

UNRAVELING RESEARCH OPPORTUNITIES FOR UNDERGRADUATE MEDICAL STUDENTS

Abstract

Medical research is of high value to the clinicians and to the society as well. Undergraduate research plays a pivotal role in shaping the higher education comprehensively. This article titled “Unraveling research opportunities for undergraduate students” elucidates the importance of research for undergraduate students.

This document, in its body of research deals with its importance and relevance, in brief discusses the history of research and about its evolution. It highlights the discoveries made by medical students, how the keen observation and enthusiasm of students can contribute to medical research and in rationale of research explores its importance with better patient care because of evidence based medicine and new avenues research can embark upon.

In comprehensive review, an attempt is made to discuss the issues related to research, its importance in undergraduate curriculum, how and when to inculcate, how to develop research protocol and carry out the research, funding agencies available, centers that provide knowledge and conferences and journals related to are under-mined.

The monogram discusses about benefits the research can impart and challenges and barriers faced by the undergraduate students in pursuing medical research. The present scenario of research and issues related to undergraduate research are unwrapped. undergraduate research in western countries and the Indian context are briefed.

In conclusion, the monogram stresses about importance of research for undergraduate

Authors

Prof. (Dr.) Ganga S. Pilli

MHPE Scholar

Institute of Health Professions Education,
Sri Balaji Vidyapeeth, Puducherry

Professor and Head, Pathology, KAHAR
(KLE University), JGMM Medical College,
Hubballi

Dr Prof Shivasakthy Manivasakan

Director

Institute of Health Professions Education,
Sri Balaji Vidyapeeth, Puducherry

medical students and deals with its avenues and barriers.

Keywords: undergraduate, medical, education, research, opportunities, challenges, funding, conferences, journals, western, curriculum,

I. INTRODUCTION TO UNDERGRADUATE MEDICAL RESEARCH

The Greek philosopher Socrates in the fifth century states that “Life without inquiry is not worth living as a human being”.⁽¹⁾

According to the National Medical Council, the goals of Indian Medical Graduate are to be a:

1. Clinician
2. Leader and member of health care team
3. Communicator
4. Lifelong learner and
5. Professional

In continuing safe and effective care to attain global health standards, Evidence Based Medicine (EBM) remains the corner stone of clinical practice in decision making. Ensuring the attainment of knowledge and skills for Undergraduate (UG) student and the general practitioner, the most important task is to maintain quality standards and reduce errors which can harm the patient during clinical practice.

The undergraduate student has to be familiar with:

1. Basic medical knowledge
2. Clinical practice
3. Translational research
4. Evidence based medicine

All these factors apply to the care of the patient, for safe and effective care in decision making. While, we discuss about research, let us look into the definition of research.

Definition of Research

The research is defined as assiduous examination to validate and define the prevailing knowledge in context of society and its environment.¹ Through the new knowledge one tries to discover something new to the scientific field. It will initiate, modify or terminate the present understanding on a particular subject.

Research is a systematic investigation into and study of materials and resources in order to establish facts and arrive at new conclusions. In simple words, research is a systematic inquiry to describe, explain, predict and control the observed phenomenon.

Research at UG level is a self-directed work under the guidance and supervision of mentors or advisors. This helps the students to work under supervision and in this process, they gain

confidence. The undergraduate students can investigate on a subject of their interest with their mentors and participate in research projects.

The definition of research has many views based upon the context of the research across diverse areas of interest. This has impact on defining the research in the teaching-learning processes and the type of relationship it can take. The research can be pure or basic, connected with specific and well-defined disciplinary areas, and applied research dealing with more multidisciplinary nature.^(2,3)

Some of the questions that need to be answered while conducting research are:

1. Why research?
2. Where to do?
3. What to do?
4. When to do
5. How to do? and
6. Who should do?

Why research - encompasses:

- Research will complement academic knowledge.
- Stimulate the students to learn and apply knowledge.
- Enhances oral and communication skills.
- It has been shown in a study that, participation in research, engaging in publication from UG level, especially working on data analysis, enhances problem solving ability, critical analysis of literature search and scientific writing contributes enormously to the development of essential medical skills.
- Research helps the undergraduate students to develop self-discipline, commitment, responsibility, determination and competitive edge in order to carry out the project in a short span of time. It also helps in pursuing academic career.⁽⁴⁾
- Research instills confidence, increases independence of own thought, self-motivation to learn and take active role in learning.⁽⁵⁾
- Studies have shown that, students exposed to research in early age, contribute to better scientific outcome and aid in better patient care. Hence, teaching research skills need to be incorporated into medical curriculum.^(6,7)

In this monogram, a sincere effort is made to study the following aims and objectives.

- 1. Primary Objective:** To find out research opportunities for undergraduate medical students.
- 2. Secondary Objective:** To find out associated benefits and challenges involving research.

This monogram is restricted only to undergraduate medical students. Undergraduate research for dental and other health care systems is not addressed here.

II. METHODOLOGY

An extensive literature review on research opportunities and issues related to research for undergraduate medical students has been carried out.

Search Strategy employed: A comprehensive search strategy has been employed to identify relevant literature. Data bases like PubMed, Medline, Scopus, Web of Science, Up to date, institution's websites and google search are included.

III. BODY OF RESEARCH

In the body of the research, the following topics are covered:

1. Importance and relevance
2. Brief History and evolution of medical research
3. Discoveries made by medical students
4. Rationale and initial experience

Importance and Relevance

To develop as future physicians, research to UG students has many advantages in learning through evidence based medicine for better patient care. The research is defined as assiduous examination to validate and define the prevailing knowledge in context of society and its environment.⁽¹⁾

Through new knowledge one tries to discover something. It will initiate, modify or terminate the present understanding. Research at UG level is self-directed work under the guidance and supervision of mentors or advisors. This helps the students to work under supervision and in the process they gain confidence. The undergraduate students with their mentors can investigate the subject of their interest by taking up research projects.

Research helps students to understand their academic syllabus better and pursue the subject of their interest in depth. They get a glimpse of what they get from the course they are studying and they can make an informed decision about their careers.⁽⁸⁾

Apart from increased evidence based medicine, it also drives the translational research for physicians and researchers from bench to bedside. Hence, research is a critical component of modern medical education.⁽⁹⁾

Brief History and Evolution of Medical Research

Abraham Flexner was an educator who played major role in the introduction of modern education in American medical schools and universities. Flexner through Carnegie foundation commission surveyed the quality of 155 medical schools in United States and Canada. His report in the year 1910, has sensational impact on medical education. After detailed analysis of the study he addressed the poor quality of curricula and teaching facilities, lack of standardization,, financial gains of the management rather than quality education. He stressed the need of formal analytical training in academic medical schools with full time faculty which is functioning till today. This transformation has occurred as an aftermath effect of Flexner's report.⁽¹⁰⁾

In the year 2012, the Association of Medical Education in Europe (AMEE) introduced a guide “Developing research skills in medical students”. This provides the guidelines for the individuals involved in curriculum design. It describes why research skills and its attributes are important to those who are pursuing medical career. It also describes why research skills and ethos of research should be instilled into medical professionals of future and every medical student should understand research methods and their benefits. The guide concludes that understanding of research can be greatly enhanced by encouraging active participation of undergraduate medical students in research activities.⁽¹¹⁾

In the year 2015, World Foundation for Medical Education (WFME) brought out similar guidelines to improve standards of research. The regulation of medical curricula at national level should encourage participation of students in research. For example, in United Kingdom, in its outcomes for medical graduates the GMC, states that the newly graduated doctors must be able to apply scientific methods and approaches of medical research and integrate these acquired skills in health care practice.^(12.)

Discoveries Made by Medical Students

Scientific research focuses more on Evidence-Based Medicine. During a relatively short time of medical education as undergraduates, one should study a lot, draw conclusions, internalize, grab the opportunity and apply what is learnt to clinical practice in future.

Medical history, describes many discoveries due to keen observation, enthusiasm and hard work of undergraduates. A few of the important discoveries are listed below (Table 1).

