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EVOLUTION AND MEDICINE

Awareness and Acceptance of Evolution and Evolutionary Medicine Among Medical Students in Pakistan

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Abstract Evolutionary medicine is a perspective on medical sciences derived through application of theory of evolution to aid in therapeutics. This study sought to determine the level of knowledge and acceptance of evolutionary theory in medical students along with their attitude toward teaching evolutionary medicine as a part of their undergraduate course. Factors that are likely to cause difficulty in teaching evolutionary medicine were also identified. A cross-sectional study was carried out at Army Medical College, National University of Sciences and Technology, Pakistan in which 299 medical students were selected by nonprobability convenient sampling technique to participate in the study. Participants' views were obtained by a structured questionnaire comprised of three sections: appreciation of evolutionary medicine, acceptance of evolutionary theory, knowledge of evolutionary theory. Medical students had a low acceptance [mean measure of acceptance of theory of evolution (MATE)=58.32] and a low knowledge (mean score of 5.20 out of a total ten marks). Students believed that religious beliefs, lack of resources, and an existent extensive medical curriculum would cause difficulty in imparting such an education despite its potential to improve medical research and clinical practice. Only 37.2% agreed that the subject should be taught in medical schools as an individual subject.

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Introduction

Charles Darwin's highly acclaimed theory of natural selection (1859) has not only served as the unifying principle in biology but also explains and provides new breakthroughs in the fields of psychology (Simonton 1999), medicine (Nesse et al. 2009), and even robotics (Floreano and Keller 2010). From being the key concept behind self-evolving robots to expounding our learning and cognitive abilities, often dubbed as the "evolved abilities," the ramifications of Darwin's theory are indeed anything but limited.

Even though one of the foremost fields to benefit from this theory was medicine, the extent of the practical application had been rather limited until recently when it has been employed to elucidate various physiological and pathological conditions, and is being increasingly referred to as "evolutionary medicine" or "Darwinian medicine" (Nesse et al. 2009). Evolutionary medicine is a perspective on medical sciences derived through application of theory of evolution to aid in therapeutics. Whereas the traditional view on medicine deals with mechanistic and physical explanations for health and disease, evolutionary medicine explains these phenomena as adaptive behaviors (Nesse et al. 2006). The implications of this novel discipline extend to both clinical and basic medical sciences.

Considering its obvious significance, it seems rather an oversight that evolutionary medicine has still not been incorporated into the medical curriculum (Nesse and Schiffman 2003), and in general, medical students are not taught evolutionary origins of various physiological and

pathological phenomena such as diarrhea, fever, cancer and aging. This matter was discussed at the Sackler Colloquium of the National Academy of Sciences' "Evolution in Health and Medicine," held on the 2nd and 3rd of April 2009, at the National Academy of Sciences in Washington, D.C. Papers (Nesse et al. 2009) published as a result of such discussions reiterated the importance of evolutionary biology in medicine and recommended inclusion of evolutionary medicine in premedical, medical, and specialized courses, as a separate course or in the form of a few chapters included in the textbooks already being taught. Academics behind such efforts have time and again commended evolutionary medicine for its immense integrative power.

The introduction of evolutionary medicine in the classroom, however, is not a simple task. The obvious difficulty is the controversy about the validity of the theory of evolution itself, let alone its specialized applications. Despite its explanatory power, the theory has received widespread disagreement and resistance all over the world. A discouraging situation is present in the U.S. where only 40% agree with the naturalistic view of evolution (Miller et al. 2006). In a study undertaken in Turkey, the only Muslim country where any such study has been conducted, the acceptance rate is a mere 25% (Miller et al. 2006). Considering the fact that Turkey is one of the most educated Muslim countries, one can expect the acceptance in rest of the Islamic world to be much lower. According to another study targeted at Muslim populations, it was found that only 16% of Indonesians, 14% of Pakistanis, 8% of Egyptians, 11% of Malaysians, and 22% of Turks agree that Darwin's theory is probably or most certainly true (Hameed 2008). These figures reflect how far the Islamic world lags behind in appreciating evolutionary biology, let alone harnessing the complete potential of this theory. Before evolutionary medicine can be introduced in the medical curriculum, it is mandatory that students have sufficient awareness and acceptance of evolutionary theory. Considering the results of the "Islam and Evolution" research project for Pakistan (Asghar et al. 2009), 80% of students surveyed believed that "the first humans on planet Earth were created by God, not gradually, but in their present form." In circumstances like these, teaching evolutionary medicine in such a country may cause further widespread non-acceptance and opposition.

