BMJ Open Factors influencing subspecialty choice among medical students: a systematic review and meta-analysis

Yahan Yang,^{1,2} Jiawei Li,³ Xiaohang Wu,¹ Jinghui Wang,¹ Wangting Li,¹ Yi Zhu,^{4,5} Chuan Chen,^{4,6} Haotian Lin⁷

To cite: Yang Y, Li J, Wu X, *et al.* Factors influencing subspecialty choice among medical students: a systematic review and meta-analysis. *BMJ Open* 2019;**9**:e022097. doi:10.1136/bmjopen-2018-022097

► Prepublication history and additional material for this paper are available online. To view these files, please visit the journal online (<http://dx.doi.org/10.1136/bmjopen-2018-022097>).

Received 3 February 2018

Revised 15 January 2019

Accepted 8 February 2019

© Author(s) (or their employer(s)) 2019. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

For numbered affiliations see end of article.

Correspondence to

Dr Haotian Lin;
haot.lin@hotmail.com

ABSTRACT

Objective To characterise 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 June 2018. 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 recruited medical students include students in medical school, internship, residency training and fellowship, who are about to or have just made a specialty choice. The estimates were pooled using a random-effects meta-analysis model due to the between-study heterogeneity.

Results Data were extracted from 75 studies (882 209 individuals). Overall, the factors influencing medical students' choice of subspecialty training mainly included academic interests (75.29%), competencies (55.15%), controllable lifestyles or flexible work schedules (53.00%), patient service orientation (50.04%), medical teachers or mentors (46.93%), career opportunities (44.00%), workload or working hours (37.99%), income (34.70%), length of training (32.30%), prestige (31.17%), 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 (79.66% [95% CI 70.73% to 86.39%] vs 60.41% [95% CI 43.44% to 75.19%]; $Q = 3.51$, $p = 0.02$). The EOI value of prestige was lower in developed countries than that in developing countries (23.96% [95% CI 19.20% to 29.47%] vs 47.65% [95% CI 34.41% to 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 optimise the distribution of physicians among different departments by modifying these influencing factors.

INTRODUCTION

Because of the population ageing, increased workload on doctors through increased

Strengths and limitations of this study

- This is the first study that provides 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.

number of consultations and in managing patients with multimorbidity, 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.^{1–5} Some specialties and subspecialties, such as family medicine and palliative medicine,^{6 7} are experiencing a desperate shortage of physicians, whereas other specialties and subspecialties, such as cardiology, ophthalmology and ear, nose and throat surgery, are highly competitive specialties with low success rate for candidates.^{8 9}

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.¹⁰ 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.^{11 12} 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.¹³ 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 medical students made a definitive subspecialty choice during their first year of medical school.¹⁴ However, students were prone to changing their subspecialty preference during medical school and internship.¹⁵ Notably, students may also reject certain subspecialties during their medical school training, even those they have previously seriously considered.¹⁶ Therefore, identifying the factors that influence students' choice of subspecialty will enable a better understanding of the current shortage/overload of physicians in specific fields and contribute to policy-building and decision-making to improve the training and recruitment of students in the future.

We thus conducted a systematic review and a meta-analysis to investigate the influencing factors and the extent of their influence on the choice of subspecialty training among medical students. More specifically, we focused on the following questions. First, can we gain a better understanding of students' preferences for medical specialty according to the primary influencing factor? Second, do the subgroups according to world region and survey years examined in this study differ significantly with regard to the weight that students place on the identified influencing factor?

METHODS

We developed a review protocol (registration number: PROSPERO CRD42017053781) prior to commencing the study. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines was used to ensure the reporting quality of this review (see online supplementary figure S1).¹⁷

Search strategy and study eligibility

We performed a literature search in June 2018 using the Cochrane Library, Medline, Web of Science, CNKI and ERIC databases without language restrictions. Articles were screened by title, abstract and reference list, and by correspondence with study investigators. Potentially relevant papers were first identified by reviewing the titles and abstracts, and the full text of each retrieved article was then assessed. A detailed example of search strategy for Medline/PubMed is shown in online supplementary methods S1. Studies were included if they were systematic review or cross-sectional studies, reported data on medical students, were published in peer-reviewed journals and used a validated method to assess the extent of their influence (EOI) on the choice of subspecialty, such as paediatric gastroenterology and vascular surgery, or its corresponding specialty, such as paediatrics and surgery. Because of the differences between medical education systems in the world, the medical students we recruited include the students in medical school, internship, residency training and fellowship, students who are about to make a specialty choice and students who have just made a specialty choice. A guide to medical specialty, available at <https://www.abms.org/member-boards/>

specialty-subspecialty-certificates/, was used to identify the medical specialty and subspecialty of our research. We also conducted an additional search using OpenGrey. However, no additional articles were further included. All searches were performed using Google chrome (V.54.0.2840).

Data extraction and quality assessment

Each article was reviewed by two trained investigators (YY and JL) and the following information was independently extracted from each selected article using a standardised form: study design, geographic location, years of survey, journal, sample size, average age of the participants, the number and percentage of male participants and the influencing factors and the extent of their influence. A third investigator was consulted if disagreements occurred. Each study may involve one or several influencing factors. An 11-item checklist which was recommended by Agency for Healthcare Research and Quality (AHRQ), used for cross-sectional studies,¹⁸ available at <https://www.ncbi.nlm.nih.gov/books/NBK35156/>, was used to assess the quality of the studies. All discrepancies were resolved via discussion and consensus.

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.¹⁹ Between-study heterogeneity was assessed using the Cochran's Q-test, and was quantified with 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.^{20 21} Potential sources of heterogeneity were identified using meta-regression.²² Four categorical covariates were defined as potential sources of heterogeneity by examining the studies conducted in the USA versus the studies conducted in other countries, the studies conducted before 2010 versus those conducted after 2010, the studies concerning subspecialty only versus those that were not specific to a subspecialty, and the studies with a sample size < 200 versus the studies with a sample size ≥ 200 . Subgroup analyses were performed for each factor in the studies in developed countries versus developing countries and studies conducted before 2010 versus after 2010. The EOI value of competencies in developing countries was not statistically significant (81.21% [95% CI 75.27% to 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%.²³ 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.^{24 25} Fill and trim approach, which imputes estimates from hypothetical negative unpublished reports,²⁶ was also used to investigate the publication bias if the Egger's

test was significant. All analyses were performed using R (V.3.3.1, The R Foundation, Vienna, Austria). The statistical tests were two-sided with a significance threshold of $p < 0.05$.

