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Review Article

Status of Research in Education in Pharmacology: The Indian Scene During the Last Five Years

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The medical knowledge-flow has moved on from the conventional classrooms to virtual classrooms and flip classrooms.Many academicians in past have tried to innovate in the area of medical education to keep up with the ever increasing gap between quality of medical education and recommended teaching learning methods. Authors accessed various medical databases such as PubMed, Google Scholar, Embase, Scopus, Index Copernicus to find out the research studies undertaken in pharmacology education in India during last 5 years (2012-2017). It was found that the researchers from India have implemented various novel and diverse teaching-learning methods such as crossword puzzles, 'E-learning' modules, active learning modules, pre-lecture assignments, poetry, casebased learning (CBL), role-plays, seminars, etc. to arouse interest in the subject and knowledge retention. There were research projects focused on assessment including development of blue printing, and implementation of OSPE, structured oral examinations, etc. Review articles attracted attention to the prevailing, pan-India confusion regarding use of animals for demonstrations and examinations for pharmacology. Evaluation of pharmacological programmes reported additions or alterations that are needed to be made pertaining to the objectives, teaching methodologies, assessment strategies of the current undergraduate and postgraduate pharmacology curriculum. Medical educators have tried, at institutional level, to innovate and incorporate relevant changes to the teaching methodologies, assessment and curriculum. However,these efforts are individual and not comprehensive. Systematic and robust research programs are warranted to identify and address the lacunae/deficiencies in present pharmacology curriculum implementation.

Keywords: Pharmacology Teaching; 2nd MBBS; Assessment; Teaching-Learning Methods; Curriculum

Introduction

Modern Medicine is an ever-changing branch of science, and Pharmacology forms the vanguard of this change. Teaching medicine in this ever-evolving and ever-changing scenario is challenging. Teaching of medicine has not kept pace with the evolution of medical science as well as technological developments in education. Furthermore, the medical knowledge-flow has moved on from the conventional classrooms to incorporate virtual world of internet. The virtual classroom allows to connect teachers and students from different parts of India (or globe) who can have face-to-face teaching without being physically present before each other and this can be asynchronous (wherein students can visit the classroom to learn from any place, may be multiple times, according to the availability of time and their own pace) (Fallon, 2011). In addition, popularity of flipped classroom is increasing wherein online lectures are viewed prior to entering in the actual classroom. In the subsequent classroom the students are assigned group activities that require their engagement for concept clarification or problem solving and are supervised by a teacher who gives feedback and assesses whether key ideas are learnt by the students. Such collaborative learning promotes their active learning about the topic to be taught (Baepler *et al*., 2014). This shift can, if not already, make the current teaching practices redundant, because they are teacher-centred, based upon information banking approach and promotes passive, and superficial learning (Sawant and Rizvi, 2015). Many academicians have tried to innovate in the area of medical education to keep up with the

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emerging concepts, principles and strategies of education, despite the fact that they may not have adequate resources or technology. Their prime objective is to maintain and promote quality of education; the biggest challenge being faculty development for change. The following status report attempts to provide a brief account of these various initiatives in the Indian set up with limited resources undertaken in past five years. It must be noted that pharmacology as a subject not only features in medical curriculum but it is also an integral part of curricula imparting training to dental, nursing, pharmacy and physiotherapy and occupational therapy students.

Original research papers, case studies, opinion pieces with regards to education in pharmacology, in medical and allied subjects published in last five years (2012-2017), were searched on the internet through agency of various academic search engines such as Google Scholar, PubMed, EMBASE, Scopus, Index Copernicus etc. using term 'pharmacology' along with terms (in all permutation and combinations) as: medical education, teaching learning methods, assessment, curriculum, undergraduate, postgraduate, training, student, resident, MBBS, nursing, BDS, pharmacy, perception questionnaire, tutorial and feedback. The total articles retrieved were 95 out of which 77 articles were used in this compilation. The articles pertaining to entire MBBS curriculum (which involves pharmacology as a part) or to other educational programs not involving pharmacology (but written by pharmacologists) were excluded. The selected articles were then categorized under teaching-learning methods, assessment and curriculum reforms for the purpose of this report. A special mention needs to be made of the Indian Journal of Pharmacology, the journal of Indian Pharmacological Society which has always encouraged publication of articles on pharmacology education. In 2016, the journal brought out a special supplement to share with its readers innovations attempted by various academicians in pharmacology education and its possible impact (Desai, 2016). The current report includes a brief account of most of the articles from this supplement.

Teaching - Learning Methods

There were two types of studies related to teaching-learning methods: (i) The first type included implementation of innovative teaching-learning method and evaluation of its effects on students' learning, acceptance and motivation while (ii) the other type included evaluation of effectiveness of teaching-learning methods which are currently in use. An account of these studies is presented below.

Innovative Teaching Learning Methods

One of the roles of a teacher is to motivate the students. This can be done through innovative teaching-learning modules, which are active, generate interest among students so that they find the learning enjoyable and with better retention.With this thought process many academicians in the last 5 years conducted research projects implementing newer teaching- learning methods (Table 1).

All the studies were done in students of 2nd MBBS (One year after joining the medical course), the year in which Pharmacology subject is taught for a period of 3 semesters. In majority of studies the newer methods were compared with those routinely used in the department (e.g. lectures, tutorials). Perceptions of the students collected as feedback were the indicators rather than the actual learning that took place. Perception of faculty regarding the change in the behaviour of students (in terms of knowledge, skills and attitude) remains to be evaluated in many cases. In some studies where such attempts were made to assess learning, the assessment methods differ in different test groups (Palapalli *et al*., 2016) or between test group and control group (Sukhlecha *et al*., 2016).

With innovative strategies equally important is the development of skill of self-learning in students to drive them to be life-long learners. Educators did research projects which encouraged motivation, self-learning and arousal of interest in the subject of pharmacology. The researchers have introduced novel methods like interactive seminars, case study, student led objective tutorial (SLOT), student led seminars (SLS), case based learning (CBL) and its modification, patient based teaching, active learning modules, team based learning (TBL), poetry, cricket game settings, autobiography of drugs, crossword puzzles, pre-lecture assignments, flipped classroom activity,computer assisted learning (CAL), e-learning modules and integrated teaching with assignments to promote active learning. Of these, cricket game setting was

Table 1: Studies carried out to evaluate innovative teaching-learning methods and their effects on students' learning, acceptance and motivation

