FELLOWSHIP OUTCOMES AND FACTORS ASSOCIATED WITH SCIENTIFIC SUCCESSFULNESS OF JUNIOR RESEARCHERS IN CROATIA

Ozren POLAŠEK
Faculty of Medicine, Zagreb

Marko PETROVEČKI
Zagreb

Dragan PRIMORAC
Ministry of Science, Education and Sports
of the Republic of Croatia, Zagreb

Mladen PETROVEČKI
Dubrava University Hospital, Zagreb

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We analyzed data on the junior researchers, using a sample of junior researchers whose fellowship supports from the Croatian Ministry of Science, Education and Sports were terminated between 1999 and 2005. Completing a PhD degree was positively associated with female gender, co-authoring a scientific article with the mentor, and above-average scientific production of the junior researcher. Junior researchers who were among top 10% of students according to their grade point average during undergraduate studies had significantly lower odds of completing a PhD degree during fellowship, as well as junior researchers who were employed in biomedicine. The study results indicate the potential points which could be influenced during the junior researchers selection process and at the moment of granting fellowships, both with an aim to improve the effectiveness of the junior researcher fellowship support system in the Republic of Croatia.

Key words: doctoral degree, employment, human resources, junior researcher, scientific production

✉ Mladen Petrovečki, Dubrava University Hospital,
Avenue G. Šuška 6, 10 000 Zagreb, Croatia.
E-mail: mp@kbd.hr

INTRODUCTION

The system of employing top graduate students as junior researchers in science and higher education system was officially launched by the Croatian Ministry of Science, Education and Sports (MSES) in 1991 (MSES, 2006a). The main goal of the system was to engage young graduates in science, offer them scientific education and the opportunity to complete masters (MSc) and doctoral (PhD) degrees. Additionally, the system provides the basis for the selection of best candidates among junior researchers for full-time employment in scientific and higher education institutions. The selection of candidates for junior researcher is based on the indicators of their undergraduate academic performance. Grade point average has always been used as the key criterion, along with the candidate's age and duration of education (MSES, 2005a).

A junior researcher is being employed at a higher education institution, institute or other organization registered in the Croatian Register of Scientific Organizations (*Narodne novine*, 2003b; 2004a) as a co-worker on a research project approved and supported by the MSES. A junior researcher is involved in the research on the topic defined by the research project, while the project leader, usually but not necessarily, becomes a mentor. During the research project, the project leader submits regular annual reports to the MSES and supervises all aspects of the junior researcher's development (*Narodne novine*, 2003b). Since 1991, the regulations determining the status and terms of advancement of junior researchers have changed several times. According to the Act on Scientific Activity and Higher Education (*Narodne novine*, 2003a; 2003b; 2003c; 2004b; 2004c), duration of junior researcher fellowship is determined by two periods. During the first period of six years, a junior researcher has to complete doctoral studies and a PhD thesis (actual law does not recognize the possibility of completing a master's degree). If, within the given period, a junior researcher completes a PhD degree, he or she has the possibility to extend the term of employment contract for four years more, during which he or she continues to work in the same institution on the same research project and receives the salary from the MSES.

Among the previous studies on the system of junior researchers and young scientists in Croatia in general, several studies should be singled out. These studies investigated the questions of the education of young scientists and perception of science and employment in science (Prpić, 2003), factors associated with the scientific production (Prpić, 2000), ethical attitudes of young scientists (Prpić, 2005), gender differences in scientific production (Prpić, 2002a), and problems of young scientists in general (Prpić, 2004). Among the topics related to young scientists and very important for the science policy of the Republic of Croatia are discussions about the loss of academic staff to other countries, *brain drain*, and movement of academic staff from the science and education sector into other sectors in the country, *brain waste* (Marušić, 1996; Golub, 2001; Golub, 2002; Horvat, 2004). The results of the study conducted in 2000 illustrated that junior researchers prone to leaving the country were dissatisfied with their prospects in Croatia and listed personal and institutional financial problems as additional reasons (Adamović and Mežnarić, 2003). The results of a similar study conducted among the students of Zagreb University School of Medicine showed that the perception of the employment possibilities was the most important factor determining the choice of the employment place (Polašek et al., 2006a).

Since the idea of employing junior researchers is based on the stimulation of their future higher education and research activity, one of the fundamental questions of system successfulness is the question of the junior research fellowship outcomes, reflected in the successful completion of a PhD degree and getting employment once the MSES fellowship support has terminated. The idea of developing such a system of governmental support in science is definitely stimulating, but some studies have implied that there are also negative indicators. For example, between 1995 and 2000, 48% of fellowships were either terminated before the end of the term or were not extended because junior researchers did not fulfill the continuation criteria (completing masters or doctoral degree) within the given time period (Prpić, 2002b). Additionally, only 18% of junior researchers remained employed in the higher education and science system after the fellowship termination (Prpić, 2002b). Thus, the aim of the present study was to perform a systematic analysis of available data on junior researchers and identify factors that could serve as possible indicators for selection of more successful candidates for junior researcher fellowships. Such criteria could prove important for the government to implement science policy in accordance with the set guidelines (Petrovečki, 2006; Petrovečki et al., 2006; MSES, 2006b).

PARTICIPANTS AND METHODS

We collected the MSES data on junior researchers whose fellowship contracts were terminated in the period between January 1, 1999 and December 31, 2005, irrespective of the calendar year when they became junior researchers.

