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Educational interventions to ensure provision of doctors in rural areas – a systematic review

REVIEW ARTICLE

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BACKGROUND

Recruiting doctors in rural areas is challenging, and various educational interventions to ensure the provision of doctors in rural areas have been introduced in many countries. This study aimed to collect knowledge about the undergraduate medical education interventions that have been introduced in order to recruit doctors to rural areas, and the results of these interventions.

MATERIAL AND METHOD

We undertook a systematic search in the databases Cinahl, Eric, Medline and PsycInfo using the search words rural, remote, workforce, physicians, recruitment and retention. We included articles that met the following criteria: the educational interventions were clearly described, the study population consisted of medical graduates, and outcome measures included place of work (rural/non-rural) after graduation.

RESULTS

The analysis included 58 articles and encompassed educational interventions in ten countries. There were five main types of interventions, often used in combination: preferential admission from rural areas, curriculum relevant to rural medicine, decentralised education, practice-oriented learning in rural areas, and compulsory service periods in rural areas after graduation. The majority of the studies (42) compared place of work (rural/non-rural) of doctors who had graduated with and without these interventions – only two of the studies reported non-significant differences in place of work. In 26 studies, the odds ratio for rural place of work was significant at a level of 5 %, with odds ratios between 1.5 and 17.2. In 14 studies there were significant differences in the proportion with a rural/non-rural place of work, with differences ranging from 11 to 55 percentage points.

INTERPRETATION

Changing the focus of undergraduate medical education towards the development of knowledge, skills and teaching arenas that equip doctors with competencies to work in rural areas has an impact on the recruitment of doctors in rural areas.

In Norway, there is a broad consensus that all inhabitants should be entitled to equal access to health services, irrespective of factors such as place of residence. This entitlement is challenged by problems in recruiting and retaining health personnel in rural communities and smaller hospitals. We are aware of various solutions for meeting the demand for doctors, for example frequent use of locums and international recruitment. Norway has joined the World Health Organization's Global Code of Practice on the International Recruitment of Health Personnel. This obligates us to build an effective healthcare workforce and reduce the need to recruit from abroad (1).

In 2010, an independent, global Lancet commission pointed out that unequal access to doctors, domestically as well as between countries, represented a challenge to medical education internationally. In relation to ensuring that patients and populations have access to medical competence, the commission also argued that medical education programmes were more geared towards developing competence to work in hospitals as opposed to primary care services (2). In 2019, the Grimstad Committee recommended expanding the range of health services in which medical students in Norway are trained and proposed to establish more decentralised education models at the faculties of medicine (3). Such models have been established in UiT The Arctic University of Norway (the Bodø model in 2009 and the Finnmark model in 2017) and the Norwegian University of Science and Technology (NTNU Link in 2018).

Internationally, undergraduate medical education has for at least 50 years been geared towards strengthening the recruitment of doctors in rural areas. Most literature about educational interventions to meet the demand for doctors focuses on interventions in Australia, the United States and Canada, but some articles also deal with interventions in Africa, Asia and Europe. Relevant educational interventions span a wide spectrum and range from establishing new educational institutions in locations where recruitment of doctors is especially difficult, to letting students live and learn in rural areas over longer periods. The medical education programme at the University of Tromsø has been described as the first *whole school* established to help meet the demand for doctors in a region with an insufficient supply, and is highlighted as a special European case in the international context (4).

We have undertaken a systematic review of the available literature to answer these research questions: Which interventions have been established in undergraduate medical education to recruit doctors to rural areas? What results have been achieved?

Evidence base

In the review, we used the guidelines from PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-analyses*) (5) and SWiM (*Synthesis Without Meta-analysis*) (6).

Initial literature searches were made in Medline based on an unpublished protocol of inclusion and exclusion criteria. This was adjusted during the process; for example, we decided to restrict the search to undergraduate medical education and to programmes with outcome measures that included place of work (rural/non-rural) after graduation. This informed the choice of search terms. In collaboration with a university librarian, we searched in the Cinahl (Ebsco), Eric (Ebsco), Medline (Ovid) and PsycInfo (Ovid) databases using 'rural', 'remote', 'workforce', 'physicians', 'recruitment' and 'retention' as search terms. See the appendix for a description of the search strategies.

The search was concluded on 3 June 2020 and was restricted to articles in English or a Scandinavian language published in peer-reviewed journals. After removing duplicates, we were left with 2 101 hits. The articles were first assessed for relevance in light of their title and summary. Rayyan, an electronic tool that permits two or more persons to review the references blinded and independently of each other in light of specific inclusion and exclusion criteria, was used in the selection. Three of the authors (BA, MG and AF) participated in this phase. We started with a blinded assessment of a set of 50 articles in order to calibrate a shared assessment approach. The remaining articles were evenly distributed for selection. We also included 14 articles from our own literature archive. The 182 articles that were chosen were read in full-text versions by all authors, and 58 were included. We included all articles that met the following criteria: the educational interventions were clearly described, the study population consisted of medical graduates, and the outcome measures included place of work (rural/non-rural) after graduation.

We excluded studies that dealt with specialist training, non-medical programmes and studies of poor quality (defined as the combination of *few participants* (< 100) and *lack of a control group*), as well as studies from the same university when other studies were deemed to be better. The flowchart in Figure 1 shows the selection process (5). From the included studies we extracted analysis results on the graduates' place of work, categorised as *rural* and *non-rural*.