Patient and public involvement

Patients and the public were not involved in development of the research question and outcome measures, nor the study design. The study does not involve patient recruitment, and patients were not involved in conduct of the study. We plan to liaise closely with patients, special interest groups and charities in the dissemination of our results in printed and electronic media.

RESULTS

Study characteristics

Seventy-five cross-sectional studies involving a total of 882 209 individuals that were published between January 1977 and May 2018 were included in the present research (table 1). Thirty-four studies were conducted in North America, twenty-four in Europe, seven in Asia, five in Oceania, three in Africa and two in South America. The median number of participants per study was 243 (range 37–29 227). Fourteen studies included students who had already selected subspecialties, whereas 61 did not. The influencing factors were ranked according to the frequency of occurrence and each factor was identified when at least five papers were available describing it. The influencing factors for subspecialty choice were then 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 practising the specialty), competencies, patient service orientation, medical teachers or mentors, career opportunities, workload or working hours (characterised 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. 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. Studies assessed for influencing factors using questionnaires validated to medical students asking the extent of certain factors the studies investigated. 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 analysed articles. For the remaining 10 criteria, 6 studies received nine points, 8 studies received eight points, 17 studies received seven points, 33 studies received six points, 9 studies received 5 points and 2 studies received four points (scores for individual studies are presented in online supplementary table S1).

Primary analysis

A meta-analysis was performed on the 12 influencing factors (table 2): academic interests (see online supplementary figure S2), competencies (see online supplementary figure S3), controllable lifestyle or flexible work schedule (see online supplementary figure S4), patient service orientation (see online supplementary figure S5), medical teachers or mentors (see online supplementary figure S6), career opportunities (see online supplementary figure S7), workload or working hours (see online supplementary figure S8), income (see online supplementary figure S9), length of training (see online supplementary figure S10), prestige (see online supplementary figure S11), advice from others (see online supplementary figure S12) and student debt (see online supplementary figure S13). All the factors were significant with evidence of between-study heterogeneity ($p < 0.0001$). A sensitivity analysis, in which the meta-analysis was serially repeated after the exclusion of each study, demonstrated that no individual study affected the overall extent of a factor's influence.

Meta-regression and subgroup analysis

We performed meta-regression to identify the potential sources of heterogeneity using common instructions when at least five studies were available and at least two studies were in each comparator subgroup (table 3). Some of the heterogeneities observed among the 12 factors can be partially explained by country, survey years, specialty and sample size.

EOI values were further analysed by subgroup (see online supplementary table S2) according to world region (figure 1) and survey year (figure 2). The EOI value of academic interests in developed countries was higher than that in developing countries (79.66% [95% CI 70.73% to 86.39% vs 60.41% [95% CI 43.44% to 75.19%]; $Q = 3.51$, $p = 0.02$). Conversely, a lower EOI value of prestige was found in studies conducted in developed countries than in developing countries (23.96% [95% CI 19.20% to 29.47%] vs 47.65% [95% CI 34.41% to 61.24%]; $Q = 4.71$, $p = 0.01$). No statistically significant subgroup differences in the EOI values of the other influencing factors were noted between developed countries and developing countries. In addition, no statistically significant differences in the EOI values of the influencing factors were observed when subgroup analysis was performed by survey year.

Assessment of publication bias

We generated a funnel plot with proportion as the abscissa and SE as the ordinate. A visual inspection of the funnel

