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A systematic analysis of doctoral publication trends in South Africa

It is incumbent upon doctoral students that their work makes a substantive contribution to the field within which it is conducted. Dissemination of this work beyond the dissertation, whether whilst studying or after graduation, is necessary to ensure that the contribution does not remain largely dormant. While dissemination can take many forms, peer-reviewed journal articles are the key medium by which knowledge is shared. We aimed to establish the proportion of doctoral theses that results in journal publications by linking South African doctoral thesis metadata to journal articles authored by doctoral candidates. To effect this matching, a customised data set was created that comprised two large databases: the South African Theses Database (SATD), which documented all doctoral degrees awarded in South Africa (2005–2014), and the South African Knowledgebase (SAK), which listed all publications submitted for subsidy to the South African Department of Higher Education and Training (2005–2017). The process followed several iterations of matching and verification, including manual inspection of the data, in order to isolate only those records for which the link was established beyond doubt. Over the period under review, 47.6% of graduates, representing 22 of the 26 higher education institutions, published at least one journal article. Results further indicate increasingly higher publication rates over time. To explore whether the journal article identified was a direct product of the study, a similarity index was developed. Over 75% of records demonstrated high similarity. While the trend towards increasing publications by graduates is promising, work in this area should be ongoing.

Significance:

- In spite of increasing trends in publications by graduates, many are not disseminating their work, suggesting that significant bodies of research are potentially not being shared with the academic community and are therefore not contributing to the relevant discipline or field.
- This study provides baseline data from which a number of further investigations can be launched, such as exploring the extent to which doctoral candidates who are also academics are publishing their work; the factors that enable or constrain publication; the other avenues of dissemination used; and whether publishing or not publishing can serve as a proxy for the quality of the doctoral work.

Introduction

The South African Higher Education Qualifications Sub-Framework describes doctoral studies as needing to 'make a significant and original academic contribution especially at the frontiers of a discipline or field'[1]. Knowledge creation is an unconditional expectation of doctoral work.[2,3] However, this knowledge contribution will remain largely dormant and 'invisible' if the work is not disseminated beyond the student, the supervisor and the examiners, limiting the opportunity for sharing the academic contribution with others.[4] While institutional e-repositories have made access to dissertations easier than before, most of the work documented in the thesis will require additional forms of dissemination if it is indeed to contribute to the frontiers of the relevant discipline or field. One could even argue that there is a moral obligation on doctoral graduates to ensure that their research is readily accessible to other researchers. Doctoral study is the most highly subsidised higher education qualification and taxpayers have a right to benefit from the potential value and contributions of such research. Implicit in conducting research at postgraduate level, therefore, is the notion of dissemination, typically through publication in an academic journal or similar artefact.[5] While dissemination may take many forms – such as patents, community workshops, news articles and so on – accredited conference proceedings and journal articles remain the key means by which knowledge is shared and thereby cumulatively built.

The South African Higher Education Qualifications Sub-Framework further indicates that the doctorate should 'satisfy peer review and merit publication'[1]. Thus, the expectation of publishing some aspect of one's research more widely, is not only for ensuring dissemination of the knowledge, but also could be used as an additional measure of the quality of the thesis. Having a reliable estimate of the number of publications emanating from the doctorate over an extended time frame provides a proxy for understanding the extent to which the doctoral graduate translated their work into more accessible publication outlets as well as continued a specific line of research or not.

It has been argued that the African continent needs 'tens of thousands more PhDs'[6]. In South Africa, there is a national mandate to significantly increase the number of PhD graduates to 100 per million of the population by 2030.[7] In various policy documents – the National Research and Development Strategy of 2002[8] and the Ten-year Innovation Plan of 2008[9] – the target is 5000 PhDs per year by 2030. In a recent report by SciSTIP[10] on *The State of the South African Research Enterprise*, it is shown that this target is in fact achievable under certain conditions, and given the current upward trajectory. Data show that slightly over 3300 students graduated with a doctoral degree in 2018, a sharp increase from the 1420 graduates in 2010 and 973 in 2000.[10]

Debates about the quality of a doctorate play out quite differently from one country to the next. In many Global North countries, the PhD agenda has become one of employability and relevance for industry as the number of PhDs produced far exceeds the number required by academia.[10] But, in South Africa, a significant proportion of doctoral candidates (around 35%) are in fact academics[6] who pursue doctoral studies as part of their 'training for an academic career'[1]. The demand for academics to obtain a doctoral degree is emphasised when one keeps in mind that

2018–2019 Department of Higher Education and Training data indicate that only 45% of permanent academic staff in South Africa have PhDs[11] while the National Development Plan goal is for 75% of academics to have doctorates by 2030[7].

As alluded to above, South Africa has witnessed a steady and, since 2008, rapid growth in the number of both doctoral enrolments and doctoral graduates. There probably are a number of different drivers for this growth, including the significant subsidy paid to institutions by the DHET for doctoral study both in terms of teaching input (enrolment) and research output (graduates). The extent of the increase in the numbers of doctoral graduates and the commensurate increase in the subsidy amounts paid since the promulgation of the 2005 funding formula are evident in Table 1.

