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# ELECTRONIC CONTINUING MEDICAL EDUCATION: Approaches to better understand the general practitioners' intention to use eCME and assess their competences

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# ELECTRONIC CONTINUING MEDICAL EDUCATION: approaches to better understand general practitioners' intention to use eCME and assess their competences

## THESIS FOR DOCTORAL DEGREE (Ph.D.)

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*To my Mother and Father, who has forgotten themselves in order to give me better opportunities in life.*

*To my wife, who is the most encouraging person in my life!*

*To my mother-in-law, whose prayers I need for my life!*

*And to Ilya, who is my motivation me to graduate soon and start a new life!*

# ABSTRACT

General Practitioners (GP) update their knowledge and skills by participating in continuing medical education (CME) and electronic CME (eCME) programs. The overall aims of this thesis were to (a) understand GPs' intention to use eCME and the factors that affect its use and (b) to explore how a self-assessment activity works in an eCME context when also compared to actual prescribing behavior.

We used the theory of planned behavior (TPB) to understand GPs' intention to use eCME. The factors' dimensionality of the TPB was determined. The resulting model explaining the factors that lead to positive intention to use eCME had quite good fit indices. The perceived behavioral control and attitudinal constructs of the TPB were included in the model, but the subjective norms construct was not. Finally, we could explain 66% of the intention's variance using this resulting model. The use of a TPB-based survey can increase the rigor of the research/evaluation and support CME directors and researchers in assessing, exploring, and improving GPs' intention to use eCME.

We also designed a self-assessment with electronic cases in eCME context. The data collected were analyzed for five forms of evidence. We could not find any statistical significant association between the assessment scores and their previous actual prescription outcome indicators. More than 80% of the GPs were satisfied with the cases and the self-assessment. Furthermore, about 85% of them became more curious about antibiotic prescription after participating in the program. We recommend using the self-assessment as a tool to personalize learning at the course level or even at the CME level. Specifically, we can integrate this activity with, for example, an antibiotic stewardship CME course and, based on the performance of the learners on their prior knowledge assessment, provide personalized learning materials. The absence of a correlation between the GPs' previous antibiotic prescription and assessment result can demonstrate the sufficiency of the GPs' knowledge in this field. To improve antibiotic prescription, further research for exploring and addressing the gap between knowledge and practice is needed. One implication of this research is to adapt eCME content to learners' prior knowledge to diminish the time spent on learning activities without compromising knowledge gain. This could be a strategy to motivate busy physicians to improve their competencies.

# LIST OF ORIGINAL PAPERS

I. **Hadadgar A**, Changiz T, Masiello I, Dehghani Z, Mirshahzadeh N, Zary N. Applicability of the theory of planned behavior in explaining the general practitioners eLearning use in continuing medical education. BMC Medical Education. 2016; 16(1):215.

II. **Hadadgar A**, Changiz T, Dehghani Z, Backheden M, Mirshahzadeh N, Zary N, Masiello I. A Theory-Based Study of Factors Explaining General Practitioners' Intention to Use and Participation in Electronic Continuing Medical Education. The Journal of Continuing Education in the Health Professions. 2016; 36(4):290.

III. **Hadadgar A**, Changiz T, Kononowicz A, Safaeian L, Mirshahzadeh N, Najimi A, Ahmadi F, Mostafavizadeh K, Zary N, Masiello I. Validity of self-assessment using electronic clinical cases in continuing medical education. Manuscript

IV. **Hadadgar A**, Safaeian L, Mirshahzadeh N, Zary N, Changiz T, Masiello I. Antibiotic prescription in primary care: Investigation of association between GPs self-assessed knowledge vs. actual prescription practice. Manuscript

**Other publications during the PhD study**

I. Zhu E, **Hadadgar A**, Masiello I, Zary N. Augmented reality in healthcare education: an integrative review. PeerJ. 2014; 2:e469.

II. Paul P, Toon E, **Hadadgar A**, Jirwe M, Saxena N, Lim KT, Semwal M, Tudor Car L, Zary N, Lockwood C, Car J. Online-and local area network (LAN)-based eLearning interventions for medical doctors' education (protocol for systematic review). The Cochrane Library. 2016.

# CONTENTS

# LIST OF ABBREVIATIONS

| | |
|---|---|
| CME | continuing medical education |
| TPB | theory of planned behavior |
| GP | general practitioner |
| CFA | confirmatory factor analysis |
| EFA | exploratory factor analysis |
| IUMS | Isfahan University of Medical Sciences |
| PBC | perceived behavioral control |
| SN | subjective norms |

# 1 INTRODUCTION

## 1.1 Outline of the studies

In this PhD project, we developed an e-learning activity for general practitioners with the aim to improve antibiotic prescription regimen. The PhD project is divided into two main studies and four sub-studies.

| Study | Subject area | Research design (**Analysis of data**) |
|---|---|---|
| **I:** Exploring GPs' intention to use eCME | **Sub-study I**: Applicability of the theory of planned behavior to construct a questionnaire that can explain the intention to use eCME | Instrument validation study (Factor analysis) |
| | **Sub-study II:** A theory-based study of factors explaining general practitioners' intention to use eCME | Technology adoption study (Regression analysis) |
| **II:** Electronic case-based self-assessment in eCME | **Sub-study III:** Validity of self-assessment using electronic clinical cases in CME | Validity study (Validity evidence of self-assessment) |
| | **Sub-study IV:** Investigating GPs' rational antibiotic treatment: Electronic self-assessment vs. previous prescription outcomes | Correlational study (Correlation analysis) |

In the first part, I will introduce briefly the several concepts forming this thesis project. In the second and third sections, I will state the aims and various empirical methods used in this research. In the fourth and fifth sections, I will present the findings divided per sub-study and the analysis for each study. The sixth section provides my concluding remarks as well as the implications of this research. At the end all the persons who, in some way, have contributed to my work are duly acknowledged.

The fundamental aim of this thesis was to understand GPs' intention to use eCME and the factors that affect the use of eCME, and to explore how a self-assessment activity works in an eCME context. The specific knowledge developed in this thesis may benefit the following groups: (a) CME office managers and trainers who may use this thesis' findings to modify their programs based on users' intention and self-assessment results, (b) the educational technology industry/community that may benefit from the empirical evidence to improve their software in terms of users' expectations, and (c) the researchers who may develop a better understanding about how general practitioners intend to use e-learning and self-assessments.

## 1.2 Antibiotic prescription and resistance

Antibiotic resistance is a major worldwide health issue and without any intervention, it could cause about 10 million deaths by 2050 (O'Neill 2014). A systematic review showed that antibiotics use in primary care settings plays an important contribution to antibiotic resistance (Costelloe et al. 2010). Antibiotic prescription by GPs may be affected by many factors, such as the physicians' knowledge and clinical experience, diagnostic uncertainty, sociocultural factors, communication issues, perceived expectations of patients, financial interests, gender, time since graduation, and practice location (Stålsby Lundborg & Tamhankar 2014; Akici et al. 2004; Safaeian et al. 2015). Teixeira Rodrigues and his colleagues created a theoretical framework of the interconnection among the factors that influence antibiotic prescribing (Teixeira Rodrigues et al. 2013). To explain the complex prescribing process, they developed a framework based on the knowledge, attitudes, and practice (KAP) model and added a number of related factors to the model, such as the GP's socio-demographic factors, patient-related factors, health system related factors, and the pharmaceutical industry (Figure 1).

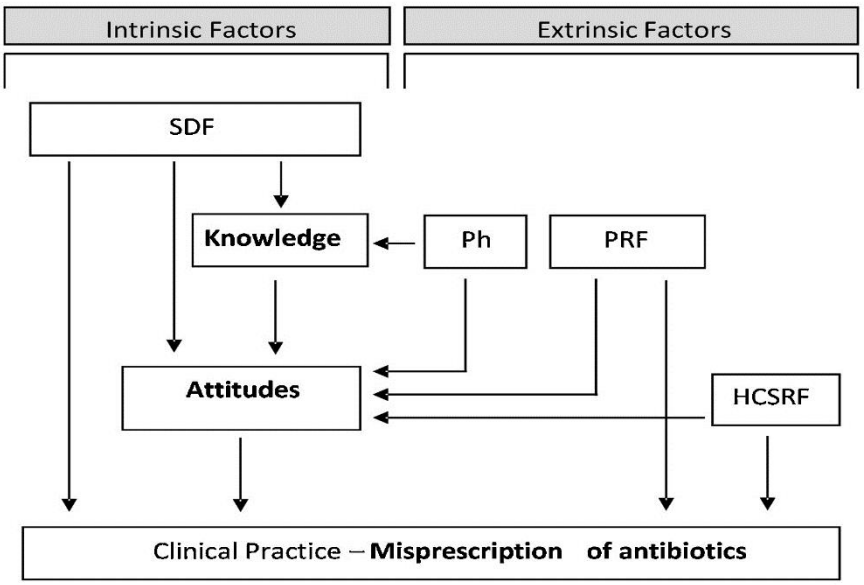



**Figure 1. The theoretical framework of the factors that influence antibiotic prescribing (adopted from** (Teixeira Rodrigues et al. 2013)

In Iran, antimicrobial drugs were reported as the most frequent prescription (about 50%) by GPs (Safaeian et al. 2011). Although during the last years prescription outcome indicators have improved in Iran, there remains the need to develop effective educational interventions to improve physicians' prescription behavior (Safaeian et al. 2011). In most countries, there is no assessment for practicing physicians after graduation, but they usually participate in CME programs in order to improve their skills.

## 1.3 Continuing medical education

Given the fast pace with which knowledge expands and technology develops, updating the knowledge and skills of physicians and other health professionals is necessary in order to ensure that the care they provide is based on the latest medical evidence. Therefore, in an increasing number of countries (Davis et al. 2008; Simper 2014), including middle-income countries such as Iran (Ebadi et al. 2007), CME is mandatory for all practicing physicians.

The use of e-learning in CME (eCME) could improve accessibility, increase flexibility, and provide rapid response to public health needs on a large scale (Cook et al. 2008; Davis et al. 2008). Additional aspects that contribute to the increased use of eCME are the digitalization of information and emerging new generations of digital native learners (Robin et al. 2011). Although eCME is growing rapidly (Harris et al. 2010), physicians seem to have different beliefs about this form of learning and training. While some are very positive about using e-learning for CME (Mirzaei et al. 2012; Autti et al. 2007), others still prefer a more traditional training approach (Vollmar et al. 2009). As a scalable and cost-effective way of training, it is, therefore, worth exploring the physicians' intention to use eCME. If we can estimate the important factors that facilitate or limit eCME use, we can manipulate these factors to improve the usage.