No.	Study reference	T-L method	Study design	No. of students	Indicators with results	Authors' opinions/remarks
1	Dawane *et al.*, (2014)	Tutorial, interactive seminar and case study	Prospective, interventional, comparative study	153 (25/group)	***Student performance*** ● Improvement in post-test scores (Maximum with tutorials) ***Student perception*** ● Order of preference for teaching method: Tutorials > Lectures > Case study > Seminars ● Text books and class notes as resource material for studying (56%) ● Pharmacotherapy lectures should be taught in III MBBS ● Clinical pharmacology and case studies to be included (80%)	Tutorials ensured understanding Case scenarios should be included in all teaching learning sessions for interest arousal and to connect learning of Pharmacology to patient care
2	Arora and Hashilkar, (2016)	Student led objective tutorial (SLOT)	Prospective, randomized two arm study Comparator: Conventional tutorial (CT)	173 (divided into 2 groups)	***Student performance*** ● Post-test scores (SLOT: 12.6 ± 5.5 *vs*.CT: 11.5 ± 4.9; p = 0.39) ● Percentage of students passing (SLOT: 35 *vs*. CT: 20; p = 0.042) ***Student perceptions*** ● Stimulated interest in the topic (89%) ● Improved learning (65%) ● Enjoyable (94%)	Increases ability to learn independently
3	Sukhlecha *et al.*, (2016)	Student led objective tutorial (SLOT)	Prospective, two arm study Comparator : CT	141 (SLOT=70 vs CT= 71; with further division as 5-6 students/ group)	***Student performance*** ● Improvement from Pre- to Post-test scores SLOT: from 5.1 ± 2 to 11.2 ± 1.8, p < 0.0001 *vs* CT: 5 ± 2 to 7.2 ± 2, p < 0.001)	SLOT promotes active learning through group work Role of faculty mainly as facilitator
4	Palapalli *et al.*, (2016)	Student led seminars (SLS) (included patient oriented problem solving exercises (POPSE)/seminar with pre- and post-test sessions/role play sessions/seminar followed by quiz/ seminar followed by group discussions)	Prospective, interventional study	121	***Student performance*** ● POPSE sessions: 10/ 15 teams scored > 75% marks ● Improvement in post-test scores (from Pre-test score: 4.73 ± 2.2 to Post-test score of 7 ± 1.9; p < 0.001) ● Role plays: 13/15 teams scored >50% marks ● Quiz:: 4/9 teams scored >50% marks ***Student perceptions*** ● Interactive (60.33%)	Modified seminars promoted active participation, created enthusiasm, and interest to learning, improved peer interaction, team work, communication skills, and organization of a presentation Potential to personality development

5	Chaudhary *et al*., (2015)	Role play using various props for teaching mechanism of action of antimicrobial drugs inhibiting bacterial protein synthesis	Single group, observational cross-sectional study	46	***Improvement in post-test (MCQs):*** ● Absolute learning gain was 0.52 ● Relative learning gain was 1.86 ● Class average normalized gain: 0.72 ***Student perception*** ● Role play improved understanding of the topic taught. (n=40)· ● Interactive process· ● Visualization of phenomenon helped in retention of knowledge	Role play can be effectively utilized for selected topics of molecular pharmacology Role play increases active learning and critical reasoning, which help to understand complex mechanisms of drug action
6	Lavanya *et al*., (2016)	Role-play for medication counselling	Single group, observational, questionnaire based study	122	***Student perception***· ● Immense confidence in communicating therapy details (90%) ● Better retention of pharmacology concepts and preferred more such sessions	Role-play fosters communication skills, which are essential in real-life physician-patient interaction
7	Jalgaonkar *et al*., (2012)	Role play method (RPM) and case based learning (CBL) in small group sessions	Prospective, single group perception study	180 (Role play 80 and CBL: 84)	***Students perceptions***· ● Appreciated as facilitates understanding (CBL by 88.10% and RPM by 93.75%) ● Enhanced intellectual curiosity (CBL: 57.14% and RPM: 73.75%); ● Learning atmosphere perceived as comfortable (CBL: 82.14% and RPM: 77.50%); ● Satisfied with T-L method (CBL: 63.10% and RPM: 55.00%); ● Knowledge and skill acquired would help in clinical practice (CBL: 78.57% and RPM: 91.25%)	Trained facilitators are required for successful implementation
8	Vora and Shah, (2016)	CBL(paper cases)	Prospective, randomized, 2- arm studyComparator: Didactic lectures	68	***Student performance***· ● Better test scores with CBL *vs* Didactic lectures ($p < 0.001$) ***Students perceptions***· ● Improved understanding (82%) ● Self-directed learning enhancement (91.17%) ● Enhanced learning due to learning (97.05%)	CBL developed critical thinking and aroused interest amongst participants
9	Kenchaiah and Krishna, (2016)	CBL(paper cases)	Prospective, single group, with 2 interventions, Didactic lecture (TTM) followed by CBL	76	***Student performance***· ● Improvement in scores (TTM: 12.2±1.81 *vs* CBL 14.9± 2.1; $p < 0.001$) ***Students perceptions***· ● Interesting method (CBL: 100% *vs* TTM: 5.2%) ● Motivated to learn and enhanced self-learning (CBL: 100 % *vs* TTM: 3.9%) ● Better understanding (CBL: 100 % *vs*TTM: 3.9%)	To integrate pharmacology knowledge to bedside clinic, CBL is better

					• All agreed that CBL helped to memorize the facts easily, increased interaction and made clinical learning easier • CBL increased sensitivity towards patient's problem (96%)	
10	Gupta *et al.*, (2014)	Modified CBL (mCBL) Simulated bedside teaching sessions with case scenario	Prospective, single group, perception study	188 (3 batches)	***Student perceptions***· • mCBL effective (97.3%) • mCBL were better than theory lectures and tutorials (76.09%) • Enhanced learning due to correlation of the topic with clinical scenario, reinforcement of the important points by clinicians and the interactivity ***Faculty perception*** • High level of satisfaction	Can reduce theory lectures Needs efforts in preparation of case and coordination among departments Good acceptance by students and faculty
11	Thenrajan and Murugan, (2016)	Patient based teaching	Prospective, comparative, 2 arm study (test group: patient based teaching and control group: CBL)	50 (25 /group)	***Student performance***· • student performance on prescription writing skill : mean score 12.04 (compared to 9.6 in control Group) ***Student perception*** on patient based teaching • More interesting and motivating • Focused • Made students more responsible, empathic toward patients • Helped to remember the subject easily	Use of real patients in teaching prescription writing provides strong contextualization and is more relevant
12	Tripathi *et al*., (2015)	Active learning modules (ALM) in small group setting (Therap-eutic problems on case scenarios, critical appraisal of prescriptions and drug identification)	Prospective, randomized, 2- arm, crossover study Comparator: : Tutorials	180 (90 per group)	***Student performance***· • Improved post-test scores (ALM: 15.9 ± 2.7 *vs*. Tutorials: 11.3 ± 1.9; $p < 0.05$) ***Student perceptions***· • Interactive (ALM: 77 % *vs* Tutorial: 41%) • Enhanced understanding with clinical reasoning skills (ALM: 43% *vs* Tutorial: 28%) • Aroused intellectual curiosity (ALM: 52 % *vs* Tutorial: 39%) • Self-learning enhancement (ALM: 45% *vs* Tutorial: 16 %) • Questioning each other facilitated understanding (ALM: 71% *vs* Tutorial: 28%)	Training of faculty is needed for ALM development and implementation ALM promotes effective learning Nevertheless, students preferred tutorial mode of learning as they felt they are comfortable and felt it was compatible with questions asked in the University examination
13	Rao and Shenoy, (2013)	Team based teaching (TBL)	Prospective, single arm, interventional study	36 (6/group)	***Student performance*** : • Pretest score 3.667 ± 0.82 increased to 4.24 ± 0.66 score ($p = 0.0052$)	TBL sessions provided opportunity for active learning in small groups

