Assessing the Awareness of Egyptian Medical Students about Responsible Conduct of Research and Research Ethics: Impact of an Educational Campaign

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\section*{ABSTRACT}
This is a quasi-experimental pre-post assessment study utilizing an anonymous self-administered questionnaire to assess Egyptian medical students’ awareness about responsible conduct of research (RCR) and research ethics. Students’ were assessed before and after an RCR awareness campaign. Our results showed that most of the pre-campaign respondents were not familiar with the basic principles and terms of RCR. An increase in the awareness about RCR across all discussed topics was noted following the campaign. We concluded that an educational awareness campaign is effective in increasing medical students’ awareness about RCR and should be incorporated into current medical school curricula in Egypt.

\section*{KEYWORDS}
Egypt; medical students; plagiarism; research misconduct; responsible conduct

\section*{Introduction}
Recommendations were issued in 1982 by the Association of the American Medical Colleges in a report titled “The Maintenance of High Ethical Standards in the Conduct of Research” (Association of American Medical Colleges, 1982), after several widely publicized instances of scientific misconduct that called into question the integrity of the whole research enterprise (Broad, 1980; Kalichman, 2013). The report recommended that faculty and their institutions should be responsible for maintaining the highest ethical standards in research and quickly and fairly investigating any alleged misconduct. However, they stopped short of recommending formal instruction in good research practices. It was not until the publication of the 1989 Institute of Medicine (IOM)’s report “The Responsible Conduct of Research
in the Health Sciences” that an explicit recommendation was made to not only hold formal courses, but to incorporate responsible conduct of research (RCR) education into various undergraduate and graduate curricula for all science students (Steneck and Bulger, 2007). In an attempt to instill these ethical standards, the United States National Institutes of Health (NIH) announced on December 22, 1989 and again on August 17, 1990 that applicants on NIH training grants receive instruction in RCR. The text of the 1989 notice required that “a description of the formal or informal activities related to the instruction about the responsible conduct of research … be incorporated into the proposed research training program” (National Institutes of Health, 1989). In 1992, the NIH requested that all applicants to the “Institutional National Research Service Award (NRSA) Research Training Grants (T32, T34)” include a clear description for RCR training activities in their programs, and provided a list of essential topics that should be covered in applications submitted in 1993 onwards (Steneck and Bulger, 2007; National Institutes of Health, 1992).

A study assessing the impact of these recommendations concluded that RCR training programs are indeed essential for scientists to acquire the required skills and knowledge in research ethics (Mastroianni and Kahn, 1999). Subsequently, another study demonstrated the importance of ongoing and continuing RCR education, and the inadequacy of one-time training programs (McGee et al., 2008). To ensure that these training activities are integrated into the research enterprise, institutions of higher learning in many countries such as the United States and Canada established offices of research ethics to provide training for faculty and students to promote research integrity, and to avoid dishonesty and research misconduct (Titus, 2014; Zimmerman and Wallace, 2013). To reduce the likelihood of research misconduct and to increase scientists’ knowledge and skills in research ethics, educational institutions in Europe and the United States in the last 25 years have steadily expanded their RCR education programs (Novossiolova and Sture, 2012; Kalichman and Plemmons, 2015). In contrast, education in universities, colleges, and institutes of higher education about ethical standards of scientific research and RCR remained poorly developed in African countries (Kombe et al., 2013; Okonta and Rossouw, 2013). Specifically, training in scientific integrity and RCR in Egyptian research institutions remains weak and advanced training is very much needed for researchers. This is particularly relevant given how scientific research has been growing exponentially in Egypt in the last decade(Normile, 2008; Kermani, 2013; The Guardian, 2011; Mansour et al., 2015).

The proportion of research in the biomedical sciences in Egyptian universities has increased much more rapidly than in the other sciences, with 38% attributed to biomedical research compared to research in agriculture (9%), engineering (10%), physical and natural sciences (11%),
humanities (12%), and sociology (22%) (Bond et al., 2012). Despite the increased research output, a recent study showed that about 28% of health research conducted in Middle Eastern countries did not receive prior ethical approval from an ethics committees (Abdur Rab et al., 2008). This may be attributed to inadequate knowledge among researchers about the importance of research ethics and RCR and the lack of institutional policies mandating review by ethics committees, and ensuring that the principles of RCR are applied in all steps of research. In the last decade, Egyptian educational institutions increased their capacity for human subject protection and RCR through a National Institutes of Health, Fogarty-Sponsored Training Program (Silverman et al., 2013; Sleem, El-Kamary, and Silverman 2010). Starting in 2004, Egyptian faculty members trained in these disciplines were able to establish ethics committees, training workshops and propagate the concepts of research ethics and human subject protections in their institutions. While faculty members gained greater knowledge in this field, Egyptian medical students were still not being adequately educated in these concepts.