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 <i>et al</i> , ⁴³ 2015	UK	2012	2978	NR	NR	6
Cochran <i>et al</i> , ⁴⁴ 2005	USA	2002	408	27.2	214 (52.45)	5
Hauer <i>et al</i> , ⁴⁵ 2008	USA	2007	1177	NR	NR	6
Johnson <i>et al</i> , ⁴⁶ 2012	USA	2012	622	NR	NR	6
Kiolbassa <i>et al</i> , ⁴⁷ 2011	Germany	2010	1114	24.1	408 (36.62)	5
Klingensmith <i>et al</i> , ⁴⁸ 2015	USA	2013	792	NR	539 (68.06)	6
Lee <i>et al</i> , ⁴⁹ 2012	USA	2012	100	NR	58 (58)	7
Macdonald <i>et al</i> , ⁵⁰ 2012	New Zealand	2011	134	NR	79 (58.96)	7
Parsa <i>et al</i> , ³⁹ 2010	Iran	2006–2007	137	27.34	49 (35.77)	7
Paiva <i>et al</i> , ⁵¹ 1982	USA	1982	144	NR	NR	6
Ni Chroinin <i>et al</i> , ⁵² 2013	UK	2009–2011	274	NR	112 (40.89)	7
Newton <i>et al</i> , ³⁴ 2005	USA	1998–2004	1258	NR	642 (51.03)	8
Rogers <i>et al</i> , ⁵³ 1990	USA	1989	266	NR	205 (77.07)	6
Abendroth <i>et al</i> , ⁵⁴ 2014	Germany	2007–2012	45	NR	14 (31)	7
Alawad <i>et al</i> , ⁵⁵ 2015	USA	2010–2011	45	NR	36 (80)	8
Azizzadeh <i>et al</i> , ⁵⁶ 2003	USA	2002	130	NR	NR	6
Celenza <i>et al</i> , ⁵⁷ 2012	Australia	2009	216	NR	121 (56.02)	8
Dolan-Evans <i>et al</i> , ⁵⁸ 2014	Australia	2013	419	NR	215 (51.31)	8
Boyd <i>et al</i> , ⁵⁹ 2009	USA	2005–2006	5848	NR	2982 (50.99)	8
Egerton <i>et al</i> , ⁶⁰ 1985	Ireland	1977–1981	134	30	82 (61.19)	6
Diderichsen <i>et al</i> , ⁶¹ 2013	Sweden	2006–2009	372	27	157 (42.20)	6
Ferrari <i>et al</i> , ⁶² 2013	Italy, UK	2009–2011	45	25	NR	9
Freire <i>et al</i> , ⁶³ 2011	Brazil	2006–2008	290	23	102 (35.17)	7
Buddeberg-Fischer <i>et al</i> , ⁶⁴ 2006	Switzerland	2001–2003	522	31.1	241 (46.17)	9
Dorsey <i>et al</i> , ⁶⁵ 2005	USA	2003	11 029	NR	4964 (45.01)	6
Ekenze <i>et al</i> , ⁶⁶ 2013	Nigeria	2009–2010	96	25.9	NR	7
Barikani <i>et al</i> , ⁶⁷ 2012	Australia	2008–2009	49	21.7	NR	6
Bittaye <i>et al</i> , ⁶⁸ 2012	Gambia	2011	106	24.1	48 (45.28)	6
Bonura <i>et al</i> , ⁶⁹ 2016	USA	2015	590	NR	321 (54.40)	9
Al-Fouzan <i>et al</i> , ⁷⁰ 2012	Kuwait	2011–2012	144	NR	NR	7
AlKot <i>et al</i> , ⁷¹ 2015	Egypt	2013	451	21.8	NR	7
Borges <i>et al</i> , ⁷² 2009	USA	2001–2005	341	NR	NR	5
Budd <i>et al</i> , ⁷³ 2011	UK	2011	870	22	NR	7
Corrigan <i>et al</i> , ⁷⁴ 2007	Ireland	2007	222	NR	142 (63.96)	7
Davis <i>et al</i> , ⁷⁵ 2016	UK	2016	173	NR	76 (43.93)	7
Deutsch <i>et al</i> , ⁷⁶ 2015	Germany	2011	659	27.9	NR	8
Gardner <i>et al</i> , ⁷⁷ 2014	Australia	1993–2005	631	NR	NR	7
Dias <i>et al</i> , ⁷⁸ 2013	UK	2013	495	NR	438 (88.48)	5
Goltz <i>et al</i> , ⁷⁹ 2013	USA	2012	102	24.5	34 (33.33)	6
Gupta <i>et al</i> , ⁸⁰ 2013	India	2013	243	NR	179 (73.36)	6
Hanzlick <i>et al</i> , ⁸¹ 2008	USA	2006	161	NR	NR	6
Harris <i>et al</i> , ⁸² 2005	USA	1991–2002	104	NR	53 (50.96)	6
Hauer <i>et al</i> , ⁸³ 2008	USA	2008	80	NR	NR	6
Labiris <i>et al</i> , ⁸⁴ 2014	Greece	2014	111	23.6	55 (49.54)	6
Lambert <i>et al</i> , ⁸⁵ 2008	UK	2007	17 393	NR	NR	6
Shah <i>et al</i> , ⁸⁶ 2012	USA	2011	892	NR	NR	6

Continued

Table 1 Continued

First author, year	Country	Survey years	Sample size	Average age	Men, No. (%)	Scores
Lefevre <i>et al</i> , ⁸⁷ 2010	USA	2008	1555	NR	589 (37.88)	6
Vicente <i>et al</i> , ⁸⁸ 2013	Chile	2013	30	NR	NR	6
Wiesenfeld <i>et al</i> , ⁸⁹ 2014	Canada	2013	60	NR	NR	7
Lam <i>et al</i> , ⁹⁰ 2016	Hong Kong	2015	228	23	NR	9
Hartung <i>et al</i> , ⁹¹ 2005	USA	2004	192	20.59	74 (38.54)	4
Girasek <i>et al</i> , ⁹² 2011	Hungary	2011	536	NR	NR	5
Zuccato <i>et al</i> , ⁹³ 2015	Canada	2012	37	NR	24 (65)	6
Wilbanks <i>et al</i> , ⁹⁴ 2015	USA	2011–2013	29 227	NR	15 164 (51.99)	9
West <i>et al</i> , ⁹⁵ 2009	USA	2005–2007	14 890	NR	8700 (58.43)	6
Watmough <i>et al</i> , ⁹⁶ 2007	UK	2005	116	NR	66 (56.90)	4
Thakur <i>et al</i> , ⁹⁷ 2001	USA	2001	56	NR	53 (95)	8
Scott <i>et al</i> , ⁹⁸ 2011	Canada	2002–2004	1542	NR	NR	6
Schnuth <i>et al</i> , ⁹⁹ 2003	USA	2002	203	NR	72 (53.47)	6
Richards <i>et al</i> , ¹⁰⁰ 2009	UK	2009	150	NR	108 (72.00)	5
Reed <i>et al</i> , ¹⁰¹ 2009	USA	2008	2022	NR	1354 (66.96)	9
de Souza <i>et al</i> , ¹⁰² 2015	Portugal	2012	1303	NR	NR	7
Pikoulis <i>et al</i> , ¹⁰³ 2010	Greece	2006–2007	87	NR	NR	6
Ozer <i>et al</i> , ¹⁰⁴ 2015	Turkey	2013	98	27.7	26 (26.53)	6
Noble <i>et al</i> , ¹⁰⁵ 2004	Canada	2004	21 296	NR	NR	8
Noble <i>et al</i> , ¹⁰⁶ 2010	Canada	2007	120	NR	NR	5
Newton <i>et al</i> , ³⁴ 2005	USA	2004	1286	NR	NR	6
Moore <i>et al</i> , ¹⁰⁷ 2012	USA	2011	337	26	179 (53.12)	6
Momen <i>et al</i> , ¹⁰⁸ 2015	Iran	2014–2015	38	35.6	11 (29)	6
Mehmood <i>et al</i> , ¹⁰⁹ 2012	Saudi Arabia	2012	550	NR	348 (63.27)	6
Loriot <i>et al</i> , ¹¹⁰ 2010	France	2007	44	NR	17 (39)	7
Lefevre <i>et al</i> , ¹¹¹ 2010	France	2008	522	23.8	198 (37.93)	7
Vo <i>et al</i> , ¹¹² 2017	Canada	2017	90	22.5	52 (57.78)	5
Grasreiner <i>et al</i> , ¹¹³ 2018	Germany	2014–2016	181	24	33 (18.10)	6
Alkhannen <i>et al</i> , ¹¹⁴ 2018	Saudi Arabia	2017	436	NA	250 (57.00)	5

Footnotes, scores: quality score of the AHRQ scale.

plots revealed minimal asymmetry among the various influencing factors (see online supplementary figure S14), and the results were concentrated in the narrow upper part of the graph. There was evidence of small study effect in the meta-analysis of 'patient service orientation' (Egger's test, $p=0.02$). However, the trim-and-fill method showed the publication bias-corrected estimate remained statistically significant (63.79%, 95% CI 58.20% to 69.04%).