					***Student perception* on TBL** ● Better knowledge gain ● Better understanding ● Reduced the time required for self-study ● Increased self-confidence and facilitates team work Average median score for the perception questionnaire items: 3.63	
14	Kalra *et al*., (2016)	Poetry writing followed by reflections based on scenarios/ Triggers provided	Prospective, non-comparative, qualitative	120 (10 students/ group; 12 groups)	***Faculty rating of quality of poetry*** (on Likert scale, 1 to 5 from Poor to Excellent) ● ~70% faculty rated the poetry as good and ~30% as fair ***Emotional responses of students*** Appreciated by 90% (5% reported as kiddish and 5% average)	Adjunct to conventional teaching Requires time, commitment and self-motivation Poetry creation can help students to assimilate knowledge for a lifetime
15	Joshi *et al*., (2016)	Cricket game setting to teach cardiovascular pharmacology	Prospective, randomized, 2- arm, interventional study Comparator: Tutorial on a topic covered in lecture	77 (test: 44, Control: 33)	***Student performance:*** ● Gain of knowledge comparable in test and control group ***Student perception:*** ● Game-cricket setting: Useful and relevant (81.4%) ● Learning experience: 91% rated as good, very good and excellent ● Whole process rating (Likert scale, 10 points; 0: worst and 10: best): 64% from test group rated it ≥ 7	May help to memorize difficult topics as it arouses interest with active learning
16	Joshi and Ganjiwale, (2015)	Identification of drugs and answering questions posed on the 'Autobiography of Drugs' written by the faculty	Prospective, single group, perception study	174 (2 batches)	***Student perception*** : ● Helped to improve basic pharmacology knowledge (92%) ● Revising pharmacology enjoyable and interesting with enhanced learning (92%) ● Increased critical thinking and interest during class (87%) ● However, all topics cannot be covered by this method and it was time consuming	Not a replacement for lectures but useful for revision, which helps generating enthusiasm, sustaining interest and in better recall
17	Gaikwad and Tankhiwale, (2012)	Crossword puzzles	Open labelled, randomized, 2 arms interventional study Comparator: self-learning the given topic	70 (n=35/ group)	***Student performance:*** ● Improvement from Pre- to Post-test scores (Crossword puzzle solving: from 6.09 ± 1.30 to 12.87 ± 1.39, p <0.05 *vs* Self-learning: 6.03 ± 1.39 to 9.74 ± 3.17, p >0.05 ● Absolute learning gain (Crossword puzzle solving: 33.9 % *vs* Self-learning:18.55%) ● Relative learning gain (Crossword puzzle solving: 111.33 % vs Self-learning: 61.53 %)	Challenging, problem solving activity Promoted active learning Improved knowledge

					Student perception: ● Accepted and appreciated highly by the students	
18	Ahsan and Mallik, (2016)	Pre-lecture assignment (PLA): clinical case	Prospective, randomized, 2-arms interventional study Comparator: No pre-lecture assignment and no prior disclosure of lecture topic	150 (75/ group)	***Student performance*** ● Percentage of students getting > 50% marks in the post-lecture MCQ test (PLA: 82.14, Control: 52.38) ● MCQ Test score (PLA: 18.35 ± 5.37 *vs* Control: 15.07 ± 5.58, p <0.05)	PLA promotes active and student-centric learning It increases comprehension, analysis and skills required for rational therapeutic decisions
19	Gubbiyappa *et al*., (2016)	Flipped classroom (FC) activity: e-learning resources and quiz (pre-test) using Poll Everywhere as audience response system (ARS), followed by discussion on questions	Prospective interventional interrupted time series study with pre-test (quiz) and post-test (end of semester examination) assessment	112 pharmacy UG students (semester V)	***Student perception*** ● FC activity as an effective teaching-learning tool: inspired to learn and clarified concepts ● More lectures should be conducted in the FC mode ***Performance in quiz*** ● Low achievers in the quiz were 3 times more at the risk of providing neutral or negative feedback ***Performance in end of semester examination*** ● Those who gave neutral/negative feedback on FC activity were 3.9 times at the risk of during post-test	FC activity engaged students, promoted active learning, fostered critical thinking and higher cognitive level
20	Sengupta *et al*., (2017)	Computer assisted learning (CAL) supplementing conventional teaching	Prospective, 2- arm, interventional study	115 (Conventional teaching group (n=55) and CAL+ conventional teaching (n=60)	***Student performance*** ● Post-session 15 item MCQ test (immediately after the intervention) scores were comparable in both group ● Post-session MCQ test (after 30 days of intervention) scores were better in CAL + conventional teaching group 9.65±1.2 (*vs* 6.4±1.1 in conventional group) ***Student perception*** ● Student acceptability score for the TL sessions was comparable in both groups	CAL improves knowledge retention Integration of specific CAL tools with conventional teaching can improve understanding and performance
21	Tripathi *et al*., (2016)	Blended learning module: Adverse drug reaction reporting (e-mailing an ADR narrative and online filling of the "suspected ADR reporting form" - SARF (b) practical session on ADR	Prospective, single group, pre-and post-test study based on ADR narrative	Batch 1: 171 Batch 2: 179	● Progressive improvement in scores given to SARF (Batch1: Basal: 16.2; Month1: 26.4; Month 6: 27.3 and Batch 2: Basal 10.5; Month 1: 27.8; Month 6: 30.3)	Practice improves accuracy of filling SARF To be used to inculcate better ADR reporting practices in budding physicians

		reporting (c) post-practical SARF filling for different ADR narratives at 1 and 6 months)				
22	Eachempati *et al*., (2016)	Blended learning modules (9 online sessions coupled with face to face discussions)	Prospective, cross-sectional study	145 dental students (2 batches -3rd and 4th year BDS; 10 /group)	***Analysis of student reflections*** Identification of following: ● Merits of blended learning (better clarity, use time efficiently, enhanced knowledge for better patient care) ● Prescription writing skill with rational selection of drugs : improved ● Dosages of drugs: retained better and prescribed confidently ● Identification of strengths and weakness: better application of pathology and pharmacology information to management of diseases	Blended learning module was successfully implemented for reinforcing dental pharmacology
23	Gaikwad and Tankhiwale, (2014)	'e-Learning' modules (on 3 topics)	Quasi-experimental, single group pre- and post-test study	42	***Student performance*** ● Improvement from Pre- to Post-test scores: from 11.56 ± 2.9 to 19.94 ± 6.13, $p < 0.001$) ● Absolute learning gain (Module-1: 29.47%, Module- 2: 40.31%, Module-3: 22.5%) ● Relative learning gain (Module-1: 60.22%, Module -2: 127.72%, Module-3: 64.29%) ***Student perceptions*** ● User friendly, improved understanding, good learning experience and improved examination performance	Effective and well perceived by the students Appealed to faculty members Can be blended with traditional teaching
24	Yadav *et al*., (2016)	Integrated teaching modules -Vertical and horizontal	Prospective, single group, crossover study (two modules on epilepsy and TB)	165	***Student perceptions*** ● Provided better understanding of the topic (75.5%) ● Should be regularly part of the curriculum (41%) ● Increased self-confidence (45%) ***Faculty perception*** ● Useful method for understanding concepts (88%) but time consuming (44%) and needs faculty training (55%) ● Difficult task is interdepartmental coordination (76%)	Feasible due to excellent coordination among disciplines Appreciated by students and faculty

