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Factors Influencing Subspecialty Choice Among Medical Students: A Systematic Review and Meta-analysis

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4 **Title Page**
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7 **Factors Influencing Subspecialty Choice Among Medical Students: A Systematic**
8 **Review and Meta-analysis**
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ABSTRACT

Objective To characterize the contributing factors that affect medical students' subspecialty choice and to estimate the extent of influence of individual factors on the students' decision-making process.

Design Systematic review and meta-analysis.

Methods A systematic search of the Cochrane Library, ERIC, Web of Science, CNKI and PubMed databases was conducted for studies published between January 1977 and October 2016. Information concerning study characteristics, influential factors, and the extent of their influence (EOI) was extracted independently by two trained investigators. EOI is the percentage level that describes how much each of the factors influenced students' choice of subspecialty. The estimates were pooled using a random-effects meta-analysis model due to the between-study heterogeneity.

Results Data were extracted from 72 studies (881,502 individuals). Overall, the factors influencing medical students' choice of subspecialty training mainly included academic interests (74.87%), competencies (55.15%), controllable lifestyles or flexible work schedules (53.06%), patient service orientation (49.35%), medical teachers or mentors (46.93%), career opportunities (44.00%), workload or working hours (37.92%), income (35.25%), length of training (32.30%), prestige (31.29%), advice from others (28.24%), and student debt (15.33%), with significant between-study heterogeneity

($P < 0.0001$). Subgroup analyses revealed that the EOI of academic interests was higher in developed countries than that in developing countries (79.30% [95% confidence interval (CI), 70.09%; 86.24%] vs. 60.41% [95% CI, 43.44%; 75.19%]; $Q = 3.37$ $P = 0.02$). The EOI value of prestige was lower in developed countries than that in developing countries (24.45% [95% CI, 19.46%; 30.25%] vs. 48.02% [95% CI, 32.40%; 64.03%]; $Q = 4.31$ $P = 0.01$).

Conclusions This systematic review and meta-analysis provided a quantitative evaluation of the top 12 influencing factors associated with medical students' choice of subspecialty. Our findings provide the basis for the development of specific, effective strategies to optimize the distribution of physicians among different departments by modifying these influencing factors.

Systematic review registration PROSPERO CRD42017053781.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- Our research emphasize that a reliable estimate of the factors associated with medical students' subspecialty choice is critical to obtaining a better understanding of students' perceptions, and the findings of the present study can facilitate the development of intervention strategies tailored to the needs of various healthcare systems.
- A large number of studies conducted in varied populations have been included.

- The differences in the characteristics of country, survey years, specialty, the type of data used and sample size across studies represent a major limitation of our study.

KEYWORDS Medical students, career choice, meta-analysis

For peer review only

Introduction

Medical students' choice of subspecialty represents the process that students' majored in medicine decide to choose a medical specialty, such as pediatrics and surgery, and their sub-discipline, such as nephrology and neurosurgery. With the development of the social economy and the improvement in people's living standards, the demand for physicians continues to increase; however, an imbalance in the supply of physicians in different subspecialties has become a growing concern in both developed and developing countries.^{1 2} Some subspecialties, such as family medicine and palliative medicine,^{3 4} are experiencing a desperate shortage of physicians, whereas other subspecialties, such as cardiology, ophthalmology and ear, nose and throat (ENT) surgery, require several years of training before admission due to intense competition.^{5 6}

Specialty choice is the product of a complex interconnection of student expectation, department expectation, and competition for available spots, and student choice is where the choice begins.⁷ Previous studies have suggested that medical students' choice of subspecialty is essential to the maintenance of an adequate medical workforce and a balanced development of the medical system.^{8 9} However, the influencing factors underlying students' subspecialty choice have not been systemically reviewed. Recent changes in the training and practice environment may influence medical students' career choice.¹⁰ Additionally, the variability in preferences over time and in students' attitudes towards career choices can further complicate this assessment. For example, a study in the UK indicated that half of the

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4 medical students made a definitive subspecialty choice during their first year of
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6 medical school.¹¹ However, students were prone to changing their subspecialty
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8 preference during medical school and internship.¹² Notably, students may also reject
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10 certain subspecialties during their medical school training, even those they have
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12 previously seriously considered.¹³ Therefore, identifying the factors that influence
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14 students' choice of subspecialty will enable a better understanding of the current
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16 shortage/overload of physicians in specific fields and contribute to policy-building
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18 and decision-making to improve the training and recruitment of students in the future.
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22 We thus conducted a systematic review and a meta-analysis to investigate the
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24 influencing factors and the extent of their influence on the choice of subspecialty
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26 training among medical students. More specifically, we focused on the following
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28 questions. First, can we gain a better understanding of students' preferences for
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30 medical specialty according to the primary influencing factor? Second, do the
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32 subgroups according to world region and survey years examined in this study differ
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34 significantly with regard to the weight that students place on the identified
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36 influencing factor?
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39 40 **Methods**

41 42 43 **Search Strategy and Study Eligibility**

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46 Cross-sectional studies published between January 1977 and October 2016 that
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48 reported on factors influencing medical students' choice of subspecialty were
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50 identified using the Cochrane Library, Medline, Web of Science, CNKI and ERIC
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4 databases. Articles were screened by title, abstract and reference list, and by
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6 correspondence with study investigators using the approach recommended by the
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8 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)
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10 guidelines (**Fig. S1**).¹⁴ Potentially relevant papers were first identified by reviewing
11
12 the titles and abstracts, and the full text of each retrieved article was then assessed.
13
14 The search strategy is shown in **Methods S1**. Studies were included if they reported
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16 data on medical students, were published in peer-reviewed journals, and used a
17
18 validated method to assess the extent of a factor's influence on the choice of
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20 subspecialty.
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23 24 **Data Extraction and Quality Assessment**

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27 The following information was independently extracted from each article by 2 trained
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29 investigators (Y.Y. and J.L.) using a standardized form: study design, geographic
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31 location, years of survey, journal, sample size, average age of the participants, the
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33 number and percentage of male participants, and the influencing factors and the
34
35 extent of their influence. Each study may involve one or several influencing factors.
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37 The Newcastle-Ottawa Scale (NOS) recommended by the Agency for Healthcare
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39 Research and Quality (AHRQ), available at
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41 http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp, were used to assess
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43 the quality of the studies. All discrepancies were resolved via discussion and
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45 consensus.
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49 50 **Statistical Analysis**

As considerable heterogeneity was expected because of the multiple sources of variances, a random effects meta-analysis model was used to estimate the influencing factors and the extent of their influence.¹⁵ Between-study heterogeneity was assessed using the I^2 statistic, which was calculated to describe the percentage of total variation caused by heterogeneity across studies, with $\geq 50\%$ indicating considerable heterogeneity.^{16 17} Potential sources of heterogeneity were identified using meta-regression.¹⁸ Subgroup analyses were performed for each factor in the studies in developed countries vs. developing countries and studies conducted before 2010 vs. after 2010. The EOI value of competencies in developing countries was not statistically significant (81.21% [95% CI, 75.27%; 86.51%], $P=0.1436$), and no studies on the influence of student debt in developing countries were found. The Q-test based on the analysis of variance was used to compare the subgroups, with a significance threshold of 5%.¹⁹ The influence of individual studies on the overall EOI value was explored by serially excluding each study in a sensitivity analysis. Publication bias was investigated using a funnel plot test and Egger's test.^{20 21} All analyses were performed using R (version 3.3.1, The R Foundation, Vienna, Austria). The statistical tests were 2-sided with a significance threshold of $P<0.05$.

Results

Study Characteristics

Seventy-two studies involving a total of 881,502 individuals were included in the present research (**Table 1**). Thirty-three studies were conducted in North America, 23 in Europe, 6 in Asia, 5 in Oceania, 3 in Africa, and 2 in South America. The median

number of participants per study was 254.5 (range 37-29,227). Thirteen studies included students who had already selected subspecialties, whereas 59 did not. The influencing factors for subspecialty choice were classified according to 17 aspects, including academic interests, controllable lifestyle or flexible work schedule (defined as flexibility that allows physicians to control the number of hours devoted to practicing the specialty), competencies, patient service orientation, medical teachers or mentors, career opportunities, workload or working hours (characterized by the physician's time spent on professional responsibilities), income, prestige, length of training, advice from others (advice from family, friends, and other students), student debt, experience with the subject, working environment, personality, gender and job security. The influencing factors were ranked according to the frequency of occurrence and each factor was identified when at least 5 papers were available describing it. Personality and gender are common factors that affect the choice of subspecialty among medical students, but most of the relevant literature has not reported on the extent of these factors' influence. Moreover, the funnel plots were clearly asymmetrical with regard to experience with the subject, the working environment and job variety, indicating the existence of publication bias. Thus, the analysis of the remaining 12 influencing factors were shown in this paper. Quality assessment scores for the included studies are listed in **Table 1**. None of the studies received a point for the second AHRQ Quality Indicator, which requires studies to list the inclusion and exclusion criteria for exposed and unexposed subjects (cases and controls) or refer to previous publications, since no comparison studies were referenced in the analyzed articles. For the remaining 10 criteria, 6 studies received 9

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4 points, 8 studies received 8 points, 17 studies received 7 points, 32 studies received 6
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6 points, 7 studies received 5 points and 2 studies received 4 points (scores for
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8 individual studies are presented in **Table S1**).
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10 11 **Primary Analysis**

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14 A meta-analysis was performed on the 12 influencing factors (**Table 2**): academic
15 interests (**Fig. S2**), competencies (**Fig. S3**), controllable lifestyle or flexible work
16 schedule (**Fig. S4**), patient service orientation (**Fig. S5**), medical teachers or mentors
17 (**Fig. S6**), career opportunities (**Fig. S7**), workload or working hours (**Fig. S8**),
18 income (**Fig. S9**), length of training (**Fig. S10**), prestige (**Fig. S11**), advice from
19 others (**Fig. S12**) and student debt (**Fig. S13**). All the factors were significant with
20 evidence of between-study heterogeneity ($P < 0.0001$). A sensitivity analysis, in which
21 the meta-analysis was serially repeated after the exclusion of each study,
22 demonstrated that no individual study affected the overall extent of a factor's
23 influence.
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37 **Meta-regression and Subgroup Analysis**

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40 Using common instructions when at least 5 studies were available and at least 2
41 studies were in each comparator subgroup, four categorical covariates were identified
42 as potential sources of heterogeneity by examining the studies conducted in the
43 United States (US) vs. the studies conducted in other countries, the studies conducted
44 before 2010 vs. those conducted after 2010, the studies concerning subspecialty only
45 vs. those that were not specific to a subspecialty, and the studies with a sample size
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4 <200 vs. the studies with a sample size ≥ 200 (**Table 3**). Some of the heterogeneities
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6 observed among the 12 factors can be partially explained by country, survey years,
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8 specialty and sample size.
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11 EOI values were further analyzed by subgroup (**Table S2**) according to world region
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13 (**Fig. 1**) and survey year (**Fig. 2**). The EOI value of academic interests in developed
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15 countries was higher than that in developing countries (79.30% [95% CI, 70.09%;
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17 86.24%] vs. 60.41% [95% CI, 43.44%; 75.19%]; $Q=3.37$ $P=0.02$). Conversely, a
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19 lower EOI value of prestige was found in studies conducted in developed countries
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21 than in developing countries (24.45% [95% CI, 19.46%; 30.25%] vs. 48.02% [95%
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23 CI, 32.40%; 64.03%]; $Q=4.31$ $P=0.01$). No statistically significant subgroup
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25 differences in the EOI values of the other influencing factors were noted between
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27 developed countries and developing countries. In addition, no statistically significant
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29 differences in the EOI values of the influencing factors were observed when
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31 subgroup analysis was performed by survey year.
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36 **Assessment of Publication Bias**

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39 We generated a funnel plot with proportion as the abscissa and standard error as the
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41 ordinate. A visual inspection of the funnel plots revealed minimal asymmetry among
42
43 the various influencing factors (**Fig. S14**), and the results were concentrated in the
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45 narrow upper part of the graph. However, there was evidence of small study effect in
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47 the meta-analysis of “patient service orientation” (Egger’s test $P=0.02$).
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51 **Discussion**

Implications

This systematic review and meta-analysis involved 72 studies with 881,502 medical students. Twelve influencing factors were analyzed. These factors can be classified into two categories: economic factors and non-economic factors. We found that the EOI of the economic factors, including income (35.25%) and student debt (15.33%), may not depend on the region's level of economic development. However, income remained a major influencing factor in the process of choosing a subspecialty. In the US, 15% of full-time family medicine physicians earned less than \$100,000 in 2004, which is significantly less than the income earned by invasive cardiologists (median income=\$427,815), neurosurgeons (median income=\$211,094), and orthopedists (median income=\$335,646).²² This economic inequality made family medicine less attractive to medical school graduates.²³ Benefits such as health insurance and tuition reimbursement have been shown to be the most common economic incentives used to attract applicants.²⁴

The non-economic factors can be divided into individual factors, specialty-related factors and others. First, individual factors, including academic interest and competencies, have a considerable impact on students' subspecialty choice, with EOI values of 74.87% and 55.15%, respectively. In addition, in the subgroup analysis, although academic interests were less influential in developing countries than in developed countries (79.30% [95% CI, 70.09%; 86.24%] vs. 60.41% [95% CI, 43.44%; 75.19%]; $Q=3.37$ $P=0.02$), they were still the most influential of the 12 factors regardless of regional economic level. These findings indicate that

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4 subspecialties with a shortage of manpower may attract more students by increasing
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6 students' interests and improving the quality of education. Previous studies indicated
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8 that early subspecialty exposure in medical education may arouse students' academic
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10 interest and improve their clinical competence.^{23 25} For example, an elective
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12 extracurricular program designed to facilitate early contact with family medicine
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14 physicians was found to significantly improve students' interest and clinical skills,
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16 especially communication skills, in family medicine.²⁶ Furthermore, dispelling myths
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18 and espousing the positive aspects of a discipline may provide a better understanding
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20 of certain subspecialties; this approach could also be effective in increasing students'
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22 academic interest.²⁷ For instance, family medicine is often considered a discipline
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24 that requires less professional skills and knowledge. This misconception demotivates
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26 students from choosing family medicine as their future career subspecialty, and this
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28 trend may eventually lead to a shortage of family physicians.²⁷ Eliminating such
29
30 prejudices may help students pay greater attention to the areas in short supply and
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32 restore their interests in other specialties.
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38 Second, the specialty-related factors included controllable lifestyle/flexible work
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40 schedule (EOI of 53.06%), career opportunities (EOI of 44.00%), workload (EOI of
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42 37.92%) and training length (EOI of 32.30%). Of these factors, lifestyle varied
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44 between different areas. Additionally, although certain specialties, such as general
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46 surgery, seem to have an adequate number of surgeons on a per capita basis in the US,
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48 there is still a poor geographic distribution within the surgical workforce according to
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50 the type of surgical practice.²⁸ The inflexible lifestyle is a common reason that
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4 students perceive surgery to be less attractive.²⁸ Reorganization of expected work
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6 hours within shared practices and the increased use of physician extenders and
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8 technologies such as electronic medical records may give physicians more flexibility
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10 in work schedules.²⁹ Moreover, providing promotion opportunities and shortening the
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12 length of training are possible strategies to recruit new staff in subspecialties that
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14 require a long period of post-graduate residency training, such as neurosurgery.³⁰

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18 Finally, other factors such as service orientation (EOI of 49.35%), medical teachers
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20 or mentors (EOI of 46.93%), prestige (EOI of 31.29%), and advice from others (EOI
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22 of 28.24%) also contribute to the decision-making process of medical students. For
23
24 example, the desire to care for patients with end-stage diseases contributed to the
25
26 decision to enter palliative medicine in 86% of the medical students.⁴ Additionally,
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28 exposure to mentors in a particular clinical field such as internal medicine has been
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30 strongly associated with medical students' choice of clinical field.³¹ Moreover,
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32 improving the occupational prestige of areas such as family medicine, pathology, and
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34 radiology may help reshape the distribution of the workforce.^{25 32 33}

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38 In our study, several findings are especially noteworthy. First, interest was far more
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40 important than income in deciding subspecialty. In our study, interest was the
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42 top-ranked influencing factor (EOI of 74.87%) of subspecialty choice, while income
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44 was ranked lower (EOI of 35.25%). This finding argues against the possible default
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46 belief that raising physician's wages alone could solve the uneven distribution of
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48 clinicians among subspecialties. Our findings highlight that cultivating and
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50 stimulating students' professional interests may help improve the maldistribution of
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4 medical resources in a more efficient and cost-saving manner.
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7 Second, improving abilities in a certain subspecialty of interest can greatly affect
8 medical students' professional choice. In our study, competencies ranked second in
9 influence, which may reflect the impact of admission conditions on students' choice
10 of subspecialty. Hence, to reduce the risk that students are restricted to the
11 subspecialty of their interest due to a lack of personal skills, medical education
12 should focus more on enhancing students' personal competencies in addition to their
13 academic interests.
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23 Third, balancing medical resources is a complex process in practical terms, as the
24 influencing factors are not mutually exclusive. The shortage of physicians in certain
25 subspecialties may increase physician workload, resulting in less time for teaching.
26 Hence, the quality of teaching cannot be guaranteed, and students may tend to avoid
27 choosing these subspecialties, thus worsening the imbalance in the medical
28 workforce. Additionally, some of the 12 factors identified are not amenable to
29 practical interventions. For example, prestige cannot be immediately increased using
30 interventional strategies.³² Overall, effective strategies must be multi-pronged and
31 incorporate several different aspects, and maldistribution in the workforce should not
32 be tackled through a simple adjustment of one influencing factor.
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45 **Interpretations of the results of this meta-analysis**

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48 Our meta-regression stratified by the study-level characteristics found that country,
49 survey years, subspecialty and sample size may contribute to the heterogeneity
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4 between studies. There was no significant difference in the sensitivity analysis, which
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6 indicated that the results of the meta-analysis were convincing. The funnel plots and
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8 Egger's tests revealed that most of the publication bias was small ($P>0.05$), except
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10 for the meta-analysis of "patient service orientation". Moreover, the majority of the
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12 studies collected in the database were from developed countries rather than
13
14 developing countries.
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16 17 18 **Limitations**

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20 Several limitations should be considered when interpreting the findings of this study.
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22 First, the students involved in our study included medical students at different stages
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24 of their medical education. Students' perception about different subspecialties may
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26 change during medical training. For example, compared to an intern, a freshman
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28 student may place greater emphasis on income and prestige when considering a
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30 career choice.³⁴ Second, our meta-analysis summarized the data from different
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32 geographic regions around the world, and the general conclusions may not be
33
34 appropriate to guide policy development in each region. Enhanced effort is needed to
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36 develop specific intervention strategies according to the specific medical career grade,
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38 economic level, religious beliefs, healthcare system, educational system and endemic
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40 diseases of different countries and regions. Third, the surveys in the various studies
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42 were also conducted using different methods. Most of the questionnaires used a
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44 Likert scale. Therefore, when we converted the results to a percentage representing
45
46 the extent of a factor's influence, the Likert scale items were treated as interval
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48 data.³⁵⁻³⁷ Consequently, there may have been differences in the conversion process.
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4 Fourth, a secondary meta-analysis of longitudinal studies may better reflect changes
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6 in influencing factors and the extent of their influence over time. Finally, the analysis
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8 relied on aggregated published data. A multicenter prospective study would provide a
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10 more accurate estimate of the influencing factors and the extent of their influence on
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12 medical students' choice of subspecialty.
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15 **Conclusion**

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18 In conclusion, this systematic review and meta-analysis provided a summary
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20 evaluation of 12 influencing factors and the extent of their influence on the choice of
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22 subspecialty training among medical students. Understanding students' attitudes
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24 toward their subspecialty decision-making process could provide the basis for
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26 developing strategies to increase the attractiveness of subspecialties experiencing a
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28 shortage of manpower, thereby balancing the distribution of medical recourses.
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4 **Contributors:** Haotian Lin contributed to the conceptualising and design of the study,
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6 and to research funding, coordinated the research and oversaw the project. Yahan
7
8 Yang, Jiawei Li and Xiaohang Wu contributed to data collection and interpretation,
9
10 and to data analysis. Jinghui Wang, Yi Zhu, Chuan Chen and Wangting Li contributed
11
12 to the design of the study. All authors contributed to the drafting and revision of the
13
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Legends

Table 1. Selected Characteristics of the 76 Studies Included in this Systematic Review and Meta-analysis

Table 2. Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty

Table 3. Meta-regression of the EOI Value Stratified by Study-level Characteristics

Figure 1. Bar Graph of the Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty Stratified by Region.

Figure 2. Bar Graph of the Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty Stratified by Survey Year.

Supplements

Methods S1. Search strategy used in the current systematic review and meta-analysis.

Table S1. Quality Assessment of the Included Studies.

Table S2. Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty Stratified by Region and Survey Year.

Figure S1. Flow Diagram of the Study Inclusion Process.

Figure S2. Forest Plot of "Academic Interest".

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4 **Figure S3. Forest Plot of “Competencies”.**
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7 **Figure S4. Forest Plot of “Controllable Lifestyle or Flexible Work Schedule”.**
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10 **Figure S5. Forest Plot of “Patient Service Orientation”.**
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13 **Figure S6. Forest Plot of “Medical Teachers or Mentors”.**
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16 **Figure S7. Forest Plot of “Career Opportunities”.**
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19 **Figure S8. Forest Plot of “Workload or Working Hours”.**
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22 **Figure S9. Forest Plot of “Income”.**
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25 **Figure S10. Forest Plot of “Length of Training”.**
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28 **Figure S11. Forest Plot of “Prestige”.**
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31 **Figure S12. Forest Plot of “Advice from Others”.**
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34 **Figure S13. Forest Plot of “Student Debt”.**
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37 **Figure S14. Funnel Plots of the Publication Bias Tests of the 12 Factors.**
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Table 1. Selected Characteristics of the 76 Studies Included in this Systematic Review and Meta-analysis

First Author, Year	Country	Survey years	Sample size	Average age	Men, No. (%)	Scores
Smith et al, ³⁸ 2015	UK	2012	2,978	NR	NR	6
Cochran et al, ³⁹ 2005	USA	2002	408	27.2	214 (52.45)	5
Hauer et al, ⁴⁰ 2008	USA	2007	1,177	NR	NR	6
Johnson et al, ⁴¹ 2012	USA	2012	622	NR	NR	6
Kiolbassa et al, ⁴² 2011	Germany	2010	1,114	24.1	408 (36.62)	5
Klingensmith et al, ⁴³ 2015	USA	2013	792	NR	539 (68.06)	6
Lee et al, ⁴⁴ 2012	USA	2012	100	NR	58 (58)	7
Macdonald et al, ⁴⁵ 2012	New Zealand	2011	134	NR	79 (58.96)	7
Parsa et al, ³⁴ 2010	Iran	2006-2007	137	27.34	49 (35.77)	7
Paiva et al, ⁴⁶ 1982	USA	1982	144	NR	NR	6
Ni Chroinin et al, ⁴⁷ 2013	UK	2009-2011	274	NR	112 (40.89)	7
Newton et al, ²⁹ 2005	USA	1998-2004	1,258	NR	642 (51.03)	8
Rogers et al, ⁴⁸ 1990	USA	1989	266	NR	205 (77.07)	6
Abendroth J et al, ⁴⁹ 2014	Germany	2007-2012	45	NR	14 (31)	7
Alawad et al, ⁵⁰ 2015	USA	2010-2011	45	NR	36 (80)	8
Azizzadeh et al, ⁵¹ 2003	USA	2002	130	NR	NR	6
Celenza et al, ⁵² 2012	Australia	2009	216	NR	121 (56.02)	8
Dolan-Evans et al, ⁵³ 2014	Australia	2013	419	NR	215 (51.31)	8
Boyd et al, ⁵⁴ 2009	USA	2005-2006	5,848	NR	2,982 (50.99)	8
Egerton et al, ⁵⁵ 1985	Ireland	1977-1981	134	30	82 (61.19)	6
Diderichsen et al, ⁵⁶ 2013	Sweden	2006-2009	372	27	157 (42.20)	6
Ferrari et al, ⁵⁷ 2013	Italy, UK	2009-2011	45	25	NR	9
Freire et al, ⁵⁸ 2011	Brazil	2006-2008	290	23	102 (35.17)	7
Buddeberg-Fischer et al, ⁵⁹ 2006	Switzerland	2001-2003	522	31.1	241 (46.17)	9
Dorsey et al, ⁶⁰ 2005	USA	2003	11,029	NR	4,964 (45.01)	6
Ekenze et al, ⁶¹ 2013	Nigeria	2009-2010	96	25.9	NR	7
Barikani et al, ⁶² 2012	Australia	2008-2009	49	21.7	NR	6
Bittaye et al, ⁶³ 2012	Gambia	2011	106	24.1	48 (45.28)	6
Bonura et al, ⁶⁴ 2016	USA	2015	590	NR	321 (54.40)	9
Al-Fouzan et al, ⁶⁵ 2012	Kuwait	2011-2012	144	NR	NR	7
AlKot et al, ⁶⁶ 2015	Egypt	2013	451	21.8	NR	7
Borges et al, ⁶⁷ 2009	USA	2001-2005	341	NR	NR	5
Budd et al, ⁶⁸ 2011	UK	2011	870	22	NR	7
Corrigan et al, ⁶⁹ 2007	Ireland	2007	222	NR	142 (63.96)	7
Davis et al, ⁷⁰ 2016	UK	2016	173	NR	76 (43.93)	7

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4	Deutsch et al, ⁷¹ 2015	Germany	2011	659	27.9	NR	8
5	Gardner et al, ⁷² 2014	Australia	1993-2005	631	NR	NR	7
6	Dias et al, ⁷³ 2013	UK	2013	495	NR	438 (88.48)	5
7	Goltz et al, ⁷⁴ 2013	USA	2012	102	24.5	34 (33.33)	6
8	Gupta et al, ⁷⁵ 2013	India	2013	243	NR	179 (73.36)	6
9	Hanzlick et al, ⁷⁶ 2008	USA	2006	161	NR	NR	6
10	Harris et al, ⁷⁷ 2005	USA	1991-2002	104	NR	53 (50.96)	6
11	Hauer et al, ⁷⁸ 2008	USA	2008	80	NR	NR	6
12	Labiris et al, ⁷⁹ 2014	Greece	2014	111	23.6	55 (49.54)	6
13	Lambert et al, ⁸⁰ 2008	UK	2007	17,393	NR	NR	6
14	Shah et al, ⁸¹ 2012	USA	2011	892	NR	NR	6
15	Lefevre et al, ⁸² 2010	USA	2008	1,555	NR	589 (37.88)	6
16	Vicente et al, ⁸³ 2013	Chile	2013	30	NR	NR	6
17	Wiesenfeld et al, ⁸⁴ 2014	Canada	2013	60	NR	NR	7
18	Lam et al, ⁸⁵ 2016	Hong Kong	2015	228	23	NR	9
19	Hartung et al, ⁸⁶ 2005	USA	2004	192	20.59	74 (38.54)	4
20	Girasek et al, ⁸⁷ 2011	Hungary	2011	536	NR	NR	5
21	Zuccato et al, ⁸⁸ 2015	Canada	2012	37	NR	24 (65)	6
22	Wilbanks et al, ⁸⁹ 2015	USA	2011-2013	29,227	NR	15,164 (51.99)	9
23	West et al, ⁹⁰ 2009	USA	2005-2007	14,890	NR	8,700 (58.43)	6
24	Watmough et al, ⁹¹ 2007	UK	2005	116	NR	66 (56.90)	4
25	Thakur et al, ⁹² 2001	USA	2001	56	NR	53 (95)	8
26	Scott et al, ⁹³ 2011	Canada	2002-2004	1,542	NR	NR	6
27	Schnuth et al, ⁹⁴ 2003	USA	2002	203	NR	72 (53.47)	6
28	Richards et al, ⁹⁵ 2009	UK	2009	150	NR	108 (72.00)	5
29	Reed et al, ⁹⁶ 2009	USA	2008	2,022	NR	1,354 (66.96)	9
30	de Souza et al, ⁹⁷ 2015	Portugal	2012	1,303	NR	NR	7
31	Pikoulis et al, ⁹⁸ 2010	Greece	2006-2007	87	NR	NR	6
32	Ozer et al, ⁹⁹ 2015	Turkey	2013	98	27.7	26 (26.53)	6
33	Noble et al, ¹⁰⁰ 2004	Canada	2004	21,296	NR	NR	8
34	Noble et al, ¹⁰¹ 2010	Canada	2007	120	NR	NR	5
35	Newton et al, ¹⁰² 2005	USA	2004	1,286	NR	NR	6
36	Moore et al, ¹⁰³ 2012	USA	2011	337	26	179 (53.12)	6
37	Momen et al, ¹⁰⁴ 2015	Iran	2014-2015	38	35.6	11 (29)	6
38	Mehmood et al, ¹⁰⁵ 2012	Saudi Arabia	2012	550	NR	348 (63.27)	6
39	Loriot et al, ¹⁰⁶ 2010	France	2007	44	NR	17 (39)	7
40	Lefevre et al, ¹⁰⁷ 2010	France	2008	522	23.8	198 (37.93)	7
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Table 2. Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty

Factor	No. of studies	Total no. of participants	EOI (%)	value	<i>I-square</i> (%)	<i>Tau-square</i>	<i>P-Value</i>
Academic interests	37	82,276	74.87	99.80	1.60	<0.0001	
Competencies	17	76,515	55.15	99.90	3.44	<0.0001	
Controllable lifestyle or flexible work schedule	42	102,384	53.06	99.50	0.45	<0.0001	
Patient service orientation	34	45,865	49.35	98.70	0.41	<0.0001	
Medical teachers or mentors	32	85,071	46.93	99.80	1.14	<0.0001	
Career opportunities	38	81,923	44.00	99.70	1.15	<0.0001	
Workload or working hours	19	21,870	37.92	98.40	0.72	<0.0001	
Income	49	109,610	35.25	99.70	1.09	<0.0001	
Length of training	18	42,046	32.30	98.10	0.20	<0.0001	
Prestige	24	30,012	31.29	98.40	0.53	<0.0001	
Advice from others	18	82,692	28.24	99.80	0.02	<0.0001	
Student debt	8	38,917	15.33	98.80	0.27	<0.0001	

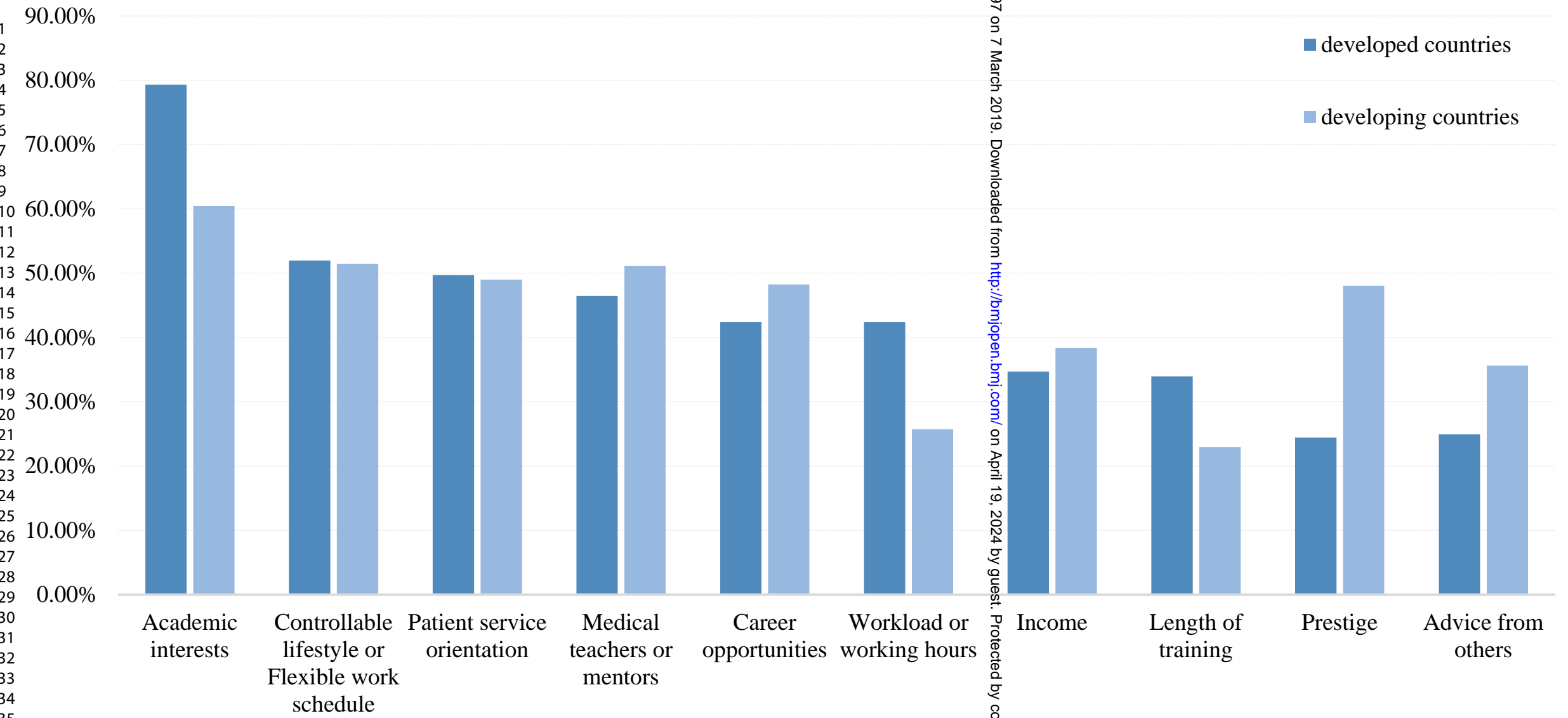
Table 3. Meta-regression of the EOI Value Stratified by Study-level Characteristics

Factor		P-Value
Academic interests	Country	0.6302
	Survey years	0.2711
	Specialty	0.4008
	Sample size	0.6537
Competencies	Country	0.8376
	Survey years	0.0151
	Specialty	0.9398
	Sample size	0.5823
Controllable lifestyle or flexible work schedule	Country	0.9614
	Survey years	0.9822
	Specialty	0.0035
	Sample size	0.7203
Patient service orientation	Country	0.0833
	Survey years	0.8524
	Specialty	0.0010
	Sample size	0.6358
Medical teachers or mentors	Country	0.0007
	Survey years	0.6376
	Specialty	0.8141
	Sample size	0.5894
Career opportunities	Country	0.5828
	Survey years	0.7546
	Specialty	0.0077
	Sample size	0.0081
Workload or working hours	Country	0.3981
	Survey years	0.3922
	Specialty	0.1070
	Sample size	0.8205
Income	Country	0.7390
	Survey years	0.8774
	Specialty	0.0480
	Sample size	0.6786
Length of training	Country	0.7854
	Survey years	0.7229
	Specialty	0.5667
Prestige	Sample size	0.7082
	Country	0.3485

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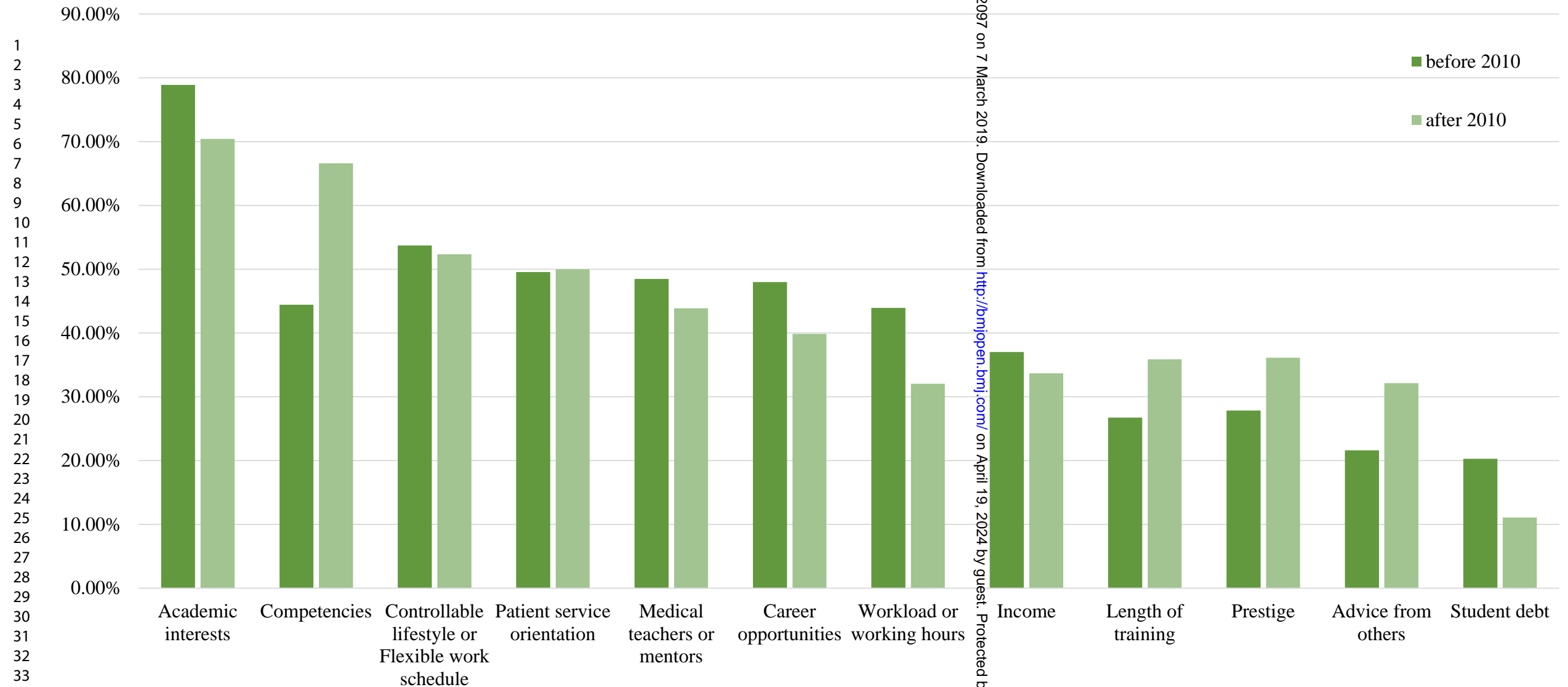
	Survey years	0.0950
	Specialty	0.0172
	Sample size	0.5214
	Country	0.9328
Advice from others	Survey years	0.0057
	Specialty	<0.0001
	Sample size<200	<0.0001
	Country	0.0001
Student debt	Survey years	0.5502
	Sample size	0.0343

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4 **SI Methods. Search strategy used in the current systematic review and**
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11 ***Medical Students***

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14 1. Students, Medical [Mesh]

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14. Cross sectional study [Publication
Type]

15. Cross sectional study [Mesh Terms]

16. Systematic review

17. Systematic review [Publication

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18. Systematic review [Mesh Terms]

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30 ***Subspecialty Choice***

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32 6. Career choices

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36 8. Choices career

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38 9. Specialties

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40 10. Sub-specialties

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42 11. Sub-discipline

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44 12. OR / 6 – 11

19. Meta-analysis [Title/Abstract]

20. Meta-analysis [Mesh Terms]

21. Meta-analysis [Publication Type]

22. OR / 12 – 21

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52 ***Factors***

23. Factors

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60 ***Combined search***

53 ***Study design***

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55 13. Cross sectional study

24. #5 AND #12AND #22 AND #23

Abbreviations: MeSH, Medical Subject Heading in Pubmed.

Table S1. Quality assessment of the included studies

Quality assessment criteria	1	2	3	4	5	6	7	8	9	10	11	Scores
1 Smith et al, ³⁸ 2015	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
2 Cochran et al, ³⁹ 2005	Y	U	Y	Y	N	Y	N	Y	N	N	N	5
3 Hauer et al, ⁴⁰ 2008	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
4 Johnson et al, ⁴¹ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
5 Kiobassa et al, ⁴² 2011	Y	U	Y	Y	N	Y	N	Y	N	N	N	5
6 Klingensmith et al, ⁴³ 2015	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
7 Lee et al, ⁴⁴ 2012	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
8 Macdonald et al, ⁴⁵ 2012	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
9 Parsa et al, ³⁴ 2010	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
10 Paiva et al, ⁴⁶ 1982	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
11 Ni Chroinin et al, ⁴⁷ 2013	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
12 Newton et al, ²⁹ 2005	Y	U	Y	Y	Y	Y	Y	Y	N	Y	N	8
13 Rogers et al, ⁴⁸ 1990	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
14 Abendroth J et al, ⁴⁹ 2014	Y	U	Y	Y	N	Y	N	Y	N	Y	Y	7
15 Alawad et al, ⁵⁰ 2015	Y	U	Y	Y	N	Y	Y	Y	Y	Y	N	8
16 Azizzadeh et al, ⁵¹ 2003	Y	U	Y	Y	Y	Y	N	N	N	Y	N	6
17 Celenza et al, ⁵² 2012	Y	U	Y	Y	Y	Y	Y	N	Y	Y	N	8
18 Dolan-Evans et al, ⁵³ 2014	Y	U	Y	Y	Y	Y	N	Y	N	Y	Y	8
19 Boyd et al, ⁵⁴ 2009	Y	U	Y	Y	Y	Y	Y	Y	N	Y	N	8
20 Egerton et al, ⁵⁵ 1985	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
21 Diderichsen et al, ⁵⁶ 2013	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
22 Ferrari et al, ⁵⁷ 2013	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	N	9
23 Freire et al, ⁵⁸ 2011	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
24 Buddeberg-Fischer et al, ⁵⁹ 2006	Y	U	Y	Y	N	Y	Y	Y	Y	Y	Y	9
25 Dorsey et al, ⁶⁰ 2005	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
26 Ekenze et al, ⁶¹ 2013	Y	U	Y	Y	Y	Y	Y	N	N	Y	N	7
27 Barikani et al, ⁶² 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
28 Bittaye et al, ⁶³ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
29 Bonura et al, ⁶⁴ 2016	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	N	9
30 Al-Fouzan et al, ⁶⁵ 2012	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
31 AlKot et al, ⁶⁶ 2015	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
32 Borges et al, ⁶⁷ 2009	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
33 Budd et al, ⁶⁸ 2011	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
34 Corrigan et al, ⁶⁹ 2007	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
35 Davis et al, ⁷⁰ 2016	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
36 Deutsch et al, ⁷¹ 2015	Y	U	Y	Y	Y	Y	N	Y	Y	Y	N	8
37 Gardner et al, ⁷² 2014	Y	U	Y	Y	N	Y	N	Y	N	Y	N	7
38 Dias et al, ⁷³ 2013	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
39 Goltz et al, ⁷⁴ 2013	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
40 Gupta et al, ⁷⁵ 2013	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
41 Hanzlick et al, ⁷⁶ 2008	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
42 Harris et al, ⁷⁷ 2005	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
43 Hauer et al, ⁷⁸ 2008	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
44 Labiris et al, ⁷⁹ 2014	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
45 Lambert et al, ⁸⁰ 2008	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
46 Shah et al, ⁸¹ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
47 Lefevre et al, ⁸² 2010	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
48 Vicente et al, ⁸³ 2013	Y	U	Y	Y	N	N	Y	N	Y	Y	N	6
49 Wiesenfeld et al, ⁸⁴ 2014	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
50 Lam et al, ⁸⁵ 2016	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	N	9
51 Hartung et al, ⁸⁶ 2005	Y	U	Y	Y	N	Y	N	N	N	N	N	4
52 Girasek et al, ⁸⁷ 2011	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
53 Zuccato et al, ⁸⁸ 2015	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	6
54 Wilbanks et al, ⁸⁹ 2015	Y	U	Y	Y	N	Y	Y	Y	Y	Y	Y	9
55 West et al, ⁹⁰ 2009	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	6
56 Watmough et al, ⁹¹ 2007	Y	U	Y	Y	N	N	N	N	N	Y	N	4
57 Thakur et al, ⁹² 2001	Y	U	Y	Y	Y	Y	Y	N	Y	Y	N	8
58 Scott et al, ⁹³ 2011	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
59 Schnuth et al, ⁹⁴ 2003	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
60 Richards et al, ⁹⁵ 2009	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
61 Reed et al, ⁹⁶ 2009	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	N	9
62 de Souza et al, ⁹⁷ 2015	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
63 Pikoulis et al, ⁹⁸ 2010	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
64 Ozer et al, ⁹⁹ 2015	Y	U	Y	Y	N	N	Y	N	Y	Y	N	6
65 Noble et al, ¹⁰⁰ 2004	Y	U	Y	Y	Y	Y	Y	Y	N	Y	N	8
66 Noble et al, ¹⁰¹ 2010	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
67 Newton et al, ¹⁰² 2005	Y	U	Y	Y	N	Y	Y	N	N	Y	N	6
68 Moore et al, ¹⁰³ 2012	Y	U	Y	Y	Y	Y	N	Y	N	N	N	6
69 Momen et al, ¹⁰⁴ 2015	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
70 Mehmood et al, ¹⁰⁵ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
71 Loriot et al, ¹⁰⁶ 2010	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
72 Lefevre et al, ¹⁰⁷ 2010	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7

Quality assessment criteria in detail

1. Define the source of information (survey, record review).
2. List the inclusion and exclusion criteria for the exposed and unexposed subjects (cases and controls) or refer to previous publications.
3. Indicate the time period used for identifying patients.
4. Indicate whether the subjects were consecutive if not population-based.
5. Indicate whether the evaluators of the subjective components of the study were masked to the other aspects of participants' status.
6. Describe any assessments undertaken for quality assurance purposes (e.g., test/retest of primary outcome measurements)
7. Explain any patient exclusion from the analyses.
8. Describe how confounding was assessed and/or controlled.
9. If applicable, explain how missing data were handled in the analysis.
10. Summarize the patient response rates and the completeness of the data collection.
11. Clarify what follow-up, if any, was expected and the percentage of patients with incomplete data or follow-up.

“Y”: Yes; **“N”:** No; **“U”:** Unclear.

Table S2. Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty Stratified by Region and Survey Year.