DISCUSSION

Implications

This systematic review and meta-analysis involved 75 studies with 882 209 medical students. Twelve influencing factors were analysed. 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 (34.70%) 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 specialty or subspecialty. In the USA, 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 orthopaedists (median income=\$335 646).²⁷ This economic inequality made family medicine less attractive to medical school graduates.²⁸ Benefits such as health insurance and tuition reimbursement have been shown to be the most common economic incentives used to attract applicants.²⁹

The non-economic factors can be divided into individual factors, specialty-related factors and others. First, individual factors, including academic interest and

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 extent of influence value		Cochran's Q	I ² (%)	τ^2	P value
				Lower	Upper				
Academic interests	38	82 366	75.29	66.93	82.11	14 719.76	99.70	1.60	<0.0001
Competencies	17	76 515	55.15	33.63	74.90	23 572.74	99.90	3.44	<0.0001
Controllable lifestyle or flexible work schedule	44	1 01 001	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	15 216.32	99.80	1.14	<0.0001
Career opportunities	38	81 923	44.00	32.26	48.78	13 553.20	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	1 09 791	34.70	28.36	41.62	16 952.48	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

competencies, have a considerable impact on students' subspecialty choice, with EOI values of 75.29% and 55.15%, respectively. In addition, in the subgroup analysis, although academic interests were less influential in developing countries than in developed countries (79.66% [95% CI 70.73% to 86.39% vs 60.41% [95% CI 43.44% to 75.19%]; $Q=3.51$, $p=0.02$), they were still the most influential of the 12 factors regardless of regional economic level. These findings indicate that subspecialties with a shortage of manpower may attract more students by increasing students' interests and improving the quality of education. Previous studies indicated that early specialty exposure in medical education may arouse students' academic interest and improve their clinical competence.^{28 30} For example, an elective extracurricular programme designed to facilitate early contact with family medicine physicians was found to significantly improve students' interest and clinical skills, especially communication skills, in family medicine.³¹ Furthermore, dispelling myths and espousing the positive aspects of a discipline may provide a better understanding of certain specialties; this approach could also be effective in increasing students' academic interest.³² For instance, family medicine is often considered a discipline that requires less professional skills and knowledge. This misconception demotivates students from choosing family medicine as their future career specialty, and this trend may eventually lead to a shortage of family physicians.³² Eliminating such prejudices may help students pay greater attention to the areas in short supply and restore their interests in other specialties.

Second, the specialty-related factors included controllable lifestyle/flexible work schedule (EOI of 53.00%), career opportunities (EOI of 44.00%), workload (EOI of 37.99%) and training length (EOI of 32.30%). Of these

factors, lifestyle varied between different areas. Additionally, although certain specialties, such as general surgery, seem to have an adequate number of surgeons on a per capita basis in the USA, there is still a poor geographic distribution within the surgical workforce according to the type of surgical practice.³³ The inflexible lifestyle is a common reason that students perceive surgery to be less attractive.³³ Reorganisation of expected work hours within shared practices and the increased use of physician extenders and technologies such as electronic medical records may give physicians more flexibility in work schedules.³⁴ Moreover, providing promotion opportunities and shortening the length of training are possible strategies to recruit new staff in subspecialties that require a long period of postgraduate residency training, such as neurosurgery.³⁵

Finally, other factors such as service orientation (EOI of 50.74%), medical teachers or mentors (EOI of 46.93%), prestige (EOI of 34.68%) and advice from others (EOI of 28.24%) also contribute to the decision-making process of medical students. For example, the desire to care for patients with end-stage diseases contributed to the decision to enter palliative medicine in 86% of the medical students.⁷ Additionally, exposure to mentors in a particular clinical field such as internal medicine has been strongly associated with medical students' choice of clinical field.³⁶ Moreover, improving the occupational prestige of areas such as family medicine, pathology and radiology may help reshape the distribution of the workforce.^{30 37 38}

In our study, several findings are especially noteworthy. First, interest was far more important than income in deciding subspecialty. In our study, interest was the top-ranked influencing factor (EOI of 75.29%) of subspecialty choice, while income was ranked lower (EOI of

Table 3 Meta-regression of the extent of influence value stratified by study-level characteristics

		95 CI% of estimate		
Factor	Estimate	Lower	Upper	P value
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

Continued

Table 3 Continued

Factor	Estimate	95CI% of estimate		P value
		Lower	Upper	
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
Specialty	−0.2017	−0.2790	−0.1244	<0.0001
Sample size	0.2125	0.1309	0.2941	<0.0001
Student debt				
Country	2.7853	2.0544	3.5162	0.0001
Survey years	−0.1567	−0.6707	0.3573	0.5502
Sample size	−0.5248	−1.0108	−0.0388	0.0343

34.70%). This finding argues against the possible default belief that raising physician's wages alone could solve the uneven distribution of clinicians among subspecialties. Our findings highlight that cultivating and stimulating students' professional interests may help improve the maldistribution of medical resources in a more efficient and cost-saving manner.

Second, improving abilities in a certain subspecialty of interest can greatly affect medical students' professional choice. In our study, competencies ranked second in influence, which may reflect the impact of admission conditions on students' choice of subspecialty. Hence, to reduce the risk that students are restricted to the subspecialty of their interest due to a lack of personal skills,

medical education should focus more on enhancing students' personal competencies in addition to their academic interests.