Junior researcher is a term for a person who is, as a rule, employed for the first time after graduation, and aims to complete a PhD degree. Sometimes, research fellow is termed "research novice" or "research assistant", which all correspond to the term "znanstveni novak" in Croatian. Although the term research trainee might provide even better translation, the official website of MSES suggests the translation as junior researcher (MSES, 2006b, for example), which is therefore used throughout this article.

Measurements

From April to July 2006, we collected demographic data available from the MSES archive on junior researchers, the place and duration of their employment, and their mentors. Additionally, we searched a bibliographic database Web of Science (http://wos.irb.hr) to collect data on scientific articles published by the junior researchers included in the study. The number of articles published by a junior researcher was determined for the period before and during the fellowship. The same search was performed to determine a total scientific production of their mentors and the number of articles co-authored by both mentor and junior researcher, published during the fellowship duration.

Based on these data, we introduced some new variables. Two binary variables (yes, no) were knowledge on publishing, if junior researcher published at least one article before the beginning of the fellowship and if mentor and junior researcher co-authored at least one article published during fellowship. Average annual scientific production of the junior researcher during the fellowship was defined as the ratio of the total number of articles published by a junior researcher during fellowship and years of his or her employment as a junior researcher. The obtained values were expressed as percentiles (marked by single quotation sign in this article) to indicate the rank of a junior researcher by the number of published articles in relation to all other junior researchers.

Transformation to percentiles was performed separately for each scientific area because the areas differ in the level of publishing activity (Prpić, 2003; van Raan, 2005; Nacionalno vijeće za znanost, 2005). Accordingly, junior researchers were compared by the average annual scientific production percentile only within the scientific area in which they published. Due to non-normal data distribution, percentile values of average annual scientific production were transformed into ordinal variables. Junior researchers in each scientific area were classified into three groups: those who had no publication or those who showed average scientific output (0'-74'), those who had above-average output (75'-89'), and those who had exceptionally high scientific output (90'-100'). Thus we obtained a standardized indicator of average annual scientific production for each junior researcher. A similar procedure was applied for the assessment of scientific productivity of the mentors. Mentors in each scientific area were also classified into three groups according to a total number of articles they published: below average (0'-24'), average (25'-75') and above-average scientific productivity (76'-100').

Areas and institutions

Institutions where junior researchers were employed were classified as (a) research institutions (public scientific institutes conducting scientific research and mostly not participating in teaching activities), (b) educational institutions (Croatian universities, primarily involved in higher education, but scientific research as well), and (c) other institutions, where higher education and scientific research are not the main activities but the principal investigators originated from. This group encompassed the Croatian Academy of Sciences and Arts, Croatian Lexicographic Institute, other scientific institutes, institutions with registered scientific units, hospitals and clinical hospitals, etc.

Statistical analysis

Due to non-normal data distribution, numerical data were presented with median with interquartile range, calculated as a difference between the 75th and 25th percentile and used as an indicator of data variability. Categorical data were presented with absolute and relative frequencies (n, %). In data analysis, chi-square was used for categorical variables and Mann-Whitney test was used to compare two groups of numerical variables. Duration of employment was analyzed with Breslow test within Kaplan-Meier analysis.

Binary logistic regression was used to predict the completion of the PhD degree. The main numerical indicator of this method is adjusted odds ratio (OR). $OR>1$ indicates that the observed predictor was positively associated with the criterion variable, i. e. completion of the PhD degree, whereas $OR<1$ indicated that the observed predictor was negatively associated with the criterion variable. Proportion of variance ex-plained by the binary logistic regression was expressed as Nagelkerke R^2 (Nagelkerke, 1991). Data analysis was performed with Statistical Package for Social Sciences v. 14.0 (SPSS Inc., Chicago, IL, USA). Only $P<0.05$ was considered statistically significant.

RESULTS

The study encompassed data on 1,320 junior researchers whose fellowships terminated between January 1, 1999 and December 31, 2005 (Table 1). There were 434 (32.9%) junior researchers who completed a PhD degree by the end of the fellowship, while 886 (67.1%) left the MSES support system with a master's degree or without any degree. Dynamics of employment was very uneven ("fellowship granted" and "fellowship started" in Table 2), but there was a clear and steady increase in the total number of junior researcher positions ("total No. of employed" in Table 2), with the number of supports that were started (number of junior researchers who started receiving salary in a particular calendar year) closely following the number of supports that were granted. The number of terminated fellowships also gradually increased during the study period. Number of terminated fellowships while a junior researcher was holding a PhD degree varied over time, with the highest proportion recorded in 2003 (Table 2).

➲ TABLE 1
Outcomes of fellowship among junior researchers whose fellowships have terminated in 1999-2005 period[a]

Fellowship outcomes	N (%)
PhD, employed within MSES[b]	298 (22.6)
PhD, employed outside MSES	128 (9.7)
PhD, others[c]	8 (0.6)
PhD, total	434 (32.9)
MSc, employed within MSES[d]	119 (9.0)
MSc, dropped-out	210 (15.9)
MSc, others[c]	14 (1.1)
No scientific affiliation, employed within MSES[d]	60 (4.5)
No scientific affiliation, dropped-out	444 (33.6)
No scientific affiliation, others[c]	39 (3.0)
No PhD, total	886 (67.1)
Total	1,320 (100.0)

[a] Abbreviations: PhD – doctor of philosophy; MSc – master of science; MSES – Ministry of Science, Education and Sports.
[b] Junior researchers who advanced in their career and received a long-term position from the MSES.
[c] Junior researchers with unavailable outcome records, or other outcomes.
[d] Some junior researchers were employed on a long-term basis before completing a PhD degree, as the post became available, and the junior researcher was (as a rule) in an advanced stage of the PhD thesis submission.

