

## Reorganization and Updating the Pharmacy Education in Egypt: A Review Study on the Transition from B Pharm to Pharm D Degree

Received: 25<sup>th</sup> July 2022  
Accepted: 23<sup>rd</sup> September, 2022  
Published: 1<sup>st</sup> October, 2022

Mohamed A. Salem<sup>1§</sup>, Shahira M. Ezzat<sup>2,3</sup>, Dalia I. Hemdan<sup>1</sup>, Ahmed Zayed<sup>4\*</sup>

<sup>1</sup>Department of Pharmacognosy and Natural Products, Faculty of Pharmacy, Menoufia University, Menoufia, Egypt

<sup>2</sup>Pharmacognosy Department, Faculty of Pharmacy, Cairo University, Cairo, Egypt

<sup>3</sup>Department of Pharmacognosy, Faculty of Pharmacy, October University for Modern Sciences and Arts (MSA), Giza, Egypt

<sup>4</sup>Department of Pharmacognosy, College of Pharmacy, Tanta University, Tanta, Egypt

DOI:10.21608/jampr.2022.152370.1043

[jampr.journals.ekb.eg](http://jampr.journals.ekb.eg)

### ABSTRACT

During the last years, pharmaceutical industry and pharmacy profession have greatly expanded worldwide because of more modernization, digitalization, and globalization. In contrast, the situation in Egypt is very complex since the pharmacists' role is still underutilized either by the community or the health care system. Based on the modern global requirements of the pharmacy profession and an official analysis of the Egyptian pharmaceutical community performed has adopted the decision of the Ministry of Higher Education (MoHE) for a transition in the pharmaceutical education in Egypt. This transition aimed at upgrading the educational and professional level of the graduates of the faculties of pharmacy. In addition, it included replacing of the current pharmacy bachelor degree (B Pharm) with the doctor of pharmacy (Pharm D) degree. The aim of this paper was to highlight the current scenario of pharmacy education in Egypt and the future challenges of pharmaceutical industry and pharmacy profession in the era of the fourth industrial revolution (FIR). Switching from B Pharm to Pharm D in Egypt is just the first step to introduce better quality of pharmaceutical education. However, the FIR may change the strategies of patient counselling, drug delivery and prescriptions dispensing to more computer-aided scenarios.

**Keywords:** Education, Fourth industrial revolution, Pharmacy, Pharm D.

## 1. INTRODUCTION

During the last years, health care systems have greatly expanded worldwide because of more modernization, digitalization, and globalization, especially after 2030 Agenda for Sustainable Development was adopted at the 2015 UN-summit, which cannot be provided without a better education

quality.<sup>1</sup> The health care system in any country aims at the promoting, restoring or maintaining health.<sup>2</sup> World health organization (WHO) defined health as “a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity”.<sup>2</sup> Healthcare providers within institutions or organizations include medical doctors, nurses, midwives, pharmacists, dentists, and all other technical staff. Pharmacist are considered an indispensable part of the health care system. As health care providers, pharmacists ensure the effectiveness, safety, proper formulation and dispensing of drugs.<sup>3</sup> As a health profession, pharmacy links both basic sciences such as biology, chemistry and mathematics and

\* Department of Pharmacognosy, Faculty of Pharmacy, Tanta University, Egypt.  
E-mail address: ahmed.zayed1@pharm.tanta.edu.eg

§ Department of Pharmacognosy and Natural Products, Faculty of Pharmacy, Menoufia University, Menoufia, Egypt  
E-mail address: mohamed.salem@phrm.menoufia.edu.eg

applied sciences such as pharmaceuticals and pharmacy practice.

The history of pharmacy dates back from The Neanderthals around 50,000 BC who use natural resources such as fossils as medicine, the medicinal records from Babylonia circa 2600 BC to the first drug store in Baghdad that was established late in the 8th century.<sup>4</sup> Later, various civilians in China, Egypt, Persia and Europe developed the role of pharmacy to maintain the health.<sup>5</sup> The concept of the “Seven-star pharmacist” was introduced by WHO considering the pharmacist “caregiver, decision-maker, communicator, manager, life-long learner, teacher, and leader”.<sup>6</sup>

The role of pharmacist has expanded in the last 30 years from dispensing to clinical pharmacy practice.<sup>7</sup> In recent years, especially in developing countries, the concept of clinical pharmacy has been introduced in many hospitals. The current research highlighted the reorganization of the pharmacy education in Egypt, where there has been a transition from the old B Pharm to Pharm D Degree with updating the courses delivered to faculty students. These updates should be in parallel with the international requirements and make the pharmacists able to perform the new duties and roles of the present responsibilities. In addition, a field analysis about the pharmacy education in Egypt, including faculties and infra-structures, was carried out. Finally, how is the influence of the fourth industrial revolution on pharmacy practice and if it will be compatible and suitable for this reorganization or not.