## 1.4 The theory of planned behavior

Discovering the human behavior and its dynamics has been one of the concerns of science. Icek Ajzen developed the theory of planned behavior (TPB) that can describe and predict behaviors and intentions (Ajzen 1991). This theory has been applied to various fields, such as advertising, public relations, and healthcare (Ajzen 1991). It can explain individuals' behavior of a new technology adoption quite well; not only does it describe the relationship between constructs, but it also helps uncover specific factors that can affect the adoption or use of technology (Taylor & Todd 1995). Researchers have used this theory for measuring perceived barriers for completing an e-learning program on evidence-based medicine (Gagnon et al. 2007), student intention to adopt mobile learning (Cheon et al. 2012), and acceptance of a software in an undergraduate curriculum (Nkenke et al. 2012). TPB can deliver specific information about users, which is needed to conduct improvements (Mathieson 1991). In addition, TPB has been used to design CME interventions in order to promote behavior changes (Buriak et al. 2015) and assess CME's effectiveness (Tian et al. 2010).

In TPB, behavioral intentions are a proxy for real behaviors, which are determined by a

combination of a person's attitudes, subjective norms, and perceived behavioral control (Figure 2). Generally, the more positive the attitude, subjective norms, and perceived behavioral control towards a specific behavior are, the stronger the person's intention to perform it.

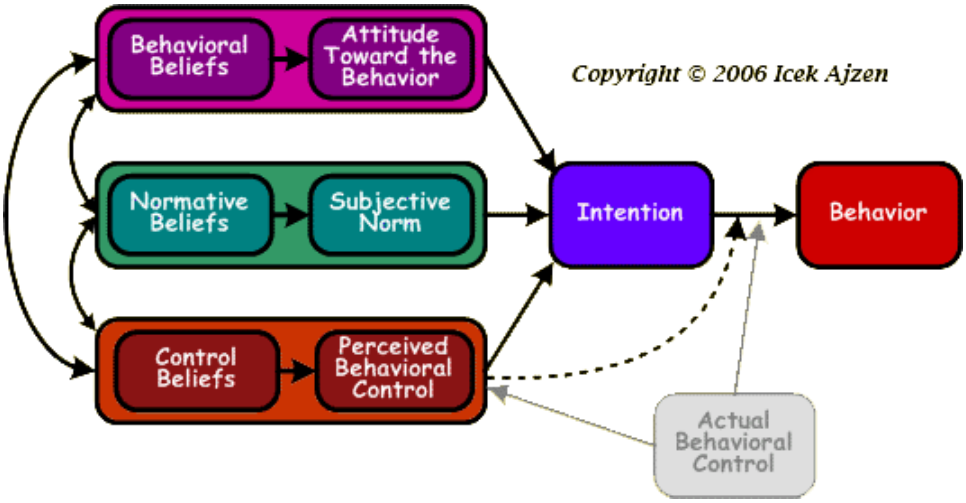



**Figure 2. The constructs of the theory of planned behavior**

## 1.5 Self-assessment

Physicians usually select a CME course based on the self-assessment of their learning needs as well as the availability and number of credits offered in CME courses. There is evidence, however, about physicians' limited ability to self-assess their learning needs accurately (Davis et al. 2006). For example, family physicians tend to follow education about topics at which they are already proficient, avoiding areas in which they are less competent but would probably benefit from more training (Sibley et al. 1982). Safe practice in medicine needs awareness of when a physician lacks the specific knowledge or skill to make a good clinical decision for a particular patient. The term self-assessment is used to describe two kind of activities: "self-rating" is one aspect, whereas the other is a self-administered examination of knowledge or clinical performance (Davis et al. 2006). In this thesis, I will use the later aspect. Computer-assisted testing could optimize self-assessment (Hols-Elders et al. 2008) and increase its authenticity.

### Web-based cases for self-assessment

Electronic or web-based cases are used increasingly in health professions education and assessment of health practitioners' ability to improve their clinical decision making skills (Thistlethwaite et al. 2012), especially at the undergraduate level. Taking a case-based self-assessment can help a GP evaluate his/her knowledge of common infectious diseases in

outpatient settings and receive related feedback for improvement. Web-based cases for self-assessment are a valid tool for measuring the quality of clinical practice, besides being inexpensive and easy to use (Peabody et al. 2004). These electronic cases can also be beneficial to use within the larger scope of a health system to investigate the lack of (if any) clinical knowledge among GPs, in order to develop related improvement interventions (Norcini et al. 2004). A web-based case for self-assessment could simulate a real patient encounter and increase both the objectivity and feasibility of the assessment (Round et al. 2009).

While working with electronic cases, a physician can assess differential diagnoses, therapeutics plans, and other medical decision-making skills by comparing own decisions to those of experts built in the system and receive tailored feedback (Posel et al. 2009). Furthermore, a physician is able to see her/his own progress and outcome of the choices, being either positive or negative; it keeps her/him engaged, helps her/him to self-assess as well as to identify further learning needs. Therefore, a well-designed and validated electronic case could represent an objective form of self-assessment (Round et al. 2009).

### Validly of self-assessment

A valid self-assessment format could be a combination of a self-driven approach validated repeatedly by an automated external source. A valid assessment instrument that results in justifiable, relevant, and meaningful assessment requires the gathering of evidence in a systematic manner (Kane 2001). Messick proposed a unified model that comprises the evidence from five elements: content, response process, internal structure, relations with other variables, and consequences (Cook, Zendejas, et al. 2014; Downing 2003), which I also used in my work and explain further on.

# 2 AIM AND RESEARCH QUESTIONS

The fundamental aim of this thesis was to understand GPs' intention to use eCME and the factors that affect the use of eCME, and to explore how a self-assessment activity works in an eCME context. The specific aims and research questions for each sub-study are stated in the following:

| | **Aim** | **Research questions** |
|---|---|---|
| **Study I** | **Sub-study I:** To explore a theory-driven approach by applying TPB in the construction of a questionnaire and then evaluate its ability to model and explain GPs' intention to use eCME. | 1. How do factors extracted by an exploratory factor analysis match the theoretical constructs of TPB?<br>2. How does the statistical model of GPs' intentions fit the data collected from an eCME setting?<br>3. How does the model map GPs' intention to use eCME? |
| | **Sub-study II:** To identify the important factors—enablers and barriers—that influence the intention of GPs in Iran to use eCME by making rigorous application of the TPB. | 1. What are the most important factors correlated with GPs' intention to use eCME?<br>2. What are the most important predicting factors for GPs' intention to use eCME?<br>3. What are the main predictors of an active eCME use in terms of the three constructs of the TPB and background factors? |
| **Study II** | **Sub-study III:** To analyze the validity of a self-assessment test using electronic cases in measuring GPs' knowledge | 1. To what extent does different validity evidence support electronic cases as a format of self-assessment activity in a CME context? |
| | **Sub-study IV:** To evaluate the correlation between GPs' previous prescription outcome indicators and their competencies measured through self-assessment. | 1. Do GPs' actual prescription indicators correlate with their performance on electronic case-based self-assessment?<br>2. How can other extrinsic and intrinsic factors explain variations in self-assessment results and prescription indicators? |

# 3 METHODS

## 3.1 Setting

**CME:** The CME program at the Isfahan University of Medical Sciences (IUMS) was used as the context of these studies. IUMS was representative of the contexts where CME was mandatory for all physicians and particularly relevant to middle-income countries in terms of access to technology. Most GPs participated in face-to-face CME seminars, and less in eCME programs, in order to update their knowledge and earn the required credits. A GP pays to participate in seminars or eCME, and corporate sponsorship is not allowed in Iran.

**eCME**: Using online learning for CME is a relatively new approach to Iranian physicians, and most physicians are not so experienced in this type of training. At the time of this thesis, the conventional eCME method was offline e-learning, such as CD/DVD ROMs. Based on CME regulations, physicians must pass an online multiple choice test to earn credits from eCME. GPs could acquire up to 50% of their CME credits via eCME.

## 3.2 Participants

General practitioners hold a crucial role in healthcare. They are the first formal agents for medical consultation and medicine prescription. For this reason, GPs were the subjects of this research. An increased understanding of their eCME use would help improve their training and optimize eCME delivery. Detailed demographics of the participants are found below in each sub-study.

## 3.3 Study I: Using the theory of planned behavior to study GPs' intention to use eCME

This study consisted of two sub-studies: one aimed at constructing a questionnaire to measure GPs' intention to use eCME (Paper I), and the other aimed at identifying the factors that influence the intention to use eCME (Paper II). We followed the recommended standard steps by Francis and colleagues (Francis et al. 2004) to create the TPB questionnaire. They are briefly mentioned here, but for more information, please see related articles (Hadadgar, Changiz, Masiello, et al. 2016; Hadadgar, Changiz, Dehghani, et al. 2016).

### 3.3.1 Elicitation study

The first step with TPB is to discover the participants' beliefs about the subject matter, which is usually called "elicitation study." In our project, an open-ended questionnaire (about the positive and negative dimensions of the TPB constructs) was distributed among the physicians in CME seminars.

### 3.3.2 Development, validation, and distribution of the questionnaire

The authors defined the target behavior and also four constructs of the study, namely, intention (the outcome variable), attitude, subjective norms, and perceived behavioral control (PBC). A standard TPB questionnaire includes items used to measure all of its related constructs. From the elicitation study, we developed the questionnaire, and after we have ensured that we had at least three items for each construct of the TPB, we then checked the questionnaire's validity with six experts in CME and four physicians. The final questionnaire had 25 items in four TPB dimensions. The translated version of the questionnaire is included in appendix. GPs who attended the IUMS CME on-site seminars in autumn 2014 were invited to participate in the study.

### 3.3.3 Data analysis

We had three independent variables (i.e., attitude, subjective norms, and perceived behavioral control). The questionnaire items were rated, ranging from completely disagree (-3) to completely agree (+3) on a 7-point Likert scale. We used seven background factors (i.e., gender, age, past experience, frequency of computer use, internet access, practice setting, and place of residence), based on previous studies on eCME use.

#### *3.3.3.1 Sub-study I analysis*

We conducted an exploratory factor analysis using the principal component analysis method to evaluate the loading of variables. We used SPSS V.22 and Amos V.22 (IBM, Chicago, USA). With the exploratory factor analysis results, we executed confirmatory factor analysis and structural equation modeling by Amos in order to create measurement and structural models. Some of the Likert items had missing values (mostly for subjective norms items), and we imputed them via a regression model in Amos.