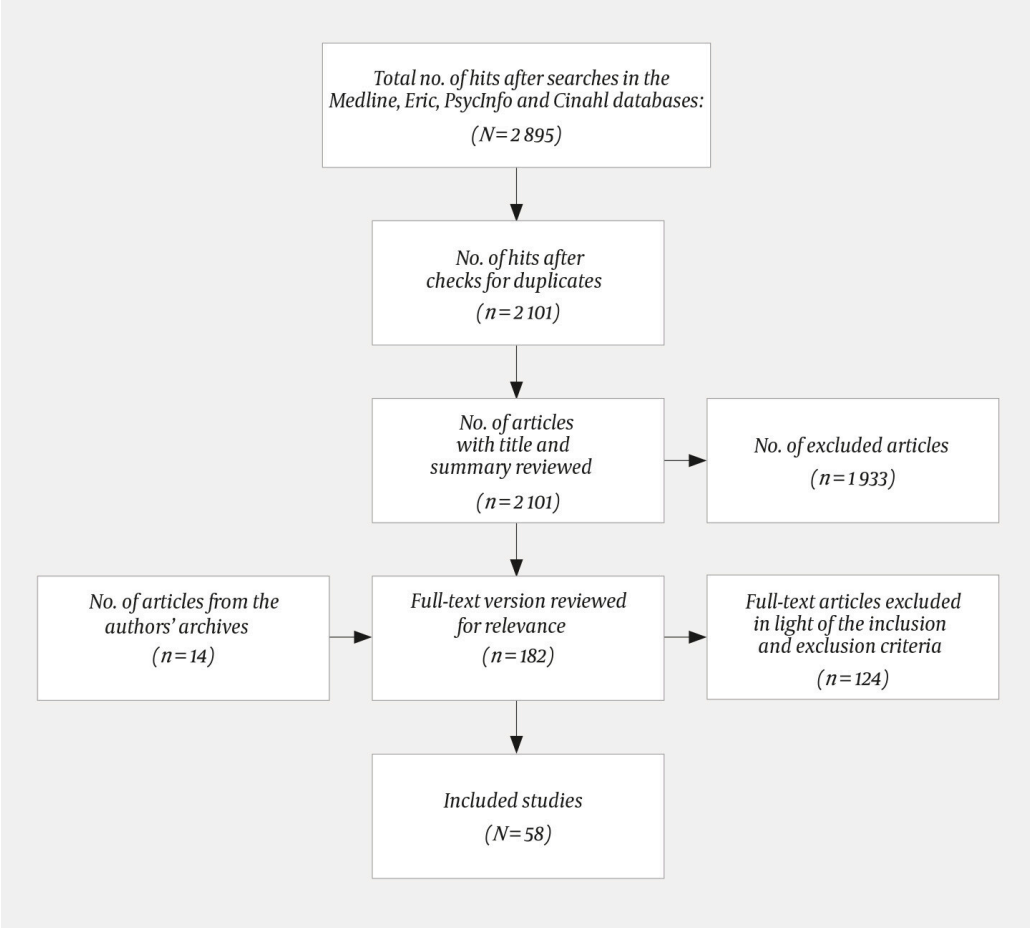

Figure 1 Flowchart showing the stages of the systematic selection of literature

Since the included studies documented investigations with a variety of designs, we used narrative synthesis as our method of analysis (7). The synthesis encompassed four main elements (7, 8): describing and understanding the educational interventions; describing the results of the educational interventions such as they are reported in the studies in the most uniform way possible; exploring correlations in the results; and assessing the robustness of the synthesis.

The educational interventions were categorised into five main types. First, each educational intervention in the included articles was described without any reference to categories. After the first full read-through of the articles, we formulated a number of proposals for categories in English, since this was the language used in the articles: *admission* (pre-/post-), *expanding medical education*, *rural placement/practice*, *whole school*, *commitment to work rural*, *curriculum*, *community involvement* and *financial support*. After further read-throughs, we refined these into five categories that were better delineated and as mutually exclusive as possible. These are described in the results section.

The term *rural area* is commonly understood in a generic sense, but there is no definitive definition of this in the literature. Some studies define rurality on the basis of formal indices of centrality that distinguish between relative rates of access to services in different geographical areas. The Australian Standard Geographical Classification-Remoteness Areas (ASGC-RA) is one such example. Here, the scores 2–5 define various rural areas, and a score of 1 means a major urban area. Other studies construct their own definitions of rural. In an article from Japan (9), rural communities were defined in terms of the number of inhabitants per square kilometre, the number of doctors and the ratio of doctors to the number of inhabitants. In the Congo, a rural area was defined as an area

without a legally appointed mayor (10). These inconsistencies mean that studies based on different definitions of a rural area are not directly comparable. Our use of the term *rural area* reflects the definition in the individual articles.

Results

The analysis included educational interventions aimed at ensuring the provision of doctors in rural areas in ten countries. In total, we included 58 articles from Australia (n = 21), United States (n = 16), Canada (n = 7), Norway (n = 3), Thailand (n = 3), New Zealand (n = 2), Philippines (n = 2), Japan (n = 2), Congo (n = 1) and Brazil (n = 1). Thirty-eight studies were cross-sectional studies, in the sense that they investigated the place of work at a single point in time, 18 were longitudinal studies that investigated the place of work at more than one point in time, and two were literature reviews. Forty-two studies were based on registry data and 34 studies included more than 500 graduates. The studies had been published in the period 1993–2019, of which 32 were published after 2014. Forty-seven studies focused on candidates from a single university.

Table 1 summarises the characteristics and results from the articles (9–66), while Tables 2a–2j provide further details.

Table 1

Articles included in the systematic review and the educational interventions they describe: 1 = preferential admission from rural areas, 2 = curriculum relevant to rural medicine, 3 = decentralised education, 4 = practice-oriented learning in rural areas, 5 = compulsory service periods in rural areas after graduation.

Author(s)	Educational interventions
Alexandersen et al. 2004 (11)	3, 4
Boonluksiri et al. 2018 (12)	1, 3, 5
Campbell et al. 2019 (13)	1, 2, 3, 4, 5
Clark et al. 2013 (14)	1, 3, 4
Crump et al. 2013 (15)	3, 4
Figueiredo et al. 2019 (16)	3
Florence et al. 2007 (17)	2, 4
Fournier & Henderson 2005 (18)	4
Gaski et al. 2017 (19)	3, 4
Guilbault & Vinson 2017 (20)	4
Gupta et al. 2019 (21)	1, 3, 4
Halaas et al. 2008 (22)	1, 3, 4
Halili et al. 2017 (23)	4
Jamar et al. 2014 (24)	1, 3, 4
Kitchener et al. 2015 (25)	1, 2, 3, 4, 5

Author(s)	Educational interventions
Kwan et al. 2017 (26)	1, 3, 4, 5
Longombe 2009 (10)	3
Lovato et al. 2019 (27)	3, 4
MacDowell et al. 2013 (28)	1, 2, 4
Magnus & Tollan 1993 (29)	3, 4
Mathews et al. 2017 (30)	1, 2, 3, 4
Matsumoto et al. 2008a (9)	1, 5
Matsumoto et al. 2008b (31)	1, 5
Matthews et al. 2015 (32)	1, 3
May et al. 2018 (33)	1, 3, 4
McDonnel Smedts & Lowe 2007 (34)	1, 3, 4
McGirr et al. 2019 (35)	1, 3, 4
McGrail et al. 2018 (36)	1, 3, 4
McKillop et al. 2017 (37)	1, 3
Moore et al. 2018 (38)	1, 3, 4
Murray et al. 2018 (39)	4
Myhre et al. 2016 (40)	3, 4
O'Sullivan et al. 2018a (41)	1, 3, 4
O'Sullivan et al. 2018b (42)	1, 3, 4
Pagaiya et al. 2015 (43)	1, 3, 5
Pathman 1994 (44)	3, 4
Playford & Cheong 2012 (45)	1, 3, 4
Playford & Puddey 2017 (46)	1, 3, 4, 5
Playford et al. 2014 (47)	1, 3, 4
Playford et al. 2015 (48)	1, 3, 4
Playford et al. 2016 (49)	1, 3, 4
Playford et al. 2019 (50)	1, 3, 4, 5
Quinn et al. 2011 (51)	1, 2, 4
Rabinowitz et al. 2005 (52)	1, 2, 4
Rabinowitz et al. 2011 (53)	1, 2, 4
Ray et al. 2015 (54)	1, 3, 4
Rhyne et al. 2006 (55)	4
Rosenblatt 1996 (56)	5
Rourke et al. 2018 (57)	1, 2, 3, 4
Sen Gupta et al. 2014 (58)	1, 3, 4

Author(s)	Educational interventions
Smucny et al. 2005 (59)	4
Tate & Aoki 2012 (60)	4
Techakehakij & Arora 2017(61)	1, 3, 5
Wendling et al. 2016 (62)	3, 4
Wenghofer et al. 2017 (63)	1, 2, 3, 4
Wheat et al. 2008 (64)	1, 2, 3, 4
Woolley et al. 2018 (65)	4
Zink et al. 2010 (66)	1, 3, 4

Table 2a

Included articles from Australia. Educational interventions: 1 = preferential admission from rural areas, 2 = curriculum relevant to rural medicine, 3 = decentralised education, 4 = practice-oriented learning in rural areas, 5 = compulsory service periods in rural areas after graduation

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
McGirr et al. 2019 (35)	All medical graduates from 12 universities with *rural clinical school* in 2011 (n = 1 695)	Workplace as per 2017 (Register)	1, 3, 4	Comparative cross-sectional study	17 % of those who had completed the *rural clinical school* had their workplace in a rural area. The proportion with their workplace in a rural area varied between 6 % and 56 % in different university cohorts ($p < 0.001$). The odds ratio (OR) for doctors who completed the *rural clinical school* having a workplace in a rural area was 1.9 (95 % CI 1.45–2.49) when compared with doctors who had not completed such a programme.

