Introduction

INTRODUCTION

Globally medical schools are faced with a limited number of student places and manifold applicants. Therefore, student selection is an internationally widespread practice. Medical schools aim to offer the places available only to those applicants with the highest probability of a successful medical training and subsequent career, in view of the high expense and significant societal relevance of training competent medical doctors. To reach this goal, several selection procedures have been developed (Kreiter & Axelson, 2013) although the evidence that these procedures indeed do identify either better achieving students (Salvatori, 2001; Siu & Reiter, 2009) or ultimately competent professional doctors is limited (Benbassat & Baumal, 2007). Let alone that misbehaviour in the future can be excluded (Papadakis, Teherani, et al., 2005).

Most medical schools have traditionally relied on academic criteria in admission procedures, such as prior academic attainment and aptitude tests (Julie, 2007; Parry, Mathers, et al., 2006). Reviews of the literature have shown that prior academic attainment has a moderate predictive value for subsequent academic performance, with correlations of 0.40–0.50 (McGaghie, 2002; Salvatori, 2001; Siu & Reiter, 2009). Similarly, aptitude tests have an acceptable predictive value for pre-clinical performance, showing correlations of 0.31–0.54 with Grade Point Averages (GPAs) in third year of the medical school (Julian, 2005; Wiley & Koenig, 1996). However, it proved to be to be more difficult to predict clinical performance during clerkships (Basco Jr., Gilbert, et al., 2000; Hamdy, Prasad, et al., 2006). Given an explained variance of less than 10%, the relationship between prior academic attainment and performance during clerkships is much weaker (Baars, Wimmers, et al., 2009; Peat, Woodburry, et al., 1982; Veloski, Callahan, et al., 2000). Aptitude tests have a low to moderate predictive value for clerkships, with an explained variance in clinical performance of approximately 15% (Donnon, Paolucci, et al., 2007).

The decrease in predictive value of prior academic attainment and aptitude tests with increasing time prior to medical school admission has also been shown for schools with undergraduate entry in the Netherlands and Germany (Stegers-Jager, Steyerberg, et al., 2015; Trost, Nauels, et al., 1998). Additionally, selection on prior academic attainment is known to have an adverse impact on the percentage of selected candidates from non-traditional applicants including those from minority or lower social-economic backgrounds (Cleland, Dowell, et al., 2012).

In the last decades medical schools have included other student attributes than prior academic attainment or aptitude tests in their selection procedures, since the basis of performance in medical school appeared to be multifactorial with intellectual ability as well as other, non-academic, attributes playing an important role (Collins, White, et al., 1995), resulting in two types of predictors: academic predictors with prior academic attainment and aptitude tests as their best representative, and non-academic predictors, such as ability-based tests or the multiple mini interview (Benbassat & Baumal, 2007; Kreiter & Axelson, 2013; Prideaux, Roberts, et al., 2011). The rationale behind the addition of these so-called non-academic attributes to selection is that, next to strong cognitive abilities, medical doctors need other skills and competences, such as communication, collaboration, and professional integrity (Hojat, Erdmann, et al., 2013). Furthermore, certain personality characteristics such as conscientiousness have a positive bearing on student performance during medical school (Ferguson, James, et al., 2003; Lievens, Coetsier, et al., 2002). However, not all skills and characteristics can be assumed to be 'teachable' and some may need to be present at the start of medical school (Patterson, Knight, et al., 2016). Therefore, there is a need for sophisticated tools to assess such non-academic characteristics for the purpose of selecting medical students (Collin, Violato, et al., 2009; Ferguson, James, et al., 2002; Kulatunga-Moruzi & Norman, 2002; Siu & Reiter, 2009).