25	Bala *et al*., (2016)	Integrated teaching and concept map (CM)	Prospective, interventional	150	***Student performance*** ● Significant improvement inpost-test scoresafter integrated teaching and CM ● Significant improvement in MCQ and PBQ scores after CM compared tointegrated teaching ***Student perception*** ● CM engaged the interest and improved learning as it summarizes key ideas (87%) ● Preferred CM as an add on to theoretical lecture (88%)	Use of CM to motivate students and generate interest It improves knowledge
26	Deb *et al*., (2013)	Partial integrated program (conventional teaching followed by OPD visits)	Quasi-experimental study	67	***Student perception*** ● Better understanding of concepts (median score 4 on scale of 1 to 5) ● Aroused interest (median score 4 on scale of 1to 5) ● Better ability to memorize (median score 3 on scale of 1to 5) ● Enhanced interpretative skills (median score 4 on scale of 1to 5)	Short term module can supplement the conventional education

an interesting method (Joshi *et al*., 2016). The researchers made 2 'cricket' teams with 11 batsman [with drug information] and 11 bowlers [with disease and co-morbid conditions] per team and teacher served as an umpire. The bowlers asked 10 questions in the form of short answer type, true/false, and multiple choice questions to the batsman and "runs" in form of points were allocated for every correct answer by the umpire. The control group underwent a tutorial, wherein the teacher asked questions to the students on a topic. A point to note is gain in knowledge was similar in both the groups but the students enjoyed the learning process in the cricket game setting.

It was also interesting to note that role plays which are usually used for developing communication skills (Lavanya *et al*., 2016) or for topics related to affective domain can be used to teach pharmacodynamics (as used by Chaudhary *et al*., 2015 for mechanism of action of antibiotics). However, both have mentioned the study design as observational, which is not appropriate according to us. It should be remembered that the educational methods used in various studies are the interventions by the researchers and their effects in terms of improvement in knowledge or acceptability by students are assessed using various indicators such as pre- and post- test or student perceptions e.g., Chaudhary *et al*., (2015) used indicators as MCQ test for knowledge and questionnaire for student perception. Their study plan also proves that the design is not cross-sectional. Lavanya *et al*. (2016) used role plays as intervention and then studied the student perceptions using a questionnaire.

Similarly, one should be careful while using the term randomized study. One needs to describe the technique of randomization. Randomization in educational setting done for the students of the same class may not eliminate bias completely as the students of both test and control tend to interact with each other and learn from sharing each other's learning experiences.

Unconventional learning experiences also help to arouse interest in students, which is a first step towards learning. This has been explored by organizing an intercollegiate Collage and Crossword Competition on the theme 'ADR Monitoring & Reporting'. In the news report from Uppsala

Monitoring Centre of WHO, it has been reported that around 100 students participated in collage competitions, worked in team to prepare collage, which were then displayed and created awareness amongst participants and viewers about various aspects of pharmacovigilance (Manikandan and Sivagnanam, 2012). Similarly, 200 students participated in the crossword puzzle competition, which was followed up by debrief session. The feedback of participants revealed that such events help improving students' knowledge, attitude and practice of ADR monitoring and reporting.

Utility of an unconventional method of using 'metaphors' to teach aminoglycosides and its respective spectrum has been reported in a communication to the editor (Khilnani *et al*., 2016). The authors tried to implement horizontal integration with microbiology using metaphors in a story format. The authors did opine that preparing such metaphors required imaginative and innovative thinking from the faculty but, such metaphors could serve as efficient teaching-learning tools.

Evaluation of Teaching - Learning Methods

An attempt has been made to explore 2nd MBBS student's (n=140) feedback on teaching-learning methodology in pharmacology with the help of pre-validated 22-item questionnaire (Bhosale *et al*., 2013). The authors did get some interesting perceptions of students regarding various topics and their usefulness. For example, 40-50% students found cardiovascular system, central nervous system and general pharmacology as the most interesting topics, followed by autonomic nervous system. Topics like drugs acting on respiratory and gastrointestinal system, and autacoids were considered as less interesting. These opinions were based on the perception of students that the drugs belonging to cardiovascular system, chemotherapy and central nervous system have more application in clinical practice during internship. Seminars, demonstrations on manikin and museum visits were mentioned as good adjuvants to routine teaching. Students suggested to use interactive teaching strategies with due emphasis on practical aspects like dose calculations, prescription writing and reviewing, comments on fixed dose combinations, emergency drugs and applied clinical pharmacology. Students also suggested regular post-topic assessment (either MCQ test or viva) was required to consolidate their learning.

Similarly, in a questionnaire based study (Prasad *et al*., 2014) conducted to ascertain the opinion of medical students (n=74) regarding pharmacology syllabus and the methods of teaching pharmacology, the students opined that integration of pharmacology with clinical subjects can improve the understanding of the subject. Students also suggested that rational use of medicine, clinical trials, paediatric and geriatric pharmacology were the important topics that should be included and emphasized upon in the curriculum. The authors stated that regular evaluation of teaching methods by the students and taking their feedback regarding improving the teaching-learning method and subsequently redesigning the curriculum can enhance the learning capacity of the medical students. Even an attempt has been to find out the 'likes' and 'dislikes' in pharmacology TL methods and topics as stated by students (n=115) (Subhash *et al*., 2014).Students (80%) preferred powerpoint presentations, 62% students preferred reading pharmacology once in a month and 75% students liked clinical pharmacology topics over experimental pharmacology.Students (92%) voted for multiple choice questions over others as effective assessment methods.

A cross-sectional, questionnaire (23-item) based study has been published which evaluated students' (n=64) perception of teaching - learning in pharmacology (Manjunath *et al*., 2015). The students' responses were similar to that found earlier (Bhosale *et al*., 2013). Students suggested methods to improvise the existing teaching learning methods by including video-assisted learning for better understanding of mechanism of action of drugs, inclusion of real cases in hospital with problem solving approach and group discussions. The perception of students indicate that they need clinically oriented learning of subjects, which has application in future practice of medicine and is therefore relevant. An interesting point revealed that only 10.93% students were willing to consider pharmacology as one of the subject for post-graduation. The authors opined that pharmacology faculty usually tend to teach 'everything' under the umbrella of subject of pharmacology ignoring the needs of would be practicing physicians. In a perception questionnaire based study (Krishna *et al*., 2015) regarding use of teaching methodology revealed that

77% students were in favour of inclusion of real life case studies and their treatment whereas 73% of the students showed interest in problem based learning. Students (65%) agreed that pharmacology must be integrated with theclinical sciences using real cases from hospitals.

It has been suggested that pharmacologists need to reform their teaching methods (Ghosh *et al*., 2016). The authors observed students (n=230) who participated in the study, perceived pharmacology as interesting (64.3%) and 28.7% students opined that this subject was useful in future but a lot of cramming is needed to retain the information. However, only 35.6% students opined that large group lecture classes were most helpful for understanding. Practical classes and demonstration classes helped to understand the subject was stated by 15% of students. Students appreciated prescription writing (35.6%), therapeutic problems (51.3%) and drug interaction (33%). On the contrary, pharmacy seemed less interesting to 53.4% students as it is no longer needed in their future medical life. The authors suggested to take note of students' preference for curriculum and to modify the current curriculum accordingly.