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Playford et al. 2019 (50)	All medical graduates from University of Western Australia admitted 2004–10 (n = 878)	Workplace as per 2013, 2014, 2016, 2017 and 2018 (Register)	1, 3, 4, 5	Comparative longitudinal study, includes workplace over a five-year period	Linear trend among those with their workplace in a rural area (rates of increase 2013–18): urban background/no *rural clinical school* 1.18 (95 % CI 1.08–1.29), rural background/no *rural clinical school* 1.16 (95 % CI 0.99–1.37), urban background/*rural clinical school* 1.04 (95 % CI 0.95–1.14) and rural background/*rural clinical school* 1.23 (95 % CI 1.09–1.40). Those who were bound to compulsory service in a rural area more frequently worked in rural area than those who no such obligation (OR = 1.9; 95 % CI 1.53–2.40).
Playford & Puddey 2017 (46)	All medical graduates from University of Western Australia admitted 2004–10 (n = 1 026)	Workplace as per 2014 (Register)	1, 3, 4, 5	Comparative cross-sectional study	The odds ratio for rural employment was 3.0 (95 % CI 1.90 to 4.64) among those who had completed *rural clinical school*, and 1.1 (95 % CI 0.45 to 2.67) for those who had applied for, but not completed *rural clinical school*, compared to those who had no interest in rural employment. Those with a subsidised study place and who were obliged to complete compulsory service in a rural area more frequently worked in rural area than those with no subsidised study place (OR = 4.2; 95 % CI 2.20 to 8.06).

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Playford et al. 2015 (48)	All medical graduates from University of Western Australia admitted 1980–2011 (n = 3 282)	Workplace as per 2014 (Register)	1, 3, 4	Comparative cross-sectional study	The odds ratio for employment in zones 3–5 on the Australian centrality index ARGC-RA (= outer regional to very remote) was 4.4 (95 % CI 2.26 to 8.67) for those who had completed *rural clinical school* compared to those who had not.
Playford et al. 2014 (47)	All medical graduates from University of Western Australia admitted 2002–09 (n = 1 017)	Workplace as per 2013 (Register)	1, 3, 4	Comparative cross-sectional study	The odds ratio for rural employment among those who had completed *rural clinical school*, compared to those who had not, was 7.5 (95 % CI 3.5 to 15.8) and 5.1 (95 % CI 2.9 to 9.1) among doctors who grew up in rural and urban areas respectively.
Playford & Cheong 2012 (45)	All medical graduates from University of Western Australia 2003–07 (n = 490)	Workplace for the two first years after graduation (Register)	1, 3, 4	Comparative longitudinal study, includes two-year follow-up	The odds ratio for rural employment one year after graduation among those who had completed *rural clinical school* was 1.5 (95 % CI 0.97 to 2.38) compared to those who had no such training. Two years after graduation, the corresponding odds ratio was 3.0 (95 % CI 1.65 to 5.59)
Gupta et al. 2019 (21)	All medical graduates from University of Western Australia with *rural clinical school* admitted 2002–11 (n = 488)	Number of *rural tours* in 2006–20 (Register)	1, 3, 4	Longitudinal study with no control group	A *rural tour* is defined as a period of rural employment of at least two weeks' duration. 51 % had completed one or more *rural tours* and provided a total of 342 man-years. 26 % had worked in a rural area for more than one year.

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Playford et al. 2016 (49)	All medical graduates from University of Western Australia with *rural clinical school* admitted 2002–12 (n = 417)	Workplace until 2013 (Register)	1, 3, 4	Cross-sectional study with no control group	In 2013, 17 % were working in rural areas. 72 % had been working in a rural area after graduation. On average, 21 % of the hours worked since graduation were in rural areas.
Clark et al. 2013 (14)	All medical graduates from University of Sidney 2005–07 (n = 448)	Workplace immediately after graduation (Survey, 55 % response rate)	1, 3, 4	Comparative cross-sectional study	21 % of those who had completed *rural clinical school* and 10 % of those who had no such training took up employment in a rural area immediately after graduation (p = 0.05). The proportion that entered a rural practice immediately after *rural clinical school* was 24 % among doctors from a rural background and 20 % among those with an urban background.
Kwan et al. 2017 (26)	All medical graduates from University of Queensland admitted 2002–11 (n = 729)	Time in rural practice after graduation until 2012 (Survey, 48 % response rate)	1, 3, 4, 5	Comparative longitudinal study that investigates the scope of rural practice over time	The odds ratio for being in a *longer-term rural practice* among those who had completed *rural clinical school* with one or two years of practice-oriented learning was 5.4 (95 % CI 3.15–9.20) and 2.9 (95 % CI 1.77 to 4.58) respectively, compared with those who had not completed *rural clinical school*. Those with a subsidised study place and a compulsory service period in a rural area more frequently worked in rural areas compared to those without (OR = 2.1, 95 % CI 1.19 to 3.76).

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
May et al. 2018 (33)	All medical graduates from University of New England and University of Newcastle 2012–14 (n = 426)	Workplace as per 2016/17 (Register)	1, 3, 4	Comparative cross-sectional study	10 % worked in rural areas. The unadjusted odds ratio for rural employment was 6.3 (95 % CI 2.92 to 13.56) for those who had completed *rural clinical school* compared with those who had not. The OR was 6.1 (95 % CI 2.72 to 13.59) in the analysis that adjusted for gender, age, rural/urban background and compulsory service period.
Jamar et al. 2014 (24)	All medical graduates from University of Adelaide with *rural clinical school* admitted 2003–10 (n = 124)	Workplace after graduation until 2012 (Survey, 58 % response rate)	1, 3, 4	Longitudinal study with no control group	In 2012, 21 % worked in rural areas. In the 1st, 2nd, 3rd, 4th, 5th, 6th and 7th year after graduation, 19 %, 33 %, 32 %, 29 %, 37 %, 26 % and 43 % worked in rural areas respectively.

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Campbell et al. 2019 (13)	All medical graduates from Monash University 2008–16 (n = 2 412)	Workplace as per 2017 (Register)	1, 2, 3, 4, 5	Comparative cross-sectional study	The odds ratio for rural employment among those who had completed *rural clinical school* in the form of a *longitudinal integrated clerkship* and other training in rural areas was 5.6 (95 % CI 2.81 to 11.20); among those who had completed *rural clinical school* in the form of a *longitudinal integrated clerkship* it was 1.7 (95 % CI 0.59 to 5.04); among those who had completed *rural clinical school* with more than one year of practice-oriented learning in rural areas it was 3.0 (95 % CI 1.87 to 4.77); and among those who had completed *rural clinical school* with one year of practice-oriented learning in rural areas it was 2.2 (95 % CI 1.20 to 4.19) compared with those who had not completed *rural clinical school.*

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
McGrail et al. 2018 (36)	All medical graduates from Monash University 2008–16 (n = 2 451)	Workplace as per 2017 (Register)	1, 3, 4	Comparative cross-sectional study	The odds ratio for the workplace being the same as the site for practice-oriented learning in a rural area was 3.4 (95 % CI 1.89 to 5.98) for those who had undergone practice-oriented learning in a rural area for 18–24 months, compared with those who had undergone practice-oriented learning in a rural area for 12 months. The odds ratio for the workplace being the same as the site for practice-oriented learning in a rural area was 4.5 (95 % CI 2.14 to 9.36) for those who had undergone training in a rural area and taken substantial parts of their schooling in the same area, compared to those who had no such training or schooling.
O'Sullivan et al. 2018a (41)	All medical graduates from Monash University 2008–16 (n = 2 412)	Workplace as per 2017 (Register)	1, 3, 4	Comparative cross-sectional study	The odds ratio for rural employment increased with the length of the practice-oriented learning period in a rural area. For those with one year, it was 1.8 (95 % CI 1.15 to 2.79), for those with > 1 year and < 2 years, the OR was 2.3 (95 % CI 1.54 to 3.32) and for those with more than two years the OR was 4.4 (95 % CI 3.03 to 6.47), compared with those who had no *rural clinical school.*