In Pakistan, evolution has been taught in high schools as part of the course of biology. Since 2006, the Pakistan Academy of Science has also become signatory to the "inter academy panel" which provides guidelines about teaching evolution in schools. The theory is included in the biology books taught in high school. Each chapter of this book—including the chapter explaining evolution—starts with a verse from Quran, the holy book of the Muslim faith. But what is taught in the class is dependent ultimately on the teacher's comprehension and approach toward the theory since the subject is not critically discussed in the book. Thus, lack of proper high school education concerning evolution causes most of the students entering medical colleges to have inadequate knowledge and misconceptions about the theory. This might limit their appreciation and application of the theory in their studies. Moreover, considering that Pakistani medical students form a significant percentage of the pool of international medical graduates (American Medical Association 2007) applying for residency in developed countries, the importance of teaching evolutionary concepts in medical colleges in Pakistan is further intensified, as the licensure exams might include questions to test knowledge of evolutionary medicine in the future, as per recommendations of Sackler colloquium.

However, any introduction of such an education needs proper evaluation of current levels of acceptance and appreciation of the evolutionary theory in medical students and also identification of the factors that might cause hindrance in imparting such education. Thus, our study aims to:

1. Assess the appreciation of evolutionary medicine among Pakistani medical students if it is introduced in the medical curriculum
2. Identify the importance of various factors that in view of the students might cause problems in imparting such education
3. Identify the level of acceptance of the theory of evolution in medical students of Pakistan
4. Identify the level of knowledge of the theory of evolution in medical students of Pakistan

Methods

Participants

Study participants were undergraduate medical students enrolled in Army Medical College (AMC), National University of Sciences and Technology, Rawalpindi, Pakistan in November 2010. Students from all five years of the MBBS were included in the study, and out of the total 800 medical students in the college, 299 students participated in the study. The sampling technique used was nonprobability convenient-size sampling.

Materials and Procedures

A cross-sectional study was carried out using a structured questionnaire-based survey. Approval was first obtained from the ethical committee of AMC for undertaking the study.

We distributed 800 copies of the structured questionnaire among the students. Students were allowed to complete the questionnaires at their ease and told to put the completed forms in a locked box placed inside each class. Students were told beforehand that it is not mandatory to complete the questionnaire; therefore, their completing the form would imply that they are consenting to be a part of the study. We received 299 completed forms, of which 271 were processed via SPSS version 18. Twenty-eight forms were excluded on the basis of an exclusion criterion: a question in the questionnaire that asked the participant not to mark any option. If this question was marked, indicating that student is marking without reading the questions, the questionnaire was excluded from the study.

Design of the Questionnaire

The questionnaire consisting of a total of 40 multiple choice questions was divided into three parts: to evaluate the participant's knowledge, his/her acceptance of the evolutionary theory, and his/her stance toward teaching evolutionary medicine as a part of the curriculum of the medical college. Participants were also asked one question in the first section about the factors which he/she thinks would affect teaching of evolutionary medicine in medical schools.

Attitude Toward Evolutionary Medicine

This part consisted of a short passage adapted from the book *Evolution in Health and Disease* (Stearns and Koella 2008) introducing the participants to evolutionary medicine, followed by nine questions asking their opinion about the scope of evolutionary medicine. The first eight questions consisted of three options (yes, no, do not know) and the last question asked the participant to choose two factors from a list which in their opinion would cause the most difficulty in introducing evolutionary medicine in the MBBS curriculum.

Acceptance of Theory of Evolution

For this part, a standard instrument (Rutledge and Sadler 2007) developed by Michael L. Rutledge and Kim C. Sadler was used with permission from the authors. The instrument comprises twenty questions, each of which has five options: strongly agree, agree, undecided, disagree, and strongly disagree. The answers are graded on the Likert's scale from 20 to 100, with 100 being highest acceptance. The resulting scores are divided into five categories, described in Table 1. Cronbach's Alpha score for this part came out to be 0.873 for the sample size taken. Therefore, the instrument was highly reliable for use in the present study.