With the aim to add these characteristics to the selection procedure and thereby enhance the predictive validity of the interview, the multiple mini-interview (MMI) was developed: an admission procedure resembling an objective structured clinical examination with multiple short-interview stations (Eva, Rosenfeld, et al., 2004). Although the results of only small groups of students have been presented, the MMI has shown promising results in predicting clerkship and licensing examination results (Pau, Jeevaratnam, et al., 2013; Reiter, Eva, et al., 2007). Another selection method developed is Situational Judgment Testing (SJT) in which an applicant is provided with scenarios and subsequently asked to judge the appropriateness of reactions to the difficult situations that may be encountered during medical school (De Leng, Stegers-Jager, et al., 2016). Tested in a large Belgian cohort over four years a video-based SJT proved to be able to predict final medical school examinations and doctor certification performance but had little, although significant, added value over de cognitive tests (i.e. 2.2% for doctor performance) (Lievens, 2013).

An intuitively appealing applicant characteristic that has been proposed to be used for selection is motivation for medical school and the medical profession as a career choice. However, motivation is difficult to assess reliably and instruments that gauge motivation in most cases rely on self-report. An alternative way of determining

motivation is evaluating motivated behaviour, i.e. extracurricular activities during pre-university education (puECAs) (O'Neill, Hartvigsen, et al., 2011; Schripsema, van Trigt, et al., 2014). Such extra-curricular activities are carried out by a person as a result of the intrinsic motivation and the willingness to learn specific tasks, thereby satisfying the interest and ambition of the person performing the task and showing that an applicant exceeds the requirements of admission to medical school and is willing to go the extra mile. Therefore, it has a high authenticity in describing a person. Astin proposed an involvement theory where involvement was defined as active participation in all kinds of (extra)curricular and social activities (Astin, 1999 (originally published 1984)). Highly involved students had a lower risk to drop out. He and Pike reported that involvement in a variety of curricular and co-curricular activities was directly related to augmented general abilities (Astin, 1975; Pike, 2000). Huang and Chang found that improvements of academic, communication and interpersonal skills were associated with intra- and extracurricular involvement (Huang & Chang, 2004).

In the light of best evidence medical education (Harden, Grant, et al., 1999) the validity of a selection method should be tested using an adequate control group; ideally a group of randomly admitted students. This was made possible by the three ways of gaining admittance to medical school in the Netherlands since 2000: a) direct access for highest achievers, b) a national weighted lottery procedure, and c) a local selection procedure.

Students with a pu-GPA ≥ 8.0 (ranging from 5.5 to 10.0) are granted direct access. All other qualified applicants are able to gain access to medical school through a national weighted lottery procedure, in which the chance of admittance rises with increasing pre-university GPA (pu-GPA). Although weighted and thereby biased by academic attainment, the lottery approaches randomly admittance fairly good. Applicants are assigned to the medical school of their choice according to availability. Those who take part in the lottery can also choose to apply to a local selection procedure. These selection procedures precede the lottery so rejected applicants can subsequently participate in the lottery. It is this unique co-existence of the national lottery and a local selection procedure that provides two perfectly comparable groups.

Only a few medical schools implemented a local selection procedure in the first years after the introduction in 2000. Ten Cate et al. described the selection procedures used in two Dutch medical schools (ten Cate & Hendrix, 2001; ten Cate, Hendrix, et al., 2002). In one school selection was based on cognitive abilities, in the other selection relied on assessment of non-cognitive abilities such as motivation

and views on the medical profession. Both medical schools selected 24 students. After one year of follow up, a comparison of the results of the selected students with those of 341 lottery-admitted students revealed that selected students obtained only a slightly higher mean grade on written examinations. Based on these findings the two medical school decided to stop using their selection procedures due to lack of discriminative value above the national lottery and they stuck to that conclusion in later years (Lutke Schipholt & Lijftogt, 2010; Reijn, 2006). A third medical school selected 56 students using a three-step procedure (Hulsman, van der Ende, et al., 2007) and compared its outcomes with those of 446 lottery-admitted controls in two year-cohorts. The selection procedure involved the writing of an essay, cognitive tests and an examination of social skills. After one year of follow-up, no difference in academic achievement was found between selected students and lottery controls. All three medical schools never published results of subsequent years. Only recently the faculty of medical sciences of the University of Groningen reported the results of a multifaceted selection process which is partly based on the selection method described in this thesis (Schripsema, van Trigt, et al., 2014).