Table 1: To show Discoveries made by Medical Students

No	Name	Year/place	Discovery
1	Jay Maclean, Charles Best Martin Flack William T.G. Morton		Heparin, insulin, the sino-atrial node and ether anaesthesia
2	Paul Ehrlich	1878	Mast cells(as a student) metachromatic granules (as a Ph.D scholar)
3	Niels Stensen	(1638- 1686/ Danish anatomist	parotid duct in sheep in 1661 described later the "Fallot's tetralogy", the Stensen's foramina
4	Olof Rudbeck	1630-1702	Pioneer in lymphatic system. As a student decribed lymphatic connection between the intestines and the circulating blood, leading the prepared nutrients via the thoracic duct to the veins
5	Paul Langerhans	1847- 1888	islets in the pancreas cells in the skin
6	Jayant Vaidya,	Goa Medical College in 1986,	The mechanism of this effect of posture on autonomic control of sweating, which is controlled by the sympathetic cholinergic outflow,
7	McLean,	1916, Johns Hopkins University,	investigating pro-coagulant preparations, isolated fat soluble phosphatide anti-coagulant.
8	Howell	early 1920s,	isolated a water-soluble polysaccharide anticoagulant, heparin
9	Manu Liladhdar	1955/KEM Hospital,	As a student during December 1955, wrote to Hamilton Bailey about his observation that fixed adduction deformity in

	Kothari,	Bombay.	inflammation of the hip can be measured visually without moving the patients limb. Only by inspecting the inguino-scrotal or inguino-labial curve, male's inguinal hernia and the female can be differentiated from the femoral hernia.
10	Sally Rohan,	2022/New Jersey	a 27-year-old medical student in, her papillary carcinoma thyroid during ^{an} ultrasound class

Still as a student Heparin was discovered by Jay McLean along with his advisor Howell, Insulin, sino-atrial node and ether anesthesia are some of the major discoveries made by medical students.⁽¹³⁾

Paul Ehrlich in the year 1878 identified Mast cells when he was still a medical student, later in his doctoral work described aniline dyes which stained mast cells with metachromatic granules, and he coined the name mastzellen.¹⁴

Neils Stensen, a Danish anatomist, natural scientist, and a theologist was a medical student when he discovered the parotid duct in sheep in 1661. In later years, he described 'Fallot's Tetralogy a congenital cardiac anomaly, the Stensen's foramina, an incisive foramina of hard palate which transmits terminal branch of the descending palatine artery and nasopalatine nerve..⁽¹⁴⁾

Olof Rudbeck (1630-1702) carried out a pioneering study of lymphatic system in his student days at Uppsala University in Sweden. He began dissecting small animals and found the lymphatic connection between the intestines and the circulating blood leading to the entry of nutrients via the thoracic duct to the veins.⁽¹⁴⁾

As a student, Paul Langerhans discovered dendritic cells of the skin and he demonstrated these cells with gold chloride staining of Julius Conheim in the year 1868. During his doctoral work at Berlin Pathological Institute, contributed to the discovery of islets of pancreas which are known by his name.⁽¹⁴⁾

Jayant Vaidya presently onco-surgeon at London, during his undergraduate days at Goa Medical College observed postural effect of autonomic control of sweating which is controlled by sympathetic nerves. He made the observation that while lying on right side at night, left side was profusely sweating although his left side was receiving cooler air from the fan and same was true for the other side. He conducted an experiment on 16 people and confirmed the findings. As an onco-surgeon, he has developed an intra-operative therapy for post-lumpectomy cases of breast cancer patients at University College, London along with other two scientists.⁽¹⁴⁾

Kothari, as a student in the year 1955 at KEM hospital Mumbai, wrote to Hamilton Bailey about his observation that fixed adduction deformity in inflammation of the hip can be measured visually without moving the patient's limb.⁽¹⁴⁾

Jay Maclean, in the year 1916 as a second year medical student at John Hopkins University was working under the guidance of Howell who was investigating pro-coagulant properties. He isolated a fat soluble anti-coagulant, Howell later in the year 1918 isolated water soluble polysaccharide anti-coagulant and he coined the term Heparin for fat soluble anti-coagulant

and gave credit to McLean, although it was different from phosphatide preparations previously isolated. The work of McLean changed the directions of Howell's team to work upon anti-coagulants which in later years led to discovery of polysaccharides.⁽¹⁴⁾

Sally Rohan, a 27 year old medical student in New Jersey made an unexpected discovery about her Papillary Carcinoma thyroid during USG class in the year 2022 which would have gone unnoticed.⁽¹⁵⁾

Rationale

Research in medical education has addressed the discovery of new treatment modalities, drugs, and understanding of unknown findings since time immortal. This is required for better patient care for may be undergraduates or postgraduates, researchers or educators.

UG research plays a pivotal role in shaping the students comprehensive higher education journey. It enriches the academic understanding; engages the students actively in knowledge creation.⁽¹⁶⁾ As already established in the past, the keen observation and involvement into the subject, as medical students have discovered many of the unknown facts and contributed to the medical field. Heparin and pancreatic islets are the best examples.

Ensuring attainment of knowledge and skills for a student who is future general physician, it is most important to maintain quality standards and reduce malpractice errors. Studies have shown that engagement in research which involves, data collection, data analysis, problem solving, critical appraisal of literature and scientific writing contributes substantially to development of minimum necessary skills.^(17,18) Researching and publishing, students learn to critique the evidences for responsible decision making and helping them in better patient care by avoiding medical failures in their practice.⁽¹⁹⁾

There is evidence that integration of teaching research to undergraduates helps them to reform into comprehensive professionals by closely related to evidence based medicine and in addition contribute to the production of scientific knowledge to the learners.⁽²⁰⁾ The medical students also research and publish the scientific articles to increase their competitiveness and make their career advancements.⁽²¹⁾

IV. COMPREHENSIVE REVIEW

In comprehensive review the following issues have been discussed:

1. Research address in UG curriculum and when to inculcate research to undergraduate students
2. Conceptual frame work when and how to implement
3. Development of research protocol
4. Funding agencies for UG research, Centers providing knowledge regarding research, Conferences for medical students and Students medical journals for publication

Research as a Part of UG Curriculum and When to Inculcate Research to Undergraduate Medical Students

In India, though in MBBS program with traditional curriculum, no focus has been placed on the fundamentals of biomedical research, most of the medical graduates pursue postgraduate studies and biomedical research after completing their MBBS program, which necessitates a thorough understanding of research methods. Preparing undergraduate students for biomedical research methodology can make them to gain a better understanding of the subject. The National Medical Council has transformed the traditional UG medical curriculum into a skill based learning course. The decision to offer two mandatory electives of four weeks duration between III phase part I and II years has been welcomed by the educators. Students can work upon their area of interest during this time of electives. Some of the students can choose research as an elective and work towards data collection for a short time project. It allows medical students to gain transformative experience in basic science or research and clinical subjects or rural/community experience.

A need arises to have institutional policies and teacher training programs to develop a competency to promote a “research culture.” A study conducted for faculty and students. as a guiding document for research initiated by UG medical students showed point-to-point detailed Research module (Table 2).²²

Table 2: Research Module as elective for UG medical Students ⁽²²⁾

Name of the elective	Undergraduate Medical Student-Initiated Research (Hands on Experience in Basic Biomedical Research)
Learning objectives of elective	The students should be able to 1. accurately describe the types of research (e.g., research design, sampling), data, measurement tools, and ethical aspects (e.g., consent, confidentiality) of research. 2. frame a research question and generate a hypothesis accurately. 3. develop a concept note/research protocol accurately 4. accurately plan the data management (data entry; measures of distribution; confidence interval and probability value; basic statistics like chi-square test, t-test, etc.) 5. perform literature search and referencing accurately
Number of students that can be accommodated in this elective	Up to 10
Prerequisites for elective	Having a valid e-mail ID Having access to the internet and a device where the student can do the literature search and data analysis Basic readings in biomedical research and biostatistics
Weak wise activities	Week 1: Seminars (explaining the basics of research methodology, data, measurement tools, and ethical aspects of research); Understanding the research gaps, research needs, Developing research question, Generating hypothesis, writing a protocol Week 2: Observation of research activities carried out in University (data collection, lab tests, consenting process, data entry, data monitoring)

	Week 3: Observation of research activities carried out in University data collection, lab tests, consenting process, data entry, and data monitoring) Week 4: Understanding the research protocol submission requirements, literature search, referencing, writing the report, writing an abstract, basic biostatistics At every weekend: Reflection, Formative assessment
Learning resources	Cochrane library: https://crowd.cochrane.org/ • National Programme on Technology Enhanced Learning (NPTEL) Supported by Indian Council for Medical Research-National Institute of Epidemiology (ICMR-NIE), Chennai: Basics of biomedical research: https://www.youtube.com/watch?v=ZTu8OHlpJw0&list=PLyqSpQzTE6M84uhv2xVd-sF0I1VZU9XVO (23 videos) • Zotero: https://www.zotero.org
Assessment	At least 75% attendance (18/24 days in four weeks) Completed log book Completed worksheets Meeting the research objectives (formative assessment: Viva and MCQs)
Student: 3rd MBBS part 1. Number of hours per day = 3 hours and a total of 72 hours over four weeks (considering six working days in a week).	

