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Narrative Review

Student selection in radiography education. A narrative review

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ABSTRACT

Objectives: Due to effects on study success, radiography student selection has a major impact on higher education institutions and applicants. However, there is very little research to demonstrate which selection methods and contents are most successful in radiography education. This study aimed to describe the methods and contents used in radiography student selection and factors related to study success.
Key findings: A narrative review was undertaken. A computerized search in four databases limited to studies published between January 2000 and June 2021. Ten quantitative, mainly retrospective, studies were included. The review identified 23 selection methods; of these, interview (n = 4), Scholastic Aptitude Test (n = 3), American College Test (n = 2) and reference letter (n = 2) were used more than once in radiography student selection. The content of the selection methods was identified in four categories including 44 factors. The most often assessed content was category of learning skills while the least often assessed concerned categories of social skills, personality traits and career choice. Regarding study success, factors of learning skills, namely mathematics, physics, biology, anatomy, physiology, natural sciences, a composite of factors comprising electronics and a composite of factors comprising mechanics predicted study success. Factors of social skills, personality traits and career choice were not related to study success.
Conclusion: The methods used and contents assessed vary greatly in radiography student selection. The results suggest using the content in the four categories in the selection of radiography students.
Implications for practice: Further research is needed to clarify the methods, with knowledge of the reliability and validity and the contents for the suggested categories, and to demonstrate their relationship to study success and identify the core content of radiography student selection especially in European context.

Introduction

Radiography student selection has a major effect on higher education institutions and applicants every year because of the high number of applications. It is estimated that there are approximately 500,000 radiographers working worldwide within healthcare,[1] which gives an indication of the number of applicants to education each year. In the United Kingdom, there were approximately 10,600 applicants to radiography in 2018–2019; of these, 1700 received a study place.[2] In addition, the student numbers in diagnostic and therapeutic radiography have increased in 2020 compared to the year 2019 in all regions of England. The suggested reason for this is the promotion of the study field by the professionals which has increased the interest for the radiography education.[3] Furthermore, radiography student selection processes should include methods which predict student success.[4,5,6,7] There is some evidence that successful student selection may improve retention and promote long-term commitment to the radiography profession.[8,9,10,11]

Radiography professionals' expertise focuses on the use of medically important diagnostic and therapeutic procedures when providing ionizing radiation to patients.[4,5,9,10,12,13] In addition to technical knowledge and skills, professionals must be able to engage appropriately and empathically with patients who are seriously ill.[4,5,9,10] The importance of problem-solving skills and

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ability to engage with other professionals has also been brought up by the professionals.[9,10] These requirements of the profession should be considered when planning student selection methods to select applicants with adequate knowledge and skills to study in radiography education. Moreover, there is accumulating evidence of concerns over the quality of applicants[8] and an increase in student attrition rates.[14,15,16] In the United Kingdom, the attrition rates among radiography students have been little higher than in higher education.[16] The most recent figures from the years 2018–2019 among diagnostic radiography students is 14% and therapeutic students 24% and in 2014–2015 11% and 21% respectively.[2,17] The attrition rates in higher education were 11% during years 2014–2015.[17]

In most European countries, radiography education is offered at Bachelor level, which is equal to the European Qualification Framework (EQF) level 6.[4,12] Besides the commitment to EQF level 6, radiography education follows the European Directives for safety standards (2013/59/Euratom), which defines the competences, responsibilities, and tasks among professionals involved in medical exposure in either diagnostic or therapeutic procedures.[13] Furthermore, in most European countries, the radiography profession is a regulated profession, highlighting professional responsibility and qualifications to practice the profession of medical imaging and radiotherapy.[12,18] The field of radiography consists of diagnostic radiography, radiotherapy, and nuclear medicine disciplines.[10,12] However, there are some educational differences between countries, some having one education covering all these disciplines while others have a specific education for each.[4,12] Educational differences also include the length and the number of credits required to complete the training.[12] In this article, the term "radiography" is used to refer to all three above-mentioned disciplines.