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Ray et al. 2015 (54)	All medical graduates from James Cook University 2005–13 (n = 856)	Workplace as per 2005–2013 (Register/ personal contact)	1, 3, 4	Comparative longitudinal study	The odds ratio for rural employment one year after graduation was 2.6 (95 % CI 1.9 to 3.6) for those who grew up in centrality zone 3 and 1.8 (95 % CI 0.9 to 3.6) for those who grew up in centrality zones 4–5, compared to those who grew up in a more urban area (ARGC-RA zone 1–2). In the ninth year after graduation, the corresponding ORs were 4.2 (95 % CI 1.3 to 13.8) and 9.5 (95 % CI 0.8 to 109.2) respectively.
Sen Gupta et al. 2014 (58)	All medical graduates from James Cook University 2005–11 (n = 536)	Workplace as per 2005–11 (Register)	1, 3, 4	Comparative longitudinal study	After graduation, 60 % of the total hours worked had been spent in rural areas. The first year after graduation, 69 % of those from a rural background and 43 % of those from an urban background had their workplace in a rural area. In the 6th and 7th year after graduation, 67 % of those with a rural background and 43 % of those with an urban background had their workplace in a rural area.
Kitchener et al. 2015 (25)	All medical graduates from Griffith University 2010–13 (n = 472)	Workplace immediately after graduation 2011–14 (Register)	1, 2, 3, 4, 5	Comparative cross-sectional study	The odds ratio for rural employment was 11.9 (95 % CI 6.08 to 23.32) for those from a *rural clinical school*, compared with those who had not completed such training.

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
McDonnel Smedts & Lowe 2007 (34)	All medical graduates from Flinders University 1999–2005 (n = 452)	First workplace after graduation (Register)	1, 3, 4	Comparative cross-sectional study	54 % of those who completed *rural clinical school* in the Northern Territory continued working in this area immediately after graduation, compared to 4 % of those who did not complete *rural clinical school* in the area. Among those who admitted to such a school on a quota basis in the Northern Territory, 70 % continued working in the area after graduation. Among those who completed *clinical school* in the Northern Territory, but not on a quota basis, 48 % continued working in the area after graduation.
Moore et al. 2018 (38)	All medical graduates from Australian National University 2007–17 (n = 965)	Workplace after graduation and as per 2018 (Register/web)	1, 3, 4	Comparative longitudinal study	25 % of those who had completed *rural clinical school* and 9 % of those who had not completed such a school were employed in a rural area. Among those who had completed *rural clinical school*, 38 % were employed in a rural area 6–11 years after graduation, while the corresponding figure after 1–5 years was 16 % ($p < 0.001$). The same trend, i.e. that the proportion of rural employment increased over time, was also found among those who had not completed *rural clinical school*: 13 % worked in rural areas 6–11 years after graduation, while after 1–5 years 5 % ($p < 0.0006$) did so.

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
O'Sullivan et al. 2018b (42)	The study describes the characteristics and outcomes of *rural clinical school*, including various effects of different student characteristics (26 articles)	Workplace (Literature search)	1, 3, 4	Literature review of comparative studies	The results from the literature review indicate that doctors who have completed *rural clinical school* are consistently associated with a higher probability of rural employment at the early stages of their career compared with those who did not attend such a school. This result applies irrespective of the way in which this *rural clinical school* is structured. Furthermore, the results indicate that the selection of students from a rural background and the provision of practice-oriented learning in rural areas for students from an urban background could further enhance the effect of *rural clinical school.*

Table 2b

Included articles from the United States. Educational interventions: 1 = preferential admission from rural areas, 2 = curriculum relevant to rural medicine, 3 = decentralised education, 4 = practice-oriented learning in rural areas, 5 = compulsory service periods in rural areas after graduation

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Guilbault & Vinson 2017 (20)	Articles on undergraduate medical education with practice-oriented learning in rural areas and areas with low doctor coverage (10 articles)	Workplace (Literature search)	4	Literature study based on comparative studies	It was nearly three times as likely for doctors who had undergone practice-oriented learning in a rural area or in areas with low doctor coverage to be employed in such an area after specialisation compared to doctors with no such practice-oriented learning during their undergraduate education (RR 2.9; 95 % CI 2.17 to 4.00).
Pathman et al. 1994 (44)	Doctors in primary care, trained in the USA 1970–80, who worked in rural practices in 1981, 50 % in the National Health Service Corps (n = 303)	Workplace 1981 and 1990 (Survey, 81 % response)	3, 4	Longitudinal study, no control group	No educational factors were associated with the duration of rural employment in this sample.
Rosenblatt et al. 1996 (56)	Medical graduates 1980–83 who received the National Health Service Corps stipend during medical school, completed specialist training in general practice and worked in rural areas (n = 383)	Workplace and duration of all work until 1994 (Survey, 76 % response)	5	Longitudinal study, no control group	26 % were employed in the area to which they had been allocated by the National Health Service Corps and had remained there for 6.1 years on average after completing the compulsory period. In addition, 27 % still worked in a rural area.

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Florence et al. 2007 (17)	All students who attended the inter-professional *community partnership program* at East Tennessee State University 1992–2002 (n = 84; 24 doctors), matched with students who attended the standard training programme (n = 168; 36 doctors)	Workplace as per 2002 (Survey, response from 69 % in *community partnership program and* 43 % in the standard programme)	2, 4	Comparative cross-sectional study	46 % of the doctors with a *community partnership program and* 31 % of the doctors with a standard programme worked in a rural area (p < 0.01) after graduation.
Wendling et al. 2016 (62)	All medical graduates from Michigan State University 1978–2006 who had completed their specialisation by 2011 (*upper peninsula rural physician program*: n = 168, standard programme: n = 2 610)	Workplace as per 2011 (Register)	3, 4	Comparative cross-sectional study	45 % of those who had studied in the *upper peninsula rural physician program* and 14 % of the other doctors worked in a rural area (p < 0.001). The odds ratio for rural employment among those from the *upper peninsula rural physician program* was 3.09 (2.12 to 4.50) compared with those from other campuses.
Smucny et al. 2005 (59)	All medical graduates from State University of New York, Upstate Medical University 1990–2003 (*rural medical education program*: n = 132, standard programme: n = 1 969)	Workplace as per 2004 (Register)	4	Comparative cross-sectional study	A larger proportion of those from the *rural medical education program* worked in rural areas, 26 % vs. 7 % (p < 0.0001).

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Rabinowitz et al. 2005 (52)	All medical graduates from Thomas Jefferson University 1978–86 (*physician shortage area program*: n = 148, standard programme: n = 1 798)	Workplace as per 2002 and 11–16 years previously (Register)	1, 2, 4	Comparative longitudinal study	Of 38 doctors from the *physician shortage area program* who were in general practice, 68 % still worked in general practice in the same district in 2002. The corresponding proportion for 54 doctors from the standard programme was 46 % (p = 0.03). Doctors from the *physician shortage area program* remained in general practice in the same district longer than doctors from the standard programme (p = 0.04).
Rabinowitz et al. 2011 (53)	All medical graduates from Thomas Jefferson University 1992–2002 (graduates: n = 2 385, *physician shortage area program*: n = 104)	Workplace as per 2007 (Register)	1, 2, 4	Comparative cross-sectional study	43 % of those from the *physician shortage area program* and 16 % of those from the standard programme worked in rural areas (RR 2.7; 95 % CI 2.1 to 3.5).