➲ TABLE 2
Dynamics of the granted and started fellowship, total number of employed junior researchers, and fellowship outcomes for the junior researchers whose support by the Ministry of Science, Education and Sports (MSES) was terminated during the 1999-2005 period. The data were obtained from the MSES archive on junior researchers

Year	Number of junior researchers				
	Fellowship granted	Fellowship started	Total number of employed junior researchers at the end of the year	Terminated MSES fellowship support: Total number	Terminated MSES fellowship support: PhD degrees (%)
1999	118	119	1,342	128	39 (30.5)
2000	460	394	1,636	142	33 (23.2)
2001	631	581	2,103	160	40 (25.0)
2002	341	393	2,297	171	54 (31.6)
2003	194	181	2,245	270	116 (43.0)
2004	565	464	2,586	211	73 (34.6)
2005	178	241	2,511	238	79 (33.2)
Total	2,487	2,373	–	1,320	434 (32.9)

TABLE 3
Demographics, number of completed PhD degrees, employment characteristics, and scientific productivity of junior researchers whose support by the MSES was terminated during the 1999-2005 period, according to scientific areas

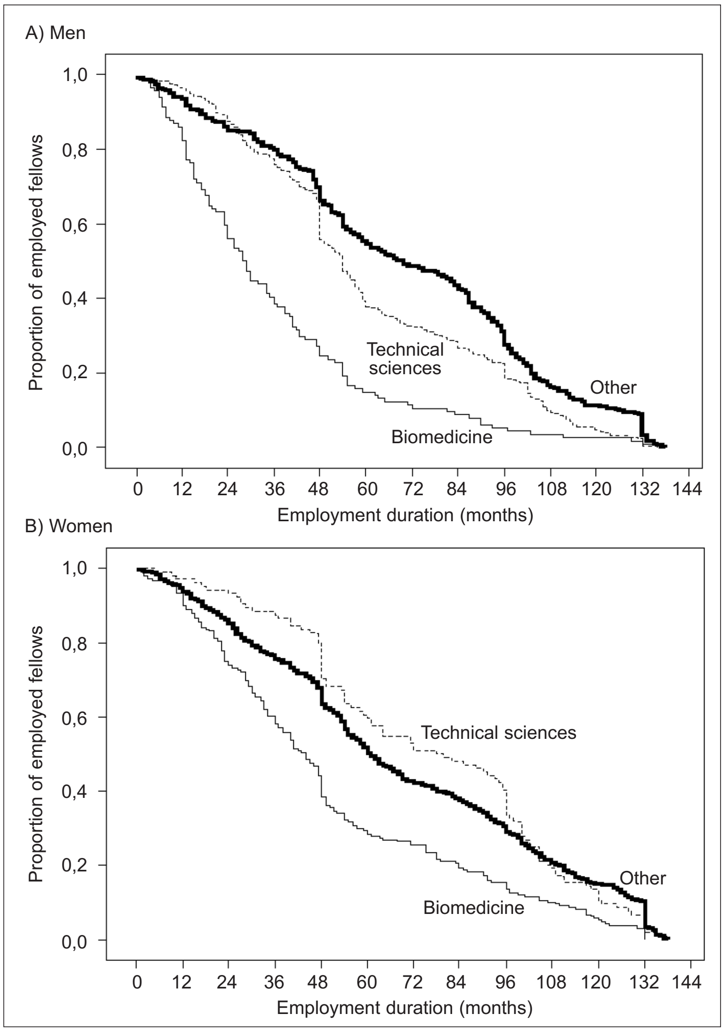
There were slightly more women among junior researchers in this study (670 or 50.8% female fellows, Table 3). The proportion of female junior researchers was significantly higher in biomedicine, social sciences, and humanities, while significantly lower in technical sciences (Table 3). The highest proportion of doctoral degrees was completed in natural sciences and humanities, whereas the proportion of completed PhD degrees in technical sciences and biomedicine was significantly lower, compared to all others (Table 3).

