Universidade do Minho
Escola de Ciências da Saúde

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Tese de Doutoramento em Ciências da Saúde

Trabalho efectuado sob a orientação do
Doutor Manuel João Tavares Mendes da Costa
Professor Associado da Escola de Ciências da Saúde
Universidade do Minho

e do
Doutor Patrício Ricardo Soares Costa
Professor Auxiliar da Escola de Ciências da Saúde
Universidade do Minho

outubro de 2016

STATEMENT OF INTEGRITY

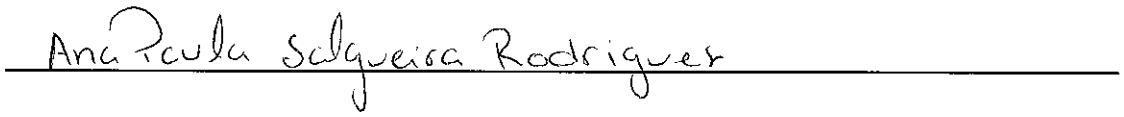
I hereby declare having conducted my thesis with integrity. I confirm that I have not used plagiarism or any form of falsification of results in the process of the thesis elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

University of Minho, 22nd October, 2016

Full name:
Ana Paula Salgueira Rodrigues

Signature:



"O que é bonito neste mundo, e anima,
é ver que na vindima de cada sonho
fica a cepa a sonhar outra aventura.
E que a doçura que não se prova
se transfigura
noutra doçura muito mais pura
e muito mais nova."
— Miguel Torga

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Abstract

Historically, physicians have played important roles in the advancement of medicine and in the improvement of medical care, disseminating research findings and assuming leadership and health advocacy responsibilities. In recent years, there has been an increasing recognition of such roles within competency frameworks in medical education.

Medical schools have the responsibility to promote these competencies. Exploring the underlying factors associated with student's engagement in scientific research and leadership is important to inform policies and strategies.

Student's engagement might result from the interplay between context and individual variables. However, little is known about medical students engagement in activities that go beyond the core curriculum of medical schools.

Also, it is important to understand the relationship between pre and post graduation engagement in scientific research and leadership, since one of the objectives of undergraduate medical training is to succeed in promoting engagement behaviors in future physicians.

The main research questions addressed in this thesis were: (1) To what extent individual characteristics of medical students and doctors influence their engagement in scientific research and leadership? and (2) Does engagement in those activities as a medical student predict future engagement after graduation?

The three studies in this Thesis were conducted in the School of Health Sciences of the University of Minho (Portugal) and explored the role of individual characteristics (personality, socio-demographic and academic performance) on the engagement in scientific research and leadership activities of medical students.

Furthermore, this Thesis addressed the relationship between engagement in scientific research after graduation and graduates' individual characteristics (personality, socio-demographic and performance) and also prior engagement in scientific research during medical school.

Finally, the link between prior engagement in leadership during medical school and engagement in leadership after graduation was investigated.

Two types of data sources were used: self-reported measures and official data. All studies used a quantitative approach. Different statistical procedures (regression models, classification tree, Chi-square test) were performed to test our research hypothesis.

The results show that individual characteristics have a significant contribution for the explanation of medical students engagement in scientific research and leadership activities.

In addition, prior engagement in scientific research during medical school significantly predicts later engagement in PhD programs and research papers publication.

Finally, prior engagement in leadership during medical school is associated to engagement in leadership after graduation.

In conclusion, this work reveals that it is important to consider personality traits, socio-demographic variables, academic performance and previous engagement to predict the engagement of medical students and doctors in scientific research and leadership.

Resumo

Historicamente, os médicos têm desempenhado um papel importante no avanço da medicina e na melhoria dos cuidados de saúde, disseminando os resultados da investigação médica e assumindo responsabilidades de liderança e de defesa da saúde das populações. Nos últimos anos, estes papéis têm merecido um reconhecimento crescente nos referenciais internacionais que enquadram as competências a desenvolver durante a formação dos futuros médicos. Cabe às escolas médicas promover essas competências. Para informar as políticas e estratégias necessárias, torna-se importante explorar os fatores subjacentes ao envolvimento dos alunos de medicina na investigação científica e na liderança.

O envolvimento dos alunos nestas atividades resulta da interação entre o contexto e as variáveis individuais. No entanto, o conhecimento disponível sobre o envolvimento de estudantes de medicina em atividades que vão para além do curriculum de medicina é ainda escasso.

Além disso, a compreensão da relação entre o envolvimento pré e pós-graduado em investigação científica e liderança é importante, pois um dos objetivos principais da formação médica pré-graduada é a promoção do envolvimento dos futuros médicos nestas atividades.

As principais questões de investigação abordadas nesta Tese foram: (1) Em que medida as características individuais dos estudantes de medicina e dos médicos influenciam o seu envolvimento na investigação científica e liderança? e (2) O envolvimento durante a escola médica está associado ao envolvimento futuro nessas atividades após a o término do curso?

Os três estudos nesta tese foram realizados na Escola de Ciências da Saúde da Universidade do Minho (Portugal) e exploraram o papel das características individuais (personalidade, características sociodemográficas e desempenho académico) no envolvimento de estudantes de Medicina em atividades de investigação científica e liderança.

Além disso, esta Tese abordou a relação entre as características individuais, o envolvimento em investigação científica durante o curso de medicina e o futuro envolvimento dos médicos em investigação científica após a graduação.

Finalmente, foi investigada a relação entre o envolvimento em atividades de liderança durante a escola médica e o envolvimento em atividades de liderança após a graduação.

Os dados foram provenientes de duas fontes distintas: autorrelato e dados oficiais sobre a participação. Todos os estudos usaram uma abordagem de natureza quantitativa. Foram utilizados procedimentos estatísticos diferentes (modelos de regressão, árvore de classificação, teste do qui-quadrado) para testar as hipóteses de investigação.

Os resultados revelam que as características individuais têm uma contribuição significativa para a explicação do envolvimento de estudantes de medicina em atividades de investigação científica e de liderança, no contexto do estudo.

Além disso, demonstram que o envolvimento em investigação científica durante o curso prevê significativamente o envolvimento futuro em programas de doutoramento e a publicação de trabalhos de investigação.

Finalmente, estabelece uma associação entre o envolvimento em atividades de liderança durante o curso e o envolvimento em atividades de liderança após a graduação.

Em conclusão, este estudo revelou a importância de considerar os traços de personalidade, as variáveis sociodemográficas, o desempenho académico e o envolvimento anterior na predição do envolvimento de estudantes de medicina e graduados em atividades de investigação científica e de liderança.

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Abbreviations

CANMEDS: Canadian Medical Education Directions for Specialists

GPA: Grade Point Average

FCT: Portuguese Foundation for Science and Technology

ELECSUM: Longitudinal Study of the School of Health Sciences – University of Minho

NEO-FFI: NEO Five-Factor Inventory

ECS/UM: School of Health Sciences – University of Minho

Thesis Outline

The present Thesis is organized in 5 Chapters. Chapter 1 is the introduction. The experimental work is presented in chapters 2, 3 and 4 (in the form of research articles) and Chapter 5 is the discussion.

The manuscript in Chapter 2 was published in 2012 by the journal BMC Medical Education. The manuscript in Chapter 4 has been submitted to the same publication. The manuscript in Chapter 3 is in preparation for submission to the journal Academic Medicine.

Chapter 1 presents an overall introduction to the Thesis and outlines the research rationale. This chapter aims to illustrate the importance of the engagement in scientific research and leadership within the medical education context and to clarify the relevance of studying the influence of individual differences. The claims draw from the wider literature on college students' engagement in general, on medical students and graduates engagement in scientific research and leadership and on individual differences and its relation to behavior.

The study described in Chapter 2, explores the predictors of medical students' engagement in scientific research activities during medical school, focusing on students' individual characteristics (personality, socio-demographic and academic performance).

In Chapter 3, we investigate predictors of junior doctors' engagement in scientific research activities, focusing on individual characteristics (personality, socio-demographic and academic performance) and prior engagement behavior.

The study in Chapter 4 identifies predictors of medical students' engagement in leadership (as an elected student representative) during medical school, focusing on students' individual

characteristics (personality, socio-demographic and academic performance). The relationship between undergraduate student leadership and leadership in postgraduate scientific or professional organizations is also explored.

The Thesis concludes with the overall discussion and conclusions, included in Chapter 5. The major findings of this work are contextualized within current literature. Achievements and limitations are critically discussed and future perspectives are presented.

CHAPTER 1 – Introduction

Introduction

1. The importance of physicians as scholars and leaders for Medical Schools

The ultimate responsibility of Medical Schools to society is the graduation of physicians who meet individual health care needs in the populations and contribute to the understanding and improvement of health systems. The definition of such medical graduate has evolved across time and geography in an effort to identify and develop the essential roles physicians will assume through out their professional career as a medical expert: As a result, several graduates or specialists' competency frameworks have been developed and updated across the years by professional bodies, like "Tomorrows Doctors" by the UK's General Medical Council [1], or the "Canadian Medical Education Directions for Specialists" (CANMEDS) by the Royal College of Physicians of Canada [2]. Some physician roles are transversal across frameworks. One is the participation in the process of creation and dissemination of knowledge (scholar), acting as a disseminator of research findings and a participant in research relevant to health care [3]. Another role is assuming leadership and health advocacy responsibilities, influencing the system and contributing to improve health in the community or population they serve and to their responsibilities towards the profession, including commitment to professional standards and collegiality. It falls upon Medical Schools to promote these competencies in students during their first years of training.

With this in mind, it becomes relevant to identify the activities in which a medical student engages during the medical degree that might be instrumental for their future competencies. Active engagement in scientific research activities (participating and disseminating research) and in student's associations (improving health in the community or population they serve, commitment to professional standards and collegiality) is amongst those activities, as they are endowed with the attributes for the required roles of physicians as scholars, health advocates and leaders.

In light of its recognized importance, several medical schools around the globe are now emphasizing research activities in their curricula by introducing research methodology courses [4, 5], by requiring engagement in research projects [6, 7] and by encouraging students to publish [8, 9]. As for leadership promotion during undergraduate training, the available literature is very scarce [10], particularly about student´s involvement in associations and self-governance.

Educational research on college impact also supports the importance of promoting this type of engagement during undergraduate school. One of the major conclusions drawn from research in this area is that behavior, attitudes, values, educational growth and career choices are deeply influenced by the activities in which the students engage during their college years [11, 12].

2. Student engagement: concept and impact

Theoretically, engagement - in the literature sometimes designated involvement or participation - is conceptualized as the time and effort students put into educational activities empirically associated with the outcomes desired by the institution [13].

Student engagement is increasingly of primary importance in contemporary conceptualizations of quality in higher education (amongst other factors like student selection, academic reputation, faculty and financial resources) [14, 15].

Engagement includes various dimensions, like investment in the academic experience of college, engagement in educationally relevant activities (co-curricular) and interaction with faculty and peers [12, 16]. These activities can take place both in-class and out-of-class and are important to students' success [13].

Research suggests that engagement in extracurricular activities is linked to college students' sense of institutional engagement or attachment to their school. Thus, it has a variety of positive impacts. It not only decreases the likelihood of academic failure or dropping out, but also improves competencies such as the ability to manage time and other skills, higher satisfaction with peers, gains in leadership skills, and gains in self-esteem, higher persistence, greater sense of personal responsibility, more knowledge about professional contexts and personal vocational interests [12]. This seems to be a generalized trend, as even "non-specific" engagement

behaviors, like interacting with staff, seem to have a powerful impact on learning when they take place outside of the classroom and respond to individual student needs [12, 17]. Interestingly, in a previous study with college students, 40% of students identified educational experiences outside the class as the most significant in their training [16]. Also, extra curricular activities are promoters of self directed learning and lifelong learning because they offer opportunities to motivate and promote the habit of investing in activities that go beyond the curriculum [12, 18].

Obviously, there are many activities in college that compete for students' time and energy. The activities students' choose to invest time will shape the competencies they acquire during college [18]. As students' time and energy are a finite resource, it is very important for schools to know if students' efforts lead to desired outcomes and are linked to the institutions' mission [13, 18].

Understanding the dynamics between engagement in college and future engagement is important, as this process will have little or no social impact at all if it does not translate into post-college engagement behavior [19].

3. Medical Students and Graduates: engagement in scientific research

Physicians play a central role in connecting healthcare to research [20–22]. Medical doctors role in this relation is played not only by physician-scientists, clinical researchers, clinical investigators, doctors in academic medicine (referring to a medical doctor who dedicates all or some of his professional time to translational or clinical research), but also by better-equipped physicians, whose major professional role is in the clinical setting. All physicians are expected to contribute amidst their principal clinical role. These are expected to practice evidence-based medicine, to be aware and apply new scientific discoveries to their practice, to communicate their clinical needs to researchers and also to convey research findings to their patients in a comprehensive way [2, 22].

Despite the widely recognized importance of scientifically active physicians, since 1979, when Wyngaarden published "The clinical investigator as an endangered species", concerns for the future of physician-scientist have been in the spotlight. Most of the available data refer to the USA

and point to a decrease in physician-scientists numbers [23–27] and to a decline in the percentage of medical students interested in pursuing (at least partially) a research career [28]. Some reasons for this decline have been identified by practicing physicians: less financial support, emphasis on clinical practice, but also insufficient or inadequate exposure to research before choosing a professional pathway [29–31].

Some findings have uncovered associations between undergraduate medical research experiences and graduate research [32, 33], namely: (1) participation in research methodology courses and better attitudes towards science [4, 5, 34]; (2) participating in required research experiences and publishing reports [8, 34] or being involved in postgraduate research [35]; (3) intensive research experiences and receiving a faculty appointment with research responsibility [36]; (4) publishing research and/or having an MD/PhD and choosing academic medicine [23, 37, 38].

Some factors were identified as barriers for medical students involvement in research such as lack of time, mentors availability, insufficient training in research methodology and the perception that the student's work will not be properly recognized [39–41]. In one study, only 31% of medical students reported being involved in extra curricular research and 10% stated they "would not under any circumstances participate in extra curricular research" [39] . In another study, 24% of the students reported having no interest in participating in research [40].

Students' attitudes, beliefs and intentions to engage in research/science have been shown to be related to individual characteristics, socio-demographic variables, like gender [28, 42], economical variables [43] and educational factors (activities during medical school [23, 30, 33–35, 44, 45]. Most of the studies conducted about factors that influence medical students and physicians to pursue an academic career have small sample sizes, provide little detail on methodologies and are grounded in self-reported data, attitudes, intentions or other indirect measures [33, 43]. These studies also do not provide follow-up information about postgraduate engagement in research [33]. A recent systematic review with meta-analysis concluded that student intentions to perform research during or after medical school (around 72%) do not translate into actual engagement rates (less than 33%) [43]. Thus, the extent to which individual

characteristics and educational experiences influence medical students and physicians to voluntarily engage in scientific research activities is considerably underexplored.

4. Medical Students and Graduates: engagement in leadership

There are some evidences to the benefits of the involvement of college students in governance and students' representation, such as student exposure to democratic practice and, potentially, a better informed democratic citizenship [13].

The majority of available research on this topic has focused on how involvement correlates to students' cognitive and psychosocial development. Involvement in students' organizations (college students) has been shown to be strongly associated with higher levels of vocational and psychological development [46], capacity for mature interpersonal relationships and increased tolerance and acceptance of differences among individuals [47], increased sense of citizenship [48], humanitarism and civic involvement [49]. Participation in students' organizations has also been shown to have a positive effect on students' cognitive development [16, 31, 50, 51]. Also participation of student in governance is linked to increased levels of students' satisfaction with the University experience, stronger academic performance and higher engagement with their institutions as ALUMNI (former students) [52, 53]. A closer look into this type of engagement, suggests that joining and leading an organization is positive for example, for academic autonomy, cultural participation and career planning, than just attending a meeting [46]. More specifically, leadership responsibilities have been positively linked to developmental skills at entry and after three years in college [54], citizenship and leadership efficacy [48], development of humanitarism [13, 16], civic involvement [49], cognitive complexity and gains in practical and interpersonal competence [13].