## 2. PHARMACY EDUCATION IN EGYPT: THE CURRENT SCENARIO

The Faculty of Pharmacy, Cairo University was the first educational institute for Pharmacy in Egypt and was founded in 1827 as the School of Medicine and Pharmacy.<sup>8</sup> The education system was based on studying pharmacy for five years after finishing the higher school directly on the basis of the marks obtained in the final exam without college capabilities and national pre-licensure exams.<sup>8</sup> Nevertheless, a new credential program has been established in some faculties to graduate clinical or patients-oriented pharmacists parallel to the industrial- and community pharmacies-oriented program. Both programs give the bachelor degree (B Pharm) in pharmaceutical sciences and pharmaceutical sciences (clinical pharmacy), respectively).

However, the pharmaceutical studies sector committee has studied the pharmaceutical education systems in Egypt, neighboring countries (e.g., Arabic, Middle Eastern and African) and developed countries in the field of pharmacy, in order to find out the need of the pharmaceutical market for pharmacists and provide valuable data helping to formulate the future plans and economic policies for pharmaceutical education in Egypt. Besides, keeping up with the pharmaceutical education system with modern global systems will allow the Egyptian graduates to compete for job

opportunities nationally and internationally in specialized pharmacy fields.

In 2000, the United States was the first country that adopted a 6-year Pharm D program instead of the five-year bachelor degree in pharmacy.<sup>9</sup> This Pharm D system focused mainly on clinical pharmacy practice through cost-effective care in pay-for-performance models for hospitals and health-systems to achieve positive patient outcomes.<sup>10</sup> Moreover, due to increasing of the global trend towards Pharm D degree educational program, other countries have transitioned from the B Pharm to the Pharm D degree, such as Canada, Hungary, Italy, Japan, South Korea, Pakistan, Saudi Arabia, Thailand, Benin, Cameroon, Republic of Congo, Senegal, Tunisia, Nigeria and Ghana<sup>9,11</sup> and finally Egypt in 2019.

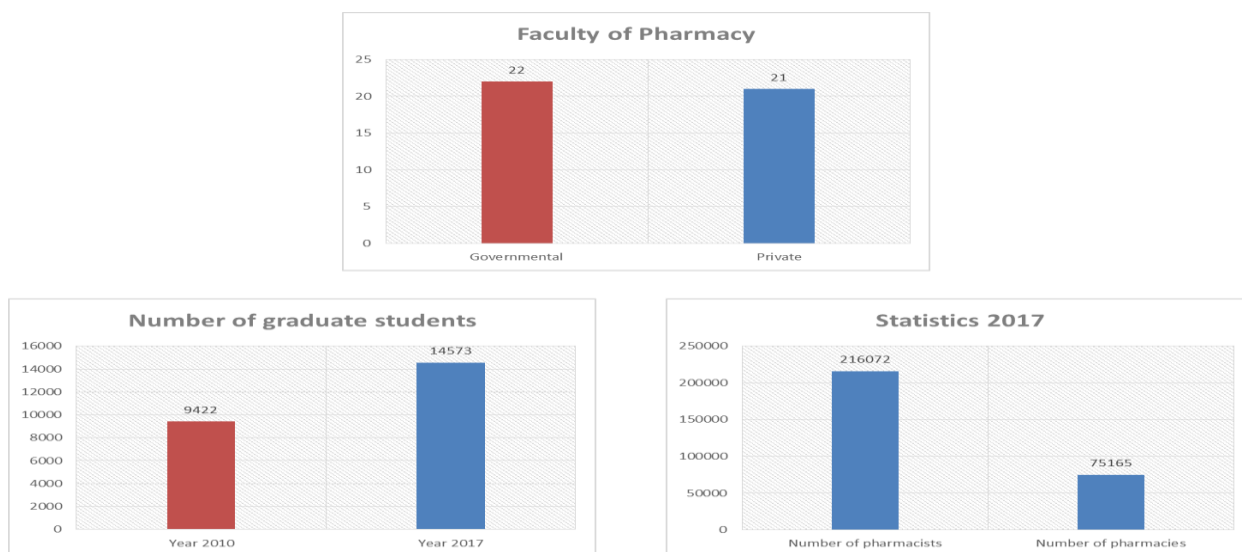
Before 2019, the Pharm D degree in Egypt was a postgraduate professional degree offered by some faculties of pharmacy. It is a professional degree after earning the B Pharm degree. For two calendar years, the postgraduates study clinical courses, such as pharmacotherapy, pharmacokinetics, hospital pharmacy and pharmaceutical care of many diseases. Therefore, the Egyptian Ministry of Higher Education (MoHE) and its pharmaceutical studies sector committee have believed that transition from 5-year B Pharm to 6-year Pharm D degree will ensure the adequacy of the education system with international systems, in addition to attracting international students to study in Egypt. The Pharm D degree will also be a prerequisite for the pharmacy profession, either a community- or industrial pharmacist or to become a clinical pharmacist.