Third, balancing medical resources is a complex process in practical terms, as the influencing factors are not mutually exclusive. The shortage of physicians in certain subspecialties may increase physician workload, resulting in less time for teaching. Hence, the quality of teaching cannot be guaranteed, and students may tend to avoid choosing these subspecialties, thus worsening the imbalance in the medical workforce. Additionally, some of the 12 factors identified are not amenable to practical interventions. For example, prestige cannot be immediately increased using interventional strategies.³⁷ Overall,

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.

effective strategies must be multipronged and incorporate several different aspects, and maldistribution in the workforce should not be tackled through a simple adjustment of one influencing factor.

Interpretations of the results of this meta-analysis

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

Limitations

Several limitations should be considered when interpreting the findings of this study. First, the students involved in our study included medical students at different stages of their medical education. Students' perception about different subspecialties may change during medical training until the students applies for specialty training. For example, compared with an intern, a freshman student may place greater emphasis on income and prestige when considering a career choice.³⁹ A subgroup analysis stratified by the stages of medical education and a secondary meta-analysis of longitudinal studies may better reflect changes in influencing factors and the extent of their influence over time. Second, our meta-analysis summarised the data from different geographic regions around the world, and the general conclusions may not be appropriate to guide policy development in each region. Enhanced effort is needed to develop specific intervention strategies according to the specific economic level, religious beliefs, health-care system, educational system and endemic diseases of

different countries and regions. Subgroup analysis stratified by organisational and medical training factors would provide more information of the factors influencing subspecialty choice among medical students. Third, the surveys in the various studies were also conducted using different methods. Most of the questionnaires used a Likert scale. Therefore, when we converted the results to a percentage representing the extent of a factor's influence, the Likert scale items were treated as interval data.^{40–42} Consequently, there may have been differences in the conversion process. Finally, the analysis relied on aggregated published data. A multicentre prospective study would provide more accurate estimate of the influencing factors and the extent of their influence on medical students' choice of subspecialty.

CONCLUSION

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

Author affiliations

¹State Key Laboratory of Ophthalmology, Sun Yat-Sen University Zhongshan Ophthalmic Center, Guangzhou, China

²Zhongshan School of Medicine, Sun Yat-Sen University, Guangzhou, China

³Zhongshan School of Mathematics, Sun Yat-Sen University, Guangzhou, China

⁴Department of Molecular and Cellular Pharmacology, University of Miami School of Medicine, Miami, Florida, USA

⁵Cataract, Sun Yat-Sen University Zhongshan Ophthalmic Center, Guangzhou, China

⁶State Key Laboratory of Ophthalmology, Zhongshan Ophthalmic Center, Sun Yat-sen University, Guangzhou, China

⁷Cataract, State Key Laboratory of Ophthalmology, Zhongshan Ophthalmic Center, Sun Yat-sen University, Guangzhou, China

Contributors HL contributed to the conceptualising and design of the study and to research funding, coordinated the research and oversaw the project. YY, JL and XW contributed to data collection and interpretation, and to data analysis. JW, YZ, CC and WL contributed to the design of the study. All authors contributed to the drafting and revision of the paper and approved the final manuscript for publication.

Funding The principal investigator of this study (Haotian Lin) is currently supported by National key R & D project (2018YFC010302), the Key Research Plan for the National Natural Science Foundation of China Cultivation Project (91546101), the National Natural Science Foundation of China (81770967), the Fundamental Research Funds for the Central Universities (16ykjc28), the Guangdong Provincial Natural Science Foundation for Distinguished Young Scholars of China (2014A030306030), the Guangdong Province Universities and Colleges Youth Pearl River Scholar Funded Scheme (2016), the Clinical Research and Translational Medical Center of Pediatric Cataract in Guangzhou City (201505032017516) and Ministry of Science and Technology of China Grants (2015CB964600).

Disclaimer These sponsors and funding organisations had no role in the design or performance of this study.

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement Extracted data are available upon request to the corresponding author.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