Given that medical students are expected to comprise the majority of future clinicians working in health related research, it stands to reason that they would benefit the most from early training in research ethics and RCR. In the present study, we hypothesized that medical students, as future researchers, were inadequately trained in research ethics/RCR/scientific integrity and would benefit from an organized educational awareness campaign, and we aimed to assess their awareness of basic RCR terms and principles at baseline and after attending an RCR educational awareness campaign held at Ain Shams University Faculty of Medicine.

**Methods**

**Study design**

This is a quasi-experimental pre-post assessment descriptive study with no control group, conducted at Ain Shams University Faculty of Medicine. A specifically designed questionnaire (Supplementary Materials) was used to assess medical students’ awareness about basic RCR terms and principles before and after an educational campaign on the topic. For the purpose of this study, we assessed research ethics, RCR, and scientific integrity interchangeably. The specific aims of the study were to: 1) measure the baseline level of awareness about RCR among medical students; 2) complete an educational awareness campaign to introduce the concepts and principles of RCR through face-to-face discussions with the students; and 3) determine the success of the educational campaign as a potential method of teaching that can be applied at other Egyptian universities.
To achieve our aims, the questionnaire was administered to medical students to assess their baseline pre-campaign knowledge. This was followed by a three-day educational RCR campaign, followed by a post-campaign assessment using the same questionnaire administered to the subset of students who completed the pre-campaign assessment and attended the three-day campaign in its entirety.

**Study preparation**

Prior to the start of the study, a group of medical students from the Ain Shams Medical Students’ Research Association (AMSRA) were selected and trained by the study faculty on how to administer and explain the questions in the assessment questionnaire. AMSRA is a student organization at the Faculty of Medicine that is focused on encouraging and facilitating the conduct of medical research by medical students. It is comprised of, and managed by, medical students under the supervision and mentorship of highly qualified and experienced research faculty.

**Study participants**

Medical education in Egypt consists of six academic years of education (three years of basic sciences and three years of clinical training) at any one of Egypt’s 24 universities, followed by 1–2 years of internships (Barnard, 2002; Elshayeb, 2010). Medical students from all six academic years were invited to participate by AMSRA students. All medical students were eligible to participate and attend the RCR educational awareness program. The participating students were made aware of the purpose of the study, and after verbally consenting to participate, they were offered the pre-campaign questionnaire to complete. A trained AMSRA student remained close to the participating medical student to explain any questionnaire-related queries by the student. In some instances, the queries were explained in Arabic, the native language of the students, whenever necessary. It should be mentioned that although the AMSRA students interacted face-to-face with the participating students, the absolute majority of the participants were not known to the AMSRA students, and none of the enrolled students were asked to identify themselves or to add their names to the questionnaires, thereby rendering the questionnaire responses anonymous.

**Ethical approval and informed consent**

The Ethics Committee of the Faculty of Medicine, Ain-Shams University approved the study prior to the conduct of any assessments. Prior to study participation, participants were verbally informed about the purpose of the
study and the identity of the conducting party. They were made aware that participation was voluntary and anonymous and refusal to participate would not result in any academic penalty. Only those who provided verbal consent were invited to complete the questionnaires. By completing the pre- and post-campaign assessment questionnaires, the participants were aware that they would be providing their consent for participating in the study, including awareness that the data may be published.

**Data collection tool**

The questionnaire used in this study was created by the authors in this study based on the objectives of the educational campaign and was created using information from publicly available materials at the Office of Research Integrity, U.S. Department of Health and Human Services (Korenman, 2006). This questionnaire was then reviewed with several other faculty members, including faculty from the Department of Epidemiology at Ain Shams University, and their feedback was incorporated into a revised version of the questionnaire. A pilot study was conducted on 30 medical students to assure their understanding of the survey’s questions. A few questions that were unclear to the students were modified, and the revised questionnaire was tested in another 30 students and found to be well understood by the students. This final tested version of the questionnaire was used for both the pre- and post-campaign assessment of the participating students.