## 3. FIELD STUDY ABOUT THE PHARMACY EDUCATION IN EGYPT

To rationalize and discuss the Egyptian decision, the need for transition, process and challenges faced the new Pharm D program, a study of the official data available at the Egyptian pharmacist syndicate in 2017, revealed significant changes in pharmaceutical market, including:

### a. Faculties and infra-structures

There were 43 faculties of pharmacy till 2017 spread in 20 of the 27 governorates in Egypt, of which 22 belong to governmental universities, including Al-Azhar University and 21 belong to private universities. In addition, there are no faculties belonging to civil universities (Figure 1). Moreover, 14 faculties (6 governmental and 8 private) have been established after 2017 increasing the number to 57 faculties in 2019. In comparison with the number of faculties before 2010, where they were only 24 faculties,<sup>12</sup> there was an increase by more than 100%. The private universities were prohibited till 1996, in which the regulations gave the permission to be established and performed their educational missions (Nour, 2017).

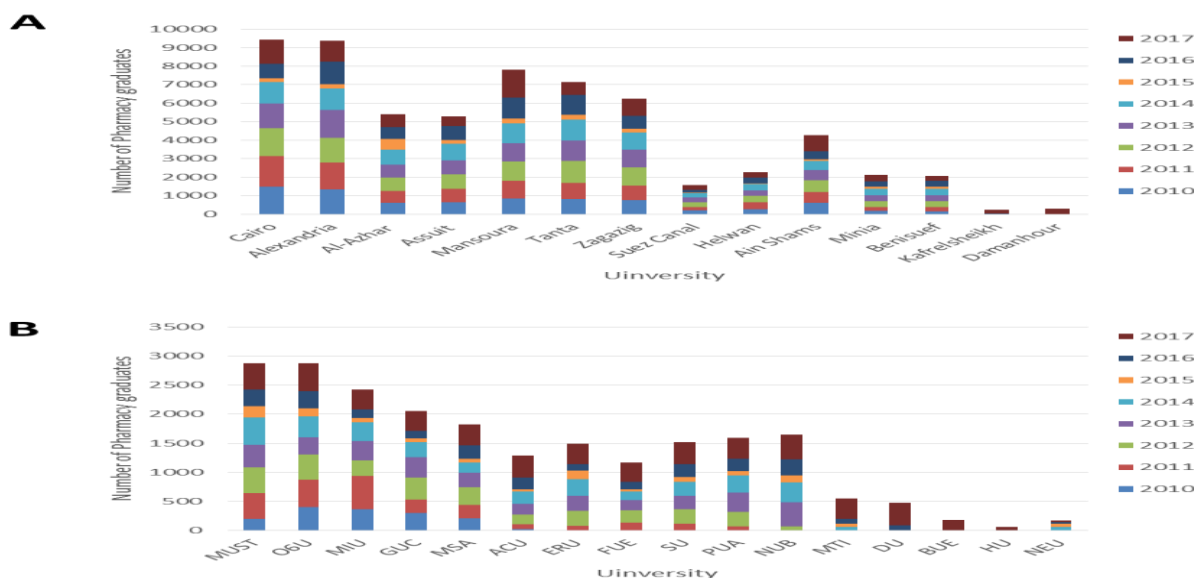


**Figure 1:** The current statistics about the number of pharmacy colleges, pharmacists, and pharmacies in Egypt. Data were retrieved from the pharmaceutical studies sector committee of the Egyptian Ministry of Higher Education, Egyptian pharmacist syndicate and Egyptian Ministry of Health and Population.

b. Number of graduates

A steady increase was shown from 2010 to 2017 in the number of graduates of pharmacy faculties. As the number of graduates of the faculties of pharmacy increased from 9422 (2010) and to 14573 (2017) with a percent increase of 54.7% (Figure 1). Of whom 5175 graduates from 15 private faculties

by 35% and 9398 pharmacists from 14 governmental institutes with 65% of the total number of graduates. These numbers did not include the new 14 faculties started in 2018 which will add more graduates in the next few years. Figure 2 summarizes the number of graduates alongside between 2010 and 2017.