	Scientific field						
Characteristics	Natural	Technical	Bio-medicine	Bio-technology	Social	Hu-manities	Total
Women junior researchers (n, %)	145 (45.4)	104 (33.7)	208 (68.2)	39 (58.1)	100 (64.3)	74 (54.8)	670 (50.8)
P[a]	0.928	<0.001	<0.001	0.799	<0.001	0.012	n/a
PhD degree (n, %)	157 (54.7)	87 (24.3)	55 (17.1)	30 (38.0)	55 (35.7)	50 (41.7)	434 (32.9)
P[a]	<0.001	<0.001	<0.001	0.320	0.425	0.032	n/a
Median employment duration for junior researchers (interquartile range)							
Men	85.0 (55.0)	54.0 (52.0)	28.5 (34.0)	57.0 (58.0)	54.0 (54.0)	62.0 (62.0)	54.0 (62.0)
P[b]	<0.001	0.456	<0.001	0.532	0.606	0.354	n/a
Women	86.0 (70.0)	79.0 (56.0)	44.0 (52.0)	62.0 (58.0)	50.0 (63.0)	54.0 (60.0)	55.0 (63.0)
P[b]	<0.001	0.001	<0.001	0.726	0.145	0.705	n/a
Gender differences in employment duration[b]	0.370	<0.001	<0.001	0.795	0.469	0.983	0.132
Median number of published articles per junior researcher (interquartile range)	1.0 (8.0)	0.0 (0.0)	1.0 (3.0)	0.0 (1.0)	0.0 (0.0)	0.0 (0.0)	0.0 (2.0)
Median annual scientific production of junior researcher (interquartile range)							
Men	0.3 (1.1)	0.0 (0.0)	0.4 (1.2)	0.0 (0.3)	0.0 (0.0)	0.0 (0.0)	0.0 (0.3)
Women	0.1 (0.8)	0.0 (0.1)	0.1 (0.8)	0.0 (0.2)	0.0 (0.0)	0.0 (0.0)	0.0 (0.3)
Gender differences in annual scientific production[c]	0.016	0.115	0.069	0.609	0.396	0.031	0.741
Total number of junior researchers	287	358	322	79	154	120	1,320

[a] χ^2 test; compared to other scientific areas; [b] Breslow test; vs. remaining scientific areas; [c] Mann--Whitney test; n/a – not available.

The median employment duration of junior researchers was 54 months (interquartile range 62) for men and 55 (interquartile range 63) for women. Statistically significant difference was found in employment duration between different scientific areas (Table 3). The longest employment duration was recorded in natural sciences, and the shortest in biomedicine (Table 3). Gender differences in employment duration were found in technical sciences and biomedicine. The shortest employment duration was found in biomedicine for both male and female junior researchers (Breslow P<0.001 for both, compared to remaining scientific areas) (Table 3, Fig. 1). Men junior researchers in technical sciences were employed for a shorter period compared to junior researchers in other scientific areas, while women junior researchers in technical sciences were employed longer compared to all others (Fig. 1a, b).

➲ FIGURE 1
Employment duration for (a) men and (b) women employed as junior researchers in biomedicine, technical sciences, and other scientific groups (natural, biotechnology, social sciences and humanities). Starting proportion for all groups is 1.0 (100% of junior researchers, beginning of employment), and the ending proportion is 0.0 (MSES support finished).



The junior researchers included in the study had a total of 2,834 authorships during fellowship (number of co-authorships was higher than the actual number of published articles, because two or more junior researchers could have co-authored the same article). The highest number of articles indexed in the Web of Science was published by junior researchers in biomedicine, and the lowest by junior researchers in social sciences and humanities (Table 3, median number of articles published per junior researcher). There were 836 (63.3%) junior researchers who did not publish a single article in journals indexed in the Web of Science during their fellowship. Furthermore, 6.7% of junior researchers co-authored a total of 52.1% of all published articles and 13.2% of junior researchers coauthored a total of 76.2% articles (data not presented). Analysis of the average annual scientific production showed that there were significant gender differences in some areas, namely men junior researchers in natural and social sciences had higher average annual scientific production (Table 3).

To predict completion of a PhD degree among junior researchers, logistic regression was used with a total of 10 predictors (Table 4; statistical model explained 34.8% of variance). Identified predictors positively associated with completing a PhD degree were female gender, employment in natural sciences, co-authoring an article published in a journal indexed in the Web of Science with the mentor, and above-average scientific production of the junior researcher (Table 4). Predictors that were negatively associated with completion of a PhD degree were being among top 10% of undergraduate students according to grade point average, employment at Universities outside large cities, in educational or other institutions, and in biomedicine (Table 4).

TABLE 4
Factors associated with completing a PhD degree among junior researchers whose support by the Ministry of Science, Education and Sports was terminated during 1999--2005 period; logistic regression results

Predictor variable	%	P	Odds ratio	95% confidence interval
Junior researcher among the 10% of best undergraduate students according to grade point average				
No[a]	47.3		1.00	
Yes	18.9	<0.001	0.23	0.17-0.31
Junior researcher's gender				
Men[a]	30.6		1.00	
Women	35.1	0.029	1.38	1.03-1.84
Junior researcher published a scientific article in a journal indexed in the Web of Science as an undergraduate student				
No[a]	33.3		1.00	
Yes	27.4	0.256	0.71	0.39-1.28

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Predictor variable	%	P	Odds ratio	95% confidence interval
University				
Zagreb[a]	35.0	0.133	1.00	
Rijeka	22.9	0.690	0.89	0.52-1.55
Split	32.7	0.526	0.85	0.52-1.40
Osijek	25.0	0.923	1.04	0.51-2.10
Other	7.7	0.010	0.14	0.03-0.62
Institution type				
Research institutes[a]	57.9	<0.001	1.00	
Educational institutions	28.8	0.001	0.55	0.39-0.77
Other institutions	10.9	<0.001	0.20	0.11-0.36
Research field				
Natural[a]	54.7	<0.001	1.00	
Technical	24.3	0.081	0.68	0.44-1.05
Biomedicine	17.1	<0.001	0.22	0.14-0.35
Biotechnical	38.0	0.547	0.83	0.45-1.52
Social sciences	35.7	0.648	0.89	0.54-1.46
Humanities	41.7	0.444	1.23	0.72-2.11
Mentor's gender				
Men[a]	31.6		1.00	
Women	37.8	0.974	1.01	0.72-1.41
Mentor's scientific production class				
Below average (0'-24')[a]	35.1	0.385	1.00	
Average (25'-75')	38.1	0.184	0.79	0.56-1.11
Above average (76'-100')	26.7	0.750	0.94	0.62-1.41
Junior researcher and mentor co-authored an article in a journal that was indexed in the Web of Science				
No[a]	28.3		1.00	
Yes	47.2	<0.001	2.27	1.51-3.43
Junior researcher's scientific production class				
Average (0'-74')[a]	24.5	<0.001	1.00	
Above average (75'-89')	54.1	<0.001	2.21	1.50-3.25
Exceptional (90'-100')	49.0	<0.001	2.94	1.62-5.34

