

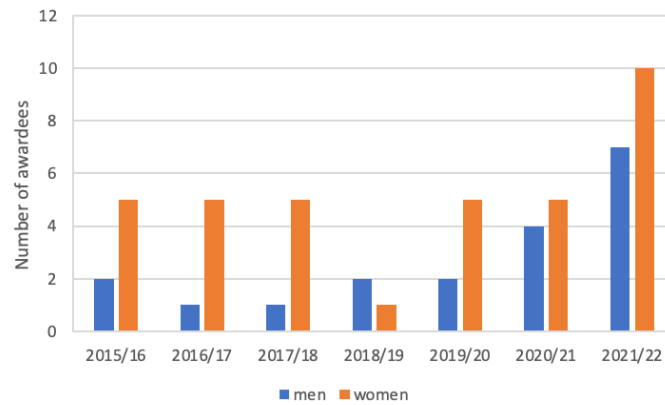


Figure 1. Distribution of awardees by sex, by year (2015/16–2021/22).

The number of awardees showed no significant difference from year to year ($\chi^2=1.397$, $P=.237$). The distribution of candidates by sex per year is shown in Figure 1. The ratio of men to the total number of awardees was 0.07 (12%) and the corresponding figure for women was 0.14 (14%).

Supervision

A total of 89 PhD supervisors, 32 men and 57 women, had supervised the awardees; 29 of them (53%) had more than one PhD supervisor (Table 2); the combinations of the supervisors' fields in those cases are also shown in Table 2, indicating the predominance of complementary supervisor expertise. Most of the supervisors were professors or equivalent ($n=67$), and six candidates had members of the Serbian Academy of Sciences and Arts as their supervisors.

Trends in cumulative impact factor

The median cumulative IF per thesis varied from 5.6 to 7.6 (Table 3), but its increase over the period of study was not significant ($y=0.309+0.511x$, $P=.580$). Nevertheless, in 2021/22, the cumulative IF in the case of two awardees was 10–20, and in that of one, it was above 20. The journals in which the awardees published their thesis-based papers are listed in Table 4. Half of the published papers were in open-access journals, and *PLOS One*

topped the list with 5 papers. The full list of journals in which the awardees had published their thesis-related papers is shown in Supplemental Table.

Analysis of keywords

A word cloud of keywords from the entire set of the honoured theses (Figure 2) showed that the most common keywords in the award-winning theses were disease, polymorphisms, risk, system, oxidative stress, and MRI, followed by Parkinson or Parkinsonism, markers, and cancer. The organs most often examined or involved were the heart (cardiac), blood, brain, liver, and bone.

Keyword co-occurrence maps based on the titles, abstracts, and thesis keywords (Figure 3) showed six clusters. The most prominent keywords in each of these six clusters were as follows: Cluster 1, 'concentration', 'treatment', and 'heart failure (hf) group'; Cluster 2, 'genotype', 'oxidative stress', and 'role'; Cluster 3, 'therapy', 'pregnancy', and 'women'; Cluster 4, 'age' and 'predictor'; Cluster 5, 'sample' and 'sequence'; and Cluster 6, 'tinnitus', 'risk factor', and 'carrier'.

Discussion

The FMUB set a threshold of cumulative IF of 5 or higher to 'set the bar' above the

Table 2. Characteristics of supervisors of awardees

	Median (25th–75th percentile)	
Number of supervisors per candidate	2 (1–2)	
Supervisors' sex	Number	%
Man	32	36.0
Woman	57	64.0
Number of candidates with more than one supervisor	29	53.0
Two supervisors	24	43.6
Three supervisors	5	9.1
Supervisors' major fields (two supervisors)		
Basic and clinical	11	45.8
Basic and basic or translational	7	29.2
Clinical and clinical	3	12.5
Clinical and public health	3	12.5
Supervisors' major fields (three supervisors)		
Clinical and clinical and public health	2	40.0
Clinical and clinical and basic	2	40.0
Clinical and public health and basic	1	20.0
Supervisors' title		
Professor or equivalent	67	75.3
Assistant professor or equivalent	22	24.7

cumulative IF of 95% of the theses defended. In the present study, a steady rise in the number of award-winning theses was observed, crossing the threshold – a trend reflecting higher quality of the theses as well as stronger motivation on the part of the doctoral candidates to publish in internationally recognised journals. This was particularly evident in the field of public health, especially epidemiology. The doctoral programmes or modules

in epidemiology and molecular medicine are the two oldest such programmes within the modern concept of doctoral studies at the FMUB, with the most experienced supervisors and high-quality methods. It is, therefore, not surprising that theses from these two programmes were honoured most often. It should be noted that the theses included in this study were based mostly on research conducted between 2012 and 2020, and COVID-19 was *not* among the most frequent keywords – the greater success of public health in the award-winning theses was therefore *unrelated* to COVID-19. Nevertheless, in the years following 2020, one may expect a further rise in the number of such theses based on work related to various aspects of COVID-19.