Factor		No. of studies	Total no. of participants	Extent of influence (%)	<i>P</i> -Value	<i>Q</i> -Value
Academic interest	developed	27	79,910	79.30	0.02	3.37
	developing	10	2,366	60.41		
	before 2010	29	44,174	78.88	0.33	1.40
	after 2010	8	38,102	70.44		
Competencies	before 2010	9	43,134	44.44	0.21	1.86
	after 2010	8	33,381	66.60		
Controllable lifestyle or flexible work schedule	developed	36	100,799	51.97	0.53	0.89
	developing	6	1,581	51.47		
Patient service orientation	before 2010	22	62,945	53.72	0.99	0.02
	after 2010	20	39,439	52.34		
	developed	25	43,964	49.69		
Medical teachers or mentors	developing	9	1,901	48.99	0.99	0.02
	before 2010	18	40,997	49.56		
	after 2010	16	4,868	49.97		
Career opportunities	developed	28	84,076	46.43	0.73	0.48
	developing	4	995	51.14		
	before 2010	21	49,654	48.48	0.70	0.54
	after 2010	11	35,417	43.87		
Workload or working hours	developed	31	79,867	42.36	0.60	0.74
	developing	7	2,056	48.24		
	before 2010	20	43,417	47.97		
Income	after 2010	18	38,506	39.87	0.24	1.68
	developed	14	20,789	42.36		
	developing	5	1,081	25.72	0.34	1.35
	before 2010	9	19,456	43.93		
Length of training	after 2010	10	2,414	32.04	0.42	1.17
	developed	38	106,910	34.69		
	developing	11	2,700	38.36	0.90	0.17
	before 2010	25	68,714	37.01		
Prestige	after 2010	24	40,896	33.69	0.50	0.95
	developed	15	41,246	33.95		
	developing	3	800	22.92		
Advice from others	before 2010	7	8,811	26.72	0.28	1.59
	after 2010	11	33,234	35.87		
	developed	16	27,806	24.45		
Student debt	developing	8	2,206	48.02	0.01	4.31
	before 2010	12	25,542	27.86		
	after 2010	12	4,470	36.12		
Student debt	developed	14	81,205	24.95	0.36	1.33
	developing	4	1,487	35.62		
	before 2010	10	48,319	21.61		
Student debt	after 2010	8	34,373	32.13	0.31	1.47
	before 2010	5	6,610	20.29		
	after 2010	3	32,307	11.08		

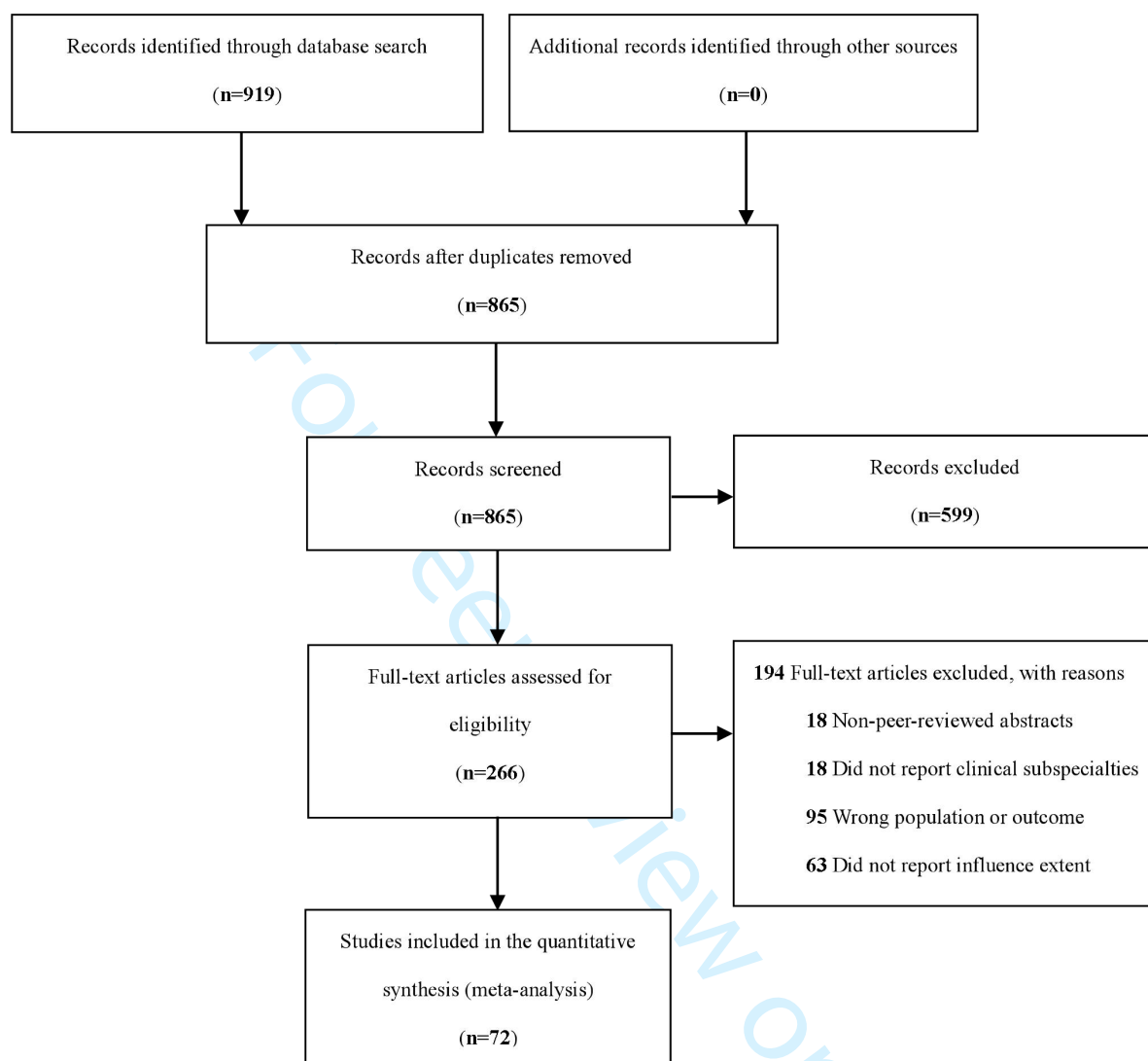
Figure S1. Flow Diagram of the Study Inclusion.

Figure S2. Forest Plot of “Academic Interest”.

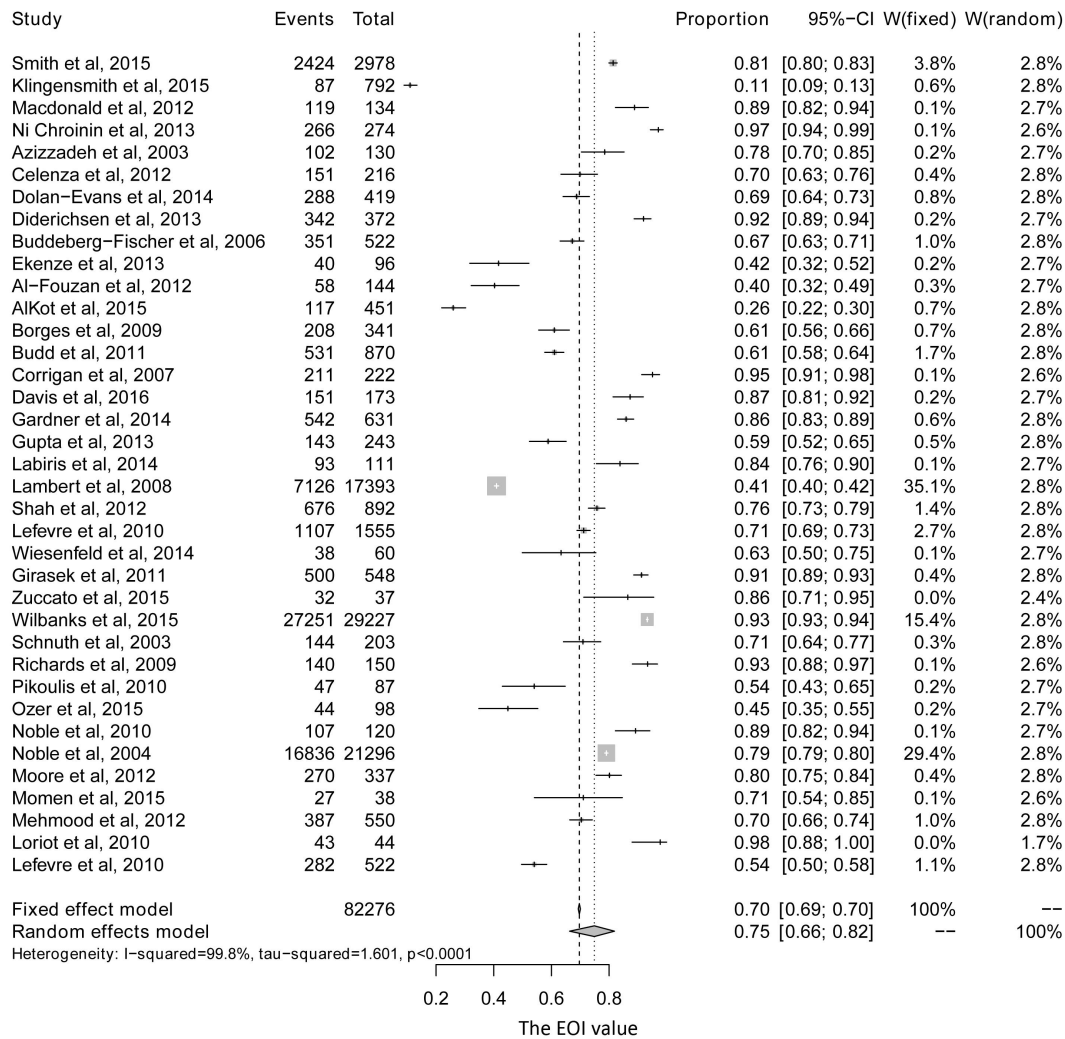


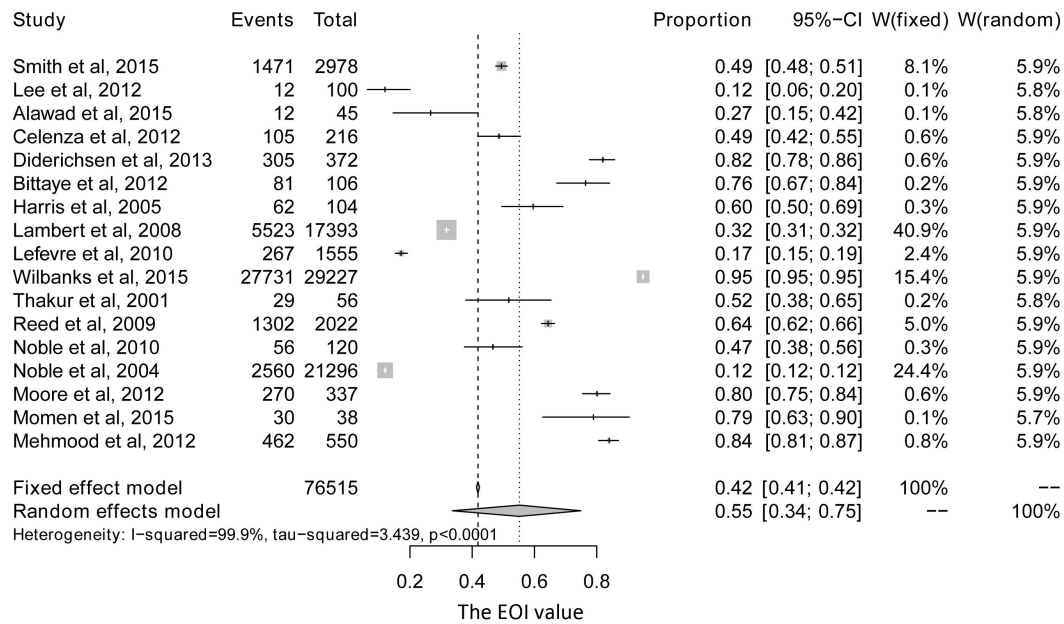
Figure S3. Forest Plot of “Competencies”.

Figure S4. Forest Plot of “Controllable Lifestyle or Flexible Work Schedule”.

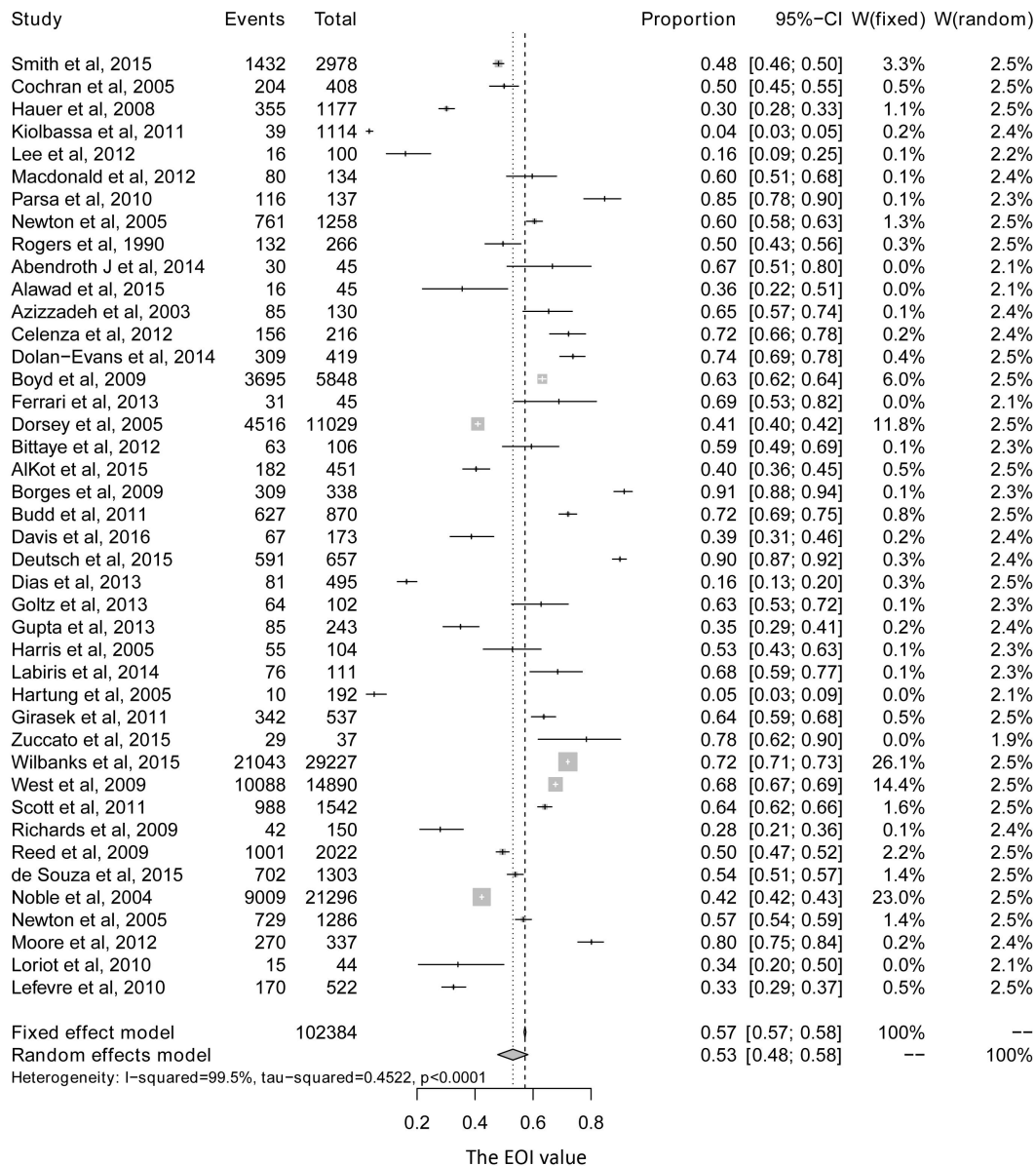


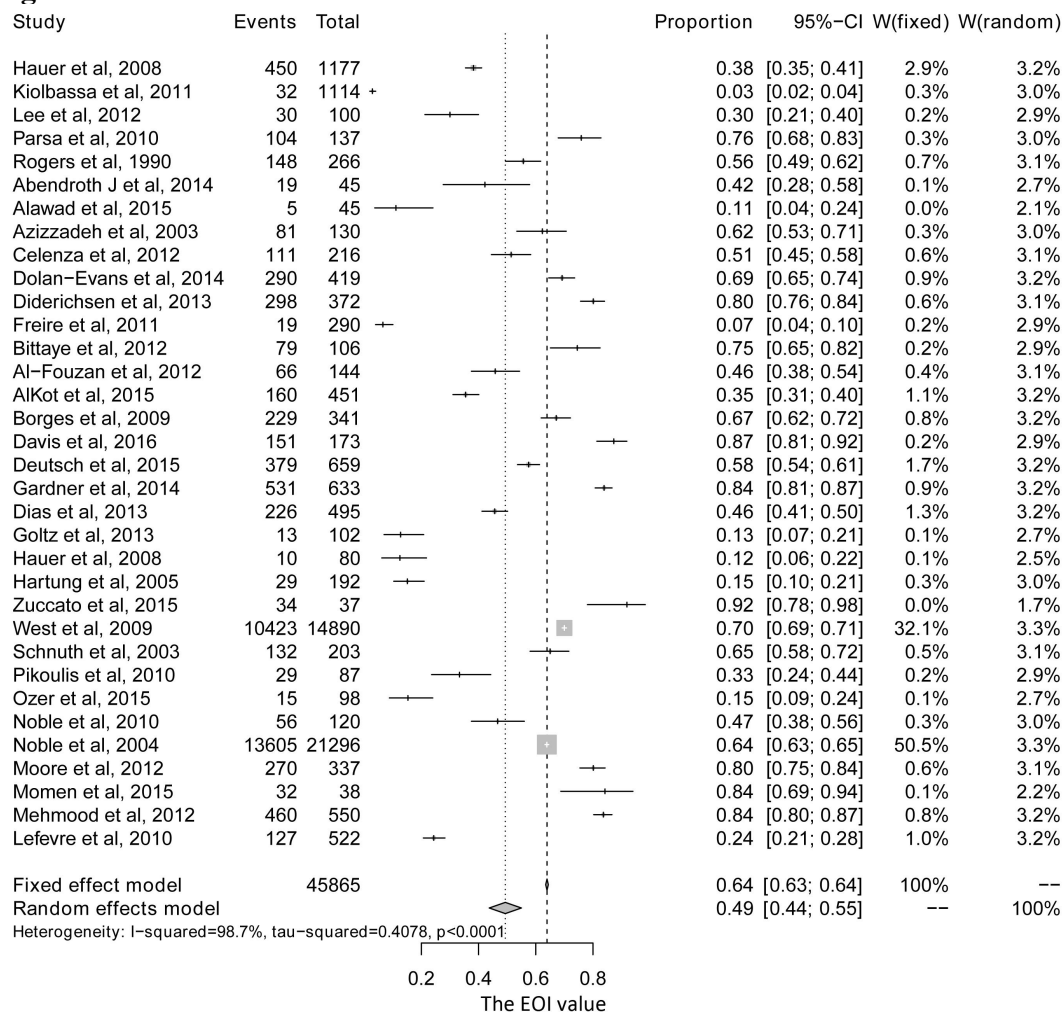
Figure S5. Forest Plot of “Patient Service Orientation”.

Figure S6. Forest Plot of “Medical Teachers or Mentors”.

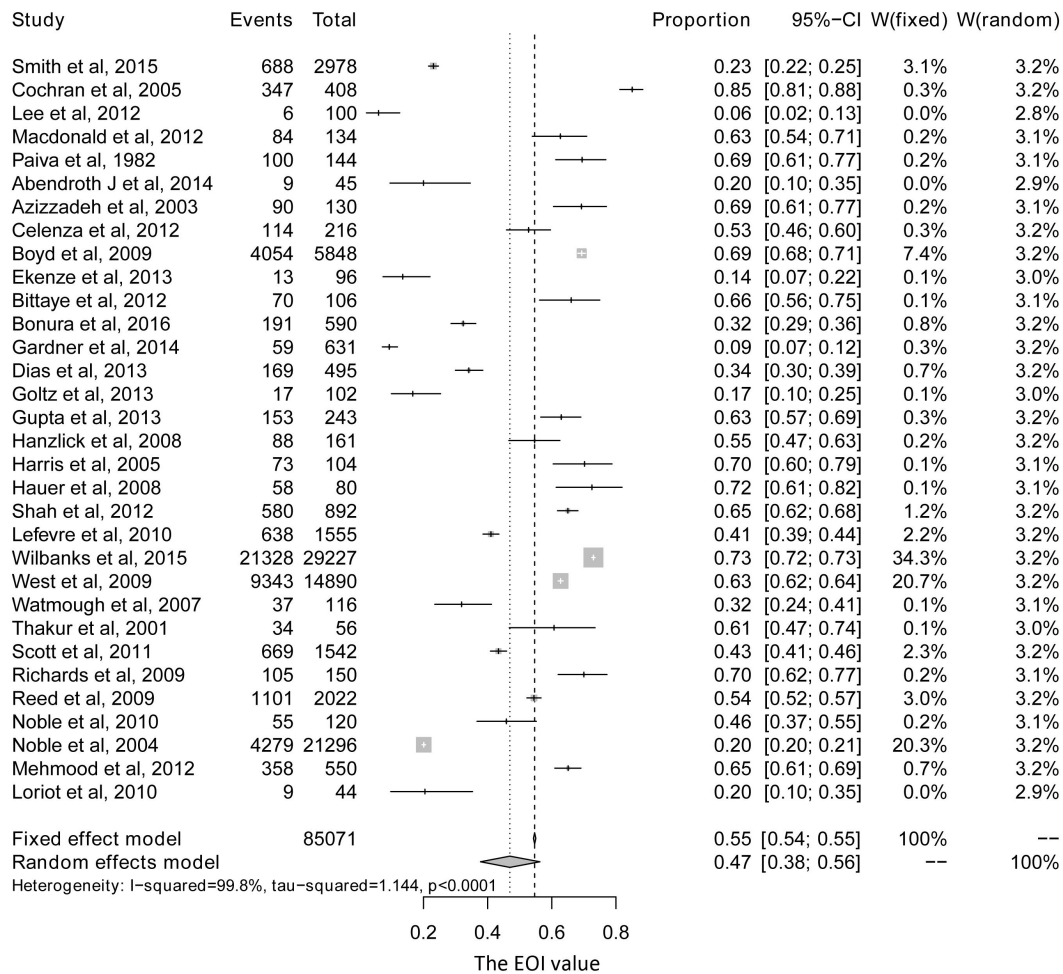


Figure S7. Forest Plot of “Career Opportunities”.

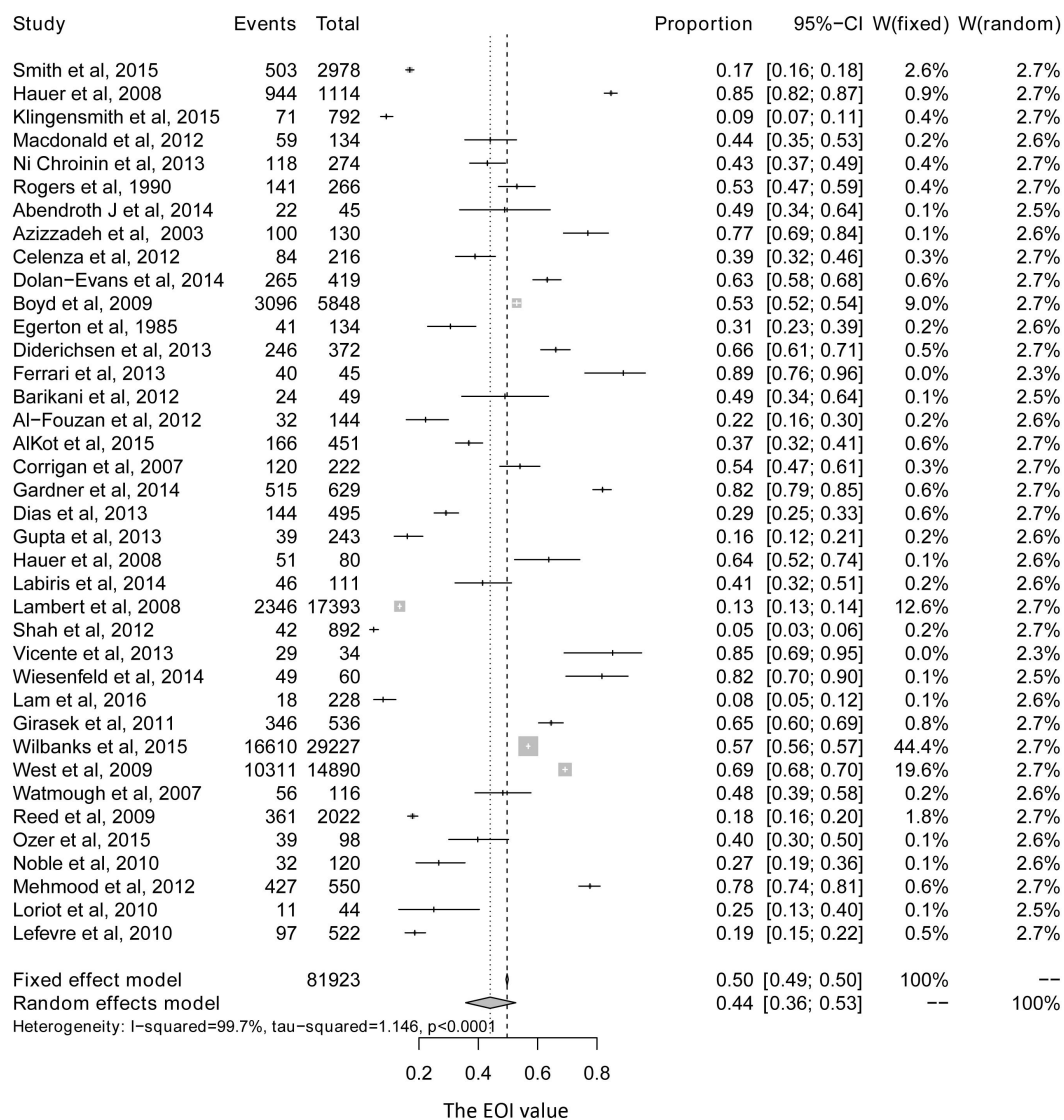
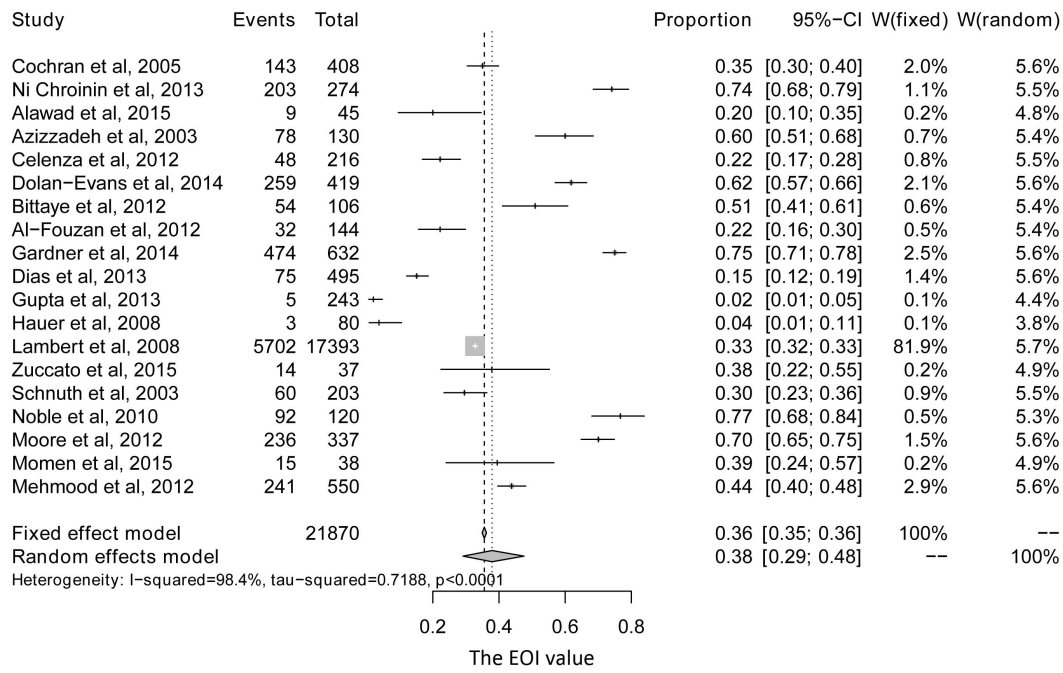


Figure S8. Forest Plot of “Workload or Working Hours”.



Review only

Figure S9. Forest Plot of “Income”.

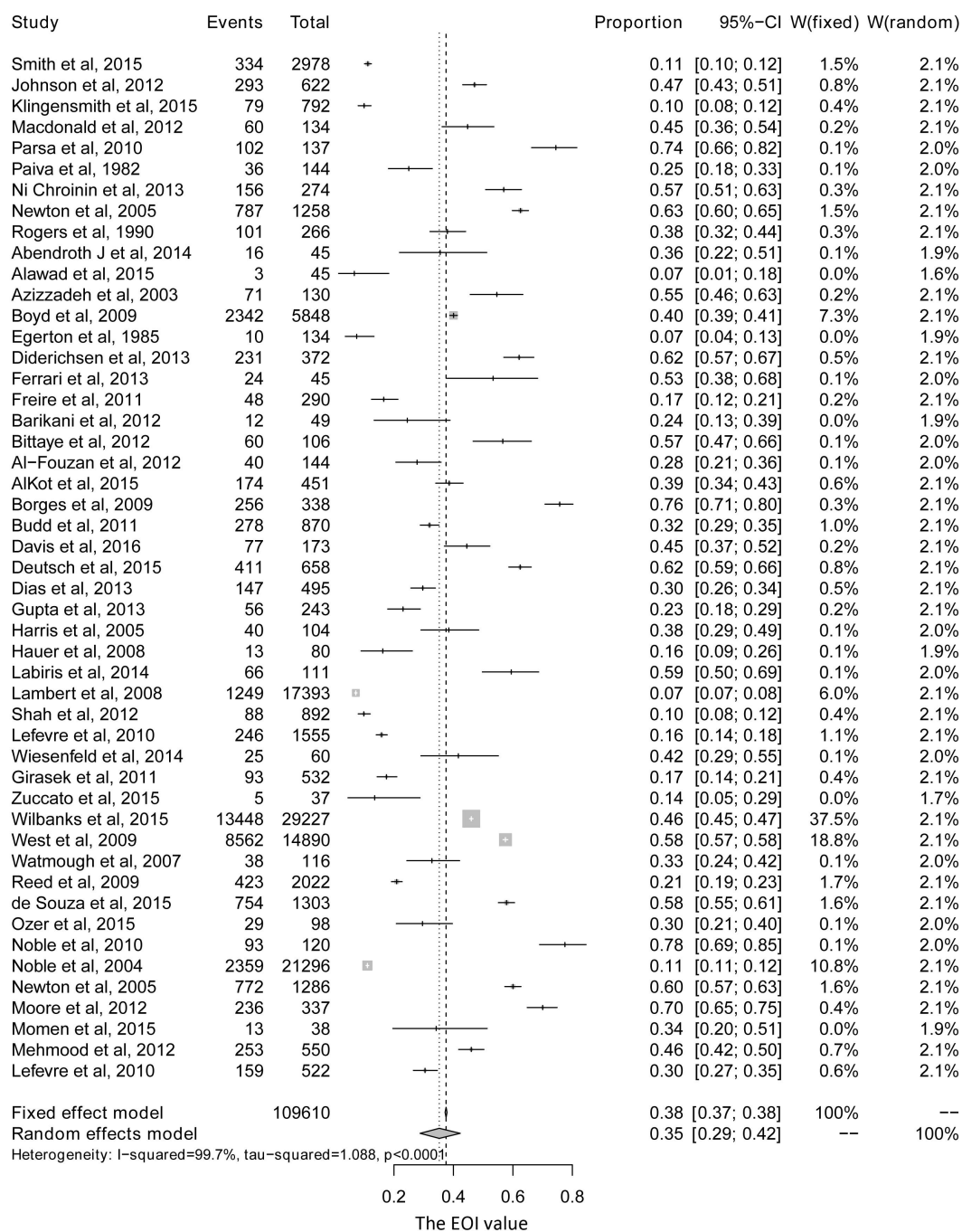


Figure S10. Forest Plot of “Length of Training”.

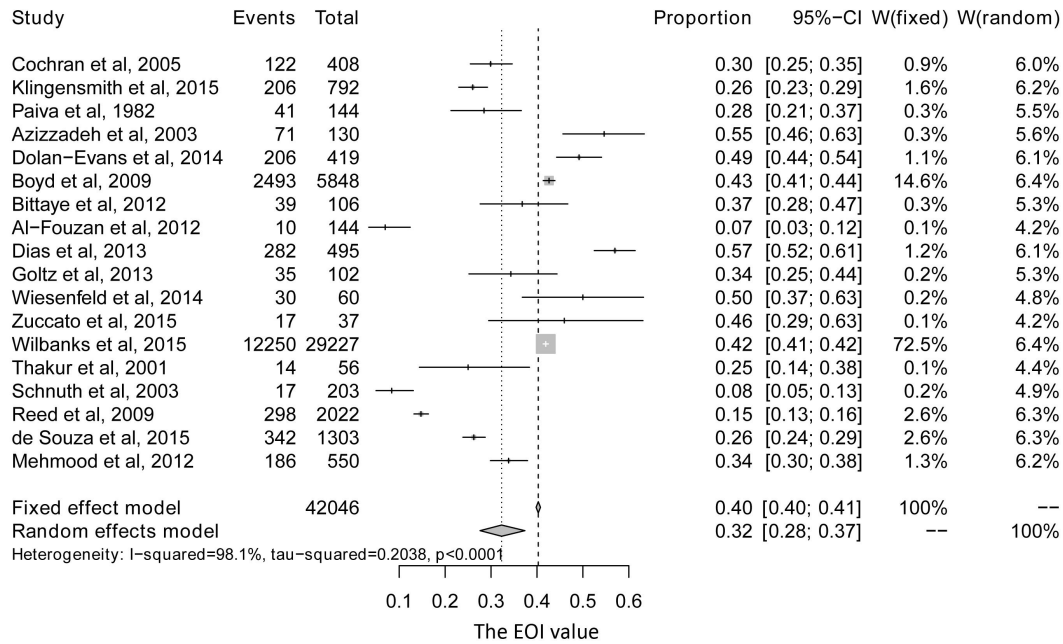


Figure S11. Forest Plot of “Prestige”.

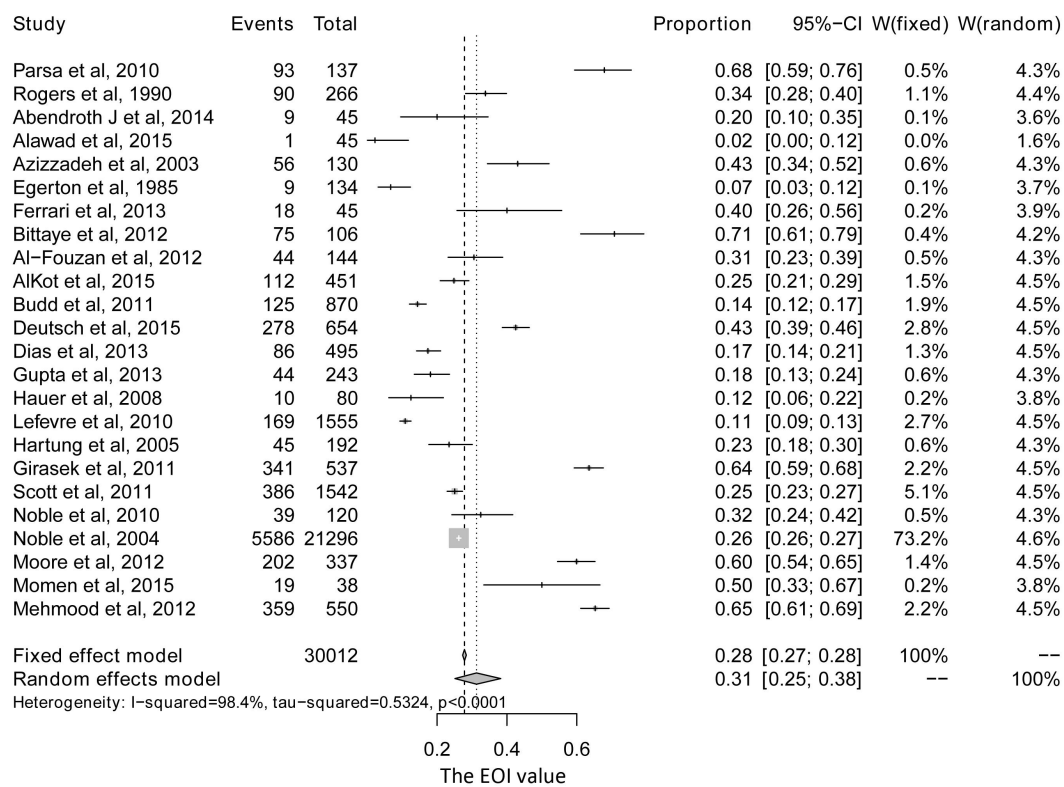


Figure S12. Forest Plot of “Advice from Others”.

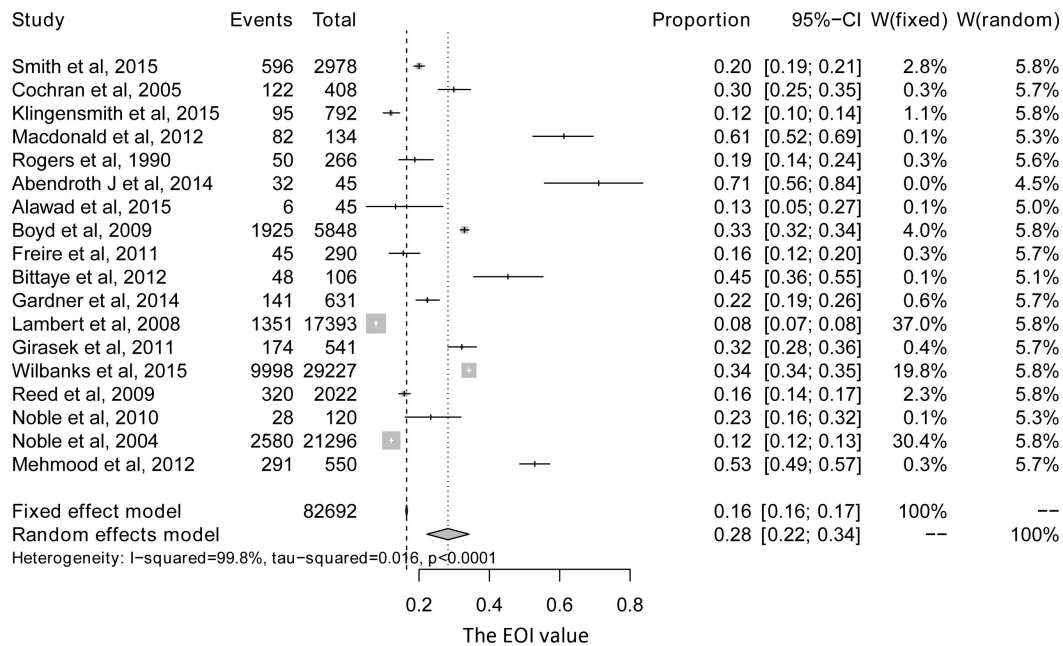


Figure S13. Forest Plot of “Student Debt”.

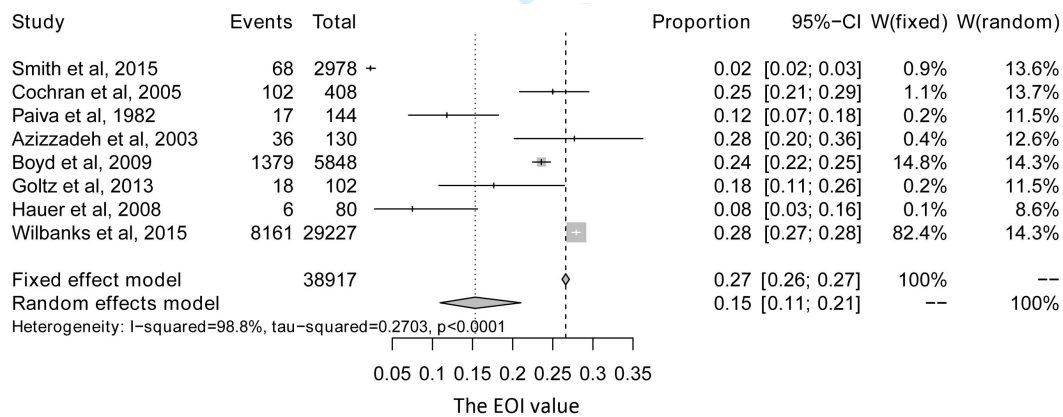
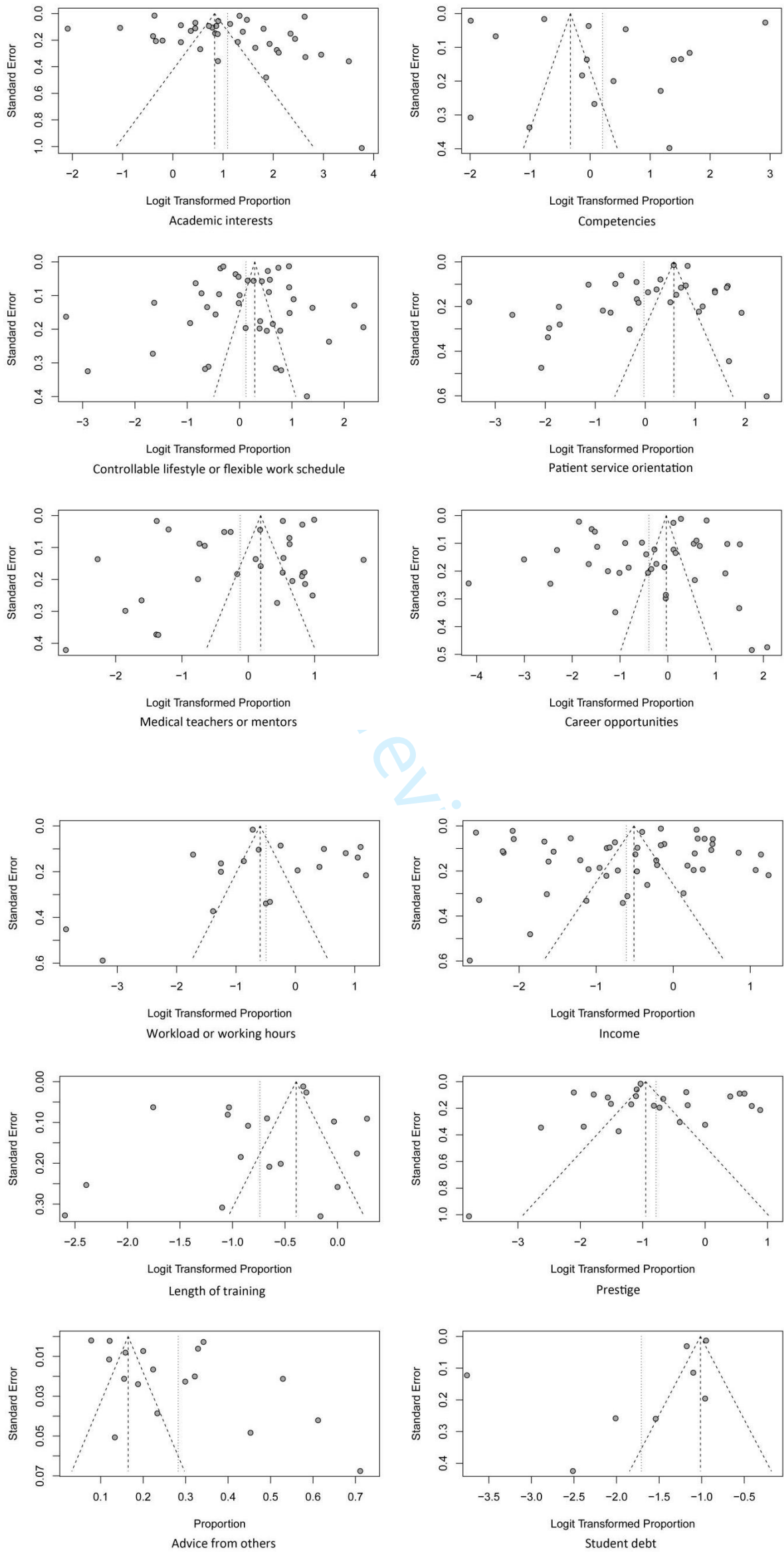


Figure S14. Funnel Plots of the Publication Bias Testing of the 12 Factors.





PRISMA 2009 Checklist

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Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2-3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	3
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	5
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5-6
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	6-7
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	6-7
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	7

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PRISMA 2009 Checklist

Page 1 of 2

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	7
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	7
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	5, 7
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	7-8
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	8
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	8
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	8-9
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	8-9
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	8-9
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	9-13
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	13
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	14
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	15

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

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BMJ Open

Factors Influencing Subspecialty Choice Among Medical Students: A Systematic Review and Meta-analysis

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Primary Subject Heading:	Medical education and training
Secondary Subject Heading:	Medical education and training
Keywords:	Medical students, Career choice, Meta-analysis

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3 **1 Title Page**
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5 **2 Factors Influencing Subspecialty Choice Among Medical Students: A Systematic**
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7 **3 Review and Meta-analysis**
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9 4 Yahan Yang, M.D.^{1,2}; Jiawei Li, M.D.³; Xiaohang Wu, M.D.¹; Jinghui Wang, M.D.¹;
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11 5 Wangting Li, M.D.¹; Yi Zhu, M.D.^{1,4}; Chuan Chen, M.D.^{1,4}; Haotian Lin, M.D., Ph.
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51 24 Word count for text: 3122
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3 26 **ABSTRACT**
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5 27 **Objective** To characterize the contributing factors that affect medical students'
6
7 28 subspecialty choice and to estimate the extent of influence of individual
8
9 29 factors on the students' decision-making process.
10

11 30 **Design** Systematic review and meta-analysis.
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13 31 **Methods** A systematic search of the Cochrane Library, ERIC, Web of Science, CNKI
14
15 32 and PubMed databases was conducted for studies published between January
16
17 33 1977 and June 2018. Information concerning study characteristics, influential
18
19 34 factors, and the extent of their influence (EOI) was extracted independently
20
21 35 by two trained investigators. EOI is the percentage level that describes how
22
23 36 much each of the factors influenced students' choice of subspecialty. The
24
25 37 estimates were pooled using a random-effects meta-analysis model due to the
26
27 38 between-study heterogeneity.
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30
31 39 **Results** Data were extracted from 75 studies (882,209 individuals). Overall, the
32
33 40 factors influencing medical students' choice of subspecialty training mainly
34
35 41 included academic interests (75.29%), competencies (55.15%), controllable
36
37 42 lifestyles or flexible work schedules (53.00%), patient service orientation
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39 43 (50.04%), medical teachers or mentors (46.93%), career opportunities
40
41 44 (44.00%), workload or working hours (37.99%), income (34.70%), length of
42
43 45 training (32.30%), prestige (31.17%), advice from others (28.24%), and
44
45 46 student debt (15.33%), with significant between-study heterogeneity
46
47 47 ($P<0.0001$). Subgroup analyses revealed that the EOI of academic interests
48
49 48 was higher in developed countries than that in developing countries (79.66%
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51 49 [95% confidence interval (CI), 70.73%; 86.39%] vs. 60.41% [95% CI,
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53 50 43.44%; 75.19%]; $Q=3.51$ $P=0.02$). The EOI value of prestige was lower in
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developed countries than that in developing countries (23.96% [95% CI, 19.20%; 29.47%] vs. 47.65% [95% CI, 34.41%; 61.24%]; $Q=4.71$ $P=0.01$).

Conclusions This systematic review and meta-analysis provided a quantitative evaluation of the top 12 influencing factors associated with medical students' choice of subspecialty. Our findings provide the basis for the development of specific, effective strategies to optimize the distribution of physicians among different departments by modifying these influencing factors.

Systematic review registration PROSPERO CRD42017053781.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- This is the first study that provide a systematic estimate of the factors associated with medical students' subspecialty choices.
- A large number of studies conducted in varied populations have been included.
- The differences in the characteristics of country, survey years, specialty, the type of data used and sample size across studies represent a major limitation of our study.