#### *3.3.3.2 Sub-study II analysis*

To determine the associations between the categorical variables, we used a Chi-square test, and to check the effects of the independent variables and background factors on the dependent variables, a hierarchical multiple regression analysis was conducted. Finally, a logistic regression was also performed to find the predictors for active users (Ajzen 2005).

## 3.4 Study II: Using electronic cases for self-assessment in CME

This study consisted of two parts. First, we developed a self-assessment test with web-based cases and examined its validity evidence (Manuscript III). Then, we compared the GPs' results on this test with their previous actual prescriptions (Manuscript IV).

### 3.4.1 Study context

The study was announced with flyers, on the CME Website of IUMS in Iran, and during

CME courses. GPs interested in participating were referred to the program's webpage, where they found information about the purpose of the study, the institution, the researchers behind it, how privacy was assured, and how the data would be used and reported. The GPs consented to enrolment by creating an account. Figure 3 shows a holistic map of the intervention.

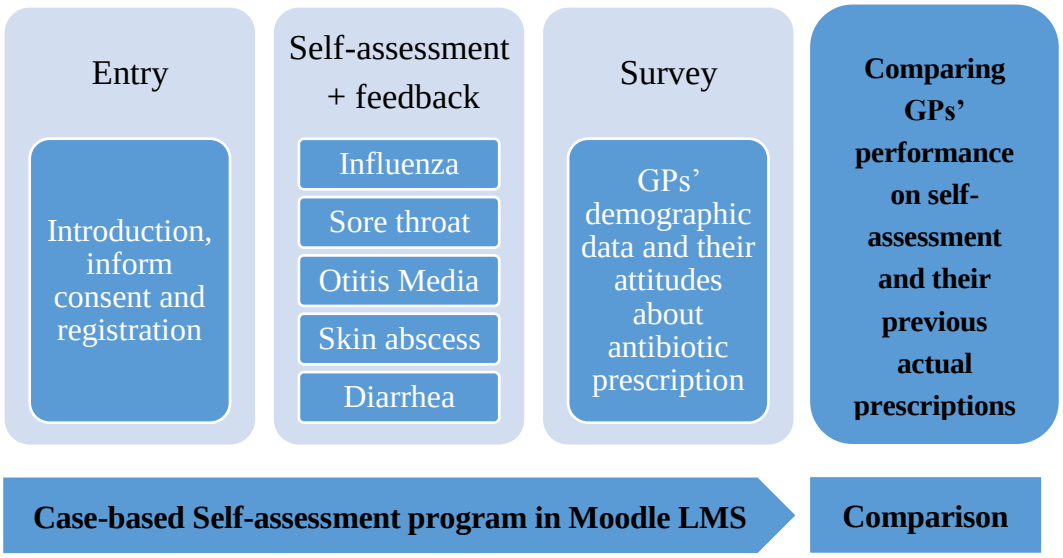



**Figure 3. Overview of the intervention**

### 3.4.2 Designing the self-assessment model

To explore the GPs' competencies around antibiotic prescription, we modified the Mucklow's framework (Mucklow et al. 2012)to fit the purpose of our sub-study. The framework was modified for accurate diagnosis as well as antibiotic-prescribing competencies, and shortened to be suitable for eCME self-assessment by GPs. The three critical steps of the framework are presented in Table 1.

**Table 1. Steps in the electronic case and the related competencies**

| |
|---|
| **Step 1: Make a diagnosis**<br>• Recognize important elements when assessing signs of infection |
| **Step 2: Establish a therapeutic approach and discuss it with patient**<br>• Recognize when not to prescribe antimicrobials, and when to use alternatives<br>• Educate patients (and family members) in when antibiotics are not required |
| **Step 3: Choose the drug and delivery format**<br>• Prescribe antimicrobials based on knowledge of the spectrum of activity<br>• Understand local microbial susceptibility patterns when considering empiric treatments<br>• Know how to select the appropriate antimicrobial, paying due consideration to local guidance, how, and where, to access this<br>• Avoid the unnecessary use of broad-spectrum antimicrobials |

The learning management system (LMS) provided embedded feedback during the self-assessment at both item and question level. An example is shown in Figure 4.


**Figure 4. The electronic case display and its feedback features**

### 3.4.3 Integration of self-assessment in a Learning Management System

The electronic cases were created in the Moodle LMS [The Moodle Project https://moodle.org] using the Quiz plugin. The structure of the educational program consisted of five parts, and after finishing each part, the next one was accessible to the

participant (except the "further reading" part):

- Introduction and registration
- An exemplary case to introduce the main parts to the participants (i.e., scenario, questions, answers, specific feedback, general feedback, and right answer(s))
- Five cases in one activity. We started the test with an easy case
- Demographic data and satisfaction questionnaire
- Further reading: Related guidelines and a pamphlet about antibiotic use and resistance.

### 3.4.4 Data sources

This is a comparative cross sectional study, and we used STROBE statement for reporting the results (von Elm et al. 2008). We had an independent variable (i.e., GPs' self-assessment results), dependent variable (i.e., previous prescription outcome indicators), and related factors (i.e., age, gender, practice setting, patient visits per day, and attitudes towards antibiotic prescription).

**Prescription outcome indicators of participants:** In Iran, the Rational Use of Drugs (RUD) Committee collects prescriptions data from all the physicians around the country. We checked the participants' prescription data from the RUD committee. For each GP, the data included the following: total number of prescription notes, mean number of drugs per prescription, mean cost of prescriptions, average percentage of patients who received antimicrobial drugs, average percentage of patients who received injectable drugs, and average percentage of patients who received corticosteroid drugs (Safaeian et al. 2011).

**Related factors:** the participants' age, gender, graduation date, practice setting, patient visit per week, attitudes about antibiotic prescription, and resistance were asked at the end of the online self-assessment part.

### 3.4.5 Data collection for the validity evidence

After logging into the program, the GPs started with an exemplary case with instructions. Later, they were administered the main test with five cases. Finally, they answered a survey and finished the program. Within 2 weeks of completion, they received a reward (2 free CME tokens). The whole program was available for two months for the eligible GPs. Prior to the program, the researchers conducted a pilot study with six GPs to determine the face validity of the cases and related feedback. Messick's unified model was used to develop and check the validity evidence of self-assessment (Cook, Zendejas, et al. 2014; Downing 2003).

#### *3.4.5.1 Content evidence*

Three steps (in a,b,c below) were taken to guarantee that the test content (i.e., scenarios, questions, response items, and feedback) reflected the necessary skills for diagnosis and treatment of common outpatient infectious diseases:

**a. Development of the electronic cases:** The case stems were selected from medical casebooks to ensure content validity. Approximately 20 cases were suitable, but five were chosen based on the following criteria: suitable for office-based primary care of a GP, mixed viral and bacterial signs and symptoms, prevalence of the disease in Iran, and the possibility of creating multiple scenarios in the electronic cases. The five cases were otitis media, diarrhea, skin abscess, sore throat, and influenza. The five cases were further adapted to the local context, and the researchers created 16 scenarios for self-assessment. The main goal with the cases was to help GPs assess their competencies related to diagnosis and treatment of common infectious diseases in an outpatient setting and provide feedback to them based on their performance. For each scenario, we developed key feature (KF) and multiple choice question (MCQ) format items, in which sometimes more than one answer could be correct. After making a final decision on the answer, the user received an immediate feedback for that item; in case of a mistake, they would receive the correct answer and a general feedback about the whole scenario so that they could learn and prevent a possible wrong answer, which might affect the later stages. The learner could not change his/her answer after submission.

**b. Validation by experts:** Experts in related domains, namely, infectious diseases (2 specialists), pediatrics (2), clinical pharmacology (2), and gastroenterology (1) validated the cases and related feedback on each scenario.

**c. Measuring GPs' perception about the cases:** Huwendiek and colleagues developed and validated a questionnaire for evaluating electronic cases design with a special emphasis on fostering clinical reasoning (Huwendiek et al. 2015). We used four of the seven items in the questionnaire and fitted them for the eCME context for GPs as the final satisfaction survey. At the end of this survey, there was also an open-ended question for suggesting possible improvements to the program.

#### *3.4.5.2 Response process evidence:*

After a test attempt, the GPs could see the correct answers. Users may have been tempted to cheat in order to receive the free CME tokens. Therefore, we analyzed the data to check if the users answered the test after a very short time or answered from similar IP addresses at the same time and with same answers.

#### *3.4.5.3 Internal structure evidence:*

We checked the reliability measurement criteria to ensure each question's reliability and removed the item if necessary. We used CITAS (an Excel spreadsheet extension) to analyze the assessment results (Assessment Systems 2016). The recommended range for item difficulty (the proportion of users who correctly answered an item) is 0.2–0.8, and for the discrimination index (the power of the item to differentiate between examinees with high and low levels of knowledge or ability), a score above 0.2 is good (Oermann & Gaberson 2013). CITAS uses the Kuder–Richardson Formula 20 for measuring reliability and point biserial correlation for discrimination index.

#### *3.4.5.4 Relations with other variables evidence:*

We obtained the participants' prescription outcome indicators from the regional RUD committee. It is an end proxy of their competencies regarding diagnosis and management of common infections. We used SPSS V.22 (IBM, Chicago, USA), and Pearson and Spearman correlations based on the type of data. The self-assessment score data were ordinary, but we treated the data as numerical. Most of the prescription outcome indicators were continuous variables. The statistical significance level below 0.05 and the correlation coefficient above 0.3 were significant in our study.

#### *3.4.5.5 Consequences evidence:*

Since the self-assessment was a rather small intervention, we estimated that its impact on GPs' behavior was likely to be limited and below a detectable level. Furthermore, monitoring the participants' subsequent enrollment into other CME courses to measure the intervention's effectiveness was not feasible at the time of the study. As a feasible way to evaluate if using the electronic cases as self-assessment could be a motivating factor for GPs to change their behavior, we decided to ask them to rate if their participation in this program has made them more interested in antibiotic prescription.

## 3.5 Ethical considerations

The ethical approval for both study protocols was granted by the research ethics committee (IRB) of the Isfahan University of Medical Sciences (Study I, IRB number= 293158, and Study II, IRB number= 295088).

