The evaluation and comparison on different types of resident doctors in training through DxR Clinician system

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Abstract. Compared with the traditional problem-based learning (PBL) mode, computer-based case simulations (CCS) are more advanced in aspects of clinical reasoning, critical thinking and clinical thinking. CCS program, Diagnosis & Reasoning (DxR) Clinician, has been used for assessment of clinical diagnosis and treatment skills in more than 300 medical colleges and universities around the world. However, the evaluating effectiveness and practicability of this software continue to be uncertain and ambiguity in China. Moreover, the influence factors of the DxR evaluation score are still remain indefinite. The purpose of this study was to investigate the impact of training years, professional background and educational background on DxR scores in order to better improve the clinical skills of residents. Eighty one resident doctors were selected as the experimental subjects to conduct the clinical skills assessment with DxR Clinician. The relationships between residents’ scores in DxR Clinician components (overall score, diagnostic score, and management score) and their training years, professional background and educational background were analysed using simultaneous regression. The results showed that years of training, professional background and educational background are potential influence factors of DxR evaluation score. The average DxR Clinician scores in this study are generally lower than foreign research, so we should strengthen resident standardized training to improve our clinical skills.

1. Introduction

In view of the transformation of modern medical model and concern for the patients’ safety, the mode of medical education has shown significant changes based on the advanced computer technology in education around the world [1]. The core of the curricula gradually focuses on the clinical reasoning skills rather than the acquisition of knowledge. DxR ClinicianTM [2] was the world's first virtual patient software, developed by Drs. Myers and Dorsey teamed up with software engineer Eldon Benz in the University of Southern Illinois in 1995, for teaching and evaluating clinical reasoning skills of physical therapy students [3]. The software provided a stimulated patient and allowed the student to question the patient, conduct a simulated physical examination, order lab tests and choose from a complete list of diagnostic procedures. The evaluation of the clinical reasoning skills was supported by sophisticated
scoring tools and the software also allowed instructors to gain insight into the students’ reasoning process as they worked through the case study, based on real patient data [4].

The DxR has appeared for more than 20 years and over 300 medical colleges and universities around the world have got an access to the introduction and utilization of this software. DxR clinician system is the combination of standardized patients and traditional electronic standardized patients not only satisfy the demands of patients’ repeatability, standardization and authenticity but also meet the requirements of systematic and integrity cognition of disease [2]. In addition, various studies in Asian, Africa and Australia have demonstrated the reliability and validity of it. A pilot evaluation of DxR in fourth year medicine at the University of Sydney showed the software was efficient for both student learning and teachers’ evaluation [5]. The feasibility study conducted at Taipei medical university hospital in 2013 found all medical students (30/30; 100%) were satisfied with the integration of DxR into objective structured clinical examination (OSCE), and expressed intentions of having further DxR experiences if there is any chance [6]. Mariam Fida et al. reported that internal consistency reliability of DxR scores was high (α=0.862) in medical students during the academic year 2011-2012 [7].

The DxR clinician system is used in foreign countries, and there are few in China, and hardly any studies focused on factors influencing DxR evaluation score, especially for resident doctors in China. Because of the different medical models and training programs at home and abroad, there are differences in the factors that affect the DxR score. Therefore, using the DxR clinician system to evaluate the clinical skills of residents, and further explore the impact of certain factors on the DxR score, is of great significance to introduce such reliable and effective methods in China, and thus more effectively cultivate and enhance clinical skills of resident doctors.In this study, the identities of resident doctors rotating at department of respiration were classified into four categories, including resident doctors of Qilu Hospital (hired by Qilu Hospital), resident doctors of other hospitals (enrolled by contract), social trainee (not hired by any other hospitals) and graduate students in professional Master’s degree. Thus, the in-built factors of different identities of resident doctors might have significant impact on the effect of resident standardized training. The objective of this study was to examine the effects of professional/educational background, clinical department and degree, on DxR evaluation score, adjusting for the confounding factors including gender and hospital.

2. Materials and methods
All eighty-one resident doctors rotating at department of respiration in Qilu hospital were selected as the study objects and worked as an individual to complete the DxR evaluation test after and receiving the two-month resident standardized training. Information of potential influence factors including years of training (from years 2 to years 5), professional background (rehabilitation, emergency treatment, radiotherapy, internal medicine, general practice and neurology), educational background (bachelor, master and doctor degree) and affiliated hospital (Qilu Hospital and Non-Qilu Hospital) were collected before formal testing.

One typical respiratory clinical case - chronic obstructive pulmonary disease (COPD) was selected for formal testing by clinical instruction teachers who were responsible for the resident doctors’ professional knowledge training.