The questionnaire (included in the supplementary materials) consists of 17 questions divided into three sections. It was designed to be self-administered anonymously, with the availability of trained study staff to address questions in person as needed. The first two sections (Section I and II) were intended to assess whether the participants believed they knew the meaning of some baseline RCR terms and principles, and the sources from which they acquired that knowledge. The first section, included Questions 1–3 and collected information about the student’s gender and year of study (Years 1–6) and asked a basic question about whether they heard about [the university] research courses before (Q1), whether they knew the meaning of RCR in scientific research (Q2) and whether they participated in research projects (Q3). The second section (Questions 4–10) included seven questions that assessed whether the student believed they knew the meaning of the following RCR terms and ethics related concepts, and the sources from which they acquired this knowledge: Q4) plagiarism; Q5) fabrication and falsification; Q6) peer review; Q7) conflict of interest; Q8) animal welfare; Q9) the Belmont report; and Q10) the institutional review board (IRB).

The third section (Questions 11–17) was intended to examine the participants about their understanding of some RCR and ethical concepts through seven multiple-choice questions regarding commonly-encountered ethical and
RCR issues. The chosen topics in the third section were: Q11) research misconduct; Q12) authorship; Q13) acknowledgements; Q14) peer review; Q15) mentor-trainee relationship; Q16) sharing data; and Q17) conflict of interest.

**Pre-campaign assessment**

The participating students who verbally consented to participate in the study were asked to answer the questionnaires on their own and to ask the AMSRA students if they had any queries about the questionnaire. On average, each participant required 15–20 minutes to complete the questionnaire. All participants who completed the pre-campaign questionnaire were invited to attend the three-day educational campaign.

**The educational awareness campaign**

A three-day educational campaign was conducted with the goal of raising awareness about RCR among medical students. The materials prepared for the campaign included a simplified booklet with information about basic RCR principles and terms. The booklet and other materials used in the campaign were prepared using references from the National Science Foundation and National Institutes of Health (National Institutes of Health, 2015, National Science Foundation). The three-day campaign was held from March 17–19, 2013, on the Ain Shams Faculty of Medicine main campus. On the first two days of the campaign, a variety of educational activities including case studies and games to teach the principles of RCR topics were delivered in an informative and appealing manner. On the third and last day of the campaign, experts were invited to present lectures and specific talks on different RCR topics, with a focus on research ethics in life sciences and medicine.

**Post-campaign assessment**

At the end of the last day of the educational campaign, the same pre-campaign questionnaire was distributed to all the participants for the post-campaign assessment component of the study. It should be noted that students who completed the post-campaign assessment were those who completed a pre-campaign assessment and attended the three-day educational campaign in its entirety, after excluding those with irregular attendance.

**Statistical analysis**

Statistical analysis of the collected data was done using the Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, Version 20.0,
Results

Medical student participation

A total of 600 medical students from all six academic years gave verbal consent to participate in the study, and were offered the questionnaire for the pre-campaign assessment. Of those, 556 completed the questionnaire (92.7%), and all were invited to attend the educational campaign. Only 100 students attended all three days of the campaign and were eligible to complete the post-campaign assessment. All 100 were offered the questionnaire for the post-campaign assessment component of the study, and 95 students who attended all three days of the campaign completed it (95%).

Pre- and post-campaign assessments

The pre-campaign respondents (n = 556) were drawn from the different academic years of medical school. As shown in Figure 1, pre-campaign students self-reported their academic year as follows: First Year students: 94 (16.9%); Second Year: 122 (21.9); Third Year: 13 (2.3%); Fourth Year: 75 (13.5%); Fifth Year: 99 (17.8%); and Sixth Year: 84 (15.1%); at the same time, 69 (12.4%) students preferred not to state their academic year. The post-campaign 95 students self-reported that their academic year was as follows: First Year students: 2 students (2.1%); Second Year: 5 (5.3%); Third Year: 2 (2.1%); Fourth Year: 40 (42.1%); Fifth Year: 12 (12.6%); and Sixth Year: 28 (29.5%); at the same time, 6 (6.3%) students did not state their academic year (Figure 1). The majority of pre-campaign respondents were from the Second Year, while the majority of post-campaign respondents were from the Fourth Year.