KEYWORDS Medical students, career choice, meta-analysis

70 Introduction

71 Because of the population aging, increased workload on doctors through increased
72 number of consultations and in managing patients with multi-morbidity, the demand
73 for physicians continues to increase; however, an imbalance in the supply of
74 physicians in different subspecialties has become a growing concern in both
75 developed and developing countries.¹⁻⁵ Some specialties and subspecialties, such as
76 family medicine and palliative medicine,^{6,7} are experiencing a desperate shortage of
77 physicians, whereas other specialties and subspecialties, such as cardiology,
78 ophthalmology and ear, nose and throat (ENT) surgery, require several years of
79 training before admission due to intense competition.^{8,9}

80 Specialty choice is the product of a complex interconnection of student expectation,
81 department expectation, and competition for available spots, and student choice is
82 where the choice begins.¹⁰ Previous studies have suggested that medical students'
83 choice of subspecialty is essential to the maintenance of an adequate medical
84 workforce and a balanced development of the medical system.^{11,12} However, the
85 influencing factors underlying students' subspecialty choice have not been
86 systemically reviewed. Recent changes in the training and practice environment may
87 influence medical students' career choice.¹³ Additionally, the variability in
88 preferences over time and in students' attitudes towards career choices can further
89 complicate this assessment. For example, a study in the UK indicated that half of the
90 medical students made a definitive subspecialty choice during their first year of
91 medical school.¹⁴ However, students were prone to changing their subspecialty
92 preference during medical school and internship.¹⁵ Notably, students may also reject
93 certain subspecialties during their medical school training, even those they have
94 previously seriously considered.¹⁶ Therefore, identifying the factors that influence

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3 95 students' choice of subspecialty will enable a better understanding of the current
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5 96 shortage/overload of physicians in specific fields and contribute to policy-building
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7 97 and decision-making to improve the training and recruitment of students in the future.
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9 98 We thus conducted a systematic review and a meta-analysis to investigate the
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11 99 influencing factors and the extent of their influence on the choice of subspecialty
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13 100 training among medical students. More specifically, we focused on the following
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15 101 questions. First, can we gain a better understanding of students' preferences for
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17 102 medical specialty according to the primary influencing factor? Second, do the
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19 103 subgroups according to world region and survey years examined in this study differ
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21 104 significantly with regard to the weight that students place on the identified
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23 105 influencing factor?
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25 26 27 106 **Methods**

28
29 107 We developed a review protocol (registration number: PROSPERO
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31 108 CRD42017053781) prior to commencing the study. The Preferred Reporting Items
32
33 109 for Systematic Reviews and Meta-Analyses (PRISMA) guidelines was used to ensure
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35 110 the reporting quality of this review (Fig. S1).¹⁷
36

37 38 111 **Search Strategy and Study Eligibility**

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40 112 We performed a literature search in June 2018 using the Cochrane Library, Medline,
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42 113 Web of Science, CNKI and ERIC databases without language restrictions. Articles
43
44 114 were screened by title, abstract and reference list, and by correspondence with study
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46 115 investigators. Potentially relevant papers were first identified by reviewing the titles
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48 116 and abstracts, and the full text of each retrieved article was then assessed. A detailed
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50 117 example of search strategy for Medline/PubMed is shown in **Methods S1**. Studies
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52 118 were included if they reported data on medical students, were published in
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54 119 peer-reviewed journals, and used a validated method to assess the extent of a factor's
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3 120 influence on the choice of subspecialty, such as pediatric gastroenterology and
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5 121 vascular surgery, or its corresponding specialty, such as pediatrics and surgery.
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7 122 Because of the differences between medical education systems in the world, the
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9 123 medical students we recruited includes the student in medical school, internship,
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11 124 residency training and fellowship, containing the students who about to make a
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13 125 specialty choice and students who has just made a specialty choice. A guide to
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15 126 medical specialty, available at
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17 <https://www.abms.org/member-boards/specialty-subspecialty-certificates/>, were used
18
19 127
20 128 to identify the medical specialty and subspecialty of our research. We also conducted
21
22 129 an additional search using OpenGrey. However, no additional articles were further
23
24 130 included. All searches were performed using Google chrome (version 54.0.2840).

131 **Data Extraction and Quality Assessment**

132 The following information was independently extracted from each article by 2 trained
133 investigators (Y.Y. and J.L.) using a standardized form: study design, geographic
134 location, years of survey, journal, sample size, average age of the participants, the
135 number and percentage of male participants, and the influencing factors and the
136 extent of their influence. A third investigator was consulted if disagreements occurred.
137 Each study may involve one or several influencing factors. An 11-item checklist
138 which was recommended by Agency for Healthcare Research and Quality (AHRQ),
139 used for cross-sectional studies, available at
140 <https://www.ncbi.nlm.nih.gov/books/NBK35156/>, were used to assess the quality of
141 the studies. All discrepancies were resolved via discussion and consensus.

142 **Statistical Analysis**

143 As considerable heterogeneity was expected because of the multiple sources of
144 variances, a random effects meta-analysis model was used to estimate the influencing

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3 145 factors and the extent of their influence.¹⁸ Between-study heterogeneity was assessed
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5 146 using the I^2 statistic, which was calculated to describe the percentage of total
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7 147 variation caused by heterogeneity across studies, with $\geq 50\%$ indicating considerable
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9 148 heterogeneity.^{19 20} Potential sources of heterogeneity were identified using
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11 149 meta-regression.²¹ Subgroup analyses were performed for each factor in the studies in
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13 150 developed countries vs. developing countries and studies conducted before 2010 vs.
14
15 151 after 2010. The EOI value of competencies in developing countries was not
16
17 152 statistically significant (81.21% [95% CI, 75.27%; 86.51%], $P=0.1436$), and no
18
19 153 studies on the influence of student debt in developing countries were found. The
20
21 154 Q-test based on the analysis of variance was used to compare the subgroups, with a
22
23 155 significance threshold of 5%.²² The influence of individual studies on the overall EOI
24
25 156 value was explored by serially excluding each study in a sensitivity analysis.
26
27 157 Publication bias was investigated using a funnel plot test and Egger's test.^{23 24} All
28
29 158 analyses were performed using R (version 3.3.1, The R Foundation, Vienna, Austria).
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31 159 The statistical tests were 2-sided with a significance threshold of $P<0.05$.

32 33 34 35 160 **Results**

36 37 38 161 **Study Characteristics**

39
40 162 Seventy-five cross-sectional studies involving a total of 882,209 individuals that
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42 163 published between January 1977 and May 2018 were included in the present research
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44 164 **(Table 1)**. Thirty-four studies were conducted in North America, 24 in Europe, 7 in
45
46 165 Asia, 5 in Oceania, 3 in Africa, and 2 in South America. The median number of
47
48 166 participants per study was 243 (range 37-29,227). Fourteen studies included students
49
50 167 who had already selected subspecialties, whereas 61 did not. The influencing factors
51
52 168 were ranked according to the frequency of occurrence and each factor was identified
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54 169 when at least 5 papers were available describing it. The influencing factors for

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3 170 subspecialty choice were then classified according to 17 aspects, including academic
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5 171 interests, controllable lifestyle or flexible work schedule (defined as flexibility that
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7 172 allows physicians to control the number of hours devoted to practicing the specialty),
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9 173 competencies, patient service orientation, medical teachers or mentors, career
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11 174 opportunities, workload or working hours (characterized by the physician's time
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13 175 spent on professional responsibilities), income, prestige, length of training, advice
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15 176 from others (advice from family, friends, and other students), student debt,
16
17 177 experience with the subject, working environment, personality, gender and job
18
19 178 security. Personality and gender are common factors that affect the choice of
20
21 179 subspecialty among medical students, but most of the relevant literature has not
22
23 180 reported on the extent of these factors' influence. Moreover, the funnel plots were
24
25 181 clearly asymmetrical with regard to experience with the subject, the working
26
27 182 environment and job variety, indicating the existence of publication bias. Thus, the
28
29 183 analysis of the remaining 12 influencing factors were shown in this paper. Studies
30
31 184 assessed for influencing factors using questionnaires validated to medical students
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33 185 asking the extent of certain factors the studies investigated. Quality assessment scores
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35 186 for the included studies are listed in **Table 1**. None of the studies received a point for
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37 187 the second AHRQ Quality Indicator, which requires studies to list the inclusion and
38
39 188 exclusion criteria for exposed and unexposed subjects (cases and controls) or refer to
40
41 189 previous publications, since no comparison studies were referenced in the analyzed
42
43 190 articles. For the remaining 10 criteria, 6 studies received 9 points, 8 studies received
44
45 191 8 points, 17 studies received 7 points, 33 studies received 6 points, 9 studies received
46
47 192 5 points and 2 studies received 4 points (scores for individual studies are presented in
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49 193 **Table S1**).

194 **Primary Analysis**

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3 195 A meta-analysis was performed on the 12 influencing factors (**Table 2**): academic
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5 196 interests (**Fig. S2**), competencies (**Fig. S3**), controllable lifestyle or flexible work
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7 197 schedule (**Fig. S4**), patient service orientation (**Fig. S5**), medical teachers or mentors
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9 198 (**Fig. S6**), career opportunities (**Fig. S7**), workload or working hours (**Fig. S8**),
10
11 199 income (**Fig. S9**), length of training (**Fig. S10**), prestige (**Fig. S11**), advice from
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13 200 others (**Fig. S12**) and student debt (**Fig. S13**). All the factors were significant with
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15 201 evidence of between-study heterogeneity ($P < 0.0001$). A sensitivity analysis, in which
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17 202 the meta-analysis was serially repeated after the exclusion of each study,
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19 203 demonstrated that no individual study affected the overall extent of a factor's
20
21 204 influence.

205 **Meta-regression and Subgroup Analysis**

206 Using common instructions when at least 5 studies were available and at least 2
207 studies were in each comparator subgroup, four categorical covariates were identified
208 as potential sources of heterogeneity by examining the studies conducted in the
209 United States (US) vs. the studies conducted in other countries, the studies conducted
210 before 2010 vs. those conducted after 2010, the studies concerning subspecialty only
211 vs. those that were not specific to a subspecialty, and the studies with a sample size
212 < 200 vs. the studies with a sample size ≥ 200 (**Table 3**). Some of the heterogeneities
213 observed among the 12 factors can be partially explained by country, survey years,
214 specialty and sample size.

215 EOI values were further analyzed by subgroup (**Table S2**) according to world region
216 (**Fig. 1**) and survey year (**Fig. 2**). The EOI value of academic interests in developed
217 countries was higher than that in developing countries (79.66% [95% CI, 70.73%;
218 86.39% vs. 60.41% [95% CI, 43.44%; 75.19%]; $Q = 3.51$ $P = 0.02$). Conversely, a
219 lower EOI value of prestige was found in studies conducted in developed countries

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3 220 than in developing countries (23.96% [95% CI, 19.20%; 29.47%] vs. 47.65% [95%
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5 221 CI, 34.41%; 61.24%]; $Q=4.71$ $P=0.01$). No statistically significant subgroup
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7 222 differences in the EOI values of the other influencing factors were noted between
8
9 223 developed countries and developing countries. In addition, no statistically significant
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11 224 differences in the EOI values of the influencing factors were observed when
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13 225 subgroup analysis was performed by survey year.

16 226 **Assessment of Publication Bias**

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18 227 We generated a funnel plot with proportion as the abscissa and standard error as the
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20 228 ordinate. A visual inspection of the funnel plots revealed minimal asymmetry among
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22 229 the various influencing factors (**Fig. S14**), and the results were concentrated in the
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24 230 narrow upper part of the graph. However, there was evidence of small study effect in
25
26 231 the meta-analysis of “patient service orientation” (Egger’s test $P=0.02$).

29 232 **Discussion**

31 233 **Implications**

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33 234 This systematic review and meta-analysis involved 75 studies with 882,209 medical
34
35 235 students. Twelve influencing factors were analyzed. These factors can be classified
36
37 236 into two categories: economic factors and non-economic factors. We found that the
38
39 237 EOI of the economic factors, including income (34.70%) and student debt (15.33%),
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41 238 may not depend on the region’s level of economic development. However, income
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43 239 remained a major influencing factor in the process of choosing a specialty or
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45 240 subspecialty. In the US, 15% of full-time family medicine physicians earned less than
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47 241 \$100,000 in 2004, which is significantly less than the income earned by invasive
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49 242 cardiologists (median income=\$427,815), neurosurgeons (median income=\$211,094),
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51 243 and orthopedists (median income=\$335,646).²⁵ This economic inequality made
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53 244 family medicine less attractive to medical school graduates.²⁶ Benefits such as health

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3 245 insurance and tuition reimbursement have been shown to be the most common
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5 246 economic incentives used to attract applicants.²⁷
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7 247 The non-economic factors can be divided into individual factors, specialty-related
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9 248 factors and others. First, individual factors, including academic interest and
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11 249 competencies, have a considerable impact on students' subspecialty choice, with EOI
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13 250 values of 75.29% and 55.15%, respectively. In addition, in the subgroup analysis,
14
15 251 although academic interests were less influential in developing countries than in
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17 252 developed countries (79.66% [95% CI, 70.73%; 86.39% vs. 60.41% [95% CI,
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19 253 43.44%; 75.19%]; $Q=3.51$ $P=0.02$), they were still the most influential of the 12
20
21 254 factors regardless of regional economic level. These findings indicate that
22
23 255 subspecialties with a shortage of manpower may attract more students by increasing
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25 256 students' interests and improving the quality of education. Previous studies indicated
26
27 257 that early specialty exposure in medical education may arouse students' academic
28
29 258 interest and improve their clinical competence.^{26 28} For example, an elective
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31 259 extracurricular program designed to facilitate early contact with family medicine
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33 260 physicians was found to significantly improve students' interest and clinical skills,
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35 261 especially communication skills, in family medicine.²⁹ Furthermore, dispelling myths
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37 262 and espousing the positive aspects of a discipline may provide a better understanding
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39 263 of certain specialties; this approach could also be effective in increasing students'
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41 264 academic interest.³⁰ For instance, family medicine is often considered a discipline
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43 265 that requires less professional skills and knowledge. This misconception demotivates
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45 266 students from choosing family medicine as their future career specialty, and this trend
46
47 267 may eventually lead to a shortage of family physicians.³⁰ Eliminating such prejudices
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49 268 may help students pay greater attention to the areas in short supply and restore their
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51 269 interests in other specialties.
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3 270 Second, the specialty-related factors included controllable lifestyle/flexible work
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5 271 schedule (EOI of 53.00%), career opportunities (EOI of 44.00%), workload (EOI of
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7 272 37.99%) and training length (EOI of 32.30%). Of these factors, lifestyle varied
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9 273 between different areas. Additionally, although certain specialties, such as general
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11 274 surgery, seem to have an adequate number of surgeons on a per capita basis in the US,
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13 275 there is still a poor geographic distribution within the surgical workforce according to
14
15 276 the type of surgical practice.³¹ The inflexible lifestyle is a common reason that
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17 277 students perceive surgery to be less attractive.³¹ Reorganization of expected work
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19 278 hours within shared practices and the increased use of physician extenders and
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21 279 technologies such as electronic medical records may give physicians more flexibility
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23 280 in work schedules.³² Moreover, providing promotion opportunities and shortening the
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25 281 length of training are possible strategies to recruit new staff in subspecialties that
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27 282 require a long period of post-graduate residency training, such as neurosurgery.³³
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29 283 Finally, other factors such as service orientation (EOI of 50.74%), medical teachers
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31 284 or mentors (EOI of 46.93%), prestige (EOI of 34.68%), and advice from others (EOI
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33 285 of 28.24%) also contribute to the decision-making process of medical students. For
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35 286 example, the desire to care for patients with end-stage diseases contributed to the
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37 287 decision to enter palliative medicine in 86% of the medical students.⁷ Additionally,
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39 288 exposure to mentors in a particular clinical field such as internal medicine has been
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41 289 strongly associated with medical students' choice of clinical field.³⁴ Moreover,
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43 290 improving the occupational prestige of areas such as family medicine, pathology, and
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45 291 radiology may help reshape the distribution of the workforce.^{28 35 36}
46
47 292 In our study, several findings are especially noteworthy. First, interest was far more
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49 293 important than income in deciding subspecialty. In our study, interest was the
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51 294 top-ranked influencing factor (EOI of 75.29%) of subspecialty choice, while income

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3 295 was ranked lower (EOI of 34.70%). This finding argues against the possible default
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5 296 belief that raising physician's wages alone could solve the uneven distribution of
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7 297 clinicians among subspecialties. Our findings highlight that cultivating and
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9 298 stimulating students' professional interests may help improve the maldistribution of
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11 299 medical resources in a more efficient and cost-saving manner.

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13 300 Second, improving abilities in a certain subspecialty of interest can greatly affect
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15 301 medical students' professional choice. In our study, competencies ranked second in
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17 302 influence, which may reflect the impact of admission conditions on students' choice
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19 303 of subspecialty. Hence, to reduce the risk that students are restricted to the
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21 304 subspecialty of their interest due to a lack of personal skills, medical education
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23 305 should focus more on enhancing students' personal competencies in addition to their
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25 306 academic interests.

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28 307 Third, balancing medical resources is a complex process in practical terms, as the
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30 308 influencing factors are not mutually exclusive. The shortage of physicians in certain
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32 309 subspecialties may increase physician workload, resulting in less time for teaching.
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34 310 Hence, the quality of teaching cannot be guaranteed, and students may tend to avoid
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36 311 choosing these subspecialties, thus worsening the imbalance in the medical
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38 312 workforce. Additionally, some of the 12 factors identified are not amenable to
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40 313 practical interventions. For example, prestige cannot be immediately increased using
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42 314 interventional strategies.³⁵ Overall, effective strategies must be multi-pronged and
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44 315 incorporate several different aspects, and maldistribution in the workforce should not
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46 316 be tackled through a simple adjustment of one influencing factor.

317 **Interpretations of the results of this meta-analysis**

318 Our meta-regression stratified by the study-level characteristics found that country,
319 survey years, subspecialty and sample size may contribute to the heterogeneity

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3 320 between studies. There was no significant difference in the sensitivity analysis, which
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5 321 indicated that the results of the meta-analysis were convincing. The funnel plots and
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7 322 Egger's tests revealed that most of the publication bias was small ($P>0.05$), except
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9 323 for the meta-analysis of "patient service orientation". Moreover, the majority of the
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11 324 studies collected in the database were from developed countries rather than
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13 325 developing countries.

16 326 **Limitations**

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18 327 Several limitations should be considered when interpreting the findings of this study.
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20 328 First, the students involved in our study included medical students at different stages
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22 329 of their medical education. Students' perception about different subspecialties may
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24 330 change during medical training until the students applies for specialty training. For
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26 331 example, compared to an intern, a freshman student may place greater emphasis on
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28 332 income and prestige when considering a career choice.³⁷ A subgroup analysis
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30 333 stratified by the stages of medical education and a secondary meta-analysis of
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32 334 longitudinal studies may better reflect changes in influencing factors and the extent
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34 335 of their influence over time. Second, our meta-analysis summarized the data from
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36 336 different geographic regions around the world, and the general conclusions may not
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38 337 be appropriate to guide policy development in each region. Enhanced effort is needed
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40 338 to develop specific intervention strategies according to the specific economic level,
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42 339 religious beliefs, healthcare system, educational system and endemic diseases of
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44 340 different countries and regions. Subgroup analysis stratified by organizational and
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46 341 medical training factors would provide more information of the factors influencing
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48 342 subspecialty choice among medical students. Third, the surveys in the various studies
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50 343 were also conducted using different methods. Most of the questionnaires used a
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52 344 Likert scale. Therefore, when we converted the results to a percentage representing

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3 345 the extent of a factor's influence, the Likert scale items were treated as interval
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5 346 data.³⁸⁻⁴⁰ Consequently, there may have been differences in the conversion process.
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7 347 Finally, the analysis relied on aggregated published data. A multicenter prospective
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9 348 study would provide more accurate estimate of the influencing factors and the extent
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11 349 of their influence on medical students' choice of subspecialty.

13 350 **Conclusion**

15 351 In conclusion, this systematic review and meta-analysis provided a summary
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17 352 evaluation of 12 influencing factors and the extent of their influence on the choice of
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19 353 subspecialty training among medical students. Understanding students' attitudes
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21 354 toward their subspecialty decision-making process could provide the basis for
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23 355 developing strategies to increase the attractiveness of subspecialties experiencing a
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25 356 shortage of manpower, thereby balancing the distribution of medical recourses.
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5 358 and to research funding, coordinated the research and oversaw the project. Yahan
6
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8
9 360 and to data analysis. Jinghui Wang, Yi Zhu, Chuan Chen and Wangting Li contributed
10
11 361 to the design of the study. All authors contributed to the drafting and revision of the
12
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14
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42
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45 377 **Data sharing:** No additional data available.

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48 378 **Patient and public involvement:** Patients and the public were not involved in
49
50 379 development of the research question and outcome measures, nor the study design.
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52 380 The study does not involve patient recruitment, and patients were not involved in
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381 conduct of the study. We plan to liaise closely with patients, special interest groups,
 382 and charities in the dissemination of our results in printed and electronic media.

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Table 1. Selected Characteristics of the 75 Studies Included in this Systematic Review and Meta-analysis

First Author, Year	Country	Survey years	Sample size	Average age	Men, No. (%)	Scores
Smith et al, ⁴¹ 2015	UK	2012	2,978	NR	NR	6
Cochran et al, ⁴² 2005	USA	2002	408	27.2	214 (52.45)	5
Hauer et al, ⁴³ 2008	USA	2007	1,177	NR	NR	6
Johnson et al, ⁴⁴ 2012	USA	2012	622	NR	NR	6
Kiolbassa et al, ⁴⁵ 2011	Germany	2010	1,114	24.1	408 (36.62)	5
Klingensmith et al, ⁴⁶ 2015	USA	2013	792	NR	539 (68.06)	6
Lee et al, ⁴⁷ 2012	USA	2012	100	NR	58 (58)	7
Macdonald et al, ⁴⁸ 2012	New Zealand	2011	134	NR	79 (58.96)	7
Parsa et al, ³⁷ 2010	Iran	2006-2007	137	27.34	49 (35.77)	7
Paiva et al, ⁴⁹ 1982	USA	1982	144	NR	NR	6
Ni Chroinin et al, ⁵⁰ 2013	UK	2009-2011	274	NR	112 (40.89)	7
Newton et al, ³² 2005	USA	1998-2004	1,258	NR	642 (51.03)	8
Rogers et al, ⁵¹ 1990	USA	1989	266	NR	205 (77.07)	6
Abendroth J et al, ⁵² 2014	Germany	2007-2012	45	NR	14 (31)	7
Alawad et al, ⁵³ 2015	USA	2010-2011	45	NR	36 (80)	8
Azizzadeh et al, ⁵⁴ 2003	USA	2002	130	NR	NR	6
Celenza et al, ⁵⁵ 2012	Australia	2009	216	NR	121 (56.02)	8
Dolan-Evans et al, ⁵⁶ 2014	Australia	2013	419	NR	215 (51.31)	8
Boyd et al, ⁵⁷ 2009	USA	2005-2006	5,848	NR	2,982 (50.99)	8
Egerton et al, ⁵⁸ 1985	Ireland	1977-1981	134	30	82 (61.19)	6
Diderichsen et al, ⁵⁹ 2013	Sweden	2006-2009	372	27	157 (42.20)	6
Ferrari et al, ⁶⁰ 2013	Italy, UK	2009-2011	45	25	NR	9
Freire et al, ⁶¹ 2011	Brazil	2006-2008	290	23	102 (35.17)	7
Buddeberg-Fischer et al, ⁶² 2006	Switzerland	2001-2003	522	31.1	241 (46.17)	9
Dorsey et al, ⁶³ 2005	USA	2003	11,029	NR	4,964 (45.01)	6
Ekenze et al, ⁶⁴ 2013	Nigeria	2009-2010	96	25.9	NR	7
Barikani et al, ⁶⁵ 2012	Australia	2008-2009	49	21.7	NR	6
Bittaye et al, ⁶⁶ 2012	Gambia	2011	106	24.1	48 (45.28)	6
Bonura et al, ⁶⁷ 2016	USA	2015	590	NR	321 (54.40)	9
Al-Fouzan et al, ⁶⁸ 2012	Kuwait	2011-2012	144	NR	NR	7
AlKot et al, ⁶⁹ 2015	Egypt	2013	451	21.8	NR	7
Borges et al, ⁷⁰ 2009	USA	2001-2005	341	NR	NR	5
Budd et al, ⁷¹ 2011	UK	2011	870	22	NR	7
Corrigan et al, ⁷² 2007	Ireland	2007	222	NR	142 (63.96)	7
Davis et al, ⁷³ 2016	UK	2016	173	NR	76 (43.93)	7
Deutsch et al, ⁷⁴ 2015	Germany	2011	659	27.9	NR	8
Gardner et al, ⁷⁵ 2014	Australia	1993-2005	631	NR	NR	7
Dias et al, ⁷⁶ 2013	UK	2013	495	NR	438 (88.48)	5
Goltz et al, ⁷⁷ 2013	USA	2012	102	24.5	34 (33.33)	6
Gupta et al, ⁷⁸ 2013	India	2013	243	NR	179 (73.36)	6

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3		Hanzlick et al, ⁷⁹ 2008	USA	2006	161	NR	NR	6
4		Harris et al, ⁸⁰ 2005	USA	1991-2002	104	NR	53 (50.96)	6
5		Hauer et al, ⁸¹ 2008	USA	2008	80	NR	NR	6
6		Labiris et al, ⁸² 2014	Greece	2014	111	23.6	55 (49.54)	6
7		Lambert et al, ⁸³ 2008	UK	2007	17,393	NR	NR	6
8		Shah et al, ⁸⁴ 2012	USA	2011	892	NR	NR	6
9		Lefevre et al, ⁸⁵ 2010	USA	2008	1,555	NR	589 (37.88)	6
10		Vicente et al, ⁸⁶ 2013	Chile	2013	30	NR	NR	6
11		Wiesenfeld et al, ⁸⁷ 2014	Canada	2013	60	NR	NR	7
12		Lam et al, ⁸⁸ 2016	Hong Kong	2015	228	23	NR	9
13		Hartung et al, ⁸⁹ 2005	USA	2004	192	20.59	74 (38.54)	4
14		Girasek et al, ⁹⁰ 2011	Hungary	2011	536	NR	NR	5
15		Zuccato et al, ⁹¹ 2015	Canada	2012	37	NR	24 (65)	6
16		Wilbanks et al, ⁹² 2015	USA	2011-2013	29,227	NR	15,164 (51.99)	9
17		West et al, ⁹³ 2009	USA	2005-2007	14,890	NR	8,700 (58.43)	6
18		Watmough et al, ⁹⁴ 2007	UK	2005	116	NR	66 (56.90)	4
19		Thakur et al, ⁹⁵ 2001	USA	2001	56	NR	53 (95)	8
20		Scott et al, ⁹⁶ 2011	Canada	2002-2004	1,542	NR	NR	6
21		Schnuth et al, ⁹⁷ 2003	USA	2002	203	NR	72 (53.47)	6
22		Richards et al, ⁹⁸ 2009	UK	2009	150	NR	108 (72.00)	5
23		Reed et al, ⁹⁹ 2009	USA	2008	2,022	NR	1,354 (66.96)	9
24		de Souza et al, ¹⁰⁰ 2015	Portugal	2012	1,303	NR	NR	7
25		Pikoulis et al, ¹⁰¹ 2010	Greece	2006-2007	87	NR	NR	6
26		Ozer et al, ¹⁰² 2015	Turkey	2013	98	27.7	26 (26.53)	6
27		Noble et al, ¹⁰³ 2004	Canada	2004	21,296	NR	NR	8
28		Noble et al, ¹⁰⁴ 2010	Canada	2007	120	NR	NR	5
29		Newton et al, ¹⁰⁵ 2005	USA	2004	1,286	NR	NR	6
30		Moore et al, ¹⁰⁶ 2012	USA	2011	337	26	179 (53.12)	6
31		Momen et al, ¹⁰⁷ 2015	Iran	2014-2015	38	35.6	11 (29)	6
32		Mehmood et al, ¹⁰⁸ 2012	Saudi Arabia	2012	550	NR	348 (63.27)	6
33		Loriot et al, ¹⁰⁹ 2010	France	2007	44	NR	17 (39)	7
34		Lefevre et al, ¹¹⁰ 2010	France	2008	522	23.8	198 (37.93)	7
35		Vo et al, ¹¹¹ 2017	Canada	2017	90	22.5	52 (57.78)	5
36		Grasreiner et al, ¹¹² 2018	Germany	2014-2016	181	24	33 (18.10)	6
37		Alkhaman et al, ¹¹³ 2018	Saudi Arabia	2017	436	NA	250 (57.00)	5

728 Footnotes: scores: quality score of the AHRQ scale.

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Table 2. Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty

Factor	No. of studies	Total no. of participants	EOI value (%)	95 CI% of EOI		<i>I-square</i> (%)	<i>Tau-square</i>	<i>P-Value</i>
				value				
				Lower	Upper			
Academic interests	38	82,366	75.29	66.93	82.11	99.70	1.60	<0.0001
Competencies	17	76,515	55.15	33.63	74.90	99.90	3.44	<0.0001
Controllable lifestyle or flexible work schedule	44	101,001	53.00	47.90	58.03	99.50	0.45	<0.0001
Patient service orientation	37	46,572	50.04	44.65	55.43	98.70	0.41	<0.0001
Medical teachers or	32	85,071	46.93	37.77	56.30	99.80	1.14	<0.0001
Career opportunities	38	81,923	44.00	32.26	48.78	99.70	1.15	<0.0001
Workload or working hours	20	22,051	37.99	29.59	47.19	98.30	0.69	<0.0001
Income	50	109,791	34.70	28.36	41.62	99.70	1.09	<0.0001
Length of training	18	42,046	32.30	27.61	37.37	98.10	0.20	<0.0001
Prestige	26	30,629	31.17	26.32	37.69	98.30	0.52	<0.0001
Advice from others	18	82,692	28.24	22.26	34.23	99.80	0.02	<0.0001
Student debt	8	38,917	15.33	10.96	21.03	98.80	0.27	<0.0001

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Table 3. Meta-regression of the EOI Value Stratified by Study-level Characteristics

Factor		estimate	95 CI% of estimate		P-Value
			Lower	Upper	
Academic interests	Country	-0.2314	-1.1575	0.6946	0.6302
	Survey years	0.3811	-0.3580	1.1202	0.2711
	Specialty	-0.4892	-1.5345	0.5562	0.4008
	Sample size	0.2362	-0.5488	1.0212	0.6537
Competencies	Country	0.6946	-1.1461	0.8938	0.8376
	Survey years	-1.0418	-2.0950	0.0114	0.0151
	Specialty	0.0904	-1.5786	1.7594	0.9398
	Sample size	-0.5720	-1.8606	0.7166	0.5823
Controllable lifestyle or flexible work schedule	Country	-0.1261	-1.1461	0.8938	0.9614
	Survey years	-0.0001	-0.4052	0.4051	0.9822
	Specialty	-0.8989	-1.4979	-0.3000	0.0035
	Sample size	-0.0518	-0.4396	0.3361	0.7203
Patient service orientation	Country	-0.6238	-1.3118	0.0642	0.0833
	Survey years	-0.0414	-0.6912	0.6083	0.8524
	Specialty	-1.5982	-2.5227	-0.6737	0.0010
	Sample size	-0.1157	-0.7473	0.5159	0.6358
Medical teachers or mentors	Country	0.7395	0.3117	1.1674	0.0007
	Survey years	0.1133	-0.3580	0.5845	0.6376
	Specialty	0.0605	-0.4441	0.5652	0.8141
	Sample size	-0.1202	-0.5567	0.3163	0.5894
Career opportunities	Country	0.1075	-0.7030	0.9179	0.5828
	Survey years	0.3284	-0.3913	1.0480	0.7546
	Specialty	-0.9292	-1.8015	-0.0570	0.0077
	Sample size	0.3654	0.1156	1.5478	0.0081
Workload or working hours	Country	-0.4535	-1.5086	0.6016	0.3981
	Survey years	0.4624	-0.5417	1.4665	0.3922
	Specialty	-0.9878	-2.1727	0.1972	0.1070
	Sample size	0.0982	-0.8589	1.0553	0.8205
Income	Country	0.1058	-0.4665	0.6781	0.7390
	Survey years	0.0999	-0.4379	0.6377	0.8774
	Specialty	-0.6457	-1.3267	0.0352	0.0480
	Sample size	0.0523	-0.4826	0.5872	0.6786
Length of training	Country	-0.1559	-1.2782	0.9664	0.7854
	Survey years	-0.2158	-1.4089	0.9772	0.7229
	Specialty	0.3959	-0.9585	1.7502	0.5667
	Sample size	0.1565	-0.6631	0.9761	0.7082
Prestige	Country	-0.3346	-1.0799	0.4106	0.3485
	Survey years	-0.4513	-1.1378	0.2352	0.0950
	Specialty	-1.0112	-1.8980	-0.1244	0.0172
	Sample size	0.0355	-0.6013	0.6723	0.5214
Advice from others	Country	-0.0097	-0.0722	0.0529	0.9328
	Survey years	-0.0861	-0.1471	-0.0251	0.0057

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	Specialty	-0.2017	-0.2790	-0.1244	<0.0001
	Sample size	0.2125	0.1309	0.2941	<0.0001
	Country	2.7853	2.0544	3.5162	0.0001
Student debt	Survey years	-0.1567	-0.6707	0.3573	0.5502
	Sample size	-0.5248	-1.0108	-0.0388	0.0343

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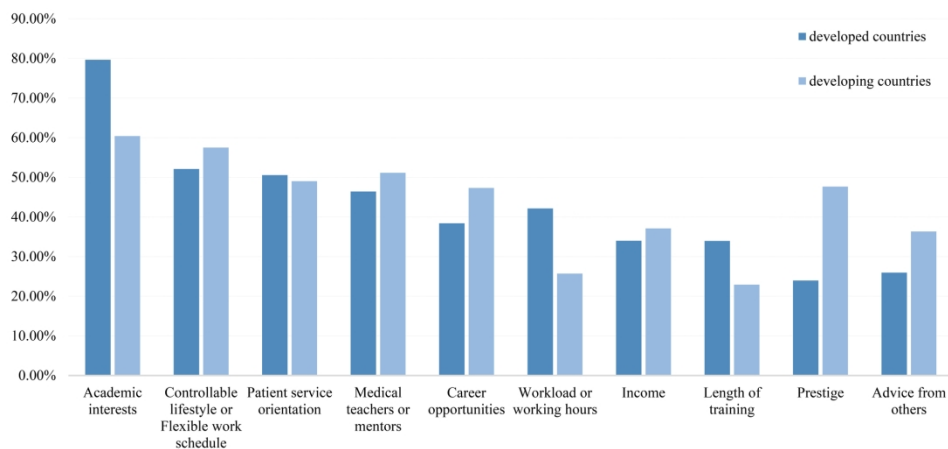


Figure 1. Bar Graph of the Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty Stratified by Region.

190x107mm (300 x 300 DPI)

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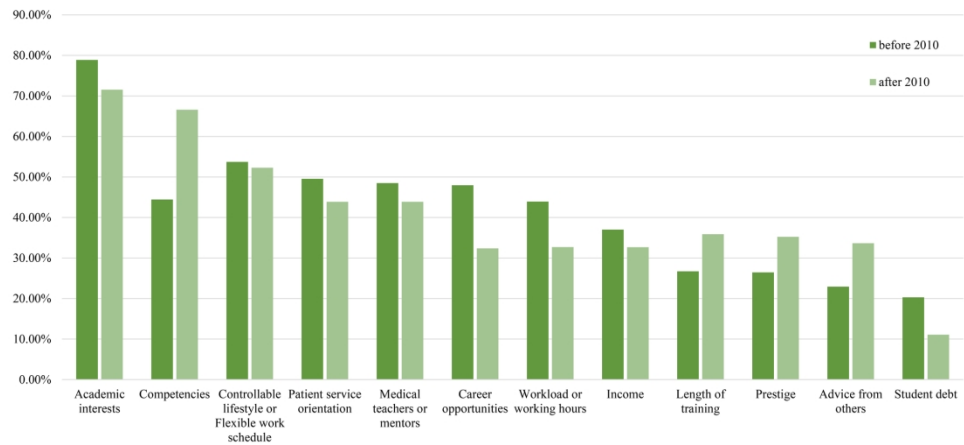


Figure 2. Bar Graph of the Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty Stratified by Survey Year.

190x107mm (300 x 300 DPI)

SI Methods. Search strategy used in the current systematic review and meta-analysis.

Medical Students

1. Students, Medical [Mesh]

2. Medical students

3. Medical student

4. Student, Medical

5. OR / 1 – 4

13. Cross sectional study

14. Cross sectional study [Publication Type]

15. Cross sectional study [Mesh Terms]

16. Systematic review

17. Systematic review [Publication Type]

18. Systematic review [Mesh Terms]

Subspecialty Choice

6. Career choices

7. Choice, Career

8. Choices career

9. Specialties

10. Sub-specialties

11. Sub-discipline

12. OR / 6 – 11

19. Meta-analysis [Title/Abstract]

20. Meta-analysis [Mesh Terms]

21. Meta-analysis [Publication Type]

22. OR / 12 – 21

Factors

23. Factors

Combined search

Study design

23. #5 AND #12AND #22 AND #2

Abbreviations: MeSH, Medical Subject Heading in PubMed

Table S1. Quality assessment of the included studies

Quality assessment criteria	1	2	3	4	5	6	7	8	9	10	11	Scores
1 Smith et al, ⁴¹ 2015	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
2 Cochran et al, ⁴² 2005	Y	U	Y	Y	N	Y	N	Y	N	N	N	5
3 Hauer et al, ⁴³ 2008	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
4 Johnson et al, ⁴⁴ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
5 Kiolbassa et al, ⁴⁵ 2011	Y	U	Y	Y	N	Y	N	Y	N	N	N	5
6 Klingensmith et al, ⁴⁶ 2015	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
7 Lee et al, ⁴⁷ 2012	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
8 Macdonald et al, ⁴⁸ 2012	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
9 Parsa et al, ³⁷ 2010	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
10 Paiva et al, ⁴⁹ 1982	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
11 Ni Chroinin et al, ⁵⁰ 2013	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
12 Newton et al, ³² 2005	Y	U	Y	Y	Y	Y	Y	Y	N	Y	N	8
13 Rogers et al, ⁵¹ 1990	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
14 Abendroth J et al, ⁵² 2014	Y	U	Y	Y	N	Y	N	Y	N	Y	Y	7
15 Alawad et al, ⁵³ 2015	Y	U	Y	Y	N	Y	Y	Y	Y	Y	N	8
16 Azizzadeh et al, ⁵⁴ 2003	Y	U	Y	Y	Y	Y	N	N	N	Y	N	6
17 Celenza et al, ⁵⁵ 2012	Y	U	Y	Y	Y	Y	Y	N	Y	Y	N	8
18 Dolan-Evans et al, ⁵⁶ 2014	Y	U	Y	Y	Y	Y	N	Y	N	Y	Y	8
19 Boyd et al, ⁵⁷ 2009	Y	U	Y	Y	Y	Y	Y	Y	N	Y	N	8
20 Egerton et al, ⁵⁸ 1985	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
21 Diderichsen et al, ⁵⁹ 2013	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
22 Ferrari et al, ⁶⁰ 2013	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	N	9
23 Freire et al, ⁶¹ 2011	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
24 Buddeberg-Fischer et al, ⁶² 2006	Y	U	Y	Y	N	Y	Y	Y	Y	Y	Y	9
25 Dorsey et al, ⁶³ 2005	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
26 Ekenze et al, ⁶⁴ 2013	Y	U	Y	Y	Y	Y	Y	N	N	Y	N	7
27 Barikani et al, ⁶⁵ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
28 Bittaye et al, ⁶⁶ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
39 Bonura et al, ⁶⁷ 2016	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	N	9
30 Al-Fouzan et al, ⁶⁸ 2012	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
31 AlKot et al, ⁶⁹ 2015	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
32 Borges et al, ⁷⁰ 2009	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
33 Budd et al, ⁷¹ 2011	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
34 Corrigan et al, ⁷² 2007	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
35 Davis et al, ⁷³ 2016	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
36 Deutsch et al, ⁷⁴ 2015	Y	U	Y	Y	Y	Y	N	Y	Y	Y	N	8
37 Gardner et al, ⁷⁵ 2014	Y	U	Y	Y	N	Y	N	Y	N	Y	N	7
38 Dias et al, ⁷⁶ 2013	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
39 Goltz et al, ⁷⁷ 2013	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
40 Gupta et al, ⁷⁸ 2013	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
41 Hanzlick et al, ⁷⁹ 2008	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
42 Harris et al, ⁸⁰ 2005	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
43 Hauer et al, ⁸¹ 2008	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
44 Labiris et al, ⁸² 2014	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
45 Lambert et al, ⁸³ 2008	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
46 Shah et al, ⁸⁴ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
47 Lefevre et al, ⁸⁵ 2010	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
48 Vicente et al, ⁸⁶ 2013	Y	U	Y	Y	N	N	Y	N	Y	Y	N	6
49 Wiesenfeld et al, ⁸⁷ 2014	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
50 Lam et al, ⁸⁸ 2016	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	N	9
51 Hartung et al, ⁸⁹ 2005	Y	U	Y	Y	N	Y	N	N	N	N	N	4
52 Girasek et al, ⁹⁰ 2011	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
53 Zuccato et al, ⁹¹ 2015	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
54 Wilbanks et al, ⁹² 2015	Y	U	Y	Y	N	Y	Y	Y	Y	Y	Y	9
55 West et al, ⁹³ 2009	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
56 Watmough et al, ⁹⁴ 2007	Y	U	Y	Y	N	N	N	N	N	Y	N	4
57 Thakur et al, ⁹⁵ 2001	Y	U	Y	Y	Y	Y	Y	N	Y	Y	N	8
58 Scott et al, ⁹⁶ 2011	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
59 Schnuth et al, ⁹⁷ 2003	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
60 Richards et al, ⁹⁸ 2009	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
61 Reed et al, ⁹⁹ 2009	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	N	9
62 de Souza et al, ¹⁰⁰ 2015	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
63 Pikoulis et al, ¹⁰¹ 2010	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
64 Ozer et al, ¹⁰² 2015	Y	U	Y	Y	N	N	Y	N	Y	Y	N	6
65 Noble et al, ¹⁰³ 2004	Y	U	Y	Y	Y	Y	Y	Y	N	Y	N	8
66 Noble et al, ¹⁰⁴ 2010	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
67 Newton et al, ¹⁰⁵ 2005	Y	U	Y	Y	N	Y	Y	N	N	Y	N	6
68 Moore et al, ¹⁰⁶ 2012	Y	U	Y	Y	Y	Y	N	Y	N	N	N	6
69 Momen et al, ¹⁰⁷ 2015	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
70 Mehmood et al, ¹⁰⁸ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
71 Loriot et al, ¹⁰⁹ 2010	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
72 Lefevre et al, ¹¹⁰ 2010	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
73 Vo et al, ¹¹¹ 2017	Y	U	Y	Y	Y	N	N	N	N	Y	N	5
74 Grasreiner et al, ¹¹² 2018	Y	U	Y	Y	Y	Y	N	N	N	Y	N	6
75 Alkhannen et al, ¹¹³ 2018	Y	U	Y	Y	N	N	Y	N	N	Y	N	5

Quality assessment criteria in detail

1. Define the source of information (survey, record review).
2. List the inclusion and exclusion criteria for the exposed and unexposed subjects (cases and controls) or refer to previous publications.
3. Indicate the time period used for identifying patients.
4. Indicate whether the subjects were consecutive if not population-based.
5. Indicate whether the evaluators of the subjective components of the study were masked to the other aspects of participants' status.
6. Describe any assessments undertaken for quality assurance purposes (e.g., test/retest of primary outcome measurements)
7. Explain any patient exclusion from the analyses.
8. Describe how confounding was assessed and/or controlled.
9. If applicable, explain how missing data were handled in the analysis.
10. Summarize the patient response rates and the completeness of the data collection.
11. Clarify what follow-up, if any, was expected and the percentage of patients with incomplete data or follow-up.

“Y”: Yes; “N”: No; “U”: Unclear.

Table S2. Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty Stratified by Region and Survey Year.

Factor		No. of studies	Total no. of participants	Extent of influence (%)	95 CI% of EOI value		<i>I-square</i> (%)	<i>P</i> -Value	<i>Q</i> -Value		
					Lower	Upper					
Academic interest	developed	28	80,000	79.66	70.73	86.39	99.8	0.02	3.51		
	developing	10	2,366	60.41	43.44	75.19	98.0				
	before 2010	29	44,174	78.88	69.04	86.22	99.7	0.40	1.21		
	after 2010	9	38,192	71.54	57.66	82.27	99.6				
Competencies	before 2010	9	43,134	44.40	29.11	60.83	99.8	0.21	1.86		
	after 2010	8	33,381	66.60	34.48	88.31	99.8				
Controllable lifestyle or flexible work schedule	developed	37	100,980	52.11	46.52	57.65	99.6	0.63	0.68		
	developing	7	2,017	57.50	45.81	68.41	95.9				
	before 2010	22	62,945	53.72	47.48	59.84	99.4			0.97	0.05
after 2010	22	40,056	52.29	43.51	60.93	99.2					
Patient service orientation	developed	27	44,235	50.56	44.68	56.42	98.8	0.74	0.48		
	developing	10	2,337	49.02	31.62	66.67	98.1				
	before 2010	18	40,997	49.56	43.29	55.84	98.8			0.70	0.54
	after 2010	19	5,579	43.87	38.62	63.80	98.3				
Medical teachers or mentors	developed	28	84,076	46.43	36.63	56.52	99.8	0.73	0.48		
	developing	4	995	51.14	33.97	68.04	95.4				
	before 2010	21	49,654	48.48	36.93	60.19	99.8			0.70	0.54
	after 2010	11	35,417	43.87	27.94	61.18	99.7				
Career opportunities	developed	31	79,867	38.41	29.61	48.04	99.8	0.60	0.74		
	developing	7	2,056	47.32	30.38	64.91	98.1				
	before 2010	20	43,417	47.97	33.54	62.74	99.8			0.24	1.68
	after 2010	18	38,506	32.38	21.68	45.31	99.5				
Workload or working hours	developed	15	20,970	42.14	31.35	53.72	98.6	0.34	1.39		
	developing	5	1,081	25.72	13.29	43.88	95.3				
	before 2010	9	19,456	43.93	29.43	59.54	98.8			0.41	1.21
	after 2010	11	2,595	32.70	29.43	59.54	97.4				
Income	developed	39	107,091	34.01	26.89	41.93	99.8	0.84	0.29		
	developing	11	2,700	37.11	27.06	48.41	96.4				
	before 2010	25	68,714	37.01	25.95	49.62	99.8			0.41	1.18
	after 2010	25	41,077	32.67	26.04	40.07	98.9				
Length of training	developed	15	41,246	33.95	28.72	39.60	98.4	0.31	1.48		
	developing	3	800	22.92	10.94	41.85	94.0				
	before 2010	7	8,811	26.72	15.89	41.29	98.9			0.28	1.59
	after 2010	11	33,234	35.87	29.67	42.59	96.9				
Prestige	developed	17	27,987	23.96	19.20	29.47	97.3	0.01	4.71		
	developing	9	2,642	47.65	34.41	61.24	97.6				
	before 2010	12	25,542	26.46	20.78	33.03	96.7			0.25	1.67
	after 2010	14	5,087	35.22	24.70	47.40	98.3				
Advice from others	developed	14	81,205	25.95	19.27	32.64	99.8	0.36	1.33		
	developing	4	1,487	36.34	18.91	53.77	98.1				
	before 2010	10	48,319	22.93	17.85	28.01	99.5			0.31	1.47
	after 2010	8	34,373	33.65	25.12	42.18	99.1				
Student debt	before 2010	5	6,610	20.29	15.86	25.57	81.8	0.69	0.59		
	after 2010	3	32,307	11.08	1.58	49.08	99.6				

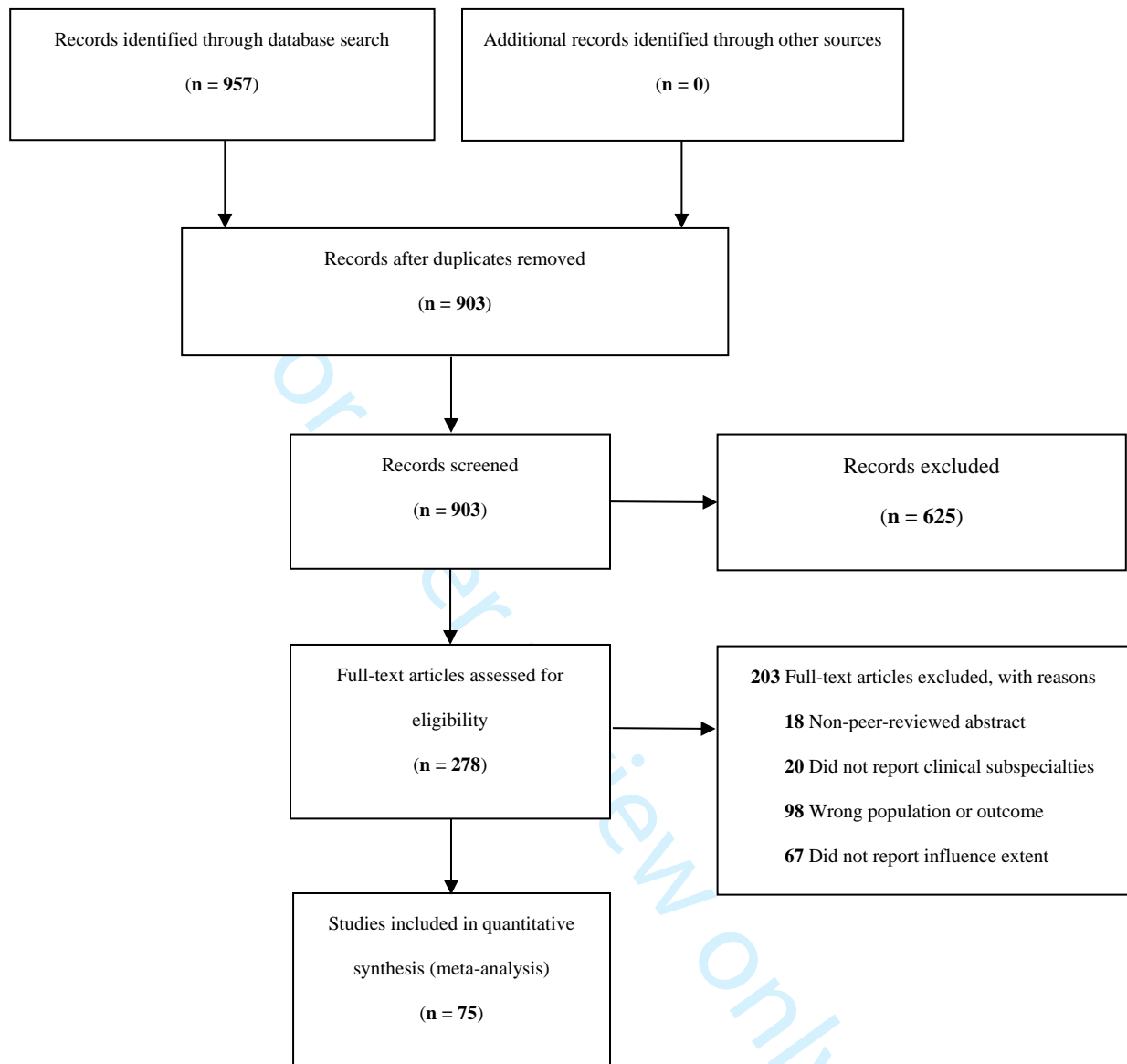
Figure S1. Flow Diagram of the Study Inclusion.