**For the first study**, the participants were informed about the research study in two ways: (a) verbally during the seminar where the questionnaires were distributed and (b) by having them read the written information about the study prior to answering the questionnaire. In both occasions, it was clearly pointed out that filling in the questionnaire indicated their understanding and willingness to participate in the study. Additionally, signing an informed

consent for this study was not required by the IRB, provided that the collected data could only be used for research purposes and were stored according to the international social science research guidelines.

**For the second study**, we informed the participants about the aim of the study and asked them to sign an online informed consent (Eysenbach & Wyatt 2002). The physicians reviewed related information on the program's introduction webpage (i.e., the purpose of the study, institutions behind the study, how privacy was assured, details about with whom data were shared, and how data were reported). If they accepted to share their data with the researchers, they would proceed to the registration system.

# 4 FINDINGS

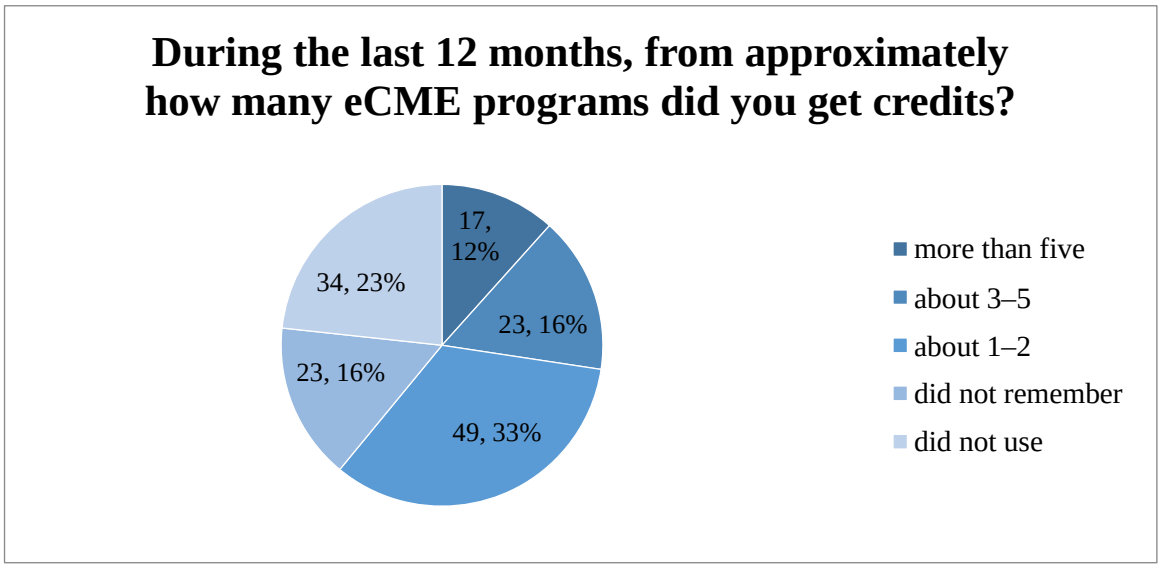
## 4.1 Study I: Using the theory of planned behavior to study GPs' intention to use eCME

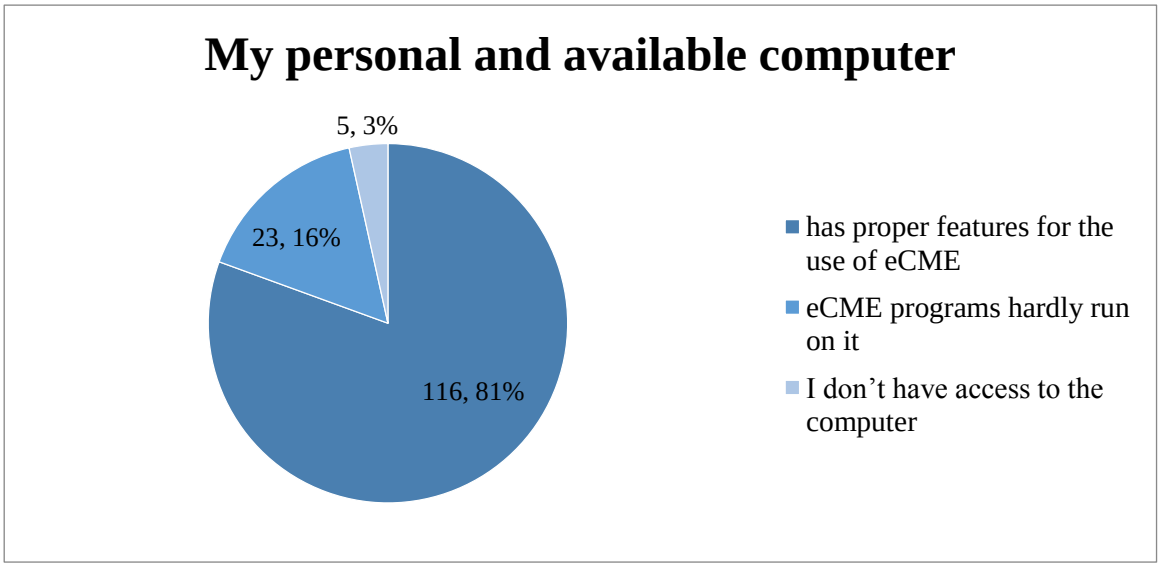
The participants in this study comprised 148 GPs who agreed to fill out the questionnaire. We excluded two incomplete questionnaires. Of the participants, 40% (n=58) were female, and the average age of the participants was 43 (from 28 to 72). Other demographic and background data were presented in Figure 5.

### 4.1.1 Dimensionality of the developed model—Sub-study I

In this phase, by doing an exploratory factor analysis (EFA), we created a model and evaluated its dimensionality with TPB's constructs (refer to the first research question). For the EFA, we used the Principal Component Analysis method for extraction, the oblique method for rotation (i.e., direct oblimin because most of the factors had a correlation above 0.3) (Meyers et al. 2006) and the pattern matrix for the factor loading (Tabachnick & Fidell 2007). We excluded three items that had high skewness (>2) and kurtosis (>7) before the EFA (Curran et al. 1996). The excluded items, based on mean, standard deviation, skewness and kurtosis, respectively, were Q14 (working with the computer/Internet, 2.40, 1.19, -2.76, 8.67), Q16 (personal computer features, 2.7, 0.49, -2.11, 3.72), and Q17 (computer skills, 2.29, 1.23, -2.20, 5.22).

In the primary EFA, we found five factors with an Eigen value higher than 1, which explained 58% of the variance. Then, we limited the factor numbers to four to fit the TPB constructs, which, therefore, explained 54.1% of the variance. The communalities for each item were sufficiently high (all above 0.3), indicating that the items were adequately correlated for a factor analysis (Table 2). The internal consistency for each factor was moderate to high, with the lowest Cronbach's alpha at 0.56. For naming the factors, we considered the TPB constructs and also items with higher loadings in each factor (Meyers et al. 2006).



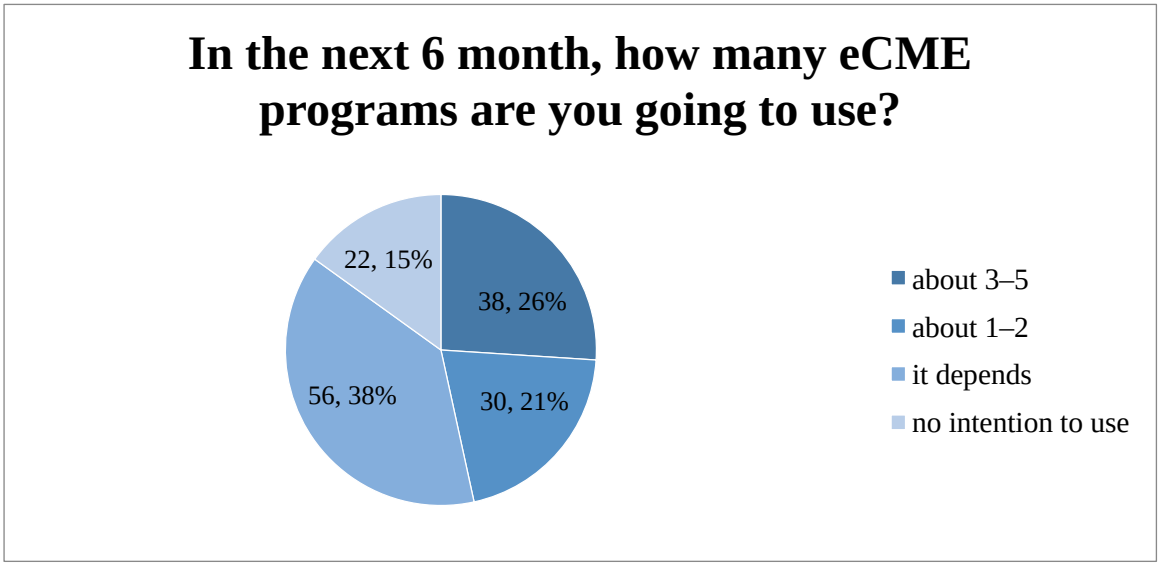




**Figure 5. Demographic and background data of the participants**

The KMO measure of sampling adequacy was 0.837, and the Bartlett's test of sphericity was statistically significant (p< .01). The factors demonstrated sufficient discriminant validity. The factor correlation data were as follows: factor 1 (2, -0.32; 3, 0.35 and 4, 0.26), factor 2 (3, -0.32; 4, 0.11) and factor 3 (4, -0.24). We did not have any component correlation above 0.70, and we could not assume them to be orthogonal. We removed Q13, because it had cross loadings.