The analysis of the scientific fields and sub-fields revealed that the FMUB was particularly strong in doctoral education and research on epidemiology, molecular medicine, and

Table 3. Cumulative impact factors of the award-winning theses, by the year of thesis defence

Academic year of thesis defence	Median IF	25th percentile	75th percentile
2015/16	6.0	5.3	7.4
2016/17	7.3	5.3	11.6
2017/18	7.6	5.7	8.3
2018/19	5.6	5.2	6.3
2019/20	7.2	5.7	9.0
2020/21	5.6	5.3	7.6
2021/22	7.4	5.8	9.4

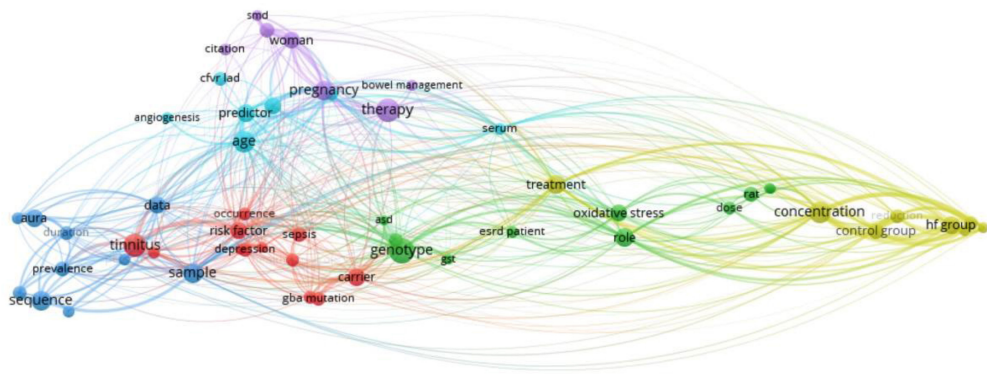


Figure 3. Co-occurrence map of keywords from award-winning theses.

and relevant' should be 'context dependent'. In other words, this document emphasises the limitations of evaluating research based on quantitative indicators and encourages qualitative assessment of research. In smaller developing countries such as Serbia, the emphasis on quantitative criteria for evaluating doctoral theses, established (in 2006) when the new Bologna-based concept of doctoral studies was introduced, was of utmost importance to research, development, and improving doctoral education. Before 2006, it was not mandatory to publish papers based on the thesis in internationally recognized journals, which often meant that the results of doctoral work could not be promoted internationally even when, in some cases, they were internationally relevant. Indeed, unpublished findings from doctoral theses are 'a lost opportunity' for both the candidate and the scientific community,³ especially for theses written in languages other than English.⁴ Therefore, making the publication of papers based on doctoral work in journals with an IF (listed in the *Journal Citation Reports* by Clarivate) mandatory, a requirement introduced in 2006, had a very positive effect because these submissions had to undergo international peer review, thereby securing an independent qualitative evaluation of the results of the thesis

and ensuring international relevance and recognition of doctoral work at the FMUB. This requirement has certainly promoted research and development, fostered scholarly publishing, and promoted international collaboration, resulting in the FMUB being more competitive in the European research area. However, in recent years, more and more journals have been turning to open-access publishing, which, given the limited or no financial support from the country or universities, could place a serious financial burden on doctoral students, lowering their chances of publishing their work in such journals.⁴ This is a serious challenge, especially for the undeveloped and developing countries, and any updates to the relevant policy need to consider this new reality in terms of publication costs. Although nearly half of the papers covered in the present study were published open access, mostly in journals with lower open-access fees and/or in journals offering discounts to authors from developing countries, the issue of the costs of publishing in open-access journals is becoming a growing concern in Serbia.

The authors are aware that quantitative evaluation, especially if based predominantly on a journal's IF, has inherent limitations. Therefore, new approaches are being considered to supplement the current

method of evaluation with stronger qualitative assessments, searching for the optimal combination of the two approaches – qualitative and quantitative – suited to the local context at present. Indeed, most of the standards in medical and doctoral education do not require any strict formalistic adoption of rules and standards, respect the autonomy of research organizations, and emphasise the need to adopt and adapt best practices to the local context to ensure local growth and stimulate further development.^{1,2,5,6} As to the qualitative criteria that could be used, the principles outlined in the Agreement on Reforming Research Assessment,² published by CoARA (2022), could be consulted. Specifically, this document emphasises the need to ‘reward the originality of ideas’ and ‘results beyond the state-of-the-art’, keeping in mind the fundamental principles of fair and transparent peer review processes. An earlier article written by scientists who were members of the jury for awarding the best doctoral thesis on behalf of the Netherlands Association for Medical Education suggested the following specific evaluation criteria: ‘size, breadth of research skills exhibited, coherence of studies, relevance to field, validity, style, communicative power and ethics, and impact of the work’, but acknowledged the importance of local context, allowing that there may be reasonable differences in awarding practices among different countries and institutions.⁷