Such engagement favors more than the individual participant, as he becomes a representative voice for other individuals [13] contributing to the quality of the learning environment, the experiences of his peers [50, 55] and the quality of the institution itself [15].

To the best of our knowledge, there is little evidence about the impact of engagement in leadership in postgraduate professional life. Also, little is known about the rates of participation or the reasons why students get involved (or not) in such activities. In a study about leadership capacities in college students, 20% of college seniors reported never having participated in any college organization and 46% of seniors reported never having had the chance to serve in a leadership role while in college [48].

Specifically in medical students, a study about leadership competencies reported that students rated communication skills, ethics, conflict resolution, time management, managed care, management principles, coding and billing, quality improvement, public speaking, (among others) as important competencies to be developed during medical school. In the same study, qualitative data seems to show that those competencies might be associated with being an elective representative rather than with traditional coursework [56].

There are many definitions of leadership, as well as behaviors that might be considered as student leadership behavior such as (but not restricted to), being involved in community service, being involved in student's affairs and educational groups during college, or being elected as a student representative. The same applies after graduation, when leadership behavior in the clinical setting can mean (among other things) being appointed to leadership/management responsibilities or being elected as a representative in scientific and professional associations (collegiality). For the sake of clarity, in this study, engagement in leadership refers to engagement as an elected student representative (for students) and as an elected representative in scientific or professional associations after graduation (for graduates).

5. Engagement behavior and individual differences

The constructivist conceptualization of student engagement implies the interplay between students and the educational context. The educational context, in which the educationally purposeful activities take place, impacts on student learning and engagement [15, 57, 58].

However, the decision, initiative and action to engage or not to engage, rests on the individual [15]. Human behavior is elaborated, multifaceted and convoluted, and there is a big repertoire of behavioral choices at any given time. This makes behavior hard to anticipate.

To understand the individual determinants of concrete engagement behaviors, it is important to consider individual differences in personality, culture, abilities and interests [59]. Research on individual differences provides some understanding about how and why people differ by studying several nonobservable or "latent" constructs, such as intelligence and personality, which represent major sources of variation in behavior.

This study considered the contribution of personality traits, socio-demographic (gender, being a first generation student and leaving the family home) and performance variables (Grade point average – GPA) to better understand medical students engagement in scientific research and leadership activities.

5.1. Personality

Personality is a general, not an absolute, disposition to act in specific ways. For example, measures of trait curiosity will be more accurate to predict whether an individual will ask many questions within a five years timeframe than during a specific class. Behavior is a consequence not only of situational factors (that affect motivation and mood), but also of internal disposition as personality characteristics and interests that tend to be longitudinally stable over time and across situations [59, 60].

The relevance of personality is well established in many research fields, including physical and mental health, quality of social relationships, occupational choice, satisfaction and performance, and pro and antisocial behaviors in the community [60], accounting for approximately 16% of results' explained variance [59]. They refer to an individual's typical performance over a set of situations and over time [59, 61].

More specifically in what regards to medical education, personality (higher consciousness) has been shown to have predictive validity regarding different outcomes like different motivations when choosing a medical degree [62], academic performance in medical students [63, 64] and medical specialty choice [65–67].

The Five Factor Model or Personality (AKA Big Five) is set on the assumption that the major dimensions of individual differences can be derived from the total number of lexical descriptors in any given language. The model is the result of statistical analysis of those descriptors that cluster together and form five global factors:

- Neuroticism: can be described as the tendency to experience negative emotions, like anxiety, depression, and anger. It is sometimes called emotional instability, or is reversed and referred to as emotional stability. Individuals with higher levels of neuroticism are emotionally more reactive and more vulnerable to stress with a tendency to experience anxiety. The primary facets of neuroticism are anxiety, angry hostility, depression, self-consciousness, impulsiveness, and vulnerability.
- Extraversion: is marked by pronounced engagement with the external world. Extroverted individuals tend to enthusiastic, action-oriented individuals. They thrive in social interactions and stimulation and come off as high energetic and talkative. The primary facets of extraversion are warmth, gregariousness, assertiveness, activity, excitement-seeking, and positive emotions.
- Openness to Experience: represents intellectual curiosity and willingness to try new sensations and ideas. Individuals with higher scores in openness to experience tend to be unconventional, imaginative, inventive, and flexible in their behavior, thoughts and opinions. It comprises the primary facets of fantasy, aesthetics, feelings, actions, ideas, and values.
- Agreeableness (also known as sociability): refers to friendly, considerate, trust and trustworthy behavior. Individuals with higher scores in this trait can be described as considerate, friendly, warm, tolerant, helpful and have a general predisposition for getting along with others. Agreeableness comprises the primary facets of trust, straight forwardness, altruism, compliance, modesty, and tender-mindedness.
- Conscientiousness: is associated with proactivity, responsibility, and achievement. Individuals with higher score in consciousness prime for their efficiency, organization, determination, and productivity and planned rather than spontaneous behavior. This factor includes the primary facets of competence, order, dutifulness, achievement striving, self-discipline, and deliberation.

Despite criticism to the Big Five Model (lack of theoretical explanations, modest inter-correlations between traits when the neuroticism scale is inverted and may neglect other domains of personality) it has sown good validity and reliability and its acceptance (and acceptance of the NEO inventories) has allowed the comparison and replication of studies across cultures [59, 68].

5.2. Socio-demographic characteristics

Research in Higher Education has revealed that individual variables, like gender, parental education or living at home are associated with undergraduate students' engagement in extracurricular activities [12].

Living on campus (or within walking distance), as opposed to commuting or living in the family home, has been positively correlated to engagement in informal and out-of-class college activities [11, 69]. These students also report higher gains in intellectual and scientific skills, personal and social development [11].

First generation college students were found to be less involved in campus activities [51, 69]. They also reported less intellectual development, lower educational aspirations and perceived their college environment as less supportive [69]. Parents' higher educational background has also been identified as a predictor for the intention to apply to a doctoral program in health care [70].

Previous studies with college students found that while women were regularly elected as representatives, they were under-represented in presidential and vice-presidential positions within student government [71]. Also, no significant differences were found between the number of female and male students with a leadership position within the student government [72]. Although, female students seem to show lower political involvement (political interest, discussion, and information-seeking) [73].

More specifically, for medical students [39] and medical doctors [30], gender imbalances in engagement in scientific research have been reported, with male subjects being more likely to engage. Female medical students are less likely to report the intention of doing a PhD [39, 70] or pursuing research careers [28]. Also, female medical students who report the intention of pursuing a research career as a freshman, are more likely than man to decrease their interest, by the time they are seniors [28]. This gender gap is also found in medical students and medical doctors perception of competencies for research activities. Male students report feeling significantly more competent in transferable and research-specific skills and biological statistics [74] and female doctors rate their skills related to clinical research lower than male doctors [75].

5.3. Performance

Some evidence has been found about an association between lower performance in college students and being disengaged from college activities [12, 58]. Also medical students' higher Grade Point Average (GPA) has been associated with attitudes towards research [4] and choosing academic medicine [43].

6. The School of Health Sciences of the University of Minho

This study took place in a Portuguese Medical School: The School of Health Sciences of the University of Minho. The school was founded in 2000 and the 6 years undergraduate medical degree started in 2001. The medical school has a built-in research institute/culture with research in the domains of Microbiology and Infection, Neurosciences, Surgical Sciences and two pilot research lines in Community Health and Medical Education. All faculty members are expected to have research duties, which are included in their agreement with the school. Students' engagement in scientific research activities is valued and incentivized.

The school has always promoted students engagement in self-governance providing structural support to the medical students' association and other recreational groups like the music group.

As part of the University of Minho's community, medical students also have an opportunity to engage with multiple and diverse groups: cultural, sports and recreational that exist at the university level.

Since 2001, the school keeps a longitudinal research database of students' records, as part of an ongoing Longitudinal Study that gathered information about factors influencing the professional competence of medical graduates at School of Health Sciences. This study aims to document the quality of the school's graduates and to identify perspective elements of individual professional performance and educational pathways. In its beginnings the study was sponsored by a grant from the Portuguese Foundation for Science and Technology (FCT).

In 2013, the school was granted an Aspire Award for "Student Engagement" by the Association of Medical Education in Europe. To achieve excellence in this area there must be evidence of students' contribution to the academic community and their involvement and participation in teaching and learning experience.

7. Central research questions and overview

Overall, recommendations from professional bodies in medical education and the wider literature on college students, are clear about the importance of policies that intent to foster the engagement of undergraduate students in activities beyond the curriculum. Furthermore, the sparse literature on medical student engagement in scientific research and leadership provides little information about the individual related factors. Apart from being scarce, the studies are primarily based in non-verified self-reported information, which constitutes an important methodological limitation. An in depth understanding, of how these factors interplay to translate into actual engagement behaviors, is lacking. The same holds true for engagement in research and leadership after graduation and its relation to previous behavior during medical school.

The research reports that constitute this Thesis build on these previous assertions and focus on clarifying the contribution of individual variables to medical student's engagement in scientific research and leadership during medical school. The research reports also address the contribution of such behavior to engagement in scientific research and leadership after graduation.

The primary research aims within this Thesis are:

- To assess the influence of individual characteristics including personality traits, socio-demographic characteristics and academic performance, on voluntary engagement in scientific research of undergraduate medical students (investigated in research paper 1);
- To determine to what extent student individual characteristics and participation in research opportunities is predictive of actual research engagement during the early post-graduate years (investigated in research paper 2);
- To assess the influence of individual characteristics, including personality traits, socio-demographic characteristics and academic performance, on student leadership as elected student representative during medical school (investigated in research paper 3);
- To assess the extent to what being an elected student leader can explain leadership in postgraduate scientific or professional organizations (investigated in research paper 3).

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CHAPTER 2 - Individual characteristics and student's engagement in scientific research: a cross-sectional study.

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Individual characteristics and student's engagement in scientific research: a cross-sectional study

Ana Salgueira[1*†], Patrício Costa[1†], Mónica Gonçalves[1†], Eunice Magalhães[1,2†] and Manuel João Costa[1†]

Abstract

Background: In light of the increasing recognition of the importance of physician scientists, and given the association between undergraduate research experiences with future scientific activity, it is important to identify and understand variables related to undergraduate students' decision to engage in scientific research activities. The present study assessed the influence of individual characteristics, including personality traits and socio-demographic characteristics, on voluntary engagement in scientific research of undergraduate medical students.

Methods: For this study, all undergraduate students and alumni of the School of Health Sciences in Minho, Portugal were invited to participate in a survey about voluntary engagement in scientific research activities. Data were available on socio-demographic, personality and university admission variables, as part of an ongoing longitudinal study. A regression model was used to compare (1) engaged with (2) not engaged students. A classification and regression tree model was used to compare students engaged in (3) elective curricular research (4) and extra-curricular research.

Results: A total of 466 students (88%) answered the survey. A complete set of data was available for 435 students (83%).
Higher scores in admission grade point average and the personality dimensions of "openness to experience" and "conscientiousness" increased chances of engagement. Higher "extraversion" scores had the opposite effect. Male undergraduate students were two times more likely than females to engage in curricular elective scientific research and were also more likely to engage in extra-curricular research activities.

Conclusions: This study demonstrated that student' grade point average and individual characteristics, like gender, openness and consciousness have a unique and statistically significant contribution to students' involvement in undergraduate scientific research activities.

Background

Advances in medical diagnosis and therapeutics walk hand in hand with scientific development in other disciplines like biochemistry, pharmacology or physics, as future medical care depends on today's scientific research [1,2]. More and more, physicians are called to assume a central role in the scientific research/patient care partnership. They are increasingly expected to communicate with researchers and convey clinical and translational research findings to patients and to the general public. Moreover, they are required to contribute actively to the pursuit of new knowledge, bringing clinical needs into research and taking research findings into clinical practice [3,4].

However, available data point to a decrease in the numbers of physician-scientists[5-7]. Amongst the reasons for such decline are less financial incentives, a large emphasis on clinical practice during undergraduate medical training, and insufficient or inadequate exposure to research prior to the choice of a professional pathway [8-10].

The reasons why and when physicians choose careers in academic medicine have been explored and evidence

* Correspondence: anasalgueira@ecsaude.uminho.pt
†Equal contributors
[1]Life and Health Sciences Research Institute (ICVS), School of Health Sciences, University of Minho, Campus e Gualtar, 4710-057, Braga, Portugal
Full list of author information is available at the end of the article

has been found connecting graduate and postgraduate research [11]: (a) participating in research methodology courses and more positive attitudes towards science and scientific research in medicine [12,13]; (b) participating in required research experiences and publishing research reports [14,15] or participating in postgraduate research [16]; (c) engaging in intensive research experiences and receiving a faculty appointment with research responsibility [17] and (d) publishing research as an undergraduate medical student and/or pursuing an MD/PhD and choosing academic medicine [5,18-20]. Evidence also shows that engagement in undergraduate extra-curricular scientific activity results in a higher rate of publication after graduation [21].

Medical schools can provide undergraduate students with opportunities to engage in research and thus have an important role in nurturing the interests and in developing the research skills of future physicians. Previous studies show that limitations in time, lack of mentors, insufficient training in research methodologies, and a perception that the undergraduate student's research work is not properly recognized are amongst the factors that discourage medical students from pursuing undergraduate research activities [9,22].

Research in Higher Education has revealed that undergraduates' career choices, attitudes, values, and future behaviors are deeply influenced by what students do during college [23,24] and that individual variables, like gender or parental education, are associated with undergraduate students' engagement in extra-curricular activities [23,25]. Also, personality traits have been shown to have predictive validity regarding outcomes like behavior [26], academic performance in medical students [27-29] and medical specialty choice [30-32]. Surprisingly, the influence of undergraduate medical students' individual characteristics on their involvement in research activities has not deserved attention. Current literature on student engagement in scientific research focuses on programs and how they can contribute to the pipeline for physician scientists. Identifying the individual variables that mediate this behavior is important to understand how engagement in research can be enhanced.

Our aim in this study was to assess the influence of individual characteristics, including personality traits and socio-demographic characteristics, on voluntary engagement in scientific research of undergraduate medical students.

Methods

Institutional context

The study took place in the School of Health Sciences at the University of Minho, Portugal (ECS/UM). Having a built-in research institute, the school explicitly emphasizes to students the importance of research and offers them opportunities to engage by: i) promoting research-related activities within the curriculum, ii) challenging students to engage in scientific activities during curricular electives and iii) providing opportunities for extracurricular research activities.

The independent variables in this study - personality, socio-demographic factors and University admission grade point average (GPA) - are available from the start of the medical school (2001) as part of an ongoing longitudinal study in which this research project was included. The Portuguese Data Protection Authority approved the longitudinal study. Participation in the longitudinal study is voluntary, confidential and written informed consent is asked, of all participants, every time a new piece of data is collected, and is to be integrated in the study. All data is anonymised before analysis.

Variables, instruments and data collection procedures

Independent variables

Personality measurements were obtained with the Portuguese version of NEO-FFI (NEO Five-Factor Inventory). NEO-FFI is a shortened version of the NEO PI-R [33,34] and measures 5 dimensions of personality (openness, conscientiousness, extraversion, agreeableness, and neuroticism) using a 5 point likert scale (from 0 - strongly disagree to 4 - strongly agree) with 12 items for each dimension. Scores for each dimension range from 0 to 48. The Portuguese version of NEO-FFI [35] includes 60 items with Cronbach's Alpha ranging from 0.71 (Openness) to 0.81 (Conscientiousness) and corroborates the well-established reliability, factorial structure, and cross-cultural communalities of personality according to gender, age, and educational differences. The surveys on socio-demographic variables (gender, age, parents' education background – 1st or 2nd generation student) and University admission data (choosing the ECS/UM as the 1st option, GPA - scores ranging from 0–200 used to rank students for university access) were custom-made by the research team. To measure the number of opportunities each student had to participate in undergraduate research, we created a variable called "total of opportunities" corresponding to the number of years the student was in the school, until the time of this study. These surveys are collected annually at the beginning of every academic year for each new cohort, either online or on paper.