REFERENCES

- Zurn P, Dal Poz MR, Stilwell B, *et al.* Imbalance in the health workforce. *Hum Resour Health* 2004;2:13.
- Diallo K, Zurn P, Gupta N, *et al.* Monitoring and evaluation of human resources for health: an international perspective. *Hum Resour Health* 2003;1:3.
- Anderson GF, Hussey PS. Population aging: a comparison among industrialized countries. *Health Aff* 2000;19:191–203.
- Hobbs FDR, Bankhead C, Mukhtar T, *et al.* Clinical workload in UK primary care: a retrospective analysis of 100 million consultations in England, 2007–14. *Lancet* 2016;387:2323–30.
- Reeve J, Blakeman T, Freeman GK, *et al.* Generalist solutions to complex problems: generating practice-based evidence—the example of managing multi-morbidity. *BMC Fam Pract* 2013;14:112.
- Bodenheimer T. Primary care—will it survive? *N Engl J Med* 2006;355:861–4.
- Legrand SB, Heintz JB. Palliative medicine fellowship: a study of resident choices. *J Pain Symptom Manage* 2012;43:558–68.
- Kim YY, Kim UN, Kim YS, *et al.* Factors associated with the specialty choice of Korean medical students: a cross-sectional survey. *Hum Resour Health* 2016;14:8.
- McNally SA. Competition ratios for different specialties and the effect of gender and immigration status. *J R Soc Med* 2008;101:489–92.
- Reed VA, Jernstedt GC, Reber ES. Understanding and improving medical student specialty choice: a synthesis of the literature using decision theory as a referent. *Teach Learn Med* 2001;13:117–29.
- Al-Ansari SS, Khafagy MA. Factors affecting the choice of health specialty by medical graduates. *Journal of Family & Community Medicine* 2015;13:119–23.
- Leduc N, Vanasse A, Scott I, *et al.* The career decision-making process of medical students and residents and the choice of specialty and practice location: how does Postgraduate Medical Education fit in? 2011.
- Delamothe T. Modernising medical careers: final report. *BMJ* 2008;336:54–5.
- Goldacre MJ, Laxton L, Harrison EM, *et al.* Early career choices and successful career progression in surgery in the UK: prospective cohort studies. *BMC Surg* 2010;10:11.
- Weissman C, Zisk-Rony RY, Schroeder JE, *et al.* Medical specialty considerations by medical students early in their clinical experience. *Isr J Health Policy Res* 2012;1:13.
- Jackson C, Ball J, Hirsh W, *et al.* *Informing choices: the need for career advice in medical training*. Cambridge: National institute for careers Education and Counseling, 2003.
- Moher D, Liberati A, Tetzlaff J, *et al.* Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *J Clin Epidemiol* 2009;62:1006–12.
- Rostom A, Dube C, Cranney A, *et al.* Celiac disease. *Evid Rep Technol Assess* 2004;104:1–6.
- Borenstein M, Hedges LV, Higgins JP, *et al.* A basic introduction to fixed-effect and random-effects models for meta-analysis. *Res Synth Methods* 2010;1:97–111.
- Higgins JP, Thompson SG, Deeks JJ, *et al.* Measuring inconsistency in meta-analyses. *BMJ* 2003;327:557–60.
- Higgins JP, Thompson SG. Quantifying heterogeneity in a meta-analysis. *Stat Med* 2002;21:1539–58.
- Sterne JA, Jüni P, Schulz KF, *et al.* Statistical methods for assessing the influence of study characteristics on treatment effects in 'meta-epidemiological' research. *Stat Med* 2002;21:1513–24.
- Borenstein M, Hedges LV, Higgins J, *et al.* Criticisms of meta-analysis. *Introduction to meta-analysis* 2009:377–87.
- Egger M, Smith GD, Schneider M, *et al.* Bias in meta-analysis detected by a simple, graphical test. *BMJ* 1997;315:629–34.
- Sterne JA, Egger M. Funnel plots for detecting bias in meta-analysis: guidelines on choice of axis. *J Clin Epidemiol* 2001;54:1046–55.
- Duval S, Tweedie R. Trim and fill: a simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. *Biometrics* 2000;56:455–63.
- Bodenheimer T, Berenson RA, Rudolf P. The primary care-specialty income gap: why it matters. *Ann Intern Med* 2007;146:301–6.
- Bodenheimer T, Pham HH. Primary care: current problems and proposed solutions. *Health Aff* 2010;29:799–805.
- Association AH. The hospital workforce shortage: Immediate and future. *Trend Watch* 2001;3:1–8.
- Compton MT, Frank E, Elon L, *et al.* Changes in U.S. medical students' specialty interests over the course of medical school. *J Gen Intern Med* 2008;23:1095–100.
- Indyk D, Deen D, Fornari A, *et al.* The influence of longitudinal mentoring on medical student selection of primary care residencies. *BMC Med Educ* 2011;11:27.
- Gill H, McLeod S, Duerksen K, *et al.* Factors influencing medical students' choice of family medicine: effects of rural versus urban background. *Can Fam Physician* 2012;58:E649–E57.
- Richardson JD. Workforce and lifestyle issues in general surgery training and practice. *Arch Surg* 2002;137:515–20.
- Newton DA, Grayson MS, Thompson LF. The variable influence of lifestyle and income on medical students' career specialty choices: data from two U.S. medical schools, 1998–2004. *Acad Med* 2005;80:809–14.
- Orrico K. Ensuring an adequate neurosurgical workforce for 21st century. *Surgeons AAoN* 2012.
- Wright S, Wong A, Newill C. The impact of role models on medical students. *J Gen Intern Med* 1997;12:53–6.
- Glazer GM, Ruiz-Wibbelsmann JA. Decades of perceived mediocrity: prestige and radiology. *Radiology* 2011;260:311–6.
- Schwartzbaum AM, McGrath JH, Rothman RA. The perception of prestige differences among medical subspecialties. *Soc Sci Med* 1973;7:365–71.
- Parsa A, Aghazadeh A, Nejatisafa AA, *et al.* Freshmen versus interns' specialty interests. *Arch Iran Med* 2010;13:509–15.
- Komorita SS. Attitude content, intensity, and the neutral point on a likert scale. *J Soc Psychol* 1963;61:327–34.
- Baggaley AR, Hull AL. The effect of nonlinear transformations on a Likert scale. *Eval Health Prof* 1983;6:483–91.
- Norman G. Likert scales, levels of measurement and the "laws" of statistics. *Adv Health Sci Educ Theory Pract* 2010;15:625–32.
- Smith F, Lambert TW, Goldacre MJ. Factors influencing junior doctors' choices of future specialty: trends over time and demographics based on results from UK national surveys. *J R Soc Med* 2015;108:396–405.
- Cochran A, Melby S, Neumayer LA. An Internet-based survey of factors influencing medical student selection of a general surgery career. *Am J Surg* 2005;189:742–6.
- Hauer KE, Durning SJ, Kernan WN, *et al.* Factors associated with medical students' career choices regarding internal medicine. *JAMA* 2008;300:1154–64.
- Johnson AL, Sharma J, Chinchilli VM, *et al.* Why do medical students choose orthopaedics as a career? *J Bone Joint Surg Am* 2012;94:e78–.