[a] First group was always designated as a reference group (ref.); P values for a reference group were provided if there were at least three classes of predictor variable.

DISCUSSION

One of the most salient results of this study was a small number of completed PhD degrees (32.9%, Table 1), although the basic idea of being a junior researcher is to acquire scientific education and complete a PhD degree. This finding can be interpreted in several ways. From the point of view of the MSES, which evaluates the system and governmental structure in charge of financing this part of science and education sector, a third of junior researchers completing a PhD degree is not a satisfying result. The same opinion could be shared by the general public. However, if we observe this finding again from the MSES standpoint, but as an institution that defines the science policy in Croatia, we may conclude that a third of junior researchers completing a PhD degree is not a disappointing result because the system ensures the selection of the best candidates who can then become permanently employed in the science and higher education system. If one third of junior researchers complete a PhD degree within the stipulated period, and it is them who are the potential candidates for new jobs in science, then we can be satisfied with the system as a way of choosing the best among the best, as a way of finding the young people who are really willing to invest themselves into scientific work. From that point of view, we cannot say that we are dissatisfied with selection of one in three. Additionally, drop-out rates (percent of postgraduate students who terminated their support before completing a PhD degree) in the European Union vary from 15-20% in Italy (Germano, 2001) and 21% in Great Britain (Booth and Satchell, 1995) to 87% in Spain (Cebrian, 2001). The differences in the education and government systems probably account for the differences in the drop-out rates in these countries. In comparison with these rates we cannot be satisfied with almost 67% junior researcher drop-out rate in our system. Nevertheless, the need to change the current situation is expressed by the present study itself, which aims to reveal the factors for improvement of the selection process of top candidates for the junior researcher positions.

In combination with academic indicators which show that the best junior researchers leave the fellowships more often than the other, the results show that there is a possibility of losing valuable academic staff (*brain waste*). The Croatian general public is familiar with the term *brain drain*, which means that highly educated staff emigrate to other countries. However, the phenomenon which is close to the *brain drain* but has not attracted so much public attention is *brain waste*, which may represent even greater loss for science than the *brain drain* itself (Golub, 2001). *Brain waste* means a loss of highly educated staff in the country because of better employment conditions in the sectors outside the science domain, e. g. in industry. The most frequently listed reason for highly educated employees to leave science are low salaries of scientific staff, which is especially important to young researchers (Machin and Oswald, 2000). *Brain waste* was also investigated in Croatia, and the study results indicated significant dissatisfaction among young researchers, indicating that *brain waste* was an increasing problem (Golub, 2001). Several studies conducted among young people working in the higher education and science system showed that their attitude toward employment possibilities in Croatia was the main determinant of creating one's own career plans (Adamović and Mežnarić, 2003), especially finding the appropriate job and deciding to leave science as well as the country (Marušić, 1996; Golub, 2002). The fact that it is the best students and those interested in scientific work who more often consider going abroad makes the problem all the more serious (Polašek and Kolčić, 2005).

Our study also showed that employment duration differs across various scientific areas. The highest rate of junior researchers that have dropped-out from the MSES support system (and consequently had the shortest employment duration) was noted in biomedicine and technical sciences (Fig. 1). Both areas offer a wide range of possibilities for employment, often with more favorable (better salaried) working conditions, than those offered to junior researchers. This was especially prominent in biomedicine, which may be associated with characteristics of medical sciences, such as a strict hierarchical system and advancement to higher positions at older age, which is reflected in the age structure of permanently employed scientists in biomedicine (Prpić, 2002b). Drop-out rates tend to be higher in settings with higher rates of age-related discrimination and decreased rates of teamwork and horizontal cooperation (Wright and Cochrane, 2000). Additionally, junior researchers in medicine might be attracted to the clinical residencies in the medical field in which they work, further increasing their drop-out rates.

On the other hand, junior researchers working in the areas in which there are not many jobs outside the academic sector are in a less favorable situation (Prpić, 2002b) and remain employed as junior researchers for a longer time. Naturally, in such conditions, a certain number of junior researchers think about possible solutions, including *brain drain* and leaving the science system, *brain waste*. However, the low percentage of junior researchers completing a PhD degree in our study could not be unambiguously marked as negative or even *brain waste*. Junior researchers whose fellowships have terminated could have continued to take courses, still be involved in scientific work, and finally complete a PhD degree. This is an indicator of the dynamics of junior researcher fellowship, which presents only one step in the scientific career development.

How to predict who will complete a PhD degree?