**Table 2. Pattern matrix for the exploratory factor analysis of the questionnaire.**

| Item | Factor 1 (PBC) | Factor 2 (SN) | Factor 3 (Attitude) | Factor 4 (Intention) | Extraction Communality |
|---|---|---|---|---|---|
| Q09f: eCME final exam | **.792** | -.036 | .170 | -.209 | .652 |
| Q18: eCME audiovisual | **.700** | -.006 | -.009 | .018 | .498 |
| Q09c: eCME scientific quality | **.677** | .013 | .125 | .041 | .535 |
| Q09b: eCME cost | **.630** | -.061 | -.172 | .180 | .501 |
| Q03: Improving practice | **.561** | .160 | .168 | .306 | .560 |
| Q09e: eCME Q&A | **.539** | -.203 | -.144 | -.058 | .355 |
| Q19: eCME & Internet speed | **.486** | -.100 | .145 | -.019 | .330 |
| Q08: Independent learning | **.410** | -.089 | .160 | .283 | .462 |
| Q10: Encouragement by boss | .069 | **-.857** | .058 | -.067 | .757 |
| Q11: Encouragement by CME office | -.082 | **-.813** | .031 | .058 | .660 |
| Q12: Encouragement by colleagues | .137 | **-.768** | -.059 | .080 | .717 |
| Q15: Concentrate with distractors | -.103 | -.116 | .098 | **.774** | .661 |
| Q06: eCME credit possibility | -.099 | -.103 | .137 | **.710** | .578 |
| Q20: CME preference | .250 | -.011 | -.130 | **.708** | .650 |
| Q02: Intention (next 6 month) | .366 | .029 | -.034 | **.404** | .376 |
| Q04: Traffic time | .066 | .125 | **.742** | -.160 | .543 |
| Q05: Job leave | -.056 | -.107 | **.620** | .133 | .454 |
| Q09a: eCME time saving | .227 | -.043 | **.585** | .005 | .478 |
| Q09d: More eCME credits | -.054 | -.057 | **.529** | .108 | .315 |
| Q07: Recommending | .388 | -.101 | **.409** | .339 | .740 |
| Cronbach's alpha | .81 | .8 | .78 | .56 | |
| Eigen value | 6.4 | 1.7 | 1.2 | 1.5 | |

SN: subjective norms, PBC: perceived behavioral control

### 4.1.2 Descriptive measures of the TPB questionnaire—Sub-study I

The responses to items about the use of eCME are presented in Table 3. The items are ordered in an ascending mean. Encouragement by superior and CME office personnel to use eCME and the opportunity to engage in Q&A with teachers in an eCME program were

the lowest ranked items. Allowing physicians to obtain more eCME credits, less commuting/traffic time by the use of eCME, and using eCME improves my clinical practice were the highest ranked ones.

**Table 3. Descriptive measures of the TPB questionnaire**

| Item (sorted by ascending means) | Mean | Std. Deviation | Factor loading** |
|---|---|---|---|
| **Q09e- The possibilities for Q&A with teachers in an eCME program** | -.94 | 1.735 | F1 |
| **Q10- My superior encourages me to use eCME** | -.55 | 1.417 | F2 |
| **Q11- The CME office director and staff encourage me to use eCME** | -.33 | 1.537 | F2 |
| **Q20- Between two concurrent CME programs, with equal quality and same subject, which one would you prefer** | .22 | 2.204 | F4 |
| **Q12- My physician colleagues encourage me to use eCME** | .38 | 1.627 | F2 |
| **Q09b- The cost of eCME** | .52 | 1.996 | F1 |
| **Q19- Most of the eCME programs are installed and downloaded well considering the usual Internet speed** | .63 | 1.669 | F1 |
| **Q13- The rules and regulations in CME encourage me to use eCME** | .77 | 1.619 | F2 |
| **Q15- Online distractors prevent me to focus on eCME** | .83 | 2.117 | F4 |
| **Q18- Most of the educational materials and multimedia in the eCME programs from the audiovisual perspective are** | .87 | 1.581 | F1 |
| **Q09f- Final exam questions** | .99 | 1.561 | F1 |
| **Q08- Independent learning experience in eCME for me was** | 1.26 | 1.372 | F1 |
| **Q05- No need to leave the job is an important factor in my eCME use** | 1.64 | 1.742 | F3 |
| **Q09d- Possibility to gain CME credits** | 1.66 | 1.428 | F3 |
| **Q07- What is your recommendation about eCME to your colleagues?** | 1.69 | 1.084 | F4 |
| **Q09a- In terms of time saving** | 1.71 | 1.712 | F3 |
| **Q09c- Scientific quality** | 1.77 | 1.149 | F1 |
| **Q03- Using eCME improves my clinical practice** | 1.84 | 1.161 | F1 |
| **Q04- Decreasing commuting/traffic time is an important factor in my eCME use** | 1.90 | 1.595 | F3 |
| **Q06- It is better to allow physicians to obtain more credits from eCME** | 2.03 | 1.376 | F4 |
| **Q17- What is your situation in using computer for eCME?** | 2.32 | 1.188 | Removed from EFA |
| **Q14- Currently, working with the computer and the Internet is inevitable for physicians** | 2.49 | 1.002 | Removed from EFA |

### 4.1.3 Fitness of the model— Sub-study I

In order to arrive at the measurement model (refer to the second research question), we did a confirmatory factor analysis (CFA) using AMOS 22. The observed variables for each latent variable were acquired from the pattern matrix. The factor loadings of the latent to the observed variables was recommended to be higher than 0.3 (Meyers et al. 2006). The items' standardized regression weights were greater than 0.3, and all of them had significant regressions with their related latent variables. This represents the amount of change in the latent variables that is attributable to a single standard deviation unit's change in the item. We added covariance between two errors in the attitude's observed variables. All

of the modification indices were lower than 10. In order to check the model fit, we measured the indices presented in Table 4. We measured the CMIN (minimum discrepancy), which is similar to Chi-square. For an estimation of the average size of the residuals between the actual covariance and the proposed model covariance, we used RMSEA. The recommended value was also mentioned in the last row (Meyers et al. 2006). Based on the result of CFA, we assigned Q07 to the intention factor.

**Table 4. Goodness-of-fit indicators for the developed model**

| ***Indices*** | Absolute fit indices | | | Incremental fit indices | Parsimony fit indices |
|---|---|---|---|---|---|
| | CMIN/DF | CMIN p value | RMSEA | CFI | PNFI |
| **Current model** | 1.48 | p< .01 | 0.06 | *0.92* | 0.68 |
| **Recommended value** | 1-2 | P> .01 | <0.10 | *>0.95* | >0.50 |

### 4.1.4 Predictability of the developed model—Sub-study I

In order to identify the predictive power (refer to the third research question), we followed the structural equation modeling in our model using Amos. The Attitude and PBC to intention regression weights were statistically significant, but the subjective norms construct was not, so we removed its regression arrow to intention. The explained variance of intention was 66% (Figure 6). The covariance among variables was presented. Regarding the intention to use eCME in our participants, we did a subgroup analysis for access to the computer and Internet and other demographic factors, but we could not find any statistically significant results.

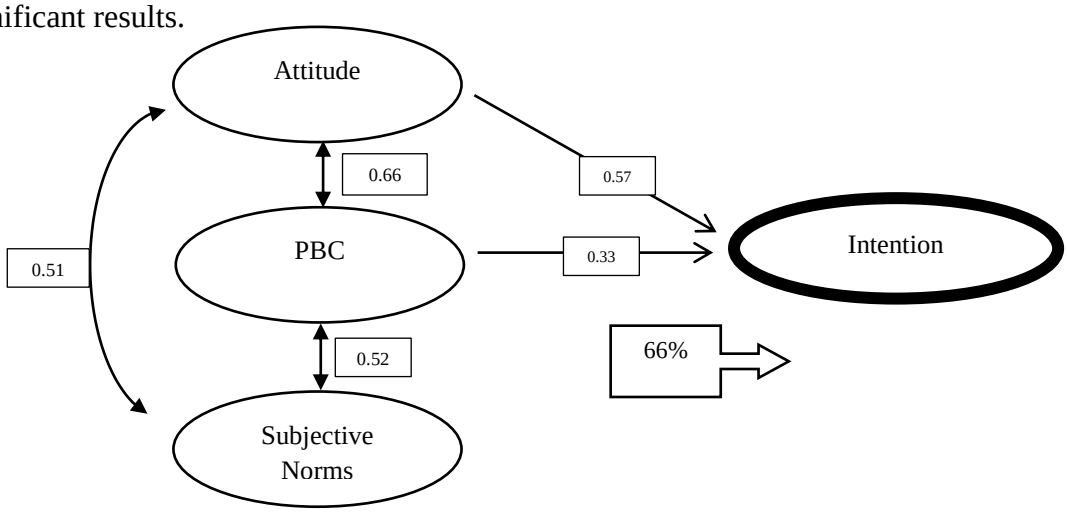



**Figure 6. Causal relationship between the four factors of the questionnaire**

### 4.1.5 Factors regarding GPs' intention to use eCME—Sub-study II

There was a statistically significant positive correlation between eCME behavior (total eCME credits earned) and intention (PC = 0.26, p < 0.01). Then, we tried to use intention

as a proxy for actual behavior. Intention also was correlated with attitude (0.65, $p< 0.01$), subjective norms (0.44, $p< 0.01$) and perceived behavioral control (0.77, $p< 0.01$). We also found a strong relation between self-reported behavior (Q01) and total of eCME credits earned (PC = 0.61, $p < 0.01$). Besides, no collinearity was detected between these variables as the correlation was less than 0.7 among the independent variables (Meyers et al. 2006).

To understand the factors that predict GPs' intention to engage in eCME, we applied the hierarchical multiple regression model. The subjective norms construct was not statistically significant here:

**Intention = (.63 * Perceived Behavioral Control) + (.29 * Attitude)**

The logistic regression model was applied to find the main predictors of an actual eCME user. The perceived behavioral control and other background factors did not have a statistically significant influence on the model:

**Being an actual eCME user = 2.21 + (1.94*Attitude) + (.57*Subjective Norms) + (.98*Seminar credits)**

## 4.2 Study II: Using electronic cases for self-assessment in CME

This study aimed at analyzing the validity of a self-assessment test using electronic cases in measuring general practitioners' diagnosing and management competencies of common infectious diseases in an outpatient setting. We wanted to know to what extent different validity evidence supported electronic cases as a format of self-assessment activity in a CME context and compared the GPs' results of self-assessment with their previous actual prescriptions results.

### 4.2.1 Validity evidence—Sub-study III

In total, 268 GPs visited the program webpage, and 50 of them decided to participate in the study. Two of the participants did not finish the test (only answered the first 8 questions). Two more participants were suspected of dishonest behavior and excluded. Thus, finally we had 46 participants. Their demographic data, self-assessment scores, and their previous prescriptions statistics are presented in Table 5.

One GP did not fill in the satisfaction survey. Of the participants, 52% (n=24) were men. Regarding their medical practice, 37% (n=17) worked in public clinics, 23.9% (n=11) in private clinics, 19.6% (n=9) in their private offices, and 17.4% (n=8) in the Social Security Organization, which is an insurance agency in Iran.

About their attitude to the phrase "Antibiotic prescription in Iran is lower than the world average," 60.9% (n=28) of the participants totally disagreed, 34.8% (n=16) agreed, and

only one person totally agreed (2%). To the question "how many patients with common cold in your office request for antibiotic prescription," 43.5% (n=20) of the participants responded more than 75%, 34.8% (n=16) about 50–75%, 15.2% (n=7) about 20–50%, and only 4.3% (n=2) mentioned less than 20%.