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Fournier & Henderson 2005 (18)	All *programs in medical sciences* (rural programmes) – medical graduates from University of Florida 1972–92 (n = 406) compared with all standard medical graduates 1975–1995 (n = 1 701)	Workplace as per 2001 (Register)	4	Comparative cross-sectional study	4.7 % of the doctors from the *program in medical sciences* and 2.4 % of the doctors from the standard program worked in a rural area, a non-significant difference.
Wheat et al. 2008 (64)	First cohort from the *rural medical scholars program* at the University of Alabama (n = 8)	Workplace as per 2004	1, 2, 3, 4	Comparative cross-sectional study	5 of 8 (62 %) worked in a rural area, compared with 14 % of the ordinary students and 9 % at the national level.
MacDowell et al. 2013 (28)	Medical graduates from University of Illinois 1997–2007: *Rural medical education* (n = 160), standard programme (n = 2 663)	Workplace as per 2012 (Register)	1, 2, 4	Comparative cross-sectional study	56 % of those with a *rural medical education* practised in a rural area, compared with 7 % of those from the standard programme (OR 17.2; 95 % CI 12.18 to 24.35).
Crump et al. 2013 (15)	Medical graduates from University of Louisville in 2001–06 (*rural campus*: n = 33, standard programme: n = 759)	Workplace, year not stated (Register)	3, 4	Comparative cross-sectional study	*Rural campus* students were six times more likely to be working in a rural area.

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Halaas et al. 2008 (22)	All medical graduates from University of Minnesota from the *rural physician associate program* 1971–2007 (Graduates: n = 1 175, working: n = 901)	Workplace as per 2007 (Register)	1, 3, 4	Longitudinal study, no control group	Those from the *rural physician associate program* in primary care were more likely to be working in a rural area than in an urban area (56 % vs. 44 %, p < 0.001). 44 % had practised in a rural area continuously.
Zink et al. 2010 (66)	All medical graduates from University of Minnesota 1990–2004 at different campuses and *rural physician associate program* at different campuses (all: n = 3 365, UMN – Duluth/*rural physician associate program*: n = 215, UMN–TC/*rural physician associate program:* n = 276, UMN–Duluth/ non-*rural physician associate program*: n = 427, UMN–TC/non-*rural physician associate program*: n = 2 447)	Workplace as per 2007 (Register)	1, 3, 4	Comparative cross-sectional study	The likelihood of working in a rural area was higher for those who had studied at the rural campus in Duluth and completed the *rural physician associate program*, OR 4.6 (95 % CI 3.01 to 7.09) and OR 4.1 (95 % CI 2.81 to 5.96) compared with the other students.
Quinn et al. 2011 (51)	Medical graduates from University of Missouri 1997–2006 with one or more rural training elements (n = 108)	First workplace after specialisation as per 2009 (Register)	1, 2, 4	Cross-sectional study, no control group	57 % of the students who attended the rural training programme chose a rural community as their first workplace.

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Rhyne et al. 2006 (55)	Graduates from University of New Mexico who had attended the inter-professional programme in rural areas 1990–2001 (medical students in the programme: n = 37, standard programme: n = 63)	Workplace, year not stated (Survey, 59 % response rate)	4	Comparative cross-sectional study	There was no difference between the proportions that chose rural employment among these doctors.

Table 2c

Included articles from Canada. Educational interventions: 1 = preferential admission from rural areas, 2 = curriculum relevant to rural medicine, 3 = decentralised education, 4 = practice-oriented learning in rural areas, 5 = compulsory service periods in rural areas after graduation

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Mathews et al. 2017 (30)	All medical graduates from Memorial University of Newfoundland 1989–2008 (n = 1 147)	Workplace as per 2004 for medical graduates in 1989–98 and as per 2014 for medical graduates in 1999–2008 (Register)	1, 2, 3, 4	Cross-sectional study with no control group	11.4 % and 5.1 % worked in rural Canada and Newfoundland/Labrador respectively early in their career. In the 1989–98 cohort, the figures were 13.6 % and 6.1 %. In the 1999–2008 cohort, the figures were 9.3 % and 4.2 %. The likelihood of working in rural Canada increased significantly for those with a rural background and specialisation in general medicine. The likelihood of working in Newfoundland/Labrador increased significantly with a rural background, childhood in Newfoundland/Labrador, parts of/entire specialisation linked to Memorial University of Newfoundland and with specialisation in general medicine.

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Rourke et al. 2018 (57)	Medical graduates from Memorial University of Newfoundland who practised general medicine in Newfoundland and Labrador in 2015 (n = 305)	Workplace in 2015 (Register)	1, 2, 3, 4	Cross-sectional study with no control group	Among all medical graduates from Memorial University of Newfoundland who were practising general medicine in Newfoundland and Labrador in 2015, 36 % worked in rural areas (22 % outside towns, 12 % in small towns) and 63 % worked in a medium-sized town.
Wenghofer et al. 2017 (63)	General practitioners in Ontario who graduated from Northern-Ontario School of Medicine vs. other medical schools 2009–13 or later (n = 535)	Workplace as per 2013 (Register)	1, 2, 3, 4	Comparative cross-sectional study	Medical graduates from Northern Ontario School of Medicine had a significantly higher likelihood of practising in rural Ontario (OR 2.6; 95 % CI 1.21 to 5.44) than medical students from other universities.
Lovato et al. 2019 (27)	All students admitted 2004–07 at the University of British Columbia (after the establishment of two regional campuses) (n = 904)	Workplace as per 2014 (Register)	3, 4	Comparative, retrospective, longitudinal study	Students who graduated from the two regional campuses were more likely to work in rural general practice than students at the main campus, after other variables were corrected for (OR 3.2; 95 % CI 1.19 to 8.83 and OR 5.4; 95 % CI 2.24 to 12.91). Working in a rural area was significantly associated with a rural background, but not with age or gender.
Myhre et al. 2016 (40)	All medical graduates from the University of Calgary 2009–2011 (n = 170)	Workplace as per 2014 (Register)	3, 4	Comparative cross-sectional study	50 % of students who completed a rural longitudinal integrated clerkship had a rural workplace, compared to 28 % of those who did not complete this programme.

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Murray et al. 2018 (39)	All medical graduates from the University of Manitoba 2004–07 (n = 344)	Workplace up to 2016–17 (Register, manual search)	4	Comparative longitudinal study	The odds ratio for rural employment was 4.0 (95 % CI 2.30 to 7.04) among those who had participated in voluntary rural clinical placements compared with those who did not.
Tate & Aoki 2012 (60)	All medical graduates from the University of Manitoba 1965–2000 (n = 2 578)	Workplace to 2006 (Survey, 47 % response rate)	4	Comparative longitudinal study	39 % had worked in a rural area. Among doctors who had worked in general practice, 58 % had had a rural workplace. The odds ratio for a rural workplace for those who had undertaken training in a rural area during their medical education was 1.7 (95 % CI 1.13 to 2.61) compared to those who had not.

Table 2d

Included articles from Norway. Educational interventions: 1 = preferential admission from rural areas, 2 = curriculum relevant to rural medicine, 3 = decentralised education, 4 = practice-oriented learning in rural areas, 5 = compulsory service periods in rural areas after graduation

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Magnus & Tollan 1993 (29)	Medical graduates from the University of Tromsø 1979–1989 (n = 350)	Workplace as per 1990 (Survey, 84 % response rate)	3, 4	Cross-sectional study with no control group	56 % of the medical graduates worked in Northern Norway. The proportion with a Northern Norway background who worked in Northern Norway was 83 %.

