# Examining Critical Thinking Skills in Family Medicine Residents

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**BACKGROUND AND OBJECTIVES:** Our objective was to determine the relationship between critical thinking skills and objective measures of academic success in a family medicine residency program.

**METHODS:** This prospective observational cohort study was set in a large Canadian family medicine residency program. Intervention was the California Critical Thinking Skills Test (CCTST), administered at three points in residency: upon entry, at mid-point, and at graduation. Results from the CCTST, Canadian Residency Matching Service file, and interview scores were compared to other measures of academic performance (Medical Colleges Admission Test [MCAT] and College of Family Physicians of Canada [CCFP] certification examination results).

**RESULTS:** For participants (n=60), significant positive correlations were found between critical thinking skills and performance on tests of knowledge. For the MCAT, CCTST scores correlated positively with full scores (n=24, r=0.57) as well as with each section score (verbal reasoning: r=0.59; physical sciences: r=0.64; biological sciences: r=0.54). For CCFP examination, CCTST correlated reliably with both sections (n=49, orals: r=0.34; short answer: r=0.47). Additionally, CCTST was a better predictor of performance on the CCFP exam than was the interview score at selection into the residency program (Fisher's r-to-z test, z=2.25).

**CONCLUSIONS:** Success on a critical thinking skills exam was found to predict success on family medicine certification examinations. Given that critical thinking skills appear to be stable throughout residency training, including an assessment of critical thinking in the selection process may help identify applicants more likely to be successful on final certification exam.

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The practice of medicine demands the highest possible skills in diagnosis and evidence-based therapeutics. However, cognitive errors can result in diagnostic and management errors.[1] For example, misdiagnoses arise from flawed data gathering and/or misinterpretation of data.[2] The best physicians think critically and problem solve through appropriate gathering and accurate interpretation of information.[3]

Critical thinking (CT) is the skill of collecting appropriate information, accurately assessing information, and using that information to reach a considered conclusion. CT integrates six primary skills: interpretation, analysis, evaluation, inference, explanation, and self-regulation.[4,5] Previous research shows that health care professional trainees' performance on critical thinking tests correlates with academic clinical decision-making[6] as well as with academic success.[7] Some research, though limited, suggests a positive relationship between CT skills and professionalism.[8,9]

Despite the clear value of CT skills in health care professions, taking the approach of teaching CT skills to trainees is problematic. In some studies CT is unchanged by training programs,[10,11] while in other studies CT improves with education.[12] One way to ensure good CT skills in trainees is to select for trainees that already demonstrate those skills. To do this, programs could include CT skills assessment during medical school or residency selection. While many CT studies to date examined nursing, pharmacy, or dental hygiene, few studies have examined physicians in training.[13-15] There is some work being done in the United Kingdom, where the situational judgement test incorporated

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into the UK Foundation Programme assesses constructs closely related to critical thinking.[16] However, no published research has examined CT skills in family medicine residents.

The objectives of this study were to examine the relationship between CT skills of family medicine residents and other assessments. For this study, we chose to compare results on the California Critical Thinking Skills Test (CCTST) with the following performance measures: (1) performance on the College of Family Physicians of Canada board equivalent examination (CCPC) at end of training, (2) performance on academic examinations such as the Medical Colleges Admission Test (MCAT), and (3) file review and interview scores from the Canadian Residency Matching Service (CaRMS) selection process.

## Methods

This research project was conducted in a large Canadian family medicine residency program from July 2011 to June 2013. The residency program is a 2-year program based on the Triple C curriculum,[17] comprised of urban and rural family medicine block-time, integrated experiences, and off service rotations. Approval for this research was obtained from the institution's Human Research Ethics Board.

Potential participants were urban- and rural-based Canadian trained residents as well as international medical graduates residents entering the program on July 1, 2011 (n=74). All residents starting the residency program were required to write the CCTST (a validated tool to objectively assess CT skills)[5] at the start, middle, and the end of their residency. At the time of writing the CCTST, support staff supervising test administration explained the study and provided the option of signing consent forms to participate in the research project.

Consent for the research study was obtained at two points: Consent 1 (obtained July 2011) requested access to the residents' rotation evaluations, CCFP exam results, and the CCTST test scores. Consent 2 was obtained at the second writing of the CCTST in June 2012. This consent requested access to data on the Licentiate of the Medical Council of Canada exams (LMCC part 1 and Part 2), MCAT, and CaRMS file review and interview scores. For international medical graduates, consent was sought for other assessment components from their residency application process.