According to previous literature, student selection in radiography education utilizes selection methods such as previous study achievement, standardized tests, and interviews, of which the final admission scores are formed. However, admission criteria vary between universities.[6,7,9] Two previous literature reviews were found regarding radiography student selection.[6,7] Ochs & Adams (2008) aimed to describe the admission criteria and tools needed to better predict academic performance in radiation therapy program. Three articles from the years 1994–2006 were included in the review; according to the results, both quantitative and qualitative data are needed to predict study success. Quantitative data referred to GPA from high school or college and qualitative data to interviews. A positive correlation was found between students' GPA and academic performance. However, a correlation between interview and academic performance was not established. The exact factors or the correlations were not described in the review.[7] In the other literature review by Ingrassia (2016), the aim was to describe admission criteria of allied health professions, including radiography education. The nine articles included in the review were published between the years 1976–2013. The results demonstrated that programs used both cognitive and noncognitive factors to predict student success. Cognitive factors included the use of GPA, math and science skills acquired in high school or college whereas noncognitive ones included the assessment of interpersonal skills, communication skills, motivation, work ethics, problem-solving skills, and knowledge of the profession. The relationships between assessed factors and study success were not interrogated. However, the review concluded that common admission criteria to predict study success of applicants in radiography education programs were not found.[6] Both reviews also concluded that there is a need to confirm factors that should be considered in the radiography selection process, and, also, to study their relationship to study success.[6,7] Similar conclusions have also been reported in other studies.[9,10,12] To conclude, there is very little research to demonstrate which selection methods and contents are most successful in radiography education.

In addition to earlier literature reviews the need to have a literature review of the selection methods and contents concerning all levels of radiography programs was also identified in the Development Project for Student Selection in the Finnish Universities of Applied Sciences 2017–2020 that aimed to develop a joint national entrance examination for all the higher education study fields.[19] The aim of this review is to describe the methods and contents used in radiography student selection and factors related to study success. The research questions are as follows: 1) What methods are used in radiography student selection, 2) What contents are assessed in radiography student selection, and 3) What factors assessed in radiography student selection are related to study success?

Methods

A narrative review was undertaken to scope the extent, range and nature of the research activity regarding student selection in radiography education, to summarize the research findings, and to identify research gaps in the existing literature.[20,21,22] This approach was chosen to identify all relevant literature regardless of the study design.[20,22] The review protocol followed the five steps of a review as described by Arksey & O'Malley (2005): 1) Identifying the research question, 2) identifying relevant studies, 3) study selection, 3) charting the data, 4) collating, summarizing, and reporting the results.[22] Even though quality assessment of the literature is not an initial priority, predetermined inclusion and exclusion criteria are important to include relevant literature.[21,22] The data analysis and synthesis of the data is more qualitative than quantitative.[21]

A computerized search was undertaken in four databases to cover relevant publications (Fig. 1). Subject headings of the databases, information specialists and preliminary searches into the chosen databases were utilized to identify search terms. Boolean operators were used to combine the search terms into search phrases (Fig. 1). The search was limited to journal articles with an available abstract, published in English, and published between January 2000 and June 2021. This time limit was chosen because radiography education largely changed from diploma to Bachelor level in Europe from the year 2000 to meet the European qualification framework at level 6.[4,12] The articles had to meet the following criteria to be selected for the review. The article needed to describe student selection methods, contents, and relationship of factors to study success in radiography education. Articles concerning post-graduate education, radiography professionals' opinions of selection, students' self-evaluation, method of monitoring students' progress and universities' recruitment strategies as well as review articles were excluded (Fig. 1).

The electronic database retrieval produced 1227 citations (Fig. 1). After removing duplicates and further screening of abstracts and full-texts, ten articles were included in the review. The screening of the reference list of the included articles did not produce any articles. Quality assessment of the included articles was not carried out, which is in the line with the relevant literature on narrative reviews.[21] It is noteworthy that all included articles were peer-reviewed, adding some evidence of the quality of the articles.

The data analysis was undertaken in four steps.[23,24] First, general information of each study (author, year, purpose, study design and participants, main results) was collated into Table 1. Second, the description of selection methods was tabulated to answer the first research question (Table 2). Third, the information from Table 2 was used to answer the second research question using inductive content analysis. The information of the factors of each method was