The results of a multivariate analysis presented in Table 4 show that several indicators may be used as predictors in the selection process of future junior researchers. Junior researchers who were in the top 10% according to their grade point average during undergraduate education had five times lower odds of completing a PhD degree in comparison with other junior researchers (OR=0.23). This result is puzzling at first glance, because it shows that the best students selected according to the MSES criteria (MSES, 2005a) complete their PhD degrees less often than other students. However, it could be that the best students often use the fellowship only as a temporary solution until they find another job. Such an approach seems to be especially pronounced among junior researchers in biomedicine and technical sciences (Fig. 1). These findings indicate that the Ministry's advice on selection of junior researchers (MSES, 2005c) is good, because it is only that – advice, not a binding legal act.

Completing a PhD degree was less probable if a junior researcher was employed at the educational or other institution, compared to those employed in the research institutions. A possible explanation of this finding lies in the type of jobs performed by junior researchers in a particular type of institution. In research institutions, junior researchers are involved in research, and it is their main activity. The experience and knowledge they acquire can simply be used for preparation of their PhD theses. In cooperation with their mentors, who are also mostly involved in research, they succeed in completing a PhD degree during their fellowship in more than half of the cases (57.9%). Junior researchers employed in educational institutions are in a more demanding situation because, in addition to their basic task (scientific publishing and working their way to a PhD degree), they have to participate in teaching activities with obligation to perform 50% of teaching quota (*Narodne novine*, 2003c). Finally, the probability to complete a PhD degree was the lowest for junior researchers employed in other institutions (OR=0.20), where their main activities are professional rather than scientific, which decreases the possibility of doing research to a greater extent. Most of the other institutions included in our study were hospitals in the Republic of Croatia (data not presented), which carry out the projects in the field of biomedical sciences, a field characterized by the lower probability of completing a PhD degree in comparison with other scientific areas. Therefore, during approving junior researcher positions in other institutions, additional attention should be paid to the quality of the project mentoring capacities, which could, theoretically, neutralize this negative effect by their supportive behavior.

Differences between scientific areas in the rates of junior researchers completing PhD degrees were an interesting finding. The highest probability to complete a PhD degree was found for junior researchers in natural sciences and for that particular reason, they were used as a comparison group (Table 4). Junior researchers in biomedicine had the lowest probability to complete a PhD degree, which was probably associated with short employment duration and higher drop-out rates from the system. Results from other studies generally support these findings, with higher completion rates in natural sciences than social sciences and humanities (Mooney, 1968; Wright and Cochrane, 2000).

Gender differences in the probability of junior researchers to complete a PhD degree were also one of the findings (OR=1.38 for women). Literature data mostly indicate lower scientific production of women, compared to men scientists (Prpić, 2002a), but this finding is not universal, at least not among junior researchers (Polašek et al., 2006b). Our analysis confirmed that male junior researchers were more productive only in distinct scientific areas, not in general (Table 3). The probability of completing a doctoral degree within the junior research system was higher for women. Studies from the 1990s indicate higher odds in men, with an interesting pattern of gender differences (Booth and Satchell, 1995). As shown by more recent studies, the probability of completing a PhD degree is still higher for men, even in more developed countries (Mastekaasa, 2005). However, in more developed countries, men also have higher drop-out rates, which is probably associated with more attractive opportunities outside the academic sector (Prpić, 2003; Mastekaasa, 2005). The results of other studies showed that gender differences in completing a PhD degree either diminished over time (Baker, 1998) or were not found at all (Wright and Cochrane, 2000). Gender differences in the probability of completing a PhD degree in our study were in accordance with the study that found significant differences in predictors of career between men and women (Melamed, 1995), where women's achievements could in greater degree be attributed to merits, fewer homemaking obligations, and favorable organizational structure, while men's achievements could in greater degree be attributed to the personality and social determinants (Melamed, 1995). At the same time, we noticed the lack of influence of the mentor's gender on the junior researcher's probability of earning a PhD degree, despite the differences in literature data indicating that men mentors were better than women (Haines, 2003), that women mentors offered higher degree of career satisfaction and consequently success (Wallace, 2001), or that mentor's gender had no significant influence on the mentor-junior researcher relationship and career outcomes (Underhill, 2006).

The logistic regression model that predicted completing a PhD degree had four significant predictors associated with scientific production. Lack of association between number of scientific articles published before the fellowship and the mentor's class of scientific production were an unexpected finding, especially in the light of the results of previous analysis in the field of biomedicine, which indicated that these two variables had the strongest influence on the scientific production of junior researcher (Polašek et al., 2006b). Possible explanation for these findings is twofold: either biomedical area differs in the dynamics and pattern of scientific production from other fields, or there is no strong association between scientific production and earning a PhD degree for junior researchers included in this study. The latter statement could have negative implications because it could be interpreted more freely as an indication of the lack of the association between scientific production and PhD degree, thereby indicting that different predictors determine whether or not a junior researcher will complete a PhD degree. This explanation could be possible if, for example, a junior researcher perceived writing a PhD thesis as a mere formality that simply had to be done in order to complete a doctoral degree, while the quality of the work was assessed by a committee. Some university schools in Croatia introduced a requirement that before a candidate can complete a PhD degree, he or she must have a published article on the same or similar topic in a journal indexed in Current Contents bibliographic database, and the impact factor of this journal has to exceed 1.0 (Zagreb University School of Medicine, 2006, for example), which makes review criteria of the topic and thesis much stricter. The introduction of this rule is what supports our considerations of the differences in the quality of dissertations and articles published after a strict international review.