**Table 5. Participants' demographic, self-assessment, and previous prescriptions data**

| | | Min | Max | Mean | Std. Deviation |
|---|---|---|---|---|---|
| **Demographic** | Age | 27 | 74 | 42.89 | 9.63 |
| | Patient visit per week | 4 | 500 | 137.17 | 129.48 |
| **Self-assessment results** | Self-assessment score (for valid questions, out of 9) | 1.00 | 9.00 | 4.89 | 1.87 |
| | Diagnostic competency | .00 | 1.00 | 0.66 | 0.28 |
| | Therapeutic plan competency | .00 | 1.00 | 0.45 | 0.27 |
| | Choosing the drug competency | .00 | 1.00 | 0.53 | 0.30 |
| **Prescription outcome indicators** | Number of prescriptions in last year | 10 | 17523 | 1823.02 | 3167.19 |
| | Percentage of patients who received antimicrobials | 6.94 | 83.92 | 35.96 | 16.21 |
| | Percentage of patients who received Corticosteroids | 0.49 | 54.91 | 12.05 | 11.83 |
| | Percentage of patients who received injection drugs | 3.22 | 70.98 | 28.74 | 18.66 |
| | Drugs per prescription | 1.77 | 4.47 | 2.99 | 0.57 |
| | Mean cost of prescriptions (1000 I.R. Rials) | 64 | 541 | 152.17 | 97.70 |

**Content evidence**: We measured the GPs' perception about the cases and the self-assessment. The findings are shown in Table 6.

**Table 6. The GPs' perceptions about the cases and the self-assessment**

| | Totally agree | Agree | Unsure | Disagree | Totally disagree |
|---|---|---|---|---|---|
| These cases are similar to my patient whom I visit every day in the office or clinic. | 23.9% (11) | 63% (29) | 6.5% (3) | 2.5% (1) | 2.5% (1) |
| Working through these cases was helpful for me to better diagnose and treat common infectious disease at the office. | 26.1% (12) | 67.4% (31) | 2.2% (1) | NA | 2.2% (1) |
| The feedback I received during interaction with cases was helpful in enhancing my clinical reasoning skills for common infectious disease. | 34.8% (16) | 56.5% (26) | 4.3% (2) | 2.2% (1) | NA |
| Overall, working through this case was a worthwhile learning experience. | 43.5% (20) | 50 (23) | 4.3% (2) | NA | NA |

**Response process evidence**: Regarding assessment security, we found four attempts that seemed improper. Two participants answered the test within a very short time (7 and 10 minutes) and obtained high scores, while two other participants connected from the same location (IP address) at almost the same time and with the same total results, but with different detailed responses. Therefore, we excluded only two participants (short time, high score) as alleged cheating attempts.

**Internal structure evidence**: The reliability and discrimination across the questions was measured, and the results are presented in Table 7. The mean item difficulty for the 16 questions was 0.62, and the mean item discrimination was 0.35. The overall reliability coefficient (KR-20) was 0.53.

**Table 7. Internal structure evidence**

| | Q# | Question type | Competency category | Difficulty index | Rpbis* (Discrimination index) |
|---|---|---|---|---|---|
| Case 1 (Sore throat) | 1** | KF | Make a diagnosis | 0.93 | 0.45 |
| | 2** | KF | Establish a therapeutic approach | 1.00 | |
| | 3** | KF | Make a diagnosis | 0.93 | 0.24 |
| | 4** | MCQ | Choose the drug and delivery format | 0.98 | 0.28 |
| Case 2 (Ear ache) | 5 | KF | Make a diagnosis | 0.67 | 0.49 |
| | 6 | KF | Establish a therapeutic approach | 0.54 | 0.52 |
| | 7 | KF | Make a diagnosis | 0.78 | 0.40 |
| | 8** | KF | Choose the drug and delivery format | 0.04 | 0.07 |
| Case 3 (Skin abscess) | 9 | MCQ | Establish a therapeutic approach | 0.26 | 0.36 |
| | 10 | MCQ | Choose the drug and delivery format | 0.28 | 0.51 |
| Case 5 (Flu like) | 11** | KF | Establish a therapeutic approach | 0.98 | 0.28 |
| | 12** | MCQ | Make a diagnosis | 0.09 | 0.10 |
| | 13 | MCQ | Establish a therapeutic approach | 0.74 | 0.53 |
| Case 6 (Diarrhea) | 14 | KF | Make a diagnosis | 0.54 | 0.44 |
| | 15 | KF | Choose the drug and delivery format | 0.78 | 0.32 |
| | 16 | MCQ | Establish a therapeutic approach | 0.28 | 0.33 |

As the next step, we excluded questions 1, 2, 3, 4, 8, 11, and 12 due to difficulty and discrimination indices that fell outside the recommended range.

**Relations with other variables evidence:** We examined the statistical association between the self-assessment scores and their previously prescription outcome indicators in the last year (12 months). We could not find any statistically significant correlation, even after

removing inappropriate items.

**Consequences evidence**: We asked the participants' opinion about whether participation in the educational program made them more curious to learn about antibiotic prescription afterwards, and 28.3% of them totally agreed, 54.3% agreed, 10.9% were unsure, and 4.3% disagreed. Additionally, 28 GPs (60.9%) visited the "further reading" part after finishing the test.

In the open-ended question of the satisfaction survey, 17 comments were captured. A simple categorization of the data returned showed that 13 participants appreciated this type of CME and requested for more similar programs. The participants suggested having more common cases, integrating these cases with on-site programs, and educating the community about the consequences of irrational antibiotic use via mass media.

### 4.2.2 Association between GPs' self-assessed knowledge and actual prescription practice—Sub-study IV

There was a consistency within the prescription outcome indicators. The main outcome variable (i.e., average percentage of patients who received antimicrobials) was correlated with the average percentage of patients who received injection drugs ($r=0.31$, $p=0.04$), mean number of drugs per prescription ($r=0.53$, $p<0.01$), and cost of prescriptions ($r= -0.46$, $p<0.01$), but not with the average percentage of patients who received corticosteroids ($p=0.07$).

To obtain a better estimation, we included only the participants who had more than 100 prescriptions in the RUD database. The score frequency for each question is presented in Table 8. We did not observe any statistically significant correlation between the total self-assessment scores and the GPs' previous antibiotic prescription rate. We explored the sub-skills in clinical decision-making (i.e., diagnosis, therapeutic plan and choosing the drug, and delivery format skills) to get a better understanding of the phenomenon. Only the diagnostic skill was positively correlated with the average percentage of patients who received antimicrobials ($r= 0.34$, $p=0.04$) and negatively with cost of prescriptions ($r= -0.42$, $p=0.01$). We also did not observe any correlation between the case variation and the GPs' previous antibiotic prescriptions.

To understand the interaction of the variables, we compared the mean of the outcome and the independent variables regarding the five related factors: GPs' perception of patient desire for antibiotics, gender, time since graduation, practice setting and patient number per week.

**Table 8. Included questions in the study**

| Case | Q# | Question type | Sub-skills | 0 | 1 |
|---|---|---|---|---|---|
| Case 2 (Ear ache) | 1 | KF | Make a diagnosis | 15 (32.6%) | 31 (67.4) |
| | 2 | KF | Establish a therapeutic approach | 21 (45.7%) | 25 (54.3) |
| | 3 | KF | Make a diagnosis | 10 (21.7%) | 36 (78.3) |
| Case 3 (Skin abscess) | 4 | MCQ | Establish a therapeutic approach | 34 (73.9%) | 12 (26.1) |
| | 5 | MCQ | Choose the drug and delivery format | 33 (71.7%) | 13 (28.3) |
| Case 4 (Flu like) | 6 | MCQ | Establish a therapeutic approach | 12 (26.1%) | 34 (73.9) |
| Case 5 (Diarrhea) | 7 | KF | Make a diagnosis | 21 (45.7%) | 25 (54.3) |
| | 8 | KF | Choose the drug and delivery format | 10 (21.5%) | 36 (78.3) |
| | 9 | MCQ | Establish a therapeutic approach | 33 (71.7%) | 13 (28.3) |
| Total score (out of 9) | | | | <5<br>19 (41.3%) | >= 5<br>27 (58.7%) |

#### *4.2.2.1 GPs' perception of patient desire for antibiotics*

GPs who had better insight about the antibiotic prescription situation in Iran, scored better assessment results (T-test, $p<0.01$, 62.2 compared to 45.5). On the contrary, those who perceived more patient requests for antibiotics scored better assessment results (T-test, $p=0.02$, 65.6 compared to 49.6). We did not observe any statistically significant correlation between the GPs' previous antibiotic prescription outcome indicators and their perception about the antibiotic prescription situation in Iran and patient request for antibiotics.

#### *4.2.2.2 Gender*

We found female physicians prescribed less injectable drugs (T-test, $p<0.01$, 18.6 compared to 35.9) and corticosteroids (T-test, $p<0.01$, 5.4 compared to 16.9) to their patients, but no differences were found for antimicrobials and also the assessment results.

#### *4.2.2.3 Patient number*

Regarding the patient number visited per week by the GPs, it was statistically correlated with the average percentage of patients who received antimicrobials ($r= -0.43$, $p<0.01$), and cost of prescriptions ($r= 0.45$, $p<0.01$).

#### *4.2.2.4 Practice setting*

Regarding the effect of the organizational policy that regulates GPs' practice, we compared the mean in the GPs who work mainly at Iran's Social Security Organization and elsewhere, and we found that they wrote out more costly prescriptions (T-test, $p<0.01$, 22500 compared to 13100 Toman (Iranian currency)), less drugs per prescription (T-test, $p<0.01$, 2.5 compared to 3.1), and less patients who received antimicrobials (T-test, $p<0.01$,

22% compared to 39%). About patient–physician relationship, we found significant differences in patient request for antibiotics among physicians who worked at their private offices compared to physicians who practice at other settings (T-test, p<0.01, 2.38 compared to 3.33 (out of 4)). Regarding prescribed antimicrobials and perceived patient request, although there were no significant differences among the groups in different practice settings, a trend could be seen, as shown in Figure 7.