Figure S2. Forest Plot of “Academic Interest”.

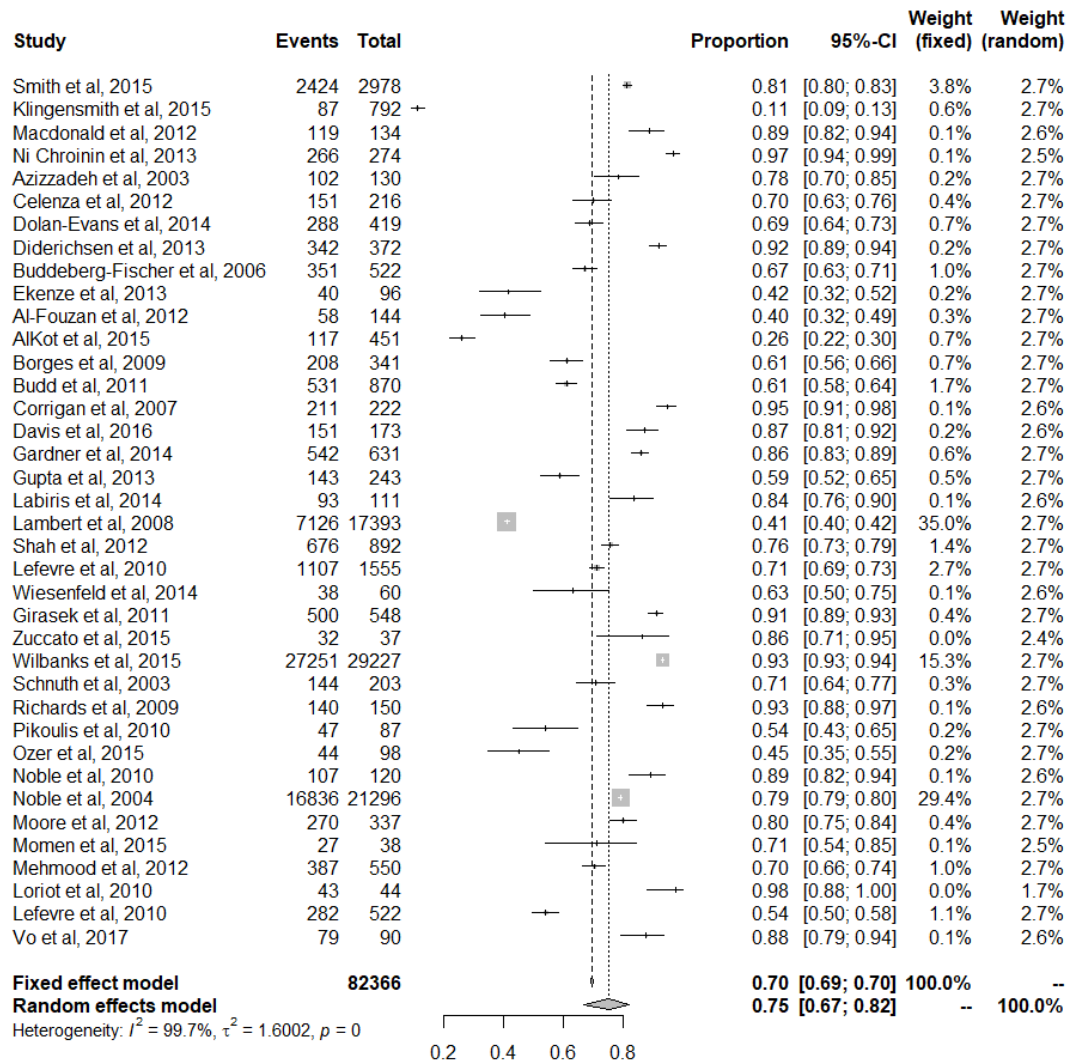
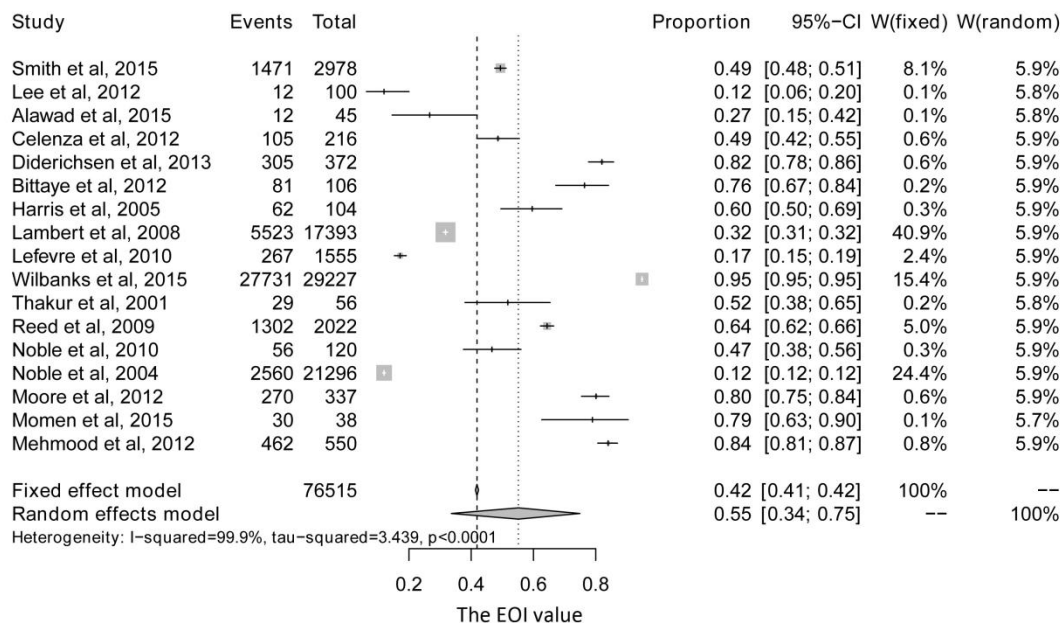


Figure S3. Forest Plot of “Competencies”.



review only

Figure S4. Forest Plot of “Controllable Lifestyle or Flexible Work Schedule”.

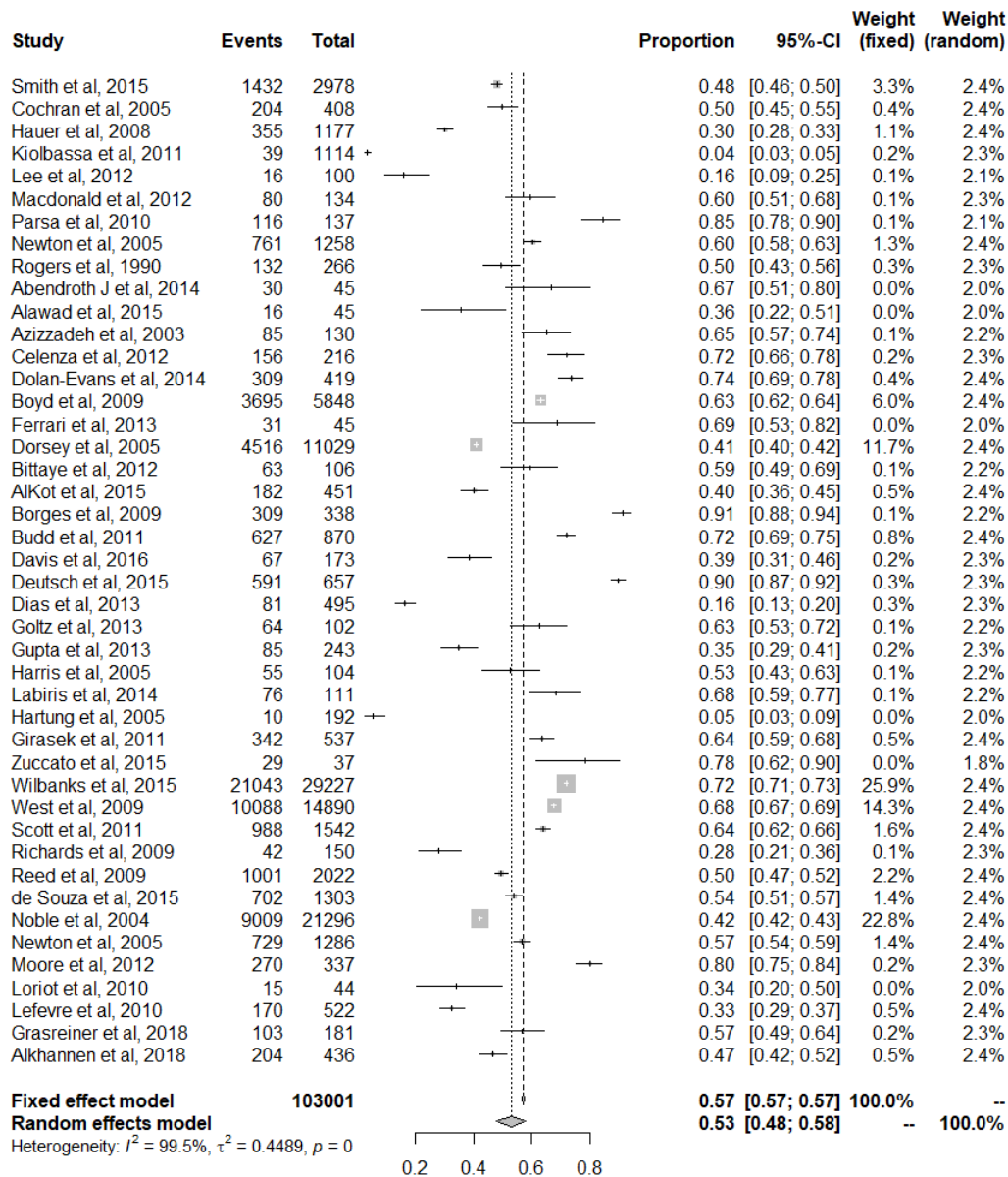


Figure S5. Forest Plot of “Patient Service Orientation”.

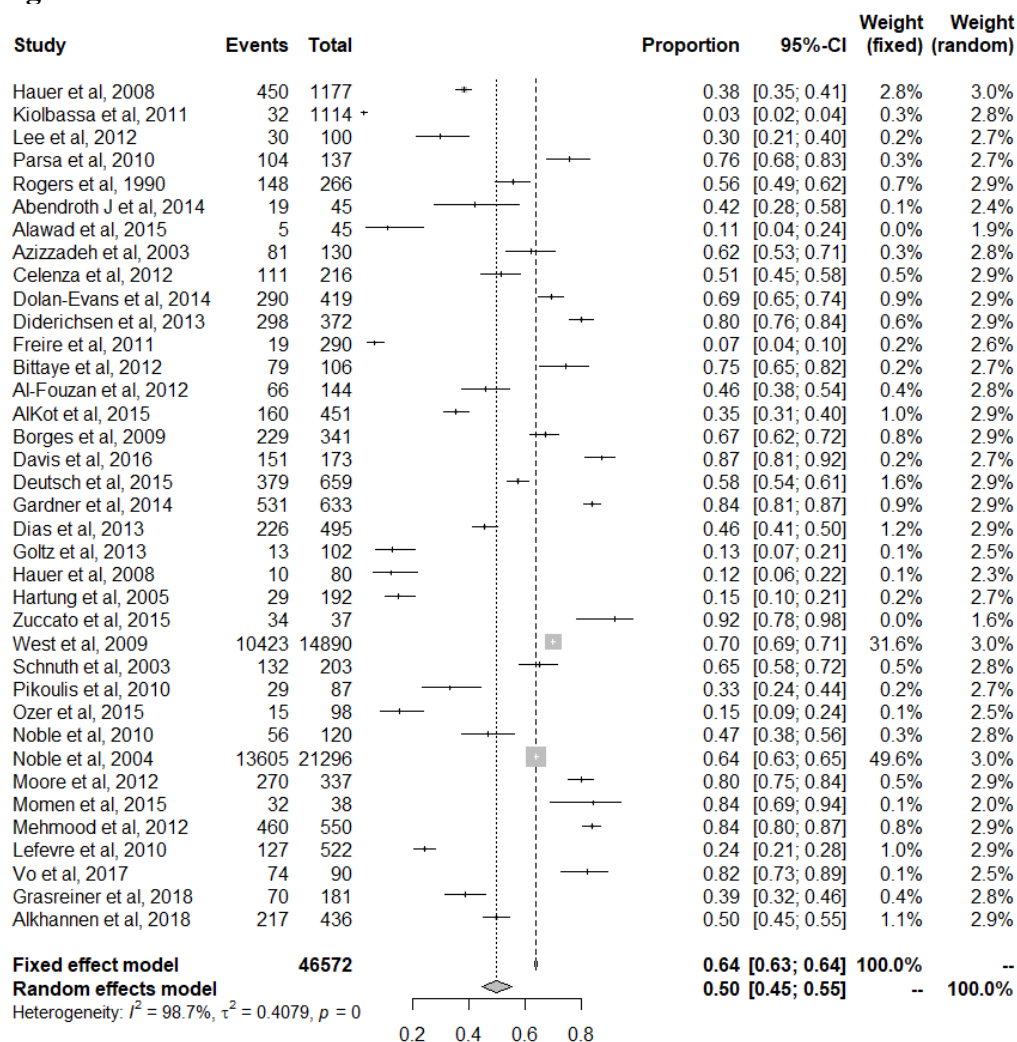


Figure S6. Forest Plot of “Medical Teachers or Mentors”.

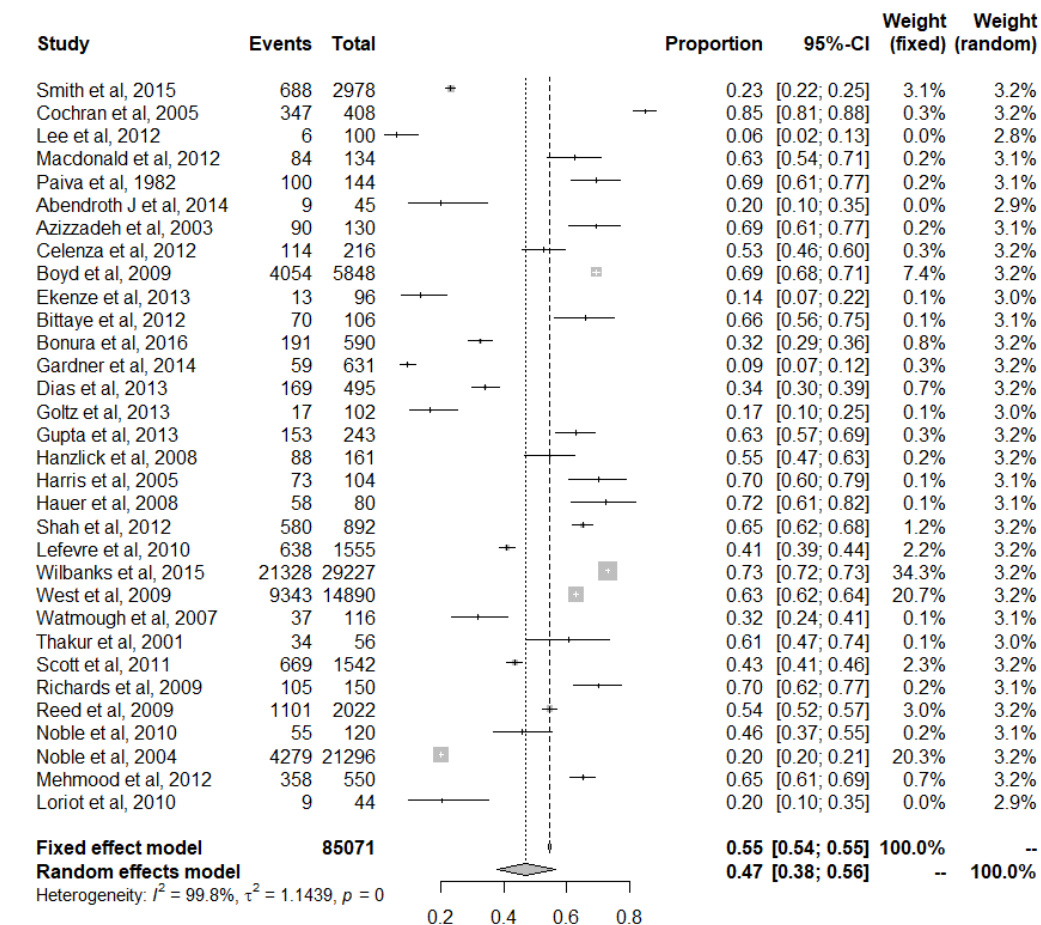


Figure S7. Forest Plot of “Career Opportunities”.

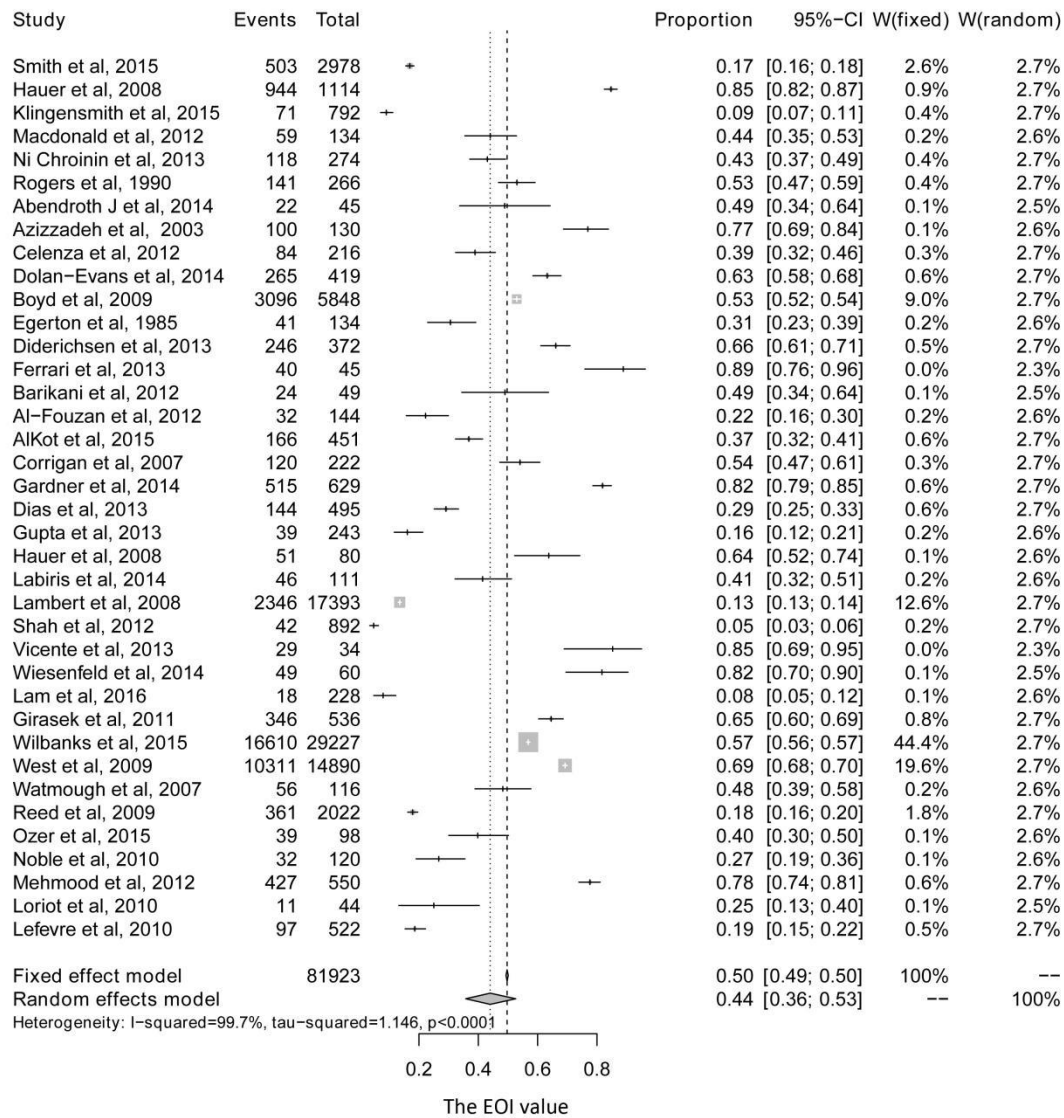


Figure S8. Forest Plot of “Workload or Working Hours”.

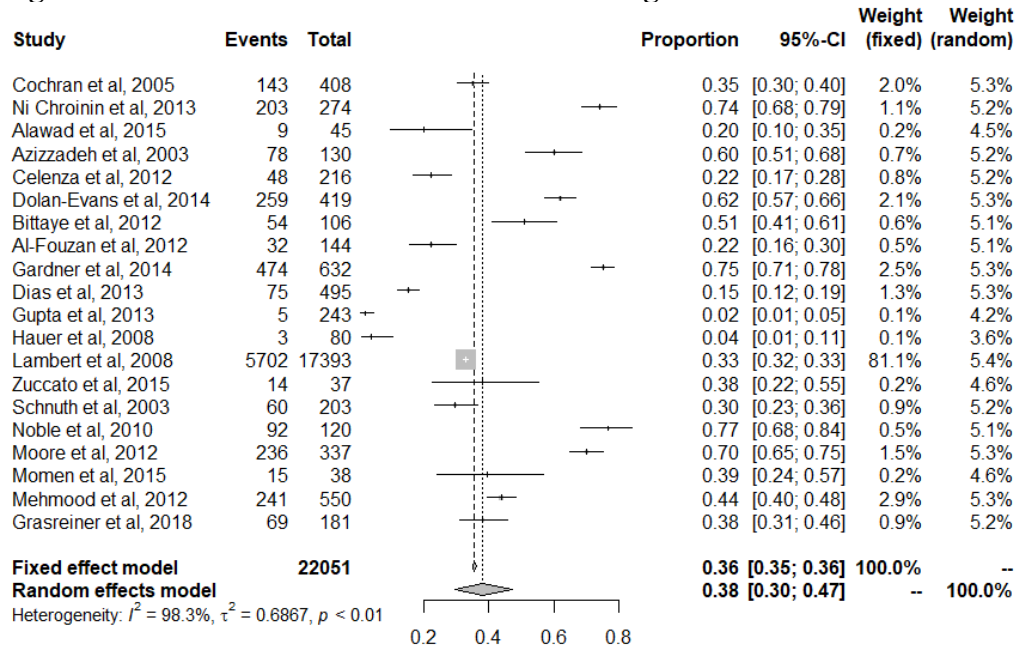


Figure S9. Forest Plot of “Income”.

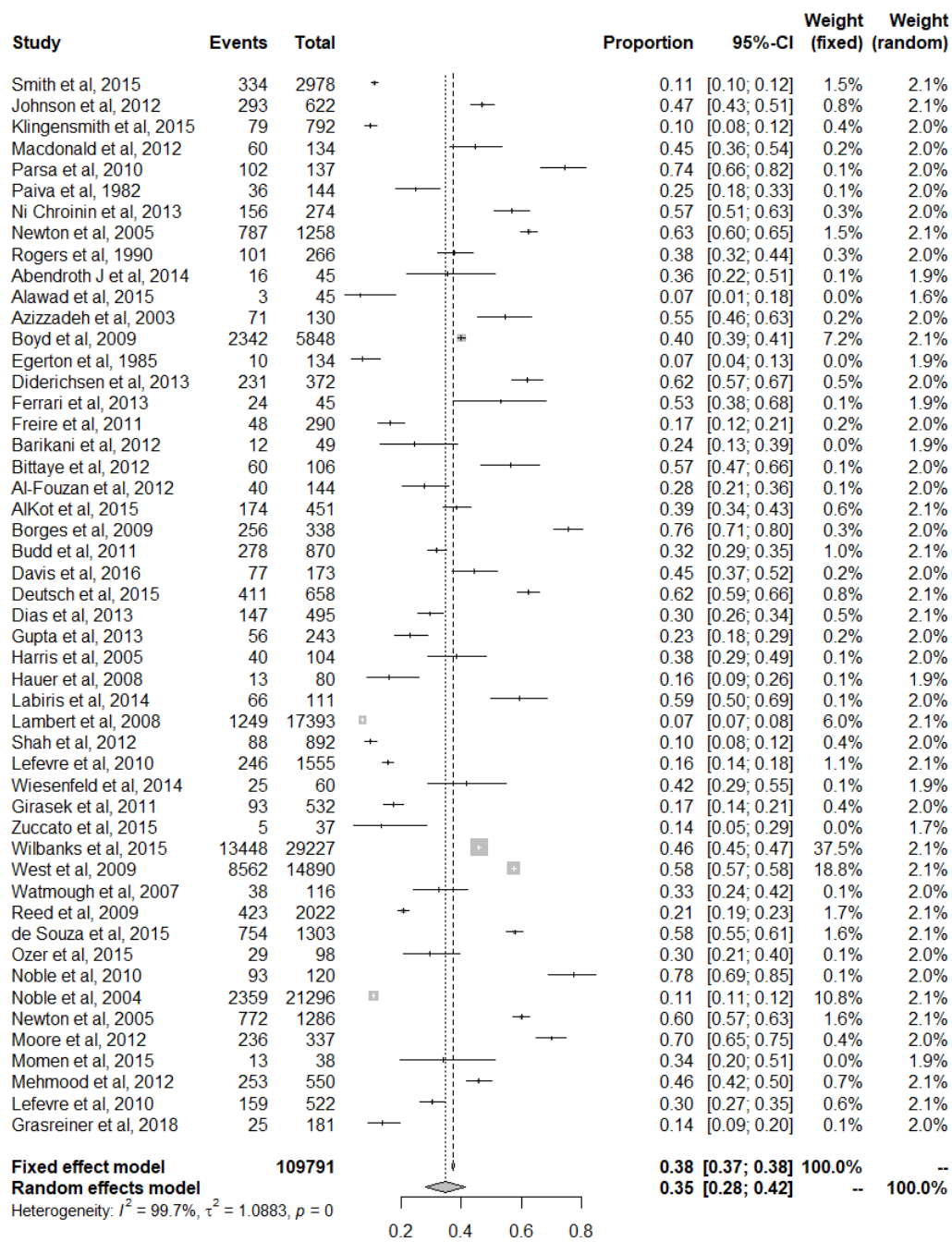
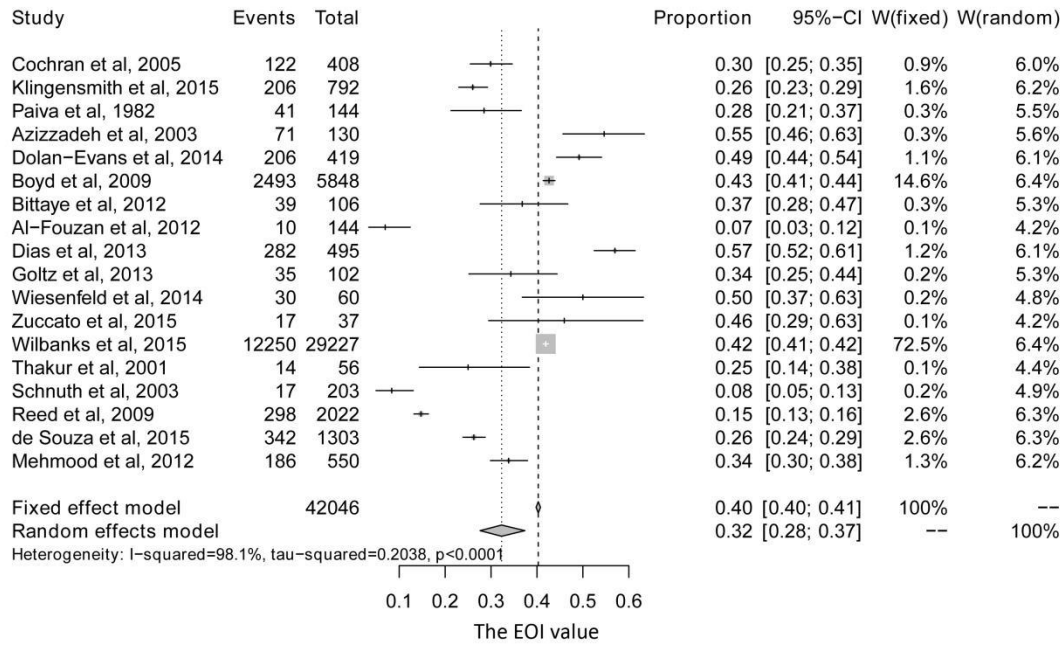
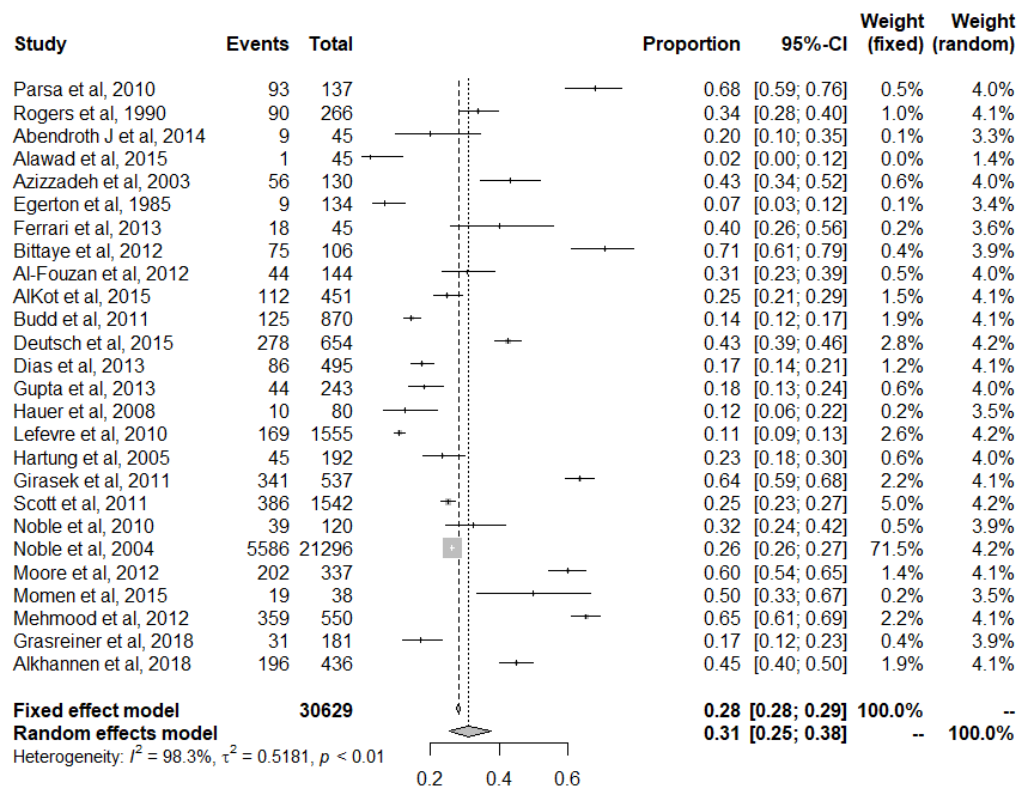


Figure S10. Forest Plot of “Length of Training”.



review only

Figure S11. Forest Plot of “Prestige”.



only

Figure S12. Forest Plot of “Advice from Others”.

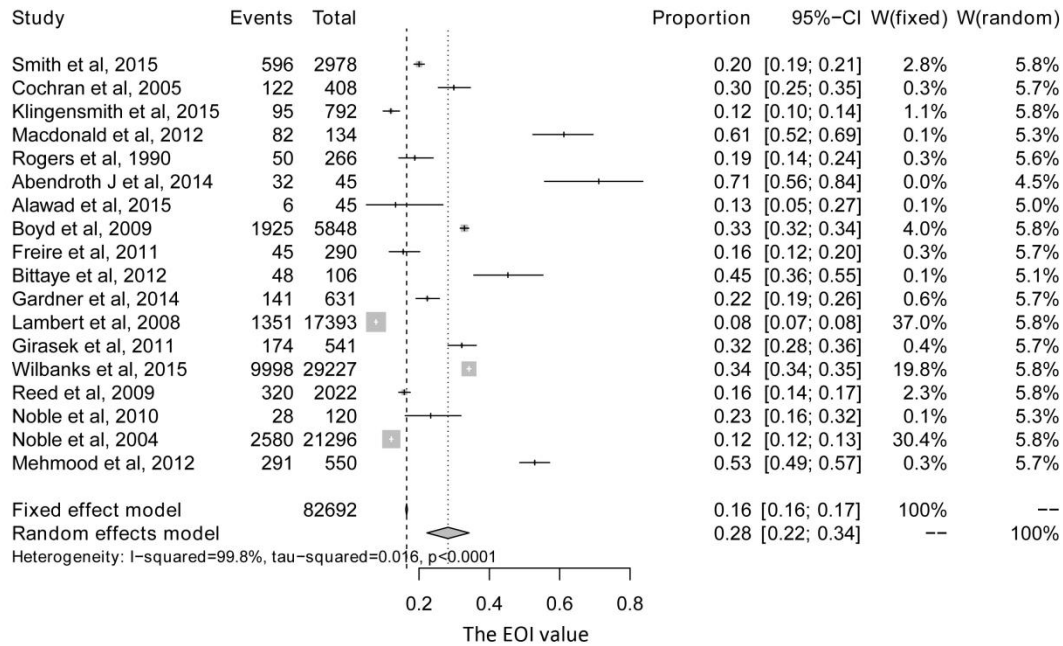


Figure S13. Forest Plot of “Student Debt”.

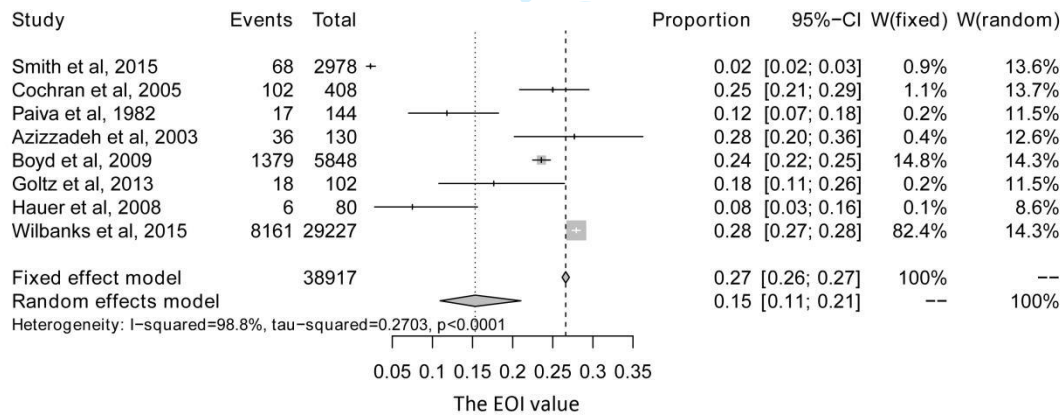
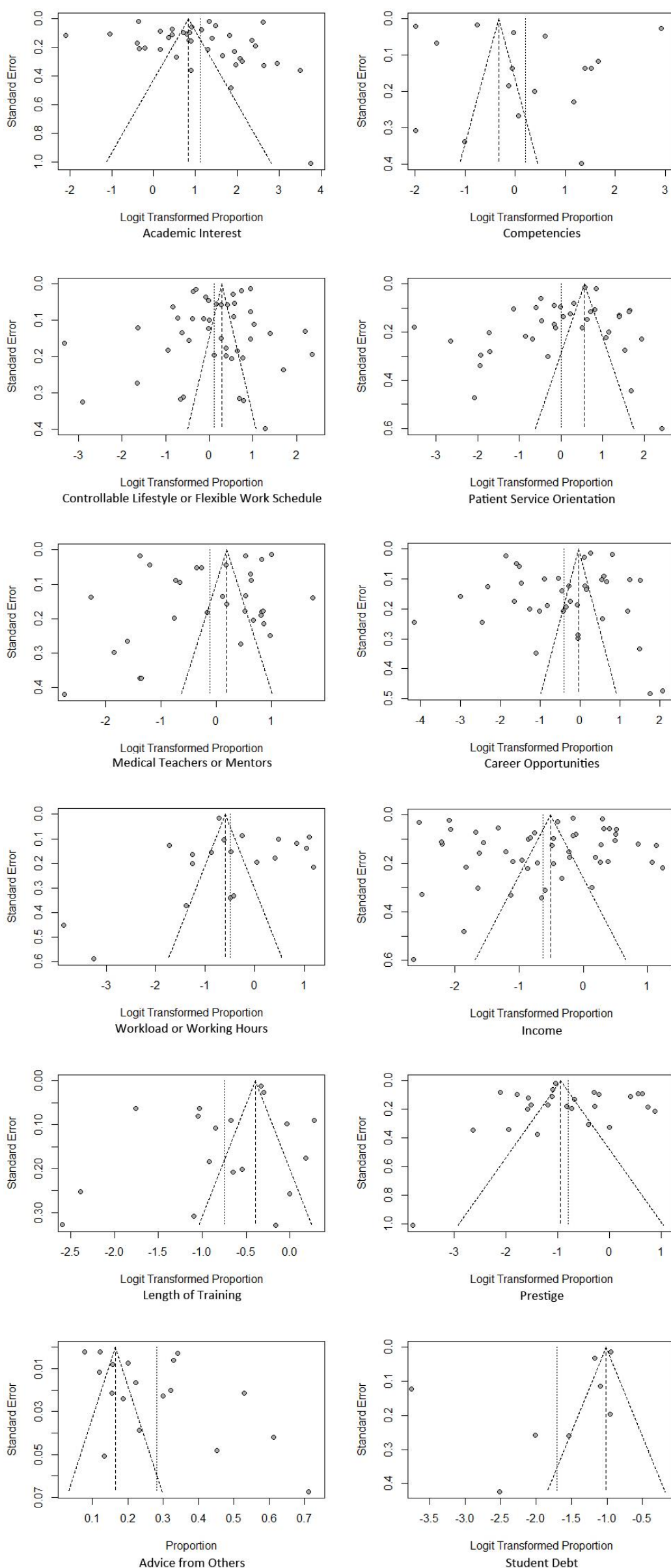


Figure S14. Funnel Plots of the Publication Bias Testing of the 12 Factors.





PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2-3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	3
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	5
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5-6
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	6-7
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	6-7
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	7

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PRISMA 2009 Checklist

Page 1 of 2

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	7
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	7
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	5, 7
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	7-8
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	8
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	8
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	8-9
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	8-9
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	8-9
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	9-13
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	13
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	14
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	15

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

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MOOSE Checklist for Meta-analyses of Observational Studies

Item No	Recommendation	Reported on Page No
Reporting of background should include		
1	Problem definition	5
2	Hypothesis statement	5
3	Description of study outcome(s)	5
4	Type of exposure or intervention used	5
5	Type of study designs used	5
6	Study population	5
Reporting of search strategy should include		
7	Qualifications of searchers (eg, librarians and investigators)	6
8	Search strategy, including time period included in the synthesis and key words	5
9	Effort to include all available studies, including contact with authors	5
10	Databases and registries searched	5
11	Search software used, name and version, including special features used (eg, explosion)	6
12	Use of hand searching (eg, reference lists of obtained articles)	5
13	List of citations located and those excluded, including justification	5-6
14	Method of addressing articles published in languages other than English	5
15	Method of handling abstracts and unpublished studies	5
16	Description of any contact with authors	5
Reporting of methods should include		
17	Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	6
18	Rationale for the selection and coding of data (eg, sound clinical principles or convenience)	6-7
19	Documentation of how data were classified and coded (eg, multiple raters, blinding and interrater reliability)	6-7
20	Assessment of confounding (eg, comparability of cases and controls in studies where appropriate)	6
21	Assessment of study quality, including blinding of quality assessors, stratification or regression on possible predictors of study results	6
22	Assessment of heterogeneity	6
23	Description of statistical methods (eg, complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated	6-7
24	Provision of appropriate tables and graphics	5-7
Reporting of results should include		
25	Graphic summarizing individual study estimates and overall estimate	8
26	Table giving descriptive information for each study included	7
27	Results of sensitivity testing (eg, subgroup analysis)	8
28	Indication of statistical uncertainty of findings	7-9

Item No	Recommendation	Reported on Page No
Reporting of discussion should include		
29	Quantitative assessment of bias (eg, publication bias)	13
30	Justification for exclusion (eg, exclusion of non-English language citations)	13-14
31	Assessment of quality of included studies	13-14
Reporting of conclusions should include		
32	Consideration of alternative explanations for observed results	14
33	Generalization of the conclusions (ie, appropriate for the data presented and within the domain of the literature review)	14
34	Guidelines for future research	14
35	Disclosure of funding source	15

From: Stroup DF, Berlin JA, Morton SC, et al, for the Meta-analysis Of Observational Studies in Epidemiology (MOOSE) Group. Meta-analysis of Observational Studies in Epidemiology. A Proposal for Reporting. *JAMA*. 2000;283(15):2008-2012. doi: 10.1001/jama.283.15.2008.

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Factors Influencing Subspecialty Choice Among Medical Students: A Systematic Review and Meta-analysis

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Keywords:	Medical students, Career choice, Meta-analysis

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1
2
3 **1 Title Page**
4

5 **2 Factors Influencing Subspecialty Choice Among Medical Students: A Systematic**
6

7 **3 Review and Meta-analysis**
8

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10

11 5 Wangting Li, M.D.¹; Yi Zhu, M.D.^{1,4}; Chuan Chen, M.D.^{1,4}; Haotian Lin, M.D., Ph.
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1
2
3 26 **ABSTRACT**
4

5 27 **Objective** To characterize the contributing factors that affect medical students'
6 subspecialty choice and to estimate the extent of influence of individual
7 factors on the students' decision-making process.
8
9

10
11 30 **Design** Systematic review and meta-analysis.

12
13 31 **Methods** A systematic search of the Cochrane Library, ERIC, Web of Science, CNKI
14 and PubMed databases was conducted for studies published between January
15 1977 and June 2018. Information concerning study characteristics, influential
16 factors, and the extent of their influence (EOI) was extracted independently
17 by two trained investigators. EOI is the percentage level that describes how
18 much each of the factors influenced students' choice of subspecialty. The
19 recruited medical students includes students in medical school, internship,
20 residency training and fellowship, who are about to or have just made a
21 specialty choice. The estimates were pooled using a random-effects
22 meta-analysis model due to the between-study heterogeneity.
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41 41 **Results** Data were extracted from 75 studies (882,209 individuals). Overall, the
42 factors influencing medical students' choice of subspecialty training mainly
43 included academic interests (75.29%), competencies (55.15%), controllable
44 lifestyles or flexible work schedules (53.00%), patient service orientation
45 (50.04%), medical teachers or mentors (46.93%), career opportunities
46 (44.00%), workload or working hours (37.99%), income (34.70%), length of
47 training (32.30%), prestige (31.17%), advice from others (28.24%), and
48 student debt (15.33%), with significant between-study heterogeneity
49 ($P < 0.0001$). Subgroup analyses revealed that the EOI of academic interests
50 was higher in developed countries than that in developing countries (79.66%

1
2
3 51 [95% confidence interval (CI), 70.73%; 86.39%] vs. 60.41% [95% CI,
4 52 43.44%; 75.19%]; $Q=3.51$ $P=0.02$). The EOI value of prestige was lower in
5 53 developed countries than that in developing countries (23.96% [95% CI,
6 54 19.20%; 29.47%] vs. 47.65% [95% CI, 34.41%; 61.24%]; $Q=4.71$ $P=0.01$).

11 **Conclusions** This systematic review and meta-analysis provided a quantitative
12 55 evaluation of the top 12 influencing factors associated with medical students'
13 56 choice of subspecialty. Our findings provide the basis for the development of
14 57 specific, effective strategies to optimize the distribution of physicians among
15 58 different departments by modifying these influencing factors.
16 59

20 60 **Systematic review registration** PROSPERO CRD42017053781.

61 **STRENGTHS AND LIMITATIONS OF THIS STUDY**

- 62 ● This is the first study that provide a systematic estimate of the factors associated
63 64 with medical students' subspecialty choices.
- 65 ● A large number of studies conducted in varied populations have been included.
- 66 ● The differences in the characteristics of country, survey years, specialty, the type
67 68 of data used and sample size across studies represent a major limitation of our
69 70 study.