In Section I of the questionnaire, Question 1, the students are asked about whether they heard about research courses being offered in the university. As shown in Table 1, slightly more than half (54.1%) had heard about the research courses before, but only 11.3% of them had attended any of them. In Question 2, they were asked whether they know the meaning of RCR, and less than half (47.8%) answered “Yes,” with the majority of their knowledge acquired from the internet (42.6% of those who answered “Yes”). In
Question 3, they were asked whether they participated in research projects other than those assigned by college/school, and a minority (20.5%) answered "Yes," with most of them participating as a data collector (34.5% of those who answered "Yes").

Section II asked whether the students knew about research ethics and RCR, and where they acquired this knowledge. As seen in Table 2, regardless of the question asked, a minority of the students (14.1% to 42.6%) knew about the seven topics that were asked (plagiarism, fabrication and falsification, peer review, conflict of interest, animal welfare, Belmont Report, IRBs). Among those who said they knew and answered "Yes," the majority said that they acquired their knowledge from reading a book, article, or paper (38.5 to 54%), except for the questions asking about the Belmont Report and IRBs, where the majority indicated that they knew about them from their college curriculum (70.2% and 44%, respectively). However, after attending the education campaign the proportion of those who responded "Yes" increased significantly as compared to their pre-campaign responses (all p < .001) as can be seen in Figure 2.

Section III of the questionnaire assessed whether respondents understood how to recognize or apply seven principles of RCR through multiple-choice questions (research misconduct, authorship, acknowledgments, peer-review, mentorship, data sharing, and conflict of interest). Our results showed that pre-campaign respondents had fewer correct answers, more incorrect answers, and more students who “don’t know,” compared to their responses after the three-day campaign. Figure 3 shows the pre-
and post-campaign results where the aggregate students’ responses before and after the three-day campaign were compared side by side. Panel A shows the percentage of students who answered correctly before and after the campaign, where there was a significant increase in the proportion of students who answered correctly for the following concepts: research misconduct, \( p = .03 \); authorship: \( p = .001 \); peer-review: \( p = .002 \); mentorship: \( p < .001 \); data sharing: \( p < .001 \), and a slight though nonsignificant improvement in the concepts of acknowledgments: \( p = .11 \) and conflict of interest: \( p = .71 \). Panel B shows the percentage of students who answered “don’t know,” and there was a significant drop in the proportion of students who did not know the answer after the three-day campaign (all \( p < .001 \)). Despite the increase in percentage of students who answered correctly, the improvement was not as much as anticipated. For example, other than the post-campaign percentage of correct answers about

### Table 1. Pre-campaign questionnaire assessment of medical students’ awareness about scientific research and responsible conduct of research (RCR) in general, and source of that knowledge (Section I of the questionnaire).  

| Section I: Awareness about scientific research and RCR in general | N (%)* | Sources of that knowledge | n (%)# |
|---|---|---|---|
| Q 1. Have you heard about research courses before? (Total responders, \( N = 556 \)) | | | |
| a. No | 255 (45.9) | | |
| b. Yes | 301 (54.1) | Did you attend any of them? | |
| i. I attended | 63 (11.3) | | |
| ii. I did not attend | 238 (79) | | |
| Q 2. Do you know the meaning of responsible conduct for scientific research? (Total responders, \( N = 550 \)) | | | |
| a. No | 287 (52.2) | If yes please identify the source | |
| b. Yes | 263 (47.8) | i. The internet only | 112 (42.6) |
| | | ii. Textbooks only | 8 (3.0) |
| | | iii. College curriculum only | 58 (22.1) |
| | | Two or more sources | 76 (28.9) |
| | | iv. Others | 9 (3.4) |
| Q 3. Did you participate in research projects other than those assigned by college/school? (Total responders, \( N = 551 \)) | | | |
| a. No | 438 (79.5) | If yes, what was your main role in it? | |
| b. Yes | 113 (20.5) | i. Principal researcher | 23 (20.4) |
| | | ii. Assistant researcher | 23 (20.4) |
| | | iii. Data collector | 39 (34.5) |
| | | iv. Data analyzer | 18 (15.9) |
| | | v. Paper drafting | 9 (8.0) |
| | | vi. Other | 1 (0.9) |

* Percentage of responders among total number of responders for each question.  
# Percentage of responders among those who responded “Yes.”
### Table 2. Pre-campaign baseline assessment of medical students’ awareness about principles of research ethics and responsible conduct of research (RCR), and sources of that knowledge (Section II of the questionnaire).