Similarly a questionnaire based study (n=100 students) was conducted wherein students opined that topics on central nervous system (60%), chemotherapy (52%) and cardiovascular pharmacology (42%) as the most interesting. Of the teaching methodologies, students (62%) found interactive lectures most helpful. Discussions at the end of the class (55 %) and encouragement given to the students to ask questions during lectures (38 %) were main ways to enhance active student participation (Prasad *et al*., 2016). Similar cross-sectional study (n=129 students) reported that 23% of students found pharmacology of gastrointestinal tract interesting (Rani, *etal.*, 2016). Majority students (52%) stated that case study and treatment discussion should be incorporated within pharmacology curriculum. Topics like drugs used in special conditions like kidney dysfunction, sexual dysfunction, recent advances in pharmacology and emergency drugs should be given due emphasis (nearly 27% students). Tutorial was the most favoured TL method by the students (32.7%) for preparing towards university examinations. With regards to practical classes, prescription writing (33.5%) was found most interesting,while experimental graphs was least interesting. In a similar manner, a cross-sectional survey involving 100 students reported that most interesting topic was general pharmacology (31%) and the most difficult one was drugs acting on autonomic nervous system (45%) (Vare *et al.*, 2017). The most important topic perceived by students in practicals was prescription writing (25%) and least was experimental graphs (2%). 81% students liked integrated teaching of pharmacology with other subjects. 91% felt calculation of pharmacokinetic parameters is clinically applicable.

Similar perceptions were reported even by dental students regarding pharmacology topics and TL methods.A survey-based study was conducted to grasp medical (n= 94) and dental students' (n=26) opinions regarding the teaching practices in pharmacology (Ahmed *et al*., 2014). It was evident that both, medical and dental students valued pharmacology in clinical decision making and favoured the need for pharmacology as a subject to be more clinically oriented (70%) as well as being technologically sound (use of CAL). Introduction of group discussion (41%), followed by introduction of clinical pharmacology exercises (31%) were the suggested changes by students. Similarly, a cross sectional survey (n=73 students) regarding TL methods in pharmacology was conducted in dental students (Rani *et al*., 2017). Majority of students (84%) preferred lecture as their preferred teaching method in Pharmacology and 70.8% of students did not prefer tutorials. Students (57.1%) wanted revision classes regularly after completion of each system; 84.7% desired pharmacology practicals to be a combination of pharmacy practicals with clinically oriented classes and 93% of them suggested pharmacology to be integrated with medicine.

It must be noted that in all the above mentioned studies, educators have tried to evaluate which topics in pharmacology are preferred. The responses appeared to be varied, however that is expected. The learning lesson from all the studies is that students prefer active learning strategies with clinical applications (either in form of integrated lectures, CBL or PBL) to make pharmacology relevant with strong knowledge retention element. This is evident from the findings of the studies described below.

There were studies which reported perceptions of students on existing specific TL methods rather than the entire syllabus and the manner in which it is taught. Students' (n=120) perceptions towards pharmacology tutorials were evaluated (Beedimani *et al*., 2016). Students (88%) stated that it was necessary to have tutorials as the group discussions brought concept clarity. Authors probed into reasons of not attending tutorials, 58% students stated that they were not prepared and lazy and 22% learners were afraid of individual questioning. Students (80%) suggested that the teacher and students should mutually decide the topic/time for tutorials. In another cross-sectional study, 94% of students (n=102) responded that tutorials helped them in understanding the topic better (Viola *et al*., 2016). The authors did opine that tutorials benefit students in learning fundamental concepts of pharmacology and their application in clinics. Student's preference for PBL (Problem Based Learning) *vs*. LBL (Literature Based Learning) methods has been evaluated (Shivraju *et al*., 2016). Out of 100 second year medical students; 37% were aware of PBL; 58% students were interested towards PBL. Students did opine that PBL achieved better understanding (49%) and analytical approach (65%). Students (53%) preferred concurrent use of both LBL and PBL for better clarification. Another interesting student perception study has been reported in which students (n=206) were asked about the feedback module implemented in the department since last 10 years (Patel *et al*., 2016). Majority students (93- 97%) perceived that the feedback session at the term ending examinations helped them to identify strong and weak areas, provided objective information about their performance,and guided them to improve their knowledge in the subject. It also motivated them to work harder (96% students).

Medical educators have not only evaluated TL methods but have gone ahead and evaluated knowledge retention of pharmacology with the existing TL methods. A crosssectional study among UG students (n= 258; 3rd year students) and interns (n=96) was conducted to evaluate knowledge retention of clinical pharmacology and rational therapeutics which they had learnt in 2nd year (Desai *et al*., 2016). The mean knowledge score (4.73±2.3) of interns was significantly reduced as compared to UGs (6.15±3.18; $P < 0.0001$). Interns (63.5%) confessed problems in selection of drugs, drug-drug interactions and prescribing in special patient population. Interns did state they were hesitant to prescribe opioids (77%), steroids (76%), vaccines (75%), and antihypertensives (62%). The authors concluded that theoretical teaching of clinical pharmacology and rational therapeutics is not retained in internship and does not adequately prepare interns to prescribe safe and rational drugs. This is an eye-opener for medical educators and emphasizes the need for reinforcing modules in subsequent years which can lead to incremental development of competencies in drug prescribing and rational drug use.

Assessment

Assessment forms an integral part of any curriculum and has to be valid, reliable and authentic. It measures achievement of pre-defined learning objectives. There is much scope for innovation and research in this area. However, very few studies have been reported related to assessment.

Attempts were made to correlate the marks obtained by students in theory and in oral examinations. Percentage of marks obtained by four batches of students (n=589), in consecutive years (2008-11), in written and *viva-voce* components of the final summative examination in pharmacology were reviewed: Batch 1 (Jan 2011 Exam, n=159), Batch 2 (Jan 2010 Exam, n=139), Batch 3 (Jan 2009 Exam, n=148), Batch 4 (Jan 2008 Exam, n=143). Based on their performance in terms of percentage of marks in aggregate, all students in a batch were classified into four categories viz., 'failed'(F) $\leq$50%, 'borderline passed' (BP) – 50-57%, 'passed' (P) $\geq$57% to <75% and 'passed with distinction' (PD) – $\geq$75%. Correlation was studied between the percentage of marks obtained by students in these categories between written and *viva-voce* examination. Significant association ($r=1$, $P<0.001$) was observed in marks obtained in viva-voce and written examination for students in 'Passed' and 'Passed with Distinction' categories in all four batches. However, no significant association was observed in marks obtained for students in 'Failed' and 'Borderline Passed' categories. These students scored better marks in *viva-voce* examination despite performing poorly in theory examination. One of the explanations provided by the authors for this disagreement was

that examiners were lenient towards weaker students in *viva- voce* examination (Ghosh *et al*., 2012). Similar findings were reported for a study conducted to assess whether performance as determined by internal assessment correlates to the final summative evaluation in 2nd year medical students in pharmacology for last 4 years (2009-2012) (Santra *et al.*, 2014). It was retrospective, non-interventional record based study based on students score sheets of pharmacology exams. It was found that the strength of correlation between internal assessment marks and total summative exam was highly significant at p <0.0001, implying that continuous assessment influences the overall performance of UG medical students.