71 **KEYWORDS** Medical students, career choice, meta-analysis

72 Introduction

73 Because of the population aging, increased workload on doctors through increased
74 number of consultations and in managing patients with multi-morbidity, the demand
75 for physicians continues to increase; however, an imbalance in the supply of
76 physicians in different subspecialties has become a growing concern in both
77 developed and developing countries.¹⁻⁵ Some specialties and subspecialties, such as
78 family medicine and palliative medicine,^{6,7} are experiencing a desperate shortage of
79 physicians, whereas other specialties and subspecialties, such as cardiology,
80 ophthalmology and ear, nose and throat (ENT) surgery, are highly competitive
81 specialties with low success rate for candidates.^{8,9}

82 Specialty choice is the product of a complex interconnection of student expectation,
83 department expectation, and competition for available spots, and student choice is
84 where the choice begins.¹⁰ Previous studies have suggested that medical students'
85 choice of subspecialty is essential to the maintenance of an adequate medical
86 workforce and a balanced development of the medical system.^{11,12} However, the
87 influencing factors underlying students' subspecialty choice have not been
88 systemically reviewed. Recent changes in the training and practice environment may
89 influence medical students' career choice.¹³ Additionally, the variability in
90 preferences over time and in students' attitudes towards career choices can further
91 complicate this assessment. For example, a study in the UK indicated that half of the
92 medical students made a definitive subspecialty choice during their first year of
93 medical school.¹⁴ However, students were prone to changing their subspecialty
94 preference during medical school and internship.¹⁵ Notably, students may also reject
95 certain subspecialties during their medical school training, even those they have
96 previously seriously considered.¹⁶ Therefore, identifying the factors that influence

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3 97 students' choice of subspecialty will enable a better understanding of the current
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5 98 shortage/overload of physicians in specific fields and contribute to policy-building
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7 99 and decision-making to improve the training and recruitment of students in the future.
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100 We thus conducted a systematic review and a meta-analysis to investigate the
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101 influencing factors and the extent of their influence on the choice of subspecialty
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102 training among medical students. More specifically, we focused on the following
13
103 questions. First, can we gain a better understanding of students' preferences for
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104 medical specialty according to the primary influencing factor? Second, do the
15
105 subgroups according to world region and survey years examined in this study differ
16
106 significantly with regard to the weight that students place on the identified
17
107 influencing factor?

108 **Methods**

109 We developed a review protocol (registration number: PROSPERO
110 CRD42017053781) prior to commencing the study. The Preferred Reporting Items
111 for Systematic Reviews and Meta-Analyses (PRISMA) guidelines was used to ensure
112 the reporting quality of this review (Fig. S1).¹⁷

113 **Search Strategy and Study Eligibility**

114 We performed a literature search in June 2018 using the Cochrane Library, Medline,
115 Web of Science, CNKI and ERIC databases without language restrictions. Articles
116 were screened by title, abstract and reference list, and by correspondence with study
117 investigators. Potentially relevant papers were first identified by reviewing the titles
118 and abstracts, and the full text of each retrieved article was then assessed. A detailed
119 example of search strategy for Medline/PubMed is shown in **Methods S1**. Studies
120 were included if they were systematic review or cross-sectional studies, reported data
121 on medical students, were published in peer-reviewed journals, and used a validated

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3 122 method to assess the extent of a factor's influence on the choice of subspecialty, such
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5 123 as pediatric gastroenterology and vascular surgery, or its corresponding specialty,
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7 124 such as pediatrics and surgery. Because of the differences between medical education
8
9 125 systems in the world, the medical students we recruited includes the student in
10
11 126 medical school, internship, residency training and fellowship, containing the students
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13 127 who about to make a specialty choice and students who has just made a specialty
14
15 128 choice. A guide to medical specialty, available at
16
17 129 <https://www.abms.org/member-boards/specialty-subspecialty-certificates/>, were used
18
19 130 to identify the medical specialty and subspecialty of our research. We also conducted
20
21 131 an additional search using OpenGrey. However, no additional articles were further
22
23 132 included. All searches were performed using Google chrome (version 54.0.2840).

26 133 **Data Extraction and Quality Assessment**

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29 134 Each article was reviewed by two trained investigators (Y.Y. and J.L.) and the
30
31 135 following information was independently extracted from each selected article using a
32
33 136 standardized form: study design, geographic location, years of survey, journal,
34
35 137 sample size, average age of the participants, the number and percentage of male
36
37 138 participants, and the influencing factors and the extent of their influence. A third
38
39 139 investigator was consulted if disagreements occurred. Each study may involve one or
40
41 140 several influencing factors. An 11-item checklist which was recommended by Agency
42
43 141 for Healthcare Research and Quality (AHRQ), used for cross-sectional studies¹⁸,
44
45 142 available at <https://www.ncbi.nlm.nih.gov/books/NBK35156/>, were used to assess the
46
47 143 quality of the studies. All discrepancies were resolved via discussion and consensus.

50 144 **Statistical Analysis**

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53 145 As considerable heterogeneity was expected because of the multiple sources of
54
55 146 variances, a random effects meta-analysis model was used to estimate the influencing

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3 147 factors and the extent of their influence.¹⁹ Between-study heterogeneity was assessed
4
5 148 using the Cochran's Q-test, and was quantified with the I^2 statistic, which was
6
7 149 calculated to describe the percentage of total variation caused by heterogeneity across
8
9 150 studies, with $\geq 50\%$ indicating considerable heterogeneity.^{20 21} Potential sources of
10
11 151 heterogeneity were identified using meta-regression.²² Four categorical covariates
12
13 152 were defined as potential sources of heterogeneity by examining the studies
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15 153 conducted in the United States (US) vs. the studies conducted in other countries, the
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17 154 studies conducted before 2010 vs. those conducted after 2010, the studies concerning
18
19 155 subspecialty only vs. those that were not specific to a subspecialty, and the studies
20
21 156 with a sample size < 200 vs. the studies with a sample size ≥ 200 . Subgroup analyses
22
23 157 were performed for each factor in the studies in developed countries vs. developing
24
25 158 countries and studies conducted before 2010 vs. after 2010. The EOI value of
26
27 159 competencies in developing countries was not statistically significant (81.21% [95%
28
29 160 CI, 75.27%; 86.51%], $P=0.1436$), and no studies on the influence of student debt in
30
31 161 developing countries were found. The Q-test based on the analysis of variance was
32
33 162 used to compare the subgroups, with a significance threshold of 5%.²³ The influence
34
35 163 of individual studies on the overall EOI value was explored by serially excluding
36
37 164 each study in a sensitivity analysis. Publication bias was investigated using a funnel
38
39 165 plot test and Egger's test.^{24 25} Fill and trim approach, which imputes estimates from
40
41 166 hypothetical negative unpublished reports,²⁶ was also used to investigate the
42
43 167 publication bias if the Egger's test was significant. All analyses were performed
44
45 168 using R (version 3.3.1, The R Foundation, Vienna, Austria). The statistical tests were
46
47 169 2-sided with a significance threshold of $P < 0.05$.

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53 170 **Patient and public involvement:** Patients and the public were not involved in
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55 171 development of the research question and outcome measures, nor the study design.

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3 172 The study does not involve patient recruitment, and patients were not involved in
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5 173 conduct of the study. We plan to liaise closely with patients, special interest groups,
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7 174 and charities in the dissemination of our results in printed and electronic media.
8

9 175 **Results**

10 176 **Study Characteristics**

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13 177 Seventy-five cross-sectional studies involving a total of 882,209 individuals that
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15 178 published between January 1977 and May 2018 were included in the present research
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17 179 **(Table 1)**. Thirty-four studies were conducted in North America, 24 in Europe, 7 in
18
19 180 Asia, 5 in Oceania, 3 in Africa, and 2 in South America. The median number of
20
21 181 participants per study was 243 (range 37-29,227). Fourteen studies included students
22
23 182 who had already selected subspecialties, whereas 61 did not. The influencing factors
24
25 183 were ranked according to the frequency of occurrence and each factor was identified
26
27 184 when at least 5 papers were available describing it. The influencing factors for
28
29 185 subspecialty choice were then classified according to 17 aspects, including academic
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31 186 interests, controllable lifestyle or flexible work schedule (defined as flexibility that
32
33 187 allows physicians to control the number of hours devoted to practicing the specialty),
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35 188 competencies, patient service orientation, medical teachers or mentors, career
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37 189 opportunities, workload or working hours (characterized by the physician's time
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39 190 spent on professional responsibilities), income, prestige, length of training, advice
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41 191 from others (advice from family, friends, and other students), student debt,
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43 192 experience with the subject, working environment, personality, gender and job
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45 193 security. Personality and gender are common factors that affect the choice of
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47 194 subspecialty among medical students, but most of the relevant literature has not
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49 195 reported on the extent of these factors' influence. Moreover, the funnel plots were
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51 196 clearly asymmetrical with regard to experience with the subject, the working
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3 197 environment and job variety, indicating the existence of publication bias. Thus, the
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5 198 analysis of the remaining 12 influencing factors were shown in this paper. Studies
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7 199 assessed for influencing factors using questionnaires validated to medical students
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9 200 asking the extent of certain factors the studies investigated. Quality assessment scores
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11 201 for the included studies are listed in **Table 1**. None of the studies received a point for
12
13 202 the second AHRQ Quality Indicator, which requires studies to list the inclusion and
14
15 203 exclusion criteria for exposed and unexposed subjects (cases and controls) or refer to
16
17 204 previous publications, since no comparison studies were referenced in the analyzed
18
19 205 articles. For the remaining 10 criteria, 6 studies received 9 points, 8 studies received
20
21 206 8 points, 17 studies received 7 points, 33 studies received 6 points, 9 studies received
22
23 207 5 points and 2 studies received 4 points (scores for individual studies are presented in
24
25 208 **Table S1**).

209 **Primary Analysis**

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31 210 A meta-analysis was performed on the 12 influencing factors (**Table 2**): academic
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33 211 interests (**Fig. S2**), competencies (**Fig. S3**), controllable lifestyle or flexible work
34
35 212 schedule (**Fig. S4**), patient service orientation (**Fig. S5**), medical teachers or mentors
36
37 213 (**Fig. S6**), career opportunities (**Fig. S7**), workload or working hours (**Fig. S8**),
38
39 214 income (**Fig. S9**), length of training (**Fig. S10**), prestige (**Fig. S11**), advice from
40
41 215 others (**Fig. S12**) and student debt (**Fig. S13**). All the factors were significant with
42
43 216 evidence of between-study heterogeneity ($P < 0.0001$). A sensitivity analysis, in which
44
45 217 the meta-analysis was serially repeated after the exclusion of each study,
46
47 218 demonstrated that no individual study affected the overall extent of a factor's
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49 219 influence.

220 **Meta-regression and Subgroup Analysis**

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53 221 We performed meta-regression to identified the potential sources of heterogeneity

222 using common instructions when at least 5 studies were available and at least 2
223 studies were in each comparator subgroup (**Table 3**). Some of the heterogeneities
224 observed among the 12 factors can be partially explained by country, survey years,
225 specialty and sample size.

226 EOI values were further analyzed by subgroup (**Table S2**) according to world region
227 (**Fig. 1**) and survey year (**Fig. 2**). The EOI value of academic interests in developed
228 countries was higher than that in developing countries (79.66% [95% CI, 70.73%;
229 86.39% vs. 60.41% [95% CI, 43.44%; 75.19%]; $Q=3.51$ $P=0.02$). Conversely, a
230 lower EOI value of prestige was found in studies conducted in developed countries
231 than in developing countries (23.96% [95% CI, 19.20%; 29.47%] vs. 47.65% [95%
232 CI, 34.41%; 61.24%]; $Q=4.71$ $P=0.01$). No statistically significant subgroup
233 differences in the EOI values of the other influencing factors were noted between
234 developed countries and developing countries. In addition, no statistically significant
235 differences in the EOI values of the influencing factors were observed when
236 subgroup analysis was performed by survey year.

237 **Assessment of Publication Bias**

238 We generated a funnel plot with proportion as the abscissa and standard error as the
239 ordinate. A visual inspection of the funnel plots revealed minimal asymmetry among
240 the various influencing factors (**Fig. S14**), and the results were concentrated in the
241 narrow upper part of the graph. There was evidence of small study effect in the
242 meta-analysis of “patient service orientation” (Egger’s test $P=0.02$). However, the
243 trim-and-fill method showed the publication-bias corrected estimate remained
244 statistically significant (63.79%, 95% CI, 58.20%; 69.04%).

245 **Discussion**

246 **Implications**

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3 247 This systematic review and meta-analysis involved 75 studies with 882,209 medical
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5 248 students. Twelve influencing factors were analyzed. These factors can be classified
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7 249 into two categories: economic factors and non-economic factors. We found that the
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9 250 EOI of the economic factors, including income (34.70%) and student debt (15.33%),
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11 251 may not depend on the region's level of economic development. However, income
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13 252 remained a major influencing factor in the process of choosing a specialty or
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15 253 subspecialty. In the US, 15% of full-time family medicine physicians earned less than
16
17 254 \$100,000 in 2004, which is significantly less than the income earned by invasive
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19 255 cardiologists (median income=\$427,815), neurosurgeons (median income=\$211,094),
20
21 256 and orthopedists (median income=\$335,646).²⁷ This economic inequality made
22
23 257 family medicine less attractive to medical school graduates.²⁸ Benefits such as health
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25 258 insurance and tuition reimbursement have been shown to be the most common
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27 259 economic incentives used to attract applicants.²⁹
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30
31 260 The non-economic factors can be divided into individual factors, specialty-related
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33 261 factors and others. First, individual factors, including academic interest and
34
35 262 competencies, have a considerable impact on students' subspecialty choice, with EOI
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37 263 values of 75.29% and 55.15%, respectively. In addition, in the subgroup analysis,
38
39 264 although academic interests were less influential in developing countries than in
40
41 265 developed countries (79.66% [95% CI, 70.73%; 86.39% vs. 60.41% [95% CI,
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43 266 43.44%; 75.19%]; $Q=3.51$ $P=0.02$), they were still the most influential of the 12
44
45 267 factors regardless of regional economic level. These findings indicate that
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47 268 subspecialties with a shortage of manpower may attract more students by increasing
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49 269 students' interests and improving the quality of education. Previous studies indicated
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51 270 that early specialty exposure in medical education may arouse students' academic
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53 271 interest and improve their clinical competence.^{28 30} For example, an elective

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3 272 extracurricular program designed to facilitate early contact with family medicine
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5 273 physicians was found to significantly improve students' interest and clinical skills,
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7 274 especially communication skills, in family medicine.³¹ Furthermore, dispelling myths
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9 275 and espousing the positive aspects of a discipline may provide a better understanding
10
11 276 of certain specialties; this approach could also be effective in increasing students'
12
13 277 academic interest.³² For instance, family medicine is often considered a discipline
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15 278 that requires less professional skills and knowledge. This misconception demotivates
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17 279 students from choosing family medicine as their future career specialty, and this trend
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19 280 may eventually lead to a shortage of family physicians.³² Eliminating such prejudices
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21 281 may help students pay greater attention to the areas in short supply and restore their
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23 282 interests in other specialties.

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26 283 Second, the specialty-related factors included controllable lifestyle/flexible work
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28 284 schedule (EOI of 53.00%), career opportunities (EOI of 44.00%), workload (EOI of
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30 285 37.99%) and training length (EOI of 32.30%). Of these factors, lifestyle varied
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32 286 between different areas. Additionally, although certain specialties, such as general
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34 287 surgery, seem to have an adequate number of surgeons on a per capita basis in the US,
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36 288 there is still a poor geographic distribution within the surgical workforce according to
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38 289 the type of surgical practice.³³ The inflexible lifestyle is a common reason that
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40 290 students perceive surgery to be less attractive.³³ Reorganization of expected work
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42 291 hours within shared practices and the increased use of physician extenders and
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44 292 technologies such as electronic medical records may give physicians more flexibility
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46 293 in work schedules.³⁴ Moreover, providing promotion opportunities and shortening the
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48 294 length of training are possible strategies to recruit new staff in subspecialties that
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50 295 require a long period of post-graduate residency training, such as neurosurgery.³⁵
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52 296 Finally, other factors such as service orientation (EOI of 50.74%), medical teachers

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3 297 or mentors (EOI of 46.93%), prestige (EOI of 34.68%), and advice from others (EOI
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5 298 of 28.24%) also contribute to the decision-making process of medical students. For
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7 299 example, the desire to care for patients with end-stage diseases contributed to the
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9 300 decision to enter palliative medicine in 86% of the medical students.⁷ Additionally,
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11 301 exposure to mentors in a particular clinical field such as internal medicine has been
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13 302 strongly associated with medical students' choice of clinical field.³⁶ Moreover,
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15 303 improving the occupational prestige of areas such as family medicine, pathology, and
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17 304 radiology may help reshape the distribution of the workforce.^{30 37 38}

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20 305 In our study, several findings are especially noteworthy. First, interest was far more
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22 306 important than income in deciding subspecialty. In our study, interest was the
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24 307 top-ranked influencing factor (EOI of 75.29%) of subspecialty choice, while income
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26 308 was ranked lower (EOI of 34.70%). This finding argues against the possible default
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28 309 belief that raising physician's wages alone could solve the uneven distribution of
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30 310 clinicians among subspecialties. Our findings highlight that cultivating and
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32 311 stimulating students' professional interests may help improve the maldistribution of
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34 312 medical resources in a more efficient and cost-saving manner.

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37 313 Second, improving abilities in a certain subspecialty of interest can greatly affect
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39 314 medical students' professional choice. In our study, competencies ranked second in
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41 315 influence, which may reflect the impact of admission conditions on students' choice
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43 316 of subspecialty. Hence, to reduce the risk that students are restricted to the
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45 317 subspecialty of their interest due to a lack of personal skills, medical education
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47 318 should focus more on enhancing students' personal competencies in addition to their
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49 319 academic interests.

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52 320 Third, balancing medical resources is a complex process in practical terms, as the
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54 321 influencing factors are not mutually exclusive. The shortage of physicians in certain

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3 322 subspecialties may increase physician workload, resulting in less time for teaching.
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5 323 Hence, the quality of teaching cannot be guaranteed, and students may tend to avoid
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7 324 choosing these subspecialties, thus worsening the imbalance in the medical
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9 325 workforce. Additionally, some of the 12 factors identified are not amenable to
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11 326 practical interventions. For example, prestige cannot be immediately increased using
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13 327 interventional strategies.³⁷ Overall, effective strategies must be multi-pronged and
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15 328 incorporate several different aspects, and maldistribution in the workforce should not
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17 329 be tackled through a simple adjustment of one influencing factor.

330 **Interpretations of the results of this meta-analysis**

331 Our meta-regression stratified by the study-level characteristics found that country,
332 survey years, subspecialty and sample size may contribute to the heterogeneity
333 between studies. There was no significant difference in the sensitivity analysis, which
334 indicated that the results of the meta-analysis were convincing. The funnel plots and
335 Egger's tests revealed that most of the publication bias was small ($P>0.05$), except
336 for the meta-analysis of "patient service orientation". Moreover, the majority of the
337 studies collected in the database were from developed countries rather than
338 developing countries.

339 **Limitations**

340 Several limitations should be considered when interpreting the findings of this study.
341 First, the students involved in our study included medical students at different stages
342 of their medical education. Students' perception about different subspecialties may
343 change during medical training until the students applies for specialty training. For
344 example, compared to an intern, a freshman student may place greater emphasis on
345 income and prestige when considering a career choice.³⁹ A subgroup analysis
346 stratified by the stages of medical education and a secondary meta-analysis of

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3 347 longitudinal studies may better reflect changes in influencing factors and the extent
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5 348 of their influence over time. Second, our meta-analysis summarized the data from
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7 349 different geographic regions around the world, and the general conclusions may not
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9 350 be appropriate to guide policy development in each region. Enhanced effort is needed
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11 351 to develop specific intervention strategies according to the specific economic level,
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13 352 religious beliefs, healthcare system, educational system and endemic diseases of
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15 353 different countries and regions. Subgroup analysis stratified by organizational and
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17 354 medical training factors would provide more information of the factors influencing
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19 355 subspecialty choice among medical students. Third, the surveys in the various studies
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21 356 were also conducted using different methods. Most of the questionnaires used a
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23 357 Likert scale. Therefore, when we converted the results to a percentage representing
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25 358 the extent of a factor's influence, the Likert scale items were treated as interval
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27 359 data.⁴⁰⁻⁴² Consequently, there may have been differences in the conversion process.
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29 360 Finally, the analysis relied on aggregated published data. A multicenter prospective
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31 361 study would provide more accurate estimate of the influencing factors and the extent
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33 362 of their influence on medical students' choice of subspecialty.
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363 **Conclusion**

364 In conclusion, this systematic review and meta-analysis provided a summary
365 evaluation of 12 influencing factors and the extent of their influence on the choice of
366 subspecialty training among medical students. Understanding students' attitudes
367 toward their subspecialty decision-making process could provide the basis for
368 developing strategies to increase the attractiveness of subspecialties experiencing a
369 shortage of manpower, thereby balancing the distribution of medical recourses.

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4
5 371 and to research funding, coordinated the research and oversaw the project. Yahan
6
7 372 Yang, Jiawei Li and Xiaohang Wu contributed to data collection and interpretation,
8
9 373 and to data analysis. Jinghui Wang, Yi Zhu, Chuan Chen and Wangting Li contributed
10
11 374 to the design of the study. All authors contributed to the drafting and revision of the
12
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Table 1. Selected Characteristics of the 75 Studies Included in this Systematic Review and Meta-analysis

First Author, Year	Country	Survey years	Sample size	Average age	Men, No. (%)	Scores
Smith et al, ⁴³ 2015	UK	2012	2,978	NR	NR	6
Cochran et al, ⁴⁴ 2005	USA	2002	408	27.2	214 (52.45)	5
Hauer et al, ⁴⁵ 2008	USA	2007	1,177	NR	NR	6
Johnson et al, ⁴⁶ 2012	USA	2012	622	NR	NR	6
Kiolbassa et al, ⁴⁷ 2011	Germany	2010	1,114	24.1	408 (36.62)	5
Klingensmith et al, ⁴⁸ 2015	USA	2013	792	NR	539 (68.06)	6
Lee et al, ⁴⁹ 2012	USA	2012	100	NR	58 (58)	7
Macdonald et al, ⁵⁰ 2012	New Zealand	2011	134	NR	79 (58.96)	7
Parsa et al, ³⁹ 2010	Iran	2006-2007	137	27.34	49 (35.77)	7
Paiva et al, ⁵¹ 1982	USA	1982	144	NR	NR	6
Ni Chroinin et al, ⁵² 2013	UK	2009-2011	274	NR	112 (40.89)	7
Newton et al, ³⁴ 2005	USA	1998-2004	1,258	NR	642 (51.03)	8
Rogers et al, ⁵³ 1990	USA	1989	266	NR	205 (77.07)	6
Abendroth J et al, ⁵⁴ 2014	Germany	2007-2012	45	NR	14 (31)	7
Alawad et al, ⁵⁵ 2015	USA	2010-2011	45	NR	36 (80)	8
Azizzadeh et al, ⁵⁶ 2003	USA	2002	130	NR	NR	6
Celenza et al, ⁵⁷ 2012	Australia	2009	216	NR	121 (56.02)	8
Dolan-Evans et al, ⁵⁸ 2014	Australia	2013	419	NR	215 (51.31)	8
Boyd et al, ⁵⁹ 2009	USA	2005-2006	5,848	NR	2,982 (50.99)	8
Egerton et al, ⁶⁰ 1985	Ireland	1977-1981	134	30	82 (61.19)	6
Diderichsen et al, ⁶¹ 2013	Sweden	2006-2009	372	27	157 (42.20)	6
Ferrari et al, ⁶² 2013	Italy, UK	2009-2011	45	25	NR	9
Freire et al, ⁶³ 2011	Brazil	2006-2008	290	23	102 (35.17)	7
Buddeberg-Fischer et al, ⁶⁴ 2006	Switzerland	2001-2003	522	31.1	241 (46.17)	9
Dorsey et al, ⁶⁵ 2005	USA	2003	11,029	NR	4,964 (45.01)	6
Ekenze et al, ⁶⁶ 2013	Nigeria	2009-2010	96	25.9	NR	7
Barikani et al, ⁶⁷ 2012	Australia	2008-2009	49	21.7	NR	6
Bittaye et al, ⁶⁸ 2012	Gambia	2011	106	24.1	48 (45.28)	6
Bonura et al, ⁶⁹ 2016	USA	2015	590	NR	321 (54.40)	9
Al-Fouzan et al, ⁷⁰ 2012	Kuwait	2011-2012	144	NR	NR	7
AlKot et al, ⁷¹ 2015	Egypt	2013	451	21.8	NR	7
Borges et al, ⁷² 2009	USA	2001-2005	341	NR	NR	5
Budd et al, ⁷³ 2011	UK	2011	870	22	NR	7
Corrigan et al, ⁷⁴ 2007	Ireland	2007	222	NR	142 (63.96)	7
Davis et al, ⁷⁵ 2016	UK	2016	173	NR	76 (43.93)	7
Deutsch et al, ⁷⁶ 2015	Germany	2011	659	27.9	NR	8
Gardner et al, ⁷⁷ 2014	Australia	1993-2005	631	NR	NR	7
Dias et al, ⁷⁸ 2013	UK	2013	495	NR	438 (88.48)	5
Goltz et al, ⁷⁹ 2013	USA	2012	102	24.5	34 (33.33)	6
Gupta et al, ⁸⁰ 2013	India	2013	243	NR	179 (73.36)	6

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3		Hanzlick et al, ⁸¹ 2008	USA	2006	161	NR	NR	6
4		Harris et al, ⁸² 2005	USA	1991-2002	104	NR	53 (50.96)	6
5		Hauer et al, ⁸³ 2008	USA	2008	80	NR	NR	6
6		Labiris et al, ⁸⁴ 2014	Greece	2014	111	23.6	55 (49.54)	6
7		Lambert et al, ⁸⁵ 2008	UK	2007	17,393	NR	NR	6
8		Shah et al, ⁸⁶ 2012	USA	2011	892	NR	NR	6
9		Lefevre et al, ⁸⁷ 2010	USA	2008	1,555	NR	589 (37.88)	6
10		Vicente et al, ⁸⁸ 2013	Chile	2013	30	NR	NR	6
11		Wiesenfeld et al, ⁸⁹ 2014	Canada	2013	60	NR	NR	7
12		Lam et al, ⁹⁰ 2016	Hong Kong	2015	228	23	NR	9
13		Hartung et al, ⁹¹ 2005	USA	2004	192	20.59	74 (38.54)	4
14		Girasek et al, ⁹² 2011	Hungary	2011	536	NR	NR	5
15		Zuccato et al, ⁹³ 2015	Canada	2012	37	NR	24 (65)	6
16		Wilbanks et al, ⁹⁴ 2015	USA	2011-2013	29,227	NR	15,164 (51.99)	9
17		West et al, ⁹⁵ 2009	USA	2005-2007	14,890	NR	8,700 (58.43)	6
18		Watmough et al, ⁹⁶ 2007	UK	2005	116	NR	66 (56.90)	4
19		Thakur et al, ⁹⁷ 2001	USA	2001	56	NR	53 (95)	8
20		Scott et al, ⁹⁸ 2011	Canada	2002-2004	1,542	NR	NR	6
21		Schnuth et al, ⁹⁹ 2003	USA	2002	203	NR	72 (53.47)	6
22		Richards et al, ¹⁰⁰ 2009	UK	2009	150	NR	108 (72.00)	5
23		Reed et al, ¹⁰¹ 2009	USA	2008	2,022	NR	1,354 (66.96)	9
24		de Souza et al, ¹⁰² 2015	Portugal	2012	1,303	NR	NR	7
25		Pikoulis et al, ¹⁰³ 2010	Greece	2006-2007	87	NR	NR	6
26		Ozer et al, ¹⁰⁴ 2015	Turkey	2013	98	27.7	26 (26.53)	6
27		Noble et al, ¹⁰⁵ 2004	Canada	2004	21,296	NR	NR	8
28		Noble et al, ¹⁰⁶ 2010	Canada	2007	120	NR	NR	5
29		Newton et al, ¹⁰⁷ 2005	USA	2004	1,286	NR	NR	6
30		Moore et al, ¹⁰⁸ 2012	USA	2011	337	26	179 (53.12)	6
31		Momen et al, ¹⁰⁹ 2015	Iran	2014-2015	38	35.6	11 (29)	6
32		Mehmood et al, ¹¹⁰ 2012	Saudi Arabia	2012	550	NR	348 (63.27)	6
33		Loriot et al, ¹¹¹ 2010	France	2007	44	NR	17 (39)	7
34		Lefevre et al, ¹¹² 2010	France	2008	522	23.8	198 (37.93)	7
35		Vo et al, ¹¹³ 2017	Canada	2017	90	22.5	52 (57.78)	5
36		Grasreiner et al, ¹¹⁴ 2018	Germany	2014-2016	181	24	33 (18.10)	6
37		Alkhaman et al, ¹¹⁵ 2018	Saudi Arabia	2017	436	NA	250 (57.00)	5
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42	742	Footnotes: scores: quality score of the AHRQ scale.						
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Table 2. Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty

Factor	No. of studies	Total no. of participants	EOI value (%)	95% CI of EOI		Cochran's <i>Q</i>	<i>I</i> -square (%)	<i>Tau</i> -square	<i>P</i> -Value
				Lower	Upper				
				Academic interests	38				
Competencies	17	76,515	55.15	33.63	74.90	23572.74	99.90	3.44	<0.0001
Controllable lifestyle or flexible work schedule	44	101,001	53.00	47.90	58.03	8624.46	99.50	0.45	<0.0001
Patient service orientation	37	46,572	50.04	44.65	55.43	2668.79	98.70	0.41	<0.0001
Medical teachers or Career opportunities	32	85,071	46.93	37.77	56.30	15216.32	99.80	1.14	<0.0001
Workload or working hours	38	81,923	44.00	32.26	48.78	13553.20	99.70	1.15	<0.0001
Income	20	22,051	37.99	29.59	47.19	584.81	98.30	0.69	<0.0001
Length of training	50	109,791	34.70	28.36	41.62	16952.48	99.70	1.09	<0.0001
Prestige	18	42,046	32.30	27.61	37.37	917.21	98.10	0.20	<0.0001
Advice from others	26	30,629	31.17	26.32	37.69	1464.67	98.30	0.52	<0.0001
Student debt	18	82,692	28.24	22.26	34.23	7679.73	99.80	0.02	<0.0001
	8	38,917	15.33	10.96	21.03	574.81	98.80	0.27	<0.0001

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Table 3. Meta-regression of the EOI Value Stratified by Study-level Characteristics

Factor		estimate	95 CI% of estimate		P-Value
			Lower	Upper	
Academic interests	Country	-0.2314	-1.1575	0.6946	0.6302
	Survey years	0.3811	-0.3580	1.1202	0.2711
	Specialty	-0.4892	-1.5345	0.5562	0.4008
	Sample size	0.2362	-0.5488	1.0212	0.6537
Competencies	Country	0.6946	-1.1461	0.8938	0.8376
	Survey years	-1.0418	-2.0950	0.0114	0.0151
	Specialty	0.0904	-1.5786	1.7594	0.9398
	Sample size	-0.5720	-1.8606	0.7166	0.5823
Controllable lifestyle or flexible work schedule	Country	-0.1261	-1.1461	0.8938	0.9614
	Survey years	-0.0001	-0.4052	0.4051	0.9822
	Specialty	-0.8989	-1.4979	-0.3000	0.0035
	Sample size	-0.0518	-0.4396	0.3361	0.7203
Patient service orientation	Country	-0.6238	-1.3118	0.0642	0.0833
	Survey years	-0.0414	-0.6912	0.6083	0.8524
	Specialty	-1.5982	-2.5227	-0.6737	0.0010
	Sample size	-0.1157	-0.7473	0.5159	0.6358
Medical teachers or mentors	Country	0.7395	0.3117	1.1674	0.0007
	Survey years	0.1133	-0.3580	0.5845	0.6376
	Specialty	0.0605	-0.4441	0.5652	0.8141
	Sample size	-0.1202	-0.5567	0.3163	0.5894
Career opportunities	Country	0.1075	-0.7030	0.9179	0.5828
	Survey years	0.3284	-0.3913	1.0480	0.7546
	Specialty	-0.9292	-1.8015	-0.0570	0.0077
	Sample size	0.3654	0.1156	1.5478	0.0081
Workload or working hours	Country	-0.4535	-1.5086	0.6016	0.3981
	Survey years	0.4624	-0.5417	1.4665	0.3922
	Specialty	-0.9878	-2.1727	0.1972	0.1070
	Sample size	0.0982	-0.8589	1.0553	0.8205
Income	Country	0.1058	-0.4665	0.6781	0.7390
	Survey years	0.0999	-0.4379	0.6377	0.8774
	Specialty	-0.6457	-1.3267	0.0352	0.0480
	Sample size	0.0523	-0.4826	0.5872	0.6786
Length of training	Country	-0.1559	-1.2782	0.9664	0.7854
	Survey years	-0.2158	-1.4089	0.9772	0.7229
	Specialty	0.3959	-0.9585	1.7502	0.5667
	Sample size	0.1565	-0.6631	0.9761	0.7082
Prestige	Country	-0.3346	-1.0799	0.4106	0.3485
	Survey years	-0.4513	-1.1378	0.2352	0.0950
	Specialty	-1.0112	-1.8980	-0.1244	0.0172
	Sample size	0.0355	-0.6013	0.6723	0.5214
Advice from others	Country	-0.0097	-0.0722	0.0529	0.9328
	Survey years	-0.0861	-0.1471	-0.0251	0.0057

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	Specialty	-0.2017	-0.2790	-0.1244	<0.0001
	Sample size	0.2125	0.1309	0.2941	<0.0001
	Country	2.7853	2.0544	3.5162	0.0001
Student debt	Survey years	-0.1567	-0.6707	0.3573	0.5502
	Sample size	-0.5248	-1.0108	-0.0388	0.0343

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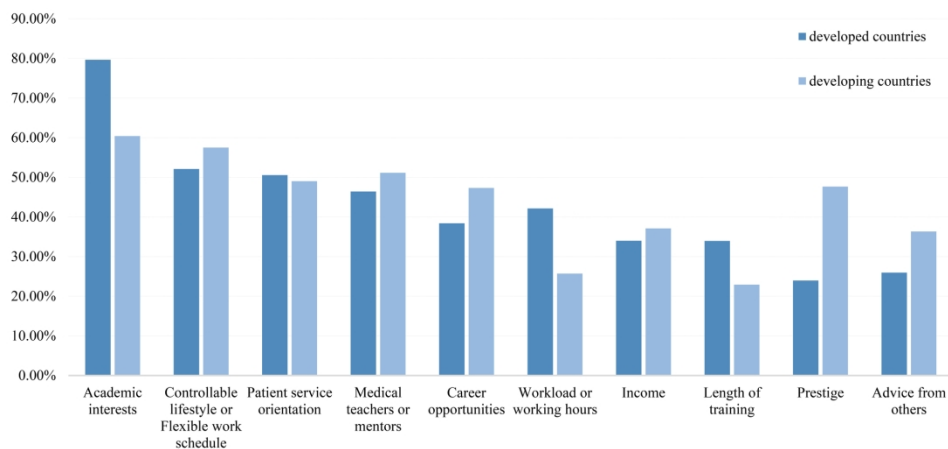


Figure 1. Bar Graph of the Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty Stratified by Region.

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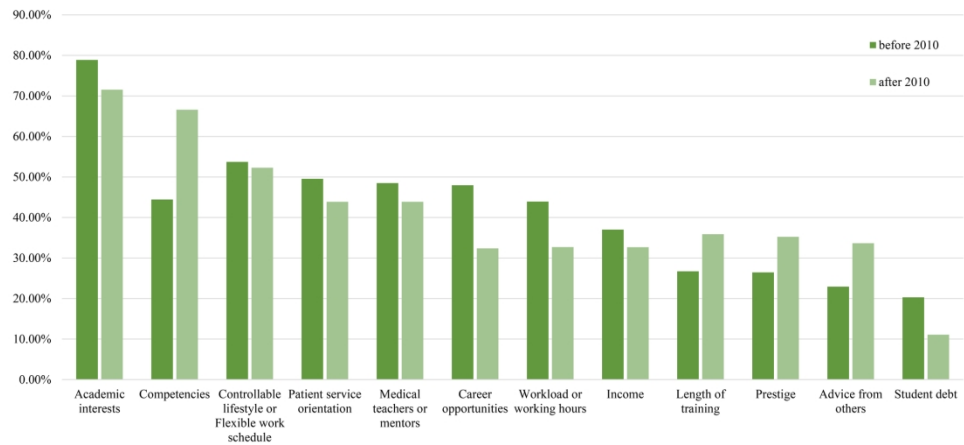


Figure 2. Bar Graph of the Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty Stratified by Survey Year.

190x107mm (300 x 300 DPI)

SI Methods. Search strategy used in the current systematic review and meta-analysis.

Medical Students

1. Students, Medical [Mesh]

2. Medical students

3. Medical student

4. Student, Medical

5. OR / 1 – 4

13. Cross sectional study

14. Cross sectional study [Publication Type]

15. Cross sectional study [Mesh Terms]

16. Systematic review

17. Systematic review [Publication Type]

18. Systematic review [Mesh Terms]

Subspecialty Choice

6. Career choices

7. Choice, Career

8. Choices career

9. Specialties

10. Sub-specialties

11. Sub-discipline

12. OR / 6 – 11

19. Meta-analysis [Title/Abstract]

20. Meta-analysis [Mesh Terms]

21. Meta-analysis [Publication Type]

22. OR / 12 – 21

Factors

23. Factors

Combined search

Study design

23. #5 AND #12AND #22 AND #2

Abbreviations: MeSH, Medical Subject Heading in PubMed

Table S1. Quality assessment of the included studies

Quality assessment criteria	1	2	3	4	5	6	7	8	9	10	11	Scores
1 Smith et al, ⁴¹ 2015	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
2 Cochran et al, ⁴² 2005	Y	U	Y	Y	N	Y	N	Y	N	N	N	5
3 Hauer et al, ⁴³ 2008	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
4 Johnson et al, ⁴⁴ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
5 Kiobassa et al, ⁴⁵ 2011	Y	U	Y	Y	N	Y	N	Y	N	N	N	5
6 Klingensmith et al, ⁴⁶ 2015	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
7 Lee et al, ⁴⁷ 2012	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
8 Macdonald et al, ⁴⁸ 2012	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
9 Parsa et al, ³⁷ 2010	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
10 Paiva et al, ⁴⁹ 1982	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
11 Ni Chroinin et al, ⁵⁰ 2013	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
12 Newton et al, ³² 2005	Y	U	Y	Y	Y	Y	Y	Y	N	Y	N	8
13 Rogers et al, ⁵¹ 1990	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
14 Abendroth J et al, ⁵² 2014	Y	U	Y	Y	N	Y	N	Y	N	Y	Y	7
15 Alawad et al, ⁵³ 2015	Y	U	Y	Y	N	Y	Y	Y	Y	Y	N	8
16 Azizzadeh et al, ⁵⁴ 2003	Y	U	Y	Y	Y	Y	N	N	N	Y	N	6
17 Celenza et al, ⁵⁵ 2012	Y	U	Y	Y	Y	Y	Y	N	Y	Y	N	8
18 Dolan-Evans et al, ⁵⁶ 2014	Y	U	Y	Y	Y	Y	N	Y	N	Y	Y	8
19 Boyd et al, ⁵⁷ 2009	Y	U	Y	Y	Y	Y	Y	Y	N	Y	N	8
20 Egerton et al, ⁵⁸ 1985	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
21 Diderichsen et al, ⁵⁹ 2013	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
22 Ferrari et al, ⁶⁰ 2013	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	N	9
23 Freire et al, ⁶¹ 2011	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
24 Buddeberg-Fischer et al, ⁶² 2006	Y	U	Y	Y	N	Y	Y	Y	Y	Y	Y	9
25 Dorsey et al, ⁶³ 2005	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
26 Ekenze et al, ⁶⁴ 2013	Y	U	Y	Y	Y	Y	Y	N	N	Y	N	7
27 Barikani et al, ⁶⁵ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
28 Bittaye et al, ⁶⁶ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
39 Bonura et al, ⁶⁷ 2016	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	N	9
30 Al-Fouzan et al, ⁶⁸ 2012	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
31 AlKot et al, ⁶⁹ 2015	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
32 Borges et al, ⁷⁰ 2009	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
33 Budd et al, ⁷¹ 2011	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
34 Corrigan et al, ⁷² 2007	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
35 Davis et al, ⁷³ 2016	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
36 Deutsch et al, ⁷⁴ 2015	Y	U	Y	Y	Y	Y	N	Y	Y	Y	N	8
37 Gardner et al, ⁷⁵ 2014	Y	U	Y	Y	N	Y	N	Y	N	Y	N	7
38 Dias et al, ⁷⁶ 2013	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
39 Goltz et al, ⁷⁷ 2013	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
40 Gupta et al, ⁷⁸ 2013	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
41 Hanzlick et al, ⁷⁹ 2008	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
42 Harris et al, ⁸⁰ 2005	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
43 Hauer et al, ⁸¹ 2008	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
44 Labiris et al, ⁸² 2014	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
45 Lambert et al, ⁸³ 2008	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
46 Shah et al, ⁸⁴ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
47 Lefevre et al, ⁸⁵ 2010	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
48 Vicente et al, ⁸⁶ 2013	Y	U	Y	Y	N	N	Y	N	Y	Y	N	6
49 Wiesenfeld et al, ⁸⁷ 2014	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
50 Lam et al, ⁸⁸ 2016	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	N	9
51 Hartung et al, ⁸⁹ 2005	Y	U	Y	Y	N	Y	N	N	N	N	N	4
52 Girasek et al, ⁹⁰ 2011	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
53 Zuccato et al, ⁹¹ 2015	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
54 Wilbanks et al, ⁹² 2015	Y	U	Y	Y	N	Y	Y	Y	Y	Y	Y	9
55 West et al, ⁹³ 2009	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
56 Watmough et al, ⁹⁴ 2007	Y	U	Y	Y	N	N	N	N	N	Y	N	4
57 Thakur et al, ⁹⁵ 2001	Y	U	Y	Y	Y	Y	Y	N	Y	Y	N	8
58 Scott et al, ⁹⁶ 2011	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
59 Schnuth et al, ⁹⁷ 2003	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
60 Richards et al, ⁹⁸ 2009	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
61 Reed et al, ⁹⁹ 2009	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	N	9
62 de Souza et al, ¹⁰⁰ 2015	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
63 Pikoulis et al, ¹⁰¹ 2010	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
64 Ozer et al, ¹⁰² 2015	Y	U	Y	Y	N	N	Y	N	Y	Y	N	6
65 Noble et al, ¹⁰³ 2004	Y	U	Y	Y	Y	Y	Y	Y	N	Y	N	8
66 Noble et al, ¹⁰⁴ 2010	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
67 Newton et al, ¹⁰⁵ 2005	Y	U	Y	Y	N	Y	Y	N	N	Y	N	6
68 Moore et al, ¹⁰⁶ 2012	Y	U	Y	Y	Y	Y	N	Y	N	N	N	6
69 Momen et al, ¹⁰⁷ 2015	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
70 Mehmood et al, ¹⁰⁸ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
71 Loriot et al, ¹⁰⁹ 2010	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
72 Lefevre et al, ¹¹⁰ 2010	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
73 Vo et al, ¹¹¹ 2017	Y	U	Y	Y	Y	N	N	N	N	Y	N	5
74 Grasreiner et al, ¹¹² 2018	Y	U	Y	Y	Y	Y	N	N	N	Y	N	6
75 Alkhannen et al, ¹¹³ 2018	Y	U	Y	Y	N	N	Y	N	N	Y	N	5

Quality assessment criteria in detail

1. Define the source of information (survey, record review).
2. List the inclusion and exclusion criteria for the exposed and unexposed subjects (cases and controls) or refer to previous publications.
3. Indicate the time period used for identifying patients.
4. Indicate whether the subjects were consecutive if not population-based.
5. Indicate whether the evaluators of the subjective components of the study were masked to the other aspects of participants' status.
6. Describe any assessments undertaken for quality assurance purposes (e.g., test/retest of primary outcome measurements)
7. Explain any patient exclusion from the analyses.
8. Describe how confounding was assessed and/or controlled.
9. If applicable, explain how missing data were handled in the analysis.
10. Summarize the patient response rates and the completeness of the data collection.
11. Clarify what follow-up, if any, was expected and the percentage of patients with incomplete data or follow-up.

“Y”: Yes; “N”: No; “U”: Unclear.

Table S2. Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty Stratified by Region and Survey Year.