Dependent variables

We asked students if they had ever been involved in undergraduate scientific research activities. All the research activities covered by the survey implied a choice made by the student to engage in scientific research either (1) as part of their curriculum (during elective curricular areas units that take place every year and allow the students to choose between research, clinical

rotations, or social/humanitarian work), or (2) as an extra-curricular activity such as (2.1) summer laboratory rotations as part of the application requirements for the MD-PhD program, (2.2) one full year part-time research scholarships for students or (2.3) on their own venture. Research type, frequency, and duration of participation were not taken into consideration in this study. Students were categorized into two groups: (i) unengaged students with no involvement in undergraduate scientific research activities and (ii) engaged students with involvement in undergraduate scientific research activities, either extra-curricular or elective, at least once (if they had at least one positive answer for any of the types of participation). Additionally, we divided all the "engaged students" into two groups according to the type of undergraduate scientific research activities: elective curricular (CA) or extra-curricular (ECA). As the two groups are not mutually exclusive (some students engaged curricular research activities, as well as extra-curricular), all the students with at least one extra-curricular research activity were included in the second group. Self-reported information in the participation survey was manually verified by matching the respondents' answers with the school's official records of participation.

The participation questionnaire was administered online at the conclusion of the 2009/2010 academic year.

Sample exclusion criteria

Besides the normal process for university admission, students can get into medical school using special access processes for athletes, military, islands and immigrants. These students' GPA is lower. All the students with GPA lower than 179.8 (the lowest GPA for the normal admission process since 2001) were discarded from the analysis (n = 106; GPA: M = 163.29; SD = 11.15).

We also excluded students who only developed scientific activities during the compulsory master's thesis (required for graduation) (n = 60).

Statistical analysis

To test the representativeness of our sample, we compared all the independent variables for the "respondent" and "non respondent" students in the research activities questionnaire using a Student *t*-test (for continuous variables) and the χ^2 test (for categorical variables).

Subjects with complete sets of information for all independent variables were selected for the following statistical analyses. Data were analyzed using IBM SPSS Statistics version 19. We performed a binary logistic regression model to test which student characteristics could explain engagement in undergraduate scientific research activities. The analysis was performed using the backward LR method (at each step, the variables in the model were analyzed to remove those that do not significantly contribute to the model). The model was obtained in 3 steps. For internal validation of results, a bootstrap analysis with 1000 samples was performed using the Enter method for the step 3 model. We used a "Classification and Regression Tree" model to explore the differences between two groups of engaged students: (1) those who chose to engage in undergraduate scientific research activities during their elective curricula areas and (2) those who decided to engage in undergraduate scientific research activities as an extra-curricular activity. This is a non-parametrical approach used to explain responses on a categorical dependent variable that can be used as an exploratory technique instead of the more traditional methods. It also has an advantage over regression in its ability to detect non-linear relationships. For this model we used CRT as the growing method, pruning on misclassification error (1 SE rule) and Gini measure for goodness of fit (impurity criteria). The minimum number of isolates in a parent node was set to 10 and 5 for the child nodes. The independent variable "opportunities" was included in the model as the "influence variable".

Results

Sample

We surveyed all students and alumni from ECS/UM (9 cohorts) on their participation in scientific research activities during medical school (n = 693). After applying the exclusion criteria, the final target population consisted of 527 students. A total of 466 (88%) students completed the online survey about participation in scientific research activities. Participation rates varied between the 9 cohorts from 72% to 92% (cohort1 92%; cohort2 90%; cohort3 92%; cohort4 91%; cohort5 91%; cohort6 92%; cohort7 92%; cohort8 72%; cohort9 91%). As for the other longitudinal study surveys, 527 students provided information for GPA, 477 for personality, 527 for university option, and 527 for gender. Figure 1 illustrates the attrition from the original number of students to the sample.

A complete set of data (personality, GPA, and socio-demographic variables) was available for 435 of the 527 eligible students (83%). 364 (69%) were females and age was quite homogeneous (M = 18.28; SD = 1.22). GPA for our sample ranged from 179.8 to 196.3 (M = 186.20; SD = 3.30).

Cross-validation of self-reported information and sample validation

Mismatch between students' self-report and official records was less than 2%. Comparison between "respondents" and "non respondents" showed no statistically significant differences for each one of the independent variables (see Table 1).

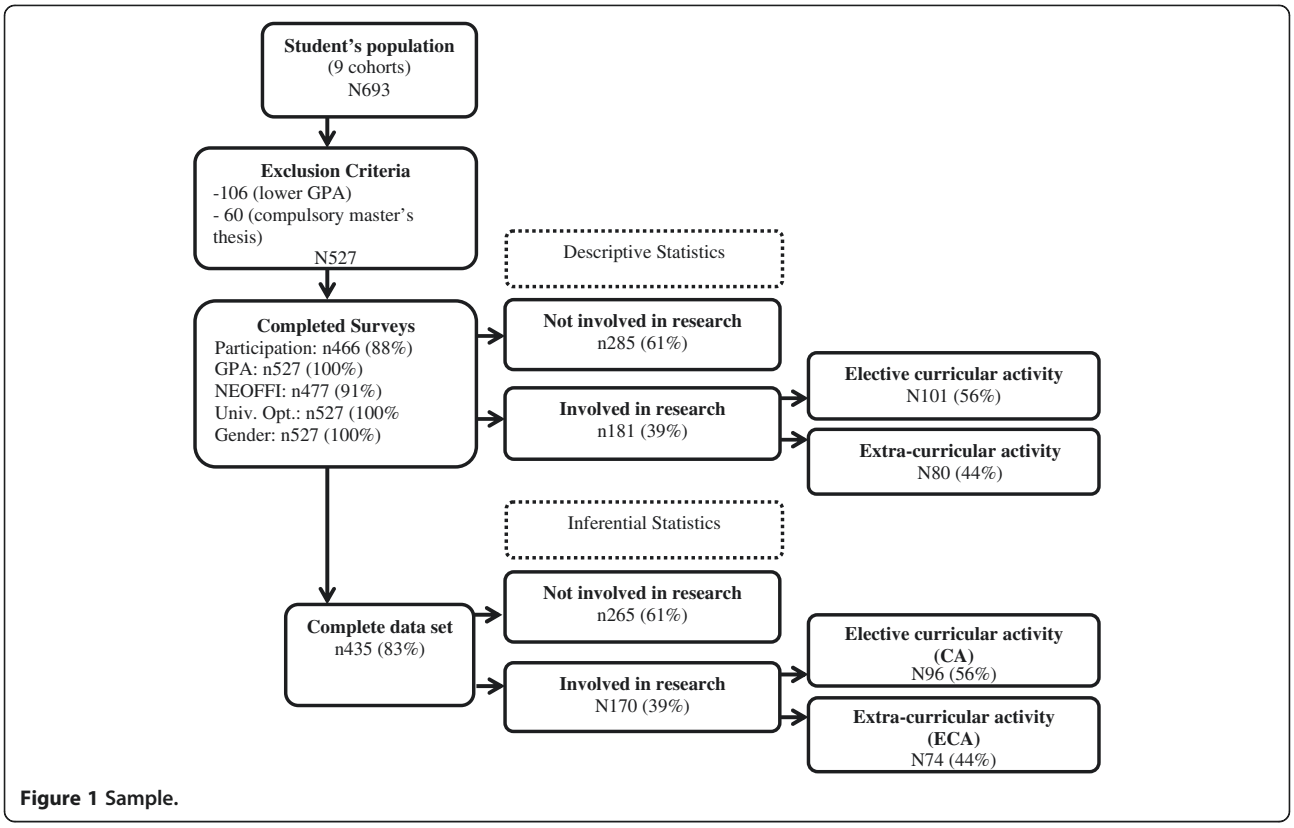

Figure 1 Sample.

Research Engagement

Over more than half (61%) of the participants had never engaged in undergraduate scientific research activities. Within the groups of students with involvement in undergraduate scientific research activities (N = 181) 56% engaged in an elective curricular activity and 44% in an extra-curricular activity.

Students' characteristics associated with engagement in research

The variables in the regression model significantly predicted engagement in undergraduate scientific research activities ($G2(8) = 123.220$; $p < .001$). Results show that male students are two times more likely to participate than females. For every five points increment in GPA, students increase their probability of participation by 67% (1.67 times more likely). Five more points in openness increase the chance of participation by 57% (1.57 times more likely) and in conscientiousness by 26% (1.26 times more likely). Scoring five points higher for extraversion decreases the chances of participation by 33% (0.67 times less likely). For every additional year in medical school there is a 1.6 fold increase in the likelihood of participation. No statistical significance was found for neuroticism nor agreeableness.

Using a cut point value of 0.5, the model correctly classifies 74% of the subjects (62% of participants and 81% of non-participants), 13% more than chance. Overall, the model explains 33% of the dependent variable's observed variance (Nagelkerke Pseudo-R^2 = .334). Hosmer-Lemeshow test showed a good model fit (χ^2HL(8) = 10.378, p = .239). The odds ratios for the original regression model and the bootstrap model are shown in Table 2. In the bootstrap analysis, the small bias and standard error values, the fact that all B values are inside the confidence intervals and the fact that statistical significance for all variables is maintained, confirm the stability of the model.

A "Decision Tree" (Figure 2) was used to identify the variables that discriminate between the students engaged in "Extra-curricular" undergraduate scientific research activities (ECA) (n = 74) and those engaged in "Curricular" undergraduate scientific research activities (CA) (n = 96). The final tree consisted of 10 nodes, 6 of which were terminal nodes.

The CRT method automatically excluded agreeableness, neuroticism, extroversion, and university option, as these variables did not make a statistically significant contribution to the final model. The first split was based on student gender. The proportion of male students involved in ECA was higher. First generation male students are more involved in ECA than second generation ones. Second generation males with higher levels of openness and higher GPA tend to be more involved in

Table 1 Sample validation: comparison between "respondents" and "non respondents" for each independent variable

INDEPENDENT VARIABLES		Non respondents		Respondents		Total		Mean difference
		n = 62		n = 465		n = 527		(T-Test/ χ^2 Test)
		n (%)	Mean/SD	n (%)	Mean/SD	n (%)	Mean/SD	
Opportunities		62 (100%)	3.6/1.9	465 (100%)	3.4/1.9	527 (100%)	3.4/1.9	t(525) = .946, n.s.
GPA		62 (100%)	186/3.2	465 (100%)	186.1/3.3	527 (100%)	186.1/3.3	t(525) = –.404, n.s.
Neuroticism		41 (66%)	24.7/6.8	437 (94%)	23.9/7.7	478 (91%)	23.9/7.6	t(476) = .804, n.s.
Extroversion		41 (66%)	32.6/7.9	437 (94%)	31.2/5.4	478 (91%)	31.3/5.7	t(475) = 1.663, n.s.
Openness		41 (66%)	29.5/5.3	436 (94%)	30.5/5.4	477 (91%)	30.4/5.4	t(475) = 1.373, n.s.
Agreeableness		41 (66%)	33.7/5.6	437 (94%)	33.9/5.3	478 (91%)	33.9/5.3	t(476) = –.160, n.s.
Conscientiousness		n41 (66%)	32.2/5.8	n436 (94%)	33.7/6.6	n477 (91%)	33.6/6.6	t(475) = 1.209, n.s.
Gender	F	43 (69%)	–	321 (69%)	–	364 (69%)	–	$\chi^2(1, N = 527) = 0.02$, n.s.
	M	19 (31%)	–	144 (31%)	–	163 (31%)	–	
This university was my first option		42 (68%)	–	356 (77%)	–	–398 (76%)		$\chi^2(1, N = 398) = 2.576$, n.s.

ECA. Female participation in ECA is related to lower levels of conscientiousness.

The risk estimate for the "Decision Tree" was .29 (SE.035). Overall the model correctly classified 72% of the subjects (81% CA and 61% ECA).

Discussion

Collectively, our results show that three out of the Big Five dimensions of personality (openness to experience, conscientiousness, and extraversion), gender, and GPA have a unique and statistically significant contribution to students' involvement in undergraduate scientific research activities.

To the best of our knowledge this is the first study to consider the contribution of student's individual characteristics to engagement in undergraduate scientific research activities. Also, this study takes into consideration a student's actual research participation behavior, rather than future intentions of participation or positive attitudes towards research and science [12,13].

Although the associations observed were statistically significant, they were modest, which is not surprising given the complexity of human behavior. That is, other individual and contextual factors might influence student's engagement (e.g. students' autonomy levels or availability of role models amongst the faculty). In fact, previous studies determined that personality variables usually account for about 14% of the variance in behavior [26]. Our model, by adding other individual characteristics to personality traits, explained 33% of the variance, thus adding an important dimension to the understanding of complex decision-making behaviors.

Personality predicts behavior to the extent that it can influence the psychological state of an individual and predispose him to action. Considering that "open individuals" are characterized as being intellectually curious, creative, and more adaptable to novel situations, their higher involvement is congruent with the type of work and intellectual curiosity demanded by scientific research. Motivation, persistence, careful planning, and the ability to delay gratification are important traits for this activity and are common to individuals with high conscientiousness scores; thus, it is not surprising that both openness and conscientiousness positively influence students' participation. In contrast, "extroverted individuals" tend to value more socially stimulating activities and are less likely to concentrate on demanding cognitive tasks, which is likely to explain a smaller involvement of highly extroverted individuals [36].

Higher GPA was linked to greater engagement in research. One of the reasons underlying this relation might be that students with higher GPAs could be more confident in their ability to use their transferable skills (for example, communication skills and time management) to tackle the demands that come with scientific research participation.

Also, results showed that male students are more likely to be involved in research. Gender imbalances in engagement have been reported [22] and might be caused by cultural and social factors that keep women from participating (for example, lower levels of autonomy and unavailability of female role models) or by different self-perceptions of competence between males and females. In fact, a study by Burgoyne et al. [37] demonstrated that male students felt significantly more competent in transferable and research-specific skills and biological statistics. It is also possible that female students are more focused on academic performance and prefer to invest their time and efforts in what they perceive to be more curriculum-related activities. Interestingly, the categorization of two sub-samples according to the type of involvement (elective curricular or extra-

Table 2 Odds ratios for the regression model: original and bootstrap

INDEPENDENT VARIABLES	Step 1		Step 2		Step 3								
	Model		Model		Model				Bootstrap (1000 samples)				
	B	Exp(B)	B	Exp(B)	B	χ^2_{WALD}	Exp(B)	Exp (B*5)	Bias	Std. Error	Sig. (2-tailed)	Conf. Int. (95%)	
OPPORTUNITIES	.480	1.616***	.480	1.616***	.475	48.860***	1.608***	–	.007	.068	.001	.358	.623
PERSONALITY TRAITS													
Extroversion	-.080	.923**	-.080	.923**	-.080	10,490**	.923**	0.670	-.003	.027	.004	-.138	-.032
Neuroticism	-.030	.971	-.030	.970	-.030	2,875	.971	–	-.002	.017	.059	-.062	.004
Openness to experience	.090	1.094***	.089	1.093***	.090	15,141***	1.094***	1.567	.001	.025	.001	.046	.146
Conscientiousness	.046	1.047*	.046	1.048*	.047	6,126*	1.049*	1.268	.001	.019	.005	.011	.088
Agreeableness	-.042	.959	-.042	.959	-.044	3,647	.957	–	-.002	.025	.064	-.096	.003
SOCIO-DEMOGRAPHICS													
Gender	.700	2.014**	.700	2.014**	.707	7,376**	2.029**	–	.014	.262	.004	.214	1.251
1st Generation Student	-.043	.958	–	–	–		–	–	–	–	–	–	–
ADMISSION DATA													
GPA	.095	1.099*	.094	1.098*	.103	8,051**	1.108**	1.672	.005	.039	.008	.030	.179
University choice	.175	1.191	.176	1.193	–		–	–	–	–	–	–	–
Constant	−19.794	.000	−19.627	.000	−21.123	9,943	.000	–	-.801	7.107	–	−35.421	−7.579
N	435		435		435								
Pseudo R-square	**.335**		**.335**		**.334**								
−2 log likelihood	458.544		458.577		458.903								

*p < .05; **p < .01; ***p < .001.

curricular), revealed the proportion of women engaged in scientific research in extra-curricular settings was even lower. However, this proportion increased if we only considered the female students with lower "conscientiousness" scores, suggesting that female students might be more focused on curricular performance.