**Figure 2:** Number of Pharmacy graduates between 2010 and 2017 as reported by the pharmaceutical studies sector committee of the Egyptian Ministry of Higher Education, Egyptian pharmacist syndicate and Egyptian Ministry of Health and Population. **A. Number of Pharmacy graduates from governmental universities, B. Number of Pharmacy graduates from private universities.** Abbreviations for private universities: MUST, Misr University for Science and Technology; O6U, October 6 University; MIU, Misr International University; GUC, German University in Cairo; MSA, October University for Modern Sciences and Arts; ACU, Ahram Canadian University; ERU, Egyptian-Russian University; FUE, Future University in Egypt; SU, Sinai University; PUA, Pharos University in Alexandria; NUB, Nahda

University; MTI, Modern University for Technology and Information; DU, Delta University for Science and Technology; BUE, British University in Cairo; HU, Heliopolis University for Sustainable Development and NEU, Non-Egyptian Universities.

c. Number of Pharmacists in relation to population

The number of registered pharmacists in Egypt reached 216072 pharmacists, according to the syndicate in 2017 at the rate of a pharmacist for every 438 citizens (Figure 1). However, the global average is a pharmacist per 1100 - 1600 individuals or in other words: 23 pharmacists per 10,000 citizens in Egypt, while the universal average is 6.2 pharmacists per 10,000 citizens. This means that the number of pharmacists has increased by approximately four times than the world average ratios.

d. Number of community pharmacies in relation to population

The number of pharmacies in Egypt amounted to more than 75165 pharmacies with one pharmacy for every 1261 citizens (Figure 1), while the international average of community is a pharmacy per 3500-5000 individuals or in other words: 8 pharmacies per 10,000 Egyptian citizens. This means that the number of pharmacies in Egypt has increased by almost three times than the world averages.

4. A SURVEY ABOUT PHARMACISTS' CURRENT STATE IN EGYPT

In a cross-sectional survey, 1500 randomly selected pharmacists from Egypt were invited to complete a survey composed of 10 questions designed to determine the state of pharmacists in Egypt in 2018. The questions were about the faculty and year of graduation, gender, age, grade, highest degree, current job, job description and percentage of satisfaction. The questionnaire was either distributed as printed paper, through a web link, via email or through the social media. A number of 968 questionnaires were filled and returned representing 64.53 % response rate (968 of 1500 pharmacist responded to the sent questionnaires) (Figure 3). The females represented 64% among respondent pharmacists. About one-third of the recruited pharmacists graduated from Cairo University (32 %). The average grade of the pharmacist screened was excellent (36%), with their graduation years ranging between 1994 and 2018, among them 27% graduated on the year 2013. The highest degree for the recruited pharmacists was the bachelor (68 %), while a small percentage represented by the doctorate (9 %) and masters (5 %). Pharmacist from different jobs and sectors were included and represented in our survey, clinical pharmacist from hospitals and clinics, community pharmacist from hospitals, pharmacists working in research institutes and universities. Although 23% of them were working in private pharmacies. Less than half (45 %) of the recruited pharmacists showed 60-80% career satisfaction, while 46 % of them had from less than 40% to 60% satisfaction on their career. A very small percentage had shown nearly full career satisfaction (9%). When the included pharmacists had been asked if they are thinking of making a career shift, more than half (55 %) of

recruited pharmacists actually thinking of making a career shift.