Oral examinations are an integral part of pharmacology assessment. In this context various factors influencing the implementation of Structured Oral Examinations (SOE) in Pharmacology has been discussed (Khilnani *et al*., 2015). In a randomized, parallel group, 2-arm study *viz:* SOE (n = 63) and Conventional Oral Examination (COE) (n = 60). Three sets of questionnaires from autonomic nervous system were prepared, each having 15 items with increasing difficulty levels and were validated by subject experts and pretested. The authors observed that SOE yielded significantly lower marks as compared to COE. There were significant inter-examiner variations in marks awarded in SOE and COE. The factors influencing implementation were difficulty in structuring viva, rigid time limits, lack of flexibility in knowledge content, monotony, and fatigue. The students perceived this format not different from COE but felt that it required in-depth preparation of topic. Faculty opined that SOE led to less drift from main topic and provided uniform coverage of topics in given time. The authors opined that conducting SOE is a resource-intensive exercise and despite structuring, inter-examiner variability was not completely eliminated.

The feasibility of structured *viva-voce* examination (SVVE) in undergraduate course to reduce the subjectivity of marking was assessed (Dhasmana *et al*., 2016). The authors observed that student's perception of SVVE was encouraging and satisfying, as compared to traditional *viva-voce* exams. Authors concluded that bias and subjectivity of *viva* were reduced by introducing SVVE despite limitations such as time constraints, availability of faculty, and motivation to bring out such changes.

Just as educators ventured in projects involving structured oral examinations, researchers have also undertaken projects based on structured practical examinations in pharmacology. The attitudes of undergraduate medical students (n=40) towards objectively structured practical examination (OSPE) component of Pharmacology practical examination versus the Traditional Practical Examinations (TPE) have been evaluated (Deshpande *et al*., 2013). Students (80%) opined that OSPE covered a wide range of topics compared with TPE. Students (85%) stated that OSPE should be followed as the method of assessment for examinations in Pharmacology. The authors concluded that OSPE was acceptable as an evaluation method for undergraduate practical. It decreased the time required to conduct the examination. OSPE was implemented in formative assessment where it was compared with conventional practical examination (CPE)(Malhotra *et al*., 2013). There was no significant difference in the mean scores between the two methods (P = 0.44). The Bland Altman plot comparing the CPE with the OSPE showed that 96% of the differences in the scores between OSPE and CPE were within the acceptable limit of 1.96 SD. Regarding the students' perceptions (n=137) of OSPE compared to CPE, 73% responded that OSPE could partially or completely replace CPE. OSPE was judged as an objective and unbiased test as compared to CPE, by 66.4% of the students.

A study has also been reported in which a module to teach parenteral drug administration skills along with OSPE stations to assess whether the same skill was developed (Devi *et al*., 2013). The 2nd year students were taught the skills of aspiration of a drug from ampoule/ vial and setting up an IV infusion. Students were randomized into case (n=20) and control (n=20) groups. The test group watched videos of skills, received demonstration and practice session before OSPE while the control group watched videos before OSPE and demonstration (and a practice session only after the OSPE). There was a significant difference between the mean OSPE scores (p <0.05) between the groups for all the 4 OSPE stations. Inter-rater reliability (ICC > 0.7) and concurrent validity (r value > 7) of all station was high. Perceptions revealed acceptability of module and OSPE stations by students

(median =4, scale 1-5). The study demonstrated that students acquire skills through practice and OSPE is a reliable and feasible mode of assessment for parenteral drug administration skills.

Student perception (n=80) regarding use of OSPE for practical assessment has been studied (Vishwakarma *et al.*, 2016). In their study OSPE was better received by the students as compared to CPE. Majority (94%) of the students rated OSPE as acceptable and opined that instructions given at each station were clear and understandable. A total of 96% of students opined that the questions asked in the OSPE contributed to their learning and helped them improve their knowledge. Authors concluded that use of OSPE is a relevant, meaningful, and feasible tool for the assessment of practical skills in undergraduate training in pharmacology.

MCQ forms an important assessment tool in most of the formative and summative examinations in pharmacology. Pre- and post-validation of MCQs is a must to maintain the quality of MCQ bank. A study attempted item analysis of 50 MCQs/items (Kaur *et al.*,2016). The difficulty index of 38 items was in the acceptable range (P = 30-70%), 11 items were too easy, and 1 item was too difficult. Discrimination index of 31 items was excellent (d > 0.35), of 12 items was good (d = 0.20–0.34), and of 7 items was poor (d < 0.20). Among 150 distracters, 27 of 150 distracters were non-functional. Based on item analysis, 6 items were discarded, 17 were revised, and 27 were kept for subsequent use. Authors opined that item analysis is a valuable tool as it helps us to retain the valuable MCQs and also helps in increasing skills of faculty in item construction. There cannot be two opinions about this statement but we strongly feel that item analysis is a mandatory prerequisite for credibility of MCQ bank and should be a routine practice.

The faculty (n=16) perceptions regarding the use of a 'Blueprint' in pharmacology theory assessment has been reported (Patel *et al*., 2016). All faculty members agreed that the blueprint ensured a uniform distribution of questions across the syllabus topics, helped to maintain a balance between questions in the recall and reasoning domains and assured the distribution of questions according to clinical importance. The faculty members also opined that the blueprint resulted in adequate weightage of important topics (90%), aligned questions with learning objectives (80%), ensured well-organised theory test papers (70%), assessed in-depth subject knowledge (60%) and minimised inter-examiner variations in selecting questions (90 %). Few faculty members believed that the blueprint created too many easy questions (10.00%) or too many difficult questions (10.00%). Use of pre-structured blueprint was appreciated by the teaching faculty as this approach helps to align the content, cognitive domains and assessment tools.

Formulating specific learning objectives, student feedback,blue printing, item analysis are considered as good teaching practices and should be routinely followed. However, many a times they may not be in place. In such scenario, these practices can be initiated as educational projects to sensitize faculty as observed through above-mentioned studies.

The experience of using 'The Three R Model of written assessment in pharmacology' has been shared (Manikandan and Gitanjali, 2016). The Three 'R's being Reduce (reduce the number of recall questions and skewing of questions towards one topic), Refine (questions have to be specific and purpose driven) and Replace (more emphasis to therapeutics). The authors also suggested inclusion of a fourth R – Rubrics (establish uniform scoring pattern). Preparation of model answers can give a clue about the inappropriately broad question with respect to the allotted marks and help in eliminating them while setting the question paper. During evaluation of answer scripts, rubrics help in bringing uniformity in the marking scheme and reduce inter- and intra-examiner variability. Thus, objectivity increases for essay/long answer and short answers questions with rubrics. This model had been successfully implemented and was appreciated by the students. The authors advised it was feasible at initial stage to implement this model at formative assessment for any department.

