Assessment Of Radiation Dose In Digital Radiography System -A Review Article

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Abstract

Background: The evaluation of patient doses has gotten more attention, but it's still a concern due to computerized technologies (Digital). Compared to a traditional screen-film system, the advancement of digital technology allows for a 50% reduction in radiation exposure without sacrificing image quality. Digital system provides similar or better diagnostic performance and several additional benefits, but there is a risk of overexposure without a negative impact on image quality. Digital radiographic imaging technologies are appropriate for various clinical applications and may produce satisfactory image quality across a wide exposure limit. Over radiation might result in increased dose levels without improving image quality; as a result, experimental data analysis is a continuous process that can provide information on radiation exposure appropriateness. Digital systems, on the other hand, stand out for their adaptability: the acquisition dose may be changed without compromising image quality, as well as vice versa. The imaging settings should be fine-tuned to achievethe optimum results from a given system. Traditional methods of dose containment, including placement and collimation, apply equally well to digital and traditional processes. Dose reduction is becoming increasingly possible because of digital technology. Simultaneously, there is a danger of drastically increasing the patient's dose without realizing it because of a lack of visual control. As a result, digital radiography requires dosage indicators and dose monitoring. A step closer to contemporary radiation protection is the adoption of picture quality classes based on the dose needs of specific clinical indications; manufacturers have made numerous enhancements to digital radiography equipment due to the detector and technological advancements. Because of digital imaging techniques, x-rays can now be storeddigitally and used at any time by altering contrast to the viewer's preference. This technique hasensured that no radiographs are lost and enables digital distribution throughout hospitals via web-based technologies.

Keywords: Digital Radiography, Radiation Exposure, Screen-Film, Dose reduction, Detectors

Introduction:

The technician benefits from digital radiography since it minimizes the amount of effort and time required by the radiographer. Radiation causes harm to the human body, as we all know. If overexposure is provided, it can cause significant damage to the body, and in some instances, it can be fatal. Thus, dose and quantity must be regulated. As we can see, the importance of computers is growing in every discipline, and radiography is no exception. In digital radiography, the difference in quality is more noticeable than in computed radiography. Digital radiography has replaced manual tasks, such as traditional radiography and conventional fluoroscopy, whichallowed clinicians to make more precise diagnoses. This breakthrough has had a significant impacton the evolution of diagnostic procedures. With digital imaging tools, this procedure has superseded conventional radiography. Except for mammography, this imaging approach was adopted in all types of radiography. There are numerous advantages to employing digital imaging technology, such as improved image quality and reduced dose. It provided precise diagnostics for image quality assurance with excellent resolution **[1].** The use of digital imaging in radiology, in conjunction with the rapid advancement of computer technology, has resulted in vastly enhanced imaging processes. As a result, diagnostic capabilities have grownin terms of both the quantity and scope of treatments available. Digital radiography systems are gradually replacing traditional fluoroscopic and film screen radiography equipment worldwide. Numerous progressive medical facilities have bought or are thinking about purchasing computed or direct digital radiography equipment with flat panel detectors or storage phosphor plates (computed radiography) (direct digital radiography). These devices represent the cutting-edge in x-ray diagnostic projection imaging. X-ray projection imaging can be done in two ways: digitally and traditionally using film screens. Both procedures are based on the same fundamental principles and require the use of ionizing radiation. In traditional film/screen radiography, the exposed film is the result of a well-established procedure. X-ray film is a non-removable record that cannot be altered after it has been developed. Information is gathered by detectors and saved in digital form within a computer in digital radiography. Individual post-processing processes as well as automatic post-processing operations are necessary **[2].** Even though they are based on separate scientific concepts, digital sensors, and screen-film radiography share many similarities. Previously, image acquisition, presentation, and archiving were made on the same film sheet.These critical functionalities of radiography have been decoupled with digital detectors, a requirement for PACS. When compared to film-screen detectors, digital sensors have a 400-fold dynamic range. The inverse link between dosage and visual contrast is removed using digital technologies. An image's contrast and brightness can be altered independently. Because digital systems lack film blackening at higher doses, there is a risk of dose creep, which is an unnoticeable rise in exposure over time when using digital systems with manual tube settings.