Knowledge of Theory of Evolution

The last section comprised ten questions, testing participants' knowledge of the theory of evolution. The structured questionnaire was based on one developed for U.S. high school students by Rutledge and Mitchell (2002). The original questionnaire has 20 questions; however, for the sake of simplification, questions with repeating concepts were removed, reducing the number of questions to ten to increase the response rate. The questions included are listed in Table 2. Each question is followed by five options with one right answer. The modified instrument was not reevaluated for validity and reliability by the authors.

Results

Of the 299 questionnaires collected, 28 were excluded using our exclusion criterion (explained earlier). After the exclusion process, results were computed from 271 surveys. Since the required sample size was 260 participants, our results are representative of medical students from AMC with 95% confidence. Among these 271 participants, 119 were males and 152 females. Distribution according to the year of study and age is described in Table 3.

Attitude Toward Evolutionary Medicine

In the first section, we set up eight questions asking the participants about their opinion regarding the scope of evolutionary medicine. After a brief introductory passage, participants were asked if they knew about evolutionary medicine already: The majority (61%) did not know about evolutionary medicine before reading the passage. Some participants (63.2%) did not think that evolutionary medicine is already being taught in Pakistan's medical colleges, and 74.3% of the students agreed that evolutionary medicine—if taught to medical students—would improve medical research, but a similar question regarding clinical practice did not receive a similar response (50.2% agreed). Also, 62.1% agreed that awareness programs should be arranged to popularize this science. When asked if evolutionary medicine should be taught as a basic medical science, 37.2% agreed, with 46.8% in disagreement and 16% undecided. However, this percentage (37.2%) increased to 43.5% when participants were asked if Pakistan should add evolutionary medicine in the BMS curriculum if Western countries do so too.

Factors Affecting Teaching of Evolutionary Medicine

When asked to choose from a list factors that might cause difficulty in teaching evolutionary medicine, 26.4% be-

Table 1 Categorization of MATE scores

Category	Very low acceptance	Low acceptance	Moderate acceptance	High acceptance	Very high acceptance
Score	20–52	53–64	65–76	77–88	89–100

lieved that religious issues would cause most difficulty and 24.7% believed that the current medical curriculum is already too lengthy to incorporate evolutionary medicine in it. 22.5% believed that there is a lack of resources for imparting such an education. Other minor factors were also identified (Fig. 1).

Acceptance of Evolutionary Theory

In the "Methods" section, we quantitatively assessed the participant's acceptance using the measure of acceptance of theory of evolution (MATE) instrument. The mean MATE score for this sample space was 58.32 (SD=11.72), which has been categorized as low acceptance by authors of the MATE. The highest-scoring group (the mode) was "low acceptance," with 94 participants (34.94% of the sample size). The category with the second-highest number of participants was of "very low acceptance," with 34.57% of the sample size falling in this category. While 23.79% had "moderate acceptance," 6.69% had "high acceptance," and none of the participants had "very high acceptance" (Fig. 2).

One question from the MATE instrument specifically dealt with religious beliefs about evolution and to assess how they affected participant's acceptance of the theory of evolution. In this question, participants were asked whether they agreed with the statement that "the theory of evolution cannot be correct since it disagrees with Quranic/biblical account of creation." While 68.1% of the participants agreed with this statement, 41.3% disagreed and the rest remained undecided. They were also asked that how many of them didn't see any contradiction between Quran/Bible and the theory. Only 11.5% saw no contradiction.

Knowledge of Evolutionary Theory

The last section of the questionnaire comprises ten questions that tested the participant's knowledge of the theory of evolution, irrespective of whether they agreed with it or not. Since a modified instrument which was not revaluated by the authors was used in this section, these should only be considered a "field study." Results of the "knowledge" section revealed that the students had a low level of knowledge about evolutionary theory, with a mean score of 5.20 (SD=1.85) out of a total score of ten. None of the participants scored ten marks. These results are displayed in Fig. 3.