In medical educational systems, an effective skill assessment ensures optimum quality of patient care. A study was conducted to develop and assess the validity and reliability of a tool used to evaluate the clinical pharmacology skills of nursing students (Navabi *et al*., 2016). An item pool was developed based on the literature review and personal interviews with

faculty members. The tools validity was determined through assessment of face validity, content validity and construct validity using exploratory factor analysis on the data provided by 2nd and 3rd semester nursing students (n=264). Based on the exploratory factor analysis, all items with special value of >1 were grouped into factors: professional behaviour, effective communication, recognition of medical terminology and nursing actions before/during/after administering medicine. These factors explained 77% of the total variance of the concept of assessment of the clinical pharmacology unit. Reliability was demonstrated by a Cronbach's alpha coefficient of 0.96. Authors concluded that the evaluation tool has an acceptable construct validity and satisfactory reliability and validity, hence can be used to ensure that nursing students are adequately skilled to work in clinical pharmacology unit.

Curriculum Reforms

Research projects involving curricular reforms were lacking but many pharmacology educators have written reviews and opinions on the current undergraduate and postgraduate curriculum.

A review stated that many experts in field of Pharmacology have opined that current curriculum of Pharmacology, for both undergraduate and postgraduate students, is inadequate (Badyal and Daniel, 2016). They have suggested that the entire curriculum requires an overhaul, with valuable inputs from students and teachers alike. These experts are of the view that MCI should keep entire teaching-learning programme uniform throughout India, with medical colleges having liberty to add to the existing teaching methods recommended by MCI. This pragmatic approach would be beneficial for students and teachers alike.

Inclusion of Animal Experimentation in Pharmacology Curriculum

Animal experimentation play an integral role in both undergraduate and postgraduate medical education in the discipline of Pharmacology. With country regulations restricting animal use has put a sudden blow to these experiments needed for teaching-learning and assessment. In an editorial, it is opined that the recent developments in terms of regulatory requirements and ethical concerns have played an important role in decreasing importance of animal experiments in pharmacology education (Gitanjali, 2012). She cited a letter by University Grants Commission that has created confusion amongst the pharmacology teachers whether or not to use animals in experiments. She also bemoaned the ambivalent stand taken by MOHFW in the said matter. It has been highlighted that learning the techniques of animal experimentation may be not be feasible in undergraduate scenario but is essential for postgraduate to understand the preclinical drug development. The author did advocate protest against the myopic vision of the government regarding animal experiments in pharmacology.

In this context, a study was done to compare the perceptions of pharmacology faculty members in southern India regarding the use of animal experiments and alternatives in undergraduate (UG) and postgraduate (PG) medical education (Shehnaz *et al*., 2012). Pharmacology faculty members from 15 medical colleges located in southern India answered a 27-item, 5-domain questionnaire with a total score of 108. The mean total score obtained for faculty members (n = 52) was significantly higher ($p < 0.001$) for PG medical education (61.2/108) than that for UG medical education (51.9/108). It was evident that pharmacology faculty members in Southern Indian Medical colleges support animal use in post graduate training. In addition, the authors opined that increased awareness is required among faculty members concerning alternatives to animal experiments in medical education.

It has also been pointed out that the discrepancy in use of animal experiments for imparting knowledge of pharmacology to students throughout India (Badyal *et al*., 2014). They are of the opinion that this anomaly should be addressed as early as possible and uniformity in animal experimentation must be achieved throughout India.It has been suggested that the regulatory bodies like MCI, CPCSEA, UGC, INSA, and ICMR should formulate uniform guidelines for all educational institutions keeping in view the expected changes in curriculum with regards to animal experimentation and upgrade undergraduate and postgraduate curriculum in pharmacology (Badyal and Desai, 2014). It is recommended that a broad consensus must be developed for removing or reducing the animal experiments from curriculum.

Further, in a letter to the editor,"Alternatives to animal experimentations" in PG pharmacology curriculum have been provided (Khilnani and Khilnani, 2016). A representative list of objectives and competency- wise contents related to alternative practical methods and techniques to be incorporated in the PG curriculum in pharmacology has been provided by the authors. A suggestion has appeared in another letter to the editor that computer models are less costly and can be used repeatedly in teaching and in assessment. They aid in easy comprehension of drug pharmacokinetics and pharmacodynamics which could ultimately guide to better therapeutic teaching (Singh *et al*., 2016). These virtual techniques may serve as an effective way of reducing animal use yet the role of animal experiments, especially in research work cannot be ruled out completely.

UG Curriculum

The current scenario of pharmacology UG curriculum has been appraised (Haranath, 2016). He commented on the history and evolution of pharmacology education. The author opined that even though the Indian pharmacology education was introduced on the lines of western pharmacology, it has not kept up with the advances seen in western pharmacology education. The author states that pharmacology practicals started with dispensing pharmacy, they were later replaced with experimental pharmacology. At present after restrictions on animals for teaching, practicals are converted to theoretical exercises on prescription writing and drug incompatibilities. Students study mostly before examinations with little influence of yearlong teaching. He suggested that to circumvent this anomaly, MCI guidelines are to be made only advisory, instead of being binding. Academic freedom should be given to the universities and teaching institutions to plan and reform their teaching programs that can be more contextual and clinically oriented.

Pharmacology UG curriculum emphasizes rational selection of medication and writing prescription, but pays little attention to impart training to students regarding specific topics that are more useful in clinical practice. Two such areas are medication safety and communicating prescriptions to patients effectively. A medication safety module (MSM) has been developed (Chandy *et al*., 2016). Four themes *viz*. adverse effects, medicines management, quality of medicines and rational use of medicines were selected. For each theme, a submodule of 30 min teaching duration was planned and implemented for 88 students from Phase 2. The focus was to acquaint students with various factors that can jeopardise patient's safety while on medicines, steps to be taken to improve the same, to make them aware of their responsibility and to encourage an integrated style of thinking and clinical management. A significant increase in post- test score was found (12.24 ± 2.23 vs 9.52 ± 2.41 pre test score; $p < 0.001$). This study pointed out the feasibility of implementing such specific learning modules within the medical curriculum.

A structured prescription communication skills programme for 2nd MBBS students has been developed (Rege *et al*., 2017). The training programme included a communication skills workshop, practice sessions, and pre- and post-programme assessment. A 5-R framework (Reasons, Regimen, Risks, Revisit instructions and Revision statements) for communicating prescribing information to patients was evolved. Case scenarios for 10 common clinical conditions encountered in outpatient settings and requiring single drug prescriptions were developed. The baseline OSCE scores revealed students' inadequate communication skills despite participation in lectures on prescribed medicines and assessment in existing curriculum. After the practice sessions, the students' ability to communicate prescribing content improved significantly from 12.97 ± 4.93 to 36.71 ± 8.85 ($p<0.01$) and the Rating Scale for Quality of Communication (RSQC) scores increased significantly from 13.83 ± 4.72 to 31.61 ± 7.93 ($p < 0.01$). The authors opined that workshop, practice and OSCEs can be easily incorporated into the existing curriculum. The 5-R framework provided a tool to improve students' communication skills regarding prescriptions and was acceptable to both students and teachers.