Table 1: Subsidies generated through graduation of doctorates in South Africa (2005–2017)

Academic year	Number of doctoral graduates	Subsidy amount (ZAR)
2005	1189	303 287 742
2006	1100	291 779 400
2007	1274	392 148 666
2008	1182	415 392 624
2009	1380	528 421 320
2010	1421	508 708 053
2011	1576	562 759 656
2012	1878	648 202 968
2013	2051	696 421 152
2014	2258	736 286 382
2015	2530	813 814 980
2016	2782	923 610 090
2017	3040	1 111 463 520

Source: Table compiled from data provided by the South African Department of Higher Education and Training (DHET)

Other drivers for increasing doctoral numbers could include the setting of national targets, and the restructuring of higher education institutions in South Africa that has seen, for example, universities of technology mount multiple initiatives to encourage academic staff to obtain their doctorates. Either way, the rapid increase since 2005 (compound average growth rate of 7.7%) has been accompanied by growing concerns about the quality of our doctoral graduates and their theses. The increase in the quantum of doctoral enrolments has placed strain on the capacity of the system to supervise such students as the ratio of enrolled students to staff with PhDs increased to 2.5 to 1 (22 572 students that could potentially be supervised by the 9032 staff with doctoral degrees). It is worth pointing out that this ratio is an average across all fields and universities. Because doctoral enrolments are not evenly distributed, but concentrated in certain fields and especially concentrated in the more research-intensive universities, this ratio in some cases is much higher. This means that the 'burden' of doctoral supervision[6] has increased significantly over the past decade. Together with a commensurate increase in the burden of master's supervision, it is not surprising that concerns over quality have arisen.

While measures such as external examination are meant to ensure that the doctoral graduates the country produces are of the appropriate standard, anecdotal evidence suggests that quality in doctoral education is already being compromised in some instances. In the first round of institutional audits undertaken by the Council on Higher Education between 2005 and 2012, for example, concerns were raised about supervisors being used as examiners and about the incidence of repeated use of a very small pool of examiners for numerous theses. This has led to many universities improving their quality assurance procedures in order to ensure that good practice in the appointment of examiners is followed. The current national review of the doctorate by the Council on Higher Education suggests that the quality of the doctorate remains an area of concern and requires scrutiny.[12]

The obvious approach to assess the quality of doctoral education in a system would be to review examiners' reports, the names and reputations of examiners as well as the records of the decisions of higher degree committees when awarding doctoral degrees. However, as far as we know, no such study has been done in South Africa and access to examiner reports is extremely difficult to obtain. Instead we analysed the links between doctoral graduation and publication. We report on the first part of this investigation here. Our aims were modest – namely to attempt to estimate what proportion of doctoral theses result in journal publications. Specifically, we focused on doctoral students who graduated between 2005 and 2014 and who published the results of their studies in any of the publications appearing on the lists of journals as accredited by the Department of Higher Education and Training (DHET) between 2005 and 2017. As far as we are aware, this is the first systematic and comprehensive study aimed at establishing what proportion of 'materials' contained in South African doctoral theses eventually found their way into peer-reviewed journals. Our research questions address whether this proportion has increased over time, and whether there are significant differences in these proportions by university and gender of graduate. In the next phase of the investigation we intend to do further analyses around the different types of dissemination strategies related to such journal outputs as well as the quality of the journals in which articles appear.

Methodology

The single biggest methodological challenge of our study was to link South African doctoral thesis metadata to journal articles authored by the doctoral candidates. As there is no national database that contains these data, we had to create a customised data set for the analysis by linking two databases housed at the Centre for Research on Evaluation, Science and Technology (CREST) at Stellenbosch University: the South African Theses Database (SATD) and South African Knowledgebase (SAK).

Over the past 5 years, CREST has been building the SATD. It is a dedicated bibliographic database of doctoral dissertations submitted at South African universities since 2000. The data have been extracted from institutional repositories and the South African National Research Foundation (NRF) database of theses and dissertations. Fields captured within the SATD are:

- Thesis title
- Doctoral candidate: surname, initials and first name
- Granting university and year of thesis
- Supervisor(s): surname, initials and first name
- Field of study (not always possible/often only department)
- Abstract (full abstract where available)
- URL (handle) to the actual depository address where the thesis is stored

At the time of conducting our analysis, the SATD included metadata on 23 547 doctoral theses for the period 2000 to 2017. This figure represented a 92.7% coverage of the 25 390 doctoral degrees awarded by South African universities over this period.[13]

The second database, the SAK, is CREST's proprietary database of scientific publications authored by South African academics and scholars. SAK is unique in several respects. Firstly, SAK contains metadata on all scientific articles that earned subsidy for South African universities under the DHET Funding Framework. This means that it includes published articles that appear not only in the Web of Science (WoS), but also in other indexes and lists, including the DHET list of South African journals (not indexed in the WoS), the Proquest International Bibliography of the Social Sciences (IBSS) list, the Norwegian list and Scopus. As a result, we are able to augment the bibliometric analyses with more detailed analyses of output in different indexes as well as to compare the numbers of outputs in national versus international journals.

Specifically, SAK includes:

- Title of the document (article/proceedings/book/chapter)
- Author(s) (surname, initial and first name)
- Source information (journal/publisher/publication year)

- Author demographics (race, gender, nationality, year of birth, rank)
- Indexing (journal list: WoS, Scopus, DHET, IBSS, SciELO)
- Scientific field (four levels of increasing detail)

Although the coverage for each of these variables is not equally good, we deem it to be sufficient to present general trends for each of the variables. Our coverage of these variables in all cases varies between 80% and 90% depending on the variable, allowing us to draw relatively robust conclusions from these analyses. The current version of SAK comprises 426 496 authorships made up of journal articles (82%), conference proceedings (13%), and books and book chapters (5%) that were submitted for subsidy to the DHET for the period 2005 to 2017.