The students have to document the details in their logbooks. After completion of the research elective, grades may be given according to the student's performance. A study summarizes by commenting that Institutions need to make a specific, measurable, achievable, realistic, and time-bound (SMART) elective module, to make it feasible. The authors conclude that, a structured research elective will help medical graduates get sensitized for medical research and improve the number and quality of publications.⁽²²⁾

According to Ahmed et. al., students focusing on research helps to develop critical thinking, clinical skills, ability to analyse and apply scientific knowledge. Furthermore, the authors also examined the challenges and barriers faced by medical students engaging with research, curriculum constraints, resource limitation and varying levels of institutional support.⁽²⁾

Research introduction into curriculum has been documented to have translated skills valuable for future clinical practice. Involvement in research improves analytical reasoning, and communication skills applicable in patient care. The research aptitude helps in their future clinical practice. Early exposure to research enhances its relevance to patient care as doctors and their involvement in postgraduate research.⁽²¹⁾ Integration of research in curriculum paves a way to lay a foundation to enhance their skills in the career.⁽²³⁾

Early in medical school, UG medical students should be introduced to research. This will inculcate analytic thinking in them and drives them to practice evidence based medicine in their later part of career.

It is ideal to encourage research during student days. It is proved that UG students who research and publish more manuscripts before graduating tend to continue to publishing, after obtaining their medical degree and even manage to publish more, up to 1.7 times compared to those who start publishing after graduation. In addition knowing basic concepts related to evidence based medicine and scientific communication helps the search for information during the study.⁽²⁴⁾

Dreyfus model of skill acquisition can be adapted to those who are interested in pursuing research (Fig.1). All the students can be exposed to fundamentals of research in the

foundation course. Interested students can spend extra time in research apart from their regular studies. The students transform from novice stage, to advance beginner stage, competent stage, proficient stage and expert stage as they move on to different phases of MBBS.

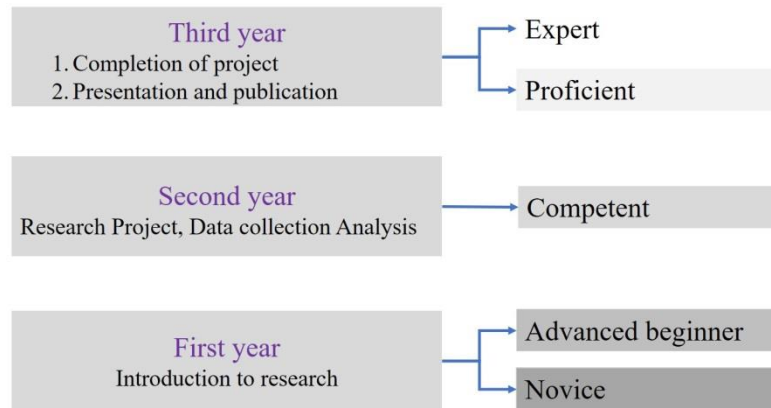


Figure 1: Dreyfus model for skill acquisition ⁽²⁵⁾

To adapt this skill acquisition model for research education, the need arises to teach research related skills in a systematic and horizontal fashion which can be meaningfully integrated to the core medical curriculum.

The fundamentals of research to newer participants can be introduced in the curriculum in the beginning, the students who are novices at this stage, and can become advanced beginners. The students interested in research can move on to learn practical skills and real life practice of paper writing and statistical analysis along with senior peers. They can join some project work under the supervision of mentors and these students will become from advance beginners to competent and proficient students, In later years of learning, the students inculcate values and behaviors who attain proficient research abilities. Such students on Dreyfus model are proficient and expert students.⁽²⁵⁾

The novice students require straight forward rigid rules and guidelines to familiarize themselves with various steps in the conduct of research. Minimizing the barriers at the entry level and demystifying the process to acquire skills that can help the novice students to get into research. At this stage didactic teaching modalities can elucidate theories and methodologies underlying research and students from novice stage will progress to advance beginners through continuous testing the concepts and developing some fundamental skills. The curricula should provide some opportunities to the research desiring students to join simple projects under mentors, allow them to gain experience, develop practical skills and consolidate their knowledge to progress to next stage of competency.

Institutions should expose students at this stage to research projects and students enter into competent stage, they are able to complete most of the tasks with supervision of mentors.

The proficient individuals undertake active participation in research and have awareness of their interests, strengths and weaknesses. They critically evaluate themselves for self-regulation and produce better quality research compared to their peers. Institutions should

connect such students with funding and research opportunities. Proficient students should be allowed to act as peer mentors in the longitudinal mentorship programs, with additional guidance from the mentors or faculty to develop intuitive research practices. ⁽²⁵⁾

Conceptual Frame Work When and How to Implement

One of the most important aspects of adapting a research culture during undergraduate program in medical schools is to create a curriculum embedded with research concepts such as i.e., epidemiology, biostatistics, research methodology, and scientific publication. ⁽²⁶⁾

The interest groups (academic & research communities) can be formed by undergraduate students, residents and professors. The professors fulfill the role of mentors as experts and act as guides to carry out projects. They participate in events of social appropriation and circulation of knowledge. They carry on various activities such as workshops, seminars and research projects. ⁽²⁴⁾

Unnikrishnan, ⁽²⁷⁾ presents a model where research can be incorporated into curriculum. He proposes research methodology training to the students in the first and second year of the course. The students can pursue research work during the time allotted for electives in the curriculum that is during their third professional year. Due to varied interests of the students and shortage of time the students may not be able to complete the research work during the short period allotted for electives.

The authors of this monogram, propose a slightly modified vertical integration model, to adapt to the medical undergraduate curriculum in India. All students in the first year can be exposed to the research methodology. In the second year of their course the interested students can be given small projects to carry out individually or in groups. The data can be collected and analyzed during second year summer holidays or can work extra time during their hospital postings. In the third year, wherein electives are offered, students can opt research as elective and complete the project, do presentations and publish by the time they finish the course.

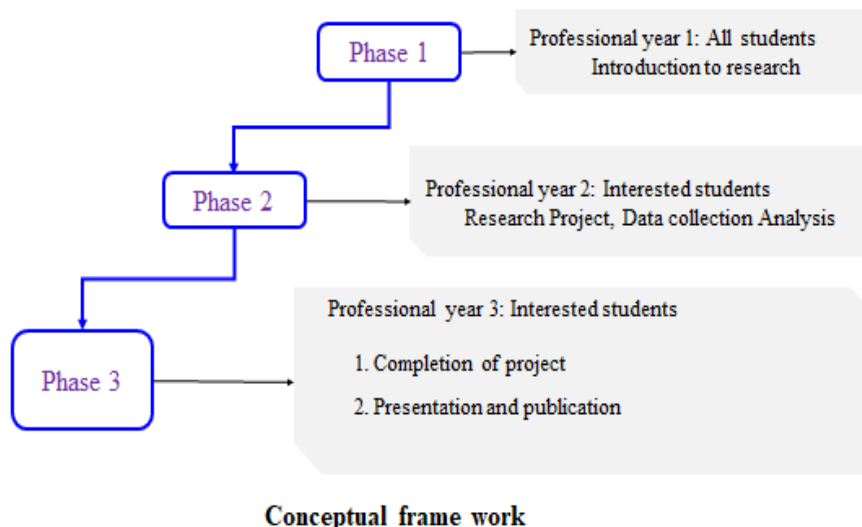


Figure 2: Conceptual framework to carry out research

Implications

- Research is an essential aspect of medical science and it needs to be adequately addressed in the undergraduate MBBS curriculum in India.
- In traditional curriculum, no focus was placed on the fundamentals of biomedical research.
- CBME, the decision to offer two “mandatory” (supervised, experiential, immersive, and self-directed) electives in four-week blocks between MBBS Third Professional Parts 1 and 2 has been appreciated by all the educators.
- It allows medical students to gain transformative experience in basic sciences or research and clinical sciences or rural/urban community experience.
- Research introduction in curriculum documented to have translated skills valuable for future clinical practice. Involvement in research improves analytical reasoning, communication skills, and its application to patient care.
- Early exposure to research enhances its relevance to patient care as doctors
- Integration of research in curriculum provides a foundation to develop the skills which help in their career.