OUTLINE OF THIS THESIS

In the Netherlands - as described above - admission takes place partly on the basis of a national lottery that is weighted for academic attainment and partly on local selection procedures. The latter gradually increasing since 2001 up to maximally 50% (Ten Cate, 2007). This dual system presented the unique opportunity to compare the results of randomly admitted and selected students and thereby establishing the added value of selection procedures. In 2001 a two-step selection procedure was developed at Erasmus MC addressing non-academic (i.e. motivated behaviour) as well as academic skills. These non-academic skills were assessed using motivation through the determination of a candidates' active involvement in extracurricular activities. The second step tested the candidates academic skills in a medical school context.

The first study presented in *chapter 2* provides an elaborate description of the newly designed selection procedure. The objective of this study was to determine whether a combination of two selection steps, one assessing academic and one assessing non-academic abilities, would lead to the admission of students whose achievement in medical school is better than that of students who had been admitted by weighted lottery. Four consecutive cohorts were entered into the study and the fol-

low up of each cohort was 2-4 years. The main outcome measures were dropout rate, study rate (credits per year) and mean grade per first examination attempt per year.

The study presented in *chapter 3* extended the comparison of selected and lottery-admitted students into the clinical phase of medical school to answer the question whether the selection procedure predicted student achievement in the clinical phase. The clinical phase are years 5 and 6 of medical school and directly come after the first four pre-clinical years. Follow-up of these cohorts was 5.5–8.5 years. The main evaluation parameter was the mean grade (GPA) obtained for the clinical phase clerkships.

The successive use of non-academic and academic criteria in the selection procedure creates the opportunity to examine the value of both types in predicting preclinical and clinical performance. In *chapter 4* the relative contribution of the non-academic and academic selection criteria to differences found in student performance, i.e. dropout rate and clerkship GPA, was descibed.

In *chapter 5* the relationship between selection using puECAs and clinical achievement is further examined by testing the hypothesis that candidates' puECAs predict their involvement in ECAs during medical school and that persistence in ECAs leads to better clinical achievement. If true, this would further support the choice of using puECAs as a non-academic selection tool in medical school selection procedures.

Finally, in *chapter 6*, the results of these studies are summarized and discussed in the light of the current scientific knowledge and currently used selection systems. Areas requiring further research are identified and discussed briefly and practical implications for the use of selection criteria at the various stages of the medical education program are described.

THE DUTCH APPROACH

The discussion about how to allocate student to medical school in the Netherlands started back in the sixties. In the preceding decades the number of students that started each year at the six medical schools approximately met the capacity of the schools. Moreover, the number of medical doctors that successfully accomplished the study met the demand for doctors required by society. However, in 1963-64, due to the baby boom after de 2nd world war, a significantly higher number of freshmen started medical school, which led to overcrowded lecture halls and training facilities, and as a result the medical schools claimed to be unable to meet the quality standards for medical education (Nota naar aanleiding van de ontwikkelingsplannen van de de universiteiten en hogescholen voor het tijdvak, 1963-1966, 1965). At the same time the Academic Council ('Academische Raad', predecessor of the 'Vereniging van Samenwerkende Nederlandse Universiteiten') published their report 'Artsenbehoefte en artsenvoorziening 1963-1982' in which they estimated the number of doctors required for health care in the Netherlands given a population of 15 million people (Godefroy, 1966). This was significantly higher than the medical schools were able to deliver at that time. Restriction of places and consequently creating a shortage of doctors was not considered an option in Parliament. Instead the Minister of Education advised the establishment of a new Faculty of Medicine, which was founded in Rotterdam in 1965 and is currently known as the Erasmus MC (Nota naar aanleiding van de ontwikkelingsplannen van de de universiteiten en hogescholen voor het tijdvak, 1963-1966, 1965).