Preparing the two databases for analysis required intensive work over a significant period of time as researchers at CREST spent many months 'cleaning' the data, and seeking to fill in missing information – a process that continued into the matching period as ongoing engagement with the data identified anomalies and gaps that needed to be addressed.

Ultimately, we decided to confine our analysis to doctoral theses granted by South African universities between 2005 and 2014 and these were then compared to all journal articles in SAK for the period 2005 to 2017. This allowed for the counting of publications for a period of between 12 years (for the 2005 graduates) and 3 years (for the 2014 graduates) after the date of graduation.

Matching records in the SATD and the SAK

Our process of matching the data in the two databases was as follows. The first step was to match the records of doctoral theses to the journal articles based on the surnames of graduates and first authors, and on the similarity between the graduating institution (in SATD) and the institution that submitted the request for publication subsidy (in SAK). Once this process had been completed, we needed to establish whether the thesis author (in SATD) and the article author (in SAK) were indeed the same person (this verification was required because of the many instances of the same surnames – especially very common surnames – in both databases). In order to establish a more verifiable link between the records in the two databases, we wrote an algorithm that assigned a similarity score between the thesis titles and the article titles (see Table 2 and Figure 1). This programmatic process was followed by a manual inspection of the results in order to isolate only those records for which the identity of the thesis author and article author had been established beyond doubt.

Despite this systematic and rigorous process, we should note two limitations. First, the likelihood of matching the records beyond reasonable doubt was reduced where graduates changed surnames (as a result, for example, of either marriage or divorce) or used a different surname, or even order of names, in their publications versus the full names provided on the cover of the theses. Second, using the university (graduating and submitting) as one identifier in the matching process could have excluded graduates who soon after graduation moved to another institution or were indeed already working at another institution at the time of graduation, and then published articles under the name of a university other than that from which they graduated. We do not view either of these issues as major weaknesses in our methodology. Given the size of the sample of theses and publications analysed, the impact of these limitations would be minimal and would simply mean that our estimates are (to a small degree) lower than the actual figures.

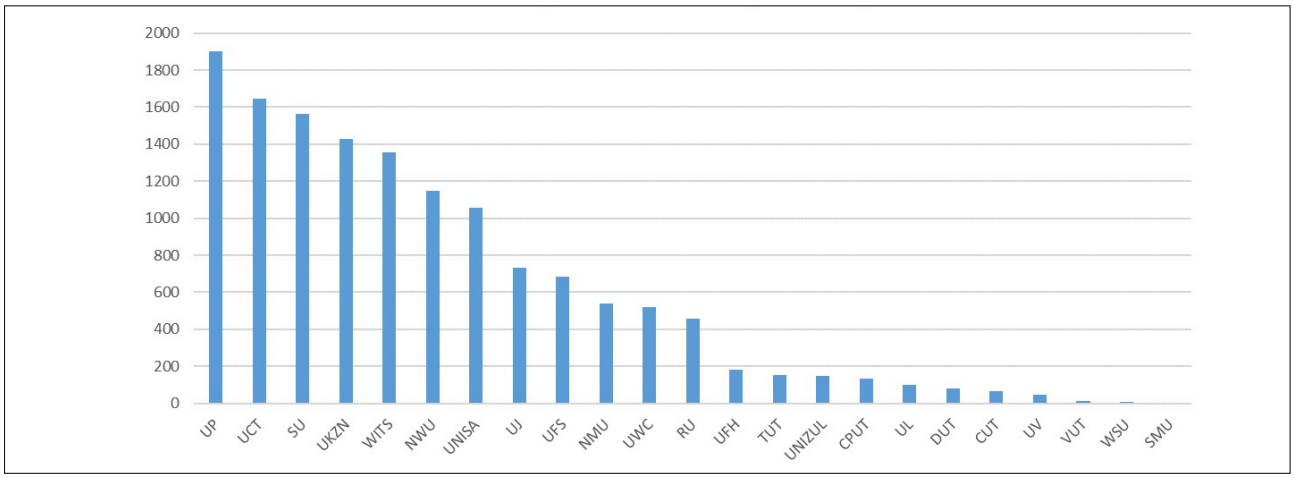
Our focus in this study is on doctoral graduates who published the findings or results of their doctoral studies in journals. We are well aware of the different publication practices across different fields. In the humanities and social sciences, for example, publications in books are deemed to be important. Fields such as the computer sciences, as well as certain subfields of engineering sciences, mathematics and economics, view conference proceedings as essential publication outlets. In the next phase of our investigation, we intend to investigate some of these other modes of publication as well. In some contexts, the dissemination of the knowledge takes place outside of academic fields altogether, through creative outputs, community workshops, policy briefs, patents and more. This is a limitation of the extent to which we can claim that publications in journals represent dissemination of knowledge developed through the doctorate, but the dominance of journal articles as the means of knowledge communication and the study's large sample size mitigate this limitation.

Results

At the time of conducting the analyses for this study, SATD contained information on 13 962 doctoral theses of students who graduated between 2005 and 2014, representing 22 of the 26 higher education institutions in South Africa (Figure 1).

The matching algorithm (Step 1) identified 51 864 *possible* authorships in SAK that could be linked to 7069 of these theses. The distribution of the similarity scores of these are summarised in Table 2.