Development of Research Protocol

The students should have adequate knowledge about the body of the research when they apply for the research projects. They should read the guidelines of the particular funding agency and prepare the protocol accordingly. The students should take help of the mentors while preparing the protocol. Some of the steps to be followed while preparing the body of research are listed below:

- Type of research
- Topic: Importance and relevance
- Generating the research hypothesis
- Writing study protocol
- Obtaining IEC approval
- Data collection
- Data analysis
- Results
- Discussion
- Summary and conclusions
- Publications and presentations

Type of Research

The types of research can be classified as

1. Primary

- a. Basic research
 - Animal experiments,
 - Experiments on humans,
 - Cell studies,

- Biochemical,
- Genetic and physiological investigations,
- Studies on the properties of drugs and materials.

b. Clinical Research

- **Interventional (or experimental):** An interventional clinical study aims to compare treatment modalities within a patient group. Randomization should be used in clinical studies so that patients are randomly assigned to therapy arms.
- **Non-Interventional (or observational):** Non-interventional clinical studies are observational studies in which patients get an individually tailored therapy.

c. Epidemiological Research

To investigate the distribution and changes in the frequency of diseases and the causes. These can be experimental or observational

2. Secondary: Reviews and meta-analysis of available studies are presented

Topic: Importance and relevance

While choosing a research topic, it's essential to consider a couple of things.

- What topic interests you?
- What unanswered questions do you want to address?
- During the decision-making and brainstorming process, here are a few helpful tips to pick the right medical research topic:
- Focus on a particular field of study
- General areas produce broad results, choose a specific area of research early in the process.
- Maybe a certain topic interests you or your mentor.
- Look into commonly researched topics

On choosing, do some preliminary research on that topic.. What have other academicians done in their papers and projects?

This initial work will help to uncover any literature gaps, which may be beneficial for the research. Try to find out unanswered questions. Ask questions such as why, how, what, who, where and when. These questions are the starting point of the project design and will act as guiding light throughout the process.

Many a times, mentor will give clear guidelines as how to choose the topic.

Determine Topic: The topic is the main point around which your work will revolve and it is possible that, the unanswered questions can be answered. Establish the main points to be worked upon

Generating the Research Hypothesis: Hypothesis is a specific prediction about a new phenomenon that should be observed if a particular theory is accurate. Generate hypothesis for your research study.

List the Aims and Objectives: Write down the primary and secondary objectives of the study. They are usually written in an abstract manner that describes the ultimate goal of the research.

Review of Literature

A literature review is a survey of scientific sources on the topic of research question, it provides an overview of existing knowledge about the research being carried out, allowing the researcher to identify relevant theories, methods, and gaps which needs to be found out or applied to the research work.

The five steps to be followed in literature review are:

1. Search for relevant information on the topic to be researched. Search in google scholar, pubmed, up to date, cochrane etc..
2. Study the relevant articles related to the research work being carried out.
3. Identify the themes, debates and gaps. Look for trends and patterns in theory, methods and results.
4. Outline the literature review structure
5. Write in order: chronological (older to recent), thematic (Organized around key themes), methodological (compare different methods being used across the studies) and theoretical (Opposing theories and models).

Writing Study Protocol

A research protocol is a comprehensive document that delineates the strategy for adhering to ethical standards for research study participants. Its purpose is to give a general summary of the work to be carried out in order to comply with institution's policies on study participant safety. Research protocols must be submitted to universities' and research centers' Institutional Review Boards (IRBs) or ethical clearance committees.

The research topic should be satisfactorily addressed in the study protocol. The history, justification, goals, design, technique, statistical considerations, and the methodology should all be covered along with references. Consent forms and data collecting protocols should be included.

1. **Study Design:** The study design should support the scientific integrity and credibility. It should include type of study, target population, sampling size, criteria for participation inclusion, exclusion and withdrawal and the expected duration of the study.
2. **Data Collection:** Whether experimental or dealing with humans, procedure, methodology in detail.

The steps to be followed are

- **Explain the Methodology:** What is the research problem and what type of data is being collected. It is quantitative data or qualitative data being collected or primary or secondary data being collected. Describe the technique or procedure in detail.

- **Describe the Methods of Data Collection:** Mention criteria for selection and exclusion. Mention tools, procedure and material used, mention how to measure variables.
- **Describe the Methods of Analysis:** In quantitative data, how data is processed and analysed. Mention data procedure software used and statistical methods applied. In qualitative data, describe in words, images, responses, themes and patterns.
- **Evaluate and Justify the Methodological Choices:** mention why a particular method is chosen amongst the other possible methods if any and also mention how this method contributes to new knowledge. Acknowledge limitations and weaknesses and strengths.

3. Obtaining Institutional Ethics Committee (IEC) /Institutional Review Boards (IRB)

Approval: Submit the study protocol to Institutional ethics committee /Institutional review board which may agree or suggest some changes which need to be incorporated. It ensures participants' rights are protected and they are safeguarded against risk and harm.

If animal experiment is being conducted it ensures less pain and minimum number of animals to be used. Replacement, reduction, refinement, responsibility, and rehabilitation or reuse are principles for the ethical considerations in conduct of scientific research involving animals.

- Replacement : Use alternative to live animals
- Reduction : Use fewer animals
- Refinement : Minimize the suffering of the experimental animals
- Responsibility : Use alternatives to live animals with same expected effect and
- Rehabilitation : Use another principle

Once IEC/IRB clearance is obtained study can be started.

The Consent Form

This document explains the study to the participants. The language used is simple and understandable and preferably in the local language of the study participants. By signing the consent form, participant gives rights to the researcher to work upon their data and material. However if the participant is not confident on the study proposal, at any time, he can withdraw from the research.

Data Analysis

Analysis of data is the process of using various techniques to investigate facts and figures to draw conclusions about a topic or question. Analyse the data for various parameters and do statistical quantification.

It involves descriptive statistics (mean, median, standard deviation), inferential statistics (hypothesis testing, confidence intervals), and multivariate analysis. Trends, correlations, outliers, and variations can be determined.

Statistical methods help to draw inferences on the population from the sample data, and data draw conclusions, and assess the significance of results.

Results

Tabulate the results obtained. Interpret the results of your analysis to see how well the data answered your original question

Discussion: The results are discussed and compared with other studies. Any deviations are substantiated.

Summary and Conclusions: Finally in brief the study results are summarized.

Take home message: Brief message is given regarding the purpose of the study to the readers

Bibliography/References

The bibliography/references are annexed after the conclusions. The sources researched to write a research paper like books, scientific articles and thesis are listed.

The citation style may be Harvard, Vancouver or as per the requirement of the format.

- In Harvard (author-date) system the list of references are arranged alphabetically by author's surname, year (and letter, if necessary) and is placed at the end of the work
- Vancouver style references are listed in order they appear.

While writing an academic/scientific paper, each conference, journal, or institution has its own rules and style for bibliography.

Annexures to be enclosed: These are listed below.

- Data collection procedure in detail be enclosed
- Budget
- Consent form
- Procedures
- IEC clearance certificate
- Certificates
- Presentations
- Articles published

Publications and Presentations

Students can publish the scientific articles of their research in suitable indexed journals and present them in conferences.

Lot of care has to be exercised while preparing the manuscript to avoid plagiarism issues and write references and quote them in the text.

Funding Agencies for UG Medical Research

There are many governments' organizations in India, which provide funds for research, grants and higher learning research fellowships, some of them include Indian Council of Medical Research (ICMR), Defense Research and Development Organization (DRDO), Science and Engineering Research Board (SERB), Department of Science and Technology (DST), Department of Biotechnology (DBT), Council of Scientific and Industrial Research (CSIR) and Department of Health Research (DHR). There are also other agencies and foundations which support research by providing grants.

Some of these above mentioned organizations along with the research grant, also provide stipend during the tenure of the research.

Many medical professionals have an extensive understanding of research and health science, but they lack knowledge regarding funding sources.⁽²⁸⁾

ICMR Short Term Studentship (ICMR-STS) ^(29,30)

ICMR is encouraging the students to pursue research. ICMR-STS funds serve as incentive for undergraduate students to take up research as a career in their future. The institutions should provide all the facilities required to carry out the work. ICMR has been enhancing the stipend from time to time to encourage the participation of the students in research. The stipend has been paid after the completion of the research project and approval of the report. From the year 2024, the funding is substantially increased and is released in phased manner.

ICMR-STS guidelines are available on the website of ICMR. The research proposal with appropriate Institutional Ethics Committee (IEC) clearance has to be submitted and after the approval work has to be carried out. Online final report submission should be done as per the directions. After evaluation of the project, result is declared by the ICMR and certificate of completion will be issued to the student(s). However, the number of projects selected is countable. (roughly 10-20% of the applications received per year)and all students may not able complete the project work.

KVPY Kishore Vaigyanik Protsahan Yojana (KVPY) (31): This is a highly competitive scholarship program funded by the Department of Science and Technology (DST), Government of India to encourage students to pursue careers in research and development in the fields of basic sciences, engineering, and medicine.

Under the KVPY program, scholarships are awarded to students who have demonstrated an exceptional aptitude for research and a strong interest in pursuing a career in science and technology. Scholarships are provided to students at different stages of their academic careers, including during their undergraduate studies, postgraduate studies, and doctoral studies.