The remaining two scientific-related variables in the model indicated that scientific production of junior researchers was a significant predictor, and that junior researcher-mentor co-authorship was also a significant PhD completion predictor. From the association of the last four science-related variables, it is possible to conclude the following: *a priori* scientific production of the mentor will have little or no influence on completing a PhD degree, and junior researcher's experience in writing and publishing scientific articles during the undergraduate studies will not be a crucial factor for PhD completion. The crucial factor will be junior researcher-mentor cooperation, reflected in co-authorship of scientific articles, which was a significant predictor in our regression model (OR=2.27). The cooperation between the mentor and junior researcher should be mutually beneficial, bringing knowledge, degree, experience, and opportunity to create a social network to the junior researcher, and prestige, help in research, and increase in academic visibility to the mentor (Mangematin, 2006). The results of our study confirm the importance of the mentor's role for the advancement of junior researcher (Fagenson-Eland et al., 1997; Haines, 2003; Bozionelos, 2004; Manathunga, 2005; Underhill, 2006; Polašek et al., 2006b), although some studies found no clear evidence of the crucial role of mentors (Sambunjak et al., 2006). Factors that influence the process of selection of co-workers indicate that mentors choose their students on the basis of a wide range of personal characteristics and institutional parameters, including a wish to learn, even if the student's abilities seem to be below average (Allen, 2004). However, mentors appreciate competent students who bring new skills and knowledge into the relationship and thus increase the extent and functionality of the mentor-student relationship (Allen, 2004). One of the key factors determining the efficiency of cooperation between the mentor and student is similarity in personal and career styles (Feldman, 1999). Although this parameter is difficult to assess at the beginning of the mentorship, one of the possible ways to improve the cooperation between mentors and future junior researchers could be the use of written essays as one of the selection criteria, in which junior researchers would express their own career interests. Other studies suggest various recommendations for improvement of mentor-student relationship, including better communication, closer matching of career goals and ambitions, purposeful participation in the program, and better supervision of the program (Godshalk and Sosik, 2003; Eby and Lockwood, 2005).

Variables that were used in the regression model explained only a third of the variance, indicating that other variables or random effects were contributing with the remaining two thirds. A third of the explained variance may appear small, but in other similar studies the degree of variance explained by different predictors in the model was also low, ranging from one-fourth (Polašek et al., 2006b) to one-third of variance (Bartley and Robitschek, 2000). The problem associated with the increase in the explained variance could be associated with a wide range of characteristics, skills, and knowledge needed by the junior researcher in order to successfully complete a PhD degree (Grove et al., 2005). One of the possible ways to analyze career predictors in more detail is to include the analysis of psychological characteristics, which have been found in some studies as a crucial factor in career development (Debacker et al., 1997; Seibert et al., 1999; Savickas, 2001; Grove et al., 2005). Future studies could investigate the association between a broader set of psychological and social characteristics of junior researchers and outcomes of their employment and scientific production, and produce a completely new set of selection criteria. The use of a wide range of predictors could be of special interest to interdisciplinary scientific teams, in which the probability of success can be associated with diversity of the group (Grove et al., 2005).

Junior researchers in Croatia

By the completion of this study on November 25, 2006, there were a total of 339 fellowships approved on 107 universities, 52 public scientific institutes, and 29 other institutions participating in research work in 2006 (MSES, 2006c). Although varying over the years, the dynamics of approving junior researcher positions showed a steady increase and since 2004, the number of junior researchers registered in the MSES support system has for the first time exceeded 2500 (Table 2). Although the results of some studies point to the organizational problems in the existing system of junior researchers (Prpić, 2002b; Prpić, 2003; Županov, 2003), it is the only system that helps young graduates to get employment in the academic sector and thereby have a chance to develop a scientific career. From the very beginning, junior researchers work with experienced scientists on the existing research projects. This form of practical work is an exceptional opportunity for them to experience what it means to be involved in research, early in their professional career.

One of the developmental problems of the system of junior researchers is lack of research abut junior researchers itself. It is associated with unavailability of data on junior researchers, for example, omission of institutions to send annual reports to the MSES, or unknown outcome after leaving the MSES support system. The lack of data, whose analysis would answer numerous questions about system efficiency, was clearly noticed during this study. The MSES practice has been to require reports on the progress of research projects and reports on junior researchers once a year. As a rule, reports were delivered unformatted, written as a free text. Since unformatted data sometimes do not contain necessary information, or the information cannot be extracted from them, authors of this study in cooperation with the personnel of the MSES' Department for Science developed two questionnaires to collect data on junior researchers. One questionnaire was filled out by the junior researcher and the other by the mentor. Questionnaires were posted on the MSES website and data on junior researchers were submitted in a formatted form, together with the final report on the work on projects (MSES, 2006d).