The next step was to undertake a visual inspection of the 51 864 records and check whether the author of each publication (in SAK) was in fact the same person as the author of the doctoral thesis (the graduate listed in SAT). This process resulted in a reduced number of 44 073 records that could be definitively matched to a thesis author. The 44 073



UP, University of Pretoria; UCT, University of Cape Town; SU, Stellenbosch University; UKZN, University of KwaZulu-Natal; Wits, University of the Witwatersrand; NWU, North-West University; Unisa, University of South Africa; UJ, University of Johannesburg; UFS, University of the Free State; NMU, Nelson Mandela University; UWC, University of the Western Cape; RU, Rhodes University; UFH, University of Fort Hare; TUT, Tshwane University of Technology; Unizul, University of Zululand; CPUT, Cape Peninsula University of Technology; UL, University of Limpopo; DUT, Durban University of Technology; CUT, Central University of Technology; UV, University of Venda; VUT, Vaal University of Technology; WSU, Walter Sisulu University; SMU, Sefako Makgatho University

Figure 1: Number of graduates listed in the South African Theses Database per institution.

records thus identified corresponded to 6650 doctoral theses (Table 3). This produced the first main finding of our study, namely that over this time period, 47.6% of doctoral graduates published at least one journal article between 2005 and 2017.

It is important that we emphasise that the results presented in Table 3 refer to any publication that we could accurately link to a specific doctoral graduate (thesis). Whether the publication (journal article) was a direct *product* of the doctoral study and clearly based on the doctoral thesis is a second question which needs to be addressed.

Table 2: Breakdown of similarity index

Range of similarity score	Count of records	Share
1	66	0.13%
0.00 to 0.1	24 658	47.54%
0.1 to 0.2	14 211	27.40%
0.2 to 0.3	6747	13.01%
0.3 to 0.4	3248	6.26%
0.4 to 0.5	1510	2.91%
0.5 to 0.6	757	1.46%
0.6 to 0.7	331	0.64%
0.7 to 0.8	185	0.36%
0.8 to 0.9	110	0.21%
0.9 to 1	41	0.08%
Grand total	**51 864**	100.00%

Table 3: Proportion of doctoral graduates linked to journal articles by year (2005–2014)

Year	Number of graduates (total)	Number of published graduates	Published graduates as a percentage of all graduates
2005	1118	389	34.8%
2006	1088	433	39.8%
2007	1313	512	39.0%
2008	1289	614	47.6%
2009	1317	600	45.6%
2010	1382	701	50.7%
2011	1425	752	52.8%
2012	1570	836	53.2%
2013	1683	927	55.1%
2014	1777	886	49.9%
Total	**13 962**	**6650**	**47.6%**

The journal articles identified through the matching procedure could in fact have been produced before, during or after the completion of the doctoral degree. In order to establish the proportions of articles that were produced before, during or after the student's thesis was completed, we subsequently recoded the publication dates of the journal articles into three time periods. In our recoding we decided to use the following decision-rules:

- Articles with a publication date of between 3 years and 7 years before the thesis completion date were coded as 'before'.
- Articles with a publication date of 3 years or less before the thesis completion date were classified as 'during'.
- Articles with a publication date after the thesis publication date were coded as 'after'.

This classification was not an entirely arbitrary decision as the average time to degree of doctoral studies in South Africa over the past two decades has been about 4 years. This average duration of time to doctoral degree varies by field, for which we have not corrected in these analyses as our focus in this paper is on general trends in doctoral publication. The decision to define 'during' as thesis year minus 3 years also meant that we only included theses with a publication date of 2008 and later in Table 4.

In addition, we set one further parameter to all our queries: we decided to present the results for 4-year constant rolling windows according to the publication date of the thesis. Setting the time window of the thesis publication year at a constant 4-year rolling window period allowed us to use the thesis publication year as the reference year for all other comparisons over time.

The results presented in Table 4 confirm a central hypothesis of our study as far as linked theses are concerned, namely that doctoral students are publishing from their theses at increasingly higher rates. This trend is clearly illustrated in the steady increase in the proportion of articles that appeared *during* the production of the thesis: from 28% in the earliest period to 39% for the most recent period (2011 to 2014). The decline in the proportion of articles after thesis publication (from 69% for the earliest period to 52% for the most recent period) is the result of the longer time period since the thesis publication date in the early years.

The increased funding by the DHET of journal articles – especially since 2005 – and the subsequent push at higher education institutions for increased publications[10] are the most plausible drivers of these increases. Another explanation for the increasing number of published studies might be the growing use of the 'PhD by publication' model whereby journal articles comprise part of the doctorate itself.[14] Recent work in this area conducted at one institution (2008–2014) suggested that this model has been adopted for approximately 26% of all theses.[15]

Table 4: Linked journal articles according to publication date

Thesis publication year	Number of linked theses	Number of published articles				% Before	% During	% After
		Before	During	After	Grand total			
2008–2011	2667	545	5128	12 575	18 248	3%	28%	69%
2009–2012	2889	987	5763	11 918	18 668	5%	31%	64%
2010–2013	3216	1440	6781	11 232	19 453	7%	35%	58%
2011–2014	3401	1771	7489	10 006	19 266	9%	39%	52%

Table 5: Ratio of articles to theses (2008–2014)

Year	Published graduates	Articles published (during)	Ratio of article to theses (during)	Articles published (during and after)	Ratio of articles to theses (during and after)
2008	614	1242	2.02	2624	4.27
2009	600	1088	1.81	2424	4.04
2010	701	1277	1.82	2676	3.82
2011	752	1521	2.02	3212	4.27
2012	836	1877	2.25	3916	4.68
2013	927	2106	2.27	4179	4.51
2014	886	1985	2.24	3667	4.14
Total	**6650**	11 096	2.09	**26 905**	**4.05**