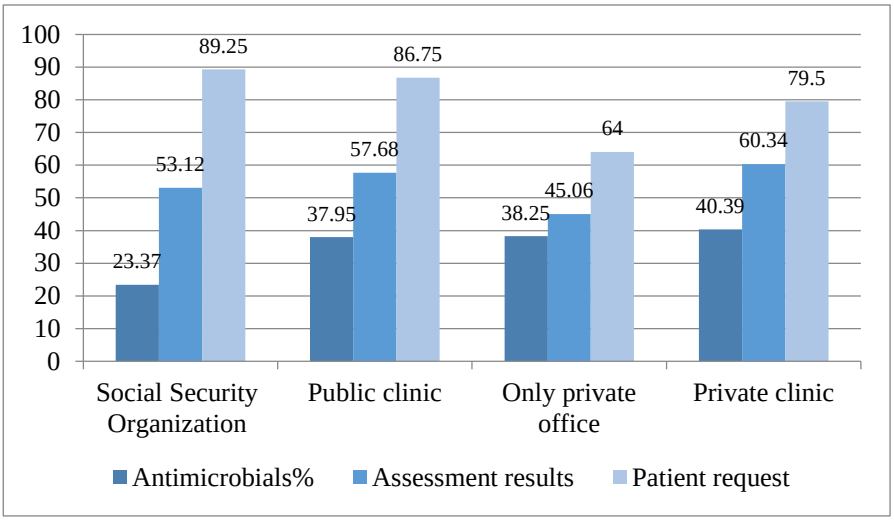



**Figure 7. Differences among the participants regarding their practice setting**

#### *4.2.2.5 Age/Time since graduation*

There was a negative correlation between age and total assessment results (r=-0.37, p=0.025). Furthermore, the GPs who graduated in the last 10 years significantly prescribed less corticosteroids (T-test, p=0.01, 5.6 compared to 14.5) compared to those who graduated 10–20 years ago. Regarding prescribed antimicrobials and perceived patient request, although there were no significant differences among graduation time groups, a trend could be seen, as shown in Figure 8.

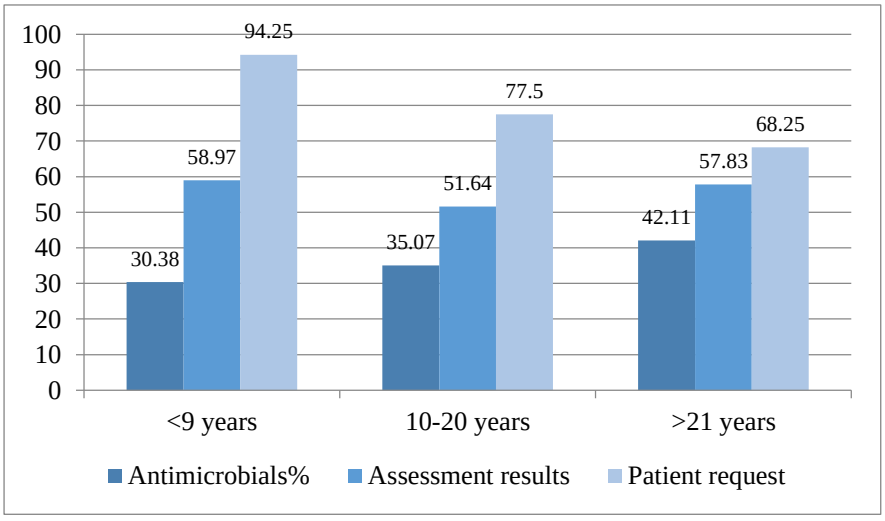



**Figure 8. Differences among the participants regarding their time since graduation**

# 5 DISCUSSION

## 5.1 Methodological considerations

Our summative aim was to understand how physicians could benefit from e-CME. In the first study, we explored if they had any intention to use this type of training and what factors were most importantly correlated with their intention to use eCME. For this part, we used TPB, which investigates human behavior in a structured and quantitative way. In the second study, we developed an eCME activity in order to help physicians understand their learning needs. We also investigated the association between the results of the GPs' self-assessment and their past real prescribing behavior. Accordingly, in both studies, we applied quantitative methods to gain a better understanding of the GPs' interaction with eCME.

## 5.2 Discussion of the main findings

### 5.2.1 What motivates GPs to use eCME?

To start using the eCME, perceived behavioral control and attitude are the main predictors of intention, which highlights the practical challenges related to actual use. With these two predictors, about 70% of the intention to use eCME variance could be explained. Technologies that are perceived to be less complex to use have a higher probability of acceptance and adoption by potential users (Rogers 2010). The participants perceived encouragement by others as the lowest-ranked item, which may explain the absence of subjective norms among the predictors. We also found that the lack of access to a computer and the Internet at home does not hinder eCME use. The relevance to clinical practice was one of the highly ranked items, and as confirmed in previous research, it is the main reason why individuals use eCME (Schoen et al. 2009). In other words, the easier to use technology is perceived and higher the clinical relevance of eCME is, the higher the prospect of eCME being used by GPs would be.

### 5.2.2 Is TPB a good theory to model GPs' intention to use eCME

There are a number of models for exploring users' behavior with new technologies. TAM (technology acceptance model) and TPB are the most commonly used. With TAM, we can explore behavior but its power to predict the behavior is low. In a study of technology acceptance among physicians, the researchers found that the component of technology usage barriers must be added to improve the power of the model. For example, that model worked well for public sector physicians who already had access to the computer and Internet in their workplace, but for physicians working in private offices, where access to

the computer/Internet is costly, the intention to use technology had lower correlation with attitude (Yarbrough & Smith 2007). In addition, TAM has features that lengthen the questionnaire; therefore, busy physicians may not fill it. For this reason, we preferred the TPB model for describing GPs' interaction with eCME.

Overall, this model demonstrated quite good fitness, which is our main outcome here. The results indicated that the questionnaire could explain 66% of the GPs' intention to use eCME. Although the explained variance is context-specific (Meyers et al. 2006), in a TPB study among GPs, researchers could explain 48% of the variations in reported intentions for following a specific guideline (Rashidian & Russell 2011). In most of the previous studies about technology acceptance among physicians, the R-square was around 0.4, demonstrating that although a significant amount of physicians' intention is explained, some predictors of this intention remain unidentified (Yarbrough & Smith 2007).

### 5.2.3 Self-assessment with web-based cases

Most of the participants rated the cases as a positive form of learning and expressed their curiosity to learn about antibiotic prescription after their participation in this program. Interestingly, almost 60% of the participants answered correctly to more than half of the self-assessment test. An adult learner needs to feel the necessity to learn, and this self-identification of learning needs is a critical part of self-directed learning (Kaufman & Mann 2010). The motivation for a physician to learn derives from the needs identified during his/her experience of clinical practice. Integrating self-assessment into CME activities may help physicians evaluate their competencies in a more accurate way (Davis et al. 2006), which in turn, indicates which courses to take to improve any deficient competency.

The self-assessment concept usually applies to formative assessment without any grade or credit-bearing consequences, and the assessment tool consequently improves learning or, at least, the willingness to learn. While considering the validity evidence for a case-based self-assessment in eCME context, the issues in our study arose by the parallel conceptualization of self-assessment as a learning activity (consequences of assessment) and an accreditation-led activity (security issues). The validity argument focuses more on assuring the accreditation part, but we need to ensure the learning part as well, which can allow the measurement of the participants' self-regulated learning as well as skills/competencies, and the monitoring of the self-assessment. As a consequence, we can observe also if the GPs' participation in self-assessment may affect their participation in related courses. Nonetheless, our intervention was small; therefore, it seems unrealistic to consider its effect on prescribing behavior.

### 5.2.4 Antimicrobial prescription: Role of knowledge

We explored the complex behavior of antibiotic prescription by the GPs in terms of their clinical knowledge and a number of other related factors such as age, gender etc. The absence of a correlation between the GPs' previous antibiotic prescription and their assessment result can demonstrate the sufficiency of the GPs' knowledge in this field. We can also conclude, as other researchers have done, that physicians may be tempted to provide self-assessment that fit an accepted professional norm that may differ from their normal clinical performance (Norcini et al. 2004). Researchers think that improving only physicians' knowledge about antibiotic therapy is an old fashioned practice (Radyowijati & Haak 2003), and knowledge alone is insufficient to predict performance in practice. It needs another type of education that helps GPs to respond to patient requests in a proper way. When GPs involve patients in therapy and use shared decision-making skills, fewer antibiotics are prescribed (Kotwani et al. 2010).

### 5.2.5 The difficulty of predicting human behavior

In both studies, we tried to understand an actual behavior (eCME usage or antimicrobial prescription) with the help of a cognitive instrument as a proxy.

In the first study, attitude and subjective norms could only predict 19% of the behavior variance (eCME use). This highlights the complexity of belief–behavior relations. In the second study, we could not observe any significant association between the knowledge domain and the actual prescribing behavior.

The lack of a correlation between practice data and self-assessment results in our second study may be derived from validity issues in the assessment instrument or in the report for prescription outcome indicators or simply the correlation between knowledge and performance is not strong enough to detect. Although we have provided relative validity evidence in the previous study (Manuscript III), we are aware that we cannot generalize the assessment results by only 10 questions, and clinical knowledge is more complex than that. Cook and his colleagues have shown that more questions enhance learning; nonetheless, the peak is at 10 questions, and additional questions only increase the completion time of self-assessment (Cook, Thompson, et al. 2014). Another issue was in the data for the prescription outcome indicators report, which were gathered in each province: We could not access all the prescriptions of GPs who work in cities in borderline areas. Research shows that low standard performance of physicians does not essentially reflect the lack of knowledge (Rethans et al. 1991), but other factors may be at play; factors that were not captured scientifically in this thesis. Literature has shown that the correlation between

“learning” and “performance in the real situation” is weak, or, at least, research has largely failed to confirm a causal linkage regarding greater learning producing a greater transfer of knowledge to practice (Bates 2004).

## 5.3 Limitations

The limited sample size was one of the main challenges in both studies. As participation was voluntary, it was hard to recruit more GPs to be involved in time- and mind-demanding activities. GPs have limited time for voluntary activities, and trying to entice them with CME credits was not a successful endeavor. Aiming at larger sample sizes probably would have provided the possibility of more precise analyses.

For the first study, the enrolment method may be biased because the potential participants were interested in the eCME program. However, in TPB studies, we had to include people who had experienced the subject of the study.

For the second study, we had issues while developing the electronic cases. Research recommends that expert clinical faculty should contribute and work together in the creation of the cases, as well as the review and revision phases of the cases (Downing 2003). Unfortunately, this was not the case in this work, even though we followed the national medical guidelines while developing the cases. We also faced difficulties in developing the KF and MCQ items, which is a time-consuming process (Schuwirth & van der Vleuten 2003) and not always error-free (Stagnaro-Green & Downing 2006).