The research and development background, utilization and operation steps of the software were introduced to resident doctors before the formal test to reduce the deviation of evaluating results due to the misoperation. Two open cases selected from case library of DxR clinician were applied to simulation test to make resident doctors familiar with essential of patient consultation, diagnosis and clinical thinking and get a further operational training. The feedback session was provided after DxR simulation test to give resident doctors an access to review the diagnostic hypotheses and enquiry process, including anamnesis, physical examination and laboratory investigations. The clinical capability was assessed by specially-assigned person based on the software's own scoring analysis program after the operation and the weighting coefficient in each evaluation part were determined by clinical teacher together with respiratory department experts to obtain a fair and reasonable grading criteria and performance standards.
Simultaneous regression models were fitted to analyze the data for DxR evaluation score using R software, version 1.0.136. Qualitative independent variable such as clinical department, professional degree and affiliated hospital were transformed into dummy variable, adjusting for the confounding factors such as gender (male and female). Interaction terms also took into consideration allowing for the conditional effects in simultaneous regression model. Regression coefficient was estimated to assess the effect of clinical department and degree on DxR evaluation score, p<0.05 was considered as statistically significant. The fitting quality of the linear regression was judged based on the value of R-squared (R²) and Akaike’s Information Criterion (AIC) [8].

3. Results

3.1. Distribution of residents and evaluation score
A total of eighty-one residents (32 males and 49 females) were included at the department of respiration in Qilu hospital, Jinan. The percentage of residents attached to Qilu Hospital was 80.2% (65/81) and to Non-Qilu Hospital was 19.8 (16/81). The distribution of residents is shown in tab. 1. The descriptive statistics for DxR Clinician evaluation score, including overall score, diagnostic score, and management score are shown in Fig. 1, Fig. 2 and Fig. 3, respectively.

| Table 1. Distribution of numbers of resident doctor on gender, hospital, academic degree and department. |
|---------------------------------------------------------------|---------------------------------------------------------------|
| **Gender**                                                   | **Years of training**                                       |
| Male                                                         | 2 years                                                     |
| 32 39.5                                                     | 24 29.6                                                     |
| Female                                                      | 3 years                                                     |
| 49 60.5                                                    | 45 55.6                                                     |
| **Affiliated hospital**                                     | 4 years                                                     |
| Qilu hospital                                               | 7 8.6                                                       |
| 65 80.2                                                    | 5 6.2                                                       |
| Non-Qilu hospital                                          | Educational background                                    |
| 16 19.8                                                    | Doctor                                                      |
| **Professional background**                                 | 24 29.6                                                     |
| Rehabilitation                                             | Master                                                      |
| 2 2.5                                                      | 24 29.6                                                     |
| Emergency treatment                                        | Bachelor                                                    |
| 4 4.9                                                      | 33 40.8                                                     |
| Radiotherapy                                               | Training mode                                              |
| 11 13.6                                                    | Qilu hospital-training                                     |
| Internal medicine                                          | 36 44.4                                                     |
| 37 45.7                                                    | Entrusted training                                         |
| General Practice                                           | 16 19.8                                                     |
| 8 9.9                                                      | Trainee                                                     |
| Neurology                                                  | 12 14.8                                                     |
| 10 12.3                                                    | Professional master                                       |
|                                                             | 17 21.0                                                     |
Figure 1. Distribution of DxR Clinician evaluation score on educational background.
Figure 2. Distribution of DxF Clinician evaluation score on years of training.
Figure 3. Distribution of DxR Clinician evaluation score on professional background.
3.2. Simultaneous regression model

For overall score, the department of emergency treatment, radiotherapy, internal medicine, general practice and neurology scored an average of 37.24, 45.84, 54.40, 35.29 and 49.48 points significant higher than the departments of rehabilitation, respectively. The Master’s degree scored an average of 37.50 points significant higher than the Doctor’s degree. However, the results for the Bachelor’s degree and years of training showed no statistical significance. The goodness-of-fit for R2 and p value of significance testing are 38.68% and 0.044, respectively (tab. 2).

Table 2. Results of multiple linear regression model of overall score.

| Included independent variables          | Regression coefficient (βi) | Standard Error | T    | P      | R2 (%) |
|-----------------------------------------|-----------------------------|----------------|------|--------|--------|
| Intercept                               | -0.42                       | 16.84          | -0.03| 0.980  | 38.68  |
| Years of training                       | -2.32                       | 1.99           | -1.17| 0.248  |        |
| Rehabilitation (Reference group)        |                             |                |      |        |        |
| Emergency treatment                     | 37.24                       | 16.00          | 2.33 | 0.023* |        |
| Radiotherapy                            | 45.84                       | 15.59          | 2.94 | 0.005**|        |
| Internal medicine                       | 54.40                       | 14.32          | 3.80 | <0.001***|       |
| General Practice                        | 35.29                       | 11.85          | 2.98 | 0.004**|        |
| Neurology                               | 49.48                       | 12.43          | 3.98 | <0.001***|       |
| Doctor (Reference group)                |                             |                |      |        |        |
| Master                                  | 37.50                       | 17.21          | 2.18 | 0.033* |        |
| Bachelor                                | 17.77                       | 9.86           | 1.80 | 0.077  |        |
| Non-Qilu hospital (Reference group)     |                             |                |      |        |        |
| Qilu hospital                           | -5.41                       | 3.90           | -1.39| 0.170  |        |
| Male (Reference group)                  |                             |                |      |        |        |
| Female                                  | 1.61                        | 2.86           | 0.56 | 0.575  |        |
| Qilu hospital-training (Reference group)|                             |                |      |        |        |
| Entrusted training                      | NA                          | NA             | NA   | NA     | NA     |
| Trainee                                 | -0.80                       | 6.46           | -0.12| 0.902  |        |
| Professional master                     | -4.15                       | 7.48           | -0.55| 0.581  |        |