Although Table 4 shows that an increasing number of doctoral graduates publish from their thesis (the 'during' category), we were also interested to establish whether this finding meant that the average number of articles per thesis had increased over this time period. Table 5 presents the results of these analyses. It is interesting that the results show no significant increase in the average number of articles per thesis over this period: whether one focuses on only those articles that appeared during the generation of thesis (average number of articles of just over 2.1) or on those articles which were published both 'during' and 'after' (up to 3 years after the graduate date, average of 4.1). This finding is interesting because it shows that although there has been an increase in the recent past of doctoral students publishing from their theses (Table 3), this increase does not mean that the average student who publishes from their thesis is generating more articles from their thesis than before. Stated differently: the increase in the number of articles that we have recorded linked to doctoral theses is due not to doctoral students on average becoming more productive, but simply that a larger proportion of doctoral students is in fact publishing from their theses.

The general trends observed above hide large differences in the publication practices of our sample. We give two examples below to illustrate this point. In both examples we have authors who have published before, during and after the completion of their theses.

The first example (Figure 2) is the profile of a student who published at least five journal articles in the period preceding the study years (2005 to 2009); five during the thesis years (2010–2013) and three subsequent to the completion of the thesis. The three articles highlighted in blue are seemingly not directly related to the thesis topic (although this is subject to further validation). The remaining articles – before, during and after – form a clearly cohesive collection of papers with a similar specialisation.

The second example (Figure 3) is the profile of a person whose thesis was published in 2012. This is also an example (similar to the example above) in which the candidate had published articles in a specific field before completion of the thesis. In fact, inspection of the actual thesis and the publication profile as illustrated below, shows the typical profile of a doctoral student who conducted a PhD by publication. All the titles highlighted in green appear as chapters in the thesis. This is clearly the profile of a scholar who had published in their field of specialisation for some time before writing up the thesis as well as continued to disseminate the results of the thesis after the degree was awarded. This is very often the profile of scientists in the natural and life sciences where the knowledge and insights produced over an extended period is cumulative in nature.

These two examples show how the profiles of publishing doctoral graduates can differ. Our very basic classification of articles ('before', 'during' and 'after') clearly hides deeper issues around differences in publication practices. We currently are investigating a more comprehensive typology of these variants.

In the remainder of the article we disaggregate our general findings further. In all of these analyses we revert to the total sample of articles linked to theses irrespective of whether these appeared before, during or after the thesis publication year. Including the 'before' category (which is the smallest category of publications) is justified for our focus now shifts away from the question of whether we have seen a clear increase in doctoral publication productivity (which has been sufficiently demonstrated above) to questions related to different publication practices at the institutional level (breakdown by university below) and at the individual level (breakdown by productivity and gender). We have excluded Walter Sisulu University (5 of their 7 doctoral graduates published articles), Sefako Makgatho University (3 of their 5 graduates

THESIS Title: The study of occupational risk factors and interventions for baker's allergy and asthma among supermarket bakery workers (2013)

Articles before thesis		Articles during thesis years		Articles after thesis publication	
Work-related respiratory allergy associated with sensitisation to storage pests and mites among grain-mill workers : allergies in the workplace	2005	Exposure to flour dust in South African Supermarket Bakeries: Modeling of Baseline Measurements of an Intervention Study	2010	Effectiveness of interventions to reduce flour dust exposures in supermarket bakeries in South Africa	2014
A pilot study of exposure to flour dust and allergens in Cape Town bakeries : allergies in the workplace	2007	Chronic airflow obstruction and respiratory symptoms following tuberculosis: a review of South African studies	2011	Exposure-response relationships for inhalant wheat allergen exposure and asthma	2015
Risk factors for allergy due to the two-spotted spider mite (Tetranychus urticae) among table grape farm workers	2007	Baker's allergy and asthma-a review of the literature.	2013	Environmental factors associated with baseline and serial changes in fractional exhaled nitric oxide (FeNO) in spice mill workers	2016
Occupational allergy and asthma among salt water fish processing workers	2008	Sensitisation to cereal flour allergens is a major determinant of elevated exhaled nitric oxide in bakers.	2013		
Determinants of asthma phenotypes in supermarket bakery workers	2009	Work-related allergic respiratory disease and asthma in spice mill workers is associated with inhalant chili pepper and garlic exposure	2013		

Figure 2: Illustrative example 1 of study and publication trajectory.

THESIS Title: Studies on embryonic development and hatchability of ostrich eggs (2012)

Articles before thesis		Articles during thesis years		Articles after thesis publication	
A preliminary study on the applicaton of image analysis for the measurements of ostrich eggshell traits	2006	Genetic parameters for ostrich incubation traits in South Africa.	2009	Changes in the air cell volume of artificially incubated ostrich eggs	2013
Direct responses in breeding values to selection of ostriches for liveweight are reproduction	2008	Influence on incubation management on pipping position, hatching ability and survival of ostrich chicks.	2011	Embryonic development in the ostrich (Struthio camelus) during the first 7 days of artificial incubation	2014
Factors related to shell deaths during artifical incubation of ostrich eggs	2007	Genetic parameters for eggshell traits in ostriches	2012	Ostrich (Struthio camelus) embryonic development form 7 to 42 days of incubation	2017
Genetic relationships between water loss and shell deaths in ostrich eggs, assessed as traits of the female	2008	Heritability of embryonic mortalities in ostrich eggs and factors affecting hatching failure of fertile eggs during artifical inbucation	2012	Dead-in-shell positions of near term ostrich embryos	2017
Systematic factors that affect ostrich egg incubation traits	2008	The development of ratite production through continued research (Centenary review)	2012		

Figure 3: Illustrative example 2 of study and publication trajectory.

published) and Vaal University of Technology (6 of their 11 graduates published) from these tables as the numbers are too small for sensible percentages to be generated.