Factor		No. of studies	Total no. of participants	Extent of influence (%)	95 CI% of EOI value		<i>I-square</i> (%)	<i>P</i> -Value	<i>Q</i> -Value		
					Lower	Upper					
Academic interest	developed	28	80,000	79.66	70.73	86.39	99.8	0.02	3.51		
	developing	10	2,366	60.41	43.44	75.19	98.0				
	before 2010	29	44,174	78.88	69.04	86.22	99.7	0.40	1.21		
	after 2010	9	38,192	71.54	57.66	82.27	99.6				
Competencies	before 2010	9	43,134	44.40	29.11	60.83	99.8	0.21	1.86		
	after 2010	8	33,381	66.60	34.48	88.31	99.8				
Controllable lifestyle or flexible work schedule	developed	37	100,980	52.11	46.52	57.65	99.6	0.63	0.68		
	developing	7	2,017	57.50	45.81	68.41	95.9				
	before 2010	22	62,945	53.72	47.48	59.84	99.4			0.97	0.05
after 2010	22	40,056	52.29	43.51	60.93	99.2					
Patient service orientation	developed	27	44,235	50.56	44.68	56.42	98.8	0.74	0.48		
	developing	10	2,337	49.02	31.62	66.67	98.1				
	before 2010	18	40,997	49.56	43.29	55.84	98.8			0.70	0.54
	after 2010	19	5,579	43.87	38.62	63.80	98.3				
Medical teachers or mentors	developed	28	84,076	46.43	36.63	56.52	99.8	0.73	0.48		
	developing	4	995	51.14	33.97	68.04	95.4				
	before 2010	21	49,654	48.48	36.93	60.19	99.8			0.70	0.54
	after 2010	11	35,417	43.87	27.94	61.18	99.7				
Career opportunities	developed	31	79,867	38.41	29.61	48.04	99.8	0.60	0.74		
	developing	7	2,056	47.32	30.38	64.91	98.1				
	before 2010	20	43,417	47.97	33.54	62.74	99.8			0.24	1.68
	after 2010	18	38,506	32.38	21.68	45.31	99.5				
Workload or working hours	developed	15	20,970	42.14	31.35	53.72	98.6	0.34	1.39		
	developing	5	1,081	25.72	13.29	43.88	95.3				
	before 2010	9	19,456	43.93	29.43	59.54	98.8			0.41	1.21
	after 2010	11	2,595	32.70	29.43	59.54	97.4				
Income	developed	39	107,091	34.01	26.89	41.93	99.8	0.84	0.29		
	developing	11	2,700	37.11	27.06	48.41	96.4				
	before 2010	25	68,714	37.01	25.95	49.62	99.8			0.41	1.18
	after 2010	25	41,077	32.67	26.04	40.07	98.9				
Length of training	developed	15	41,246	33.95	28.72	39.60	98.4	0.31	1.48		
	developing	3	800	22.92	10.94	41.85	94.0				
	before 2010	7	8,811	26.72	15.89	41.29	98.9			0.28	1.59
	after 2010	11	33,234	35.87	29.67	42.59	96.9				
Prestige	developed	17	27,987	23.96	19.20	29.47	97.3	0.01	4.71		
	developing	9	2,642	47.65	34.41	61.24	97.6				
	before 2010	12	25,542	26.46	20.78	33.03	96.7			0.25	1.67
	after 2010	14	5,087	35.22	24.70	47.40	98.3				
Advice from others	developed	14	81,205	25.95	19.27	32.64	99.8	0.36	1.33		
	developing	4	1,487	36.34	18.91	53.77	98.1				
	before 2010	10	48,319	22.93	17.85	28.01	99.5			0.31	1.47
	after 2010	8	34,373	33.65	25.12	42.18	99.1				
Student debt	before 2010	5	6,610	20.29	15.86	25.57	81.8	0.69	0.59		
	after 2010	3	32,307	11.08	1.58	49.08	99.6				

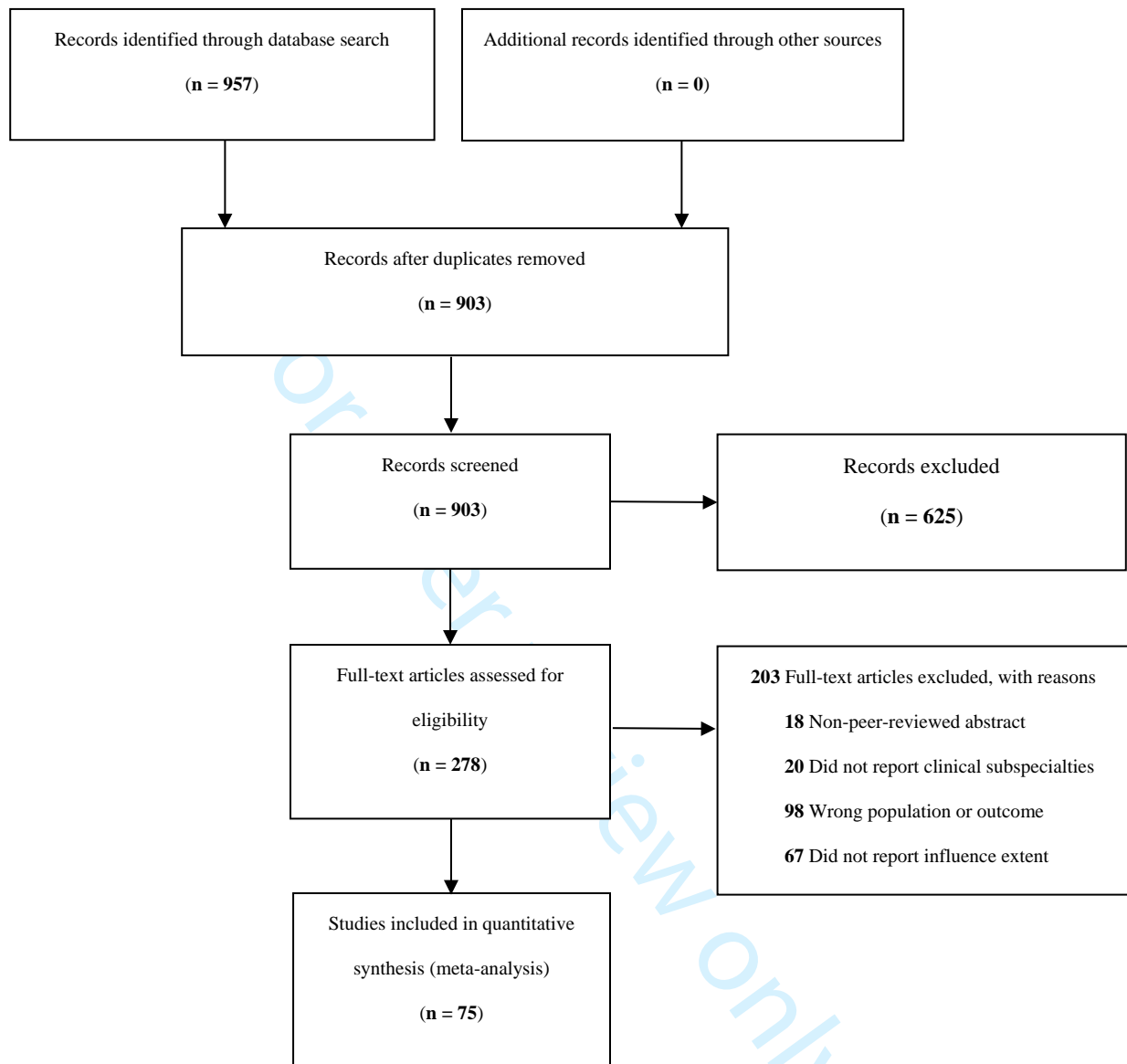
Figure S1. Flow Diagram of the Study Inclusion.

Figure S2. Forest Plot of “Academic Interest”.

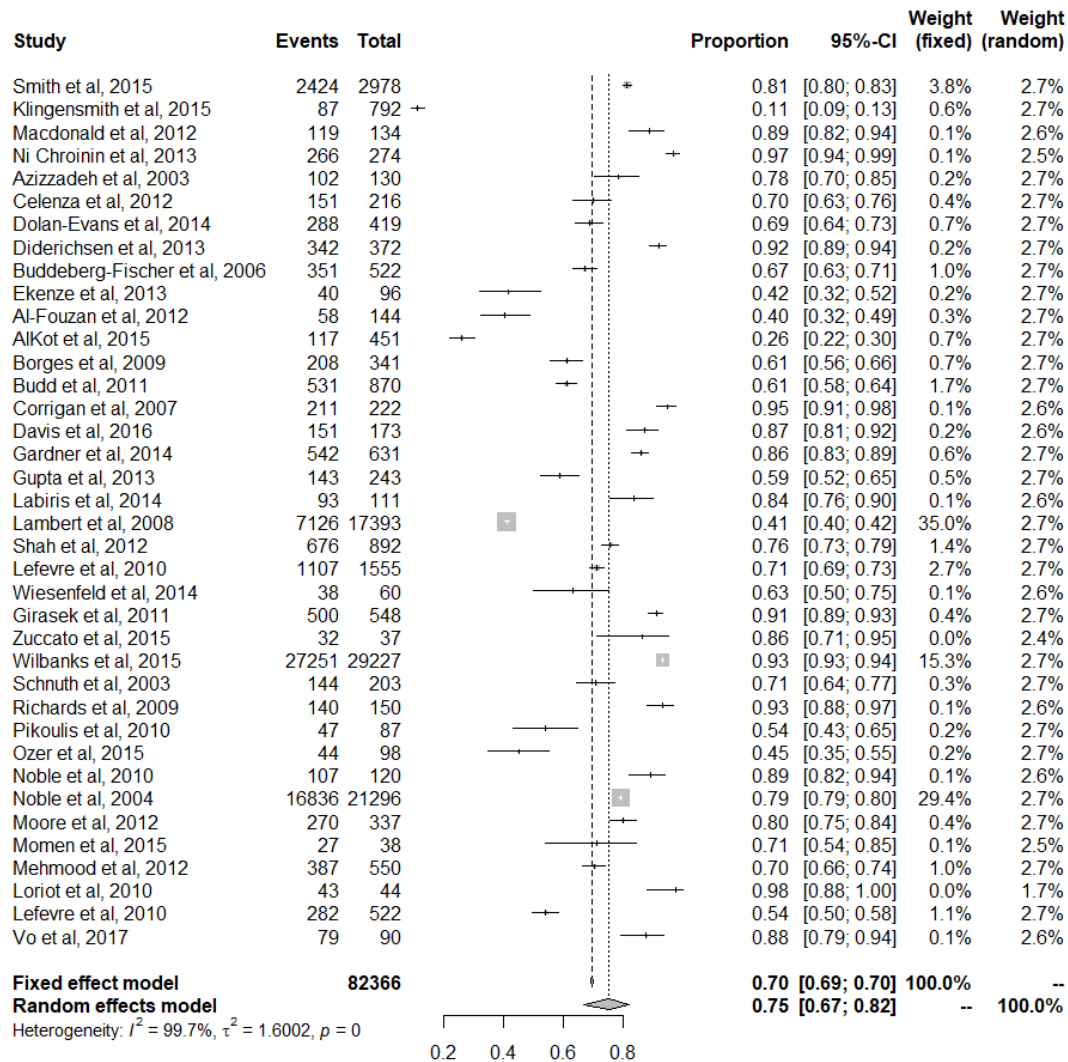
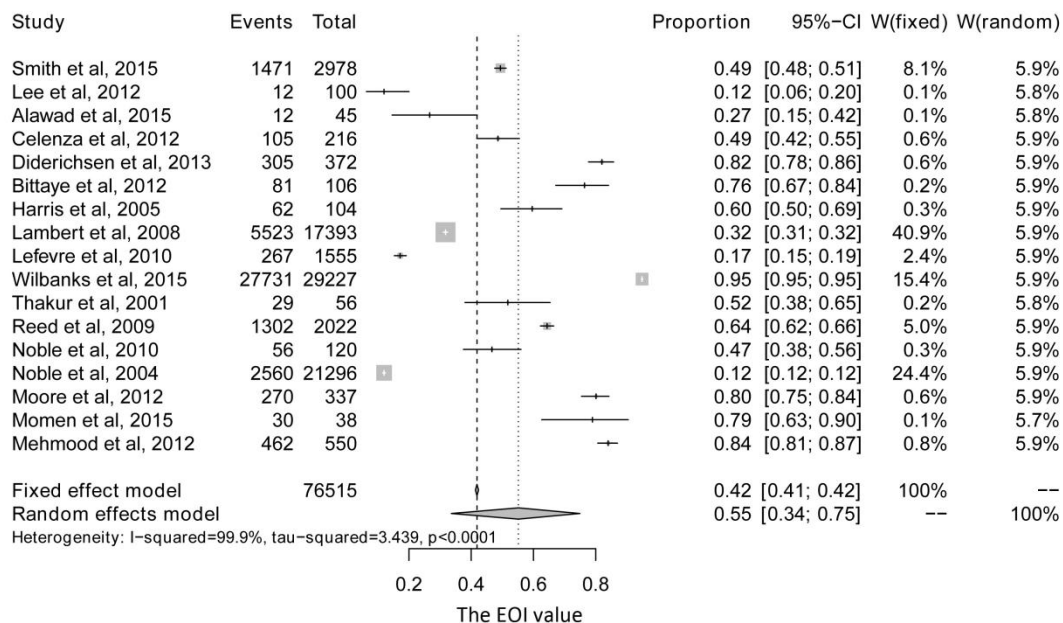


Figure S3. Forest Plot of “Competencies”.



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Figure S4. Forest Plot of “Controllable Lifestyle or Flexible Work Schedule”.

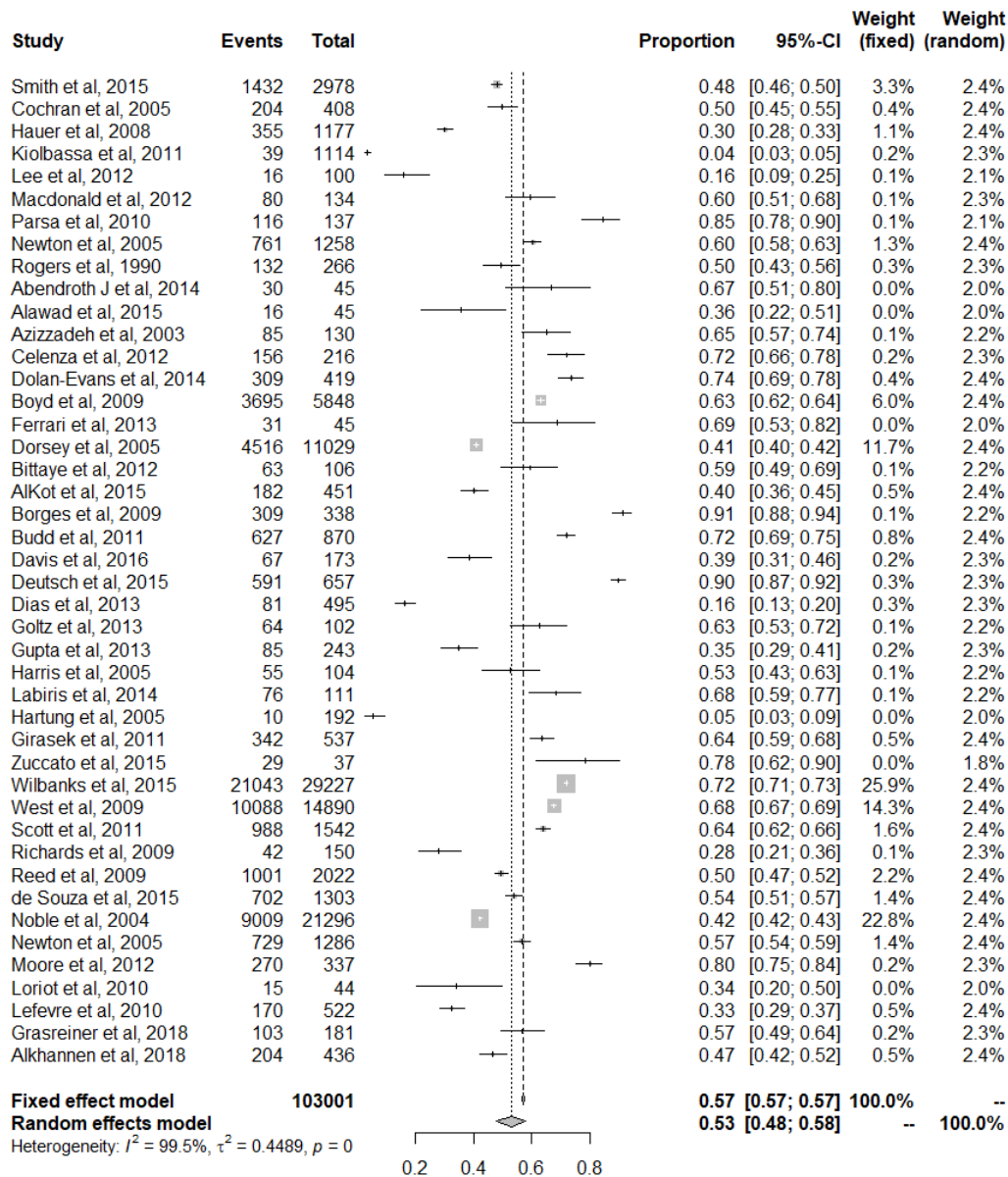


Figure S5. Forest Plot of “Patient Service Orientation”.

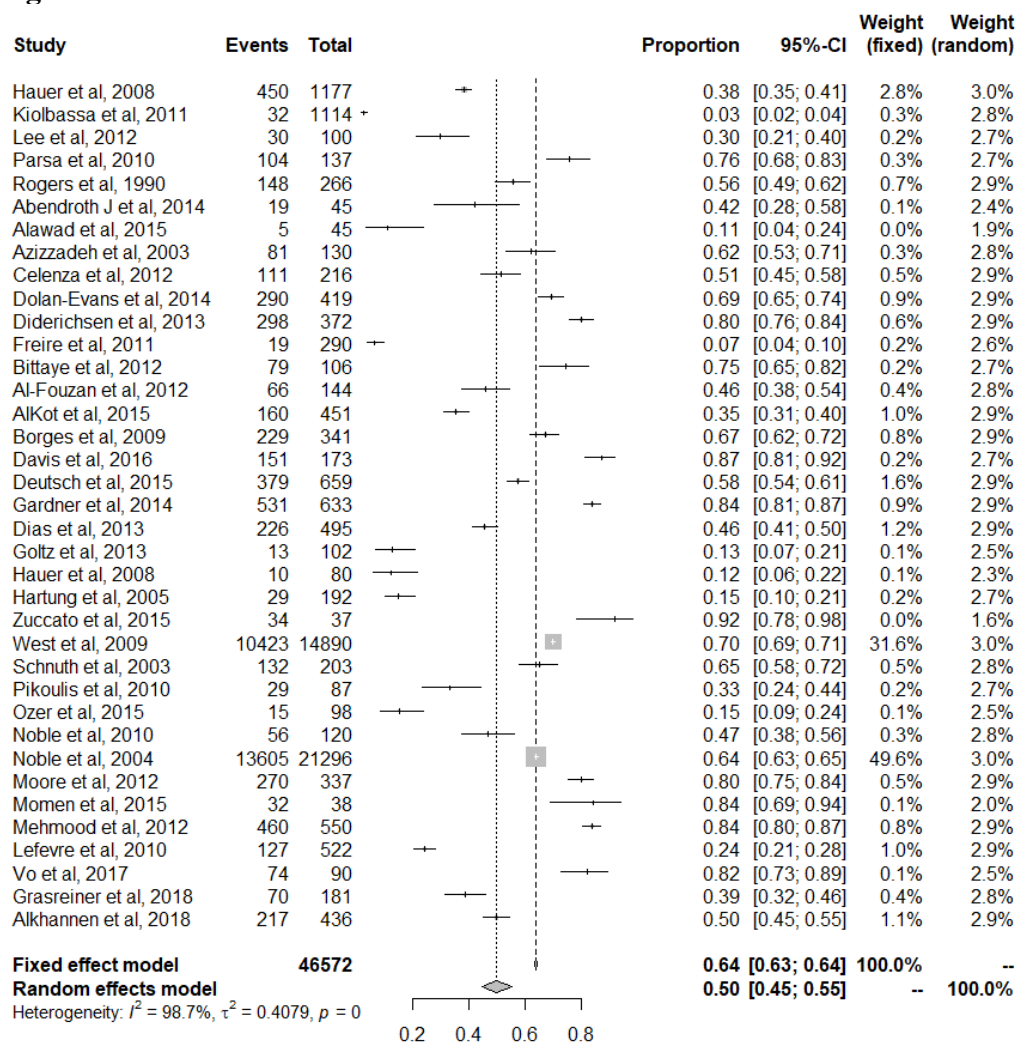


Figure S6. Forest Plot of “Medical Teachers or Mentors”.

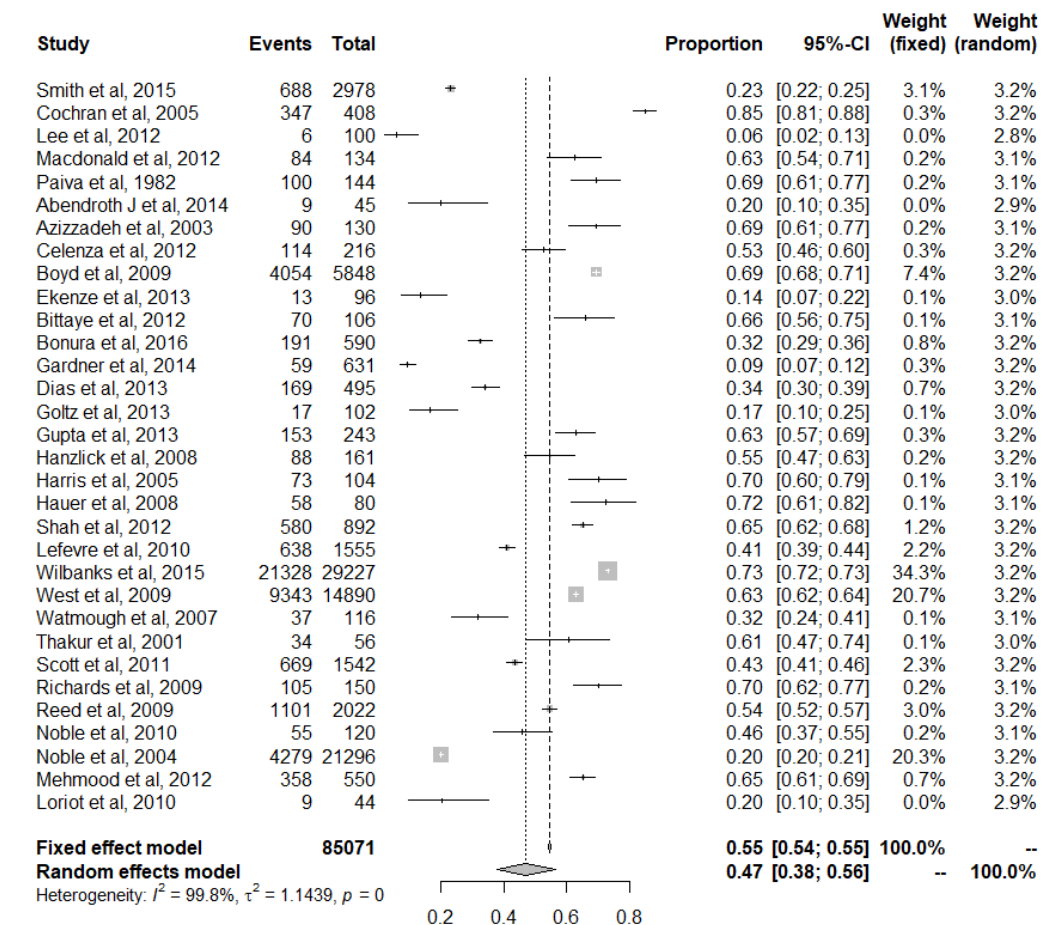


Figure S7. Forest Plot of “Career Opportunities”.

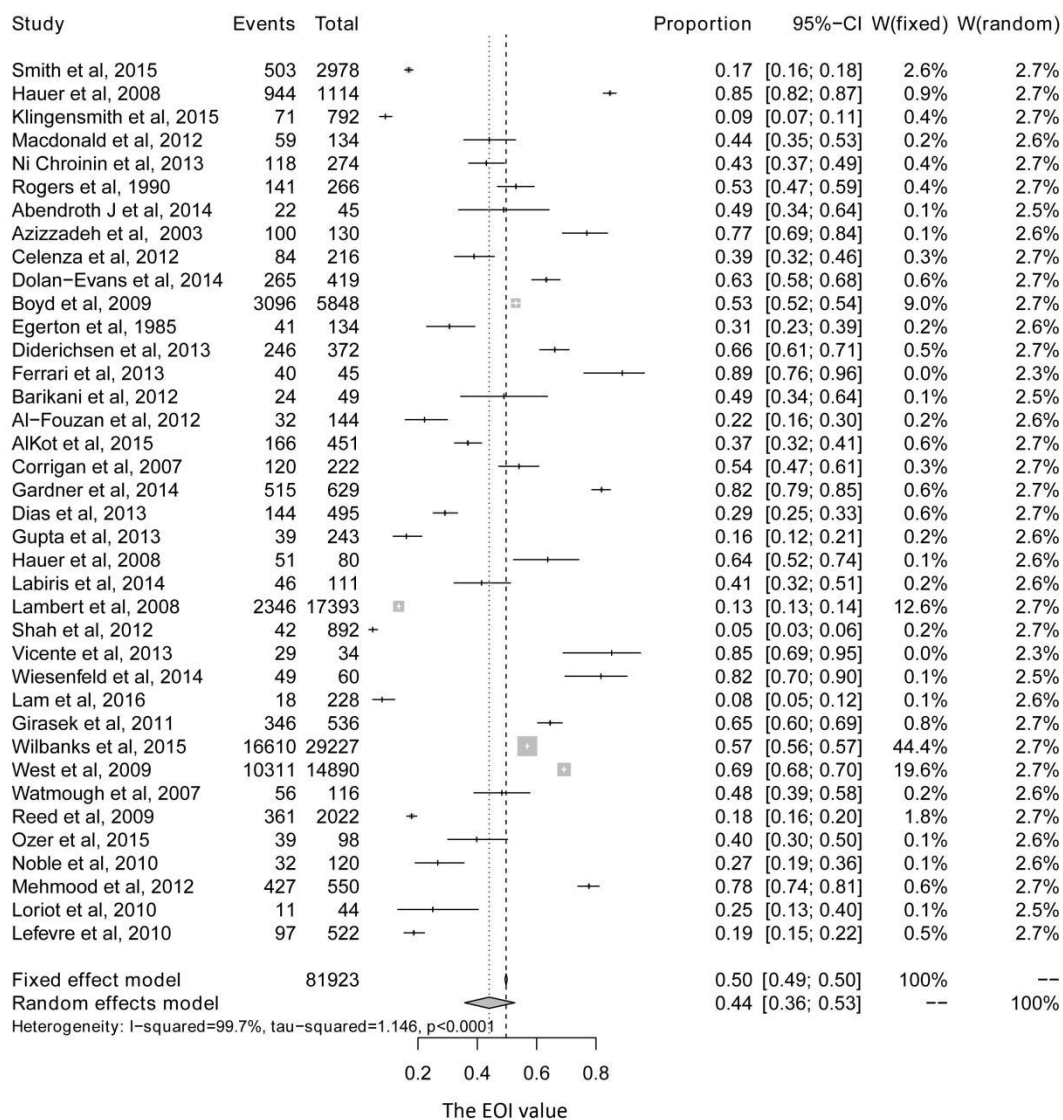


Figure S8. Forest Plot of “Workload or Working Hours”.

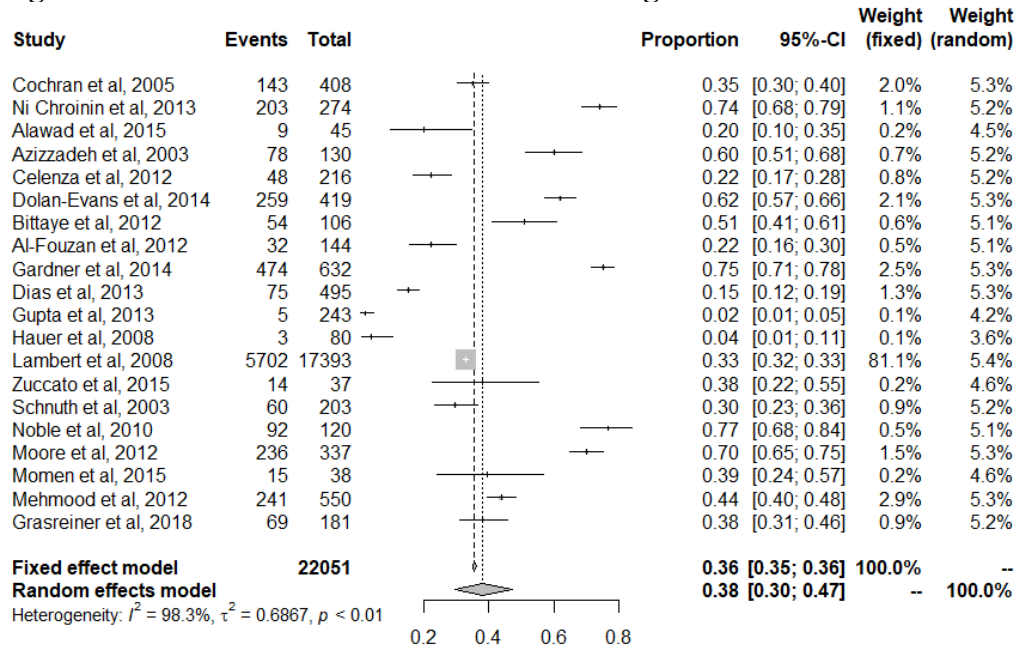


Figure S9. Forest Plot of “Income”.

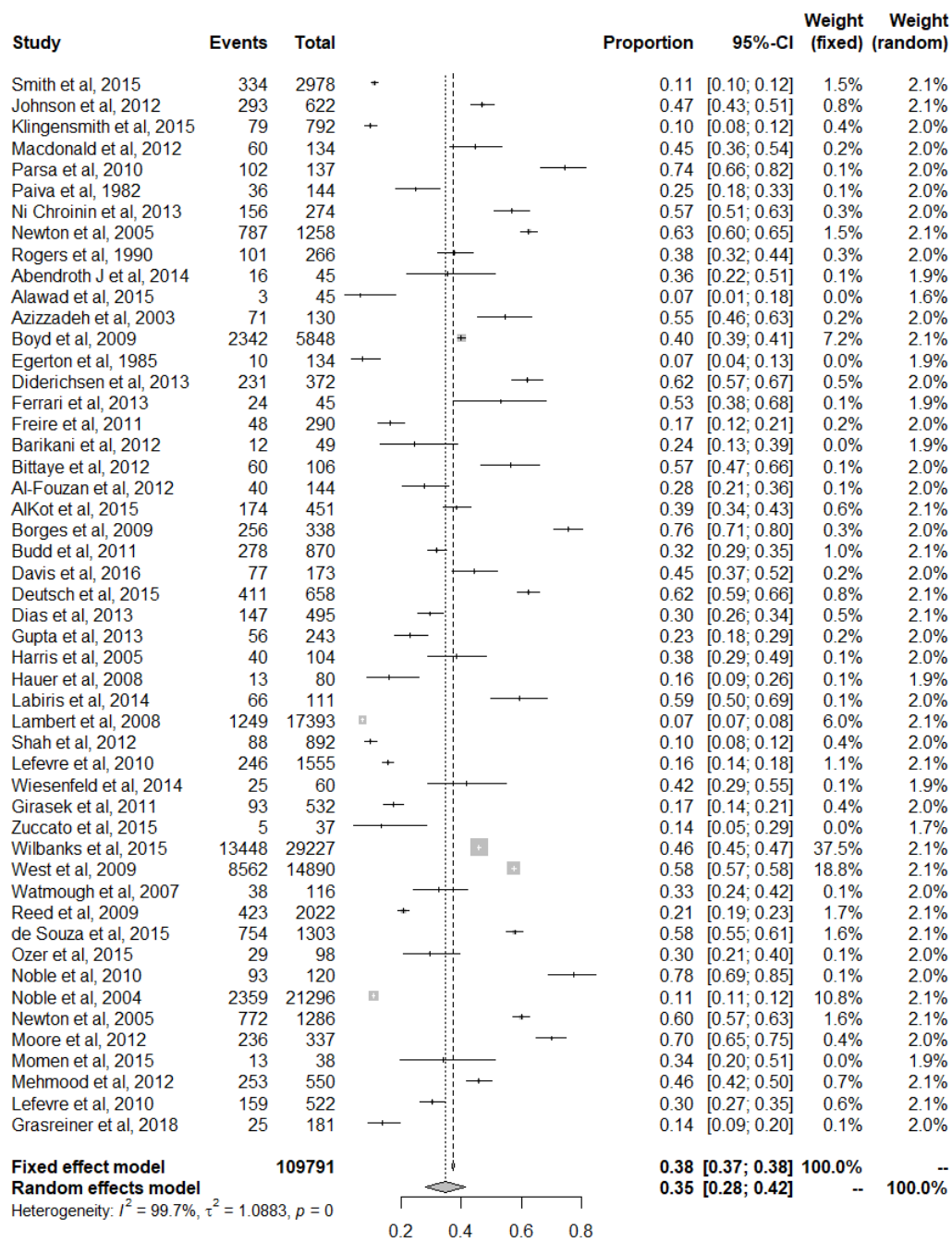
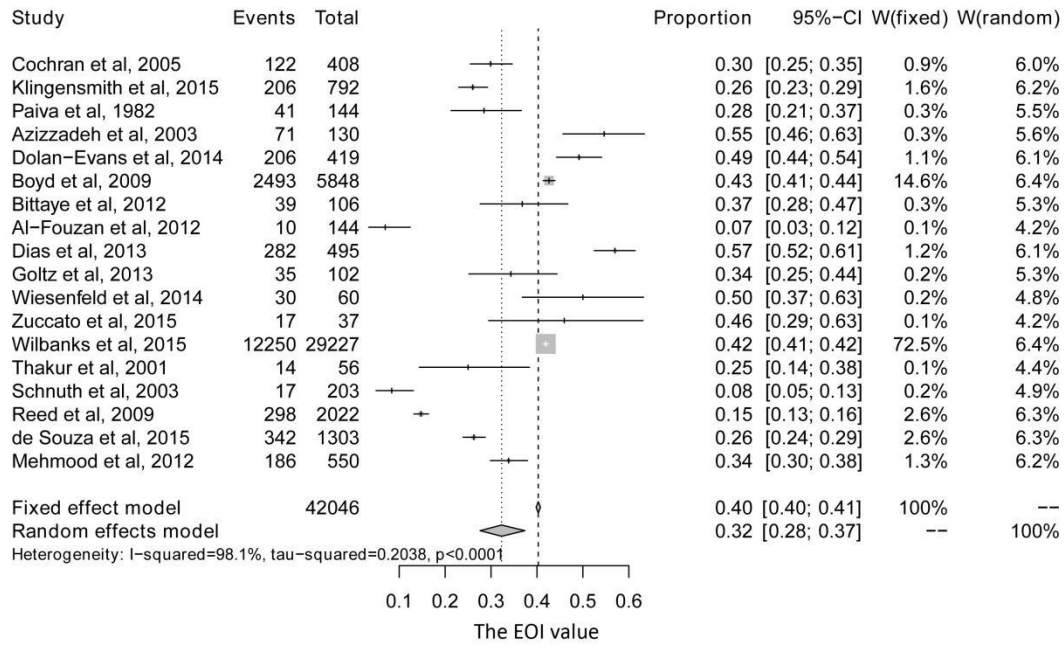
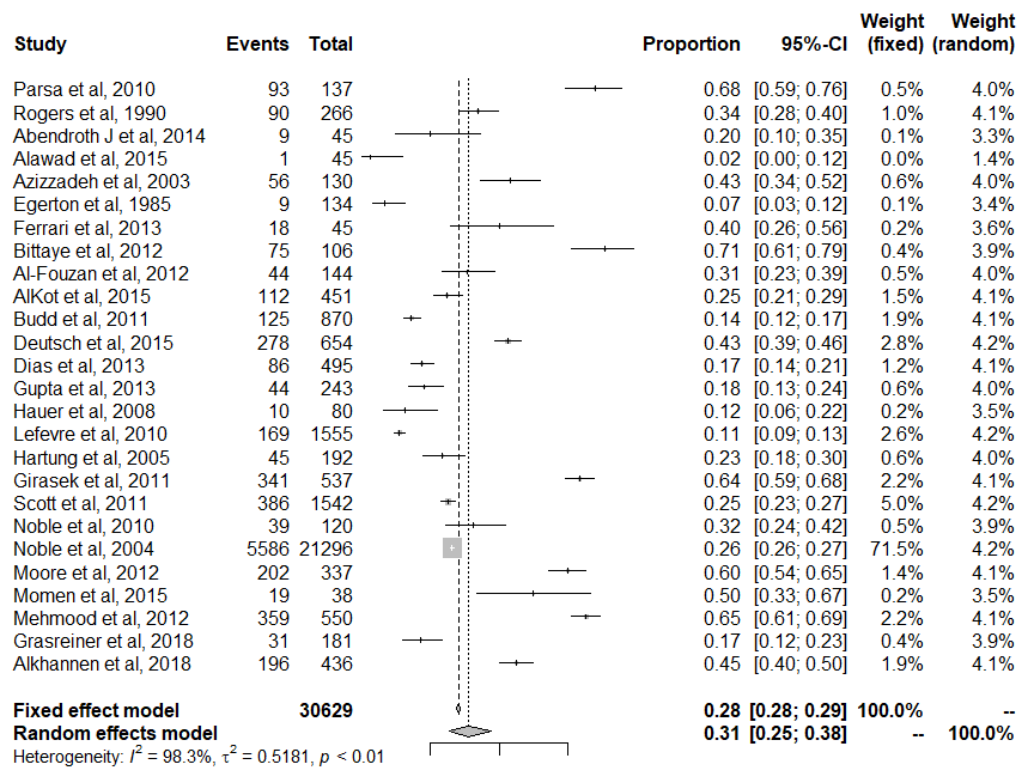


Figure S10. Forest Plot of “Length of Training”.



review only

Figure S11. Forest Plot of “Prestige”.



only

Figure S12. Forest Plot of “Advice from Others”.

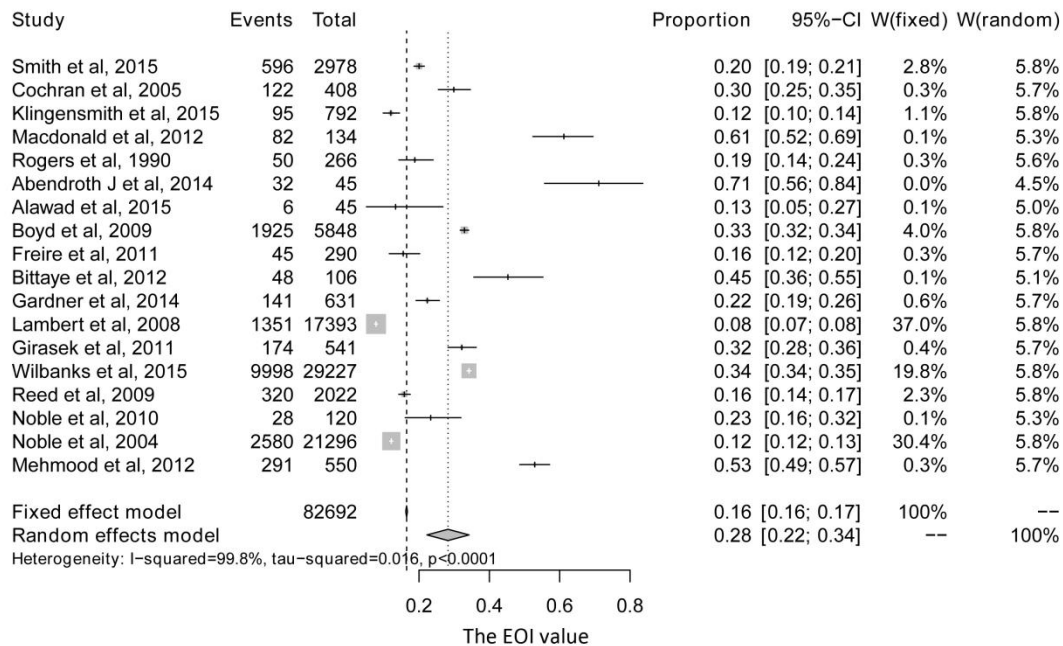


Figure S13. Forest Plot of “Student Debt”.

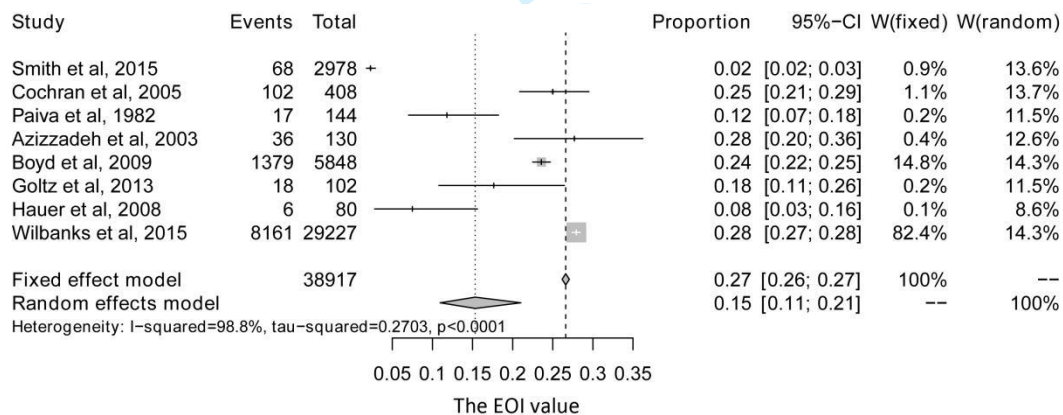
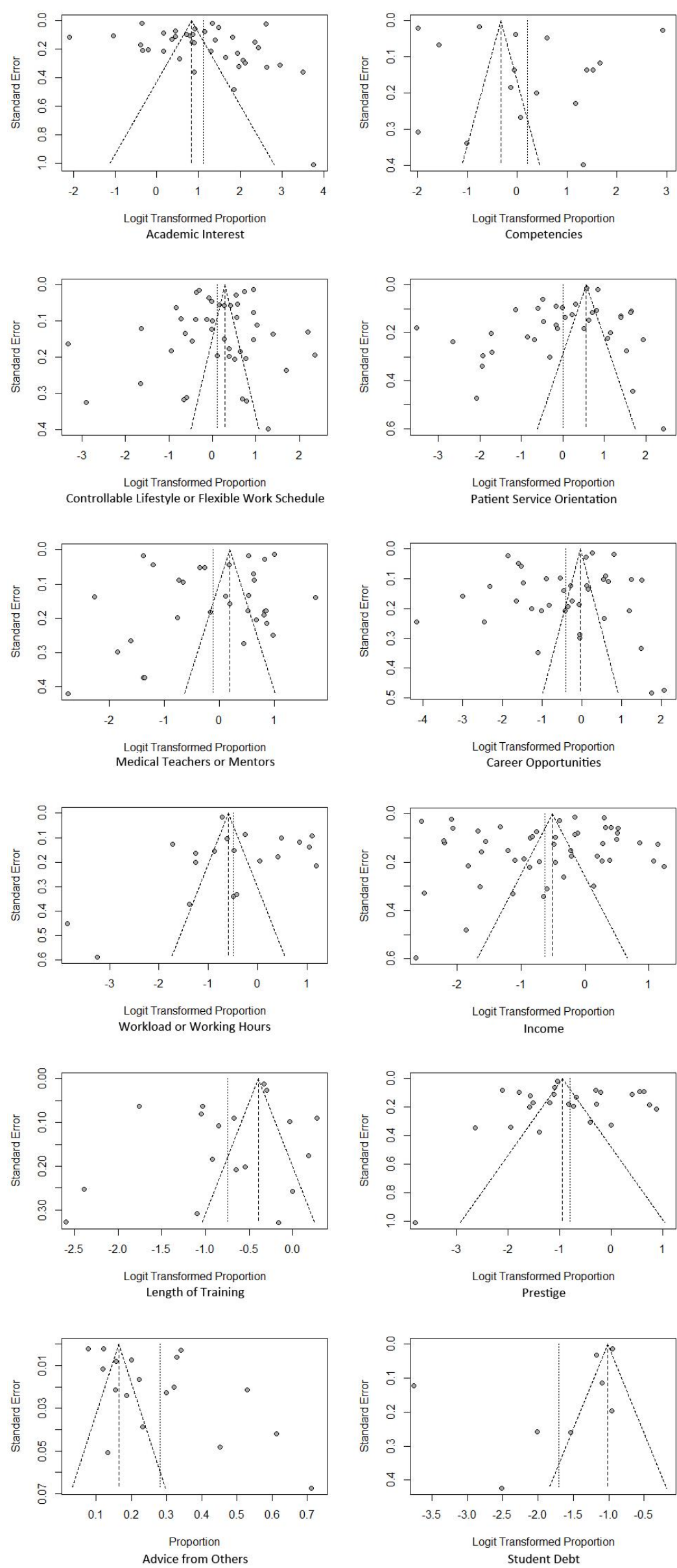


Figure S14. Funnel Plots of the Publication Bias Testing of the 12 Factors.





PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2-3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	3
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	5
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5-6
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	6-7
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	6-7
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	7

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PRISMA 2009 Checklist

Page 1 of 2

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	7
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	7
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	5, 7
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	7-8
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	8
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	8
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	8-9
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	8-9
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	8-9
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	9-13
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	13
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	14
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	15

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

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Page 2 of 2

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MOOSE Checklist for Meta-analyses of Observational Studies

Item No	Recommendation	Reported on Page No
Reporting of background should include		
1	Problem definition	5
2	Hypothesis statement	5
3	Description of study outcome(s)	5
4	Type of exposure or intervention used	5
5	Type of study designs used	5
6	Study population	5
Reporting of search strategy should include		
7	Qualifications of searchers (eg, librarians and investigators)	6
8	Search strategy, including time period included in the synthesis and key words	5
9	Effort to include all available studies, including contact with authors	5
10	Databases and registries searched	5
11	Search software used, name and version, including special features used (eg, explosion)	6
12	Use of hand searching (eg, reference lists of obtained articles)	5
13	List of citations located and those excluded, including justification	5-6
14	Method of addressing articles published in languages other than English	5
15	Method of handling abstracts and unpublished studies	5
16	Description of any contact with authors	5
Reporting of methods should include		
17	Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	6
18	Rationale for the selection and coding of data (eg, sound clinical principles or convenience)	6-7
19	Documentation of how data were classified and coded (eg, multiple raters, blinding and interrater reliability)	6-7
20	Assessment of confounding (eg, comparability of cases and controls in studies where appropriate)	6
21	Assessment of study quality, including blinding of quality assessors, stratification or regression on possible predictors of study results	6
22	Assessment of heterogeneity	6
23	Description of statistical methods (eg, complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated	6-7
24	Provision of appropriate tables and graphics	5-7
Reporting of results should include		
25	Graphic summarizing individual study estimates and overall estimate	8
26	Table giving descriptive information for each study included	7
27	Results of sensitivity testing (eg, subgroup analysis)	8
28	Indication of statistical uncertainty of findings	7-9

Item No	Recommendation	Reported on Page No
Reporting of discussion should include		
29	Quantitative assessment of bias (eg, publication bias)	13
30	Justification for exclusion (eg, exclusion of non-English language citations)	13-14
31	Assessment of quality of included studies	13-14
Reporting of conclusions should include		
32	Consideration of alternative explanations for observed results	14
33	Generalization of the conclusions (ie, appropriate for the data presented and within the domain of the literature review)	14
34	Guidelines for future research	14
35	Disclosure of funding source	15

From: Stroup DF, Berlin JA, Morton SC, et al, for the Meta-analysis Of Observational Studies in Epidemiology (MOOSE) Group. Meta-analysis of Observational Studies in Epidemiology. A Proposal for Reporting. *JAMA*. 2000;283(15):2008-2012. doi: 10.1001/jama.283.15.2008.

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Factors Influencing Subspecialty Choice Among Medical Students: A Systematic Review and Meta-analysis

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Secondary Subject Heading:	Medical education and training
Keywords:	Medical students, Career choice, Meta-analysis

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5 **1 Title Page**
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8 **2 Factors Influencing Subspecialty Choice Among Medical Students: A Systematic**
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10 **3 Review and Meta-analysis**
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13 4 Yahan Yang, M.D.^{1,2}; Jiawei Li, M.D.³; Xiaohang Wu, M.D.¹; Jinghui Wang, M.D.¹;
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5 26 **ABSTRACT**
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8 27 **Objective** To characterize the contributing factors that affect medical students'
9
10 28 subspecialty choice and to estimate the extent of influence of individual factors
11
12 29 on the students' decision-making process.
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15 30 **Design** Systematic review and meta-analysis.
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18 31 **Methods** A systematic search of the Cochrane Library, ERIC, Web of Science, CNKI
19
20 32 and PubMed databases was conducted for studies published between January
21
22 33 1977 and June 2018. Information concerning study characteristics, influential
23
24 34 factors, and the extent of their influence (EOI) was extracted independently by
25
26 35 two trained investigators. EOI is the percentage level that describes how much
27
28 36 each of the factors influenced students' choice of subspecialty. The recruited
29
30 37 medical students include students in medical school, internship, residency
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32 38 training and fellowship, who are about to or have just made a specialty choice.
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34 39 The estimates were pooled using a random-effects meta-analysis model due to
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36 40 the between-study heterogeneity.
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42 41 **Results** Data were extracted from 75 studies (882,209 individuals). Overall, the factors
43
44 42 influencing medical students' choice of subspecialty training mainly included
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46 43 academic interests (75.29%), competencies (55.15%), controllable lifestyles or
47
48 44 flexible work schedules (53.00%), patient service orientation (50.04%),
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50 45 medical teachers or mentors (46.93%), career opportunities (44.00%),
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52 46 workload or working hours (37.99%), income (34.70%), length of training
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5 47 (32.30%), prestige (31.17%), advice from others (28.24%), and student debt
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7 48 (15.33%), with significant between-study heterogeneity ($P<0.0001$). Subgroup
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9 49 analyses revealed that the EOI of academic interests was higher in developed
10
11 50 countries than that in developing countries (79.66% [95% confidence interval
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13 51 (CI), 70.73%; 86.39%] vs. 60.41% [95% CI, 43.44%; 75.19%]; $Q=3.51$
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15
16 52 $P=0.02$). The EOI value of prestige was lower in developed countries than that
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18 53 in developing countries (23.96% [95% CI, 19.20%; 29.47%] vs. 47.65% [95%
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21 54 CI, 34.41%; 61.24%]; $Q=4.71$ $P=0.01$).