A majority (94.1%) of the participants knew that meiosis is responsible for introducing genetic variability during sexual reproduction. Students were not aware of the process of evolution, as only 8.9% knew that the best phrase to describe evolutionary process is "change in population through time." A lesser number of students (30.1%) believed that evolution is change from simple to complex animals, while 31.6% of participants thought that evolution is development of characteristics in response to need. Participants were aware of the Lamarckian theory of evolution, and 61.0% correctly identified it as *inheritance of acquired characteristics*, while 28.6% of participants falsely believed that Lamarckian theory is *survival of the fittest*. A majority of participants (61%) correctly identified homologous structures as "structures that are similar due to common ancestry." In one question, participants were asked to identify that the first animals to migrate from water to land had characteristics with which they could partially survive in water; 65.1% of the participants identified it correctly. Participants were also tested on how well they could apply evolutionary theory to explain some phylogenic relationship of various species. They were asked about the explanation for similar characteristics between marine mammals and fishes. The correct answer — "Marine mammals adapted to an environment similar to that of fishes" — was chosen by 56.1%. Participants were then asked to apply their evolutionary biology concepts once again by asking them to choose the perfect life history from a list of hypothetical life histories which would be best suited for survival. A moderately high number (59.5%) picked the perfect life history for an organism by identifying that the organism with greater number of offspring, from which a larger proportion can survive to breed, is better suited for survival. Radiometric dating techniques were poorly understood by the participants, as only 14.9% of the participants knew that these rely on the fact that "the earth contains elements that change into other elements at a constant known rate." When asked about the relationship between Darwin's work and Mendelian genetics, 40.9% of the participants knew that Darwin could not fully explain his theory of natural selection because Darwin was not aware of Mendelian genetics, while 25.7% of participants wrongly attributed it to lack of biochemical techniques at that time. About half of the participants (57.2%) knew that the fossil record is evidence for large-scale evolution.

Table 2 Questions from the knowledge section along with results

		Column *N*%
Q30. Individuals within a species tend to be genetically different. The primary mechanism generating this individual variability is	**a. Meiosis**	94.1%
	b. Mitosis	1.9%
	c. Polyploidy	1.5%
	d. Duplications	.4%
	e. Asexual Reproduction	1.1%
	f. Not attempted	1.1%
Q31 Which of the following phrases best describes the process of evolution?	a. The development of humans from monkey like ancestors	4.1%
	b. The change of simple t complex animals	30.1%
	c. The development of characteristics in response to need	31.6%
	d. Change in populations through time	8.9%
	e. The change of populations solely in response to natural selection	23.8%
	f. Not attempted	1.5%
Q32. Which of the following best represents Lamarck's ideas on the evolutionary process?	a. Survival of the fittest	28.6%
	b. Inheritance of acquired characteristics	61.0%
	c. Neutral drift	3.7%
	d. Punctuated equilibrium	1.5%
	e. Assortive mating	1.5%
	f. Not attempted	3.7%
Q33. The wing of the bat and the forelimb of the dog are said to be homologous structures. This indicates that	a. They have the same function	6.7%
	b. Bats evolved from lineage of dogs	2.2%
	c. They are structures that are similar due to common ancestry	62.5%
	d. The limb bones of each are anatomicaly identical	8.9%
	e. They have a different ancestry but a common function	17.5%
	f. Not attempted	2.2%
Q34. The first animals to settle on land probably had which of the following charactersitics?	a .They were quite mobile to escape from predators	3.7%
	b. They were partially dependent on water for survival	65.1%
	c. They were capable of completely adapting to the terrestrial environment in their life span	17.5%
	d. They had wings for flight from one habitat to another	3.0%
	e. They were able to feed on terrestrial plants	8.2%
	f. Not attempted	2.6%
Q35. Marine mammals have many structural characteristics in common with fishes. The explanation that evolutionary theory would give for this similarity is	a. Fish and mammals are closely related	12.6%
	b. Fish evolved structures similar to those already existing in mammals	3.3%
	c. Marine mammals evolved directly from the fishes	22.7%
	d. Marine mammals never developed the use of limbs	2.2%
	e. Marine mammals adapted to an environment similar to that of fishes	56.1%
	f. Not attempted	3.0%
Q36. Radiometric dating techniques rely on the fact that	a. The bony portions of organisms decompose at a known rate	14.9%
	b. Organisms that lived earlier in time will tend to be found in sediments below organisms that lived more recently	34.9%
	c. The magnetic field of the earth has reversed its polarity at known intervals in geological time	7.1%
	d. The earth contains elements that change into other elements at a constant known rate	14.9%
	e. During the decomposition process organic matter is converted into radioactive elements at a known rate	21.6%
	f. not attempted	6.7%
Q38. When first proposed, Darwin's theory of natural selection did not fully explain how evolution could occur. This was due to	a. Darwin's failure to recognize that organisms could overreproduce	4.8%
	b. Darwins initail overemphasis of the significance of genetic drift	8.2%
	c. The fact that Darwin was unaware of Mendelian genetics	40.9%