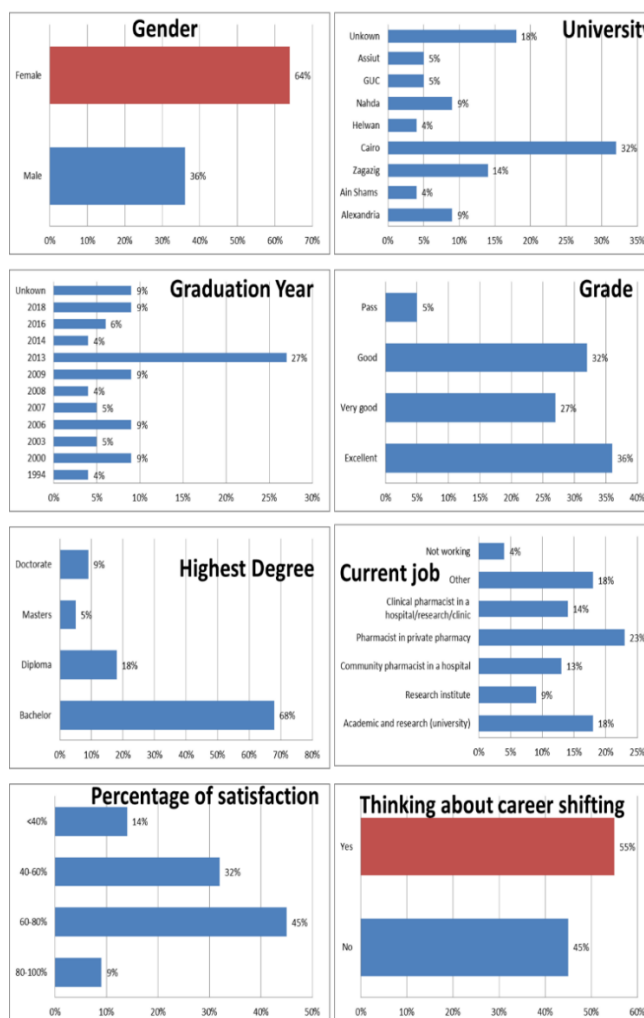


Figure 3: Characters for the recruited pharmacists in the survey about pharmacists' current state in Egypt

5. THE ROLE OF PHARMACISTS IN EGYPT: THE CURRENT SCENARIO

Although the pharmacists' roles as health care provider are well recognized worldwide, the Egyptian health providing organization have to recognize these roles. The lack of this recognition is primarily due to many reasons including limited physician-pharmacist relationship. In Egypt, pharmacists face many challenges unlike those faced by pharmacists in most developing and developed countries. The number of pharmacists and pharmacies is exceeding four-times the WHO recommendation as a percentage of the total population. Some medical doctors dispense some medications in private clinics as a part of their professional practice, although prohibited by law. There is still no separation of job description related to drug dispensing and prescribing between pharmacists and pharmacists' assistants in some community pharmacies,

especially those found in rural areas as in many cases, most Egyptian pharmacists prefer cities than rural areas. Although prohibited by law, some pharmacies in most rural areas are supervised by pharmacist-assistants.

Irrational use of medicine is serious issues in Egypt. A large proportion of the population used to buy drugs without prescriptions. This includes analgesics, anti-inflammatory and more seriously antibiotics. Pharmacist-assistants contributed largely to drug misuse, OTC drugs abuse, drug addiction, overuse of antibiotics and polypharmacy by providing misleading information about drugs, their efficacy and side effects. Selling drugs according to popular demand is a serious issue that need to be faced by the stakeholders. Additionally, some shops used to self-manufacture some natural-derived remedies without getting the proper registrations or legislations. The stakeholders should also regulate the number of pharmacies, the distance between pharmacy and the distribution of pharmacies chains. Political instability in Egypt after 2011 has caused several changes in the government, thus resulting in changes in health policy. Until now, Egyptian pharmacists are highly interested to provide pharmaceutical patient counselling, however, the community and the health care system have yet to recognize their proper roles.

## 6. THE MAIN CHALLENGES OF REORGANIZING AND MODERNIZING THE PHARMACEUTICAL EDUCATION

The large and steady increase in the number of graduates of the faculties of pharmacy, which resulted in a rise in the rate of pharmacists to the proportion of the population by nearly four times the global rates. This requires working to reduce the number of admissions to the faculties of pharmacy. The inadequacy of the current education system, including the available programs, years of study, university degrees and periods of training, in comparison with the Arab, regional and global systems, all should be improved. These points have limited the opportunities for employment abroad. This requires updating of the educational programs in line with the regional and international requirements and the new national academic standards (NARS) based on competencies in addition to attract students to study in Egypt.<sup>13</sup> The current training programs are either weak, insufficient or lack clarity. This requires upgrading of the training programs in terms of methodology, time period, places of training, documentation, organization, supervision, follow-up and evaluation.