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Alexandersen et al. 2004 (11)	Medical graduates from the University of Tromsø 1996–2001 (n = 318)	Workplace as per 2003 (Register)	3, 4	Cross-sectional study with no control group	The proportion of doctors with a Northern Norway background who worked in Northern Norway was 75 %. A declining trend was found for the proportion of doctors who grew up in Southern Norway and worked in Northern Norway.
Gaski et al. 2017 (19)	Medical graduates from the University of Tromsø 1979–2012 who had completed their residency and were still working in 2013 (n = 1 312)	Workplace as per 2016 (Geographically and in hospitals, primary health care, or other) (Register)	3, 4	Cross-sectional study with no control group	A larger proportion of Tromsø-trained general practitioners (GPs) (30 %) worked in rural municipalities compared with GPs in Norway as a whole (19 %). GPs trained in Tromsø filled 57 % of the positions in central municipalities and 34 % of the positions in rural municipalities in Northern Norway. A larger proportion of Tromsø-trained doctors in health trusts (64 %) worked at university hospitals compared with all doctors in health trusts in Norway (56 %). The University of Tromsø trained more than half of the doctors who worked at the University Hospital of Northern Norway, but only 14 % who worked at hospitals in Nordland and 28 % in Finnmark.

Table 2e

Included articles from Thailand. Educational interventions: 1 = preferential admission from rural areas, 2 = curriculum relevant to rural medicine, 3 = decentralised education, 4 = practice-oriented learning in rural areas, 5 = compulsory service periods in rural areas after graduation

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Boonluksiri et al. 2018 (12)	Medical graduates from the *Collaborative Project to Increase Production of Rural Doctors* 2001–10 (n = 10 018 doctors; n = 2 098 from the project)	Workplace four years after graduation (Data from the 37 medical schools)	1, 3, 5	Comparative cross-sectional study	A higher proportion from the project (72 %) remained in the public health service than was the case for other doctors (54 %), and particularly in rural areas (60 % versus 38 %).
Pagaiya et al. 2015 (43)	All medical graduates from the *Collaborative Project to Increase Production of Rural Doctors* in the period 2000–07 and who worked at the Ministry of Health upon graduation (n = 7 157 doctors (n = 1 093 of whom are from the project, n = 6 064 from ordinary intake)	Effect of the project a) on staying in rural areas, b) on staying in the public sector, compared with other students (Ministry of Public Health, administrative data)	1, 3, 5	Comparative cross-sectional study	29 % of the students from the project and 18 % of other students remained at hospitals in rural areas. Others were at a 1.5 times greater risk of leaving the public health service than the project group. The estimated median duration of working in rural areas was 4.2 years for the project group and 3.4 years for others.

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Techakehakij & Arora 2017 (61)	Newly qualified doctors from the *Collaborative Project to Increase Production of Rural Doctors* who started working in public hospitals in the period January 2003–October 2014 (n = 15 253)	Comparison of annual stability in the workplace and likelihood of three-year stability among doctors in rural areas	1, 3, 5	Comparative longitudinal study	More of those from the project group remained in rural areas than others (OR 2.4; 95 % CI 2.2 to 2.7). Among the four groups included in the project, there is some variation, and the group from the graduate programme for civil servants was most likely to remain in rural areas.

Table 2f

Included articles from New Zealand. Educational interventions: 1 = preferential admission from rural areas, 2 = curriculum relevant to rural medicine, 3 = decentralised education, 4 = practice-oriented learning in rural areas, 5 = compulsory service periods in rural areas after graduation

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Matthews et al. 2015 (32)	Doctors who attended Pūkawakawa, University of Auckland 2008–11 under the Māori and Pacific Admission Scheme, rural admission scheme or regular admissions. With a background from rural area/regions or towns/cities (n = 45)	Workplace (Survey, 62 % response rate)	1, 3	Cross-sectional study with no control group	62 % worked in rural or regional areas (31 % in Northland). The majority intended to work in rural areas or regionally.

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
McKillop et al. 2017 (37)	Doctors from the Pūkawakawa programme who were in their 1st or 2nd year of work, either where they had a clinical placement or elsewhere (n = 19)	Study of Pūkawakawa students' motivators and barriers to returning to the regional hospital where they did a clinical placement (Survey, interview)	1, 3	Cross-sectional study with no control group	15 of the 19 doctors surveyed had returned to the rural area hospital where they had had a clinical placement. Correspondence between personal goals and career intentions explained the choice of workplace for most. Other reasons were lifestyle, friends/family in the area as well as the reputation and experiences associated with the Pūkawakawa programme. Learning experiences were key factors.

Table 2g

Included articles from the Philippines. Educational interventions: 1 = preferential admission from rural areas, 2 = curriculum relevant to rural medicine, 3 = decentralised education, 4 = practice-oriented learning in rural areas, 5 = compulsory service periods in rural areas after graduation

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Woolley et al. 2018 (65)	Doctors who had studied at Ateneo de Zamboanga University 2003–12 (n = 232) and The University of the Philippines, Manila 1989–2013 (n = 121). All have worked for at least 6 months. Control group: n = 728	Workplace (Medical school archives. Various strategies employed to determine location of workplaces (Post, Google *docs*, survey, Facebook)	4	Comparative cross-sectional study	31 % and 61 % of doctors educated at Ateneo de Zamboanga University and the University of the Philippines Manila respectively had had clinical placements in communities with less than 100 000 inhabitants in the two areas, compared to 7 % and 12 % from conventional medical studies.

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Halili et al. 2017 (23)	Medical graduates from Ateneo de Zamboanga University in 2003–12 compared with medical graduates from conventional medical studies (223 of 232 medical graduates were from Ateneo de Zamboanga University. 119 of 464 medical graduates were from a control medical school)	Workplace (Survey)	4	Comparative cross-sectional study	The medical graduates from Ateneo de Zamboanga University were more likely to have chosen medical studies because they wanted to help others, came from lower socio-economic strata, and had a more positive attitude to working in the primary healthcare service. A larger proportion of them worked in the public health service or were general practitioners or doctors in rural areas.

Table 2h

Included articles from Japan. Educational interventions: 1 = preferential admission from rural areas, 2 = curriculum relevant to rural medicine, 3 = decentralised education, 4 = practice-oriented learning in rural areas, 5 = compulsory service periods in rural areas after graduation

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Matsumoto et al. 2008a (9)	Medical graduates from Jichi Medical University 1972–91 who had completed a nine-year compulsory service period	Workplace in 2000, 2004, 2006 (National census)	1, 5	Longitudinal study with no control group	69.8 % of the medical graduates from Jichi Medical University settled in their home county. A large proportion settled in counties with low population density or doctor density. Being a woman and doctor density were negatively associated with settling in a rural area.

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Matsumoto et al. 2008b (31)	All medical graduates from Jichi Medical University 1978–2006 (n = 1 255)	Workplace (Data from Jichi Medical University, census and survey)	1, 5	Longitudinal study without a control group	Four times as many medical graduates from Jichi Medical University worked in rural areas compared to others. Growing up in a rural area as well as specialisation in primary health care were positively associated with working in a rural area in at least one of the measurement points and with where the doctors settled after the nine-year contract.