We first present a breakdown of the percentage of doctoral graduates who published before, during or after their doctorate by university (Table 6). Given the large range in the distributions by universities, we have split the table into two to distinguish between those universities with larger samples of publishing graduates (more than 200) and those with much smaller samples of graduates (between 30 and 200).

Table 6: Percentage of doctoral graduates per institution who have published (2005–2017)

University (2005–2014)	Number of graduates	Number of graduates who have published	Percentage of graduates who have published (in descending order)
***n* = 200+**			
Rhodes University	455	266	58.46%
Stellenbosch University	1565	876	55.97%
University of Cape Town	1645	892	54.22%
University of KwaZulu-Natal	1426	762	53.44%
University of the Witwatersrand	1355	702	51.81%
North-West University	1146	579	50.52%
University of Pretoria	1900	864	45.47%
University of the Free State	682	295	43.26%
University of the Western Cape	518	217	41.89%
University of Johannesburg	731	299	40.90%
Nelson Mandela University	539	207	38.40%
University of South Africa	1056	295	27.94%
***n* < 200**			
Tshwane University of Technology	151	93	61.59%
Cape Peninsula University of Technology	132	72	54.55%
University of Fort Hare	183	78	42.62%
University of Venda	45	19	42.22%
Central University of Technology	68	25	36.76%
Durban University of Technology	82	30	36.59%
University of Limpopo	99	34	34.34%
University of Zululand	150	31	20.67%

The results (excluding the three universities with too small an output), reveal two interesting trends:

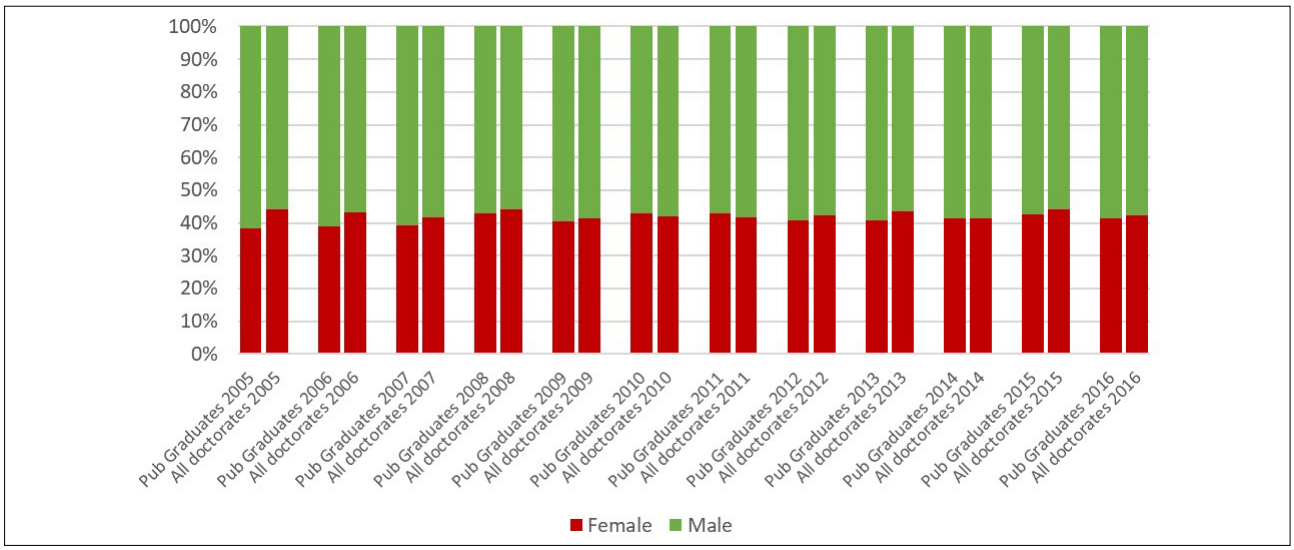
- The proportion of publishing graduates is typically highest at the traditional universities (higher than the average of 46% for the system).
- It is generally the case that doctoral graduates at the universities of technology publish from their PhDs at much lower rates (Tshwane and Cape Peninsula Universities of Technology being the exceptions).

Publication rates thus vary significantly by institution. Analysis at the level of the individual graduate also shows variance (Table 7), with 25% of graduates publishing only one article, and a significant group (41.56%) publishing from two to five articles. At the other end of the scale is a small group of 16 significant outliers who published more than 100 articles each. All of these 16 were, at the time of conducting this analysis, full-time academics who were affiliated with nine different universities; five were women, seven were black researchers, ten worked in medicine and the health sciences, only one came from the social sciences and none came from the humanities. It needs to be emphasised that the numbers in Table 7 relate only to the 6650 graduates to whom we could link publications.

Table 7: Publication rates per published graduate (before, during or after graduation within the 10-year period)

Number of articles	Number of published graduates	Percentage of published graduates
100+	18	0.27%
51–100	47	0.71%
31–50	127	1.91%
21–30	190	2.86%
11–20	676	10.18%
6–10	1112	16.74%
2–5	2779	41.84%
1	1692	25.47%

Further analyses of those doctoral graduates who have highlights the trends in terms of gender (Figure 4) and journal index (Figure 5). The disaggregation by gender shows that there is no significant difference between the proportion of articles authored by men and that authored by women in comparison to the gender distribution of all doctoral graduates for the same year.