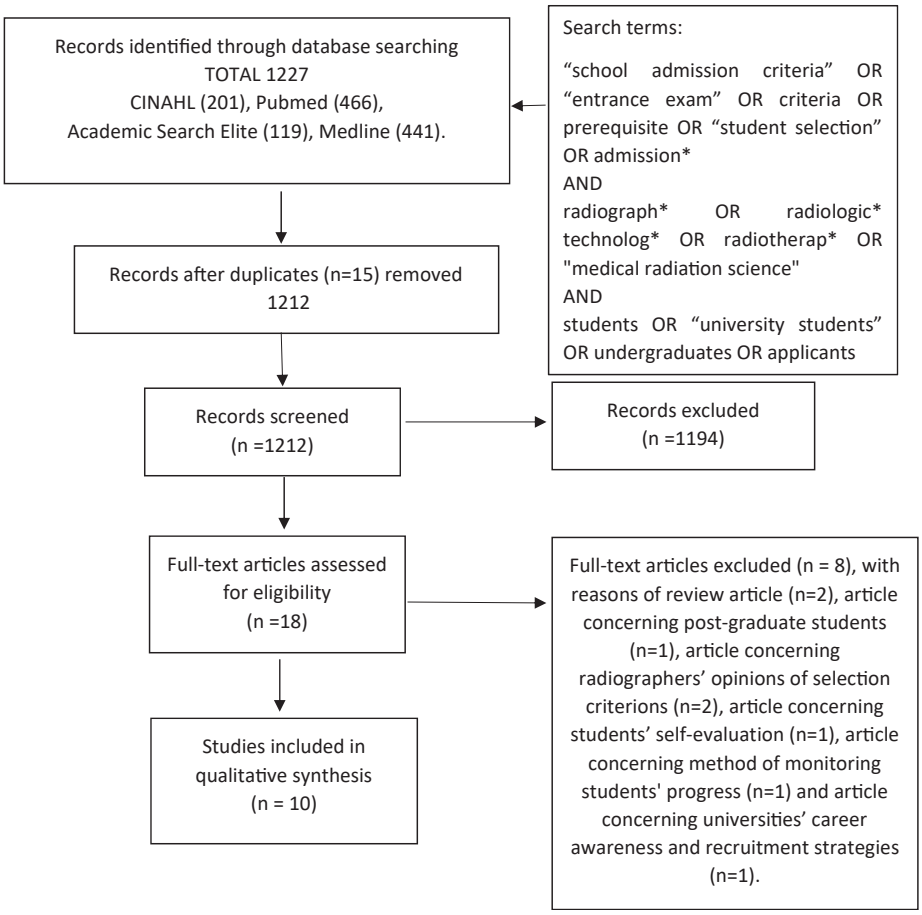

Figure 1. Description of retrieval process (PRISMA 2009 Flow Diagram).

extracted as a meaning unit, and similar meaning units were grouped together in sub-categories and finally, into main categories (Table 3). Fourth, the factors related to study success were collated into a new table to answer the third research question (Table 4).

Results

Description of the studies

Altogether, ten studies that described radiography student selection were included in this review (Table 1). The studies were published between 2001 and 2020. Eight studies were conducted in the United States, one in South Africa, and one in Canada. Eight studies were retrospective longitudinal quantitative studies, and one of the retrospective studies also used a quasi-experimental study design. Two studies were quantitative cross-sectional studies. Five studies investigated selection factors and study success focusing on students' grades.[25,26,27,28,29] The total number of students was 7,861, varying between 90 and 6443 students per study. Two studies informed the number of programs participating in the studies, one 45 and the other 327 programs.[30,31] The studies covered all educational levels of radiography education (Table 1).

Methods used in radiography student selection

In this narrative review, 23 selection methods were identified (Table 2). The most often used methods in radiography students' selection were interviews (n = 4)[27,30,31,32] and the Scholastic Aptitude Test (SAT) (n = 3).[30,31,33] Also, the use of the American College Test (ACT) and reference letter were both reported in two studies.[30,31,32] Validity of the tests was described regarding two tests, namely the Armed Services Vocational Aptitude Battery (ASVAB) and the General Scholastic Aptitude Test (GSAT),[28,34] whereas reliability was only reported for one instrument (ASVAB).[28]

Contents assessed in radiography student selection

According to the content analysis, four categories, namely learning skills, social skills, personality traits and career choice, including eleven sub-categories, were identified to describe the contents assessed in radiography student selection (Table 3). The description of contents was limited in most of the included articles. The largest numbers of factors demonstrating the contents of sub-categories were seen in science skills (n = 9), mathematical skills (n = 8) and language skills (n = 7). The smallest number of factors was observed in reasoning skills (n = 1), self-directed skills (n = 1) and perception of radiography as a profession (n = 1) (Table 3).

Factors related to study success

Regarding the results, eight factors predicted radiography students' study success (Table 4). These factors were mathematics, physics, biology, anatomy, physiology, natural sciences, a composite of factors comprising electronics (arithmetic reasoning, math

Table 1
Studies included in the current review.