*P<0.05
**P<0.01
***P<0.001

The average DxR Clinician scores in this study (overall score: 44.11, diagnostic score: 54.16 and management score: 23.96) are generally lower than foreign research. Salah Eldin Kassab et al. enrolled 245 medical students to investigate the validity of the underlying domains of the assessment framework emerging from the students’ scores using computer based case simulations [2], scoring 76.50 (Clinical Reasoning), 60.10 (Diagnostic Performance) and 77.89 (Patient Management) [9]. Rebecca Maldonado et al. revealed multimedia clinical case simulation software (MMCCSS) cases had statistically higher clinical reasoning scores than the students who completed primarily text-based PBL cases (P < 0.0001). And the clinical reasoning score in cohort 1 and cohort 2 are 71.3 and 83.0, respectively [10].

The objective of resident standardized training and DxR Clinical system was to cultivate and evaluate the clinical skills. The following two aspects were incorporated to ensure the objectivity and impartiality of this study. On the one hand, in spite of the complexity of the identity of the resident, they all meet the essential requirements of DxR evaluation testing. The resident doctors employed in Qilu Hospital were
hired by Qilu Hospital in professional recruitment process with rigid standards; the resident doctors in social training which were made up of resident doctors employed in other hospitals and social trainee, were selected via formal written exam and interview and enrolled by contract which also limited by quota; and the resident doctors in professional Master’s degree were also audited by the strict borderline. On the other hand, all of the resident doctors in different education background (Bachelor’s degree, Master’s degree and Doctor’s degree) did not get any extra clinical practice opportunities or clinical training during their learning career and no in-built biases were existed in testing resident doctors. Thus, the clinical and diagnostic skills of resident doctors are at the same level before they receive resident standardized training in Qilu Hospital.

All of the residents’ scores in DxR Clinician decreased with increasing years of training, but the significant association only observed between years of training and management score. The maldistribution of score, namely high score only appeared in 2 and 3 training years rather than in 4 and 5 training years, might lead to the moderating trend. Another possible and worrying reason is that our resident doctors paid lesser attention on the importance of resident standardized training with the growth of the training year. The tasks assigned by supervisor or promotion requesting in the career may divert their attention from resident standardized training and the study of clinical reasoning skills. The resident doctors who enter the hospital in earlier years gradually become the “old slicker” and treated the resident standardized training inactively. Meanwhile, the training mode of hospital/training units neglected the continue education towards the residents’ doctors and the fundamentality and importance for resident standardized training have been ignored with time elapsing.

Most of the departments, especially internal medicine, scored significantly higher than the departments of rehabilitation. This is likely due to the variance of professional theory knowledge. In addition, the department of internal medicine may have more access to clinical training and experience in the daily work. The variance in major and professional knowledge might contribute to the discrepancy with scores.

Compared with the resident doctors in Doctor’s degree, the research objects in a relative lower degree, especially in Master’s degree got significant higher scores in DxR clinician evaluation. One possible reason behind this counter-intuitive result is that with the in-depth of education, resident doctors in Doctor’s degree are more inclined to placing more emphasis on promotion and research project rather than resident standardized training. The superiority of Doctor’s degree may not exist in the DxR Clinician evaluation.

However, this study had some limitations. First, the sample size of this study is relatively small, and the distribution of the score did not conform to a significant normal distribution. In future research, we can further expand the sample size and conduct joint research with other major hospitals in Jinan. Second, the R2 of goodness-of-fit in results are relative small (less than 60%) which means that more than 40% explicable influence factors have not been included in the regression model. More information concerning resident doctors should be collected in the further study. In addition, only after-department evaluation of DxR clinician was conducted in this study. The further study which including before-department and after-department evaluation should both be conducted to observe the training effect in the future. At last, the scores in DxR Clinician components (overall score, diagnostic score, and management score) were all objective score and given by the system directly. More subjective scoring would be included in future studies.

4. Conclusion
We concluded that the years of training, professional background and educational background are potential influence factors of scores in DxR Clinician. As far as the length of training is concerned, as the number of years of training increases, the DxR scores of residents are all reduced, and the high score only appeared in 2 and 3 training years instead of 4 and 5 training years. The reason may be that as the training year grows, our resident doctors paid less attention on the importance of resident standardized training. In terms of professional background, the internal medicine has higher scores. These doctors may have
more opportunities to get clinical training and daily work experience. In terms of educational background, resident doctors with master's degrees have higher scores in DxR clinician evaluations.

Therefore, the importance of resident standardization training should be emphasized in future education. In particular, after 2-3 years of training, it is necessary to re-inspire the resident doctors to pay attention to standardization training. The average DxR Clinician scores in this study are generally lower than foreign research, so we should strengthen resident standardized training to improve our clinical skills.

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