PG Curriculum

Educational experts in the field of pharmacology have also commented on the inadequacies of the current curriculum in post-graduate pharmacology. It has been commented that various additions or alterations can be made to the objectives, teaching methodologies,

assessment strategies of the current post-graduate pharmacology curriculum, for the benefit of the students (Badyal *et al*., 2014). A letter to the editor highlighted the need to bring about changes in the PG training program to ensure that PG student acquires expertise and skills: management of animal house, problem solving approaches while dealing with environmental toxins and pollutants, ability of drug defence in drug regulatory meetings (Kuruvilla and Suresh Kumar, 2015). The authors also opined that participation in workshops/continuing medical educations and observatory postings can improve the scope of skill based training. The recommendations given by all medical educators are in sync with views put forth earlier (Ananthakrishnan *et al.*, 2012), which emphasized implementation of competency-based model of a 2-year course across all specialties (including pharmacology), use of offsite facilities for training and a criterion-based evaluation system entailing continuous monitoring for postgraduate teaching.

To train the postgraduates in the required skills and expertise,a rotational duty programme for practical training in pharmacology for postgraduate students (n=20) has been developed (Gajbhiye *et al*., 2016). Under this programme students were posted in bioassay laboratory, neuropharmacology laboratory, and specialized research laboratories of the department, pharmacology ward and animal house. This structured programme had weekly targets/ experiments to be accomplished, assessment and constructive feedback for the students. The perception and attitude were recorded using a questionnaire in which their adequacy of duration of posting, adequacy and relevance of the training imparted in the posting; quality and pattern of assessment and their perceived benefits from the program were evaluated. All postgraduate students found the programme adequate and relevant in terms of duration, implementation of weekly targets, training imparted and quality of assessment.

Among the PG students who opt for pharmacology, many envisage themselves in roles of medical experts in pharmaceutical industry. However, the current curriculum does not address this need of the pharmaceutical industry. Incorporating pharmaceutical industry training programmes in PG curriculum which is resource intensive and able to inculcate the skills required to be an efficient medical expert is the need of the hour. This training will not only help the PG students to perform better in their career in pharmaceutical industry, but it will also enable them to make an appropriate career choice (Kshirsagar *et al*., 2013) had reviewed the status of clinical pharmacology training and its industry applications. It was observed that clinical pharmacologists undertake multiple tasks *viz:* conducting ethical clinical trials, supporting the needs of generic drug industry, providing access to safe, effective and affordable medicines, guiding rational drug use and supervising medicines management standards for hospital accreditation. The authors stated that clinical pharmacology and research program should provide hands-on training in industry and clinical trials setting with various healthcare providers. The training should include public health perspective so as to enhance the skills as community researchers in drug development.

A letter to the editor, also reiterated the broad responsibilities for a clinical pharmacologist as teaching, research, clinical work, policy and administration, editorial work and writing (Kamath, 2016). A balanced approach is necessary to train the pharmacologist in each of these responsibilities requiring a structured, competency based curriculum to train in all these skills.

An important and evolving subspecialty-forensic pharmacology needs recognition in India. Training related to this field is lacking in the current PG curriculum (Malve, 2016). The skills and expertise of a forensic pharmacologist can be useful in a large and diverse number of legal cases. The potential contributions of forensic pharmacologists can be made in fields of toxicology, drug abuse, sports medicine and doping, alcohol consumption and associated medicolegal aspects, criminal cases, off label drug use and its associated effects along with environmental and ecological toxicity. The author has stated that in Indian scenario, trained forensic pharmacologists can definitely add value to the legal aspects of drug use and abuse.

Shift to Competency Based Medical Education

Currently MCI has stressed on Competency Based Medical Education (CBME) and accordingly the reforms in medical education are underway. CBME

and its implications on the current medical teaching practices has been discussed at length (Shah *et al.*, 2016). They reviewed various issues and challenges with development and implementation of CBME curriculum. In addition, the authors commented on the 'pros and cons' of such an approach and its future in Indian scenario. The authors opined that the strength of CBME is that it focuses on outcomes. Furthermore, it accepts that each learner is unique and learns at his/her own pace. There seems to be a better scope of teaching the "art" of medicine that includes attitudinal and communication skills and values related to ethics and professionalism. It promises greater accountability because the assessments are very close to what would actually be done in real life situations.

Pharmacology Curriculum in Other Disciplines and Institutions Not Affiliated to MCI

Apart from challenges in pharmacology curriculum in medical schools, the various opportunities and challenges in constructing the curriculum of pharmacology in pharmacy institutions in India have been reviewed (Goyal *et al.*, 2014). Considering the dynamic character of pharmacology, the syllabus should cater to the contemporary needs of the academic institutions, pharmaceutical industry and the community. The syllabus must be balanced between industry oriented pharmacology and clinical pharmacy had been recommended. Redundant animal experiments should be replaced with the simulation experiments. The authors recommended that the M. Pharm curriculum should focus on preclinical research with the inclusion of molecular biology and experiments on gene expression, proteomics, pharmacogenomics, cell culture and tissue culture. In general, at all levels, exposure of pharmacy students to hospitals and clinicians is needed.

Medical educators in India have implemented modified pharmacology curriculum in medical schools affiliated to the international universities (not under the coverage of MCI). Implementation of UG pharmacology curriculum at an international medical college using all active strategies as PBL, CBL and self directed learning (SDL) modules prepared the students for future clinical practice by inculcating higher cognitive skills and soft skills (Devi *et al.*, 2016). The revised curriculum is more contextual and relevant to clinical practice.The authors also provided model for program evaluation and also stated the challenges faced while executing the planned curriculum. Similarly in letter to editor, Rao (2014) has discussed how the pharmacology curriculum in an American medical school differed from India. The author has stated that clinically relevant topics (e.g. hypolipidemics, antiplatelets, antimicrobials) are dealt with in "Case Based Group Discussion (CBGD)", a form of SDL/active learning, wherein students are provided the learning objectives relevant to the topic and small clinical vignettes for every one or two learning objectives, two weeks in advance. Students do a self study based on the learning objectives and present the cases in groups of 6-8 students each. No lectures are delivered on these topics while the students learn the clinical applications.

Conclusion

Research in the field of Pharmacology education has occurred with the untiring efforts of individual experts, who have tried to adapt and innovate various methodologies to improve teaching learning experience and to increase knowledge retention. Adequate analysis of current practices forms the foundation of any reform in medical education. However, it was found that very few studies have been published which can throw light on the current practices, student and faculty perceptions about teaching of pharmacology and student experiences. Academicians have tried, at individual institutional level, to innovate and incorporate relevant changes to the teaching methodologies. However, a systematic approach is required to recognize and address the common lacunae encountered in present pharmacology teaching. Faculty and educators are doing research in teaching-learning methods but there is dearth of research in areas such as curriculum reforms, program evaluation, faculty development programs and student environment. In addition, there are many papers pertaining to UG pharmacology curriculum but there is a need to focus on pharmacology curriculum for postgraduates and even for the super-speciality like Clinical Pharmacology. Other point of consideration is that majority of researchers have done research projects with short term outcomes i.e. they have captured perceptions and short term performance. Studies with intermediate and long term outcomes in this field are lacking. Hence, a comprehensive, systematic and robust research

programs must be adopted to identify and address the lacunae/deficiencies in present pharmacology curriculum implementation.

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