Table 2i

Included articles from the Democratic Republic of the Congo. Educational interventions: 1 = preferential admission from rural areas, 2 = curriculum relevant to rural medicine, 3 = decentralised education, 4 = practice-oriented learning in rural areas, 5 = compulsory service periods in rural areas after graduation

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Longombe 2009 (10)	The first six cohorts at the Catholic University of Graben and L'université Evangélique en Afrique (n = 163)	Workplace (Direct contact with alumni and provincial authorities)	3	Comparative cross-sectional study	81 % of the candidates from medical studies geared towards rural areas worked in a rural area in the province where they had studied, while just 26 % of the candidates from the urban medical studies worked in the province where they studied.

Table 2j

Included articles from Brazil. Educational interventions: 1 = preferential admission from rural areas, 2 = curriculum relevant to rural medicine, 3 = decentralised education, 4 = practice-oriented learning in rural areas, 5 = compulsory service periods in rural areas after graduation

Authors	Study population (no. included)	Outcome (data source)	Interventions	Design	Results
Figueiredo et al. 2019 (16)	Municipalities with new medical studies (n = 54) compared with control municipalities (n = 408)	Change in the number of doctors and healthcare institutions per 1 000 inhabitants from 2007 to 2016 (National Register of Healthcare Establishments)	3	Comparative cross-sectional study	A better regional distribution of study places.

Table 3 gives a description of the five main types of educational interventions in the undergraduate medical education. These are further described below.

Table 3

Educational interventions in undergraduate medical education to ensure the provision of doctors in rural areas, categorised in five main types based on the literature review

Educational interventions	Details
Preferential admission from rural districts	A number of educational interventions are in the form of admission schemes, such as the admission of a larger proportion of students from rural areas, with varying geographic background criteria.
Curriculum relevant to rural medicine	Educational interventions relating to the content of undergraduate medical education can include knowledge, skills and attitudes that are particularly relevant to working in rural areas. For example, there may be a stronger focus on typical general medical issues and working methods in general medicine.
Decentralised education	All or part of the undergraduate medical education can be located outside the central areas, for example at decentralised campuses. Decentralised education also includes the establishment of new educational institutions in regions where there is a shortage of doctors (expanded medical studies/*whole school*), often combined with an increase in the number of medical students. Decentralisation often takes place in close collaboration with local authorities and primary healthcare services, with the aim of fulfilling the social mission to provide qualified doctors for rural areas.
Practice-oriented learning in rural areas	Practice-oriented learning includes externally supervised practice, i.e. the supervisor is a clinician. Clinical teaching is also included in this category. There are many different educational interventions that constitute practice-oriented learning in rural areas, and the duration of interventions also differs. This can also apply to practice-oriented learning at local and regional hospitals as opposed to university hospitals and hospitals in larger towns and cities. These include interventions aimed at summer jobs for medical students in rural areas, a rural mentoring scheme, and interventions where the student carries out a development project in a rural area.

Educational interventions	Details
Compulsory service periods in rural areas after graduation	A compulsory service period of a specified duration immediately after graduation can be combined with a student bursary, or with the students' home regions financing a number of study places that are earmarked for students from the region. In some countries, the compulsory service period is universally applied, and some doctors must carry this is out in rural areas.

Description of the educational interventions

Preferential admission from rural districts

The Australian Government established 19 rural clinical schools in the period 2000–15 (67). There is a requirement for at least 25 % of the students at such schools to be from rural areas (35). Five US universities are described with preferential admission from rural areas (17, 22, 28, 51, 53, 64), while from Canada, two universities are described with admission quotas for students from rural areas (57). In New Zealand, the University of Auckland launched a five-year admission scheme for Māori and rural students in 2008 (32). In Japan, Jichi Medical University was established in 1972 to train doctors for work in rural areas. Two to three students are recruited from each county each year, with full funding by the individual counties for six years of study (9, 31). In Thailand, the Collaborative Project to Increase Production of Rural Doctors was initiated in 1994. Around 300 students are recruited to this programme from rural areas every year (43).

Curriculum relevant to rural medicine

Some Australian rural clinical schools placed a large emphasis on learning outcomes related to primary health care and emergency medicine (13, 25). Standard medical studies placed much less emphasis on this. US universities had several different interventions: a teaching focus on health problems in rural areas and a project with a focus on rural areas (28), an interprofessional collaboration with practice-oriented learning in rural areas and development of knowledge and skills for working in rural areas (17), periodic visits to rural areas with teaching on health problems in rural areas (64), a study programme with an emphasis on general medical content (52), as well as various elective educational activities in rural areas: a summer community programme, a rural track clerkship programme, and a rural track elective programme (51). Universities in Canada also had curricula relevant to rural medicine (57, 63).

Decentralised education

Rural clinical schools in Australia were either established at a metropolitan university in the form of decentralised campuses with locally employed academic staff (13, 14, 24, 26, 33, 38, 50, 54) or as decentralised universities (57).

In the United States, there were different variants of decentralised education with decentralised campuses in rural areas during parts of the education (62, 64). Each year at the University of Louisville, 6–10 medical students could complete their 3rd and 4th year of study at a campus in a small town or in a nearby small

community (15). The third-year students in the University of Minnesota's rural physician programme spent 9–12 months in rural areas with mostly local supervision (22).

In Canada, different variants are also described: a decentralised university known as a *whole school*, with a strong focus on educating doctors to work in rural areas (57), as well as decentralised campuses, health centres and hospitals (27, 63).

In Norway, the medical studies at UiT The Arctic University of Norway were established in 1973 at a point when doctors were in short supply in Northern Norway (29). The students in the Collaborative Project to Increase Production of Rural Doctors in Thailand studied close to their hometowns. For the first three years, all students were at the same campus. In the last three years, students were in regional and rural hospitals throughout Thailand, while other students worked in clinical rotation in university hospitals and in larger cities (43). The University of Auckland admitted 24 fifth-year students who lived and studied in Northland, mostly at a hospital and with seven weeks in general medicine (32). In 1989, the Congo launched a rural medical school (10).

In 2013, the Brazilian authorities established the More Doctors for Brazil Programme with a view to increasing the number of study places, the number of specialist education programmes and the number of doctors in the primary healthcare service in areas with few doctors, and to ensuring that the content of medical education was adapted to primary health care needs. The goal was to increase the doctor density to 2.7 doctors per 1 000 inhabitants and increase medical education admissions by 11 500 students. Criteria were developed for the location of new medical studies (16).

Practice-oriented learning in rural areas

The universities in Australia with a rural clinical school were obliged to ensure that at least 25 % of the students were offered practice-oriented learning in rural areas of at least one year's duration. The two dominant models were rotations in different wards at local hospitals, in some cases combined with general practice, and general practice in local communities in the form of longitudinal integrated clerkships. In addition, at least 50 % of the students at the university in total had to have at least four weeks of practice-oriented learning in rural areas (35, 41).

In the United States, all universities in the studies included offered practice-oriented learning in rural areas, but the year of study, the scope and organisation of the activity, as well as whether it was carried out in general medicine, varied considerably between the different universities (13, 15, 17, 18, 35, 40). For example, the University of Florida had early clinical exposure to rural medicine in doctors' practices and health centres (18), while in Louisville, students in rural campuses completed all of their practice-oriented learning in rural areas in the 3rd and 4th years of study (15). Different variants are also described for Canada: a close collaboration with the local authorities, practice-oriented learning and a large focus on decentralised teaching (30, 57, 63), more targeted practice-oriented learning at decentralised campuses (27), longitudinal integrated clerkships with the possibility of a rural profile and practice-oriented learning in rural areas for one year and a focus on the students getting to meet doctors with experience in teaching and supervision with a rural focus (40), as well as practice-oriented learning periods of various lengths or summer jobs in rural areas and a rural mentoring scheme (39, 60).

Since they were introduced in 1973, one of the characteristics of the undergraduate medical education at UiT The Arctic University of Norway has been early patient contact and clinical practice in the primary healthcare service and at local hospitals (19).