Currently, the FMUB is discussing ways of revising the policy on awards to take into account new trends in the evaluation of research and researchers. One option that has received some attention is to combine qualitative and quantitative assessments in selecting the best theses by organising a competition among candidates whose theses pass a given threshold: the candidates could

briefly present their research verbally, with the winner(s) being selected based on the points awarded by, or votes from, the audience, a specialized committee, or both. This method could promote the best theses; the candidates and other researchers could learn from the award-winning presentations, and a competitive spirit would be nourished – all serving to make the PhD Day more appealing to current and future doctoral candidates. It should be noted, however, that this approach is limited by the candidates’ presentation skills and may penalise those with excellent theses who suffer from performance anxiety or relatively poor presentation skills, thereby lowering their chances of winning the award. However, presentation skills are an important component of the ‘soft skills’ that are emphasised during the entire doctoral curriculum at the FMUB. As for the quantitative threshold, there is an ongoing debate at the FMUB on whether the current threshold for the cumulative IF should be retained or raised, or whether the journal quartiles should be used instead. Furthermore, there is growing awareness that any quantitative indicators should measure article quality instead of journal quality. In that context, citations, Altmetric score, and the number of downloads might be more relevant indicators. However, using these metrics in all spheres of academic evaluation requires profound legislative and organisational changes at the level of the country and the university before the practice could be implemented at the FMUB. Once again, given the emerging trends of reforms in research assessment, the FMUB is working on defining the optimal approach in a local context that is compatible with active regulations.

Indeed, successful doctoral research is the result of interplay between individuals and the local context; thus, it is imperative

for universities and faculties to continually develop a supportive research environment⁸ through regular analysis of the structure, functions, and quality of doctoral programmes.¹ A recent bibliometric study from Tunisia, which examined all theses in general surgery defended in four national medical schools over 40 years, identified major weak points to guide educational reforms.⁹

In the future, it would be interesting to explore the challenges and strategies that the awardees employed during their study, for example, by using the approach suggested by Gimenez et al¹⁰ Different countries and regions face different challenges in doctoral education.¹¹⁻¹⁶ Indeed, it is essential to analyse the quality and productivity of doctoral programmes locally¹⁷ to design suitable strategies to enhance the prospects of enrolled candidates in a particular context.

The positive outcomes of the new doctoral curriculum established in 2006 are already seen and updated continually since then, the ORPHEUS label obtained in recognition of fulfilling the ORPHEUS standards in 2014, and the practice introduced in 2017 of honouring the best theses. It is believed that other developing countries should also design realistic strategies for improving scientific research and developing new generations of motivated researchers recognised in the international science framework. In that sense, these experiences may have broad implications for stimulating doctoral research and promoting research excellence and international publication of research results, particularly in local contexts where research has not yet received sufficient recognition and promotion.

One of the limitations of the present study is that it did not comprehensively evaluate the

theses that did not win any awards during the study period. This is not an issue for the first objective of the study, namely, to evaluate the quantitative criteria for the award-winning theses at the FMUB and to identify any trends over the examined period. However, the second objective was to evaluate the current landscape of doctoral research and to identify the hotspots of such research at the FMUB by analysing the scientific field or subfields, topics, and keywords related to the award-winning theses, and that objective would have been served better by including in the analysis all the theses defended during the study period. In the future, these theses should also be analysed to provide a fuller picture of the research landscape at the FMUB. In addition, in the future, data from the FMUB should be compared with other public medical faculties in Serbia operating in the same context and also with those from other countries and contexts in the region and beyond.

In summary, the number of award-winning theses at the FMUB increased steadily over the period of the study, which may reflect the increasing quality of doctoral research and the stronger motivation of the doctoral candidates to publish their findings in international journals. In line with the ORPHEUS *Best Practices*,¹ the FMUB is constantly evaluating the outcomes of doctoral studies and strives to continually revise its doctoral programme and procedures to raise the quality of doctoral research. In that context, it is important not only to honour the most successful or the best doctoral theses but also to continually evaluate the criteria for choosing the awardees for fostering research, improving doctoral programmes, promoting high-quality doctoral work, and disseminating the results of doctoral research. In addition, analysing the topics and keywords from the award-winning theses may reveal the current research

landscape and hotspots in doctoral research: such analysis could prove useful in the self-evaluation needed for strategic planning in research. It would also be useful to compare the outcomes of practices governing the selection of awardees and evaluation methods from different countries and contexts to devise best practices applicable to a particular local context.

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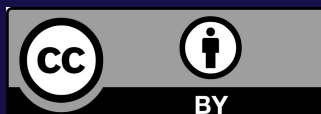
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