| Section II: Assessing the level of awareness about principles of research ethics and RCR | N (%)* | Sources of that knowledge | n (%)# |
|---|---|---|---|
| Q4. Do you know about plagiarism? (Total responders, N = 535) | 458 (85.6) | a) Reading a book/article/paper | 33 (42.9) |
| a. No | b) College curriculum | 15 (19.5) |
| b. Yes | c) Attending research course/conference | 12 (16.9) |
| | Two or more sources | 6 (7.8) |
| | d) Others…. | 10 (13.0) |
| Q5. Do you know about fabrication and falsification in research? (Total responders, N = 532) | 330 (62.0) | a) Reading a book/article/paper | 96 (47.5) |
| a. No | b) College curriculum | 58 (28.7) |
| b. Yes | c) Attending research course/conference | 18 (8.9) |
| | Two or more sources | 9 (4.5) |
| | d) Others…. | 21 (10.4) |
| Q6. Do you know about peer review? (Total responders, N = 527) | 449 (85.2) | a) Reading a book/article/paper | 30 (38.5) |
| a. No | b) College curriculum | 20 (25.6) |
| b. Yes | c) Attending research course/conference | 16 (20.5) |
| | Two or more sources | 6 (7.7) |
| | d) Others…. | 6 (7.7) |
| Q7. Do you know about conflict of interest? (Total responders, N = 524) | 301 (57.4) | a) Reading a book/article/paper | 99 (44.4) |
| a. No | b) College curriculum | 74 (33.2) |
| b. Yes | c) Attending research course/conference | 24 (10.8) |
| | Two or more sources | 16 (7.2) |

(Continued)
### Table 2. (Continued).

Section II: Assessing the level of awareness about principles of research ethics and RCR

| Q8. Do you know about the Animal Welfare Act? (Total responders, N = 525) | N (%) | Sources of that knowledge | n (%) |
|---|---|---|---|
| a. No | 401 (76.4) | d) Others... | 10 (4.5) |
| b. Yes | 124 (23.6) | a) Reading a book/article/paper | 67 (54.0) |
| | | b) College curriculum | 19 (15.3) |
| | | c) Attending research course/conference | 7 (5.6) |
| | | Two or more sources | 8 (6.5) |
| | | d) Others... | 23 (18.5) |

| Q9. Do you know about the Belmont Report (Total responders, N = 532) | N (%) | Sources of that knowledge | n (%) |
|---|---|---|---|
| a. No | 448 (84.2) | d) Others... | 2 (2.4) |
| b. Yes | 84 (15.8) | a) Reading a book/article/paper | 13 (15.5) |
| | | b) College curriculum | 59 (70.2) |
| | | c) Attending research course/conference | 3 (3.6) |
| | | Two or more sources | 7 (8.3) |
| | | d) Others... | 2 (2.4) |

| Q10. Do you know about Institutional Review Boards (IRB) (Total responders, N = 535) | N (%) | Sources of that knowledge | n (%) |
|---|---|---|---|
| a. No | 457 (85.9) | d) Others... | 3 (4.0) |
| b. Yes | 75 (14.1) | a) Reading a book/article/paper | 19 (25.3) |
| | | b) College curriculum | 33 (44.0) |
| | | c) Attending research course/conference | 17 (22.7) |
| | | Two or more sources | 3 (4.0) |
| | | d) Others... | 3 (4.0) |

* Percentage of responders among total number of responders for each question.
# Percentage of responders among those who responded “Yes.”
knowledge in peer-review (68%), mentorship (89%), and data sharing (86%), all the other concepts were answered correctly by only two-thirds or less of the students despite just completing a three-day educational campaign. Furthermore, a significant improvement in the percentage of students answering correctly was noted in only five of the seven concepts, with only a mild nonsignificant improvement in the remaining two.