Students enrolled in Class 11, Class 12, and first-year undergraduate Basic Science programs are eligible to take the exam. Generous scholarship and contingency grant and summer internship programs for research is provided to the selected students.

Though it is a good initiative it is not attracting medical and other health care students and it requires publicity and is very competitive nature. The year 2022 onwards, DST has subsumed KVPY with Inspire. The KVPY fellows have been receiving the fellowship according to the norms of DST.

KMC Manipal: Student Research Forum (SRF) ⁽³²⁾: KMC SRF helps the undergraduates' interested taking up research. It helps for ICMR- STS projects as well. It is a platform wherein students get oriented to research, work upon the topics and succeed in completing the tasks.

KAHER (KLE University) Belagavi ⁽³³⁾: KAHER has funding the UG student projects, encourages and motivates undergraduate research. It regularly conducts undergradua conferences to encourage the students

Other Programmes

- Undergraduate medical students are eligible to apply for Indian Academy of Sciences Summer research fellowship programme (SRFP) training in areas of life sciences like Infectious and non-infectious diseases, molecular biology, cell biology, microbiology, immunology, genetics etc. Indian academy of sciences, Bengaluru, Indian national Science Academy, New Delhi, the National Academy of Sciences Prayagraj have research programs for 2 months and are trained under renowned scientists for a period of two months with a substantial stipend.
- Summer Research Training Program at Centre for Cellular and Molecular Biology: The selected students will be executing a small project work under the guidance of a CCMB scientist.
- Visiting Students' Research Program (VSRP), Hyderabad involves UG students to get trained in research and helps them choose a career in research. Very meager number of students opt for such programs as, they are not able to attend their clinical postings. The enthusiastic students should take benefit by way of working under these scientists of international repute. Awareness should be created for the students from school days and 11 and 12th standard courses, such that while pursuing medical or health care graduation, they can be benefited.

Centers Providing Knowledge Regarding Medical Research

There many universities and colleges which provide certificate courses and workshops on different aspects of carrying out research

Study Webs of Active–Learning for Young Aspiring Minds (SWAYAM), a Government of India initiated platform, hosts multiple online video lectures by the experts, printable resource materials, self-assessment tests, and online sessions for doubt clarification, at low cost to its users. ⁽³⁴⁾

Massive Online Open Courses (MOOCs): The platform hosts online courses focused on medical students too. A course on research methodology and ethics are available on this platform. These courses can be taken up by refreshers and interns as a refresher course⁽³⁵⁾

Institutions and Universities: Many institutions have medical education departments which regularly conduct courses and workshops directed to motivate students to research. For example Manipal University, UDHPE department of KLE Academy of higher education and research Belagavi many other institutions conduct regularly courses and workshops on Research methodology.

Conferences for UG Medical Research

Academic conferences are essential to the growth of new scholars as medical students. Attending these events, is a learning process in which participants increase their knowledge, study skills, networking abilities, and professional connections. Particularly doctoral students utilize seminars to acquire new information. These conferences are useful to keep the current researchers rely on "not yet published" knowledge and informal contacts. These conferences provide a platform for exchange of scientific knowledge, the social settings across the country, career prospects and for networking. This helps to choose their careers, funding and linkages.⁽³⁶⁾

Conferences are important for medical students in imparting education and sharpening their skills. In workshops, students get hands-on chance to learn specific tasks or research methodology. They form major platforms or events where the students can present their work.⁽³⁷⁾

The outcomes of the research need to be disseminated amongst the medical fraternity. The conferences provide a platform to share and learn other findings from researchers. This also helps in building the confidence and presentation skills and provides an opportunity to interact with people across.

Dr. Deo Organized the First National Medical Students' Research Conference in October 2006 in Pune for graduate medical students. It provided them a forum to interact with fellow students through platform and poster presentation of their research projects. Simultaneously, they were exposed to current trends, through plenary and invited lectures by experts in different branches of medicine and biomedicine.⁽³⁸⁾

The First Asian and Second National Medical Students' Research Conference held during February 2008 attracted submission of 350 abstracts, 70 oral and 110 poster presentations. Students from all over the country presented their research papers at this venue. Asian Medical Students association (AMSA international) was conducted in Bangkok Thailand July 8th-14th, 2014.

Indian Forum for Medical Students' Research (INFORMER) is an all India medical students' body, formed in 2009, aimed at promotion of research at undergraduate students. A national level annual conference was organized under this banner providing a platform for undergraduates to present their research work at a national level. An Annual event, MEDICON

is a national level research conference exclusively for undergraduate medical students organised by INFORMER. ^(39, 40)

MEDISCON, one of the most prestigious medical college conferences in the country, under the mentorship of Dr. Chintamani and now in the eleventh edition of its existence – MEDSICON – a unique learning experience with a plethora of workshops, academic and literary events, all directed towards the collective goal of sharing of knowledge and ideas. In the year 2007, Vardhman Mahavir Medical College and Safdarjung Hospital started the annual conference as World Students' Congress. In the year 2011, under the leadership of Dr. Krishna Agarwal and Dr. Avantika Singh, it was bestowed with the name Medical Students' International Conference (MEDSICON). Initially a national conference, MEDSICON soon evolved into a global event, being attended by national as well as international delegates. MEDSICON 2023 provided an enormous learning platform to undergraduates across all parts of the country with a number of hands-on workshops, ranging from basic surgical skills to emergency and critical care; promoting research and resources collaboration under the supervision of renowned faculty.

Osmania Medical College, Hyderabad conducts annually an international undergraduate medical conference OSMECON since 2010. This provides a platform for medical undergraduates to showcase their research, the conference's repertoire has since expanded to encompass an array of captivating workshops, thought-provoking clinical case discussions, stimulating quizzes, enlightening guest lectures, engaging panel discussions and symposia.

The International Student Congress of Medical Sciences (ISCOMS) conducts regularly conferences across the globe. However, very few students from India present their research work due to lack of financial grant for travel. For outstanding work there is provision from the organizers of the conference to support and fund to attend the conference. Here experienced medical fraternity should focus on encouraging the students to participate in international conferences overseas.

Indian Medical students Association (IMSA) Conducted KARMIC 2014, at KIMS, Bengaluru, and KARMIC 2016 was organised on May 2016, Indira Gandhi Institute Of Medical Sciences, Patna, by Indian Medical Association-Students' Wing Bihar Chapter. It drew a participation of more than 600 students from all over the country.⁽⁴¹⁾ Illuminati is an annual undergraduate medical conference organised by Armed Forces Medical College, Pune. ⁽⁴²⁾ 12th Edition of AXON '23 Inter-medical fest at PSG institute of Medical sciences Coimbatore, conducted conference on with theme on AI and Technology: Pioneering Innovation and shaping the future of healthcare ". ⁽⁴³⁾

UG Medical Students' Journals for Publication

The publication of research work is also equally important as presentation in conferences. Publishing in journals exposes the student to the technique of scientific paper writing. Few journals at national and international journals are:

National Journals publishing UG articles:

1. Indian J of Medical research
2. J of Post graduate Medicine
3. Indian J of Medical Specialities

International Journals publishing UG articles:

1. MCGill J of Medicine
2. Student BMJ
3. Student Lancet
4. PLOS Medicine
5. International Journal of Medical Students

V. BENEFITS AND CHALLENGES OF UG MEDICAL RESEARCH

Benefits of UG Medical Research

Research methodology and the hypothesis-driven scientific method are used to cultivate autonomous critical thinking abilities, written and verbal communication skills. It gives undergraduate students confidence to draw inferences from the information at hand. A study by Patra and Khan⁶ concluded that undergraduate students who attended classes in the same department as the research projects, are more independent in thinking, more driven to learn, and taking more active role in their education. Thus, as undergraduates get trained for their individual careers, the research process has a highly positive influence on important learning objectives.

Despite the fact that formal teaching of research was absent from the conventional curriculum, the recently proposed and implemented competency-based curriculum initiates the development of research competence among all medical students. Emphasis has been put on introducing research in the foundation course itself, which is expected to motivate the students to take up research in future. Indeed, it has been found that students exposed to research in the early stage, not only develop critical thinking, problem solving, and good analyzing skills, but also opt for research related career and eventually contribute to a better scientific outcome. These abilities help provide better patient care, hence research education must be included in medical curricula^(6, 7)

MD/MS-Ph.D sponsored by Indian Council of Medical Research (ICMR), Govt of India, for Medical Research, Life Science and Biotechnology, Medical Graduates/ Postgraduates designed to medical graduates with outstanding academic records and encourage them to choose a career in the field of research as their postgraduate qualifications.⁽⁴⁴⁾

AIIMS, Delhi, NIMHANS Bengaluru (ICMR sponsored Ph.D) offer Senior Research Fellowship to MBBS and MBBS- Ph.D programs for research interested students. Senior Research Fellowship of 3 years is provided by ICMR, Central Scientific and Industrial Research (CSIR) and UGC. Students interested in pursuing United States Medical Licensing Examination (USMLE) benefit from publishing research in Medline indexed Journals.