47. Kiobassa K, Miksch A, Hermann K, *et al.* Becoming a general practitioner--which factors have most impact on career choice of medical students? *BMC Fam Pract* 2011;12:7.
48. Klingensmith ME, Cogbill TH, Luchette F, *et al.* Factors influencing the decision of surgery residency graduates to pursue general surgery practice versus fellowship. *Ann Surg* 2015;262:449-55.
49. Lee JY, Kerbl DC, McDougall EM, *et al.* Medical students pursuing surgical fields have no greater innate motor dexterity than those pursuing nonsurgical fields. *J Surg Educ* 2012;69:360-3.
50. Macdonald C, Cawood T. Factors influencing career decisions in internal medicine. *Intern Med J* 2012;42:918-23.
51. Paiva RE, Vu NV, Verhulst SJ. The effect of clinical experiences in medical school on specialty choice decisions. *J Med Educ* 1982;57:666-74.
52. Ni Chroinin D, Cronin E, Cullen W, *et al.* Would you be a geriatrician? Student career preferences and attitudes to a career in geriatric medicine. *Age Ageing* 2013;42:654-7.
53. Rogers LQ, Fincher RM, Lewis LA. Factors influencing medical students to choose primary care or non-primary care specialties. *Acad Med* 1990;65(9 Suppl):S47-8.
54. Abendroth J, Schnell U, Lichte T, *et al.* Motives of former interns in general practice for speciality-choice--results of a cross-sectional study among graduates 2007 to 2012. *GMS Z Med Ausbild* 2014;31.
55. Alawad AA, Khan WS, Abdelrazig YM, *et al.* Factors considered by undergraduate medical students when selecting specialty of their future careers. *Pan Afr Med J* 2015;20:6.
56. Azizzadeh A, McCollum CH, Miller CC, *et al.* Factors influencing career choice among medical students interested in surgery. *Curr Surg* 2003;60:210-3.
57. Celenza A, Bharath J, Scop J. Improving the attractiveness of an emergency medicine career to medical students: An exploratory study. *Emerg Med Australas* 2012;24:625-33.
58. Dolan-Evans E, Rogers GD. Barriers for students pursuing a surgical career and where the Surgical Interest Association can intervene. *ANZ J Surg* 2014;84:406-11.
59. Boyd JS, Clyne B, Reinert SE, *et al.* Emergency medicine career choice: a profile of factors and influences from the Association of American Medical Colleges (AAMC) graduation questionnaires. *Acad Emerg Med* 2009;16:544-9.
60. Egerton EA. Choice of career of doctors who graduated from Queen's University, Belfast in 1977. *Med Educ* 1985;19:131-7.
61. Diderichsen S, Johansson EE, Verdonk P, *et al.* Few gender differences in specialty preferences and motivational factors: a cross-sectional Swedish study on last-year medical students. *BMC Med Educ* 2013;13:8.
62. Ferrari S, Reggiani C, Mattei G, *et al.* International study of student career choice in psychiatry (ISOCCiP): results from Modena, Italy. *Int Rev Psychiatry* 2013;25:450-9.
63. Freire MC, Jordao LM, de Paula Ferreira N, *et al.* Motivation towards career choice of Brazilian freshman students in a fifteen-year period. *J Dent Educ* 2011;75:115-21.
64. Buddeberg-Fischer B, Klaghofer R, Abel T, *et al.* Swiss residents' specialty choices--impact of gender, personality traits, career motivation and life goals. *BMC Health Serv Res* 2006;6:137.
65. Dorsey ER, Jarjoura D, Rutecki GW. The influence of controllable lifestyle and sex on the specialty choices of graduating U.S. medical students, 1996-2003. *Acad Med* 2005;80:791-6.
66. Ekenze SO, Ugwumba FO, Obi UM, *et al.* Undergraduate surgery clerkship and the choice of surgery as a career: perspective from a developing country. *World J Surg* 2013;37:2094-100.
67. Barikani A, Afaghi M, Barikani F, *et al.* Perception of the medical students on their future career in Qazvin University of Medical Sciences. *Glob J Health Sci* 2012;4:176-80.
68. Bittaye M, Odukogbe AT, Nyan O, *et al.* Medical students' choices of specialty in The Gambia: the need for career counseling. *BMC Med Educ* 2012;12:72.
69. Bonura EM, Lee ES, Ramsey K, *et al.* Factors influencing internal medicine resident choice of infectious diseases or other specialties: a National Cross-sectional Study. *Clin Infect Dis* 2016;63:155-63.
70. Al-Fouzan R, Al-Ajlan S, Marwan Y, *et al.* Factors affecting future specialty choice among medical students in Kuwait. *Medical Education Online* 2012;17:19587.
71. AlKot MM, Gouda MA, Khalafallah MT, *et al.* Family Medicine in Egypt From Medical Students' Perspective: a Nationwide Survey. *Teach Learn Med* 2015;27:264-73.
72. Borges NJ, Manuel RS, Duffy RD, *et al.* Influences on specialty choice for students entering person-oriented and technique-oriented specialties. *Med Teach* 2009;31:1086-8.
73. Budd S, Kelley R, Day R, *et al.* Student attitudes to psychiatry and their clinical placements. *Med Teach* 2011;33:e586-e592.
74. Corrigan MA, Shields CJ, Redmond HP. Factors influencing surgical career choices and advancement in Ireland and Britain. *World J Surg* 2007;31:1921-9.
75. Davis CR, Trevatt AEJ, McGoldrick RB, *et al.* How to train plastic surgeons of the future. *Journal of Plastic, Reconstructive & Aesthetic Surgery* 2016;69:1134-40.
76. Deutsch T, Lippmann S, Frese T, *et al.* Who wants to become a general practitioner? Student and curriculum factors associated with choosing a GP career--a multivariable analysis with particular consideration of practice-orientated GP courses. *Scand J Prim Health Care* 2015;33:47-53.
77. Gardner SP, Roberts-Thomson KF. The effect of a change in selection procedures on students' motivation to study dentistry. *Aust Dent J* 2014;59:2-8.
78. Dias MS, Sussman JS, Durham S, *et al.* Perceived benefits and barriers to a career in pediatric neurosurgery: a survey of neurosurgical residents. *J Neurosurg Pediatr* 2013;12:422-33.
79. Goltz CJ, Bachusz RC, Mancini E, *et al.* Medical student career survey--vascular surgery awareness initiative. *Ann Vasc Surg* 2013;27:225-31.
80. Gupta NB, Khadilkar SV, Bangar SS, *et al.* Neurology as career option among postgraduate medical students. *Ann Indian Acad Neurol* 2013;16:478-82.
81. Hanzlick R, Prahlow JA, Denton S, *et al.* Selecting forensic pathology as a career: a survey of the past with an eye on the future. *Am J Forensic Med Pathol* 2008;29:114-22.
82. Harris MC, Marx J, Gallagher PR, *et al.* General vs subspecialty pediatrics: factors leading to residents' career decisions over a 12-year period. *Arch Pediatr Adolesc Med* 2005;159:212-6.
83. Hauer KE, Fagan MJ, Kernan W, *et al.* Internal medicine clerkship directors' perceptions about student interest in internal medicine careers. *J Gen Intern Med* 2008;23:1101-4.
84. Labiris G, Vamvakou V, Tsolaki O, *et al.* Perceptions of Greek medical students regarding medical profession and the specialty selection process during the economic crisis years. *Health Policy* 2014;117:203-9.
85. Lambert TW, Goldacre MJ, Bron AJ. Career choices for ophthalmology made by newly qualified doctors in the United Kingdom, 1974-2005. *BMC Ophthalmol* 2008;8:9.
86. Shah HH, Jhaveri KD, Sparks MA, *et al.* Career choice selection and satisfaction among US adult nephrology fellows. *Clin J Am Soc Nephrol* 2012;7:1513-20.
87. Lefevre JH, Roupert M, Kerneis S, *et al.* Career choices of medical students: a national survey of 1780 students. *Med Educ* 2010;44:603-12.
88. Vicente B, Rosel L. Challenges for psychiatric recruitment and training in Chile. *Int Rev Psychiatry* 2013;25:413-8.
89. Wiesenfeld L, Abbey S, Takahashi SG, *et al.* Choosing psychiatry as a career: motivators and deterrents at a critical decision-making juncture. *Can J Psychiatry* 2014;59:450-4.
90. Lam CY, Cheung CS, Hui AS. Factors influencing the career interest of medical graduates in obstetrics and gynaecology in Hong Kong: a cross-sectional questionnaire survey. *Hong Kong Med J* 2016;22:138-43.
91. Hartung PJ, Taber BJ, Richard GV. The physician values in practice scale: construction and initial validation. *Journal of Vocational Behavior* 2005;67:309-20.
92. Girasek E, Molnár R, Eke E, *et al.* The medical career choice motivations -- Results from a Hungarian study. *Open Med* 2011;6:502-9.
93. Zuccato JA, Kulkarni AV. The impact of early medical school surgical exposure on interest in neurosurgery. *Can J Neurol Sci* 2016;43:410-6.
94. Wilbanks L, Spollen J, Messias E. Factors Influencing Medical School Graduates Toward a Career in Psychiatry: analysis from the 2011-2013 Association of American Medical Colleges Graduation Questionnaire. *Acad Psychiatry* 2016;40:255-60.
95. West CP, Drefahl MM, Popkave C, *et al.* Internal medicine resident self-report of factors associated with career decisions. *J Gen Intern Med* 2009;24:946-9.
96. Watmough S, Taylor D, Ryland I. Using questionnaires to determine whether medical graduates' career choice is determined by undergraduate or postgraduate experiences. *Med Teach* 2007;29:830-2.
97. Thakur A, Fedorka P, Ko C, *et al.* Impact of mentor guidance in surgical career selection. *J Pediatr Surg* 2001;36:1802-4.
98. Scott I, Gowans M, Wright B, *et al.* Determinants of choosing a career in surgery. *Med Teach* 2011;33:1011-7.
99. Schnuth RL, Vasilenko P, Mavis B, *et al.* What influences medical students to pursue careers in obstetrics and gynecology? *Am J Obstet Gynecol* 2003;189:639-43.