Besides finding the effect of individual characteristics on undergraduate scientific research activities engagement, we found that some of these dimensions (gender, conscientiousness, openness, and GPA) are also related to the type of extra-curricular involvement students choose, which further strengthens our findings. Interestingly, parents' education was also a factor that influenced student engagement in extra-curricular undergraduate scientific research activities. In fact, for males, being a "first generation student" seems to have an impact on the type of involvement they choose to have. Available data from other studies points in different directions: first generation students were found to have lower educational aspirations and to be less involved in campus activities [38]. However, these studies were not done with medical students and it is quite possible that the very demanding selection process for medical school admission might be selecting first generation students for whom their family's educational background is not relevant for their educational attainment. Also, changes in the Portuguese educational, social, and economic reality in the past two decades might mean new career opportunities for first generation students, encouraging them, and their families, to invest in different activities that can contribute to their professional success.

If one assumes that student engagement in research is a positive behavior that should be encouraged, taking student characteristics into consideration might result in more targeted efforts of recruitment and hold greater promise in contributing to the sustainability of the physician-scientist career pipeline.

Limitations

Caution must be used in making generalizations from the study results in light of the following limitations. Although the participants in our study were exposed to similar curricula, faculty, staff, and educational opportunities (all of which can be discarded as confounding factors in the present study), they all originated from one single institution. Even though we considered the number of opportunities the students had to engage in research, the fact that not all of the students were in the same curricular stage is a limitation. Bootstrap analysis supports the validity of our regression model, but further confirmation in prospective studies

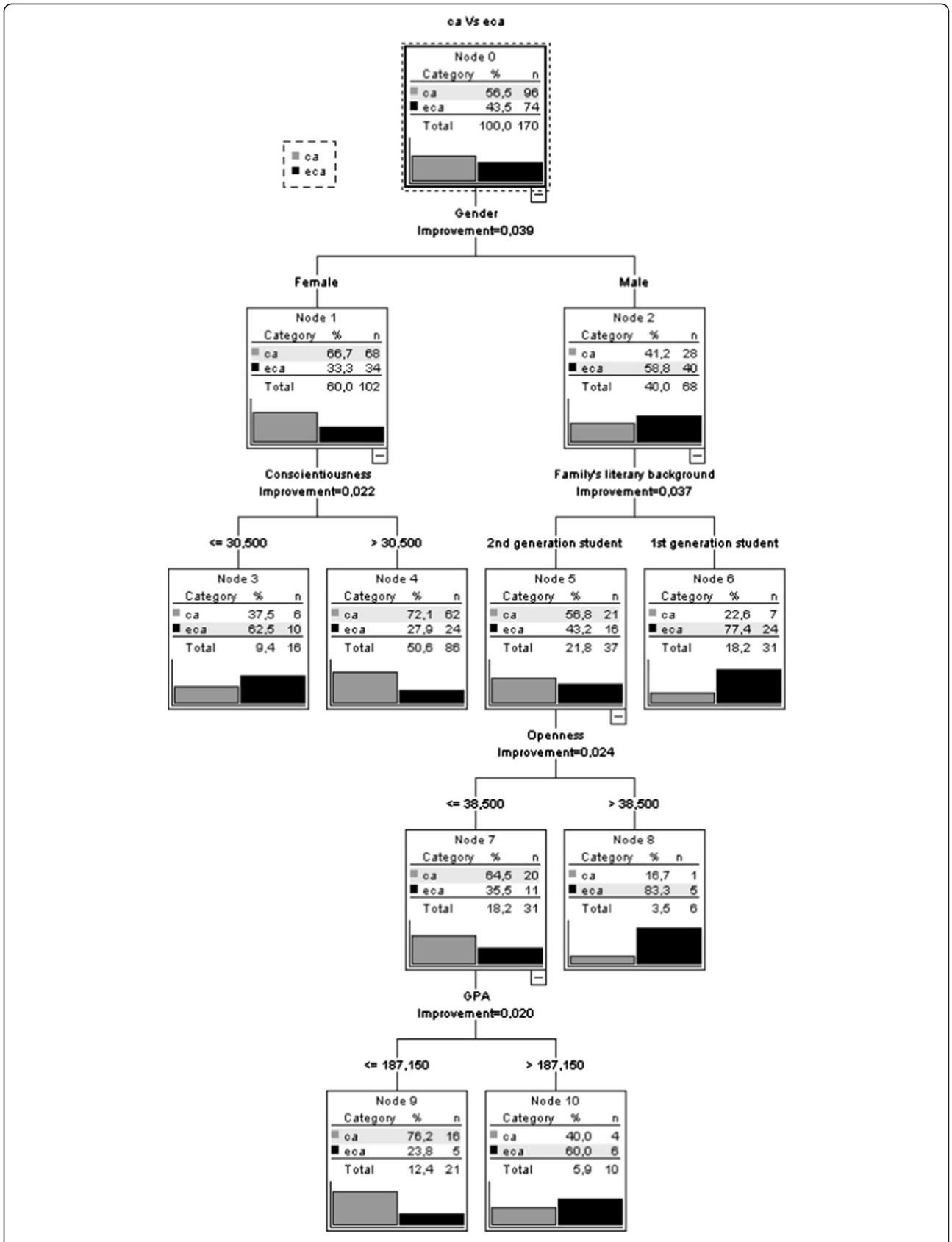

Figure 2 CRT model: decision tree.

and with future cohorts of students is needed to further address the issue. Because the number of students engaging in research activities is low, our CRT sample was small. For that reason, no cross-validation method was used and we allowed small minimum numbers of subjects in the child nodes. Further analysis with greater samples is crucial. Future studies that take into account these shortcomings will certainly contribute to a better definition and characterization of the best predictors of engagement in research activities. Our study discards all variables related to institutional context and it also does not explore subsequent behavior of engagement exhibited by the students (e.g. abandoning research after they have engaged versus maintaining the behavior in a consistent manner). Future qualitative research might give an insight on other important variables associated with student's engagement in scientific research.

Conclusions

Our results showed that male students are two times more likely to participate in research activities than females. Students with higher GPA and higher scores of openness and conscientiousness are also more likely to engage in research activities. On the contrary, higher scores in extraversion decrease the likelihood of participation. Other personality dimensions like neuroticism and agreeableness have no predictive power over students' engagement in research.

Our findings also add some insight on student's characteristics related to student's participation in extracurricular research activities, showing that male, 1st generation students are more involved and that female participation in ECA is related to lower levels of conscientiousness.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

All authors designed the study. AS, MG and EM administered the surveys. AS and PC developed the statistical analysis. AS wrote the first draft of the manuscript. All authors have reviewed and approved the text of the manuscript.

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Author details

[1]Life and Health Sciences Research Institute (ICVS), School of Health Sciences, University of Minho, Campus e Gualtar, 4710-057, Braga, Portugal. [2]Instituto Universitário de Lisboa (ISCTE-IUL), Cis-UL, Avenida das Forças Armadas, 1649-026, Lisbon, Portugal.

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CHAPTER 3 - Predictors of medical graduates' engagement in scientific research activities.

Manuscript in preparation

Predictors of medical graduates' engagement in scientific research activities

Ana Salgueira[1, 2*§], Raquel Rocha Afonso[1, 2*], Patrício Costa[1, 2], Manuel João Costa[1, 2]

[1] Life and Health Sciences Research Institute (ICVS), School of Health Sciences, University of Minho, Campus Gualtar, Braga, Portugal

[2] ICVS/3B's - PT Government Associate Laboratory, Braga/Guimarães, Portugal

*These authors contributed equally to this work

[§]Corresponding author

AS anasalgueira@ecsaude.uminho.pt

RRA raquelrafonso@gmail.com

PC pcosta@ecsaude.uminho.pt

MC mmcosta@ecsaude.uminho.pt

Abstract

Purpose: Physicians' engagement in scientific research activities is recognized as a contributor to the improvement of healthcare. Therefore it is relevant to understand what variables influence physicians' engagement in research. This study aims to determine the influence of individual characteristics and behavior during medical school in graduates' engagement in research.

Method: All alumni of the School of Health Sciences, University of Minho, Portugal, were asked in 2014 to participate in a survey about their engagement in undergraduate and postgraduate research. A longitudinal study allowed the collection of socio-demographic, performance and personality. Logistic regression models were used to determine the predictors of graduates' engagement in research.

Results: A total of 315 graduates (79%) responded to the survey and a complete set of data was available for 275 (69%). Among these, 125 (46%) reported to have been engaged in graduate research activities. Higher "openness to experience", "neuroticism" and "conscientiousness" personality dimensions scores increase chances of engagement. So does higher performance during medical school and being a male graduate. The likelihood of engaging in structured research (publishing peer review/PhD program) increases for male graduates and for those involved in voluntary research during medical school.

Conclusions: This study demonstrates that individual characteristics (personality, socio-demographic, performance and previous engagement) contribute to graduates' engagement in scientific research.

Introduction

The engagement of physicians in science is crucial for the improvement of treatment, diagnostic and prevention of diseases [1, 2]. As practicing doctors, and trained scientists, physicians engaged in research are in a position to raise scientific questions relevant for care, and also to understand and communicate scientific discoveries to researchers and colleagues. Therefore, they play a pivotal role in bringing research findings into clinical practice and communicating such findings to patients and to the general public [3–5].

There is a growing interest in understanding how medical schools might contribute to stimulate or sustain the engagement of future physicians with science [6–9].

Engagement in research experiences during medical school have been linked to increased levels of interest in research in medical graduates [9] and future career achievements in academic medicine [10]. A recent systematic review further suggests that developing medical school research is linked to choosing a career in academic medicine [8].

Therefore, medical school curricula are increasingly emphasizing research activities [9, 11–15], including research methodology courses, requiring medical students to engage in research projects and encouraging publication.

Individual characteristics, like gender and number of years in residency training, have also been considered to explain the engagement in scientific research after graduation. Data has revealed a gap between female and male interest and engagement in scientific research [10, 16–18]. Women are also more likely to report a decline in interest as they progress through medical school and to rate their research skills lower than men [17, 19].

Other individual related characteristics have been linked to the engagement in research of medical students and engagement in general. Personality traits are implicated in undergraduate' engagement in scientific research activities [20]. In fact personality traits have been shown to have predictive validity regarding outcomes like behavior [21] or academic performance [22].

There is a general scarcity of literature about the reasons why physicians engage in scientific research, particularly outside the US. The studies on the topic have small sample sizes, provide little detail on methodologies and are grounded in self-reported data, attitudes or other indirect measurements like intentions to engage [9, 10].

Despite the significant investment of resources in the development of undergraduate curricular and extracurricular opportunities, there is limited empirical evidence about the effectiveness of those activities and about the influence of individual variables in promoting the engagement in research of medical graduates. The purpose of the present study was to determine whether student individual characteristics (personality traits, gender, academic performance) and participation in research opportunities implemented in one medical school (voluntary participation in research activities during medical school), could predict actual research engagement during the early post-graduate years.

Method

Context and Ethical considerations

This research was part of the ongoing Longitudinal Study of the School of Health Sciences – University of Minho (ELECSUM).

Participation in ELECSUM is voluntary, confidential and written inform consent is asked for every new set of data collection and integration in the study. The study was approved by the Portuguese Commission for Data Protection (CNPD: 10432/2011). The study obtained formal approval from the Ethics review board of the University - *Subcomissão de Ética para as Ciências da Vida (process SECVS - 071/2013)*.

The six year undergraduate medical degree offers three types of opportunities to develop scientific research implemented at different points throughout undergraduate medical training: (a) elective curricular units in which students may participate in research projects (in basic or clinical sciences), in clinical attachments or in social work; (b) a mandatory curricular senior final year research work (project or a literature review); (c) extracurricular research activities, offered by the school (such as summer laboratory rotations to apply for the school's MD-PhD program) or initiated by the students.

Instruments and data collection

We developed and piloted an online survey, which inquired graduates about participation in (i) research projects during medical degree – types of participation, scientific field, institution and

research group – and in (ii) research after graduation. The latter could be (a) PhD research projects – enrolment and current status, institution, scientific field, title and supervisor – or (b) other research projects (non-PhD) –institution and project status (on going or finished). The survey also requested a (c) list of scientific publications authored by the graduate, requesting information such as year, journal and name used by the author for publications.

We emailed invitations to participants and reminders to non-respondents one, two and six weeks later. We contacted the remaining non-respondents via phone or the social networks, to enhance participation. The survey was available between July and October 2014.

Data already available from the ELECSUM included gender, final Grade Point Average (GPA), graduation year; and Personality scores, in the five dimensions obtained with the Portuguese version of NEO Five-Factor Inventory (NEO-FFI) [23, 24] – extraversion, openness, conscientiousness, agreeableness and neuroticism.

Participants and Sample validation

We invited a total of 399 alumni (seven cohorts: graduates from 2007 to 2013) to participate in this study. In total, 301 alumni responded, giving an overall response rate of 75,4%; response rates varied between the cohorts from 60% to 85%.

To test the representativeness of our sample, we compared independent variables available in ELECSUM for the survey's "respondents" and "non-respondents" using Student's t-test (for continuous variables) and the Chi square test (for categorical variables). Since no statistical significant differences were observed between the groups (Table 1), we can conclude that our sample could be representative of the entire population.

The final sample included 275 graduates (69% of the population), for whom complete ELECSUM data sets were available – illustrated in Figure 1.

Data Validation

We crosschecked all self-reported information about participation in undergraduate research during electives, final research project and summer laboratory rotations with ELECSUM records. We did not find mismatches for summer rotations, but we recognized mismatches of research

electives and final year project respectively for 30% and 57% of the participants. We crosschecked self-reported publications with PubMed and journals' websites, and only publications as author or co-author in a journal were considered. It was not possible to verify self-reported participation in research projects other than PhD programs or published scientific literature. The confirmed data were used to create the dependent and independent variables.

Dependent variables

We created two dependent variables: (1) Participation in "Graduate Research" and (2) Participation in "Structured Research":

(1) Participation in "Graduate Research", used in the logistic regression model 1, considered all forms of participation in graduate research (verified or not). Participants were split in two groups according to their engagement behavior as it follows: students involved in research initiatives after graduation, at least once, were considered as "engaged" (and coded as 1) and students who reported no participation in research initiatives were considered as "not engaged" (and coded as 0). We considered subjects who quitted graduate research (n=7), either from PhD program (n=3) or from non-PhD research projects (n=6) as "missing values", because they could share characteristics from participants (since they decided to engage) and non-participants (since they ended up quitting their research activities).

(2) Participation in "Structured Research", used in the logistic regression model 2, considered verified participation in a PhD program and/or publication of at least one article in a journal with impact factor. Participants were split into two groups according to their engagement behavior as follows: students involved in a PhD program and/or publication of at least one article in a journal with impact factor were considered as "engaged" (and coded as 1) and students who reported no participation in research initiatives were considered as "not engaged" (and coded as 0). We excluded (considered as "missing values") graduates who participated in research activities that did not fit structured research criteria from model 2, because although these subjects do not have evidence of structured research, they can be in an early stage of their research. So, they could be suitable for any of the groups. Dropouts were also considered as "missing values". This variable compares two contrasting groups: those who did not engage in research after graduation and those who do it in a structured and continuous way.

Independent Variables

We used socio-demographic (gender), performance (graduations GPA) and personality (NEO-FFI) variables as independent variables in the models. We also used verified voluntary participation in "undergraduate research" with two categories: 1 for verified voluntary engagement in undergraduate research during electives, summer rotations or other extracurricular activity and 0 for not engaged in voluntary undergraduate research. We included the variable "opportunities" as an influence variable, to quantify the number of research opportunities after graduation, which corresponded to the number of years since graduation.