Author(s), year, country	Aim of the research	Study design and data analysis	Participants	Results
Dunai F.A., Porter R.D. 2001, United States	To assess the Armed Services Vocational Aptitude Battery (ASVAB) predictors of student success in the diagnostic imaging course at the Air Force's School of Health Care Sciences.	Quantitative, retrospective. The data were analyzed with regression analysis and analysis of variance.	The data consisted records of 664 entry-level radiography students trained from 1994 to 1996.	Results provided two significant predictors — mechanical and electronics scores on the ASVAB - of student success as identified by final grade. Both scores were significantly different among those who passed, washed back and disenrolled.
Espen D, Wright D.L, Killion J. 2006, United States	To document admission requirements of entry-level programs in radiography accredited by the Joint Review Committee on Education in Radiologic Technology (JRCERT) in Oklahoma and Texas.	Quantitative, cross-sectional. The data were analyzed with descriptive statistics.	The data included 45 JRCERT-accredited certificate and associate degree radiography programs in Oklahoma and Texas.	Cumulative grade point average, interviews, successful completion of math and science courses, and performance on standardized tests were the most used admission criteria, although no criteria were used by all the programs surveyed.
Flores M, Simonsson M. 2012, United States.	To investigate how a number of indicators — high school achievement, high school performance, aptitude, and proactive measures taken by the student — contribute to the academic achievement of college-attending students pursuing an allied health degree.	Quantitative, retrospective. The data were analyzed with multiple linear regressions.	The study sample consisted of 224 students of dual enrollment program at the University of Texas–Texas Southmost College from 2005 through 2009.	Academic achievement was found to be a function of the independent variables examined. The variables accounted for 37% of the total variance in academic achievement among the respondents, as measured by college grade point average.
Hawking N, Elmore A, Harmon C. 2013, United States.	To assess the value of the Psychological Service Bureau's (PSB) Health Occupations Aptitude Test's tests and subtests and the pre-program college grade point average (GPA) used in the selection process for the University of Arkansis (UA) Fort Smith radiography program as predictors of academic (cognitive) and clinical (non-cognitive—affective and psychomotor) success.	Quantitative, retrospective. The data were analyzed with descriptive statistics, Pearson correlation coefficients, multivariate regression model.	The data consisted of 97 (90 graduates and 7 failures/dismissals) UA Fort Smith radiography students of an associate degree program over the past 5 years.	Results indicated a positive relationship between two of the predicator variables, pre-program college GPA and the PSB's Science test, and one criterion variable, the radiography program's GPA.
Kridiotis C.A, Bezuidenhout J, Raubenheimer J.2016, South Africa	To identify which selection criteria were predictors of academic success in the first study year of radiography.	Quantitative, retrospective. Statistical analysis included Pearson's r and linear regression analysis.	Data from 130 first-year students enrolled in the National Diploma (NDip) in Radiography at the Central University of Technology (CUT).	The matriculation Admission Points Score in National Senior Certificate (NSC APS) and core matriculation subject results in Mathematics, Physical Sciences and English were adequate predictors for first-year academic success, and the subjects Life Sciences for the NSC and Biology for the Senior Certificate (SC), showed strong predictive values for first-year academic success. According to results, the General Scholastic Aptitude Test (GSAT) did not predict academic success.
Kudlas M.J. 2006, United States	To determine the extent to which admission practices of 24 -month radiography programs affect retention rates.	Quantitative, retrospective. Analysis of variance, multiple comparison (least squares difference).	The data from 327 programs represented 6443 radiography program matriculants, 5191 graduates and 1252 withdrawals. Programs awarded certificate or associate degree.	The retention rates were higher in programs that used a competitive admission process than in those that did not. The use of selective grade point average and reference letters in the competitive admission process was significant in predicting increased retention rates in a radiography program.
Kwan J., Childs R.A., Cherryman F., Palmer C., Catton P. 2009, Canada	To investigate the relationship between admission criteria for a medical radiation sciences program and student	Quantitative, retrospective. Descriptive statistics, correlations, *t*-tests and χ^2-squared tests.	The data from 122 radiography students of bachelor's degree program consisting undergraduate grade point average (GPA), grades in undergraduate science courses,	The study results show positive correlation between preadmission overall GPA, performance in biology, mathematics, and physics, and in-program performance on

(*continued on next page*)

Table 1 (*continued*)