The research study need not be restricted to laboratory; it can be associated with diverse fields such as epidemiology or clinical medicine. Research projects teach the students the importance of a systematic approach to a problem, something that could well be of use in clinical medicine later in their professional career. Associating and working with research brings the students together with thinkers or researchers which enhances the way of tackling the problems related to patient care.

Challenges for UG Medical Research

The dearth of high-quality research conducted in Indian medical colleges might be attributed to various factors. Among the causes include inadequate mentoring, a heavy patient load, lack of infrastructure, lack of funding and multi-centric coordination of research activities, and a lack of incentives for research.

A study's conclusion⁴⁵ summarizes the idea that the federal and state governments should provide medical colleges with substantial money for research purposes. The inclusion of good medical research as an integral component of good medical practice must be reflected in both undergraduate and graduate courses. Of the 450 medical colleges in India, only 6 to 10 publish more than 60% of their research publications in indexed journals.⁴⁵

The majority of undergraduate medical students do not take up research due to many barriers and challenges inspite of their keenness in conducting research. Inadequate skills and knowledge in research methodologies, limited access to information sources; lack of time, financial aid, good inter-departmental co-ordination, in-adequate documentation of patient records and facilities are the main barriers to research. Due to the shortage of mentoring during medical school years, 46% of Postgraduates believe that a research time should be added to the curriculum. These barriers are more in developing countries compared to the developed ones. Keeping all this in mind, new strategies have to be introduced to tackle all these barriers.⁽⁴⁵⁾

Figure 3 shows factors responsible for no or less research.

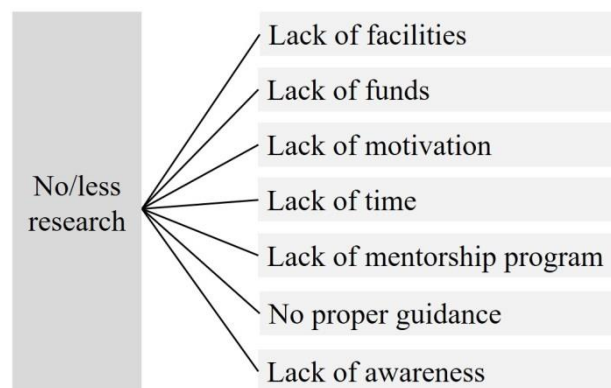


Figure 3: Important factors for No or less research

Limited Aptitude for Research and Research Ethics: In a study, most students considered research a “waste of time” and “not worth participating.” In a recent survey of >4000 students of government and private medical colleges in South India, over 97% medical students across all years and interns, were never exposed to the idea of “research” or “publication.” There was rampant plagiarism in UG medical work, which was around 59%.⁽³⁵⁾

Abysmal Funding: Indian Council of Medical Research^(29,30) has increased its funding recently for UG medical research substantially. However, the uptake of students as compared to applications remains extremely small. In 2019, out of 10,000 applicants, only 1367 got

funding. Short Term Studentship Program was introduced by the Indian Council of Medical Research established in the year 1979 to foster enthusiasm and aptitude to carry out research among medical undergraduate students.

The primary goal of this program is to give undergraduate medical students a chance to get acquainted with research methodology and techniques there in by working with their seniors for a short duration on ongoing research program or carryout independent projects.

Intramural or institutional UG research grants can be beneficial. However, such facilities are provided by a few premier institutes only.

Diminutive Returns in the Form of Publications: The number of papers published in indexed journals, even ICMR- approved projects getting published in PubMed-indexed journals, is meager.

Challenges in Showcasing Research Work: Limited accredited undergraduate and postgraduate conferences exist in India to present their work; limited funding and travel grants for international presentations adds to this and act as barriers.

Lack of Reinforcement: Less than a handful of institutions provide remuneration (in the form of awards and prizes for all the students involved in published articles, with special credit to first-author students). Lack of reinforcement results in decreased inclination towards research.

Even though for the postgraduate medical students thesis writing is required by the curriculum, much of it is completed for the sake of completion and never published after the submission to university, due to a lack of the necessary aptitude developed during the UG years. .. Consequently, the lack of students enthusiasm in research is strikingly is meagre.

Research involvement is crucial to training physicians who comprehend evidence-based medicine. Research has been mostly hidden from India's undergraduate medical program, despite being a required component of post-graduate medical education. Undergraduate research options are extremely limited. The long road to academic career, a lack of extra incentives for researchers, a lack of fundamental infrastructure, facilities, and structured mentorship programs, and a lack of encouragement are the causes of this. Lack of writing expertise for biomedical publications is an additional factor. To support the research environment in India, academic members and students need to receive additional incentives.

VI. PRESENT SCENARIO AND ISSUES RELATED TO UG MEDICAL RESEARCH

Most students graduate medical education without a fair idea of conducting research or its importance to the medical community.

In literature review, it is observed that, the research is not well represented in curricula inspite of its necessity and importance. The curriculum generally encompasses basic and clinical science subjects. In many institutions research is regarded as extra-curricular activity. There is little scope to orient the students to the concepts of epidemiology, statistics and scientific investigation as it is treated as non-curricular activity.⁽⁴⁶⁾

Medical students are to be exposed to research at UG level so that, those students with research aptitude can be picked up early. The new undergraduate curriculum of National Medical Council in India, mentions formulation of research questions as a required competency for UG students in the curriculum. The students can have basic knowledge about research and value of Evidence Based Medicine even if they may not pursue or undertake any research projects during their course of graduation.

In a study by Kalita et. al ⁽⁴⁷⁾, in the year 2015, concluded that, though Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Orissa, Rajasthan, Uttarakhand and Uttar Pradesh together account for 46% of the population of India, accounted for only 10% of the publications. About 42.5% of the articles were produced by three states namely Delhi, Maharashtra and Tamil Nadu.

A recent report reviewed articles from 1990 to 2019 which showed that only 6-10 medical colleges out of the existing 450 colleges, publish more than 60% of the research papers in indexed journals; and most of them are published by the faculty.⁽⁴⁵⁾ In view of recent changes in diseases pattern, training in medical research important aspect of medical education. Conducting medical research helps to get more precise picture of the individual/community health and also aids in health system policy making.

A cross-sectional study was conducted amongst 344 students in Chennai, Tamil Nadu in the year 2018, and only 34.3 % had conducted research of these only 17.4% published the articles, 59.6% had attended research methodology conferences but only 27.6% had presented in conferences. ⁽⁴⁸⁾

Reports by ICMR (29,30) indicate that amongst 1,00,000 undergraduate students, only 0.9% of the students have shown interest in research through various research programs. The number of applicants for ICMR-STS projects during the year 2019 were approximately 10,000 when the total number of UG medical seats available in India are almost 10 times. The student application selected after scrutiny accounted for 10% only.

Around 1,00,000 MBBS students pass out each year from 706 medical colleges offering modern medical program. Additionally, there are around 53,000 students from 733 AYUSH medical colleges annually.⁽⁴⁹⁾ Research awareness, motivation, time allocation for research initiation for presentation and publication can improve their involvement in research based and evidence based practice in their future patient care.

Oliveira et al ⁽⁵⁰⁾, in their study indicate lack of early exposure to research and introduction of basic concepts to scientific inquiry results in lack of skills. Perhaps, this is the reason for lack motivation and lack of self-efficiency amongst students.

Due to deficit in basic scientific training and motivation in the medical students currently, number of students participating in research is quite low. Paucity of time due to academic load, difficulty in choosing a specific topic to work upon, lack of mentors or faculty with experience in conducting research are the other contributing factors. ⁽²⁴⁾

In undergraduate medical education in India, socio-economic and cultural factors play a substantial role in shaping the careers as physician scientists. Lack of same gender mentors

are other contributing factors in some countries. In advanced countries students take up research to add to their curriculum vitae, help in their career advancements, pursuing opportunities and get into competitive residency programs. ^(51,52)

In a systematic review on global perspectives of research during undergraduate medical education, Institutional and non-institutional barriers are cited as reasons to not to pursue research. Institutional barriers include lack of time, lack of access to electronic resources, shortage of mentors, paucity of infrastructure, equipment and funds. Non-institutional barriers include lack of verbal and written skills and lack of self-efficiency. ⁽⁵³⁾

VII.UG MEDICAL RESEARCH IN WESTERN COUNTRIES AND THE INDIAN CONTEXT

The PubMed survey concluded that the medical doctors of USA top the list of research publications, however in Africa there is no research publication by medical students. The Asian figures are mediocre, but among the Asian group, Japan dominates and India making a scant contribution. This could be due to lack of: opportunity, time and funding. Students in western countries are supported by ample grants and facilities to propagate research. Basic interest in research work is therefore kindled better in developed countries than in the developing country like India. ⁽⁵⁴⁾

Early exposure is required to take up research in UG medical education. Some of the countries though research exposure was before medical school, students did not opt research as they were not confident to pursue research. Thus, lack of skills resulted in low motivation. ⁽⁵⁵⁾ Medical students worldwide expressed need of participation and engagement in research. Some institutions accommodate students by allowing research to be conducted during their spare time. ⁽⁵⁶⁾ A study on medical students in Jordan, concludes that, medical students have positive attitude towards research from their second year of study, inspite of having limited knowledge. They could identify the barriers that could be utilized to promote greater involvement of students in research.