# 6 CONCLUSIONS

In an eCME context, the following items summarize the findings of this study:

- We could explain 66 % of the variances of intention to using eCME. TPB can help researchers understand physicians' intention to use eCME.
- Attitude and subjective norms are the main predictors for the completion of an eCME program. It means that having a positive attitude and social support can differentiate GPs who are willing to earn eCME credits.
- Among the participants, the main predictors of intention to use eCME were perceived behavioral control and attitude.
- Self-assessment could be used as a tool to personalize learning at the course or even CME level.

By recognizing important drives and barriers for using eCME, managers and course directors can develop specific plans to improve physicians' intention to use eCME. In the future, by understanding the contribution that knowledge may play, we can develop better interventions to improve prescribing practices and focus more on policy issues to improve the indicators.

## 6.1 Implications for practice

### 6.1.1 Study I

By understanding the important factors/dimensions that facilitate eCME use, we can control them to improve its adoption and usage. For example, subjective norms can influence a physician to become an actual eCME user, and enhancing the organizational/peer support may increase her/his involvement in eCME activities. This shows how a theoretical framework can help us develop more effective eCME programs.

A practical issue concerns the lack of opportunities for question-and-answer in an eCME platform. Physicians learn from their peers and teachers in daily clinical practice (Curran et al. 2010), and it would be beneficial to provide similar opportunities for discussion and collaboration in the eLearning platform. That way, GPs can easily connect and learn from each other. It would also increase their active involvement in eCME activities (Kaufman & Mann 2010).

### 6.1.2 Study II

As researchers have already shown (Cook et al. 2008), the author also would like to suggest that probably adapting learners' prior knowledge into eCME content could diminish the

time spent on completing the learning activities without compromising knowledge gain. This could be a strategy that has relevance to clinical practice and can motivate busy physicians.

It means that the self-assessment activity can be integrated with, for example, an antibiotic stewardship CME course, and, based on the performance of the learner on a prior knowledge assessment, provide more personalized learning material. In addition, when considering self-assessment as an individual activity, the CME user can find related CME courses that can fulfill his/her competency gaps.

## 6.2 Future research

One of the main applications of the TPB model is its use for monitoring intervention studies. In this PhD project, we could not measure the participants' intention and related beliefs before and after the second study. However, if there is a strategic plan at the organizational/university level to increase health personnel's engagement in eCME activities, it is recommended to check their beliefs and attitudes before and after the intervention. First, the leaders should define which beliefs should be changed (e.g., changing attitudes, facilitating access to computer, etc.). Then, after the intervention, they can monitor the intervention's effectiveness.

An interesting consideration in this research was to increase the complexity of the self-assessment to extend to the use of virtual patients, that is, an interactive computer simulation in the education of clinical processes (Cook & Triola 2009). The borderline between electronic cases and virtual patients is blurred and disputable, and various approaches use the label interchangeably (Kononowicz et al. 2015). Since our cases were rather short and non-interactive, they are not considered "virtual patients." Yet, they share similarities with virtual patients as being case-based, presented online, tailored to be authentic in the learner context as well as being focused on clinical reasoning and decision-making skills. In the future, I am very interested in pursuing further research to integrate virtual patients into eCME. The researchers decided against increasing the technological sophistication of the study as we were focused on quick decisions fitted to the needs of busy physicians. In addition, the local researchers preferred to use the existing technical infrastructure without installing a separate virtual patient's platform, besides being unsure on the acceptance of this form of learning in the target group.

# 7 EPILOGUE - My journey as a PhD student

Coming from a medical background and being interested in computer applications in teaching and learning, I started this fantastic journey. I did my studies in a continuing professional development context. I prefer quantitative studies with applicable results. Perhaps my background in high school and the medical program has made me more of a positivistic researcher. However, here at LIME, I became exposed to qualitative research, and that has helped me understand how this type of research can answer questions that we cannot simply approach with numbers.

I had some experiences in developing and administering questionnaires in medical education (in Persian). However, with my newly acquired knowledge, I hope I can develop new questionnaires with a stronger theoretical framework and constructs in my future studies. I was thoughtful to find a related scientific framework/theory for my studies, and I have found the framework/theory very useful for designing the studies and explaining the results. In addition, I struggled to be methodologically coherent with the theories in the whole process of my research. My first study was a clarification study, which dealt with how we can model GPs' intention to use technology in their learning by applying the theory of planned behavior, whereas the second study that focused on how self-assessment works in an eCME context could be considered a justification study, where we compared the results with other sources of evidence.

I used different areas/disciplines to enrich my research approach. The problem was antibiotic resistance in the real world (i.e., in medicine and pharmacology). My focus was on understanding GPs' behaviors, as they are the key prescribers of these drugs and to ascertain their eagerness to use e-Learning. I assessed their intentions as the starting point (social psychology). Finally, I used cases as the tool for self-assessment in the eCME context (i.e., instructional technology and medical education). This broad understanding of the different fields of research will be valuable; although beyond my understanding at this very moment, but, as a researcher, I am fully aware that it will feed my curiosity.

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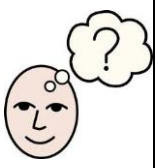
# 10 APPENDIX- STUDY I

## TPB questionnaire for eCME usage in general practitioners

**(Translated version)**

| **Personal number** | **Name** | **program** | **Questionnaire code** |
|---|---|---|---|

| | |
|---|---|
| What is this research about? | Dear colleague, as you know, by using information and communication technologies, we could improve the education. Since the production of the eCME programs is expensive, it is necessary to understand the skills and preferences of the physicians and also the barriers in this field. This study aims to do so. |
|  How to answer? | The questions are about your experience using e-learning in CME (CD and online version). If you have such an experience and you are a GP, then please fill the questionnaire. Please think more about your eCME experience, and then start to answer the questions. Filling this questionnaire is completely voluntary and your personal information will be protected in this study. Your honest answers will help to tailor future eCME programs to the users' interest and skills. For the attitudinal questions, please specify the place which is closer to your opinion, for example: Completely disagree ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- completely agree |

1- In <u>last year</u> (2013), from how many eCME programs did you get credit approximately:

(--) more than 5 programs (--) 3-5 programs (--) 1-2 programs (--) didn't use (--) don't remember

2- In the <u>next 6 month</u>, how many eCME programs are you planning to use:

(--) 3-5 programs (--) 1-2 programs (--) not decided yet or it depends (--) will not use

3- Using eCME programs help me improve my practice:

Completely disagree ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- completely agree

4- Travel time and traffic elimination is a major factor in my use of eCME:

Completely disagree ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- completely agree

5- No need to take a leave from work, is one of my reasons for using eCME:

Completely disagree ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- completely agree

6- It would be better if earning more credits through eCME is possible:

Completely disagree ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- completely agree

7- Do you recommend eCME to your colleagues:

| | | |
|---|---|---|
| I do not recommend to use eCME | ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- | As far as possible make use of eCME |

8- The experience of independent learning in eCME method, for me.....

(--)has been enjoyable (--)not successful (--)has been unpleasant (--)I think it is too early for the GPs to use

9- Please help us to know more about your experience from eCME:

Considering eCME programs you participated in, what you think of the following?

| | | |
|---|---|---|
| a | In terms of time saving | Valuable ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- Time consuming |
| b | In terms of costs | Convenient ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- expensive |
| c | In terms of scientific quality | Good ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- Bad |
| d | The convenience to earn CME credits | convenient ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- Hard |
| e | In terms of Q&A possibility with lecturers | Possible ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- Impossible |
| f | In terms of final exam questions: | Practical ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- Not practical |

10- My bosses are encouraging me to use the eCME (if you work in a hospital or medical clinic, please answer this question)

Completely disagree ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- completely agree

11- Manager and staff of the university CME office, are encouraging me to use the eCME:

Completely disagree ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- completely agree

12- My GP friends are encouraging me to use the eCME:

Completely disagree ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- completely agree

13- CME rules and regulations are encouraging for me to use the eCME:

Completely disagree ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- completely agree

14- Today, working with computer and the Internet is inevitable for physicians:

Completely disagree ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- completely agree

15- Distractors in the online environment (email, and social networks), prevent me to focus on eCME:

Completely disagree ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- completely agree

16- My personal computer ……

(--) has proper features for the use of eCME (--) eCME programs hardly run on it (--) I don't have access to the computer

17- What is your situation in using computer for eCME:

| | | |
|---|---|---|
| I am not ready to work with computers for eCME | ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- | I do all the computer works of eCME by myself |

18- According to audiovisual principles, most of the educational materials and multimedia in eCME are …….

| | | |
|---|---|---|
| monotonous and exhausting | ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- | attractive and encourage learning |

19- Considering the usual Internet speed, most of the eCME programs are run and download well:

Completely disagree ---(-3)---(-2)---(-1)---(0)---(+1)---(+2)---(+3)--- completely agree

20- Among <u>electronic</u> and <u>Seminar</u> CME programs (with same quality and subject), which one do you prefer:

electronic ◄( )( )( )( )( )( )( )► Seminar

In order to understand which kind of GPs could take more advantages of the eCME, we need some more information about your practice and interaction with eCME. Any information that you think is too personal, Please do not complete!

21- Please specify your clinical workplace (if it is necessary, select more than one option):

(--) Private office (--) Clinic/hospital University (--) Working at university administration (--)I do not practice currently

22- In the home and work, how much do you use computer?

A) **Home**: (--) Daily (--) Weekly (--) Monthly (--) I have access to computer but I don't use it (--) I don't have access to computer

B) **Work**: (--) Daily (--) Weekly (--) Monthly (--) I have access to computer but I don't use it (--) I don't have access to computer

23- In the home and work, what is your dominant method of internet connection?

A) **Home**: (--) ADSL (--) WiMAX (--) Dial up (--) I don't know (--) I don't have access to internet (--) I don't have access to computer

A) **Work**: (--) ADSL (--) WiMAX (--) Dial up (--) I don't know (--) I don't have access to internet (--) I don't have access to computer

24- How frequently do you use your email?

(--) Daily (--) Weekly (--) Monthly (--) I forgot my email password (--) I don't have email address (--) I don't have access to computer and internet

If you are interested to receive the results of this project, please mention your email here:

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At the end, thanks for your attention; we will try use the results of this project in design and implementation of the future eCME programs. If you have any tips or advice in the field of eCME please mention here:

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