Source: Higher Education and Training Management Information System (HEMIS)

Figure 4: Published doctoral graduates disaggregated by gender and year compared to total doctoral graduates disaggregated by gender and year.

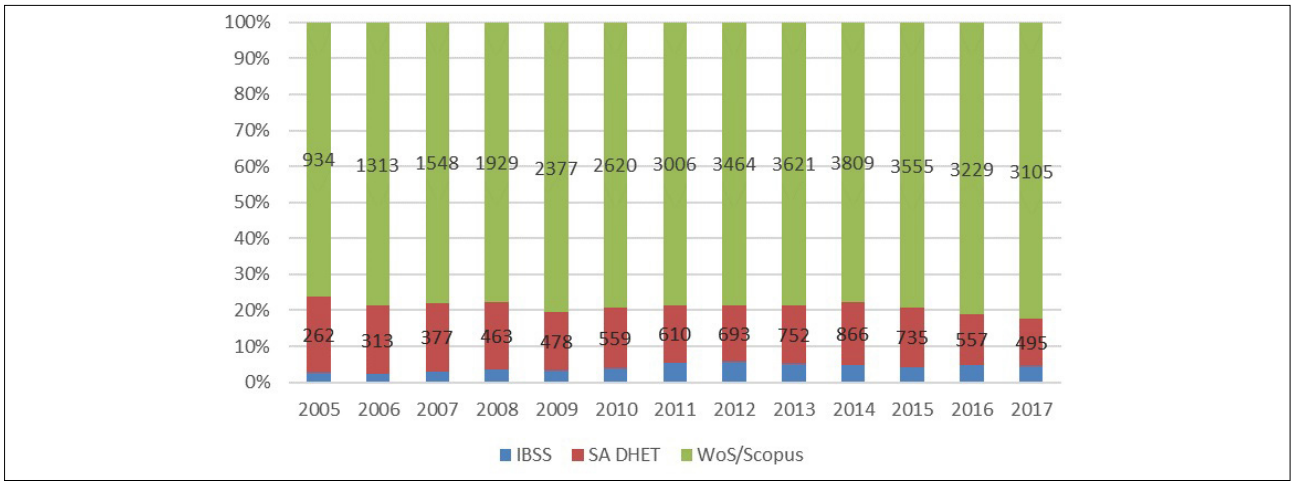


Figure 5: Articles disaggregated by journal index.

Finally, Figure 5 provides a breakdown of the publications by doctoral graduates according to the journal indexes and lists in which the relevant journals feature. For the purposes of this analysis, all articles were coded into three categories:

- Articles that appeared only in local DHET-accredited journals (and not in any other journal databases) were coded as 'SA DHET'.
- Articles that appeared only in the ProQuest IBSS list of journals (and not in any other journal databases) were coded as 'IBSS'.
- Articles that appeared in either the Web of Science and/or Scopus citation databases (and not in any other journal databases) were coded as 'WOS/Scopus'.

There has been some speculation that the pressure to publish that characterises many higher education institutions, both in South Africa and beyond[16,17], would lead academics and, by implication, also our doctoral students or graduates to publish more in local journals (DHET) or IBSS journals rather than in journals that are indexed in the two citation databases ([CA]Web of Science or Scopus). However, the evidence (Figure 5) shows a small and steady increase in the proportion of articles published in journals in the WOS or Scopus citation databases: from 76% in 2005 to 82% in 2017. This finding is important as it suggests that the increase in the rate of publications from PhD theses did not occur at the expense of publishing in more visible international journals.

Discussion

We present an analysis of journal article publications by doctoral graduates in South Africa across a specific time frame to provide a picture of the publication rates of these graduates and, in so doing, consider what this picture might indicate about the quality of doctoral work. While we found that approximately 52.2% of doctoral graduates could not be linked to any DHET-accredited publication, there is evidence of a trend toward increasing publication by graduates over the period under scrutiny, which is promising, particularly given the increase in WOS/Scopus-indexed outputs. It is important, however, to consider what lies behind these findings, the context within which they occurred, and to reflect on what they mean for doctoral education going forward. As mentioned earlier, this paper presents the first level investigation and it is clear that work in this area should be ongoing, with many aspects requiring further investigation.

We have already alluded to the issue of subsidy generation for universities, and the concomitant pressure that institutions then place on supervisors and students to 'produce'. We have also emphasised the role that the 'PhD by publication' model may have played in increasing doctoral outputs. There could, of course, be several other factors that our data cannot expose. In their work on enhancing postgraduate supervision, for example, Nulty et al.[18] identified strengthening supervisor capacity, particularly at research-intensive universities, as a mechanism to grow postgraduate publication outputs. Over the past 10 years in South Africa, initiatives such as the Strengthening Postgraduate Supervision (www.postgraduatesupervision.com) and the Enhancing Postgraduate Environments (www.postgradenvironments.com) have intentionally focused on postgraduate supervision, possibly also contributing to the increase in outputs that we now observe. On the other hand, there may be supervisors who discourage publication during doctoral studies as it may distract the student from doctoral work[4], or alternatively coerce students into publication for their own gain[19]. Clearly silent in this study are the individual student voices which could inform us about what motivates towards publication, what might enable or constrain it.