Exposure to research has direct impact on clinical practice. Hence, policy makers and educators should consider the outcomes and encourage early participation of students in the research process. ⁽⁵⁷⁾ Various schemes by Government of India have been launched recent days to promote research amongst medical students. The grants are awarded through the Indian Council for Medical research and other Initiatives. ⁽⁵⁸⁾

Until 2008, India stands at 12th position in medical research contributing 65,745 articles with a global publication share of 1.59%. ⁽⁵⁹⁾ However, the majority of these studies were conducted by faculty members/scientists from reputed medical institutes, with meager contribution from medical students. ⁽⁶⁰⁾

Despite the overwhelming importance of medical research for society, there is a marked difference in scientific productivity between high-income, low- and middle-income countries, based on the low investment in research by the governments of each country; according to 2010 statistics, the U.S. had 3867 researchers per million people, as opposed to Colombia and Venezuela, which had 193 and 200 researchers per million people, respectively ⁽⁶¹⁾

A worldwide study gathered 1625 responses from 38 nations. The analysis focused on data from countries with over 100 responses. Less than 50% of the respondents opined that their medical school provided enough research training. The main reported hurdles to student research engagement were a lack of time and difficulty in locating mentors or projects. Students' research objectives differed significantly by gender, with females preferring less research involvement. The importance of impediments and satisfaction with research training vary dramatically between countries. ⁽⁶²⁾

Majority of medical schools in western countries offer opportunities and sufficient funding and scholarship for undergraduate research. Amongst these, Harvard Medical school provides highest research programs. There are many opportunities to work as a research assistant on an existing project. A research assistantship is a motivating factor for students with little experience to get their first exposure to research.

A ten-week summer program named as SHURP is offered by the Medical Science Division at Harvard Medical School to undergraduate students from under-represented and disadvantaged backgrounds with an opportunity for training and mentorship in scientific research. ⁽⁶³⁾ At Harvard medical school, Participants will have ten weeks of paid scholarly research program under a faculty member and research mentor and Engage in weekly discussions on research career and profession.

UCONN University of Connecticut, offers funding for research to UG medical students. The Indiana medical scientist/ UG summer research is offered to undergraduate students who have completed their freshman, sophomore, or junior years with a background in biology, chemistry, physics, social & behavioral sciences, or engineering and are interested in pursuing an integrated career as a physician-scientist or physician-engineer.

The NIH Short-Term Research Training Grant (STRTG)⁽⁶⁴⁾: This grant is provided to U.S. and foreign professionals and students to carry out a collaborative research in health sector globally.

Summer Undergraduate Research Fellowships (SURF) L&S provides undergraduates in the College of Letters and Science with funding to undertake concentrated summer research in preparation for a senior thesis or other major capstone project. Fellows receive a sufficient summer stipend. SURF L&S fellows ideally be entering their final year or final semester and have no other research funding. These fellowships are funded by many philanthropic donors . ⁽⁶⁵⁾

The Academy of Medical sciences UK, INSPIRE is designed to engage medical, dental and veterinary undergraduates with research with funding to a career in research.

Many conferences are held for UG students in western countries including USA, providing an opportunity for exchange of knowledge and research know how. Some of the conferences are listed below.

- **American Medical Student Association (AMSA) Conferences:** AMSA hosts various conferences throughout the year, including the AMSA Annual Convention, which is one of the largest gatherings of medical students in the United States. These

UNRAVELING RESEARCH OPPORTUNITIES FOR UNDERGRADUATE MEDICAL STUDENTS

conferences offer workshops, networking opportunities, and chances to present research.

- **International Conference on Medical Education (ICME):** ICME is a global conference that brings together medical students, educators, and professionals to discuss innovations in medical education. It provides a platform for students to present their research and engage in discussions on various medical education topics.
- **The international conference on medical education 2024:** Future of Medical Education in Egypt (ICME), A congress where in, the young minds assemble to share what they have learned since they met last.
- **Future Healthcare Professionals Conference (FHPC):** FHPC is a conference that focuses on preparing students for careers in healthcare. It offers workshops, panels, and networking opportunities.
- **Student National Medical Association (SNMA) Annual Medical Education Conference:** SNMA is dedicated to support under-represented minority medical students with opportunities for networking, professional development, and research presentations.
- **American College of Physicians (ACP) Internal Medicine Meeting:** The ACP Internal Medicine Meeting is a large conference that offers educational sessions, networking opportunities, and research presentations for medical students, residents, and physicians.

In this monogram, the literature available is reviewed and it outlines the importance of research for undergraduate medical students.

VIII. SUMMARY AND CONCLUSION

In conclusion, the monogram titled “Unraveling research opportunities for undergraduate medical students” stresses the need of research for undergraduate medical students and deals with its avenues and barriers.

Research plays a pivotal role in undergraduate medical education. Early exposure to research inculcate with analytic thinking and evidence based learning.

The monogram discusses about benefits and challenges and barriers faced by the undergraduate students in pursuing medical research.

The present scenario of research and issues related to medical UG research are unwrapped. UG research in western countries and the Indian context is highlighted.

Hence, Policy makers and medical institutions, should provide necessary importance to undergraduate research and provide necessary learning options in the curriculum at least to provide basic understanding of research.

Teachers and mentors of medical education should guide the students who wish to take up research, in protocol preparation, proving funding agencies, conferences and publications.

IX. TAKE HOME MESSAGE

Research is cornerstone of progress in medical field. Medical undergraduate students across the world have to apply analytical skills and evidence based medicine for better patient care for which research provides a platform.

Hence, educators, policy makers, teachers and mentors should nurture research for undergraduate students.

REFERENCES

- [1] What is research? A conceptual understanding Navindhra Naidoo Department of Emergency Medical Sciences, Cape Peninsula University of Technology, P. O. Box 1906, Bellville 7535, South Africa
- [2] Ahmed Y and Khayal S. Advancing Research Training in Medical Education: Global Perspectives and Paradigms for Future Development Cureus 2024; 16(2): e54559
- [3] Carberry C, McCombe G , Tobin H , Stokes D , Last J , Bury G and Cullen W. Curriculum initiatives to enhance research skills acquisition by medical students: a scoping review BMC Medical Education. 2021; 21:312.
- [4] Shrestha A and Shrestha A. The importance of doing research as a medical student , , Kathmandu University Medical Journal 2007; 5, No. 1:138.
- [5] Petrella JK and Jung AP. Undergraduate Research: Importance, Benefits, and Challenges. Int J Exerc Sci. 2008 Jul 15;1(3):91-95.
- [6] Patra S and Khan AM. Development and implementation of a competency based module for teaching research methodology to medical undergraduates. J Educ Health Promot 2019;8:164.
- [7] McKelvie S and Standing LG. Teaching psychology research methodology across the curriculum to promote undergraduate publication: An eight course structure and two helpful practices. Front Psychol 2018;9:2295
- [8] Mulkalwar AA. Research activities of undergraduate medical students. Hurdles and the way forward. –A graduate perspective. The natl Med J India 2023;36:393-4
- [9] Benette C. Why all medical students need to experience research? Australian Medical student J 2016. Available from <http://www.amsj.org/archives/4796>
- [10] Research in Medical Education A Primer for Medical Students Association of American Medical Colleges 2015
- [11] Laidlaw A, Aiton J, Struthers J, Guild S. Developing research skills in medical students: AMEE Guide No. 69. Medical Teacher. 2012;34(9):754–71.
- [12] GMC. Outcomes for graduates document 2018 [Available from: [https:// www.gmc-uk.org](https://www.gmc-uk.org)
- [13] Stringer MD, Ahmadi O. Famous discoveries by medical students. ANZ J Surg. 2009;79:901–8
- [14] Ohry A. Outstanding discoveries made by medical students Prog Health Sci 2012, Vol 2 , No1 Discoveries made by medical students accessed from google Dec 17, 2023
- [15] 16.Erik I, Wahono NA, Yanua R, Wimardhani YS, Puspitawati R and Ami LR. Students perspective in UG research experiences in Indonacian dental schools. Int. J.Dent 2024; 2024: 5898527.
- [16] Metcalfe D. Involving medical students in research. J. R. Soc. Med. 2008;101:102–103.
- [17] Ilic D, Tepper K., Misso M. Teaching evidence-based medicine literature searching skills to medical students during the clinical years: a randomized controlled trial. J. Med. Libr. Assoc. 2012;100(3):190–196.
- [18] Ortega-Sierra M.G., Beltran-Hoyos G.E., Benjumea-Velásquez A.M., Bossio-Martínez I.M., Lozada-Martínez I.D. Surgery interest groups in medical schools: mentoring factory. J. Surg. Res. 2021;267:209–210
- [19] Pathipati AS,Taleghani N. Research in medical school: a survey evaluating why medical students take research years. Cureus. 2016;8(8):e741