**Discussion**

A study conducted in the United States revealed that international graduate students in the biomedical sciences had insufficient knowledge about the principles and concepts of RCR (Heitman et al., 2007), and teaching research ethics and the responsible conduct of science to undergraduate students resulted in a significant improvement in their RCR knowledge (Plemmons and Kalichman, 2007). While certain Middle Eastern countries, such as Saudi Arabia, included research ethics in the curriculum of several public medical colleges, it has been noted that the program lacks standardization in teaching and evaluation methods (Alkabba et al., 2013). Although courses and workshops of RCR are being embraced worldwide (Clements et al., 2013), academic education about RCR in Egyptian medical schools remains weak. In this regard, the present study was conducted at Ain Shams University to assess the level of RCR knowledge among Egyptian medical students. In addition, we conducted a three-day educational awareness campaign and assessed the knowledge gained due to their participation in the campaign.
In the present study, we assessed the level of awareness about RCR and research ethics in medical students before and after a three-day educational awareness campaign that utilized different teaching methods including interaction, discussion, communication, and printed materials. The pre-campaign results showed an inadequate awareness of the concepts of research ethics and RCR among medical students. They were not sufficiently aware of the meaning of plagiarism and research misconduct. After attending the RCR campaign, the percentage of students who reported understanding the meaning of plagiarism increased from 14.4% before the campaign to 88.4% after

![Figure 3](image-url). Assessment of the awareness about research ethics and responsible conduct of research (RCR) among pre-campaign and post-campaign respondents. Bars and percentages of pre-campaign (n = 556) and post-campaign (n = 95) respondents who answered the questions about research ethics and RCR correctly, after exclusion of those who responded “don’t know” (Panel A). Bars and percentages of pre-campaign (n = 556) and post-campaign (n = 95) questionnaire respondents who answered “don’t know” to the questions about research ethics and RCR (Panel B).
attending it (Figure 2). This significant improvement occurred in almost all tested items in the questionnaire suggesting that a short three-day workshop teaching RCR to students can be effective.

In our study, we found that 62% of the students did not understand fabrication or falsification at baseline, which was similar to a study in Norway that showed that 65% of doctoral students had no experience about scientific dishonesty and had not heard about data manipulation (Hofmann, Myhr, and Holm, 2013). Also in our study we found that only 14.8% of the pre-campaign respondents were aware of peer-review publication or its importance as a way to share research findings with the scientific community. Discussions during the three-day campaign revealed how very few students who conducted research sought to publish their findings. This was similar to a recent study conducted in Cameroon where they found that only 22 articles were published out of 180 biomedical theses studying HIV, with a rate of .17 articles per thesis (Munung, Vidal, and Ouwe-Missi-Oukem-Boyer, 2014). Conversely, another study conducted in Peru showed that 80% of students’ theses were published and the students were the first author in 83.5% of the published articles (Arriola-Quiroz et al., 2010). These contrasting findings may reflect different factors including a lack of awareness about the importance of peer-reviewed publications, lack of mentor support, and/or a low confidence among students in their ability to write in English (Bullen and Reeve, 2011).

In this study, the students had a significant increase in their awareness of the term “conflict of interest” with an increase from 42.6% of the pre-campaign respondents to 95.8% of the post-campaign respondents ($p < .001$) (Figure 2). However, when we tested them to determine if they were able to identify situations in which conflicts of interest exists, the improvement was minor (57.9% to 60.7%, $p = .71$) (Figure 3). A strong understanding of this concept is essential given that undeclared conflicts may intentionally or unintentionally result in biased research or even scientific misconduct (Masic, 2012). This was noted by a French study that assessed the level of awareness of conflict of interest among more than two thousand medical students and found that although 64.6% of the students were aware of the concept of conflict of interest they failed to correctly identify situations in which it existed (receiving a gift, being offered a meal, being invited to a conference) (Etain et al., 2014). These subtle perks are commonly provided by pharmaceutical companies, and while laws have been adopted in the United States, France, and other countries to regulate ties between physicians and the pharmaceutical industry, similar laws have yet to be implemented in Egypt. Hence, medical students in Egypt may be unaware that these small favors constitute a conflict of interest, and additional education is needed on this topic.
While various regulations pertaining to the use of animals in research, such as the Animal Welfare Act, began in the United States in the mid-1960s, developing countries still lack similar specific regulations and polices (Rahman, Walker, and Ricketts, 2005). This is particularly relevant in Egypt, where medical students use laboratory animals (mice, rats, and rabbits) in the laboratory (physiology, anatomy, etc.). In the present study, only 23.6% of the pre-campaign respondents were aware of the existence of laboratory regulations, but that percentage increased to 91.6% among post-campaign students. Our results were consistent with a study conducted in Brazil among students studying Biology, Pharmacology, Medicine, and Veterinary Medicine that showed that undergraduate and graduate students were unaware of laboratory welfare regulations (Deguchi, Molento, and De Souza, 2012). Our findings demonstrated that it is essential to teach Egyptian students about the principles of utilization and care of laboratory animals, as has been suggested elsewhere (VandeWoude, 2007).