In the Philippines, two universities developed undergraduate medical education programmes that responded to the social mission of meeting the local need for doctors. Students at one university spent one month each semester in practice-oriented learning in rural areas in years 1–3 of their studies, and ten months in the fourth year, including a local development project. The other university included six months of practice-oriented learning in rural areas in year 2, a subsequent one-year clinical internship, and then a one-year community internship in the final year (65).

Compulsory service periods in rural areas

Australian medical students could apply for state-subsidised study places with compulsory service periods in rural areas. This had to be completed within 18 years of graduation. The study places were not connected to any rural clinical school, but students at these medical schools could have a subsidised study place. Some of the Australian studies examined whether the choice of workplace was associated with having a study place with a compulsory service period (13, 26, 46, 50, 54).

Under the National Health Service Corps programme in the United States, students could apply for grants that were subject to a compulsory service period in areas with low doctor coverage after graduation (44, 56). All medical graduates of Jichi Medical University in Japan had a nine-year compulsory service period in a public hospital or rural practice in their home county. This normally included three years of postgraduate training. Those who did not complete the compulsory service period had to pay back the cost of their education (31). In Thailand, all medical students were required to serve a three-year compulsory service period in the Ministry of Health. The alternative was a fine. Medical graduates of the Collaborative Project to Increase Production of Rural Doctors had to return to their home province. Others could choose between other available positions (43).

Summary of the interventions

The overview shows that the most common educational intervention was practice-oriented learning in rural areas (48 studies). Next were decentralised education (42 studies) preferential admission from rural districts (38 studies), curriculum relevant to rural medicine (11 studies) and compulsory service periods (11 studies). Combinations of educational interventions occurred frequently. Forty-seven studies included more than one educational intervention, and 36 included three or more. Some countries, such as Australia and Thailand, had the same educational interventions at several universities. Other countries had unique interventions at individual universities and interventions that applied to all universities.

Results of the educational interventions

Forty-two studies compared the place of work (rural vs. non-rural) of doctors whose education included interventions with doctors whose education did not include interventions. Non-significant differences in the proportion who worked in a rural area were only reported in two of these studies (18, 55). In 26 studies (13, 15, 20, 25)(25–28), (28, 31, 33, 35, 36, 39, 41, 42, 45)(45–48), (48, 50, 53, 54, 60)(60–63), (66), the odds ratio (OR) for a rural place of work is statistically significant at the 5 % level, and the odds ratio varied between 1.5 and 17.2. Furthermore, in 14 studies (63, 66), significant differences (at the 5 % level) were reported in the proportion with a rural place of work between those who were covered by educational interventions and those who were not. The difference varied between 11 and 55 percentage points.

Fifteen of the studies only included medical graduates who were covered by educational interventions. Here, the proportion that had a rural place of work at one or more points in time was reported. Of these, six (9, 11, 19, 29, 31, 57) were whole school studies, where the proportion varied between 19.7 % and 79 %.

The results from the studies included are not directly comparable, partly because of the considerable variation in how soon after graduation the place of work was surveyed (from immediately after all the way to 41 years after graduation). Two of the non-significant comparative studies included the practice-oriented learning in rural areas as the only intervention (40, 61). The majority of the comparative studies with significant differences combined more than one intervention.

Correlations in the results

The interventions studied are often combined in complex, context-dependent interventions, which means that the results do not provide a basis for isolating the effects of individual interventions. There is not just one version of any educational intervention, but many, and the interventions are to some extent dynamic, i.e. they change over time. Some studies may indicate a dose–response effect, i.e. more comprehensive and consistent interventions provide better doctor coverage in areas with poor recruitment (68). Variations in the context, design and execution of the studies thus make it difficult to identify interventions that have a greater effect than others.

The robustness of the synthesis

The synthesis is based on a literature review with three clear inclusion criteria. The majority of the studies that are included are based on register data and compare candidates who were covered by educational interventions with candidates who were not. Almost all of these show that the proportion with a rural place of work was significantly higher among those who were covered by interventions than those who were not. We have also included large descriptive studies without a control group. None of the studies are based on randomised, controlled trials. This means that we cannot conclude that there is a causal relationship between interventions and working in a rural area. The unsystematic investigation of effects that can be attributed to the individual interventions and combinations of interventions in these studies means that we can only conclude which

interventions have been used, and that the interventions in varying combinations are associated with a higher tendency for medical graduates to choose to work in rural areas.

Discussion

In our systematic search, we identified studies from ten countries that have developed undergraduate medical education programmes with the goal of increasing the coverage of doctors in rural areas. The aim of most of the educational interventions was to give medical students more experience in working in a rural area as part of their education. Other interventions were preferential admission and compulsory service periods. A common reason for introducing interventions seems to be that the existing undergraduate medical education programmes did not sufficiently facilitate graduates' practising of medicine in rural areas. Several of the studies used the term 'social accountability' about the education, in the sense that educating tomorrow's doctors is not only a matter for universities and university hospitals, but is also a social mission that should entail educating doctors for all types of medical work for the entire population.

The studies showed that the choice of place to work is influenced by which applicants are admitted to undergraduate medical education, where students study and the type of teaching they receive and experience they gain. Targeted changes in educational content and the location of medical education impact on whether doctors choose to work in rural areas. Most of the studies in the literature review are from individual universities that have surveyed their own students. In some cases, this results in small studies, studies without control groups and a risk of bias in the interpretation of the results. However, the review also includes extensive and robust comparative register studies.

Our approach has highlighted methodological weaknesses in research in this field. The literature review includes a number of cross-sectional studies that study place of work at a specific point in time. There is no standardisation in how long after graduation this takes place, and the time interval from graduation to this point in time varies in the studies. This makes it difficult to compare results and does not provide information on workplace stability over time. It is also a weakness that the studies tend to ignore any skewness in admissions related to candidates' interest in working in rural areas before they are admitted to medical schools with relevant educational interventions. A further weakness is that the studies do not identify individual interventions or combinations of interventions that have a greater effect than others.

Our findings provide an overview of interventions that can be adapted to the Norwegian context. The Norwegian studies corroborate the international results. The establishment of an undergraduate medical education programme in Northern Norway has facilitated the recruitment of doctors in the region. However, the effect is greatest for the university city of Tromsø (19). Preferential admission from rural areas other than having an affiliation to the region, and compulsory service periods for medical graduates are not customary in Norway. The literature review shows the importance of undergraduate medical education focussing on knowledge, skills and teaching arenas that are not easily accessible at

university hospitals. Decentralising undergraduate medical education can increase the supply of doctors to rural areas. This supports the decentralisation that has taken place at UiT The Arctic University of Norway and the Norwegian University of Science and Technology (NTNU), and similar plans at the universities in Oslo and Bergen, and which the Grimstad Committee (3) has proposed to expand to areas with a shortage of doctors. More knowledge about the shortage of doctors, more practice-oriented learning in rural areas, which already takes place to some degree at Norway's four medical schools, and curricula that are relevant to rural medicine can contribute further.

The article has been peer-reviewed.

Main findings

We identified five key interventions in undergraduate medical education that were associated with a higher likelihood among graduates to choose a rural area as their place of work: preferential admission from rural areas, curriculum relevant to rural medicine, decentralised education, practice-oriented learning in rural areas, and compulsory service periods in rural medicine after graduation.

Nearly all studies showed that the proportion of doctors who worked in rural areas was higher among those who had been encompassed by educational interventions that developed skills and knowledge in rural medicine during their undergraduate medical education compared to those who had not.

The results provided no basis for isolating the effect of individual measures, because these tend to be combined in complex and context-dependent interventions.

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