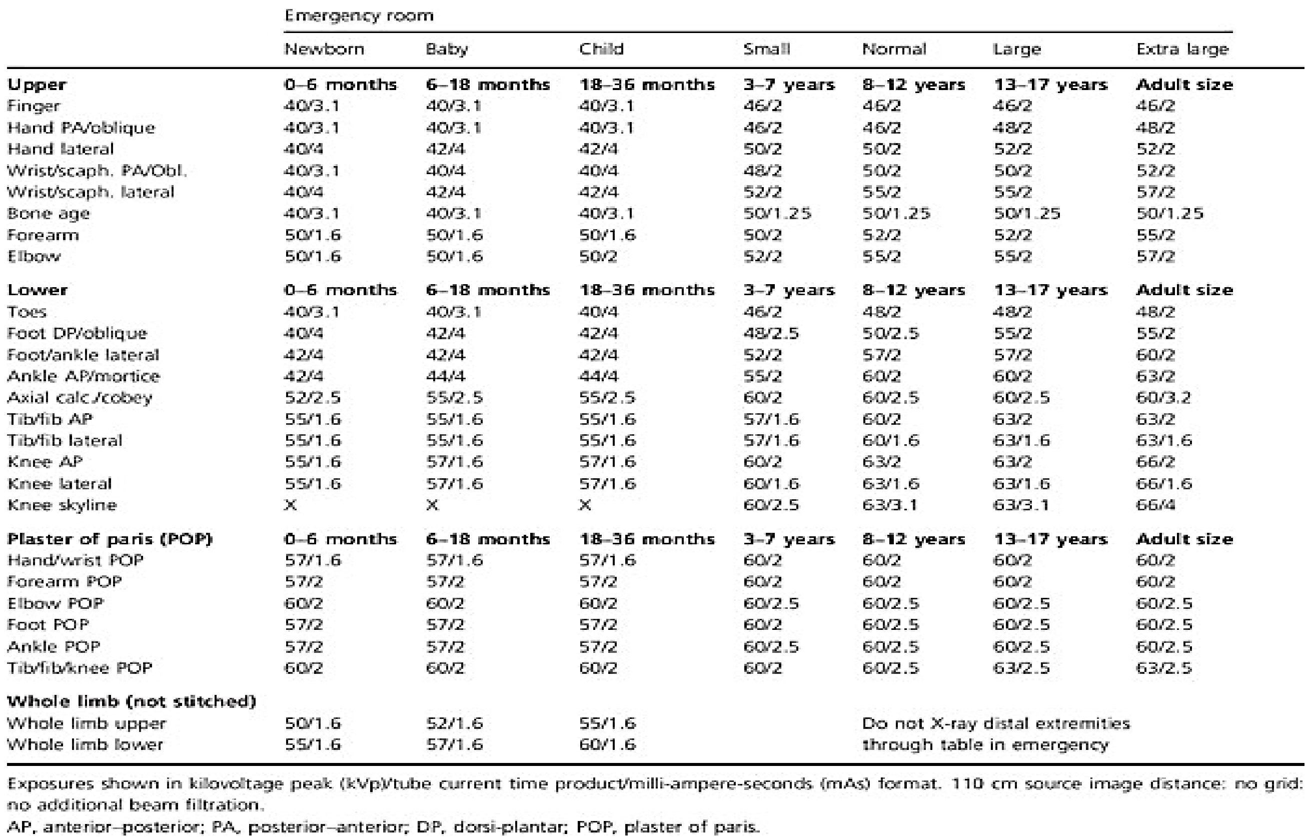
Diagnostic information is lost as image quality deteriorates, owing to insufficient image processing or poor image display. The latter entails checking for proper softcopy display functions regularly **[3].** Radiation protection is almost as old as Wilhelm Rontgen’s discovery of invisible rays on November 8, 1895. Shortly later, the harmful effects of X-rays were identified. Erythema was common among physicians and patients exposed to radiation for a long time. Although ionizing radiation can harm one's health, experimental radiological techniques are now a common element of clinical practice because the benefits to the patient far outweigh the dangers. Work and interaction with ionizing radiation are governed by guidelines, directions, ordinances, and regulations to limit individual and population exposure to radiation. In the 1957 Rome accords, Germany agreed toconvert the Euratom directives into national legislation as the European Atomic Community Euratom contracting state. The first of these orders was about personnel safety, not patient safety [**4].**