Table 2 (continued)

		Column *N*%
	d. The absence of accurate knowledge of embryology	15.6%
	e. The absence of biochemical techniques to determine the genetic similarities between species	25.7%
	f. Not attempted	4.8%
Q39. The life histories of five birds of the same species are listed below. The most evolutionary successful bird is the one that	a. Live 5 years, lays 12 eggs in a lifetime, 4 hatch and survive to breed	8.2%
	b. Live 4 years, lays 8 eggs in a lifetime, 5 hatch and survive to breed	7.4%
	c. Live 6 years, lays 2 eggs in a lifetime, 2 hatch and survive to breed	14.1%
	d. Live 4 years, lays 7 eggs in a lifetime, 6 hatch and survive to breed	59.5%
	e. Live 5 years, lays 4 eggs in a lifetime, 3 hatch and survive to breed	4.1%
	f. Not attempted	6.7%
Q40. The most compelling evidence for large-scale evolutionay change, or macroevolution, is	a. Kettler's release-recapture experiment with peppered moth	7.4%
	b. The fossil record	57.2%
	c. The occurence of mass extinctions	9.3%
	d. Domestication of plants and animals	5.6%
	e. The observed increase of mutation rates across all species	15.6%
	f. Not attempted	4.8%

Choices in **bold** indicate correct answer

Discussion

With the increasing significance of evolutionary concepts in medicine (Nesse et al. 2006), it is important to know how the Muslim medical community in general, and Pakistan's medical students in particular, are receptive to such an education. Although our sample was not representative of all the medical students in Pakistan, it still provides useful insight into this underresearched subject. The aim here was to provide a descriptive picture of appreciation of evolutionary medicine in a population of Pakistani medical students along with their awareness and acceptance about the theory of evolution, since these are hypothesized to affect the receptiveness of the student toward evolutionary medicine.

The results show that medical students have a low acceptance (mean MATE=58.32) of evolutionary theory, which corresponds with the low acceptance of evolutionary theory in the general Pakistani population (Hameed 2008), Pakistani high school students (research led by the Evolution Education Research Center at McGill University), and Pakistani doctors practicing in the U.S. (Everhart and Hameed, in preparation). Since most of these studies don't use MATE to grade acceptance, a direct comparison cannot be made. However, it is interesting to note that the mean score was higher than in a study carried out on high school biology students in the U.S. (Rutledge and Sadler 2007). Despite this low acceptance, the participants of our study acknowledged that the theory is recognized to be true in most scientific circles. The majority of participants did reject the idea that humans are the product of evolution; however, lesser disagreement was observed when asked if all animals came into existence at the same time. There was very low percentage (8.2%) of respondents who believed in young Earth creationism, an observation consistent with earlier studies (Hameed, Fall Conference on Darwin and Evolution in the Muslim World 2009).

It was not our aim to answer why acceptance follows the trend it does, i.e., why Pakistani students had a low acceptance. With our results, however, we do propose two factors which affect acceptance to evolutionary theory—yet the question is open to further investigation. The first factor that we propose for low acceptance is the clash of religious beliefs with evolutionary teachings. We deduce this from

Table 3 Distribution of participants in terms of years of study and age

Distribution of participants in terms of year of study						
Class	1st year	2nd year	3rd year	4th year	5th year	Total students
Number of participants	98	80	29	22	42	271
Distribution of participants in terms of age						
Age	18–20	21	22	23–25	Above 25	
Number of participants	81	92	35	60	3	271