Statistical analysis

We performed two binary logistic regression models to identify statistically significant influential factors of the engagement in graduate scientific research activities. We performed the analysis using the backward LR method based on likelihood ratio test and the two models were obtained in four steps. For results internal validation, we performed bootstrap analysis with 1000 samples using the Enter method for the step four of both models. Data were analyzed using IBM SPSS statistics 22.0 (IBM Corp.: Armonk, NY, 2013).

Results

Engagement in research activities

There were 122 (42%) subjects who had voluntarily engaged in research during medical school. A total number of 145 (49%) subjects reported being involved in research after graduation; of those, only 48 (26%) were involved in structured research (table 2).

Predictors of graduates' engagement in research (Model 1)

The set of predictors on Model 1 (table 3) significantly predicted engagement in research activities after graduation ($G2(6)=77.666$; $p<.001$). Statistical significance was found for the following variables: gender, final grade and neuroticism, openness to experience and

conscientiousness. Participation in undergraduate research, extraversion and agreeableness were removed from the model in steps 2, 3 and 4, respectively.

Based on the final model (step 4), the odds to engage in research for male students were 3.28 times larger than the odds for a female (OR=3.281; p<.001). For every five points increase in final GPA, the odds of engagement increased 38% (OR=1.066; p<.001). Five more points in neuroticism increased the chance of participation by 28% (OR=1.051; p<.01), in openness by 38% (OR=1.066; p<.01) and in conscientiousness by 28% (OR=1.051; p<.05). For every additional year since graduation there was a 1.4 fold increase in the odds to engage in research (OR=1.400; p<.001). Using a cut point value of 0.5, model 1 correctly classified 71% of the subjects (65% of engaged and 77% of not engaged graduates), 19.6% more than chance, in general. For participants, the gain in explanation was 65%, since Block 0 classified all subjects as non-participants.

Overall, model 1 explained 33% of the dependent variable's observed variance (Nagelkerke Pseudo-R2=.328). Hosmer-Lemeshow test showed a good model fit. In the bootstrap analysis (table 4), the small bias and standard error values, the fact that all B values are inside the CI and the fact that all statistical significance for all the variables is maintained, confirmed the stability of the model.

Predictors of graduates' engagement in Structured Research (Model 2)

The set of predictors in Model 2 (table 5) significantly predicted engagement in structured research after graduation (G2(6)=85,276; p<.001). Statistical significance was found for the following variables: participation in undergraduate research, gender and final grade. Extraversion, openness and agreeableness were removed from the model in steps 2, 3 and 4, respectively. No statistical significance was found for neuroticism, or conscientiousness.

Results show that graduates who had been engaged in research during medical school were four times more likely to engage in structured research after graduation than those who had not (OR=4.136; p<.01). Male graduates were seven times more likely to engage than females (OR=7.214; p<.001). For every five points increment in the final grade, the odds of engagement increased 47% (OR=1.080; p<.01). For every additional year since graduation there was a 1.6 fold increase in the likelihood to engage (OR=1.636; p<.01). Using a cut point value of 0.5, model two correctly classifies 87% of the subjects (62% of engaged and 96% of not engaged

graduates), 12% more than chance. For participants, the gain was explanation is 62%, since Block 0 classified all subjects as non-participants.

Overall, the model explained 54% of the dependent variable's observed variance (Nagelkerke Pseudo-R2=.540). Hosmer-Lemeshow test showed a good model fit. In the bootstrap analysis (table 6), the small bias and standard error values, the fact that all B values are inside the CI and the fact that all statistical significance for all the variables is maintained, confirmed the stability of model 2.

Table 1 - Sample validation: t-tests and χ^2-tests for comparison of independent variables between "respondents" and "non-respondents" in the survey administered to all alumni of ECS-UM, Portugal.

		Non Respondents		Respondents		Total		Mean difference
		n=89		n=301		n=399		T-test/χ^2 Test, sig.
		n (%)	*M(SD)*	n (%)	*M(SD)*	n (%)	*M(SD)*	
Gender	M	22 (26%)	-	108 (36%)	-	130 (34%)	-	χ^2 (1, n=385) = 2.757, p=.097
	F	62 (74%)	-	193 (64%)	-	255 (66%)	-	
Opportunities		84 (100%)	3.87 (1.86)	301 (100%)	3.60 (2.06)	385 (97%)	3.66 (2.02)	t(383) = 1.062, p=.289
Neuroticism		58 (69%)	23.41 (6.51)	282 (94%)	22.38 (6.90)	340 (85%)	22.56 (6.84)	t(338) = 1.050, p=.295
Extroversion		59 (70%)	30.32 (4.00)	282 (94%)	31.42 (5.56)	341 (85%)	31.23 (5.34)	t(111) = -1.783, p=.077
Openness		58 (69%)	29.98 (5.03)	282 (94%)	30.72 (5.23)	340 (85%)	30.60 (5.20)	t(338) = -.988, p=.324
Agreeableness		59 (70%)	34.22 (5.01)	282 (94%)	34.23 (5.35)	341 (85%)	34.23 (5.28)	t(339) = .009, p=.993
Conscientious.		59 (70%)	33.90 (5.78)	282 (94%)	34.38 (6.07)	341 (85%)	34.30 (6.02)	t(339) = -.562, p=.574
Final GPA		84 (100%)	147.62 (9.86)	301 (100%)	148.72 (10.09)	385 (97%)	148.48 (10.03)	t(383) = -.887, p=.376

Table 2 – Engagement in undergraduate and graduate research.

		Graduate Research [ ]			
		Not Engaged	**Structured Research**	**Unstructured Research**	**Total**
			(not mutually exclusive)		
		149 [51%]	48 [16%]	145 [49%]	294 [100%]
Undergraduate Research	Voluntary Engagement	53 [43%]	36 [30%]	69 [57%]	122
	Not Engaged	96 [56%]	12 [7%]	76 [44%]	172
Gender	Male	43 [41%]	27 [26%]	62 [59%]	105
	Female	106 [56%]	21 [11%]	83 [44%]	189
	Total	**149**	**48**	**145**	**294**

Table 3 – Binary Logistic Regression for predicting engagement in Graduate Research (Model 1) using Backward LR Method.

Independent Variables	Step 1			Step 2			Step 3			Step 4			
	B	SE	OR	B	SE	OR	B	SE	OR	B	SE	OR	Exp (B*5)
Opportunities	.318	.074	1.374***	0.317	.074	1.373***	0.317	.074	1.373***	.337	.073	1.400***	-
Participation in Undergraduate Research	.105	.300	.726	-	-	-	-	-	-	-	-	-	-
Gender (male)	1.321	.339	3.748***	1..321	.339	3.747***	1.328	.339	3.772***	1.188	.323	3.281***	-
GPA	.063	.016	1.065***	.064	.016	1.067***	.065	.016	1.067***	.064	.016	1.066***	1.377
Neuroticism	.050	.023	1.052*	.050	.023	1.051*	.054	.022	1.056**	.049	.022	1.051**	1.277
Extraversion	-.014	.028	.987	-.014	.028	0.986	-	-	-	-	-	-	-
Openness	.062	.029	1.064**	.063	.029	1.065**	.060	.028	1.062**	.064	.028	1.066**	1.377
Agreeability	.044	.029	1.045	.044	.029	1.045	.043	.029	1.044	-	-	-	-
Conscientiousness	.050	.025	1.051*	.050	.025	1.051*	.049	.025	1.050*	.050	.025	1.051*	1.284
Constant	-16.913	3.209	0.000***	-17.073	3.175	0.000***	-17.494	2.853	0.000***	-15.948	2.853	0.000***	-
-2 Log likelihood	300.705			300.828			301.102			303.387			
Cox & Snell R Square	.253			.253			.252			.246			
Nagelkerke R Square	**.338**			**.337**			**.336**			**.328**			
Hosmer and Lemeshow Test	χ^2 (8) = 6.522; p=.589			χ^2 (8) = 7.748; p=.458			χ^2 (8) = 8.114; p=.422			χ^2 (8) = 6.809; p=.557			
* p<.05; **p<.01; ***p<.001; Abbreviations: CI – Confidence Interval; SD – Standard error; GPA – Grade Point Average; n=275													

Table 4 – Binary Logistic Regression for predicting engagement in Graduate Research (Model 1): Bootstrap analysis.

Independent Variables	Bootstrap (1000 samples)			
	Bias	SE	95% CI	
			Lower	Upper
Opportunities	.015	.78	.200	.498
Participation in Undergraduate Research	-	-	-	-
Gender (male)	.053	.56	.532	1.948
GPA	.002	.016	.035	.098
Neuroticism	.003	.024	.002	.097
Extraversion	-	-	-	-
Openness	.003	.028	.011	.128
Agreeability	-	-	-	-
Conscientiousness	.003	.026	.005	.104
Constant	-.584	2.889	-22.868	-11.264

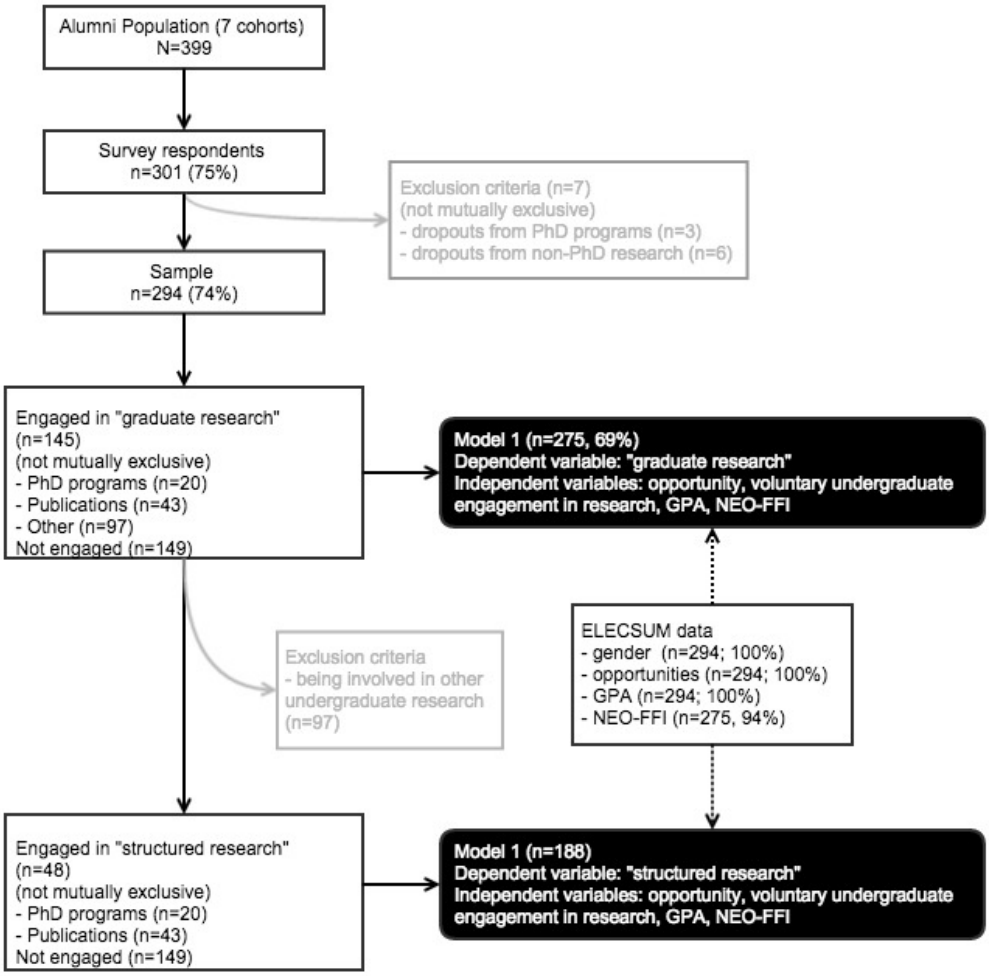
Table 5 – Binary Logistic Regression for predicting engagement in Structured Research (Model 2) using Backward LR Method and Bootstrap of its Step 4.

Independent Variables	Step 1			Step 2			Step 3			Step 4				
	B	SE	OR	B	SE	OR	B	SE	OR	B	X^2_{WALD}	SE	OR	Exp (B*5)
Opportunities	0.465	.117	1.592***	.465	.117	1.592***	.469	.116	1.598***	.492	18.423	.115	1.636***	-
Participation in Undergraduate Research	1.359	.491	3.892**	1.369	.485	3.932**	1.390	.483	4.017**	1.420	8.660	.482	4.136**	-
Gender (male)	2.117	.565	8.304***	2.118	.565	8.312***	2.164	.559	8.709***	1.976	14.523	.519	7.214***	-
GPA	.079	.025	1.082**	.079	.025	1.082**	.079	.025	1.083**	.077	9.722	.025	1.080**	1.470
Neuroticism	.063	.038	1.065	.065	.035	1.067	.068	.035	1.070	.058	3.002	.034	1.060	-
Extraversion	-.007	.048	.993	-	-	-	-	-	-	-	-	-	-	-
Openness	.038	.048	1.039	.036	.045	1.037	-	-	-	-	-	-	-	-
Agreeability	.044	.049	1.045	.044	.049	1.045	.049	.049	1.050	-	-	-	-	-
Conscientious.	.081	.042	1.084	.081	.042	1.084	.078	.041	1.082	.081	3.825	.041	1.084	-
Constant	-23.066	5.181	.000***	-23.200	5.096	.000***	-22.353	4.932	.000***	-2.181	22.124	4.291	.000***	-
-2 Log likelihood	124.478			124.497			125.134			126.162				
Cox & Snell R Square	.370			.370			.368			.365				
Nagelkerke R Square	**.548**			**.548**			**.545**			**.540**				
Hosmer and Lemeshow Test	X^2 (8) = 14.102; p=.079			X^2 (8) = 14.047; p=.081			X^2 (8) = 17.499; p=.025			X^2 (8) = 9.61; p=.293				
* p<.05; **p<.01; ***p<.001; Abbreviations: CI – Confidence Interval; SD – Standard error; GPA – Grade Point Average; n=188														

Table 6 – Binary Logistic Regression for predicting engagement in Structured Research (Model 2): Bootstrap analysis.

Independent Variables	Bootstrap (1000 samples)			
	Bias	SE	95% CI	
			Lower	Upper
Opportunities	.034	.119	.319	.793
Participation in Undergraduate Research	.095	.549	.468	2.705
Gender (male)	.159	.650	.997	3.644
GPA	.006	.027	.033	.140
Neuroticism	.005	.039	-.013	.143
Extraversion	-	-	-	-
Openness	-	-	-	-
Agreeability	-	-	-	-
Conscientiousness	.006	.050	.002	.194
Constant	-1.522	5.202	-33.862	-12.962

Figure 1 – Flow diagram of the sample and study design.



Discussion

The aim of this study, conducted in a medical school, was to assess the influence of individual characteristics, academic performance and voluntary participation in undergraduate research on actual engagement in research, upon graduation. The main findings were that a combination of individual variables - socio-demographic (gender), performance (graduation GPA), personality (NEO-FFI) and voluntary participation in undergraduate research - was predictive over engagement in research activities after graduation. Specifically, we found that female graduates tended to engage in research less than their male counterparts, thus extending reported findings in the USA to a new international context.

Regarding the contribution of individual characteristics to engagement in graduate research, it was no surprise to find positive contributes of both openness to experience and conscientiousness. Individuals with higher scores in "openness to experience" can be characterized as intellectually curious and engaged; in fact, engagement behavior is one of their distinguishing characteristics [21]. Careful planning, self-discipline and motivation, the traits from "conscientious" persons, also positively influence the development of research. High neuroticism scores were also positively associated with engagement in scientific research, which may be explained by their relatedness with reflexive behaviors and shyness, which might be congruent with the solitary and reflexive nature of lab work. These results are mostly in agreement with those found for engagement during medical school [20].