Lack of specific professional disciplines or specialization which improves the professional ability and increases job opportunities. This requires the introduction of a system that allows the preparation of a pharmacist who can work in a specialized field or to become a specialist in one of the fields of pharmaceutical work after practicing work for a specified period in this area in order to improve the professional capacity and open wider areas of specialist work (increasing job opportunities) similar to what is done in developed countries and the other members of the health team of doctors, nursing, etc. Since pharmacists can work in

different careers as academia, research, drug manufacturing, drug marketing, community pharmacy, hospital pharmacy and regulations, the future programs should allow the graduation of nutrition pharmacist, oncology pharmacist and nuclear pharmacist next to community and clinical pharmacists. Pharmacy administration and drug manufacture should be introduced as new programs.

The absence of a mechanism to assess the ability of the graduate to practice the profession before obtaining a license to practice the profession in Egypt, as is the practice in all developed countries and some other countries. This requires working on a national test in preparation for obtaining a license to practice the profession with the establishment of a training and test administration.

Increasing of the number of non-qualified practitioners, who do not have a university degree qualified to practice pharmacy or so-called "outsiders". This entails making the necessary decisions and legislation to prevent the practice of the profession of non-pharmacists.

## 7. A CLOSER LOOK AT THE NEW EDUCATIONAL SYSTEM OF PHARM D THAN B PHARM

The new applied programs have been started in 2019, according to these previously mentioned challenges. It was based on replacement of the current pharmacy bachelor degree (B Pharm) with a doctor of pharmacy degree (Pharm D) or Pharm D (Clinical Pharmacy). These degrees will be given instead of the either current pharmacy bachelor of science (B.Sc). and B Pharm (Clinical Pharmacy), respectively. Pharm D clinical pharmacy program is based on courses more related to the health care systems and patients counseling in hospitals (e.g., Clinical Pharmacy Practice, Clinical Research, and Pharmacovigilance) than pharmaceutical industries. Courses like pharmacovigilance, pharmacoconomics, and drug information have been highly emphasized in both pharmacy programs for their importance in current pharmaceutical career and education. Besides, the field training in private and governmental pharmacies and hospital pharmacies. The degree of Pharm D is the first university degree awarded by this program and is qualified to practice the profession of pharmacy after passing the national test.

In addition, the development of a comprehensive training program for the year of excellence in the appropriate training places with a regular verified system including a specific timetable, areas of training, supervision, follow-up, evaluation, and documentation. The training program includes inpatient and outpatient pharmacy, pharmaceutical manufacturing and quality control, sales and marketing of drugs, research and development, pharmaceutical inspection and regulatory affairs, pharmacovigilance, medical analysis, and clinical pharmacy. Finally, students are required to finish a graduation project in a respected area of interest. Furthermore, a national test for graduates of these programs

must be conducted in preparation for obtaining a license to practice the profession of pharmacy (Pre-Licensure Exam).

## 8. THE INFLUENCE OF THE FOURTH INDUSTRIAL REVOLUTION ON PHARMACY PRACTICE

The human use of technology will be affected by the Fourth Industrial Revolution (FIR)<sup>14</sup>. Similarly, the change from hand production to machines occurred as a result of the first industrial revolution in 1760, the development of steel, chemical and transport industries occurred in the second revolution after 1870. The third revolution which is known as the Digital Age in 1960s was stimulated by electronics and information technology development as well as the automated products. The first three revolutions developed the pharmaceutical industry and thus the pharmacy practice taken its form designed by the three revolutions.

The world is now facing the FIR, which is characterized by the internet of things (IoT).<sup>15</sup> Such IoT has been recently applied in many activities in the pharmacy viz. medication adherence improvement and drug storage monitoring.<sup>16</sup> FIR can thus create non-pharmaceutical methods for treating patients and reduce the pharmacist role in medicine supply. FIR may not show a great support to the pharmaceutical industry development. Inversely, it may give the chance for non-pharmaceutical suppliers to play a larger role in medicine supply.<sup>17</sup>

Pharmacy could get the benefit of the twenty four “general purpose technologies” (GPTs) that could be developed during the three industrial revolutions and had an effect on the entire economy of the societies such as trains, electricity, computing, the internet, artificial intelligent and block-chain.<sup>18,19</sup> GPTs could be applied to improve the industry of pharmaceutical products and the use of barcode system in dispensing of medicine in pharmacies. Now our question is, could the pharmacist get the advantage of the FIR in the same way as he did with first three revolutions?