In the following years the number of applicants continued to rise more than expected. The initial response of the medical schools was to increase the requirements of their propaedeutic (1st year) exam in order to decrease the number of students in later years. In 1972 an 'emergency law' was proposed to implement some kind of entrance selection to restrict the overwhelming numbers of students. Direct access was given to all applicants with a pre-university Grade Point Average (pu-GPA) ≥ 7.5 (on a scale of 1–10, where 1 = poor and 10 = excellent) and a lottery for the remaining applicants (Voorzieningen van tijdelijke aard met betrekking tot de inschrijving van studenten aan de Nederlandse universiteiten en hogescholen (Machtigingswet inschrijving studenten), 1972). After two years, this type of selection was terminated as a

result of the debate about a presumed inequality for those hard working but not meeting this pu-GPA and the inevitable lawsuits of those not meeting these standards (Karstanje, 1981; Wilbrink & van der Vleugel, 1974). The surplus of applicants for the available places remained. Not even the establishment of an eighth medical school founded in 1975 in Maastricht could solve this problem. Universities lobbied hard for a system in which they would be able to enlist only the best students and the Christian Democrat parties in the coalition government backed that proposal. However, the State Secretary for Education Klein, of the social democratic Labour Party, fiercely opposed this and held on to the unweighted lottery, as preferred from the egalitarian social democratic perspective. After intense debate in Parliament a compromise was reached in the form of a weighted lottery (Toelatingscriteria numerus fixus-studierichtingen voor het studiejaar 1975-1976. Brief van de Staatssecretaris van Onderwijs en Wetenschappen, 1975), which has been in use ever since.

In weighted lottery the chance of selection rises along with the pu-GPA. There are four different lottery categories defined as: 7.5 ≤ pu-GPA < 8.0; 7.0 ≤ pu-GPA < 7.5; 6.5 ≤ pu-GPA < 7.0, and 5.5 ≤ pu-GPA < 6.5. The ratio by category for admission by lottery is, respectively, 9 : 6 : 4 : 3. After selection by lottery, and if enough places are available, applicants are assigned to the medical school of their first choice.

During the 80s and 90s the law which regulates the weighted lottery as well as the registration of students was renewed every year, despite the discussion about entrance selection on other criteria. This cyclical process was finally interrupted in 1997, when a brilliant candidate with a pu-GPA of 9.6 failed three consecutive times to get admitted to medical school (van Walsum, 1998). This created the opportunity for proponents of other admission criteria to widen the discussion. The 1997 report 'Weighing weighted lottery' (Commissie Toelating Numerus Fixusopleidingen, 1997) commissioned by the Dutch government showed that a pu-GPA of eight or higher had a predictive value for student achievement at medical school. Moreover, the notion that individual characteristics might play a role at study success gained support and was gradually accepted. Also, the politically motivated controversy waned over selection procedures based on merit, motivation or on specific criteria that have a proven predictive value regarding professional success or success in medical education (Drenth, 1998).

Ultimately, in 1999 Dutch law was changed and since then students with a pu-GPA of eight or higher were exempted from the lottery admission system and directly admitted to the medical school of their choice. In addition, medical schools were allowed to select 50% of the remaining number of allotted students by their own criteria and methods (Wet van 3 april 1999 tot wijziging van de Wet op het hoger onderwijs en wetenschappelijk onderzoek, houdende aanpassingen in het systeem van selectie voor opleiding waarvoor een toelatingsbeperking is vastgesteld. [Dutch Act of Higher Education and Sientific Research], 1999). With this an opportunity arose for individual medical schools to design their own selection procedure. From 2017 onward, medical schools must select all students using a school-specific procedure.

(A detailed description of the rich Dutch history and debate about lottery and selection can be found at benwilbrink.nl/projecten/loten_nf.htm (also in English))

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