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23
24 55 **Conclusions** This systematic review and meta-analysis provided a quantitative
25
26 56 evaluation of the top 12 influencing factors associated with medical students'
27
28 57 choice of subspecialty. Our findings provide the basis for the development of
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30 58 specific, effective strategies to optimize the distribution of physicians among
31
32 59 different departments by modifying these influencing factors.

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36 60 **Systematic review registration** PROSPERO CRD42017053781.

37 38 39 61 **STRENGTHS AND LIMITATIONS OF THIS STUDY**

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42 62 ● This is the first study that provide a systematic estimate of the factors associated
43
44 63 with medical students' subspecialty choices.
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47 64 ● A large number of studies conducted in varied populations have been included.
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51 65 ● The differences in the characteristics of country, survey years, specialty, the type
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53 66 of data used and sample size across studies represent a major limitation of our
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56 67 study.

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68 KEYWORDS Medical students, career choice, meta-analysis

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72 **Introduction**

73 Because of the population aging, increased workload on doctors through increased
74 number of consultations and in managing patients with multi-morbidity, the demand
75 for physicians continues to increase; however, an imbalance in the supply of physicians
76 in different subspecialties has become a growing concern in both developed and
77 developing countries.¹⁻⁵ Some specialties and subspecialties, such as family medicine
78 and palliative medicine,^{6,7} are experiencing a desperate shortage of physicians, whereas
79 other specialties and subspecialties, such as cardiology, ophthalmology and ear, nose
80 and throat (ENT) surgery, are highly competitive specialties with low success rate for
81 candidates.^{8,9}

82 Specialty choice is the product of a complex interconnection of student expectation,
83 department expectation, and competition for available spots, and student choice is
84 where the choice begins.¹⁰ Previous studies have suggested that medical students'
85 choice of subspecialty is essential to the maintenance of an adequate medical
86 workforce and a balanced development of the medical system.^{11, 12} However, the
87 influencing factors underlying students' subspecialty choice have not been
88 systemically reviewed. Recent changes in the training and practice environment may
89 influence medical students' career choice.¹³ Additionally, the variability in preferences
90 over time and in students' attitudes towards career choices can further complicate this
91 assessment. For example, a study in the UK indicated that half of the medical students
92 made a definitive subspecialty choice during their first year of medical school.¹⁴
93 However, students were prone to changing their subspecialty preference during

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5 94 medical school and internship.¹⁵ Notably, students may also reject certain
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7 95 subspecialties during their medical school training, even those they have previously
8
9 96 seriously considered.¹⁶ Therefore, identifying the factors that influence students'
10
11 97 choice of subspecialty will enable a better understanding of the current
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13 98 shortage/overload of physicians in specific fields and contribute to policy-building and
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15 99 decision-making to improve the training and recruitment of students in the future.

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19 100 We thus conducted a systematic review and a meta-analysis to investigate the
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21 101 influencing factors and the extent of their influence on the choice of subspecialty
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23 102 training among medical students. More specifically, we focused on the following
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25 103 questions. First, can we gain a better understanding of students' preferences for
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27 104 medical specialty according to the primary influencing factor? Second, do the
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29 105 subgroups according to world region and survey years examined in this study differ
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31 106 significantly with regard to the weight that students place on the identified influencing
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33 107 factor?
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38 108 **Methods**

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41 109 We developed a review protocol (registration number: PROSPERO
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43 110 CRD42017053781) prior to commencing the study. The Preferred Reporting Items for
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45 111 Systematic Reviews and Meta-Analyses (PRISMA) guidelines was used to ensure the
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47 112 reporting quality of this review (**Fig. S1**).¹⁷
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51 113 **Search Strategy and Study Eligibility**

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55 114 We performed a literature search in June 2018 using the Cochrane Library, Medline,
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5 115 Web of Science, CNKI and ERIC databases without language restrictions. Articles
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7 116 were screened by title, abstract and reference list, and by correspondence with study
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9 117 investigators. Potentially relevant papers were first identified by reviewing the titles
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11 118 and abstracts, and the full text of each retrieved article was then assessed. A detailed
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13 119 example of search strategy for Medline/PubMed is shown in **Methods S1**. Studies were
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15 120 included if they were systematic review or cross-sectional studies, reported data on
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17 121 medical students, were published in peer-reviewed journals, and used a validated
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19 122 method to assess the EOI on the choice of subspecialty, such as pediatric
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21 123 gastroenterology and vascular surgery, or its corresponding specialty, such as
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23 124 pediatrics and surgery. Because of the differences between medical education systems
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25 125 in the world, the medical students we recruited includes the student in medical school,
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27 126 internship, residency training and fellowship, containing the students who about to
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29 127 make a specialty choice and students who has just made a specialty choice. A guide to
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31 128 medical specialty, available at [https://www.abms.org/member-boards/specialty-
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35 130 subspecialty-certificates/](https://www.abms.org/member-boards/specialty-
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33 129 subspecialty-certificates/), were used to identify the medical specialty and subspecialty
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37 131 of our research. We also conducted an additional search using OpenGrey. However,
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39 132 no additional articles were further included. All searches were performed using Google
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47 133 **Data Extraction and Quality Assessment**

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50 134 Each article was reviewed by two trained investigators (Y.Y. and J.L.) and the
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52 135 following information was independently extracted from each selected article using a
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54 136 standardized form: study design, geographic location, years of survey, journal, sample
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5 137 size, average age of the participants, the number and percentage of male participants,
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7 138 and the influencing factors and the extent of their influence. A third investigator was
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9 139 consulted if disagreements occurred. Each study may involve one or several
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11 140 influencing factors. An 11-item checklist which was recommended by Agency for
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13 141 Healthcare Research and Quality (AHRQ), used for cross-sectional studies¹⁸, available
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15 142 at <https://www.ncbi.nlm.nih.gov/books/NBK35156/>, were used to assess the quality of
16
17 143 the studies. All discrepancies were resolved via discussion and consensus.
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21 144 **Statistical Analysis**

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24 145 As considerable heterogeneity was expected because of the multiple sources of
25
26 146 variances, a random effects meta-analysis model was used to estimate the influencing
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28 147 factors and the extent of their influence.¹⁹ Between-study heterogeneity was assessed
29
30 148 using the Cochran's Q-test, and was quantified with the I^2 statistic, which was
31
32 149 calculated to describe the percentage of total variation caused by heterogeneity across
33
34 150 studies, with $\geq 50\%$ indicating considerable heterogeneity.^{20 21} Potential sources of
35
36 151 heterogeneity were identified using meta-regression.²² Four categorical covariates
37
38 152 were defined as potential sources of heterogeneity by examining the studies conducted
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40 153 in the United States (US) vs. the studies conducted in other countries, the studies
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42 154 conducted before 2010 vs. those conducted after 2010, the studies concerning
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44 155 subspecialty only vs. those that were not specific to a subspecialty, and the studies with
45
46 156 a sample size < 200 vs. the studies with a sample size ≥ 200 . Subgroup analyses were
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48 157 performed for each factor in the studies in developed countries vs. developing countries
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50 158 and studies conducted before 2010 vs. after 2010. The EOI value of competencies in
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5 159 developing countries was not statistically significant (81.21% [95% CI, 75.27%;
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7 160 86.51%], $P=0.1436$), and no studies on the influence of student debt in developing
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9 161 countries were found. The Q-test based on the analysis of variance was used to compare
10
11 162 the subgroups, with a significance threshold of 5%.²³ The influence of individual
12
13 163 studies on the overall EOI value was explored by serially excluding each study in a
14
15 164 sensitivity analysis. Publication bias was investigated using a funnel plot test and
16
17 165 Egger's test.^{24 25} Fill and trim approach, which imputes estimates from hypothetical
18
19 166 negative unpublished reports,²⁶ was also used to investigate the publication bias if the
20
21 167 Egger's test was significant. All analyses were performed using R
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23 168 (version 3.3.1, The R Foundation, Vienna, Austria). The statistical tests were 2-sided
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25 169 with a significance threshold of $P<0.05$.

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31 170 **Patient and public involvement:** Patients and the public were not involved in
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33 171 development of the research question and outcome measures, nor the study design. The
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35 172 study does not involve patient recruitment, and patients were not involved in conduct
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37 173 of the study. We plan to liaise closely with patients, special interest groups, and
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39 174 charities in the dissemination of our results in printed and electronic media.

40 41 42 43 175 **Results**

44 45 46 176 **Study Characteristics**

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49 177 Seventy-five cross-sectional studies involving a total of 882,209 individuals that
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51 178 published between January 1977 and May 2018 were included in the present research
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53 179 **(Table 1)**. Thirty-four studies were conducted in North America, 24 in Europe, 7 in

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5 180 Asia, 5 in Oceania, 3 in Africa, and 2 in South America. The median number of
6
7 181 participants per study was 243 (range 37-29,227). Fourteen studies included students
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9 182 who had already selected subspecialties, whereas 61 did not. The influencing factors
10
11 183 were ranked according to the frequency of occurrence and each factor was identified
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13 184 when at least 5 papers were available describing it. The influencing factors for
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15 185 subspecialty choice were then classified according to 17 aspects, including academic
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17 186 interests, controllable lifestyle or flexible work schedule (defined as flexibility that
18
19 187 allows physicians to control the number of hours devoted to practicing the specialty),
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21 188 competencies, patient service orientation, medical teachers or mentors, career
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23 189 opportunities, workload or working hours (characterized by the physician's time spent
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25 190 on professional responsibilities), income, prestige, length of training, advice from
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27 191 others (advice from family, friends, and other students), student debt, experience with
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29 192 the subject, working environment, personality, gender and job security. Personality and
30
31 193 gender are common factors that affect the choice of subspecialty among medical
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33 194 students, but most of the relevant literature has not reported on the extent of these
34
35 195 factors' influence. Moreover, the funnel plots were clearly asymmetrical with regard
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37 196 to experience with the subject, the working environment and job variety, indicating the
38
39 197 existence of publication bias. Thus, the analysis of the remaining 12 influencing factors
40
41 198 were shown in this paper. Studies assessed for influencing factors using questionnaires
42
43 199 validated to medical students asking the extent of certain factors the studies
44
45 200 investigated. Quality assessment scores for the included studies are listed in **Table 1**.
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47 201 None of the studies received a point for the second AHRQ Quality Indicator, which
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49 202 requires studies to list the inclusion and exclusion criteria for exposed and unexposed
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5 203 subjects (cases and controls) or refer to previous publications, since no comparison
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7 204 studies were referenced in the analyzed articles. For the remaining 10 criteria, 6 studies
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9 205 received 9 points, 8 studies received 8 points, 17 studies received 7 points, 33 studies
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11 206 received 6 points, 9 studies received 5 points and 2 studies received 4 points (scores
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14 207 for individual studies are presented in **Table S1**).

17 208 **Primary Analysis**

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20 209 A meta-analysis was performed on the 12 influencing factors (**Table 2**): academic
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22 210 interests (**Fig. S2**), competencies (**Fig. S3**), controllable lifestyle or flexible work
23
24 211 schedule (**Fig. S4**), patient service orientation (**Fig. S5**), medical teachers or mentors
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26 212 (**Fig. S6**), career opportunities (**Fig. S7**), workload or working hours (**Fig. S8**), income
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28 213 (**Fig. S9**), length of training (**Fig. S10**), prestige (**Fig. S11**), advice from others (**Fig.**
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30 214 **S12**) and student debt (**Fig. S13**). All the factors were significant with evidence of
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32 215 between-study heterogeneity ($P < 0.0001$). A sensitivity analysis, in which the meta-
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34 216 analysis was serially repeated after the exclusion of each study, demonstrated that no
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36 217 individual study affected the overall extent of a factor's influence.

41 218 **Meta-regression and Subgroup Analysis**

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45 219 We performed meta-regression to identified the potential sources of heterogeneity
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47 220 using common instructions when at least 5 studies were available and at least 2 studies
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49 221 were in each comparator subgroup (**Table 3**). Some of the heterogeneities observed
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51 222 among the 12 factors can be partially explained by country, survey years, specialty and
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53 223 sample size.

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5 224 EOI values were further analyzed by subgroup (**Table S2**) according to world region
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7 225 (**Fig. 1**) and survey year (**Fig. 2**). The EOI value of academic interests in developed
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9 226 countries was higher than that in developing countries (79.66% [95% CI, 70.73%;
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11 227 86.39% vs. 60.41% [95% CI, 43.44%; 75.19%]; $Q=3.51$ $P=0.02$). Conversely, a lower
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13 228 EOI value of prestige was found in studies conducted in developed countries than in
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15 229 developing countries (23.96% [95% CI, 19.20%; 29.47%] vs. 47.65% [95% CI,
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17 230 34.41%; 61.24%]; $Q=4.71$ $P=0.01$). No statistically significant subgroup differences
18
19 231 in the EOI values of the other influencing factors were noted between developed
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21 232 countries and developing countries. In addition, no statistically significant differences
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23 233 in the EOI values of the influencing factors were observed when subgroup analysis
24
25 234 was performed by survey year.

235 **Assessment of Publication Bias**

236 We generated a funnel plot with proportion as the abscissa and standard error as the
237 ordinate. A visual inspection of the funnel plots revealed minimal asymmetry among
238 the various influencing factors (**Fig. S14**), and the results were concentrated in the
239 narrow upper part of the graph. There was evidence of small study effect in the meta-
240 analysis of “patient service orientation” (Egger’s test $P=0.02$). However, the trim-and-
241 fill method showed the publication-bias corrected estimate remained statistically
242 significant (63.79%, 95% CI, 58.20%; 69.04%).

243 **Discussion**

244 **Implications**

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5 245 This systematic review and meta-analysis involved 75 studies with 882,209 medical
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7 246 students. Twelve influencing factors were analyzed. These factors can be classified
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9 247 into two categories: economic factors and non-economic factors. We found that the
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11 248 EOI of the economic factors, including income (34.70%) and student debt (15.33%),
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13 249 may not depend on the region's level of economic development. However, income
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15 250 remained a major influencing factor in the process of choosing a specialty or
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17 251 subspecialty. In the US, 15% of full-time family medicine physicians earned less than
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19 252 \$100,000 in 2004, which is significantly less than the income earned by invasive
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21 253 cardiologists (median income=\$427,815), neurosurgeons (median income=\$211,094),
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23 254 and orthopedists (median income=\$335,646).²⁷ This economic inequality made family
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25 255 medicine less attractive to medical school graduates.²⁸ Benefits such as health
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27 256 insurance and tuition reimbursement have been shown to be the most common
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29 257 economic incentives used to attract applicants.²⁹

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35 258 The non-economic factors can be divided into individual factors, specialty-related
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37 259 factors and others. First, individual factors, including academic interest and
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39 260 competencies, have a considerable impact on students' subspecialty choice, with EOI
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41 261 values of 75.29% and 55.15%, respectively. In addition, in the subgroup analysis,
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43 262 although academic interests were less influential in developing countries than in
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45 263 developed countries (79.66% [95% CI, 70.73%; 86.39% vs. 60.41% [95% CI, 43.44%;
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47 264 75.19%]; $Q=3.51$ $P=0.02$), they were still the most influential of the 12 factors
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49 265 regardless of regional economic level. These findings indicate that subspecialties with
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51 266 a shortage of manpower may attract more students by increasing students' interests and
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5 267 improving the quality of education. Previous studies indicated that early specialty
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7 268 exposure in medical education may arouse students' academic interest and improve
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9 269 their clinical competence.^{28 30} For example, an elective extracurricular program
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11 270 designed to facilitate early contact with family medicine physicians was found to
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13 271 significantly improve students' interest and clinical skills, especially communication
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15 272 skills, in family medicine.³¹ Furthermore, dispelling myths and espousing the positive
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17 273 aspects of a discipline may provide a better understanding of certain specialties; this
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19 274 approach could also be effective in increasing students' academic interest.³² For
20
21 275 instance, family medicine is often considered a discipline that requires less professional
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23 276 skills and knowledge. This misconception demotivates students from choosing family
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25 277 medicine as their future career specialty, and this trend may eventually lead to a
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27 278 shortage of family physicians.³² Eliminating such prejudices may help students pay
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29 279 greater attention to the areas in short supply and restore their interests in other
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31 280 specialties.

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38 281 Second, the specialty-related factors included controllable lifestyle/flexible work
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40 282 schedule (EOI of 53.00%), career opportunities (EOI of 44.00%), workload (EOI of
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42 283 37.99%) and training length (EOI of 32.30%). Of these factors, lifestyle varied between
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44 284 different areas. Additionally, although certain specialties, such as general surgery,
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46 285 seem to have an adequate number of surgeons on a per capita basis in the US, there is
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48 286 still a poor geographic distribution within the surgical workforce according to the type
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50 287 of surgical practice.³³ The inflexible lifestyle is a common reason that students perceive
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52 288 surgery to be less attractive.³³ Reorganization of expected work hours within shared
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5 289 practices and the increased use of physician extenders and technologies such as
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7 290 electronic medical records may give physicians more flexibility in work schedules.³⁴
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9 291 Moreover, providing promotion opportunities and shortening the length of training are
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11 292 possible strategies to recruit new staff in subspecialties that require a long period of
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13 293 post-graduate residency training, such as neurosurgery.³⁵
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17 294 Finally, other factors such as service orientation (EOI of 50.74%), medical teachers or
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19 295 mentors (EOI of 46.93%), prestige (EOI of 34.68%), and advice from others (EOI of
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21 296 28.24%) also contribute to the decision-making process of medical students. For
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23 297 example, the desire to care for patients with end-stage diseases contributed to the
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25 298 decision to enter palliative medicine in 86% of the medical students.⁷ Additionally,
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27 299 exposure to mentors in a particular clinical field such as internal medicine has been
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29 300 strongly associated with medical students' choice of clinical field.³⁶ Moreover,
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31 301 improving the occupational prestige of areas such as family medicine, pathology, and
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33 302 radiology may help reshape the distribution of the workforce.^{30 37 38}
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38 303 In our study, several findings are especially noteworthy. First, interest was far more
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40 304 important than income in deciding subspecialty. In our study, interest was the top-
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42 305 ranked influencing factor (EOI of 75.29%) of subspecialty choice, while income was
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44 306 ranked lower (EOI of 34.70%). This finding argues against the possible default belief
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46 307 that raising physician's wages alone could solve the uneven distribution of clinicians
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48 308 among subspecialties. Our findings highlight that cultivating and stimulating students'
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50 309 professional interests may help improve the maldistribution of medical resources in a
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52 310 more efficient and cost-saving manner.
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5 311 Second, improving abilities in a certain subspecialty of interest can greatly affect
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7 312 medical students' professional choice. In our study, competencies ranked second in
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9 313 influence, which may reflect the impact of admission conditions on students' choice of
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11 314 subspecialty. Hence, to reduce the risk that students are restricted to the subspecialty
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14 315 of their interest due to a lack of personal skills, medical education should focus more
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16 316 on enhancing students' personal competencies in addition to their academic interests.

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19 317 Third, balancing medical resources is a complex process in practical terms, as the
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21 318 influencing factors are not mutually exclusive. The shortage of physicians in certain
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23 319 subspecialties may increase physician workload, resulting in less time for teaching.
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26 320 Hence, the quality of teaching cannot be guaranteed, and students may tend to avoid
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28 321 choosing these subspecialties, thus worsening the imbalance in the medical workforce.
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31 322 Additionally, some of the 12 factors identified are not amenable to practical
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33 323 interventions. For example, prestige cannot be immediately increased using
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35 324 interventional strategies.³⁷ Overall, effective strategies must be multi-pronged and
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37 325 incorporate several different aspects, and maldistribution in the workforce should not
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39 326 be tackled through a simple adjustment of one influencing factor.

40 41 42 43 327 **Interpretations of the results of this meta-analysis**

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46 328 Our meta-regression stratified by the study-level characteristics found that country,
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48 329 survey years, subspecialty and sample size may contribute to the heterogeneity
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50 330 between studies. There was no significant difference in the sensitivity analysis, which
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52 331 indicated that the results of the meta-analysis were convincing. The funnel plots and
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54 332 Egger's tests revealed that most of the publication bias was small ($P>0.05$), except for

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5 333 the meta-analysis of “patient service orientation”. Moreover, the majority of the studies
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7 334 collected in the database were from developed countries rather than developing
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9 335 countries.

12 336 **Limitations**

15 337 Several limitations should be considered when interpreting the findings of this study.
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18 338 First, the students involved in our study included medical students at different stages
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20 339 of their medical education. Students’ perception about different subspecialties may
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22 340 change during medical training until the students applies for specialty training. For
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24 341 example, compared to an intern, a freshman student may place greater emphasis on
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26 342 income and prestige when considering a career choice.³⁹ A subgroup analysis stratified
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28 343 by the stages of medical education and a secondary meta-analysis of longitudinal
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30 344 studies may better reflect changes in influencing factors and the extent of their
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32 345 influence over time. Second, our meta-analysis summarized the data from different
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34 346 geographic regions around the world, and the general conclusions may not be
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36 347 appropriate to guide policy development in each region. Enhanced effort is needed to
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38 348 develop specific intervention strategies according to the specific economic level,
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40 349 religious beliefs, healthcare system, educational system and endemic diseases of
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42 350 different countries and regions. Subgroup analysis stratified by organizational and
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44 351 medical training factors would provide more information of the factors influencing
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46 352 subspecialty choice among medical students. Third, the surveys in the various studies
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48 353 were also conducted using different methods. Most of the questionnaires used a Likert
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50 354 scale. Therefore, when we converted the results to a percentage representing the extent
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5 355 of a factor's influence, the Likert scale items were treated as interval data.⁴⁰⁻⁴²
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7 356 Consequently, there may have been differences in the conversion process. Finally, the
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9 357 analysis relied on aggregated published data. A multicenter prospective study would
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11 358 provide more accurate estimate of the influencing factors and the extent of their
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14 359 influence on medical students' choice of subspecialty.
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17 360 **Conclusion**

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20 361 In conclusion, this systematic review and meta-analysis provided a summary
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22 362 evaluation of 12 influencing factors and the extent of their influence on the choice of
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24 363 subspecialty training among medical students. Understanding students' attitudes
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26 364 toward their subspecialty decision-making process could provide the basis for
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29 365 developing strategies to increase the attractiveness of subspecialties experiencing a
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31 366 shortage of manpower, thereby balancing the distribution of medical recourses.
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7 368 and to research funding, coordinated the research and oversaw the project. Yahan Yang,
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9 369 Jiawei Li and Xiaohang Wu contributed to data collection and interpretation, and to
10
11 370 data analysis. Jinghui Wang, Yi Zhu, Chuan Chen and Wangting Li contributed to the
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16
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51 386 **Data sharing:** Extracted data are available upon request to the corresponding author.
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Table 1. Selected Characteristics of the 75 Studies Included in this Systematic Review and Meta-analysis

First Author, Year	Country	Survey years	Sample size	Average age	Men, No. (%)	Scores
Smith et al, ⁴³ 2015	UK	2012	2,978	NR	NR	6
Cochran et al, ⁴⁴ 2005	USA	2002	408	27.2	214 (52.45)	5
Hauer et al, ⁴⁵ 2008	USA	2007	1,177	NR	NR	6
Johnson et al, ⁴⁶ 2012	USA	2012	622	NR	NR	6
Kiolbassa et al, ⁴⁷ 2011	Germany	2010	1,114	24.1	408 (36.62)	5
Klingensmith et al, ⁴⁸ 2015	USA	2013	792	NR	539 (68.06)	6
Lee et al, ⁴⁹ 2012	USA	2012	100	NR	58 (58)	7
Macdonald et al, ⁵⁰ 2012	New Zealand	2011	134	NR	79 (58.96)	7
Parsa et al, ³⁹ 2010	Iran	2006-2007	137	27.34	49 (35.77)	7
Paiva et al, ⁵¹ 1982	USA	1982	144	NR	NR	6
Ni Chroinin et al, ⁵² 2013	UK	2009-2011	274	NR	112 (40.89)	7
Newton et al, ³⁴ 2005	USA	1998-2004	1,258	NR	642 (51.03)	8
Rogers et al, ⁵³ 1990	USA	1989	266	NR	205 (77.07)	6
Abendroth J et al, ⁵⁴ 2014	Germany	2007-2012	45	NR	14 (31)	7
Alawad et al, ⁵⁵ 2015	USA	2010-2011	45	NR	36 (80)	8
Azizzadeh et al, ⁵⁶ 2003	USA	2002	130	NR	NR	6
Celenza et al, ⁵⁷ 2012	Australia	2009	216	NR	121 (56.02)	8
Dolan-Evans et al, ⁵⁸ 2014	Australia	2013	419	NR	215 (51.31)	8
Boyd et al, ⁵⁹ 2009	USA	2005-2006	5,848	NR	2,982 (50.99)	8
Egerton et al, ⁶⁰ 1985	Ireland	1977-1981	134	30	82 (61.19)	6
Diderichsen et al, ⁶¹ 2013	Sweden	2006-2009	372	27	157 (42.20)	6
Ferrari et al, ⁶² 2013	Italy, UK	2009-2011	45	25	NR	9
Freire et al, ⁶³ 2011	Brazil	2006-2008	290	23	102 (35.17)	7
Buddeberg-Fischer et al, ⁶⁴ 2006	Switzerland	2001-2003	522	31.1	241 (46.17)	9
Dorsey et al, ⁶⁵ 2005	USA	2003	11,029	NR	4,964 (45.01)	6
Ekenze et al, ⁶⁶ 2013	Nigeria	2009-2010	96	25.9	NR	7
Barikani et al, ⁶⁷ 2012	Australia	2008-2009	49	21.7	NR	6
Bittaye et al, ⁶⁸ 2012	Gambia	2011	106	24.1	48 (45.28)	6
Bonura et al, ⁶⁹ 2016	USA	2015	590	NR	321 (54.40)	9
Al-Fouzan et al, ⁷⁰ 2012	Kuwait	2011-2012	144	NR	NR	7
AlKot et al, ⁷¹ 2015	Egypt	2013	451	21.8	NR	7
Borges et al, ⁷² 2009	USA	2001-2005	341	NR	NR	5
Budd et al, ⁷³ 2011	UK	2011	870	22	NR	7
Corrigan et al, ⁷⁴ 2007	Ireland	2007	222	NR	142 (63.96)	7
Davis et al, ⁷⁵ 2016	UK	2016	173	NR	76 (43.93)	7

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Deutsch et al, ⁷⁶ 2015	Germany	2011	659	27.9	NR	8
Gardner et al, ⁷⁷ 2014	Australia	1993-2005	631	NR	NR	7
Dias et al, ⁷⁸ 2013	UK	2013	495	NR	438 (88.48)	5
Goltz et al, ⁷⁹ 2013	USA	2012	102	24.5	34 (33.33)	6
Gupta et al, ⁸⁰ 2013	India	2013	243	NR	179 (73.36)	6
Hanzlick et al, ⁸¹ 2008	USA	2006	161	NR	NR	6
Harris et al, ⁸² 2005	USA	1991-2002	104	NR	53 (50.96)	6
Hauer et al, ⁸³ 2008	USA	2008	80	NR	NR	6
Labiris et al, ⁸⁴ 2014	Greece	2014	111	23.6	55 (49.54)	6
Lambert et al, ⁸⁵ 2008	UK	2007	17,393	NR	NR	6
Shah et al, ⁸⁶ 2012	USA	2011	892	NR	NR	6
Lefevre et al, ⁸⁷ 2010	USA	2008	1,555	NR	589 (37.88)	6
Vicente et al, ⁸⁸ 2013	Chile	2013	30	NR	NR	6
Wiesenfeld et al, ⁸⁹ 2014	Canada	2013	60	NR	NR	7
Lam et al, ⁹⁰ 2016	Hong Kong	2015	228	23	NR	9
Hartung et al, ⁹¹ 2005	USA	2004	192	20.59	74 (38.54)	4
Girasek et al, ⁹² 2011	Hungary	2011	536	NR	NR	5
Zuccato et al, ⁹³ 2015	Canada	2012	37	NR	24 (65)	6
Wilbanks et al, ⁹⁴ 2015	USA	2011-2013	29,227	NR	15,164 (51.99)	9
West et al, ⁹⁵ 2009	USA	2005-2007	14,890	NR	8,700 (58.43)	6
Watmough et al, ⁹⁶ 2007	UK	2005	116	NR	66 (56.90)	4
Thakur et al, ⁹⁷ 2001	USA	2001	56	NR	53 (95)	8
Scott et al, ⁹⁸ 2011	Canada	2002-2004	1,542	NR	NR	6
Schnuth et al, ⁹⁹ 2003	USA	2002	203	NR	72 (53.47)	6
Richards et al, ¹⁰⁰ 2009	UK	2009	150	NR	108 (72.00)	5
Reed et al, ¹⁰¹ 2009	USA	2008	2,022	NR	1,354 (66.96)	9
de Souza et al, ¹⁰² 2015	Portugal	2012	1,303	NR	NR	7
Pikoulis et al, ¹⁰³ 2010	Greece	2006-2007	87	NR	NR	6
Ozer et al, ¹⁰⁴ 2015	Turkey	2013	98	27.7	26 (26.53)	6
Noble et al, ¹⁰⁵ 2004	Canada	2004	21,296	NR	NR	8
Noble et al, ¹⁰⁶ 2010	Canada	2007	120	NR	NR	5
Newton et al, ¹⁰⁷ 2005	USA	2004	1,286	NR	NR	6
Moore et al, ¹⁰⁸ 2012	USA	2011	337	26	179 (53.12)	6
Momen et al, ¹⁰⁹ 2015	Iran	2014-2015	38	35.6	11 (29)	6
Mehmood et al, ¹¹⁰ 2012	Saudi Arabia	2012	550	NR	348 (63.27)	6
Loriot et al, ¹¹¹ 2010	France	2007	44	NR	17 (39)	7
Lefevre et al, ¹¹² 2010	France	2008	522	23.8	198 (37.93)	7
Vo et al, ¹¹³ 2017	Canada	2017	90	22.5	52 (57.78)	5
Grasreiner et al, ¹¹⁴ 2018	Germany	2014-2016	181	24	33 (18.10)	6
Alkhaman et al, ¹¹⁵ 2018	Saudi Arabia	2017	436	NA	250 (57.00)	5

733 Footnotes: scores: quality score of the AHRQ scale.

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Table 2. Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty

Factor	No. of studies	Total no. of participants	EOI value (%)	95 CI% of EOI value		Cochran's <i>Q</i>	<i>I</i> -square (%)	Tau-square	<i>P</i> -Value
				Lower	Upper				
Academic interests	38	82,366	75.29	66.93	82.11	14719.76	99.70	1.60	<0.0001
Competencies	17	76,515	55.15	33.63	74.90	23572.74	99.90	3.44	<0.0001
Controllable lifestyle or flexible work schedule	44	101,001	53.00	47.90	58.03	8624.46	99.50	0.45	<0.0001
Patient service orientation	37	46,572	50.04	44.65	55.43	2668.79	98.70	0.41	<0.0001
Medical teachers or mentors	32	85,071	46.93	37.77	56.30	15216.32	99.80	1.14	<0.0001
Career opportunities	38	81,923	44.00	32.26	48.78	13553.20	99.70	1.15	<0.0001
Workload or working hours	20	22,051	37.99	29.59	47.19	584.81	98.30	0.69	<0.0001
Income	50	109,791	34.70	28.36	41.62	16952.48	99.70	1.09	<0.0001
Length of training	18	42,046	32.30	27.61	37.37	917.21	98.10	0.20	<0.0001
Prestige	26	30,629	31.17	26.32	37.69	1464.67	98.30	0.52	<0.0001
Advice from others	18	82,692	28.24	22.26	34.23	7679.73	99.80	0.02	<0.0001
Student debt	8	38,917	15.33	10.96	21.03	574.81	98.80	0.27	<0.0001

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Table 3. Meta-regression of the EOI Value Stratified by Study-level Characteristics

Factor		estimate	95 CI% of estimate		P-Value
			Lower	Upper	
Academic interests	Country	-0.2314	-1.1575	0.6946	0.6302
	Survey years	0.3811	-0.3580	1.1202	0.2711
	Specialty	-0.4892	-1.5345	0.5562	0.4008
	Sample size	0.2362	-0.5488	1.0212	0.6537
Competencies	Country	0.6946	-1.1461	0.8938	0.8376
	Survey years	-1.0418	-2.0950	0.0114	0.0151
	Specialty	0.0904	-1.5786	1.7594	0.9398
	Sample size	-0.5720	-1.8606	0.7166	0.5823
Controllable lifestyle or flexible work schedule	Country	-0.1261	-1.1461	0.8938	0.9614
	Survey years	-0.0001	-0.4052	0.4051	0.9822
	Specialty	-0.8989	-1.4979	-0.3000	0.0035
	Sample size	-0.0518	-0.4396	0.3361	0.7203
Patient service orientation	Country	-0.6238	-1.3118	0.0642	0.0833
	Survey years	-0.0414	-0.6912	0.6083	0.8524
	Specialty	-1.5982	-2.5227	-0.6737	0.0010
	Sample size	-0.1157	-0.7473	0.5159	0.6358
Medical teachers or mentors	Country	0.7395	0.3117	1.1674	0.0007
	Survey years	0.1133	-0.3580	0.5845	0.6376
	Specialty	0.0605	-0.4441	0.5652	0.8141
	Sample size	-0.1202	-0.5567	0.3163	0.5894
Career opportunities	Country	0.1075	-0.7030	0.9179	0.5828
	Survey years	0.3284	-0.3913	1.0480	0.7546
	Specialty	-0.9292	-1.8015	-0.0570	0.0077
	Sample size	0.3654	0.1156	1.5478	0.0081
Workload or working hours	Country	-0.4535	-1.5086	0.6016	0.3981
	Survey years	0.4624	-0.5417	1.4665	0.3922
	Specialty	-0.9878	-2.1727	0.1972	0.1070
	Sample size	0.0982	-0.8589	1.0553	0.8205
Income	Country	0.1058	-0.4665	0.6781	0.7390
	Survey years	0.0999	-0.4379	0.6377	0.8774
	Specialty	-0.6457	-1.3267	0.0352	0.0480
	Sample size	0.0523	-0.4826	0.5872	0.6786
Length of training	Country	-0.1559	-1.2782	0.9664	0.7854
	Survey years	-0.2158	-1.4089	0.9772	0.7229
	Specialty	0.3959	-0.9585	1.7502	0.5667
	Sample size	0.1565	-0.6631	0.9761	0.7082

	Country	-0.3346	-1.0799	0.4106	0.3485
Prestige	Survey years	-0.4513	-1.1378	0.2352	0.0950
	Specialty	-1.0112	-1.8980	-0.1244	0.0172
	Sample size	0.0355	-0.6013	0.6723	0.5214
	Country	-0.0097	-0.0722	0.0529	0.9328
Advice from others	Survey years	-0.0861	-0.1471	-0.0251	0.0057
	Specialty	-0.2017	-0.2790	-0.1244	<0.0001
	Sample size	0.2125	0.1309	0.2941	<0.0001
	Country	2.7853	2.0544	3.5162	0.0001
Student debt	Survey years	-0.1567	-0.6707	0.3573	0.5502
	Sample size	-0.5248	-1.0108	-0.0388	0.0343

736

For peer review only

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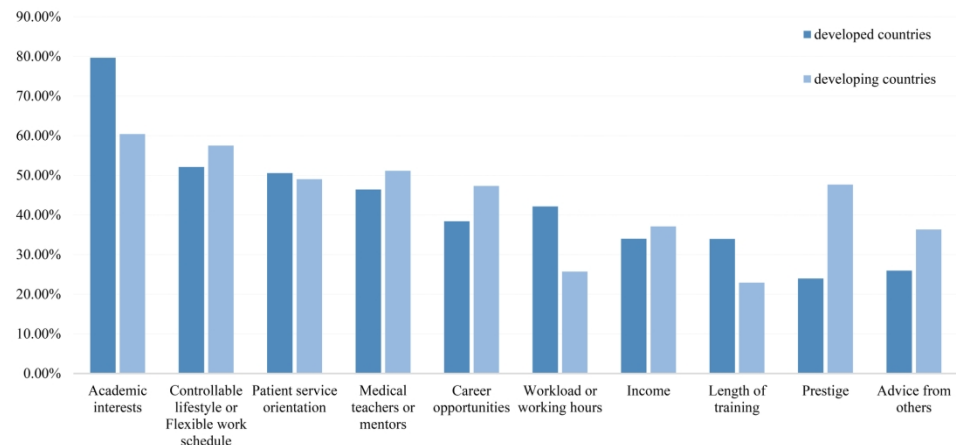


Figure 1. Bar Graph of the Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty Stratified by Region.

190x107mm (300 x 300 DPI)

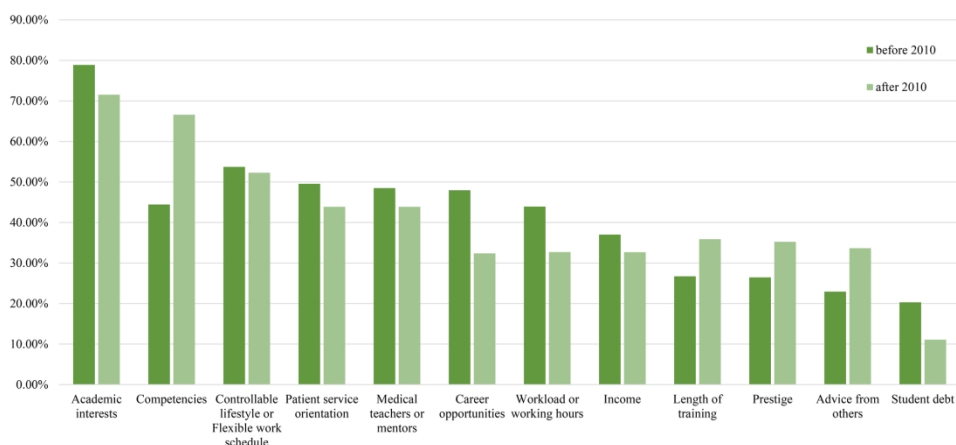


Figure 2. Bar Graph of the Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty Stratified by Survey Year.

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SI Methods. Search strategy used in the current systematic review and meta-analysis.

Medical Students

1. Students, Medical [Mesh]
2. Medical students
3. Medical student
4. Student, Medical
5. OR / 1 – 4

Subspecialty Choice

6. Career choices
7. Choice, Career
8. Choices career
9. Specialties
10. Sub-specialties
11. Sub-discipline
12. OR / 6 – 11

Study design

13. Cross sectional study
14. Cross sectional study [Publication Type]
15. Cross sectional study [Mesh Terms]
16. Systematic review
17. Systematic review [Publication Type]
18. Systematic review [Mesh Terms]
19. Meta-analysis [Title/Abstract]
20. Meta-analysis [Mesh Terms]
21. Meta-analysis [Publication Type]
22. OR / 12 – 21

Factors

23. Factors

Combined search

23. #5 AND #12AND #22 AND #2

Abbreviations: MeSH, Medical Subject Heading in PubMed

Table S1. Quality assessment of the included studies

Quality assessment criteria	1	2	3	4	5	6	7	8	9	10	11	Scores
1 Smith et al, ⁴¹ 2015	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
2 Cochran et al, ⁴² 2005	Y	U	Y	Y	N	Y	N	Y	N	N	N	5
3 Hauer et al, ⁴³ 2008	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
4 Johnson et al, ⁴⁴ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
5 Kiobassa et al, ⁴⁵ 2011	Y	U	Y	Y	N	Y	N	Y	N	N	N	5
6 Klingensmith et al, ⁴⁶ 2015	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
7 Lee et al, ⁴⁷ 2012	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
8 Macdonald et al, ⁴⁸ 2012	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
9 Parsa et al, ³⁷ 2010	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
10 Paiva et al, ⁴⁹ 1982	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
11 Ni Chroinin et al, ⁵⁰ 2013	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
12 Newton et al, ³² 2005	Y	U	Y	Y	Y	Y	Y	Y	N	Y	N	8
13 Rogers et al, ⁵¹ 1990	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
14 Abendroth J et al, ⁵² 2014	Y	U	Y	Y	N	Y	N	Y	N	Y	Y	7
15 Alawad et al, ⁵³ 2015	Y	U	Y	Y	N	Y	Y	Y	Y	Y	N	8
16 Azizzadeh et al, ⁵⁴ 2003	Y	U	Y	Y	Y	Y	N	N	N	Y	N	6
17 Celenza et al, ⁵⁵ 2012	Y	U	Y	Y	Y	Y	Y	N	Y	Y	N	8
18 Dolan-Evans et al, ⁵⁶ 2014	Y	U	Y	Y	Y	Y	N	Y	N	Y	Y	8
19 Boyd et al, ⁵⁷ 2009	Y	U	Y	Y	Y	Y	Y	Y	N	Y	N	8
20 Egerton et al, ⁵⁸ 1985	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
21 Diderichsen et al, ⁵⁹ 2013	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
22 Ferrari et al, ⁶⁰ 2013	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	N	9
23 Freire et al, ⁶¹ 2011	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
24 Buddeberg-Fischer et al, ⁶² 2006	Y	U	Y	Y	N	Y	Y	Y	Y	Y	Y	9
25 Dorsey et al, ⁶³ 2005	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
26 Ekenze et al, ⁶⁴ 2013	Y	U	Y	Y	Y	Y	Y	N	N	Y	N	7
27 Barikani et al, ⁶⁵ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
28 Bittaye et al, ⁶⁶ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
39 Bonura et al, ⁶⁷ 2016	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	N	9
30 Al-Fouzan et al, ⁶⁸ 2012	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
31 AlKot et al, ⁶⁹ 2015	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
32 Borges et al, ⁷⁰ 2009	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
33 Budd et al, ⁷¹ 2011	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
34 Corrigan et al, ⁷² 2007	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
35 Davis et al, ⁷³ 2016	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
36 Deutsch et al, ⁷⁴ 2015	Y	U	Y	Y	Y	Y	N	Y	Y	Y	N	8
37 Gardner et al, ⁷⁵ 2014	Y	U	Y	Y	N	Y	N	Y	N	Y	N	7
38 Dias et al, ⁷⁶ 2013	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
39 Goltz et al, ⁷⁷ 2013	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
40 Gupta et al, ⁷⁸ 2013	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
41 Hanzlick et al, ⁷⁹ 2008	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
42 Harris et al, ⁸⁰ 2005	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
43 Hauer et al, ⁸¹ 2008	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
44 Labiris et al, ⁸² 2014	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
45 Lambert et al, ⁸³ 2008	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
46 Shah et al, ⁸⁴ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
47 Lefevre et al, ⁸⁵ 2010	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
48 Vicente et al, ⁸⁶ 2013	Y	U	Y	Y	N	N	Y	N	Y	Y	N	6
49 Wiesenfeld et al, ⁸⁷ 2014	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
50 Lam et al, ⁸⁸ 2016	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	N	9
51 Hartung et al, ⁸⁹ 2005	Y	U	Y	Y	N	Y	N	N	N	N	N	4
52 Girasek et al, ⁹⁰ 2011	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
53 Zuccato et al, ⁹¹ 2015	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
54 Wilbanks et al, ⁹² 2015	Y	U	Y	Y	N	Y	Y	Y	Y	Y	Y	9
55 West et al, ⁹³ 2009	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
56 Watmough et al, ⁹⁴ 2007	Y	U	Y	Y	N	N	N	N	N	Y	N	4
57 Thakur et al, ⁹⁵ 2001	Y	U	Y	Y	Y	Y	Y	N	Y	Y	N	8
58 Scott et al, ⁹⁶ 2011	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
59 Schnuth et al, ⁹⁷ 2003	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
60 Richards et al, ⁹⁸ 2009	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
61 Reed et al, ⁹⁹ 2009	Y	U	Y	Y	Y	Y	Y	Y	Y	Y	N	9
62 de Souza et al, ¹⁰⁰ 2015	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
63 Pikoulis et al, ¹⁰¹ 2010	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
64 Ozer et al, ¹⁰² 2015	Y	U	Y	Y	N	N	Y	N	Y	Y	N	6
65 Noble et al, ¹⁰³ 2004	Y	U	Y	Y	Y	Y	Y	Y	N	Y	N	8
66 Noble et al, ¹⁰⁴ 2010	Y	U	Y	Y	N	Y	N	N	N	Y	N	5
67 Newton et al, ¹⁰⁵ 2005	Y	U	Y	Y	N	Y	Y	N	N	Y	N	6
68 Moore et al, ¹⁰⁶ 2012	Y	U	Y	Y	Y	Y	N	Y	N	N	N	6
69 Momen et al, ¹⁰⁷ 2015	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
70 Mehmood et al, ¹⁰⁸ 2012	Y	U	Y	Y	N	Y	N	Y	N	Y	N	6
71 Loriot et al, ¹⁰⁹ 2010	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
72 Lefevre et al, ¹¹⁰ 2010	Y	U	Y	Y	Y	Y	N	Y	N	Y	N	7
73 Vo et al, ¹¹¹ 2017	Y	U	Y	Y	Y	N	N	N	N	Y	N	5
74 Grasreiner et al, ¹¹² 2018	Y	U	Y	Y	Y	Y	N	N	N	Y	N	6
75 Alkhaman et al, ¹¹³ 2018	Y	U	Y	Y	N	N	Y	N	N	Y	N	5

Quality assessment criteria in detail

1. Define the source of information (survey, record review).
2. List the inclusion and exclusion criteria for the exposed and unexposed subjects (cases and controls) or refer to previous publications.
3. Indicate the time period used for identifying patients.
4. Indicate whether the subjects were consecutive if not population-based.
5. Indicate whether the evaluators of the subjective components of the study were masked to the other aspects of participants' status.
6. Describe any assessments undertaken for quality assurance purposes (e.g., test/retest of primary outcome measurements)
7. Explain any patient exclusion from the analyses.
8. Describe how confounding was assessed and/or controlled.
9. If applicable, explain how missing data were handled in the analysis.
10. Summarize the patient response rates and the completeness of the data collection.
11. Clarify what follow-up, if any, was expected and the percentage of patients with incomplete data or follow-up.

“Y”: Yes; “N”: No; “U”: Unclear.

Table S2. Meta-analyses of the Factors Influencing Medical Students' Choice of Subspecialty Stratified by Region and Survey Year.