The paucity of regulations for human subjects protection and the weak capacity of IRBs/research ethics committees in low and middle income countries is of particular concern, given how clinical research has increased markedly in the last decade, particularly in the Middle East (Hyder et al., 2009; Normile, 2008; Mansour et al., 2015). To determine medical students’ level of awareness regarding the participation of human subjects in clinical research, such as the content of the Belmont Report and the role of the IRB, we found only 15.8% and 14.1% of the pre-campaign respondents were aware of the Belmont Report and IRB, respectively. After attending the RCR campaign, their percentage of awareness increased to 74.7% and 55.8%, respectively. Despite this significant increase in their awareness about the role of the IRB after attending the RCR, it was still quite low (55.8%) and demonstrates how research ethics principles may be difficult to adequately understand and internalize after a brief workshop. Hence, research ethics education should become an essential component of academic classes in Egyptian medical schools, where interactive discussions can be held using examples from local research ethics violations, and students should be encouraged to attend IRB meetings where they can witness how protocols are discussed and reviewed.

We would like to mention several limitations to our study. First, we acknowledge the exploratory nature of this study, and hope that it will encourage other researchers and educators to replicate it. Second, we recognize that the students enrolled into this study were self-motivated to answer the questionnaires and attend the three-day workshop, and that the students not enrolled may have different responses. However, we would expect that those who enrolled were interested in research and likely to be even more informed than those who did not enroll, thereby suggesting that our findings are probably an overestimate of the true
level of awareness among medical students. We also acknowledge that the quasi-experimental study design and the pre- and post-campaign anonymous aggregate responses did not allow for a finer granular assessment of individual improvement among those who attended the campaign. However, we were concerned that requiring students to identify themselves could have reduced attendance significantly, and led to an even less representative student body. Now that we know that participation is likely to be high, we plan to conduct subsequent studies with identifiable subjects so that we can determine the improvement in each person’s level of knowledge after attending the workshop. We realize that the use of the same questionnaire in the pre- and post-campaign assessments may give a false impression of an improvement in the responses since the students would have been exposed to the same questions twice and became more aware of the RCR terms in the questions. However, this familiarity could not have resulted in the significant increase in awareness and correct responses that we found in the post-campaign responses. In addition, we now realize that although the questionnaire allowed us to assess the student’s awareness about some basic concepts of research ethics and RCR, it did not allow us to determine whether the students gained sufficient knowledge to recognize actual situations in which these concepts were applied.

We would also like to point out several strengths to our study including the large sample size and the significant improvement in the responses before and after the campaign. Furthermore, since our questionnaire was administered immediately before and after the campaign, we were able to truly assess the effectiveness of the campaign itself since the students would not have had an opportunity to gain knowledge from other sources. Finally, we were successful in enrolling students from all the six years of medical school. However, we could not explain why most of the campaign attendees and post-campaign respondents were predominantly from the fourth year of medical school, and perhaps it was only due to chance. However, we can speculate that since the fourth year is the first year of the student’s three-year clinical curriculum, it is possible that having interacted with patients directly they are now more motivated to better understand issues related to research ethics and RCR. Unfortunately, we were not able to investigate this increased fourth year attendance further since we only became aware of it after the end of the post-campaign assessment.

Current training efforts in Egyptian medical schools are still insufficient mainly because they are restricted to specific lectures or seminars, whereas a true integration into the curriculum where examples of RCR and research ethics get incorporated into all subjects throughout all six academic years is still lacking. This further suggests the need for increasing and standardizing the teaching of RCR to medical students in the Middle
East, including in Egyptian medical schools. Furthermore, ongoing and sustainable training is essential for students to internalize and apply the concepts and principles of RCR.

**Conclusion**

The results from our study demonstrated that there is a low level of knowledge about RCR among medical students, and the significant increase in their level of awareness and understanding after attending an educational awareness campaign about RCR suggests that placement of specific courses in their curricula can be a successful tool to teach them about the responsible conduct of scientific research. Based on our study findings, it is clear that the introduction of a robust RCR training program into current curricula of medical schools in Egypt is essential. The education of all medical students in these essential elements of RCR will ensure that future generations of clinician researchers will be able to conduct high-quality ethical research that benefits their population in particular, and contributes meaningfully to the research community worldwide.

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