In what regards predicting engagement in PhD programs or publishing a scientific paper (structured research), the contribution of personality dimensions was no longer significant. Instead, voluntary engagement in undergraduate research emerged as a primary statistical significant contributor. Since these personality traits predict engagement in undergraduate research [20], the two variables may not be dissociable and the significant weight of the variable "participation in undergraduate research" in model 2 might be partially accounted for the effect of personality traits. Indeed, graduates who had engaged voluntarily in undergraduate research were more likely to enroll in structured research (the results show a 4 fold increase) but not in graduate research in general. The disparity found in terms of the type of postgraduate research participation, might reflect factors inherent to supervisors' and departments' expectations towards involvement of junior trainees in research. In Portugal, as part of residency training, it is

mandatory for junior physicians to present posters and communications at scientific meetings: the mandatory character might have been the key element contributing to the higher number of graduates engaged in postgraduate research, as compared to long term structured research. This is an important difference, which suggests that the design of medical school policies to stimulate undergraduate medical students to conduct scientific research after graduation must consider the type of research they target. The implications of these specific results for medical education are that the significant movement towards providing medical students with mandatory research experiences within the medical school curriculum should be complemented with opportunities that capitalize voluntary engagement. In fact, the majority of the graduates (involved in research as a result of a mandatory curricular course) did not engage in scientific research after graduation (55%) and only 7% did it in a structured way.

The present results show that male graduates are three times more likely to engage in research than female (seven times if we consider only structured research). This result must be interpreted carefully because of the magnitude of its 95%CI, which is a consequence of the significant disparity in gender distribution of medical graduates' population (2:1, favoring females) and engaged graduates (inversely). In fact, gender differences in scientific research engagement, is a common phenomenon worldwide [16–18, 25, 26]. This phenomenon can be explained by cross-cultural factors, such as women's concerns to fail in combining a successful career with childbearing and family life, lower perception of abilities for research, receiving very little encouragement to become physician-scientists and lack of compelling role models [25, 26].

Higher graduation GPAs were linked to increased engagement in graduate research including structured research. Graduates with higher GPA might be more confident in their abilities to use their transferable skills in scientific challenges. And, even though GPA has been previously found to correlate significantly with agreeableness, conscientiousness, and openness to experience, it comes out as a separate contributor in the regression models.

There are some limitations to the present study that might influence the generalization of the results. First, all participants graduated in one single institution; yet, this assured that they were exposed to similar curricula, faculty, staff and educational opportunities. Additionally, even though the number of years after graduation was considered as an influence variable, we should consider that not all of the graduates are in the same professional stage and that they followed divergent medical careers in different specialties and institutions, such that, in practice, they do

not have the same access to research groups or PhD programs. As this study intends to identify the characteristics that predispose graduates to engage in research, it was important to have in consideration the type of engagement in undergraduate research activities; however, the influence of mandatory final year research projects in future engagement in research could not be assessed for the lack of a comparison group. This study has some characteristics that bring good reliability to the results, including a high response rate and the cross-validation of information provided by participants against official data that allowed us to use actual engagement (for both independent and dependent variables), rather than self-report, intention of participation or attitudes towards research, which are generally used in the literature. Further studies, with greater samples, are essential to define and characterize additional predictors of engagement in research by medical graduates.

In summary, and for all medical schools that aim at graduating "physicians with a scientific research profile" the present data seems to provide evidence to support the implementation of target driven approaches to involve those students that, having a profile prone to engage, are still not involved in research. Continuous efforts should be done to provide students with opportunities to voluntarily engage in research experiences, such as including research electives in their curricula, strengthen relationship with research institutes and hospitals and encourage professors to accept students in research projects. Additionally, faculty should be committed to promoting students engagement, by inviting them to get acquainted and involved in research projects and acting like role models. Finally, it seems important to counteract the gender disparity in medical research, by promoting specific actions that stimulate the involvement of female graduates in research.

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CHAPTER 4 - Medical student leadership: a cross-sectional study on individual characteristics and leadership after graduation.

Manuscript in preparation

Medical student leadership: a cross-sectional study on individual characteristics and leadership after graduation.

Ana Salgueira[1, 2*§], Raquel Rocha Afonso[1, 2*], Patrício Costa[1, 2], Manuel João Costa[1, 2]

[1] Life and Health Sciences Research Institute (ICVS), School of Health Sciences, University of Minho, Campus Gualtar, Braga, Portugal

[2] ICVS/3B's - PT Government Associate Laboratory, Braga/Guimarães, Portugal

*These authors contributed equally to this work

[§]Corresponding author

AS anasalgueira@ecsaude.uminho.pt

RRA raquelrafonso@gmail.com

PC pcosta@ecsaude.uminho.pt

MC mmcosta@ecsaude.uminho.pt

Abstract

Background: The importance of physician leadership is currently unquestionable. Yet, understanding of how medical students develop leadership skills or why they show leadership behaviors is limited. In particular, the influence of individual characteristics on medical students engagement in leadership behaviors is unknown. Also, it is not clear whether student leadership behaviors are linked to increased likelihood of future leadership roles in professional and scientific associations. Considering that participation in student associations as an elected representative is indicative of undergraduate student leadership, the two main objectives for this study were to clarify: (1) the influence of individual characteristics, including personality traits and socio-demographic characteristics, on that specific leadership behavior and (2) the link between this behavior during medical school and being elected for future leadership positions in scientific or professional organizations after graduation.

Methods: The participants were 260 (75%) undergraduate medical students and alumni of the School of Health Sciences in Minho, Portugal. Data were available on socio-demographic, personality and university admission variables, as part of an ongoing institutional longitudinal study. The participants were surveyed on their engagement as elected representatives, and data were crosschecked with official records. A logistic regression model was used to compare students engaged in leadership (as an elected representative) with students not engaged. A Chi square test and Pearson Phi association measure were used to test associations between undergraduate medical student leadership and postgraduate leadership roles in professional or scientific organizations.

Results: Results found that 33% (n=86) of the students had been elected as a representative during medical school and 12% (n=31) of the graduates reported having been elected to professional and/or scientific associations. Results show that personality traits and leaving the family home significantly contributed to explain engagement in leadership during the medical school. In addition, students' leadership experiences during medical school proved to be strongly

associated with holding a leadership role in scientific or professional organizations after graduation.

Conclusions: This study demonstrated the contribution of medical student's individual characteristics to engagement in leadership. Also, the study showed that engagement during medical school strongly increases chances of participation in scientific or professional organizations after graduation.

Keywords: medical students, medical graduates, individual characteristics, personality, engagement, elected representatives and leadership.

Background

Medical schools are increasingly aware of the importance of student leadership skills. At the clinical workplace, physicians must be prepared to assume leadership roles and assist institutions to face the continuous challenges in health care systems. The importance of collaborative leadership is nowadays clear in influential documents such as the Canadian Medical Education Directions for Specialists (CANMEDs) (one of the most widely adopted physician competency frameworks used by medical schools as a reference to goals orientation, training activities development and outcomes assessment)[1]. CANMEDS emphasizes the roles of physicians as leaders and health advocates influencing health systems and contributing to improved health care in the community or population they serve, for example, through collegiality and standard setting for the profession. It falls upon Medical Schools to recognize and to promote the development of students leadership skills during their undergraduate years of training [2].

Understanding how schools can foster the development of leadership in students is, however, difficult. Predictive factors that help to identify commitment of medical students to leadership are unknown. Little is also known about the influence of holding a leadership role as a medical student on postgraduate professional leadership. The available research with non medical students has explored different behaviors broadly assumed to be representative of engagement in leadership during college. Reported findings focused on how engagement in leadership contributes to student cognitive and psychosocial development [3]. College leadership responsibilities have been linked to increased developmental skills after three years in college [4], cognitive complexity and gains in practical and interpersonal competence [5], higher capacity for mature interpersonal relationships [6], higher levels of vocational and psychological development [7], increased tolerance and acceptance of differences among individuals [6], increased sense of citizenship and leadership efficacy [8], development of humanitarian values [5, 9] and civic involvement [9].

In order to foster student leadership, medical schools need to understand the elements of potentially effective leadership curricula and student leadership should be recognized and assessed. A mixed-methods study with medical students and faculty members has advanced the knowledge and the competences that should be part of an undergraduate curriculum [10].

Among others, these included communication skills, ethics, conflict resolution, time management, managed care, management principles, coding and billing, quality improvement and public speaking. Interestingly, in the same study, students expressed the view that "traditional coursework was not an effective way to teach or learn leadership" and an illustrative student comment referred hat leadership "comes more from experience, especially in terms of extracurriculars" [10]. Indeed, there are several extracurricular behaviors during medical school, which might be recognized as expressions of leadership. Those might include being involved in community service, being involved in student affairs and educational groups, or participating in student organizations as student representatives. The same applies after graduation: physician leadership can be recognized through (among other things) assuming clinical leadership or management responsibilities, or through contributing to the development of their own specialty areas in professional or scientific organizations.

The study of student leadership within contexts of extracurricular initiatives might offer clues to identify determinants of commitment to leadership in general. Therefore, the wider literature on determinants of engagement in extracurricular activities is useful to frame research around student leadership as elected representatives. The educational context (experiences and opportunities) has an impact on student engagement [11–13] but the decision to engage, or not to engage, rests on the individual [11–14] Research on individual differences provides some understanding about how and why people differ by studying several nonobservable or "latent" constructs, such as intelligence and personality, which represent major sources of variation in behavior [14]. Individual variables, like gender or parental education, have been associated with college students engagement in extra-curricular college activities [15, 16] and, more specifically, personality traits and other socio-demographic characteristics have been shown to be linked to medical students engagement in research activities [17], academic performance [18–20] and medical specialty choice [21–23]. These variables are yet to be studied when it comes to medical student engagement in leadership as an elected student representative.

Recognizing the importance of establishing an association between undergraduate medical education and post-college leadership behavior [24], this study explores the hypothesis that assuming leadership roles in medical school might be predictive of assuming physician leadership roles in post-graduate life. Starting from the stance that being an elected representative is an indicator of undergraduate student leadership, this study explored the interplay between this specific behavior and individual variables, as well as the prediction of

participation in scientific or professional organizations after graduation. Thus, the specific aims of this study were to assess (1) the influence of individual characteristics, including personality traits and socio-demographic characteristics, on student leadership as an elected student representative during medical school; (2) the extent to what undergraduate student leadership can explain leadership in postgraduate scientific or professional organizations.

Methods

Ethical considerations

The study was part of an ongoing longitudinal study (ELECSUM). Participation in the longitudinal study is voluntary, confidential and written informed consent is asked, of all participants, whenever new data is collected. The Portuguese Data Protection authority (CNPD 10432/2011) and the Ethics review board of the University - Subcomissão de Ética para as Ciências da Vida (process SECVS - 071/2013) approved the present study.

Context, population and sample exclusion criteria

The study was developed in the School of Health Sciences at the University of Minho, Portugal (ECS/UM). Both the School and the University offer the students multiple opportunities to participate in student's organizations (cultural, sports and student government).

All former students admitted to the medical school through the national admission pathway, graduated between 2007 and 2013, were considered for this study (N=399). We excluded former students who entered medical school through special admission pathways (natives from the islands of Madeira and Azores, emigrants, athletes, military, graduates). These students' GPAs are below the lowest GPA ever recorded for a student entering the program through the regular admission pathway and, depending on the special admission pathway, they differ in age, academic qualifications or professional activity. They represent less than 10% (n=53) of the total number of students when all the special programs are considered. Their number was not sufficient to include all their variables into the model.

Variables, instruments and data collection procedures

Data was available on ELECSUM for gender and admission GPA (n346/100%), for personality (n298/86%), for being a first (or second) generation student (n325/94%) and for leaving their family home on medical school admission (n317/92%). A total of 260 (75% of 346) graduates completed the online survey about participation in student organizations.

A complete set of data (personality, GPA, and socio-demographic variables) was available for 234 of the 346 eligible students (68%). Personality measures were taken with the Portuguese validated version of NEO-FFI (NEO Five-Factor Inventory) [25]. The NEO-FFI provides scores for five personality dimensions, each one defined by six facets: openness to experience (defined by fantasy, aesthetics, feelings, actions, ideas, values), conscientiousness (defined by competence, order, dutifulness, achievement striving, self-discipline, deliberation), extraversion (warmth, gregariousness, assertiveness, activity, excitement seeking, positive emotions), agreeableness (defined by trust, straightforwardness, altruism, compliance, modesty, tender-mindedness), and neuroticism (anxiety, angry hostility, depression, self-consciousness, impulsiveness, vulnerability) [25, 26] using a 5 point likert scale (1= totally disagree; 2 = disagree; 0 = without opinion; 3 = agree; 4= totally agree) with 12 items for each dimension. The Portuguese version of NEO-FFI includes 60 items with Cronbach's Alpha ranging from 0.71 (Openness) to 0.81 (conscientiousness) and corroborates the well-established reliability, factorial structure, and cross-cultural communalities of personality according to gender, age, and educational differences. The surveys on socio-demographic variables and University admission data were custom-made by the research team. These surveys, as well as the NEO-FFI are administered to the students when they arrive at the university, in paper format.

An online survey was developed and piloted, inquiring if the graduates had held a leadership position during medical school and after graduation in scientific or professional organizations. Invitations were sent to graduates and reminders to non-respondents were sent 1, 2 and 6 weeks later. Non-respondents were also contacted via phone or social networks, to enhance participation. The graduates' contact information was available in ELECSUM. The survey was available between July and October 2014. The complete set of data was anonymised before analysis.

Engagement classification

All self-reported information about being an elected student representative during medical school was crosschecked with official records; we found mismatches for 13 subjects (5% of the participants). With the verified data, a new variable was computed: "Engagement during medical school". This variable considered students who assumed responsibilities as (a) elected class representative and (b) as elected students representative in college student groups and associations. Participants were split in two groups according to their participation as follows: students elected as students representatives, at least once, were considered as "engaged" (and coded as 1) and students who had never been elected as a student representative were considered as "not engaged" (and coded as 0). A small group of students (n=12) reported being actively involved in students associations' with specific responsibilities like collaborating with the marketing department (collaborators), but without being elected. These students were considered missing, as their behavior was not verifiable and they could share characteristics from both groups.

The variable "Graduate engagement" included being an elected representative in professional and scientific organizations like the Portuguese Medical Association, the Doctors' Union or the Alumni Association. It was not possible to check self-reported engagement after graduation due to lack of official information. Participants were split in two groups according to their participation as follows: graduates that reported being an elected representative in professional and/or scientific organizations were considered as "engaged" (and coded as 1) and graduates who reported never having been elected as a representative in professional and/or scientific organizations were considered as "not engaged" (and coded as 0).

Statistical analysis

To test sample representativeness, survey's "responders" and "non-responders" were statistically compared in all relevant independent variables available in ELECSUM using Student t-tests (for continuous variables) and Chi square tests (for categorical variables). Effect size measures, Cohen's d and Pearson Phi were calculated accordingly.

Subjects with complete sets of information for all independent variables were selected for a Hierarchical Multiple Binary Logistic Regression to explore which student characteristics predicts "engagement during medical school" (engaged/not engaged). Two blocks were introduced into

the model. In the first block we introduced socio-demographic (gender and parents educational background) and college admission data (GPA and leaving their family home). In the second block we added in the model the five personality dimensions. For internal results validation, a bootstrap analysis with 1000 samples was performed using the Enter method for the final model.

We used a Chi square test and Pearson Phi association measure, for all respondents, to test if undergraduate medical student engagement is associated with "engagement after graduation" because the reduced number of events (engagement after graduation) did not allow a logistic regression analysis.

Data were analyzed using IBM SPSS Statistics 22.0 (IBM Corp.: Armonk, NY, 2013).

Results

Cross-validation of self-reported information and sample validation

Although the comparison between "responders" and "non-responders" for each of the independent variables showed a statistically significant difference for gender, the effect size of that result is very small (Φ=0.12) [27]. No other statistically significant differences were found (see Table 1). Therefore, the sample was considered representative of the population for the purpose of the present study.