The FIR may be of no benefit and represents a threat to pharmacy in case that the pharmacists think that the coming future is just an extension of the past. In this case, many intruders may appear in the pharmacy work and take over many activities that have been now confined to the pharmacists, such as online dispensaries and phone apps that may replace the personal pharmaceutical care. For this reason, the pharmacy sector should evaluate to what extent can FIR affect its future activities.

Technology is the dynamic clustering of techniques, methods and skills for producing goods or services for consumers.<sup>20</sup> In this respect, the FIR can improve all the performance of pharmacists, widen the profession outcomes or both. For example, FIR could create a more cost-effective services for community pharmacists in drug administration and patient guiding, for example, cell phone applications.<sup>21</sup> Moreover, pharmacy could use “big data” into data analytics

that prompts a remarkable development in information volumes, a fast information creation, and an augmentation in the assortment of information types accessible.<sup>22</sup> Applying advances may bolster the pharmacy as a substantial player in the medicinal services segment. These are squeezing issues needing across the board banter since they will shape the eventual fate of pharmacy practice. On the off chance that pharmacists don't upset their very own working techniques, maybe outside players will hold onto the opportunity to change the manners by which pharmacy and related administrations are given.<sup>17</sup>

Pharmaceutical care has been developed in the third industrial revolution.<sup>23</sup> During the last decade, many advances occur in communications and therapeutics. Consequently, most of pharmacies became computerized.<sup>24</sup> The inquiry, thusly, emerges: in what manner will pharmacy react to the changes? and difficulties offered by the FIR?

FIR is taking place in the healthcare sector much quicker away from pharmacy segment than in it. This develops a serious question about the future development of the pharmacy segment.<sup>25</sup> For example, if all the drug administration processes go online what will be the role of pharmacies? Moreover, if there is no more drug administration, what will be the role of the pharmacy? After struggling for thirty years to develop the clinical pharmacy practice, what will be the fate of patient guidance system if the new technologies sidestep the pharmacy and go directly to the patients? Considering such questions, partners in drug store ought to participate in open discourse about the chances and the dangers of FIR. The pharmaceutical industry in Egypt, while it is one of the most indispensable industries in the world, is facing a productivity crisis.

Additionally, pharmaceuticals are one of the most research-intensive industries in the world as it is generating a steam of new drugs which save lives and improve the quality of life. In Egypt, there is a great gap between pharmaceutical industry and academic scientific research. Therefore, the authors recommend the establishment of a specialized strategy to adopt applied scientific research that solve the challenges facing pharmaceutical industry and protect patents. As we know drug discovery requires high expenditures on research, development, and clinical testing until the production of new safe and effective pharmaceuticals which once proven, might be imitated easily, so patent protection is important and indispensable.

## 9. CONCLUSION

Improving the quality of education is indispensable for the uncontrolled globalization and digitalization. Switching from B Pharm to Pharm D in Egypt is just the first step to introduce better quality of pharmaceutical education. Finally, these changes may help filling out the great gap between pharmaceutical industry, duties of the health care system in hospitals, and academic scientific research. Also, the steady increase of graduated students from faculties of pharmacy, the

main challenges of reorganizing and modernizing the pharmaceutical education. In addition, the FIR may change the strategies of patient counselling, drug delivery and prescriptions dispensing to more computer-aided scenarios. In response, artificial intelligence (AI), IoT in the context of pharmacy education should be included to the curricula. FIR might provide more innovative technologies on one side, but also, we might lose jobs on the other side. The impact of this change on the Egyptian community regarding the economic aspects of wide application of clinical pharmacy and pharm D program is also a critical point that will be appeared in the near future.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

## LIST OF ABBREVIATION

- **AI:** Artificial intelligence
- **B Pharm:** Pharmacy bachelor degree
- **B.Sc.:** Bachelor of science
- **FIR:** Fourth industrial revolution
- **GPTs:** General purpose technologies
- **MoHE:** Ministry of higher education
- **OTC:** Over the counter
- **Pharm D:** Doctor of pharmacy degree
- **WHO:** World health organization