Methodological questions and limitations of the study

There is a series of methodological questions related to the evaluation of junior researchers. Some of the questions have been identified in the previous studies (Prpić, 2002b). The basic problem is associated with the very nature of the position of junior researcher, which represents only one stage in the continuous development of scientific career. Some junior researchers become formally employed after working with the mentor for some time and thus formally enter the system at a more advanced stage as researchers than those who became junior researchers immediately after graduation. An additional problem is that in the population of junior researchers, there are those who wish to remain employed in the science and education system and do research as well as those who do not want to do only research. Although there is some degree of convergence between these two groups (Baruch and Hall, 2004), great differences can still be expected between them with respect to their career advancement and final career goals (quick completion of a doctoral degree or systematic work on the development of personal scientific "profile" for a longer time). Furthermore, in the present study, we performed an analysis of different groups of junior researchers from six different scientific areas marked by different volume and characteristics of scientific production and advancement in career. By using the Web of Science as a source of data, we set high selection criteria and thus influenced the assessment of scientific production, especially in humanities, which are less frequently indexed in that database (Prpić, 2003; van Raan, 2005). Parameters associated with the mentor could also be a source of error, because students often have poorer relationship with mentors who are directly superior, formal mentors (Feldman, 1999), while non-formal mentors exert stronger influence on their career (Underhill, 2006). Additionally, multiple mentors are not an exception today, especially in the academic sector, in the development of modern interdisciplinary scientific areas (de Janasz and Sullivan, 2004), suggesting that we might not have precisely defined mentor's influence on the junior researcher. However, probably the greatest problem in the evaluation of efficacy of the system is associated with the unavailability of the data on some junior researchers after they leave the MSES support system, because they can complete a PhD degree after the fellowship termination. The questionnaire (MSES, 2006d) should be a significant help in this type of studies in the future, providing valuable additional information.

CONCLUSION

Our study identified several key elements that could be influenced in order to improve the junior researcher system in Croatia. Such an analysis becomes especially interesting in the conditions of all-encompassing rationalization of the higher education and science system (Manathunga, 2005; Petrovečki et al., 2006), and the projected lack of scientific staff in the European Union (European Commission, 2004). One of the important findings is a relatively small proportion of PhD degrees completed by junior researchers who were top students, especially in biomedicine.

The results of this study revealed potentially critical points upon which we could act in order to increase the efficacy of the junior researchers system and the production of the future academic and scientific staff in the Republic of Croatia.

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Ishodi novaštva i znanstvena uspješnost znanstvenih novaka u Hrvatskoj

Ozren POLAŠEK
Medicinski fakultet, Zagreb

Marko PETROVEČKI
Zagreb

Dragan PRIMORAC
Ministarstvo znanosti, obrazovanja i športa RH, Zagreb

Mladen PETROVEČKI
Klinička bolnica Dubrava, Zagreb

Analizirali smo podatke o sustavu znanstvenih novaka na uzorku onih koji su izašli iz sustava potpore Ministarstva znanosti, obrazovanja i športa Republike Hrvatske tijekom razdoblja 1999.-2005. godine. Postizanje stupnja doktora znanosti bilo je pozitivno povezano sa ženskim spolom novaka, objavljivanjem znanstvenih radova s mentorom kao koautorom i iznadprosječnom znanstvenom produkcijom novaka. Znanstveni novaci koji su bili među 10% najboljih studenata prema prosjeku ocjena diplomskog studija imali su statistički značajno manju vjerojatnost da će doktorirati u odnosu na ostale novake, kao i znanstveni novaci zaposleni u biomedicini. Rezultati ovoga istraživanja upućuju na potencijalne točke na koje se može djelovati u trenutku odabira kandidata i odobravanja zahtjeva za novačka radna mjesta, oboje s ciljem poboljšanja djelotvornosti sustava znanstvenih novaka u Republici Hrvatskoj.

Ključne riječi: doktorat znanosti, ljudski resursi, zaposlenje, znanstvena produkcija, znanstveni novak

Der Werdegang und wissenschaftliche Erfolg von Nachwuchsforschern in Kroatien

Ozren POLAŠEK
Medizinische Fakultät, Zagreb

Marko PETROVEČKI
Zagreb

Dragan PRIMORAC
Ministerium für Wissenschaft, Bildung und Sport
der Republik Kroatien, Zagreb

Mladen PETROVEČKI
Klinikum Dubrava, Zagreb

Im vorliegenden Artikel werden Daten über die im kroatischen Hochschulwesen wirkenden Nachwuchsforscher analysiert, und zwar anhand solcher, die im Zeitraum von 1999 bis 2005 im Rahmen eines vom kroatischen Ministerium für Wissenschaft, Bildung und Sport geförderten Doktoratsstudiums an ihrer Promotion arbeiteten. Die Zahl der promovierten Frauen überwog vor dem Anteil der Männer; ein positiver Bezug zur Erlangung der Doktorwürde zeigte sich fernerhin bei der Veröffentlichung wissenschaftlicher Arbeiten in Zusammenarbeit mit dem Doktorvater als Koautor sowie im Falle einer überdurchschnittlichen wissenschaftlichen Leistung. Jungforscher, die gemäß den Leistungen ihrer Diplom-Studiengänge in das obere Zehntel der Studierenden fielen, zeigten im Verhältnis zu den übrigen Jungwissenschaftlern eine statistisch wesentlich geringere Wahrscheinlichkeit der Promotion, ebenso Jungforscher, die eine reguläre Anstellung im Bereich der Biomedizin hatten. Die Ergebnisse der vorliegenden Untersuchung verweisen auf mögliche Punkte, an denen bei der Auswahl und Anstellung von Dokotratskandidaten bewusst eingewirkt werden kann, um das System der Nachwuchsforschung in der Republik Kroatien zu verbessern.

Schlüsselbegriffe: Wissenschaftliches Doktoratsstudium, menschliche Ressourcen, Anstellung, wissenschaftliche Leistung, Nachwuchsforscher