Factor		No. of studies	Total no. of participants	Extent of influence (%)	95 CI% of EOI value		<i>I-square</i> (%)	<i>P</i> -Value	<i>Q</i> -Value		
					Lower	Upper					
Academic interest	developed	28	80,000	79.66	70.73	86.39	99.8	0.02	3.51		
	developing	10	2,366	60.41	43.44	75.19	98.0				
	before 2010	29	44,174	78.88	69.04	86.22	99.7	0.40	1.21		
	after 2010	9	38,192	71.54	57.66	82.27	99.6				
Competencies	before 2010	9	43,134	44.40	29.11	60.83	99.8	0.21	1.86		
	after 2010	8	33,381	66.60	34.48	88.31	99.8				
Controllable lifestyle or flexible work schedule	developed	37	100,980	52.11	46.52	57.65	99.6	0.63	0.68		
	developing	7	2,017	57.50	45.81	68.41	95.9				
	before 2010	22	62,945	53.72	47.48	59.84	99.4			0.97	0.05
after 2010	22	40,056	52.29	43.51	60.93	99.2					
Patient service orientation	developed	27	44,235	50.56	44.68	56.42	98.8	0.74	0.48		
	developing	10	2,337	49.02	31.62	66.67	98.1				
	before 2010	18	40,997	49.56	43.29	55.84	98.8			0.70	0.54
	after 2010	19	5,579	43.87	38.62	63.80	98.3				
Medical teachers or mentors	developed	28	84,076	46.43	36.63	56.52	99.8	0.73	0.48		
	developing	4	995	51.14	33.97	68.04	95.4				
	before 2010	21	49,654	48.48	36.93	60.19	99.8			0.70	0.54
	after 2010	11	35,417	43.87	27.94	61.18	99.7				
Career opportunities	developed	31	79,867	38.41	29.61	48.04	99.8	0.60	0.74		
	developing	7	2,056	47.32	30.38	64.91	98.1				
	before 2010	20	43,417	47.97	33.54	62.74	99.8			0.24	1.68
	after 2010	18	38,506	32.38	21.68	45.31	99.5				
Workload or working hours	developed	15	20,970	42.14	31.35	53.72	98.6	0.34	1.39		
	developing	5	1,081	25.72	13.29	43.88	95.3				
	before 2010	9	19,456	43.93	29.43	59.54	98.8			0.41	1.21
	after 2010	11	2,595	32.70	29.43	59.54	97.4				
Income	developed	39	107,091	34.01	26.89	41.93	99.8	0.84	0.29		
	developing	11	2,700	37.11	27.06	48.41	96.4				
	before 2010	25	68,714	37.01	25.95	49.62	99.8			0.41	1.18
	after 2010	25	41,077	32.67	26.04	40.07	98.9				
Length of training	developed	15	41,246	33.95	28.72	39.60	98.4	0.31	1.48		
	developing	3	800	22.92	10.94	41.85	94.0				
	before 2010	7	8,811	26.72	15.89	41.29	98.9			0.28	1.59
	after 2010	11	33,234	35.87	29.67	42.59	96.9				
Prestige	developed	17	27,987	23.96	19.20	29.47	97.3	0.01	4.71		
	developing	9	2,642	47.65	34.41	61.24	97.6				
	before 2010	12	25,542	26.46	20.78	33.03	96.7			0.25	1.67
	after 2010	14	5,087	35.22	24.70	47.40	98.3				
Advice from others	developed	14	81,205	25.95	19.27	32.64	99.8	0.36	1.33		
	developing	4	1,487	36.34	18.91	53.77	98.1				
	before 2010	10	48,319	22.93	17.85	28.01	99.5			0.31	1.47
	after 2010	8	34,373	33.65	25.12	42.18	99.1				
Student debt	before 2010	5	6,610	20.29	15.86	25.57	81.8	0.69	0.59		
	after 2010	3	32,307	11.08	1.58	49.08	99.6				

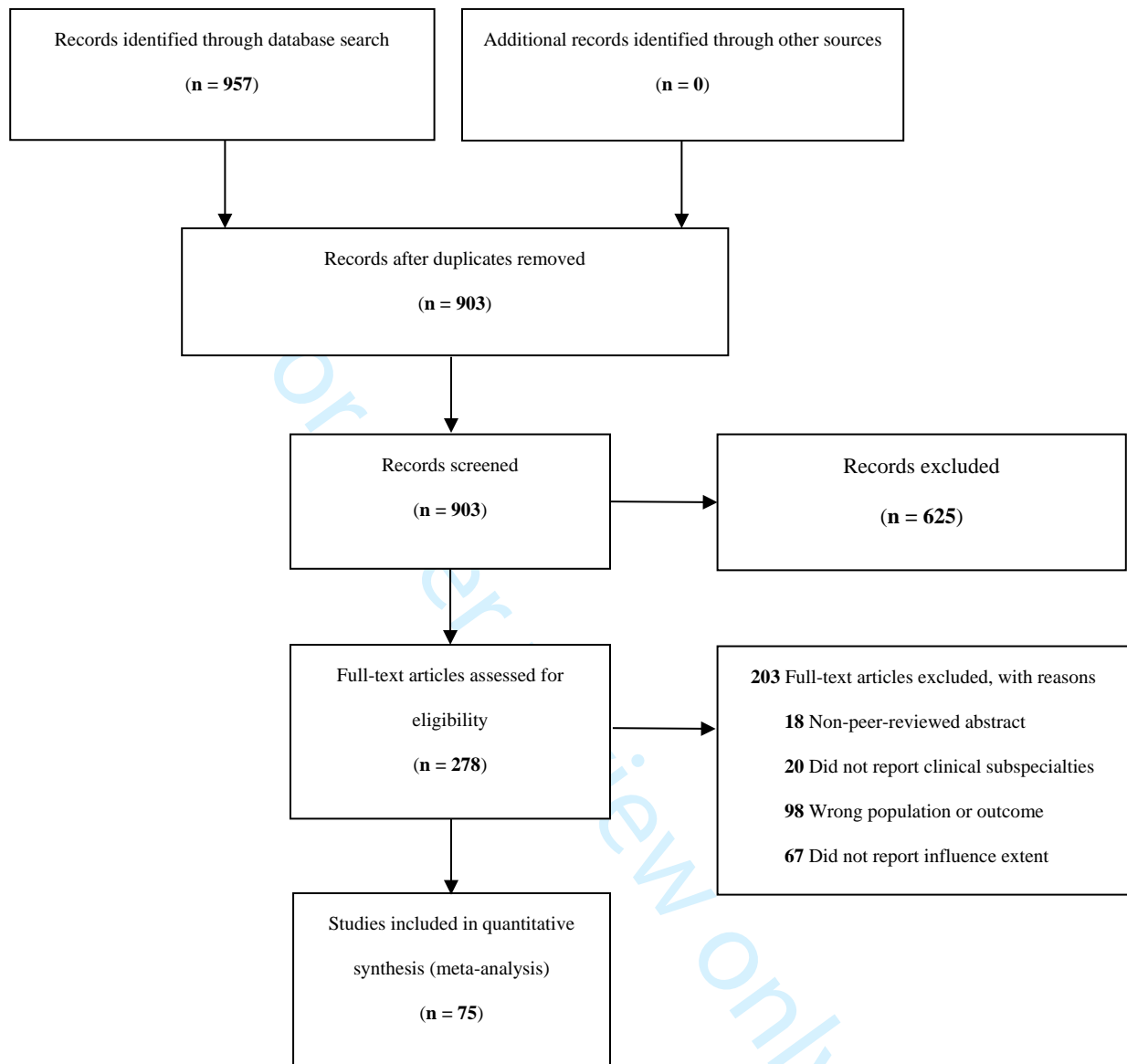
Figure S1. Flow Diagram of the Study Inclusion.

Figure S2. Forest Plot of “Academic Interest”.

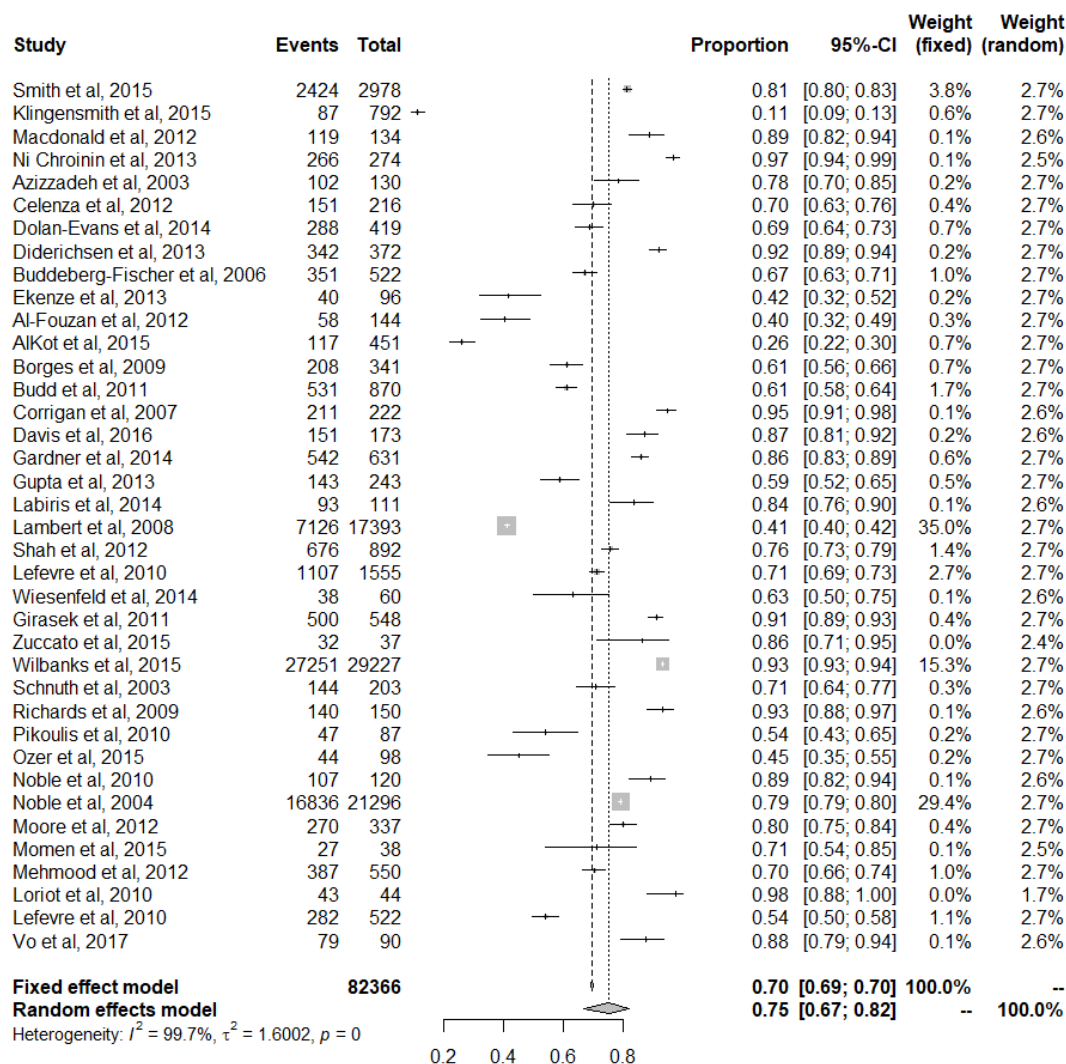
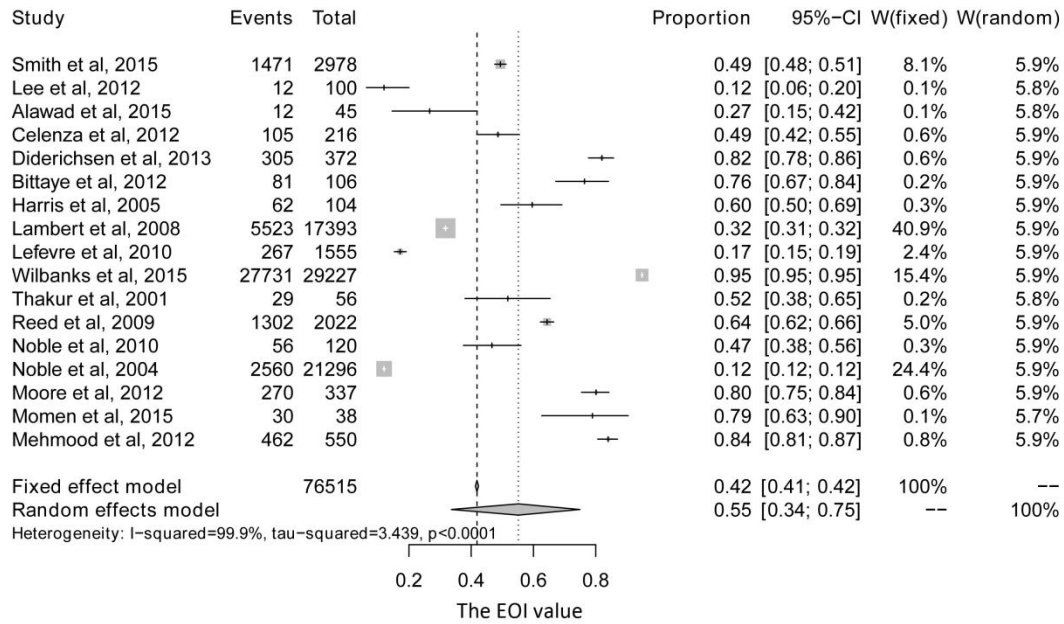


Figure S3. Forest Plot of “Competencies”.



review only

Figure S4. Forest Plot of “Controllable Lifestyle or Flexible Work Schedule”.

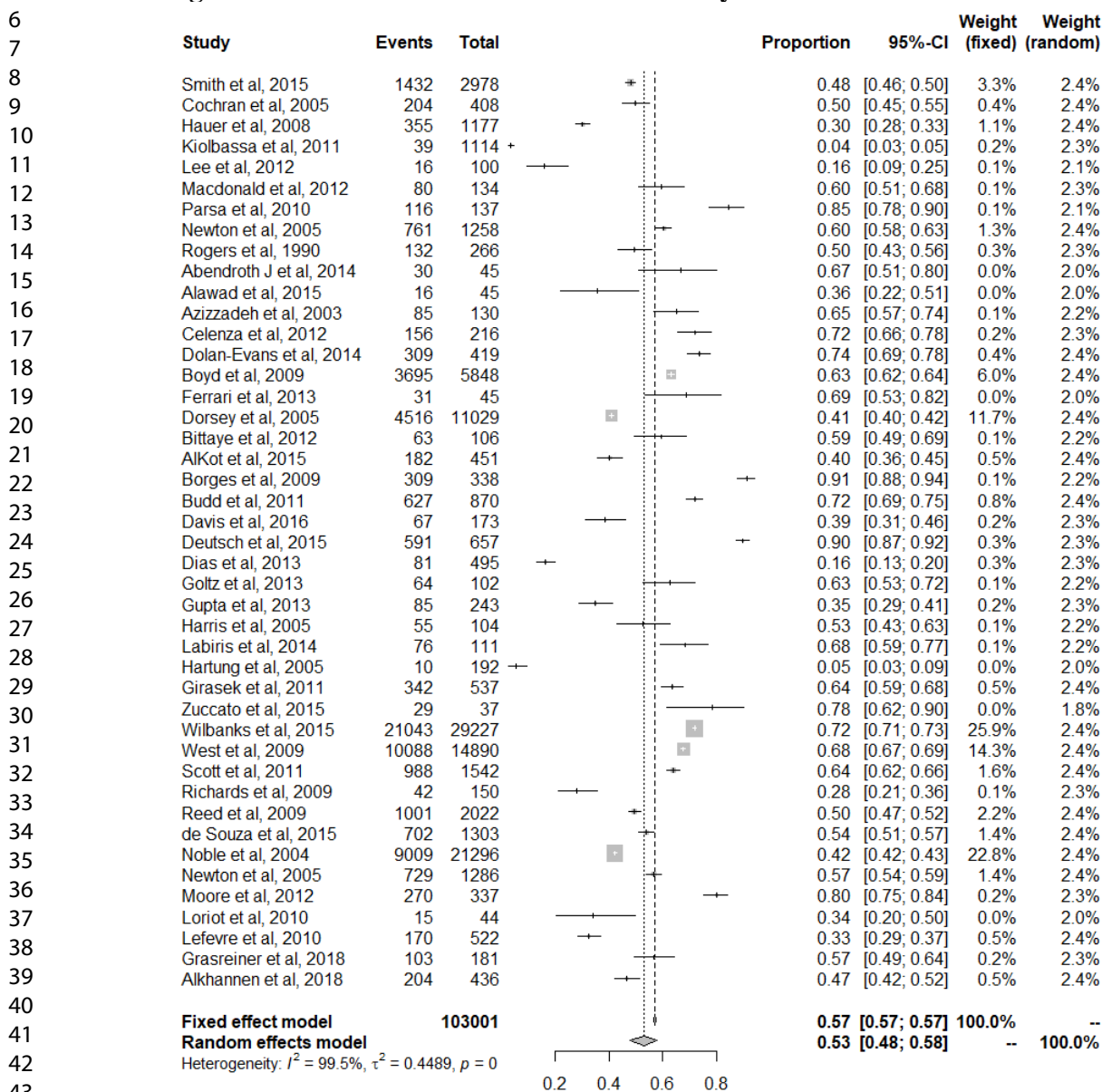


Figure S5. Forest Plot of “Patient Service Orientation”.

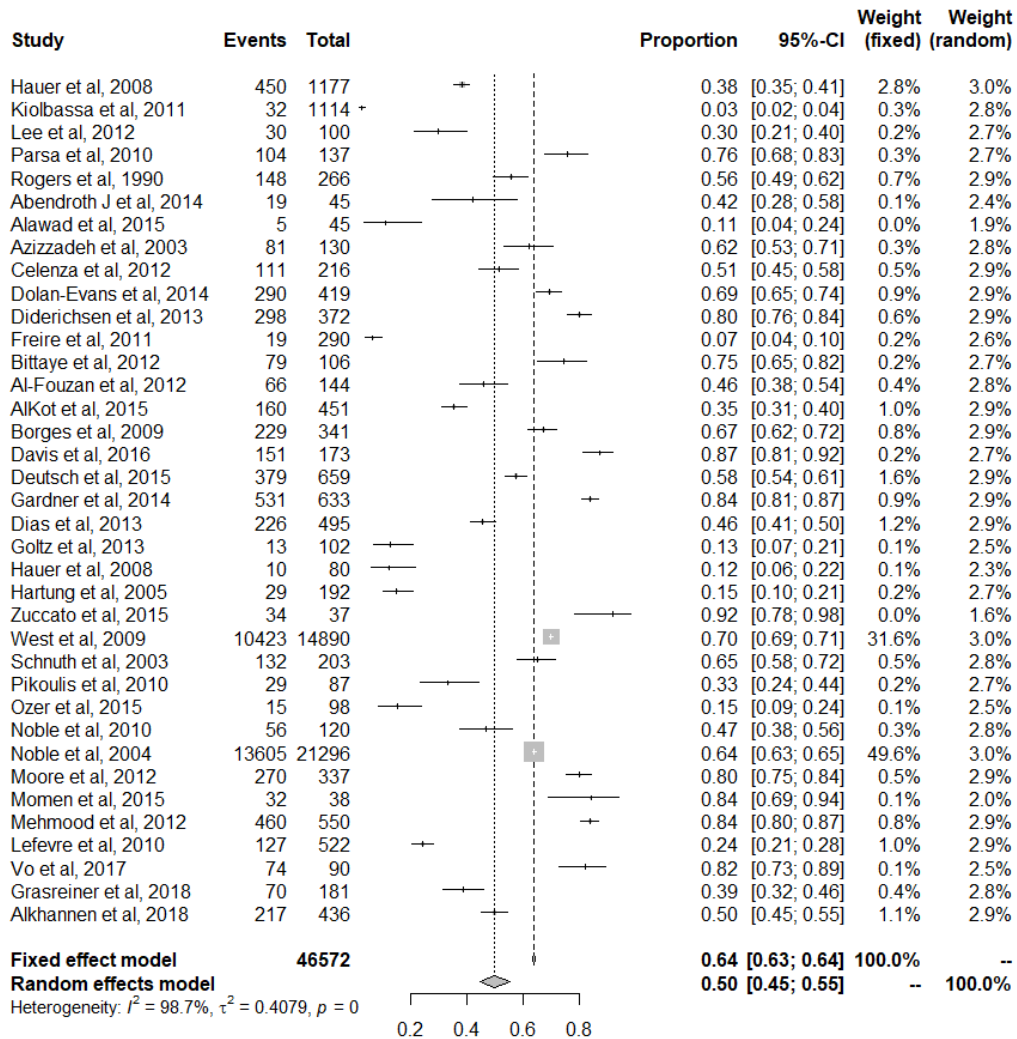


Figure S6. Forest Plot of “Medical Teachers or Mentors”.

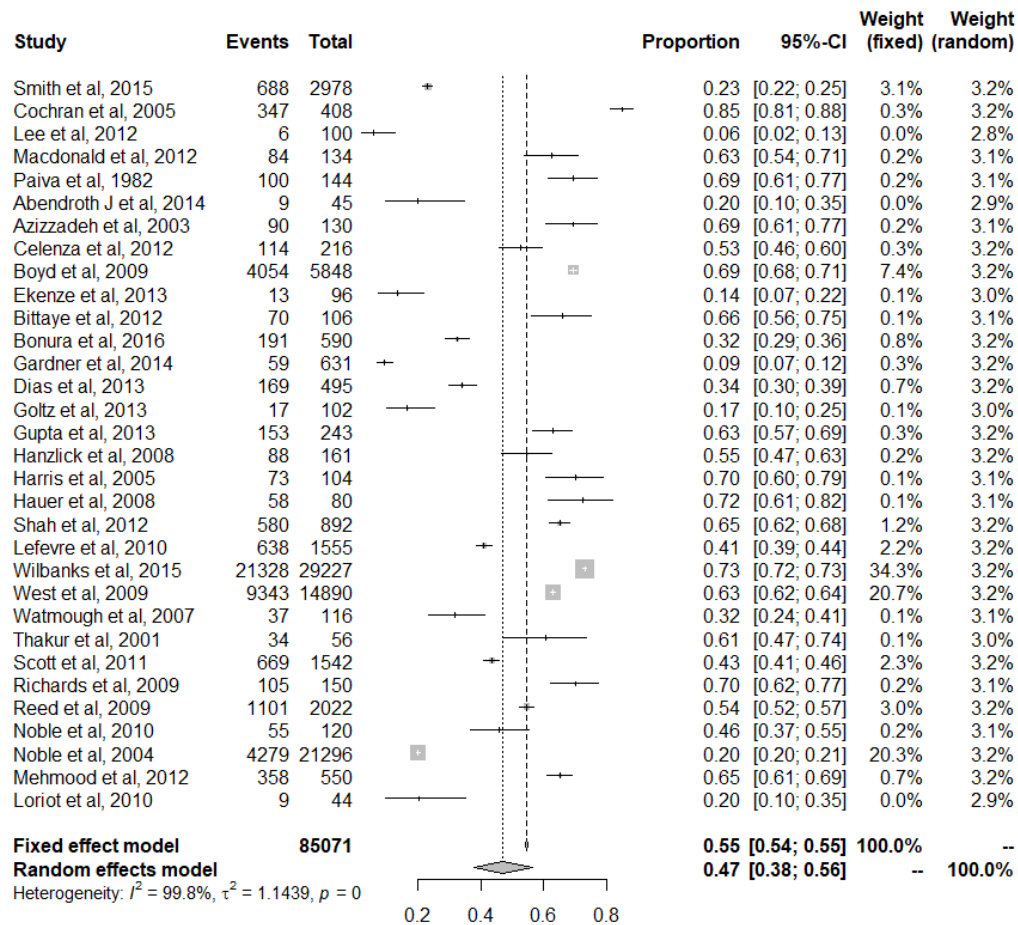


Figure S7. Forest Plot of “Career Opportunities”.

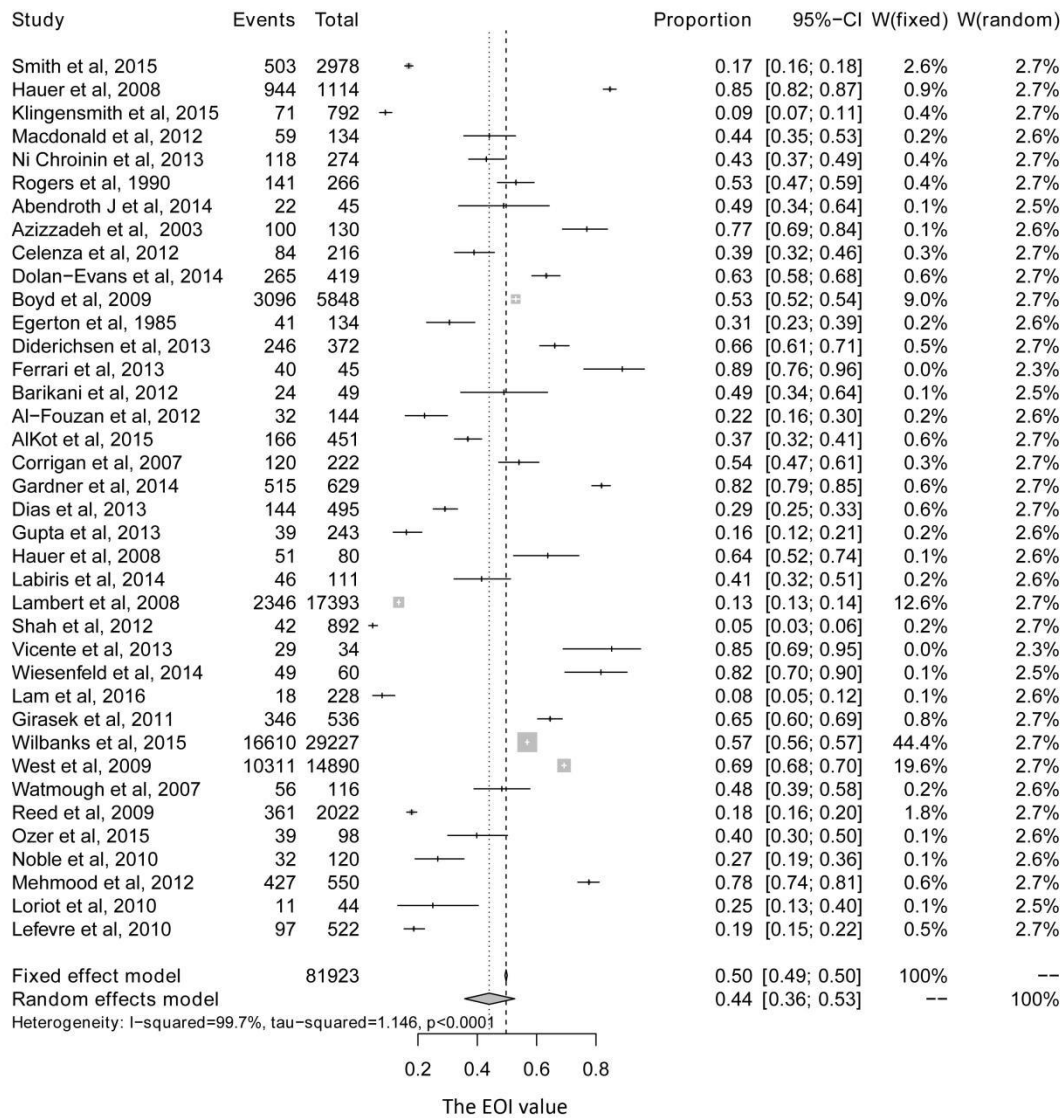
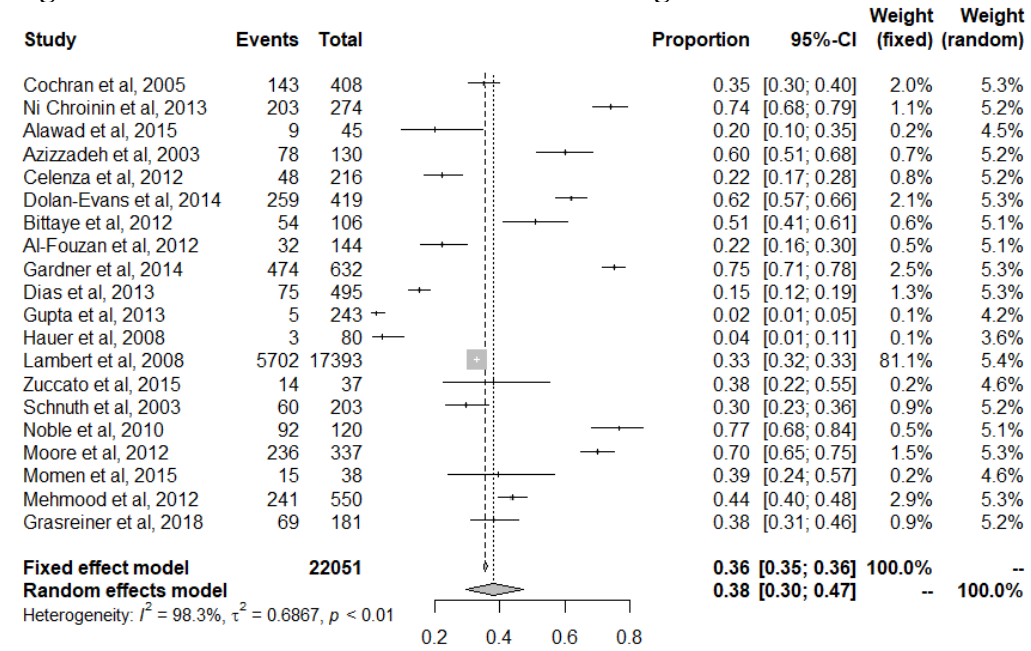


Figure S8. Forest Plot of “Workload or Working Hours”.



only

Figure S9. Forest Plot of “Income”.

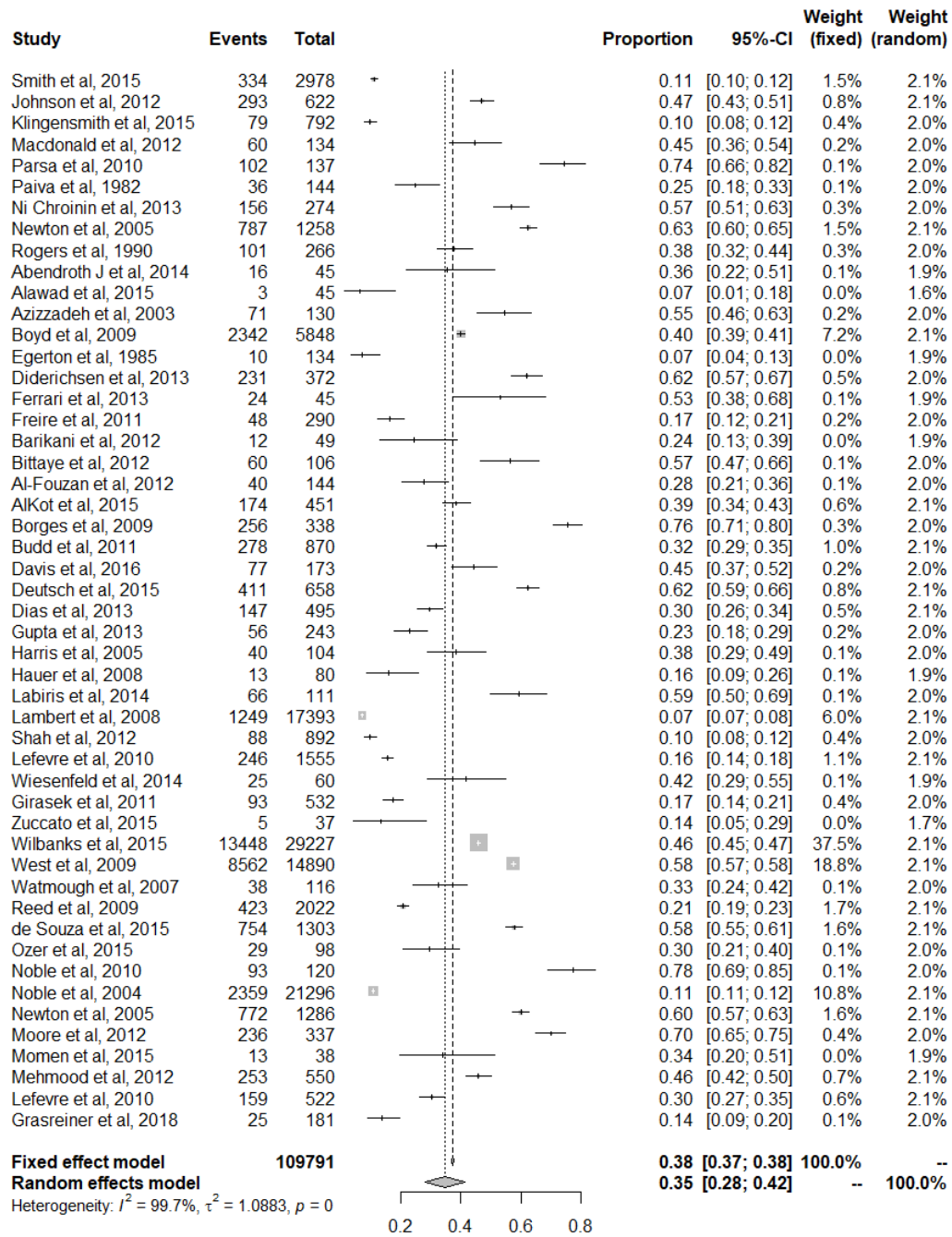
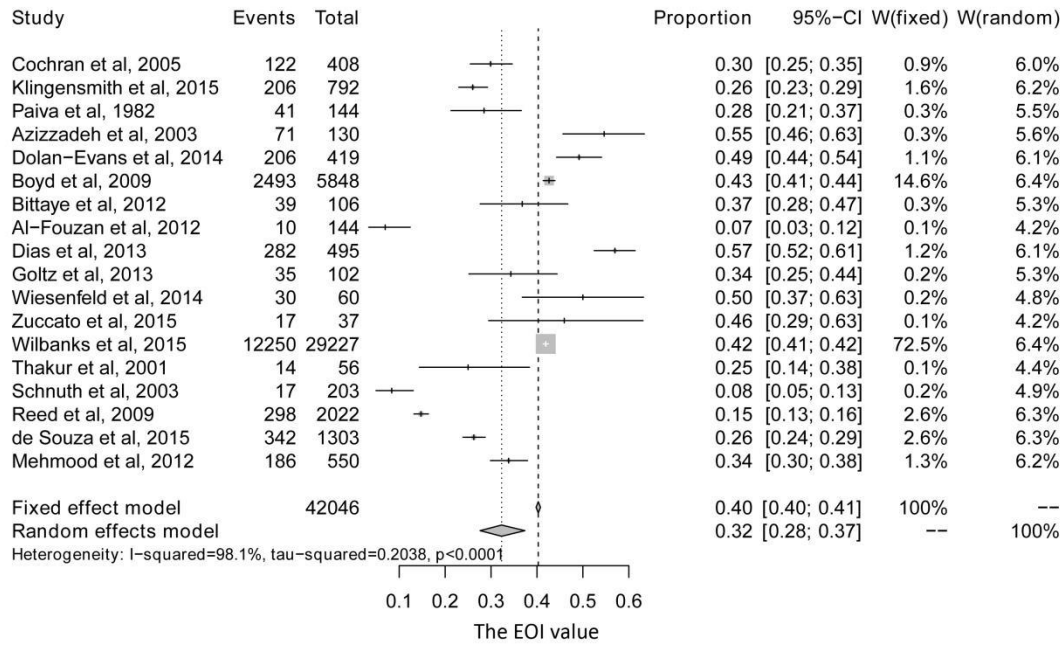
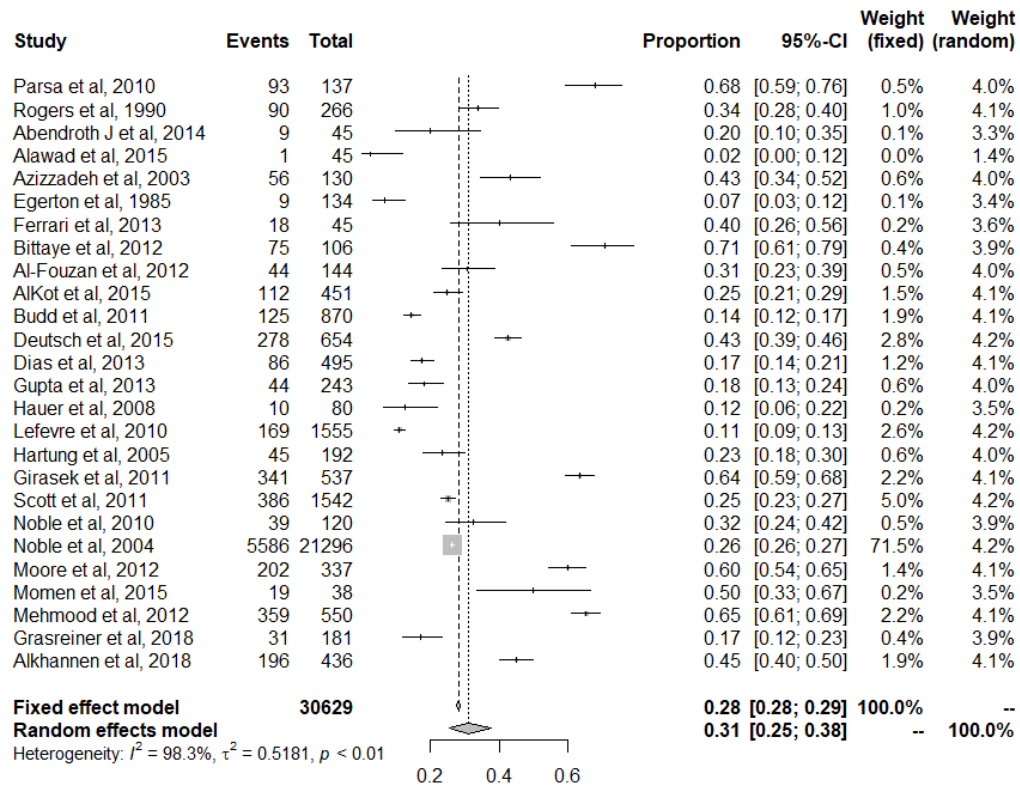


Figure S10. Forest Plot of “Length of Training”.



review only

Figure S11. Forest Plot of “Prestige”.



only

Figure S12. Forest Plot of “Advice from Others”.

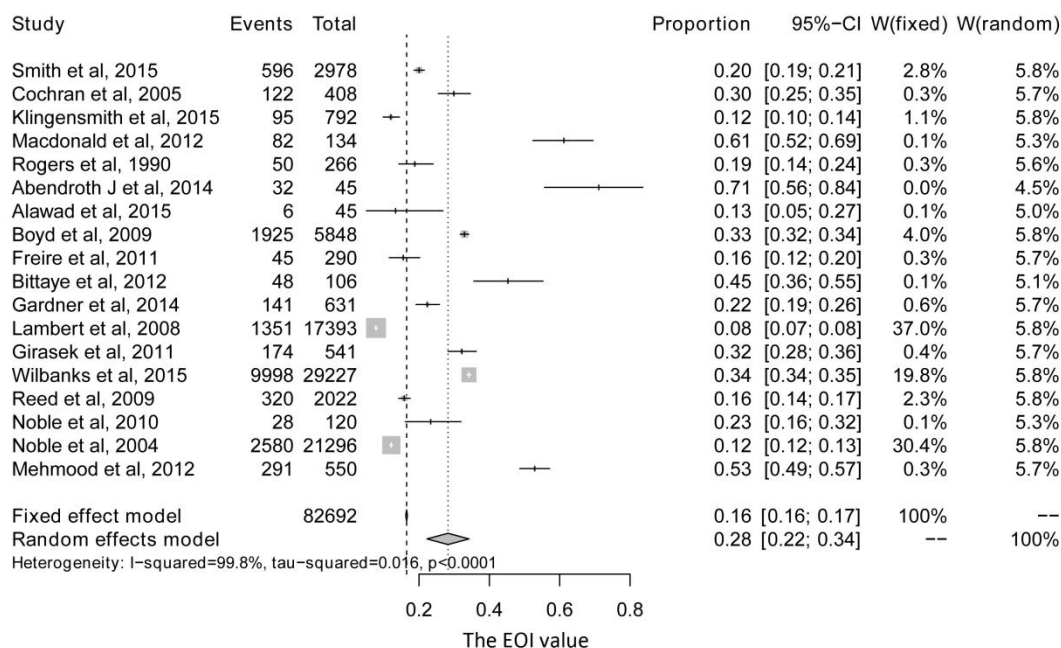


Figure S13. Forest Plot of “Student Debt”.

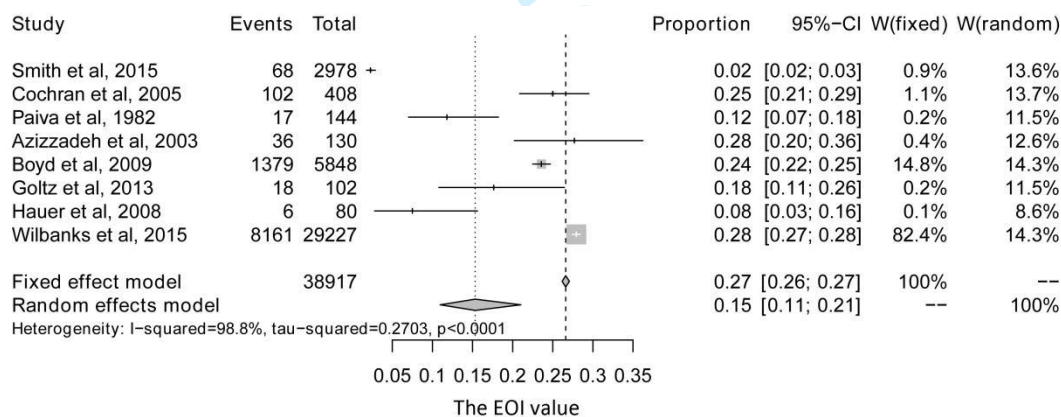
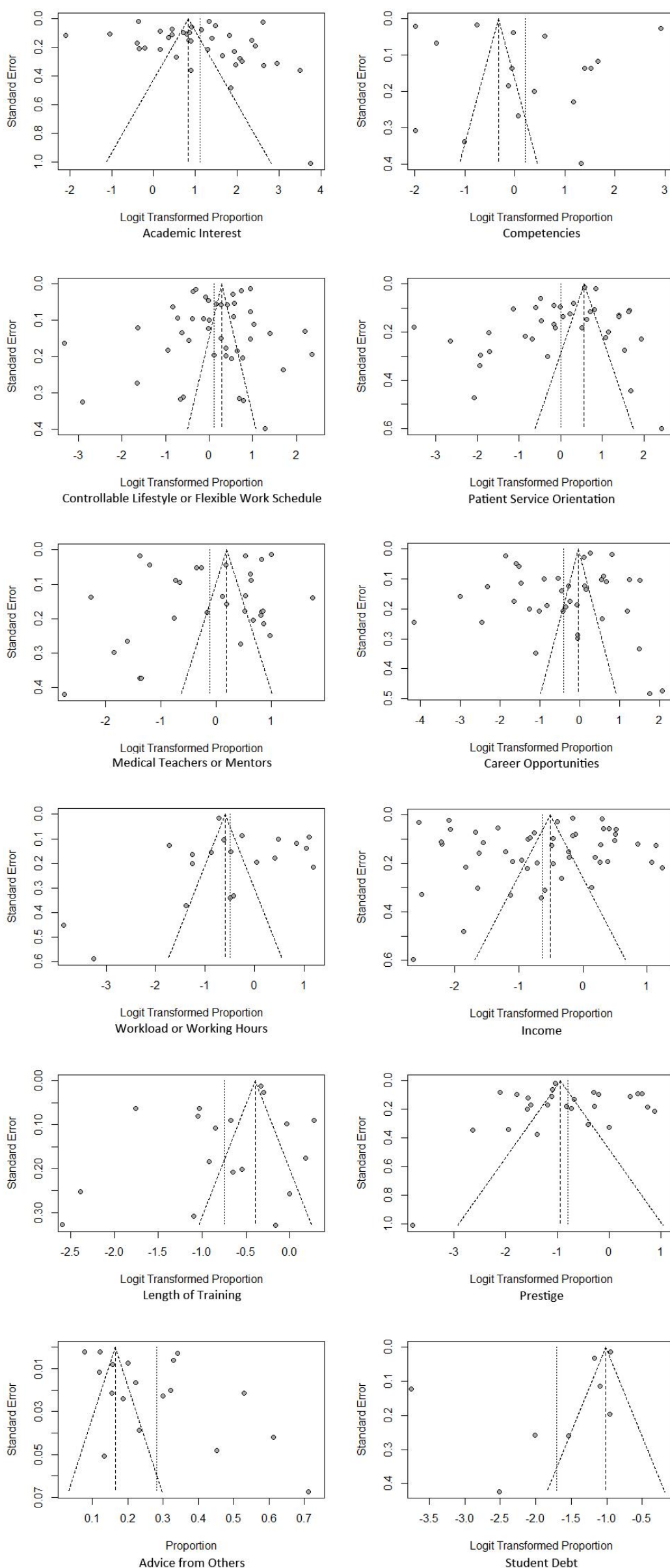


Figure S14. Funnel Plots of the Publication Bias Testing of the 12 Factors.





PRISMA 2009 Checklist

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2-3
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	4
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	5
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	3
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	5
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	5
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	5
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	5-6
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	6
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	6
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	6-7
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	6-7
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	7

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PRISMA 2009 Checklist

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Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	7
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	7
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	5, 7
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	7-8
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	8
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	8
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	8-9
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	8-9
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	8-9
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	9-13
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	13
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	14
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	15

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

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MOOSE Checklist for Meta-analyses of Observational Studies

Item No	Recommendation	Reported on Page No
Reporting of background should include		
1	Problem definition	5
2	Hypothesis statement	5
3	Description of study outcome(s)	5
4	Type of exposure or intervention used	5
5	Type of study designs used	5
6	Study population	5
Reporting of search strategy should include		
7	Qualifications of searchers (eg, librarians and investigators)	6
8	Search strategy, including time period included in the synthesis and key words	5
9	Effort to include all available studies, including contact with authors	5
10	Databases and registries searched	5
11	Search software used, name and version, including special features used (eg, explosion)	6
12	Use of hand searching (eg, reference lists of obtained articles)	5
13	List of citations located and those excluded, including justification	5-6
14	Method of addressing articles published in languages other than English	5
15	Method of handling abstracts and unpublished studies	5
16	Description of any contact with authors	5
Reporting of methods should include		
17	Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	6
18	Rationale for the selection and coding of data (eg, sound clinical principles or convenience)	6-7
19	Documentation of how data were classified and coded (eg, multiple raters, blinding and interrater reliability)	6-7
20	Assessment of confounding (eg, comparability of cases and controls in studies where appropriate)	6
21	Assessment of study quality, including blinding of quality assessors, stratification or regression on possible predictors of study results	6
22	Assessment of heterogeneity	6
23	Description of statistical methods (eg, complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated	6-7
24	Provision of appropriate tables and graphics	5-7
Reporting of results should include		
25	Graphic summarizing individual study estimates and overall estimate	8
26	Table giving descriptive information for each study included	7
27	Results of sensitivity testing (eg, subgroup analysis)	8
28	Indication of statistical uncertainty of findings	7-9

Item No	Recommendation	Reported on Page No
Reporting of discussion should include		
29	Quantitative assessment of bias (eg, publication bias)	13
30	Justification for exclusion (eg, exclusion of non-English language citations)	13-14
31	Assessment of quality of included studies	13-14
Reporting of conclusions should include		
32	Consideration of alternative explanations for observed results	14
33	Generalization of the conclusions (ie, appropriate for the data presented and within the domain of the literature review)	14
34	Guidelines for future research	14
35	Disclosure of funding source	15

From: Stroup DF, Berlin JA, Morton SC, et al, for the Meta-analysis Of Observational Studies in Epidemiology (MOOSE) Group. Meta-analysis of Observational Studies in Epidemiology. A Proposal for Reporting. *JAMA*. 2000;283(15):2008-2012. doi: 10.1001/jama.283.15.2008.

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