Author(s), year, country	Aim of the research	Study design and data analysis	Participants	Results
	success in the program and on the subsequent certification examination.		performance in program coursework, and post-graduation certification examination results.	both the technical knowledge and skills (TKS) courses and professional practice and patient care (PPP) courses, as well as exit GPA. Undergraduate grades in biology were significantly correlated with good performance in PPP courses, and preadmission GPA was significantly correlated with performance in the discipline-specific technical courses.
Menser J., Hughey A.W. 2020, United States.	To determine the traditional admissions criteria that best predict a higher graduation rate for radiography programs.	Quantitative, cross-sectional. Descriptive and analysis of variance.	618 surveys were sent to radiography programs consisting of associate and bachelor's degrees accredited by the Joint Review Committee on Education in Radiologic Technology (JRCERT), 410 surveys were returned.	Two-year programs that utilized more traditional admissions criteria had higher graduation rates, as opposed to 2-year programs with moderate to low rates. Using more criteria for admission seems to be positively related to student persistence to program completion. Analysis of Variance (ANOVA) demonstrated statistically significant differences ($p = 0.05$) between 2-year programs that use traditional admissions criteria more extensively and programs that do not approach admissions in such a comprehensive manner.
Veale B.L, Clark K.R, Killion J.B, Sharma P., 2017, United States	To examine the relationship between the Health Education Systems, Inc. (HESI) Admission Assessment (A2) and specific established admission criteria in an entry-level radiologic sciences program.	Quantitative, retrospective. Descriptive analysis and Pearson correlation.	The data consisted of 90 students of entry-level radiologic technology program. Students' grades in English, anatomy and physiology, and college-level mathematics were compared to scores on comparable categories of the HESI A2. Students' scores on program exit examinations, the HESI radiography exit examination, and the American Registry of Radiologic Technologists (ARRT) first-attempt registry scores were also compared.	There was no correlation between the HESI A2 examination and program admission criteria except when a minimum passing score of 70 was applied to the HESI A2, eliminating some students.
Webster T., McBrien S.B., Mehrer G.M., Sayles H.R. 2020, United States	To determine if the anatomy and physiology readiness exam scores would be reliable indicators of programmatic success in anatomy and physiology program coursework.	Quantitative, retrospective, and quasi-experimental. Descriptive analysis, Mann−Whitney U-test, linear regression.	Baccalaureate students that matriculated between 2013 and 2017 ($n = 91$). Data included grades from anatomy and physiology course taken during the program and a readiness examination. The readiness examination scores were correlated with program anatomy and physiology grade point average (GPA).	Data analysis revealed prerequisite GPA and the anatomy and physiology section of the readiness examination to be strong and moderate predictors of programmatic anatomy and physiology course grades.

Table 2
Methods used in radiography students' selection.

	Method	Author(s)	Description of method	Factors/subtests/ parts	Reliability	Validity
1.	American College Test (ACT)	Espen et al., 2006 Menser & Hughey, 2020	Not reported Not reported	Not reported Not reported	Not reported Not reported	Not reported Not reported
2.	Armed Services Vocational Aptitude Battery (ASVAB)	Dunai & Porter, 2001	The ASVAB assess potential skills in technical training. The battery consists of 10 subtests, which assess four composites: (1) mechanical, (2) administrative, (3) general, and (4) electronics	Subtests: General science Arithmetic reasoning Word knowledge Paragraph comprehension Numerical operations Coding speed Auto and shop information Math knowledge Mechanical comprehension Electronics information	Reliability of ASVAB has been confirmed in previous studies (Prediger 1987, Earles and Ree 1992.) The overall reliability has been 0.93. Predictor reliability correlations has been confirmed being between 0.88 and 0.92 for the ASVAB composites.	Validity of ASVAB has been confirmed previous (Jensen 1985). Validity coefficients range of 0.50–0.60. The validity coefficients between ASVAB composites have been between 0.65 and 0.73.
3.	Armed Forces Qualification Test (AFQT)	Dunai & Porter, 2001	The AFQT assess potential skills in technical training.	Test is a combination of four subtests of ASVAB: Word knowledge Paragraph comprehension Arithmetic reasoning Math knowledge	Not reported	Not reported
4.	Computerized College Placement Test (COMPASS)	Espen et al., 2006	Assesses reading, writing and prealgebra	Not reported	Not reported	Not reported
5.	General Scholastic Aptitude Test (GSAT)	Kridiotis et al., 2016	Not reported	Not reported	Not reported	Validity of GSAT has been confirmed regarding entry level Information Technology students (Jenkings 2004).
6.	Health Education Systems, Inc. Admission Assessment (HESI A2)	Veale et al., 2017	HESI A2 assess readiness of program applicants in the areas of reading comprehension, anatomy and physiology, mathematics, and chemistry.	Not reported	Not reported	Not reported
7.	Health Occupations Basic Entrance Test (HOBET)	Espen et al., 2006	Not reported	Not reported	Not reported	Not reported
8.	Psychological Service Bureau's (PSB) Health Occupations Aptitude Test	Hawking et al., 2013	Three parts out of five parts of PSB are assessed. Part I Academic Aptitude Total assess student's ability to learn. Part III Reading Comprehension. Part IV Natural Sciences Part V Vocational Adjustment Index quantifies a student's individual characteristic lifestyle.	Part I: Verbal, nonverbal and arithmetic Part III: student's ability to understand, interpret, grasp intent, observe organization of ideas, and extract information with respect to ideas and purposes. Part IV: measures the accumulation of information in the natural sciences Part V: Feelings, attitudes, personality characteristics, and behavioral traits.	Not reported	Not reported

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Table 2 (*continued*)