- [20] Fernandez A, Chen V, Quan J, Martinez A, Flowers L, Aronson L. Evaluation of a medical student research and career development program to increase diversity in academic medicine. *J Assoc Am Med Coll.* 2019;94(8):1220–8.
- [21] Chatterjee S and Kar SK, Undergraduate Research Elective under Competency- Based Medical Education (CBME) in India: Challenges and Directions. *Indian J Psychol Med.* 2023; 45(5): 548–551
- [22] Louise N, Burgoyne SOF, Boylan Geraldine B. Undergraduate medical research: the student perspective. *Med Educ Online.* 2010;10:15.
- [23] Mass-Hernández LM et al. Undergraduate research in medicine: A summary of the evidence on problems, solutions and outcomes. *Ann Med Surg (Lond).* 2022;74:103280.
- [24] Lee GSJ, Chin YH, Jiang AA, Mg CH, Nistala KRY, Iyer SG, Lee SS, Chong CS, Samarasekera DD. Teaching Medical Research to Medical Students: a Systematic Review. *Med Sci Educ.* 2021 Jan 8;31(2):945-962.
- [25] Murdoch-Eaton D, Drewery S., Elton S, Emmerson C, Marshall M, Smith JA, et al. What do medical students understand by research and research skills? Identifying research opportunities within undergraduate projects. *Med. Teach.* 2010;32(3):e152–e160.
- [26] Unnikrishnan B, Rekha T, Jain A, Mithra P, Kumar N, Holla R. Integrating research into undergraduate medical education curriculum: A 20 year experience from a medical school in coastal South India. *Indian J Community Med* 2022;47:479-82.
- [27] Verma R, Phalswal U, Shafquat N, George J. Funding opportunities for higher learning, medical and nursing research in India: An overview. *J Family Med Prim Care.* 2022 Aug;11(8):4240-4245.
- [28] Indian Council of Medical Research. Short Term Studentship (STS 2019) Proposal Result. 2019
- [29] Indian Council of Medical Research. Short Term Studentship (STS), <https://sts.icmr.org.in>
- [30] www.iisc.ernet.in/kvpy or www.kvpy.ernet.in and <http://www.online-inspire.gov.in>
- [31] www.kledeemeduniversity.edu.in
- [32] http://www.manipal.edu/ug_research .
- [33] Government of India. Swayam Central, <https://swayam.gov.in/>
- [34] Raj JP, Venkatachalam S, Amaravati R, et al. Extent of knowledge and attitudes on plagiarism among undergraduate medical students in South India—a multicentre, cross- sectional study to determine the need for incorporating research ethics in medical undergraduate curriculum. *BMC Med Educ.* 2022; 22: 1–10.
- [35] Phelan, Amy & Gupta, Prakash & Găman, Mihnea-Alexandru & Puyana, Juan & Bonilla Escobar, Francisco. (2023). Scientific Conferences for Medical Students: Why do We Need more Spaces for Students to Enhance Research?. *International Journal of Medical Students.* 11. 10.5195/ijms.2023.2274.)
- [36] Kamal M, Bhargava S, Katyal S. Role of conferences and continuing medical education (CME) in post-graduate anaesthesia education. *Indian J Anaesth.* 2022;66(1):82-84.
- [37] Deo MG. Undergraduate medical students' research in India. *J Postgrad Med.* 2008; 54:176–9.
- [38] Bhilwar M, Upadhyay RP, Dabar D, Das TK, Dara S. Need to navigate undergraduate medical curriculum towards developing research skills *Journal of Contemporary Medical Education* 2015;3:1-4.
- [39] Indian Forum for Medical students Research (INFORMER)-Observation beyond vision accessed on 14may 2024
- [40] Ranjan R Kunal K, Kishore K, Prakash A , Shah A, Kumar A. *Journal of Indira Gandhi Institute Of Medical Sciences* 2017; 3(1):p 62-63
- [41] www.illuminati.afmc.in
- [42] www.axonpsg.org
- [43] www.indiascienceandtechnology.gov.in/icmr-s
- [44] Ghosh K. Medical Research in Medical College in India: Current scenario and ways to improve it. *J Assoc Physicians India* 2019; 67: 71–73.
- [45] Crusier Des A. Brown SK, Ingram JR et al. Learning outcomes from biomedical research course for second year osteopathic medical students. *Osteopath Med Prim Care.* 2010;4:4
- [46] Kalita A, Shinde S, Patel V. Public health research in India in the new millennium: A bibliometric analysis. *Glob Health Action.* 2015;8:275-76.
- [47] Chellaiyan VG, , Manoharan A, . Jasmine A, Liaquathali FM Medical research: Perception and barriers to its practice among medical school students of Chennai *J Educ Health Promot.* 2019;8:134
- [48] Accessed google as per Jun 8, 2023
- [49] Oliveira CC, de Souza RC, Abe EHS et al. UG research in medical education: a descriptive study of study of students' views. *BMC Med Educ.* 2014;14: 51.
- [50] Peacock JG, Grande JP. A flexible, pre-clinical, medical school curriculum increases student academic productivity and the desire to conduct future research. *Biochem Mol Biol Educ.* 2015; 43:384-390.,

- [51] Abu-Zaid A, Altinawi B. Perceived barriers to physician scientist careers among female UG medical students at the college of medicine – Alfaisal University : A Saudi Arabian perspective. *Med Teach*. 2014;369Suppl 1):S3-7.
- [52] 53. Stone C, Dogbey GY, Klenzak S, Fossen KV, Tan B, and . Brannan GD. Contemporary global perspectives of medical students on research during undergraduate medical education: a systematic literature review *Med Educ Online*. 2018; 23(1): 1537430.
- [53] 54. Jimmy R, Palatty PL, D'Silva P, Baliga MS, Singh A. Are medical students inclined to do research?". *J Clin Diagn Res*. 2013;12:2892-5.
- [54] 55. Ejaz K, Shamim MS, Shamim Ms et al. Involvement of Medical students and fresh medical graduates of Karachi, Pakistan in research *J Pak Med Assoc*. 2011;61:115-120.
- [55] 56. Mitawalli HA, Al Ghamdi KM, Moussa NA. Perceptions, attitudes and practices towards research among resident physicians in training in Saudi Arabia. *East Mediterr Health J*. 2014;20: 99-104.
- [56] Mohammad A, Alqato S, Alrfooh HH et al. Knowledge, attitudes, practices and barriers of medical research amongst undergraduate students in Jordan: A cross sectional study. *BMC Medical Education* 24;23:2024.
- [57] <http://www.calicutmedicaljournal.org/2004/2/1/e1/index.html>)
- [58] Gupta BM, Bala A. A scientometric analysis of Indian research output in medicine during 1999-2008. *J Nat Sci Biol Med*. 2011;2:87–100.
- [59] Garg R and Gupta S. Are we really producing public health experts in India? Need for a paradigm shift in postgraduate teaching in community medicine. *Indian J Community Med Of Publ Indian Assoc Prev Soc Med*, 2011; 36: 93–97
- [60] Ciocca D.R., Delgado G. The reality of scientific research in Latin America; an insider's perspective. *Cell Stress Chaperones*. 2017;22(6):847–852 from Undergraduate research in medicine: A summary of the evidence on problems, solutions and outcomes *Annals of Medicine and Surgery* 74 (2022) 103280
- [61] Funston G , Piper RJ, Connell C, Foden P, Young AMH, O'Neill P. Medical student perceptions of research and research-orientated careers: An international questionnaire study *Med Teach* 2016 ;38:1041-1048.
- [62] www.harvard.edu
- [63] The NIH Short-Term Research Training Grant (STRTG)
- [64] www.surf@Berkeley.edu.