Table 1 - Sample validation: t-tests and χ2-tests for comparison of independent variables between survey "respondents" and "non-respondents".

		Non Respondents		Respondents		Total			
		n=86		n=260		n=346		T-test/χ^2 Test, sig	Effect size
		n (%)	M(SD)	n (%)	M(SD)	n (%)	M(SD)		
Gender	M	18 (21%)	-	88 (34%)	-	106 (31%)	-	χ^2 (1, n=346) = 5.07, p=.024	Φ=0.12
	F	68 (79%)	-	172 (66%)	-	240 (69%)	-		
Neuroticism		52 (60%)	23.71 (6.41)	246 (95%)	22.48 (6.88)	298 (86%)	22.69 (6.80)	t(296)=1.191 p=.216	–
Extraversion		53 (62%)	30.32 (3.94)	246 (95%)	31.56 (5.51)	299 (86%)	31.34 (5.28)	t(297) = -1.554, p=.057	–
Openness		52 (60%)	29.96 (4.48)	246 (95%)	30.87 (5.34)	298 (86%)	30.71 (5.20)	t(296) = -1.14, p=.203	–
Agreeableness		53 (62%)	34.13 (5.22)	246 (95%)	34.28 (5.27)	299 (86%)	34.25 (5.25)	t(297) =-.186, p=.852	–
Conscientious.		53 (62%)	33.66 (5.83)	246 (95%)	34.39 (6.22)	299 (86%)	34.26 (6.15)	t(297) = -.788, p=.414	–
Final GPA		86 (100%)	187.14 (3.21)	260 (100%)	186.99 (3.22)	346 (100%)	187.02 (3.22)	t(344) = 1.23, p=.267	–
Leaving the family home		57 (66%)	-	260 (100%)	-	317 (92%)	-	χ^2 (1, n=317) = .888, p=.687	–
1st generation student		67 (80%)	-	258 (99%)	-	325 (94%)	-	χ^2 (1, n=325) = 1.21, p=.493	–

Leadership engagement during medical school

We found and verified that 33% (n=86) of the participants had held a leadership role in student organizations as an elected student representative. 5% (n=12) of participants mentioned being involved as a non-elected collaborator: however, it was not possible to verify this information.

12% (n=31) of the graduates reported holding a leadership role as an elected representative in professional or scientific organizations after leaving the medical school.

We then performed a regression model to test which variables significantly predicted student's leadership during medical school (results in Table 2). In block 1 (including socio-demographic

and college access data), statistical significance was found for female gender (OR=.445; p=.006) and moving away from the family home (OR=2.771; p=.000). No statistical significance was found for GPA and for being a 1st generation student.

In block 2, with the addition of personality measures, statistical significance was found for leaving the family home (OR=3.247; p=.000) and the personality dimensions of neuroticism (OR=.925; p=.004), conscientiousness (OR=.936; p=.017) and extraversion (OR=1.074; p=.029). No statistical significance was found for GPA, being a 1st generation student and the personality dimensions of openness and agreeableness. Statistical significance for gender was not maintained. Using a cut point value of 0.5, block 1 correctly classifies 69.2% of the subjects and explains 11% of the dependent variable's observed variance (Nagelkerke Pseudo-R^2=.110), the Hosmer-Lemeshow test showed a good model fit (χ^2HL(8)= 281.157, p=.080). Block 2 (table 2) correctly classifies 71.4% of the subjects and explains 23% of the dependent variable's observed variance (Nagelkerke Pseudo-R^2=.233); for this block the Hosmer-Lemeshow test also showed a good model fit (χ^2HL(8)= 257.157, p=.168) (results in Table 2). Stability for model 2 was confirmed by a bootstrap analysis: all B values were inside the 95% confidence intervals and statistical significance was maintained for all variables; values between -.003 and .047 were obtained for bias and standard error values were between .028 and .359.

Table 2 - Odds ratios for the regression model

INDEPENDENT VARIABLES	Block 1		Block 2		
	Model		Model		
	B[§]	Exp(B)	B[§]	Exp(B)	Exp(B*5)
PERSONALITY TRAITS					
Extraversion	–	–	.072	**1,074***	1.390
Neuroticism	–	–	-.077	**.925***	0.680
Openness to experience	–	–	.030	1.03	–
Conscientiousness	–	–	-.066	**0.936***	0.719
Agreeableness	–	–	.010	1.01	–
SOCIO-DEMOGRAPHICS					
Gender	-.809	**.445****	-.478	.620	–
1st Generation Student	-.195	1.215	-.058	1.059	–
ADMISSION DATA					
GPA	-.001	.999	-.023	.977	–
Leaving the family home	1.019	**2.771*****	1.178	**3.247*****	–
Constant	-.295	.748	-3.888	48.791	–
N	234		234		
Nagelkerke Pseudo R-square	**.110**		**.233**		
-2 log likelihood	$G^2(8)=281.157$		$G^2(8)=257.407$		

[§]log-odds estimate;*p<.05; **p<.01; ***p<.001

Leadership in professional or scientific organizations after medical school

The crosstabs (chi-square) results show, with a moderate association (Φ=.43; p=.000), that students who assumed elected student leadership roles during medical school were 22.9 times more likely to report holding an elected position in professional or scientific organizations after graduation ($\chi 2$ (1, n=248) = 43.820, p<.001). Only 2% of the graduates with leadership roles in professional or scientific organizations had had no previous experience of leadership during medical school.

Discussion

This study characterized the individual determinants (personality traits and socio-demographic variables) of assuming leadership roles as elected medical students and how student leadership translated into leadership in postgraduate life. The study explored to specific leadership behavior, being an elected student representative during medical school and being an elected representative in scientific and professional associations after graduation. Results show that personality traits and leaving the family home had a statistically significant contribution to assuming student leadership roles. In addition, students' leadership experience during medical school proved to be strongly associated with leadership in scientific or professional organizations after graduation. To the best of our knowledge this is the first study to consider the contribution of medical student's individual characteristics to leadership as an elected student representative, which takes into consideration the students actual engagement behavior, rather than just self-reported engagement.

Our findings showed a positive contribution of leaving home to the likeliness of assuming elected leadership roles. Moving away from home is an influential component of the process of transition to college for first-year college students [28] with potential to have immediate repercussions [29] which can be positive – personal enrichment, contact with new ideas – but also negative – anxiety and homesickness. This might result from the fact that such participants were probably more open to campus life and events. In fact, leaving the family home might have implied the removal from social, familiar and friendship networks, prompting the involvement in new

activities as students try to belong or build new social networks. Previous research showed that students who reside on Campus are more likely than commuters to engage in extracurricular activities like leadership and sports [30]. An alternative perspective would be that those students who moved away from home had been previously involved in equivalent activities in associations (for example, high school students, sports or cultural). The possibility that these participants could have prior activities that were no longer possible to maintain, might have led them to find ways of participation in the medical school. Future research is necessary to clarify how the combination of previous behaviors and socio-environmental factors might explain increased likeliness of leadership engagement during medical school. The information that students who leave the family home are more likely to engage in leadership, might be explored by medical schools interested in promoting leadership by devising strategies that capture the interest and commitment of applicants from distinct resident districts, for example investing on quality and affordable living arrangements on campus.

Other findings demonstrated the importance of personality traits over gender participation in student elected leadership roles. In our study, apparent gender effects (which were significant, in favor of a greater participation of male students) are no longer significant, after introducing the personality variables into the regression model. Extraversion, neuroticism and conscientiousness revealed to be significant predictors of participation as elected student leadership, although in opposite directions. Extraversion was positively associated with engagement, meaning that more extraverted students are more likely to engage (for every five points increment in extraversion, students increase their probability of holding a leadership position by 39%). Neuroticism and conscientiousness personality traits, in which females tend to score higher, were found to have a negative effect association on participation (five more points in neuroticism and in conscientiousness decreased the chance of holding a leadership position by 32% and by 28%, respectively). To interpret these findings, it is important to recall that students who have higher levels of conscientiousness might tend to privilege curricular over extracurricular activities, thus reducing interaction with peers who might be more prone to participation in associations or in other extra curricular activities. In fact, peer group influence seems to be critical for the development of new political ideas and behaviors [9]. The lower likeliness of individuals with higher neuroticism scores on the scale to be student-leaders could be justified by avoidance of highly exposed activities that require, for example, taking public stances and speaking in public.

Previous studies have found individuals with higher neuroticism scales to be less engaged in the workplace (vigor, dedication and absorption) [31].

These findings second previous studies that have pointed out the importance of personality for medical students' performance [32] and career interests [32, 33] and might help guide medical schools recruitment efforts, informing their practice and recruitment methodology. This is particularly important for medical schools that are not able to select their students. For these medical schools, their opportunity to promote balanced characteristics within in the students' population stands on their ability to attract particular students.

Besides finding the effect of individual characteristics on leadership during medical school, we also found a strong association between being an elected representative during medical school and future (after graduation) leadership in scientific and professional organizations. This finding is in accordance with previous findings suggesting that what students do during the time spent in college is of the utmost importance for wider future outcomes (behavior, attitudes and values, intellectual growth and career choices) [2, 3]. This might be a promising result, as it suggests that engagement in leadership roles might be sustainable in the long run. In this regard, it is important that the framework used in this study is replicated to test the association between individual differences and other leadership behaviors, both in medical school and in postgraduate life. The implications for postgraduate institutions are that they are likely to identify potential leaders in those applicants who demonstrate a history of leadership in medical schools. Overall, this study contributes to the prevailing notion that education for leadership should be one priority for medical schools.

Limitations of the study

Caution must be used in making generalizations from the study results in light of the following limitations. This study narrowed the definition of student leadership to being elected as a representative, not including other leadership behaviors such as community service, student's affairs or education groups. Also, this study's definition of leadership after graduation is based on being an elected member and does not include clinical leadership responsibilities in day-to-day health care delivery. The participants originated from one single institution, which might help

eliminate confounding variables (curricula, faculty, staff) but also recommend caution about the generalization of the results to other contexts. In addition, although the observed associations were statistically significant they were modest; so there are furtherer individual and contextual factors that may affect student engagement. Bootstrap analysis supported the validity of our regression model, but further confirmation in prospective studies and with future cohorts of students will be needed to further address the issue. The size discrepancy between the two groups of graduates made it impossible to use a regression analysis with multiple independent variables; thus, further analysis with greater samples is crucial. Future qualitative research might also give an insight on other important variables associated with leadership roles during and after medical school.

Conclusions

Student personality traits and socio-cultural factors contribute to the likeliness of assuming leadership behaviors during medical school. Demonstrating student leadership during medical school has repercussions over showing leadership behavior in scientific or professional organizations after graduation. Further work with larger and multi-institutional participants can aid in the identification of other predictors, this study offers new knowledge about medical students and graduates engagement in research.

List of abbreviations:

CANMEDs - Canadian Medical Education Directions for Specialists

ECS/UM - School of Health Sciences at the University of Minho, Portugal

ELECSUM - Longitudinal Study of the School of Health Sciences - the University of Minho, Portugal

NEO-FFI - NEO Five-Factor Inventory

Declarations

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Ethics approval and consent to participate: The Portuguese Data Protection authority (CNPD 10432/2011) and the Ethical Committee for Life and Health Sciences of University of Minho (SECVS 071/2014) approved the study.

Consent for publication: Written informed consent to participate the research and to publish anonymous data was obtained from all participants.

Availability of data and material: All data are stored according to agreements with participants and ethical standards.

Competing interests: The authors declare that they have no competing interests.

Authors' Contributions: AS and RA proposed the study and took part in it's design, data collection, statistical analysis, writing and editing. PC took part in the study's design, statistical analysis, revised the manuscript and provided critical input. MJC took part in the study's design, writing and revision of the manuscript, provided critical input and supervised the study.

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CHAPTER 5 - General Discussion and Conclusions

Discussion and Conclusions

The engagement of medical students in activities beyond the core curriculum of medical degrees is of relevance for their holistic development. The variables that influence medical students and junior doctors decision to engage in scientific research and leadership activities are underexplored in the literature. The participation of medical students in these activities, namely scientific research and governance activities, is heterogeneous. The present Thesis clarifies which underlying individual characteristics favor such participation and the relevance of engagement in research as an undergraduate student to future engagement as a physician.

This Thesis, first explored the engagement rates of medical students and graduates in scientific research and leadership. In parallel, we assessed the contribution of personality, socio-demographic characteristics and academic performance to engagement in scientific research and governance activities during medical school. Then, the potential role of engagement during medical school in the engagement after graduation was explored. Taken together, the results herein presented clarify the role of different variables, some of which are of particular interest to medical schools, as they are putative targets of intervention.

The purpose of this discussion was also to look at the results in a more global perspective, complementing individual results have already been discussed in the research papers. Thus, herein we also want to contrast the participation in two distinct activities (research/leadership) and in two different contexts (graduation/post graduation).

1. Engagement statistics

The literature about medical student engagement in research originates mostly from the North American and/or British contexts and focuses in specific programs like MD/PhD training. Moreover, the data used in such studies consist mostly of non-verified self-reported measures of engagement, interest and intentions to engage rather than of actual behavior. Our studies cross self-reported engagement with official medical school records, increasing the reliability of the results and conclusions. These studies were also the first addressing engagement in scientific research activities within the Portuguese context. They show that approximately 40% of the students had engaged in undergraduate scientific research activities in one medical school. These results are in line with those published in a recent review/meta analysis, in which about one third of medical students were involved in research activities during the medical degree, even though around 72% had aprioristically stated their intentions to participate in those activities [1]. The slight positive difference (41% vs 33%) in our numbers is likely to reflect the impact of the active policy of our medical school in the promotion of the concept of the physician scientist.

As for the engagement of medical students in leadership positions during or after graduation there is, to the best of our knowledge, no study that reports such data in the national or international context. The closest study reports data from college students (that is, not in the context of medical school) and showed that 46% of college seniors reported never having had the chance to serve in a leadership role while in college [2]. Our study found that 33% of the subjects had been engaged in leadership as an elected student representative. This is particularly interesting as the latest guidelines for the medical arena (e.g. CANMEDS) highlight *leadership* as one of the major roles of physicians.

The future roles of medical doctors also prompted us to study in this Thesis the behavior of our medical students after graduation. The data collected in this Thesis demonstrates that 49% of the subjects under analysis reported participation in research activities after graduation; however, it is important to note that, only in 32% of these cases, this research meant being enrolled in a PhD program or publishing research papers (structured research) and, in this way, could be verified.

Regarding the engagement in professional or scientific organizations after graduation, 12% of the graduates reported having active roles in those organizations after leaving the medical school. Unfortunately, no evidence about the particular involvement of physicians in scientific or professional associations was found for the national or international context.

The comparison between engagement rates during and after graduation revealed a very interesting distinction: while there is no decline in participation in research activities, we have observed a drop of three-to-one in engagement in leadership activities. A justification for such decline is likely to emerge from the demands of residency programs, in which research is highly valued whereas leadership roles might be perceived as a less efficient way to manage time. However, given that the likelihood of participation in structured research is highly influenced by previous engagement in these activities, this result merits reflection by the institutions where the concept of physician-scientist is promoted. Additionally, the establishment of baseline rates of engagement will allow the school to test the efficacy of future programs aimed at promoting students and physicians engagement in these activities.

2. Individual Variables

As stated previously, participation in extracurricular activities is heterogeneous amongst medical students/graduates. In this Thesis, we studied individual variables that contribute to explain the likelihood of engagement in research and leadership roles. They were organized into personality variables (neuroticism, openness to experience, consciousness, agreeableness and extraversion), socio-demographic variables (gender, being a first generation student, leaving the family home), performance variables (entering GPA and graduation GPA) and previous engagement (during medical school). In the next sections, we will discuss their separate contribution for understanding/predicting engagement of medical students/graduates in research and leadership activities.