Data collection consisted of the following components:

### *California Critical Thinking Skills Test (CCTST)*

The CCTST exam is a validated and reliable[18-22] 34-item multiple-choice test. All three exam sessions were supervised with 45 minutes to complete. The exams were marked and Insight Assessment in California provided interpretation of results. Results of the test were shared with each participant, but the research team was blinded to individual participant results.

### *Certification Examination in Family Medicine*

The CCFP exam is a board-equivalent qualifying examination for Certification in Family Medicine. The CCFP exam results in three scores: a short answer written format, an oral component, and an overall result.

### *Resident File Review*

Demographics of participating residents were collected at the beginning of the study. Resident files were searched for data by HLB. DR did random checks for accuracy of data collection. Resident files contained information on rotation evaluations, some demographic data, as well as data from residents' application to the residency program (file review scores and interview scores).

### *Medical College Admission Test (MCAT)*

The MCAT is a test of knowledge and reasoning that is required for admission to most medical schools. The MCAT has three sections: Verbal Reasoning, Physical Sciences, and Biological Science. MCAT scores were obtained by self-report and from medical student transcripts.

### *Analysis*

Data were analyzed using R (v. 3.0.2; R Core Team, 2013) for descriptive, correlational, and predictive analyses. Relationships were explored using initially descriptive and correlational analyses. A regression model was calculated to determine which factors accounted for the greatest amount of variance in predicting CCFP exam scores.

## Results

Of the 67 residents who gave consent to participate in the study, five were eliminated for having completed only one CCTST, and two were removed for being more than 3 standard deviations (SD) over the mean age ($P<.002$), leaving 60 participants. Not all participants had values for all measures we consider, so we report the n for each measure we report.

### *Demographics*

Residents were representative of previous and later cohorts, with a gender split of 45% male and a mean [SD] age of 27.9 [5.1] years. Fifty (83%) were Canadian medical graduates (CMG), while 10 were international medical graduates (IMGs). Residents came from a variety of educational backgrounds (Table 1), which is typical of this residency program.

### *CCTST*

As participants wrote the CCTST at three points in time, a one-way within-subjects analysis of variance (ANOVA), using test-time as a factor, was conducted to determine if performance on the CCTST changed over time. The result ($F(2,111)=1.62$, $P=.2$) indicated that performance on the CCTST does not change significantly over time. We therefore used an averaged CCTST score for the remaining analyses.

**Table 1: Medical Schools From Which Participants Graduated**

| Medical School | Number of Participants |
|---|---|
| University of Alberta | 31 |
| University of Calgary | 3 |
| University of British Columbia | 7 |
| Dalhousie University | 3 |
| University of Manitoba | 3 |
| Northern Ontario School of Medicine | 1 |
| University of Saskatchewan | 1 |
| McMaster University | 1 |
| International medical school | 10 |

To determine if demographics had a significant influence on CCTST performance, a two-way independent samples *t* test on the CCTST scores by gender was conducted (*t* (57.5)=1.25, *P*=.22), which indicated that there is not a statistically reliable difference in CCTST scores by gender (male average [SD]: 24.5 [3.0]; female average [SD]: 23.4 [4.0]). Age was a reliable negative predictor of CCTST score (r=-0.29; *P*=.02) but time since graduation from high school (r=-0.16; *P*=.20) showed no significant effect on CCTST score.

There was a reliable difference in average CCTST score between the 50 CMGs (average [SD]=24.54 [3.00]) and the 10 IMGs (average [SD]=20.80 [4.72]; *t* (10.51)=2.41, *P*=.04).

*CCTST and Tests of Knowledge*

Scores on the CCTST were compared with scores on both the MCAT and the CCFP examination. Pearson correlations were run to determine the strength of association between MCAT scores and CCTST scores for the 24 participants (all CMGs) for whom the MCAT scores were available. Significant positive correlations were found between CT skills and the MCAT. CCTST scores correlated positively with full scores (n=26, r= 0.52; *P*=.003) as well as with each section score (verbal reasoning: r= 0.56; *P*=.001; physical sciences: r= 0.65; *P*=.0001; biological sciences: r=0.48; *P*=.005).

CCTST scores correlated reliably with both sections of the CCFP examination (n=57, 47 CMGs; orals: r=0.34; *P*=.01; short answer: r=0.41; *P*=.001).

*CCTST and CaRMS Measures*

To examine if CCTST predicted CCFP exam success better than current methods selecting residents into the residency program, we compared CCTST scores to the two main measures used for selection into our residency program: the CaRMS file score and the CaRMS interview score. The CaRMS file score includes all elements of a CaRMS application file evaluated by at least two faculty members. The CaRMS interview score involves individual interview scores from two people (a faculty member/clinical teacher and a current resident) that are averaged.