	Method	Author(s)	Description of method	Factors/subtests/ parts	Reliability	Validity
9.	Scholastic Aptitude Test (SAT)	Espen et al.,, 2006 Flores & Simonsson, 2012 Menser & Hughey, 2020	Not reported SAT assess critical reading and math, writing. Not reported	Not reported Not reported Not reported	Not reported Not reported Not reported	Not reported Not reported Not reported
10.	Tests of Adult Basic Education (TABE)	Espen et al., 2006	Not reported	Not reported	Not reported	Not reported
11.	Texas Academic Skills Program (TASP)	Espen et al., 2006	Not reported	Not reported	Not reported	Not reported
12.	Texas Assessment of Knowledge and Skills (TAKS)	Flores & Simonsson, 2012	TAKS assess English, math, social studies, and science.	Not reported	Not reported	Not reported
13.	Facility-generated examination	Espen et al., 2006	Not reported	Not reported	Not reported	Not reported
14.	Interview	Kudlas, 2006 Menser & Hughey, 2020 Kwan et al., 2009 Espen et al., 2006	Not reported Not reported An interview to assess communication, compatibility, initiative and self-evaluation. An interview to assess academic/ work history, goals, why applicant chose radiography, understanding of radiography career, motivation, and problem-solving skills.	Not reported Not reported Not reported Not reported	Not reported Not reported Not reported Not reported	Not reported Not reported Not reported Not reported
15.	Readiness examination	Webster et el., 2020	A readiness exam to assess anatomy and physiology, algebra, general chemistry, and statistics.	Not reported	Not reported	Not reported
16.	Grade point average (GPA) of the university courses from the first study year	Kwan et al., 2009	Biology, mathematics, and physics and chemistry	Not reported	Not reported	Not reported
17.	English Proficiency Test	Kridiotis et al., 2016	Not reported	Not reported	Not reported	Not reported
18.	Standardized written tests	Menser & Hughey, 2020	Not reported	Not reported	Not reported	Not reported
19.	Psychomotor tests	Menser & Hughey, 2020	Not reported	Not reported	Not reported	Not reported
20.	Noncognitive test	Kudlas, 2006	Not reported	Not reported	Not reported	Not reported
21.	Standardized test score	Kudlas, 2006	Not reported	Not reported	Not reported	Not reported
22.	Writing sample	Kudlas, 2006	Not reported	Not reported	Not reported	Not reported
23.	Reference letter	Menser & Hughey, 2020 Kudlas, 2006	Not reported Not reported	Not reported Not reported	Not reported Not reported	Not reported Not reported

knowledge, electronics information, and general science) and a composite of factors comprising mechanics (mechanical comprehension, general science and auto and shop information). Four selection methods, namely ASVAB, PSB Test, GPA and Readiness examination, were used to measure these factors, and study success was measured as program GPA or final grade,[26,27,28] course grades[25,27] and certification examination.[27] Furthermore, mathematics, physics, biology, anatomy, and physiology and a composite of factors comprising electronics and a composite of factors comprising mechanics were statistically significant predictors of study success.[25,27,28] The statistically significant correlation r-values varied between 0.285 and 0.842.

Discussion

The aim of this narrative review was to describe the methods and the contents used in radiography student selection and factors related to study success. In this review, several selection methods were identified, of which twelve were standardized tests and eleven were other instruments. The results reveal that there was no single selection method that was most frequently used; instead, different combinations of selection methods were used amongst the universities.[25,26,34] The results are in the line with previous studies which have identified a huge variety in radiography student selection methods.[6,7,9] This result may indicate that there is no common understanding of what should be assessed in radiography student selection. Also, these results largely present the current state of the methods in the Northern America. But it should be noticed that the results do not describe, what is the situation regarding usage of methods in radiography student selection in Europe. On the other hand, universities may want to emphasize different prerequisites in selecting students, e.g., selection of military radiography students[28] compared to selection of radiography students in a university.[31] Some of the reasons for the use of several different selection

Table 3
Contents assessed in radiography student selection.