2.1. Personality

The current studies have identified the personality traits that contribute to the engagement behavior of medical students in scientific research and leadership activities and also to the engagement behavior of young residents in scientific research.

Students with higher levels of openness to experience and consciousness showed higher engagement in scientific research activities. In contrast, higher levels of extraversion implied less engagement. Openness to experience had the highest impact on the probability of engagement in research activities, increasing chances of participation by 57%. These results are congruent with the characteristics associated with the corresponding traits: intellectual curiosity and willingness to try new ideas (higher openness), persistence and motivated (higher conscientiousness), deliberate and more independence of their social environment (lower extraversion) [3, 4]. Moreover, they seem aligned with the demands of investing in scientific research and partially resonate some findings of previous research: a 2006 study found that openness to experience (and also neuroticism) were predictors of an interest in science as motivation for choosing to be a medical doctor[5].

When predicting engagement in scientific research in junior doctors, the personality traits implicated in the behavior assumed a similar pattern than the one identified for student engagement during medical school, but some displayed an interesting shift. In the context of early post-graduation, openness to experience maintained its predictive power, again with the highest impact on the probability to engage (38%) and so did conscientiousness (28%). However, extraversion no longer predicted engagement in research activities of young residents. Of notice, neuroticism appeared as a positive significant predictor of post-graduate engagement in research. Most likely, these differences in personality patterns related to engagement in research activities might be related to the heterogeneity of contextual factors after graduation. In fact, whereas in the medical school, students shared the same orientations, models, behaviors and expectations, in the residency programs young doctors experience numerous new realities with diverse inherent supervisors' and departments' expectations towards involvement of junior trainees in research. Nevertheless, it is important to highlight that in large the personality traits predicting

engagement into research remained the same, as the drivers for such activities are likely to be maintained in the postgraduate context.

The personality engagement profile in student's leadership roles was different, and in some instances opposite, to that found for scientific research activities. Students with higher levels of extraversion were more likely to be elected as a student representative (as opposed to the results for engagement in research activities, where extraverted students were less likely to engage). In fact, extraversion has been found to be a good predictor of leadership roles in professional contexts [6]. Students with higher levels of neuroticism, on the other hand, were less likely to engage in leadership roles, which is consistent with the facets of anxiety, and self-consciousness that might deter an individual with higher levels of neuroticism from participating in highly gregarious and exposed activities. Also, students with higher conscientiousness levels were less likely to engage in leadership activities, probably due to the competitiveness of these activities with the curricular component of the medical degree.

Also relevant is to contrast the personality traits that are significant determinants for predicting participation in research versus leadership activities. Students with higher consciousness scores were less likely to engage in leadership, but more likely to engage in research, which might be linked to the fact that research is more a curriculum-related activity than leadership. Students with higher scores in openness to experience are just as likely to engage in leadership, but more likely to engage in scientific research (before and after graduation), suggesting that curiosity and the pursuit for knowledge are more important for engagement in research than in leadership. On the other hand, agreeableness is not a significant predictor of engagement in leadership or research. This might be related to the possibility that this trait, standing on facets like trust and altruism, might reflect a predisposition of medical students in general.

2.2. Socio-demographic Characteristics

Socio-demographic factors are also recognized as potentially relevant for participation in extracurricular activities [7, 8]. The current studies have helped in identifying some of the social and demographic factors that contribute to the engagement behavior of students and young residents in research and leadership activities.

2.2.1. Gender

Our results showed that males were more likely to engage in scientific research than females; importantly, this difference tends to become more pronounced after graduation. The same is not true for leadership activities - even though males are more likely to engage in leadership, that difference disappeared when personality traits are considered.

This study found that female students are two times less likely to engage in undergraduate research, than males. This trend is even more evident after graduation, where female junior doctors are three times less likely to engage in scientific research. These findings support previous results on female medical students research intentions [9] and interests[5]. Male medical students candidates are more likely to chose a medical career based on motivation and interest in science [5]. Not only are freshman female students less likely to report strong intentions to engage in a research related career but, also, those female students who had reported strong intentions upon their arrival at the medical school were more likely to decrease their intentions, by the time they graduate, than males [9]. As for the after graduation context, gender differences in physicians' scientific research engagement is a common phenomenon and has been reported worldwide [10–13, 9, 14]. This phenomenon is probably explained by cross-cultural factors, such as women's self perception of competence, lack of compelling role models and concerns about failing in combining a successful career with childbearing and family life.

More specifically, there seem to be differences between male and female self-perceptions of competence for research. In fact, a previous study [15] demonstrated that female students felt significantly less competent in transferable and research-specific skills and biological statistics. Also, female medical doctors have been found to assess their scientific research skills lower than male doctors, even after participating in a clinical research training program [16].

Availability and quality of mentors and role models for research have been reported as important factors in the decision to engage in scientific research both for medical students [10] and for physicians [17]. In a study with junior doctors taking a clinical research course, results showed that 71% of females identified their envisioned expert to be male [11]. This points out that gender

disparity in medical students and doctors' engagement in scientific research might be fuelling itself as the research ecosystem is mainly masculine and, hence, may not provide the necessary female role models.

Family life and childbearing might be another reason why women are less engaged in research. A retrospective longitudinal study with academic physicians at the Mayo Clinic found that men published more papers than women and achieved higher rankings in academic medicine and more leadership roles through out their career. However, after 27 years of career, women's annual publications rates were higher than men's (even though still not enough to catch up with men) [18]. Although the authors did not study other factors (e.g. marital status or number of children) this study seems to suggest that the impact of childbearing and child raising has a bigger toll on female doctor careers. In fact, women who choose academic medicine are less likely to be married [17], and female doctors involved in research training program rated their ability to spend time developing and advancing their own area of scientific knowledge lower than men [16].

Despite the profound changes towards gender equity in all labor areas in the past 100 years, research has shown that individuals have an internalized gender belief about men and women appropriate behavior in society, that emphasizes women as the major agent in domestic and child care roles, and this might have some reflection in this particular behavior [19]. It is also likely that female students and physicians are more focused on academic or job performance and choose to invest their time and efforts in what they perceive to be their responsibilities in school and at work, in congruence with mediating gender differences underlying the relationship between personality and engagement.

It was not the purpose of this work to shed light on the nature of factors that determine individual differences in personality between genders, nor to discuss the changes that gender roles underwent in the last decades in western societies. Nevertheless, these results suggest that in these particular contexts, participation in scientific research by medical students and professionals, there are clear gender differences that need to be addressed especially if we take

into consideration that, nowadays, females represent the majority of the new Portuguese medical students.

2.2.2. Leaving the family home

Previous research on this topic [20] showed that college students (i.e. not specifically in the context of medical schools) who reside on Campus are more likely than commuters to engage in activities like leadership in students associations and community service. This study reached coherent findings within a medical school, as participants who moved away from the family home were three times more likely to assume elected positions in associations than those who remained in their parents' home. This might reflect the fact that these students could have been engaged in prior activities that are no longer possible to maintain (sports, associations, etc.) and found in the medical school novel activities that prompted their engagement behavior, once exposed to this new context. Also, leaving the family home means the removal from a pre-existent social, familiar and friendship networks, prompting the involvement in new activities as students try to belong or build new social networks and are influenced by their peers. In contrast, for those who still live at the family home, changes in participation would not be essential since they are able to keep their former social networks and activities.

A note, to highlight the fact that this variable was only used in the prediction model for students' engagement in students' associations, as it was not available when the prediction model for engagement research was done. As a result, we cannot establish its predictive value for participation in research, neither establish contrasting comparisons between the two activities under analysis in this Thesis.

2.2.3. First generation student

Available data on student engagement in college (i.e. again, not specifically in the context of medical schools) has shown first generation students to have lower educational aspirations and to be less involved in campus activities [8]. Herein, this variable did not to have predictive power in students' engagement in scientific research and student's associations. Our data suggests that

being a first generation student might have an impact only when combined with other moderating factors such as gender and personality: first generation male students are more involved in extracurricular scientific research activities than second generation ones.

A possible reason for this discrepancy with the available literature might relate to the fact that the participants in previous studies were not medical students. It is possible that the highly competitive process for medical school admission might be selecting first generation students for whom their family's educational background is no longer relevant for their educational attainment. Also, changes in the Portuguese educational, social, and economic reality in the past two decades, like lower nativity rates and access to jobs in the tertiary sector, might mean new career opportunities for first generation students, encouraging them, and their families, to invest in different activities that can contribute to their professional success, thus leveling the disparities between the two groups.

2.3. Academic performance: Grade Point Average (GPA)

The present results revealed that students who achieved highest academic performances at entry and during their undergraduate studies tended to show higher engagement in research. Interestingly, the same relation was not found between academic performance and holding a leadership role.

The positive association between performance and engagement in scientific research might relate with the higher confidence that students with higher grades have in their scientific knowledge and skills, and also in their ability to use their transferable skills (for example, communication skills and time management), and their cognitive skills in general, to tackle the demands that associate with scientific research participation. In fact, cognitive ability (measured as psychometric intelligence) is the most robust and consistent predictor of academic performance. However, the predictive power of cognitive ability seems to decrease as students progress through their educational pathways [21, 22].

Other predictors such as personality traits have been systematically identified as contributing to students' performance, including medical students [23]. Traits such as consciousness, neuroticism and openness to experience have been relevant with regard to predicting educational outcomes [22]. In our prediction models, these variables (personality and performance) emerged as independent statistically significant predictors, suggesting that academic performance is *per se* a significant contributor to engagement in scientific research. Interestingly, the same does not hold true for participation in leadership activities, where GPA is not a predictor.

2.4. Previous behavior: Undergraduate engagement

This Thesis was designed to evaluate two distinct temporal contexts (during versus after graduation) for the same cohort, thus allowing for the assessment of temporal comparisons. The results showed that engagement in scientific research activities and leadership roles during medical school had a positive impact on junior doctors' engagement in scientific research and leadership. As stated before, these are very relevant results in the context of medicine, given the critical importance of these competences for the practice of healthcare providers [24].

Specifically, graduates who had been engaged in research during medical school were four times more likely to engage in structured research (PhD programs and publishing research papers) after graduation than those who have not. Remarkably, students who engaged in students' organizations during medical school were more than twenty (22.9) times more likely to engage in professional or scientific organizations after graduation. These results reinforce the fundamental role of medical schools in the nurturing of students' attitudes and career choices, a finding which is in accordance with previous studies in other contexts (i.e. college) [25]. It is not possible to determine, at this moment, whether these previous experiences contribute to the development of new interests and behaviors, or if they just reinforce pre-existing interests and predispositions – certainly, this is an interesting topic for future research studies.

3. Implications for medical schools

One of the values of the present set of findings is that it provides evidence to inform target-driven approaches of medical schools for the promotion of students' engagement rates in research and leadership roles. Interestingly, and in light of the nature of the variables that contribute to determine such engagement rates, the approaches will be dependent on whether, or not, the medical school is able to select its students.

For those medical schools that are able to select their students, efforts can be made in student selection strategies that guarantee a balanced student population, for example, avoiding a gender imbalance. It is beyond the scope of the present Thesis to discuss whether such strategies are appropriate, but the current set of data certainly reveals that gender differences have an impact on the dimension of engagement in scientific research.

For medical schools that are not able to select their students, efforts centered on attracting students with these characteristics (while in high school) are even more fundamental, as their opportunity for promoting balanced characteristics within in the students' population stands on their ability to attract particular students. For example, when trying to attract students who are more likely to engage in scientific research, and knowing that openness to experience is one of their most distinct traits, medical schools might advertise their programs using diverse strategies that specifically target these students' natural intellectual curiosity and creativity with hands-on activities, as opposed to more conventional strategies like a session with oral presentations.

The same holds for promoting students' engagement during the medical degree. For example, knowing that students who leave the family home are more likely to engage, institutions might invest on offering those students quality and affordable living on campus.

But the importance of medical students engagement in research and leadership, spans beyond the medical schools walls, as other institutions (in particularly healthcare institutions) can also

contribute to promote these behaviors. Being a predictive factor for future engagement, medical students participation in research and leadership is important for healthcare institutions and professional and scientific organizations to select (whenever possible) the workforce that best suits the institutional goals. Investing and promoting these behaviors in students can promote and nurture the human resources that will strength those institutions in the future.

4. Limitations and strengths

It is important to note that caution must be used in making generalizations from the study results in light of the following limitations. Although the participants in our study were exposed to similar curricula, faculty, staff, and educational opportunities (all of which can be discarded as confounding factors in the present study), they all originated from one single institution. The different health care institutions of the postgraduate participants were not characterized. Thus institutional variables that might be related to engagement were not considered. Also, engagement rates after graduation could not be verified (except for engagement in structured research). This study did not take into account the amount of time and commitment the students invested in these activities; or the assessment of their commitment done by other key players (like peers and mentors). The definition of student leadership refers to being elected as a representative, not including other leadership behaviors such as community service, student's affairs or education groups. Also, this study's definition of leadership after graduation is based on being an elected member and does not include clinical leadership responsibilities in day-to-day health care delivery. Even though we considered the number of opportunities the students had to engage in research, the fact that not all of the students were in the same curricular stage is a limitation. The same is true for young residents, who are in different stages of their professional track varying on the number of years that have passed since they left the medical school. The fact that students enter the medical school straight from high school, with no prior experiences in higher education, and the fact that the medical school does not select them, can limit their generalization to other educational contexts. Bootstrap analysis supports the validity of our regression model, but further confirmation in prospective studies and with future cohorts of students is needed to further address the issue. Further analysis with greater samples is needed. Future studies that take into account these shortcomings will certainly contribute to a better

definition and characterization of the best predictors of medical students and graduates engagement. Our study discards all variables related to institutional context (medical school or professional setting) and it also does not explore subsequent behavior of engagement exhibited by the students and graduates (e.g. abandoning research after they have engaged versus maintaining the behavior in a consistent manner). Future qualitative research might give an insight on other important variables associated with medical students and graduates engagement in research and leadership.

In contrast, this set of studies have some strong points, such as: i) provides the first statistics for medical students engagement at the national level; ii) it is based on verified self-reported behavior; iii) achieved high participation rates: 74% to 83%; iv) uses representative samples confirmed by comparing "respondents" and "non respondents"; v) has good quality indicators for the regression models (as well as the bootstrap analysis); and vi) the three regression models explain 23% (medical students engagement in governance), 33% (medical students and physicians engagement in research activities) and 54% (physicians engagement in structured research) of the results' variance correctly identifying between 71% and 87% of the subjects. As so, it constitutes one of the first sets of data that analysis this research topic and, as a result, represents an interesting reference for future studies.

5. Conclusions

The present work has identified the role of personality traits, socio-demographic variables, performance and previous engagement in the prediction of medical students and graduates engagement in scientific research and leadership activities.

In summary, the conclusions that can be drawn by the results of the present work are:

- The engagement rates in scientific research and leadership roles of the medical students from the School of Health Sciences of the University of Minho are 41% and 38%, respectively;
- Engagement rates in leadership drops significantly after medical school, but are maintained for research;
- Personality traits contribute to medical students' and young residents' engagement in scientific research and in leadership;
- Female students and residents are less likely to get involved in research activities;
- Personality differences related to gender differences seem to have an impact on engagement;
- Academic performance is a predictor of engagement in scientific research activities;
- Students who leave the family home are more likely to get engaged in leadership roles;
- Engagement during medical school has an impact on future engagement in research and leadership.

6. Future Perspectives

Taken together, the conclusions withdrawn from the present work reveal that individual characteristics impact on medical students' and graduates' engagement.

However, new questions arise from these observations such as:

- Are these results transferable to other contexts?
- What is the impact of existing role models, availability of mentors and other contextual factors?
- How and when students and graduates engage in research and leadership for the first time and why they persist or abandon those activities?
- What is the long-term impact of students and graduates engage in research and leadership in their professional careers?

To clarify the questions raised, it would be important to collect new longitudinal quantitative data with larger samples and also to complement that information with qualitative information to gather a more in-depth understanding of medical students and graduates engagement in research and leadership. We hope to be able to contribute to these research questions...

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