Score on the CCTST was compared to CaRMS application measures. There was no reliable correlation between the CCTST average score and either the CaRMS file score (n=51, r=-0.02, *P*>.9) or the CaRMS interview score (n=46, r=-0.10, *P*>.5).

*CCTST as a Predictor of Success*

There were 43 participants (34 CMG) for whom all information was available (CaRMS application measures, CCTST score, and CCFP orals and short answer scores). For these 43 participants, we undertook model analysis to find the best model for predicting CCFP oral and short answer scores. Models were compared using the Akaike Information Criterion (AIC), which allows for assessment of the relative goodness of fit of differently parameterized models in terms of the amount of information lost when each model is used to estimate the variable of interest.[23]

The models considered, and their relative success, are shown in Table 2. Only CCTST entered reliably into each model. Where a demographic predictor (age, gender, or CMG/IMG) entered in previously, it gets knocked out when CCTST is entered, and the CaRMS measures never enter after the CCTST: that is, there is no additional variance explained by the CaRMS measures after taking into account the variance explained by the CCTST. As indicated by the $r^2$ values, CCTST explained 11% of the variance on the CCFP oral exam (F [1,41]=4.87, *P*=.03), 23% on the CCFP written exam (F [1,41]=12.3, *P*=.001), and 20% of the variance in their average (F [1,41]=10.2, *P*= .003) (Figure 1).

## Discussion

The results of this study support the belief that CT skills, as measured by CCTST, are associated with better performance and multiple measures of academic success in residency.[7] The CCTST results were found to be a better predictor of academic success than the file review or interview scores from the CaRMS application process. CCTST scores were not influenced by age or gender and remained stable and constant over time, consistent with some previous research.[10,11]

The results of this study suggest that the CCTST may be useful as a tool for improving resident selection. Residency programs use a variety of selection criteria and tools when choosing medical students for residency training.[24,25] Family medicine programs across Canada use CaRMS to assist with selecting students, where information such as MCAT scores, rotation evaluations, curriculum vitae, letters of support,

**Table 2: Analysis of Three Regression Models for Predicting CCFP Oral, Short Answer, and Average Scores, Using Demographic (Age and Gender), CCTST Scores, and Average CaRMS Score***

| **CFPC Orals** | **Best Model** | **AIC** |
|---|---|---|
| Demographics | — | 133.8 |
| CCTST | CCTST | 130.9 |
| CaRMS | CCTST | N/A |
| Final R2: 0.11 | F (1,41)=4.87, *P*=.03 | |
| **CFPC Short Answer** | | |
| Demographics | Age | 136.6 |
| CCTST | CCTST | 132.6 |
| CaRMS | CCTST | N/A |
| Final R2: 0.23 | F (1,41)=12.3, *P*=.001 | |
| **CFPC Average** | | |
| Demographics | Age | 125.3 |
| CCTST | CCTST | 122.32 |
| CaRMS | CCTST | N/A |
| Final R2: 0.20 | F (1,41)=10.2, *P*=.003 | |

* When a new predictor contributed reliably, the model was compared to the previous model using AIC, by which lower values indicate a better model. In all three cases, the model containing only CCTST scores was the best predictor.

CCFP—College of Family Physicians of Canada
CCTST— California Critical Thinking Skills Test
CaRMS— Canadian Residency Matching Service

etc, are all evaluated and used to rank potential trainees. Other selection tools may include a personal interview, simulated patient encounters, knowledge tests, and/or essays. There is conflicting evidence that any of these tools or criteria predict success in residency training, clinical performance, or on end-of-training exams, but this research is complicated by the fact that success in medical school and residency is multi-factorial.[26-30] The exception is the multiple mini-interviews or MMI,[31-33] but the MMI has some drawbacks, most specifically cost and faculty/human resource time.

The CCTST is a validated[18,19, 21,22] critical thinking assessment tool that has been used extensively in nursing and pharmacy selection.[34-38] The CCTST can be administered either on paper or online in 45 minutes, is scored independently of the program (which reduces perceived bias), and is relatively cost-effective (approximately $10/test). These aspects suggest that the CCTST is a logistically feasible way to assess for CT skills in the selection process.