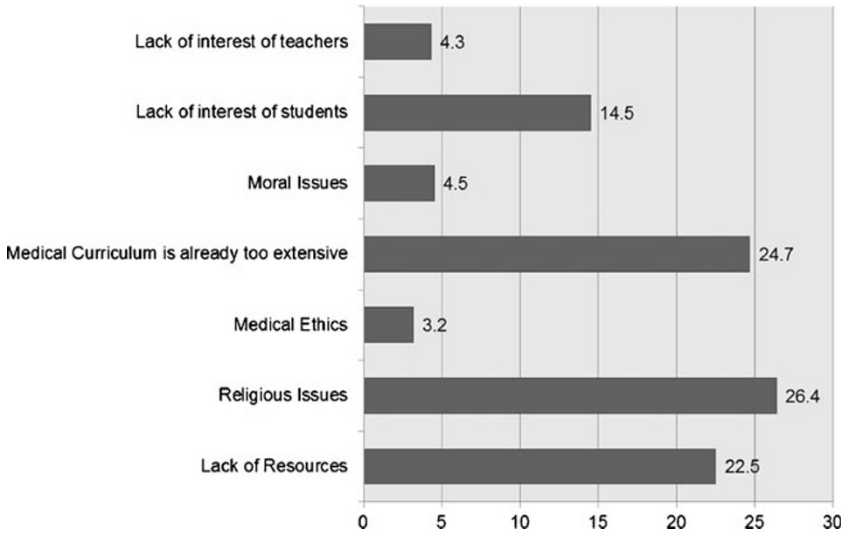

Fig. 1 Factors affecting teaching of evolutionary medicine

the finding that 68.1% of students agreed that evolutionary theory cannot be true since it disagrees with the teachings of the Quran. Thus, taking the religious sentiment of the population into account is important before introducing evolutionary medicine in the curriculum. A similar approach is taken in the current high school curriculum of Pakistan, where verses in support of the theory are included in chapters relating to evolution in the biology textbook. The efficacy of this approach nevertheless is debatable. A minority (11.5%) believed that there was no disagreement between evolutionary theory and Islamic teachings. Still, among the 88.5% who did see a contradiction, only 68.1% saw this as grounds enough to reject the theory. This provides evidence that our respondents, like the general Pakistani public are divided on the issue of religion and evolution, where they appear willing to trade off some religious views for scientific advancement and technology (Hameed, Mcgill Symposium 2009). We propose that this aspect be investigated further by grading the religiosity of the participants and taking into account their sectarian and denominational beliefs. The second reason for the low acceptance can be the lack of a thorough understanding (mean score=5.20) of the theory among the students. Although students are for the most part familiar with some evolutionary concepts, such as meiosis being the source of variability, homology of structures, and a Lamarckian idea of evolution, they do not comprehend the exact process of evolution as they confuse it with change of simple animals into complex animals and change of monkeys into humans, as per popular misconception. As the usual source of the students' knowledge regarding evolution is what they learnt in a high school biology course, their knowledge about