There are also a number of caveats that need to be considered. For example, what percentage of doctoral graduates leaves the academic environment after graduation and in so doing moves away from any work-related expectation that they should publish? Graduates may be publishing in journals that are not DHET accredited, but that are specific to their areas of interest. Differentiation also plays out across the representation of fields in the publishing arena. Some fields are more difficult to publish in than others,[20] and some prefer different outputs such as music scores, books and portfolios – our study has not accounted for these.

At a more detailed level, there is evidence of unevenness across the system as the issue of institutional histories that characterise the South African higher education system manifests here. While some universities have such low numbers of doctoral graduates that using publications as a proxy for the quality of the doctorate is highly problematic, there are universities with more than 100 doctoral graduations over this period where very few manage to publish. Two institutions stand out in Table 6. At University of Zululand, only 20.7% of their 150 PhD graduates could be matched to any publications. At Unisa, only 27.8% of their 1056 PhD graduates could be matched to any publications. Overall, the institutional data need to be read with care and interpreted through the lens of our country's complex past.

There is also the issue of academics pursuing doctoral studies. For example, we know that approximately 35% of doctoral candidates are academics. For many academics, the doctorate represents a logical next step in their academic careers[3], undertaken against the backdrop of the 'publish or perish' narrative that has become pervasive in academic circles[16,17]. Further analysis is needed to establish how many of the country's doctoral graduates who have published are indeed academics, what factors have enabled or constrained their participation in publishing, and how some of these statistics might be shifted further upwards. Knowledge production and dissemination are central to the identity of an academic, as well as being key for promotion and for successfully securing grants that will fund future work.[3,17] Focusing specifically on the outputs of doctoral graduates who are in an academic role is also important given that these graduates are expected to take on the supervision of future doctoral students. How does one take on the mantle of research mentor if one is not actively involved in the publication of research?

As far as gender of the publishing doctorates is concerned, no significant difference was found between this cohort and the gender of all doctoral graduates. To put it differently: those doctoral graduates who published were in the same proportion of the gender distribution of all doctoral graduates over the same period. Further analysis by age of the graduate and scientific discipline may reveal deeper differences.

This analysis of doctoral publication outputs has provided a stratified overview of an extremely complex issue. We acknowledge that analysing 'publications' as a collective downplays the significant variance across the publication industry in terms of quality, reach, focus, and the like. Our data do not identify those graduates who could have in fact published in non-accredited or even predatory journals. Recent work in the area of predatory publishing has identified this as a significant area of concern, with 3.4% of articles published by South African authors in the period 2005–2014 being identified as having been published in such journals.[21] It can be assumed that doctoral graduates are included in this number.

At a practical level, this study highlights the need for better tracking of publications given that graduates change their names and institutional affiliations. Many journals now require authors to include their ORCiD. It is clear that encouraging the use of ORCiD on all theses would greatly facilitate future work in this area, and indeed many universities are already implementing this as a requirement for the master's and doctoral graduates as of 2019.

Ultimately, the study provides evidence of Lotka's Law whereby most of the research publications in a system or institution are typically produced by a relatively small group of highly active academics (see also Kamler[4]). Given that 75% of those doctoral graduates who do publish manage to publish two or more articles (Table 7), this study also suggests that if graduates can 'crack the code' and obtain one publication, they are likely to move on to more. Supporting doctoral candidates and new graduates to disseminate their work through publication seems to be an important endeavour, and yet it appears that mentorship to support doctoral publication is not common practice, particularly in the social sciences.[4] Given the enormity of responsibilities associated with supervision and the 'burden of supervision' in a context of scarce resources,[6] some may argue that it is unfair to expect doctoral supervisors to take on the work of inducting graduates into the processes of writing for publication. However, as we have shown, the description of the doctorate in the Higher Education Qualifications Sub-Framework[1] makes it clear that this is indeed central to doctoral education as 'training for an academic career' through the production of knowledge that should 'merit publication'.

The study has opened up several avenues for further research, including more qualitative work, as suggested above. Future analysis of the data will also allow us to interrogate collaborations between doctoral scholars and their supervisors through co-authorships – an approach that has been identified as being enabling and generative for doctoral publication.[4] Such work could expose the 'back story' that further qualitative studies could illuminate. For example, there may be cases where the supervisor undertook extensive mentoring with regard to publication, but chose not to take co-authorship; or where the supervisor wrote the article on their own without any such mentorship and included the student as co-author in recognition for their generation and/or analysis of the data; and so forth. These issues all influence the publication landscape, directly impact on the lives of many academics and students, and therefore warrant our attention.

Finally, it should be noted that the findings from this study are not necessarily out of kilter with work conducted in other countries. In 2008, Lee and Kamler[22] observed similar trends in countries such as the UK, the USA and Australia. At the time, however, they called for doctoral programmes to be more intentionally structured to enable the dissemination of doctoral work, emphasising pedagogic practices that facilitate the graduate's entry into the disciplinary community such as co-authorship, and other writing related initiatives. As South Africa continues to strive towards strengthening research work at doctoral level, institutions should be encouraged to build support for publication throughout the doctoral journey across the initial years and beyond. Much can be learned from those fields, particularly in the natural sciences, where there is a tradition of such collaborative endeavours.

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Authors' contributions

S.v.S., S.M. and J.M. contributed to the conceptualisation of the study. S.v.S. led the writing process, and S.M. and J.M. contributed to the development of the manuscript from draft to finalisation. H.R. was responsible for data analysis and curation.

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