Category	Subcategory	Factors	Methods	Author(s)
Learning skills	Mathematical skills	Math knowledge	ASVAB	Dunai & Porter, 2001
			AFQT	Dunai & Porter, 2001
		Mathematics	SAT	Flores & Simonsson, 2012
			HESI A2	Veale et al., 2017
			TAKS	Flores & Simonsson, 2012
			GPA of the university courses from the first study year	Kwan et al., 2009
		Arithmetic	PSB Health Occupations Aptitude Test	Hawking et al., 2013
		Arithmetic reasoning	AFQT	Dunai & Porter, 2001
			ASVAB	Dunai & Porter, 2001
		Algebra	Readiness examination	Webster et al., 2020
		Statistics	Readiness examination	Webster et al., 2020
		Numerical operations	ASVAB	Dunai & Porter, 2001
		Prealgebra	COMPASS	Espen et al., 2006
	Language skills	Word knowledge	AFQT	Dunai & Porter, 2001
			ASVAB	Dunai & Porter, 2001
		Paragraph comprehension	AFQT	Dunai & Porter, 2001
			ASVAB	Dunai & Porter, 2001
		Reading	COMPASS	Espen et al., 2006
		Reading comprehension	HESI A2	Veale et al., 2017
			PSB Health Occupations Aptitude Test	Hawking et al., 2013
		Critical reading	SAT	Flores & Simonsson, 2012
		Writing	SAT	Flores & Simonsson, 2012
			COMPASS	Espen et al., 2006
		English	TAKS	Flores & Simonsson, 2012
	Science skills	General science	ASVAB	Dunai & Porter, 2001
		Natural sciences	PSB Health Occupations Aptitude Test	Hawking et al., 2013
		Science	TAKS	Flores & Simonsson, 2012
		Chemistry	HESI A2	Veale et al., 2017
			GPA of the university courses from the first study year	Kwan et al., 2009
		General chemistry	Readiness examination	Webster et al., 2020
		Anatomy	HESI A2	Veale et al., 2017
			Readiness examination	Webster et al., 2020
		Physiology	HESI A2	Veale et al., 2017
			Readiness examination	Webster et al., 2020
		Biology	GPA of the university courses from the first study year	Kwan et al., 2009
		Physics	GPA of the university courses from the first study year	Kwan et al., 2009
	Technical skills	Coding speed	ASVAB	Dunai & Porter, 2001
		Mechanical comprehension	ASVAB	Dunai & Porter, 2001
			AFQT	Dunai & Porter, 2001
		Electronics information	ASVAB	Dunai & Porter, 2001
		Auto and shop information	ASVAB	Dunai & Porter, 2001
	Reasoning skills	Problem-solving	Interview	Espen et al., 2006
	Self-directed skills	Self-evaluation	Interview	Kwan et al., 2009
Personality traits	Personal characteristics	Personality characteristics	PSB Health Occupations Aptitude Test	Hawking et al., 2013
		Behavioral traits	PSB Health Occupations Aptitude Test	Hawking et al., 2013
		Compatibility	Interview	Kwan et al., 2009
Social skills	Interpersonal communication skills	Nonverbal	PSB Health Occupations Aptitude Test	Hawking et al., 2013
		Social studies	TAKS	Flores & Simonsson, 2012
		Verbal	PSB Health Occupations Aptitude Test	Hawking et al., 2013
		Communication	Interview	Kwan et al., 2009
Career choice	Desire to work as a radiographer	Attitudes	PSB Health Occupations Aptitude Test	Hawking et al., 2013
		Motivation	Interview	Espen et al., 2006
		Why applicant chose radiography	Interview	Espen et al., 2006
		Goals	Interview	Espen et al., 2006
	Prerequisites of working as a radiographer	Initiative	Interview	Kwan et al., 2009
		Academic/work history	Interview	Espen et al., 2006
	Perception of radiography as a profession	Understanding of radiography career	Interview	Espen et al., 2006

methods may include the availability of standardized tests, university funding, different emphasis on competencies in the selection phase or in the radiography education,[10,12,14] and lack of knowledge or evidence base concerning different methods. Interview has been mentioned as a challenging method due to difficulties in judging applicants in a fair manner based on a presumably objective structured interview,[6,7,9] which is why some universities might be reluctant to include it in the selection.[6,7] Furthermore, higher education institutions should use methods that are reliable and valid in their student selection processes. However, the results of this review

Table 4
Factors related to study success in radiography education.

Factors (Method)	Study success	+/0[a]	Pearson correlation r	p-value
Mechanical -consists of factors mechanical comprehension, general science and auto and shop information (ASVAB, AFQT)	Final grade (Dunai & Porter, 2001)	+	Not reported	<0.05
Electronics -consists of factors arithmetic reasoning, math knowledge, electronics information, and general science (ASVAB, AFQT)	Final grade (Dunai & Porter, 2001)	+	Not reported	<0.05
Mathematics (GPA of the university courses from the first study year)	Technical knowledge and skills (TKS) course grades (Kwan et al., 2009)	+	0.580	<0.01 RT[b]
	Professional practice and patient care (PPP) course grades (Kwan et al., 2009)	+	0.407	Not reported
	Program GPA (Kwan et al., 2009)	+	0.523	<0.05 RT
	Certification examination (Kwan et al., 2009)	+	0.842	<0.05 RT
Physics (GPA of the university courses from the first study year)	Technical knowledge and skills (TKS) course grades (Kwan et al., 2009)	+	0.344	<0.01 RTT[c]
	Professional practice and patient care (PPP) course grades (Kwan et al., 2009)	+	0.095	Not reported
	Program GPA (Kwan et al., 2009)	+	0.285	<0.05 RTT
Biology (GPA of the university courses from the first study year)	Professional practice and patient care (PPP) course grades (Kwan et al., 2009)	+	0.475	<0.05 RT
	Technical knowledge and skills (TKS) course grades (Kwan et al., 2009)	+	0.423	<0.01 RTT
	Program GPA (Kwan et al., 2009)	+	0.401	<0.01 RTT
	Certification examination (Kwan et al., 2009)	+	0.447	<0.05 RTT
Natural sciences (PSB Health Occupations Aptitude Test)	Academic program GPA (Hawking et al., 2013)	+	0.358	<0.01
Anatomy (Readiness examination)	Anatomy course grade (Webster et al., 2020)	+	0.479	<0.05
Physiology (Readiness examination)	Physiology course grade (Webster et al., 2020)	+	0.479	<0.05
General -consists of factors word knowledge, paragraph comprehension and arithmetic reasoning (ASVAB, AFQT)	Final grade (Dunai & Porter, 2001)	0	Not reported	Not reported