### *Limitations and Directions for Future Research*

While the results from this study are unique in family medicine and have potential implications for resident selection, it should be noted that the study included residents from only one family medicine program, and participants were from one cohort. Additionally, not all members of the residency cohort participated in the full study. Future research should investigate the relationship between CT skills and academic outcomes within a larger group of participants, ideally across multiple programs. Further, future research is merited in the area of the relationship between CT skills and nonmedical knowledge assessments of residents.

## Conclusions

The findings from this study indicate that high scores on the CCTST predict success on family medicine certification examinations, to a greater degree than CaRMS file review scores or CaRMS interview scores. These findings suggest that the CCTST could be considered as a potentially valuable tool in resident selection.

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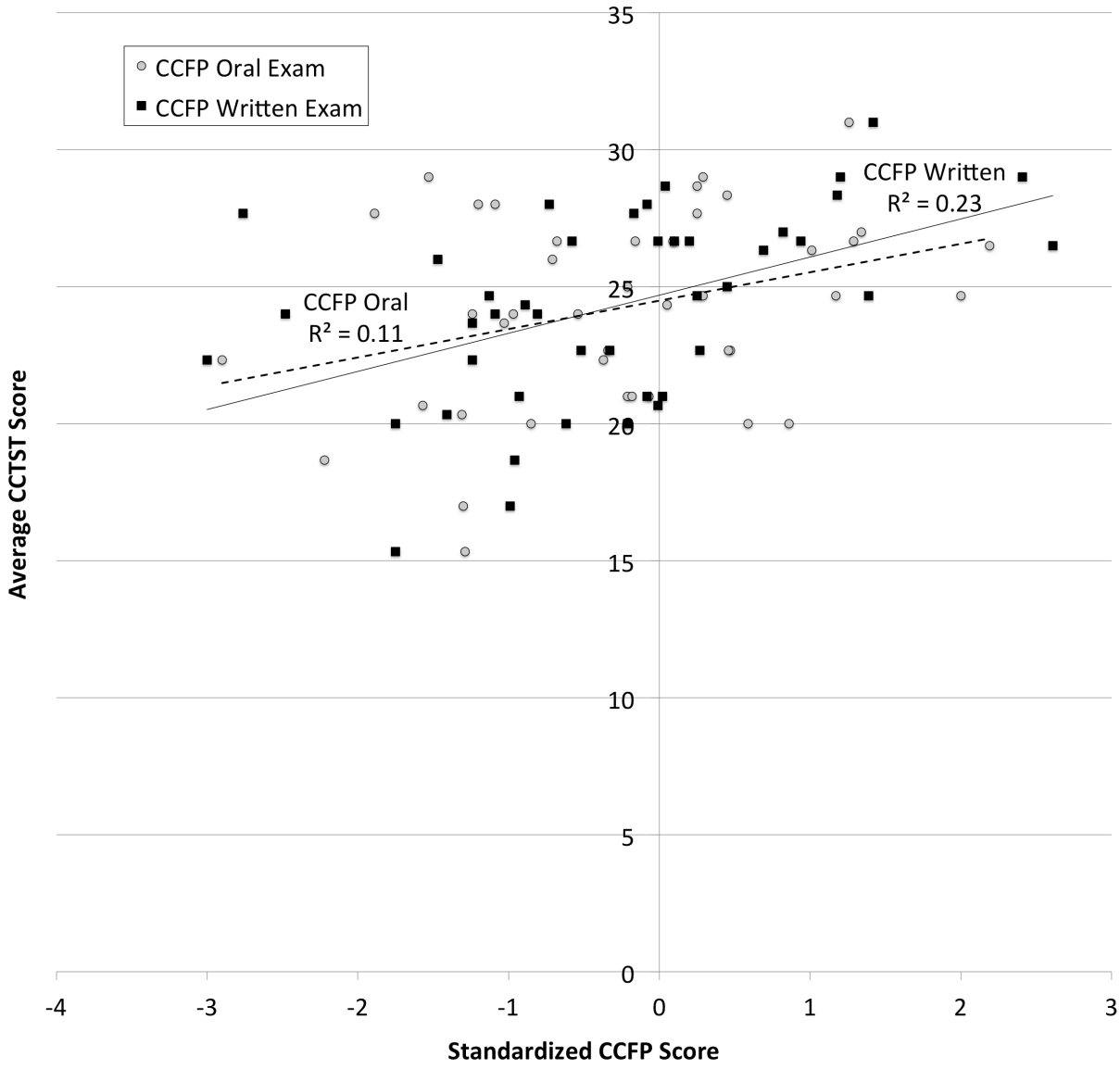
**Figure 1: Scatter Plot for Final Model Predicting Success on CCFP Exam Scores**





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