100. Richards JM, Drummond R, Murray J, *et al.* What proportion of basic surgical trainees continue in a surgical career? A survey of the factors which are important in influencing career decisions. *Surgeon* 2009;7:270–5.
101. Reed CE, Vaporciyan AA, Erikson C, *et al.* Factors dominating choice of surgical specialty. *J Am Coll Surg* 2010;210:319–24.
102. Correia Lima de Souza L, Mendonça VR, Garcia GB, *et al.* Medical specialty choice and related factors of Brazilian medical students and recent doctors. *PLoS One* 2015;10:15.
103. Pikoulis E, Avgerinos ED, Pedeli X, *et al.* Medical students' perceptions on factors influencing a surgical career: the fate of general surgery in Greece. *Surgery* 2010;148:510–5.
104. Ozer U, Ceri V, Carpar E, *et al.* Factors affecting the choice of psychiatry as a specialty and satisfaction among Turkish psychiatry residents. *Acad Psychiatry* 2016;40:299–303.
105. Noble J, Hechter FJ, Karaiskos N, *et al.* Motivational factors and future life plans of orthodontic residents in the United States. *Am J Orthod Dentofacial Orthop* 2010;137:623–30.
106. Noble J. Factors influencing career choice in ophthalmology. *Can J Ophthalmol* 2006;41:596–9.
107. Moore HB, Moore PK, Grant AR, *et al.* Future of acute care surgery: a perspective from the next generation. *J Trauma Acute Care Surg* 2012;72:94–9.
108. Momen AA, Shakurnia A. Factors influencing pediatric specialty choice among pediatric residents of Ahvaz Jundishapur University of medical sciences. *International Journal of Pediatrics-Mashhad* 2015;3:701–6.
109. Mehmood SI, Kumar A, Al-Binali A, *et al.* Specialty preferences: trends and perceptions among Saudi undergraduate medical students. *Med Teach* 2012;34:S51–60.
110. Lorient Y, Albiges-Sauvin L, Dionysopoulos D, *et al.* Why do residents choose the medical oncology specialty? Implications for future recruitment—results of the 2007 French Association of Residents in Oncology (AERIO) Survey. *Ann Oncol* 2010;21:161–5.
111. Lefèvre JH, Karila L, Kerneis S, *et al.* Motivation of French medical students to pursue surgical careers: results of national survey of 1742 students. *J Visc Surg* 2010;147:e181–6.
112. Vo A, McLean L, McInnes MDF. Medical specialty preferences in early medical school training in Canada. *Int J Med Educ* 2017;8:400–6.
113. Grasreiner D, Dahmen U, Settmacher U. Specialty preferences and influencing factors: a repeated cross-sectional survey of first- to sixth-year medical students in Jena, Germany. *BMC Med Educ* 2018;18:103.
114. Alkhaneen H, Alhusain F, Alshahri K, *et al.* Factors influencing medical students' choice of emergency medicine as a career specialty—a descriptive study of Saudi medical students. *Int J Emerg Med* 2018;11:14.