[a] +/0 refer to factor's relation to study success. + refers to positive relation, 0 refers to no relation.
[b] RT refers to radiological technology students.
[c] RTT refers to radiation therapy student.

indicate that the reliability and validity of only two selection methods, namely, ASVAB and GSAT, was reported. Also, universities often use self-developed methods, such as interviews and reference letters, that are not assessed for their reliability and validity, causing potential questions of the objectivity of these methods.[27,31] These issues highlighting reliability and validity should be taken into consideration not only when interpreting the results of this review but also in future studies. Future reviews could be extended to include other healthcare disciplines.

The contents assessed in radiography education included four categories (learning skills, social skills, personality traits and career choice), the most often assessed content being learning skills, which was incorporated in nine selection methods. The content of learning skills is partly in line with the results of the previous literature review of Ingrassia (2016) where factors such as mathematics and science skills were identified.[6] Therefore, there seems to be some evidence of the importance of assessing learning skills in the selection. However, more research is needed to establish the most important contents in the assessment. As none of the included studies were undertaken in Europe, the identified contents will need to be evaluated against the radiography education of EQF level 6 but, also, there should be taken into consideration differences between countries due to cultural variety. The contents of social skills, personality traits and career choice were less frequently assessed, being investigated in four studies using three selection methods.[26,27,31,33] The reason for this may be that these contents may be difficult to assess and therefore be less used and reported. Furthermore, the description of the contents of the different selection methods was very limited in the included articles, which may have affected the results of this review. Thus, it is suggested that in the future, a wider search on the contents of the different selection methods is undertaken utilizing other sources than traditional databases. However, it is evident from the results that radiography student selection should be multifaceted.

According to the results, several relationships between factors and study success were identified. All factors that had a statistically significant connection with study success were from the learning skills category, namely, mathematics, physics, biology, anatomy, physiology, natural sciences, a composite of factors comprising electronics and a composite of factors comprising mechanics. However, it needs to be noted that these results were based on three studies.[25,27,28] Moreover, the factors from the categories of personality traits, social skills, and career choice were not related to study success. The reason for this may be that there were only few studies that reported the assessment of these factors.[26,27,31,33] More research is needed to establish the inclusion, reliability and validity of these categories and their factors. Furthermore, only one of the studies used practice placement as an outcome for study success.[27] However, there is some evidence that students' poor success during the practice has a deteriorating effect on their studies[9,15,16] and future research should give attention to the predicting factors in terms of practice.

Strengths and limitations

As to strengths and limitations of this narrative review, the issues of search methods, search outcomes and analysis should be considered.

A preliminary search in the chosen databases was executed to scope the extent of the literature, publication years and to identify relevant search terms. An information specialist participated in the generation of the search strategy. The limitations of the search method include the use of English language, and potentially missing some less often used terms describing radiography education. The PRISMA flowchart was used to provide an accurate description of the search process. The screening of the search results was strengthened by having two authors to assess the titles, abstracts, and full texts of the studies.

The results of this review may also be influenced by the fact that the quality of the studies was not evaluated, which is in line with the nature of the narrative review.[21] However, all the included studies were peer-reviewed journal articles. Furthermore, before the analysis process, the included studies were tabulated to increase the transparency of the results. The trustworthiness of the data analysis was increased by including two of the authors in the analysis process, and by having the third author independently evaluate the results such as categories and subcategories. Finally, the results of the review may be influenced by the fact that the majority of the studies were conducted in North America. Thus, the North American selection criteria may have affected the results. Generalizability of the results should be taken cautiously due to differences in radiography educations between countries.

Conclusions

The currently used student selection methods and contents vary greatly in radiography student selection. The results of this review suggest using the content of four categories in the selection of radiography students. However, more research is needed to further establish the methods usage, with knowledge of reliability and validity, and assess the contents for each category and establish their predictive value for study success so as to identify the core content that should be assessed in radiography student selection.

Conflict of interest statement

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