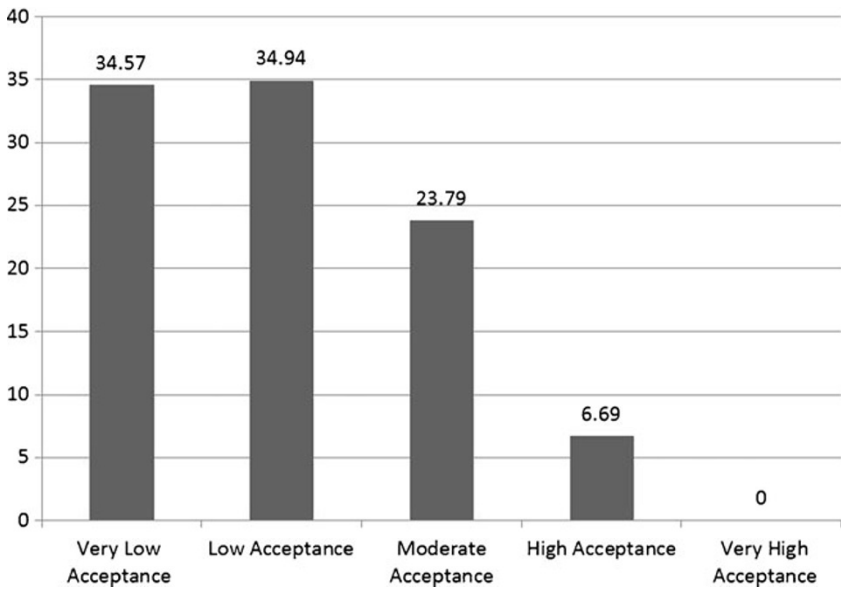

Fig. 2 Acceptance of theory of evolution categorized according to MATE scores

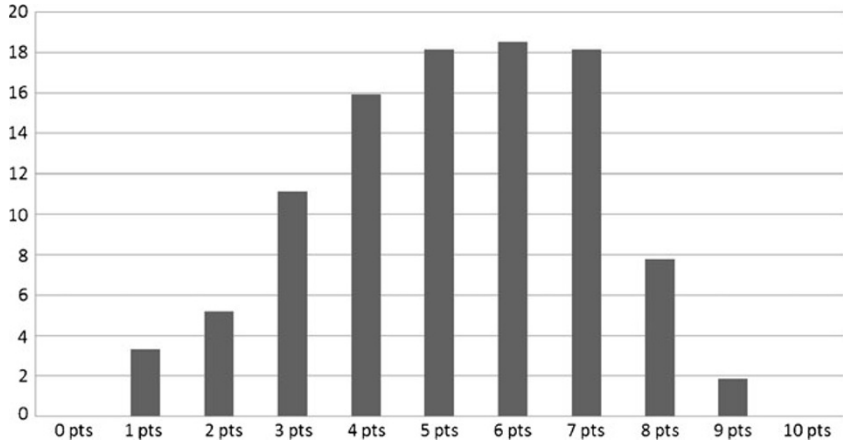

Fig. 3 Knowledge results in terms of number of questions answered

evolution is quite limited. Though the current high school curriculum in Pakistan includes comprehensive coverage of evolutionary topics including the phylogenic relationships of various organisms, one can argue that in order to improve evolutionary knowledge, high school biology curriculum needs to be amended. Since the Pakistan Academy of Sciences, being a signatory to the "IAP statement on the teaching of evolution," has already taken note of this point, further change to the curriculum would have only limited benefit. It can also be argued that since evolutionary biology does not receive appropriate emphasis by the biology teachers, (Rutledge and Mitchell 2002), their attitude toward evolutionary theory is affecting the students' knowledge. Therefore, arranging workshops to train teachers and to assess their understanding and teaching methods may improve students' knowledge of evolution.

Our results indicate that despite their low knowledge and acceptance of the theory, medical students do admit that prior knowledge of evolutionary biology would improve medical research and clinical practice (participants in our study agreed more for medical research than clinical practice). In a study carried out in the UK in 1997, 75% of the respondents from medical schools believed that evolutionary biology is relevant to training of doctors. This figure is similar to Pakistani medical students' idea that evolutionary medicine would improve medical research (Nesse and Schiffman 2003). Still, medical students do not believe that the time is yet suitable for introducing evolutionary medicine as a subject in the medical curriculum. As the medical curriculum is perceived as being too extensive already, it is probably best to integrate the subject in the current curriculum rather than introducing it as a separate subject. Also, most students agreed that such concepts are already being taught in the current curriculum. This can be attributed to the use of foreign textbooks that include paragraphs about various aspects of evolutionary medicine. Along with the lengthy curriculum, students also pointed out that lack of resources would make it difficult to teach evolutionary medicine to medical students. These include both monetary and human resources. With the health budget of Pakistan being 2.6% of the GDP (WHO 2011), the perception is correct, as diversion of already meager resources to establish new labs and teachers' training would rather be spent on other basic departments that need much improvement. The above factors may be compared to Nesse and Schiffman (2003), where deans of medical colleges in North America saw an extensive curriculum, lack of faculty, and monetary resources as the major factors that would affect teaching of evolutionary medicine. However, they did not identify religion as a significant hindrance to teaching evolutionary medicine.

The limitation of our sample size means that the study was not representative of all Pakistani medical students. Future studies with a larger sample including other medical colleges would provide a better understanding. Including other populations, such as postgraduate students and medical college faculty members' views, will provide a more wide-ranging picture. Results for knowledge of evolutionary theory from this region should be the focus for future studies as the modified instrument used in this study was not evaluated for validity and reliability. Also regression and correlation analysis of various factors and religiosity would help map the picture completely.

Conclusion

We conclude that Pakistani medical students have a low acceptance and a low knowledge of evolutionary theory. The students believed that teaching evolutionary medicine in medical schools would improve clinical practice and medical research but did not consider the present time feasible for its introduction into medical curriculum. In students' opinion, religious issues, lack of resources, and an already extensive medical curriculum would cause the most difficulty in teaching evolutionary medicine to medical students, especially in Pakistan.

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