## 10. REFERENCES

1. In focus: Sustainable Development Goal 5, <https://www.unwomen.org/en/news-stories/in-focus/2022/08/in-focus-sustainable-development-goal-5>, (accessed 23 March, 2022).
2. International Health Conference. (2002). Constitution of the World Health Organization, Bulletin of the World Health Organization, 1946, **80**, 983 - 984.
3. S. Azhar, M. A. Hassali, M. I. M. Ibrahim, et al., The role of pharmacists in developing countries: the current scenario in Pakistan, *Hum. Resour. Health*, 2009, **7**, 54.
4. S. Thamby and S. Parasuraman, Seven-Star Pharmacist concept of WHO, *J. Young Pharm.*, 2014, **2**, 1-3.
5. G. A. Bender and R. A. Thom, *Great Moments in Pharmacy: A History of Pharmacy in Pictures*, Parke-Davis, 1967.
6. WHO Consultative Group on the Role of the Pharmacist in the Health Care System & World Health Organization. Division of Drug Management and Policies., The role of the pharmacist in the health care system : preparing the future pharmacist : curricular development, World Health Organization, Geneva, 1997.
7. M. M. Abdel-Latif and K. Sabra, Clinical pharmacy practice in Egyptian hospitals. *American Journal of Health-System Pharmacy*, 2016, **73**, e63-e66.
8. S. A. Nour, Pharmacy Education in Egypt, *J. Pharm. Res.*, 2017, **1**, 127.
9. T. Supapaan, B. Y. Low, P. Wongpoowarak, et al., A transition from the BPharm to the PharmD degree in five selected countries, *Pharm. Pract. (Granada)*, 2019, **17**, 1611-1611.
10. S. J. Knoer, A. R. Eck, and A. J. Lucas, A review of American pharmacy: education, training, technology, and practice, *J. Pharm. Health Care Sci.*, 2016, **2**, 32-32.
11. T. Chanakit, B. Y. Low, P. Wongpoowarak, et al., Does a transition in education equate to a transition in practice? Thai stakeholder's perceptions of the introduction of the Doctor of Pharmacy programme, *BMC Med. Educ.* , 2015, **15**, 205-205.
12. A. M. Soliman, M. Hussein, and A. M. Abdulhalim, Pharmacoeconomic education in Egyptian schools of pharmacy, *Am. J. Pharm. Educ.*, 2013, **77**, 57-57.
13. Y. Eid, A. Agha, R. Taha et al., National Academic Reference Standards Pharmacy Education, National Authority for Quality Assurance and Accreditation of Education, 2017.
14. Schwab, Klaus. The fourth industrial revolution. Currency, 2017.
15. A. Gatouillat, Y. Badr, B. Massot, et al., Internet of Medical Things: A Review of Recent Contributions Dealing With Cyber-Physical Systems in Medicine, *IEEE Internet of Things Journal*, 2018, **5**, 3810-3822.
16. E. N. Mambou, S. M. Nlom, T. G. Swart, et al., Monitoring of the medication distribution and the refrigeration temperature in a pharmacy based on Internet of Things (IoT) technology, *2016 18th Mediterranean Electrotechnical Conference (MELECON)*, 2016, DOI: 10.1109/MELCON.2016.7495412, 1-5.
17. D. Baines, L. S. Nørgaard, and C. Rossing, The Fourth Industrial Revolution: Will it change pharmacy practice? *Res. Social Adm. Pharm.*, 2019, **16**, 1279-1281.
18. E. Helpman, General purpose technologies and economic growth. (MIT press, 1998).
19. R. G. Lipsey, K. I. Carlaw and C. T. Bekar, *Economic transformations: general purpose technologies and long-term economic growth*, OUP Oxford, 2005.
20. D. Baines, I. Bates, L. Bader, et al., Conceptualising production, productivity and technology in pharmacy practice: a novel framework for policy, education and research, *Hum. Resour. Health*, 2018, **16**, 1-9.
21. D. Baines, Community pharmacies deserve a renaissance, *Int. Pharm. J.* , 2015, **33**, 46-47.
22. D. Laney, 3D data management: Controlling data volume, velocity and variety, *META group research note*, 2001, **6**, 1.
23. A. Daemrlich, Invention, innovation systems, and the Fourth Industrial Revolution, *Technol. Innov.*, 2017, **18**, 257-265.
24. M. S. Chow, S. L. Chow and D. Kember, A conceptual basis and key components for pharmacy core curriculum in the age of artificial intelligence, *JAASP*, 2018, **7**, 15-20.
25. I. B. Soares, T. L. Imfeld-Isenegger, U. N. Makovec, et al., A survey to assess the availability, implementation rate and remuneration of pharmacist-led cognitive services throughout Europe, *Res. Social. Adm. Pharm.*, 2020, **16**, 41-47.