The ALARA Principle in Medical Imaging:

Medical physicists are familiar with the ALARA principle, which asserts that radiation dosages be kept as low as possible practically possible while considering social and economic factors. The ALARA principle also applies to medical and other radiation exposure sources, which may be less widely understood.

The core idea behind the ALARA concept may be traced back to the Manhattan Project. The concept, as well as the vocabulary used to define it, has evolved. The predecessor of today's National Council on Radiation Protection and Measurements was the National Committee on Radiation Protection. (N.C.R.P.), suggested in Report 17, published in 1954, that radiation exposure be limited "to the lowest possible level." The report of the International Commission on Radiological Protection 1954 Recommendations used a similar phrase (As Low as Possible) (I.C.R.P.). To maintain the safety of patients, radiation exposure should be limited "to the extent compatible with successful diagnostic inquiry or therapy." **[5].**

The Normal Radiation Dose:



	Emergency room						
	Newborn	Baby	Child	Small	Normal	Large	Extra large
Upper	**0–6 months**	**6–18 months**	**18–36 months**	**3–7 years**	**8–12 years**	**13–17 years**	**Adult size**
Finger	40/3.1	40/3.1	40/3.1	46/2	46/2	46/2	46/2
Hand PA/oblique	40/3.1	40/3.1	40/3.1	46/2	46/2	48/2	48/2
Hand lateral	40/4	42/4	42/4	50/2	50/2	52/2	52/2
Wrist/scaph. PA/Obl.	40/3.1	40/4	40/4	48/2	50/2	50/2	52/2
Wrist/scaph. lateral	40/4	42/4	42/4	52/2	55/2	55/2	57/2
Bone age	40/3.1	40/3.1	40/3.1	50/1.25	50/1.25	50/1.25	50/1.25
Forearm	50/1.6	50/1.6	50/1.6	50/2	52/2	52/2	55/2
Elbow	50/1.6	50/1.6	50/2	52/2	55/2	55/2	57/2
Lower	**0–6 months**	**6–18 months**	**18–36 months**	**3–7 years**	**8–12 years**	**13–17 years**	**Adult size**
Toes	40/3.1	40/3.1	40/4	46/2	48/2	48/2	48/2
Foot DP/oblique	40/4	42/4	42/4	48/2.5	50/2.5	55/2	55/2
Foot/ankle lateral	42/4	42/4	42/4	52/2	57/2	57/2	60/2
Ankle AP/mortice	42/4	44/4	44/4	55/2	60/2	60/2	63/2
Axial calc./cobey	52/2.5	55/2.5	55/2.5	60/2	60/2.5	60/2.5	60/3.2
Tib/fib AP	55/1.6	55/1.6	55/1.6	57/1.6	60/2	63/2	63/2
Tib/fib lateral	55/1.6	55/1.6	55/1.6	57/1.6	60/1.6	63/1.6	63/1.6
Knee AP	55/1.6	57/1.6	57/1.6	60/2	63/2	63/2	66/2
Knee lateral	55/1.6	57/1.6	57/1.6	60/1.6	63/1.6	63/1.6	66/1.6
Knee skyline	X	X	X	60/2.5	63/3.1	63/3.1	66/4
Plaster of paris (POP)	**0–6 months**	**6–18 months**	**18–36 months**	**3–7 years**	**8–12 years**	**13–17 years**	**Adult size**
Hand/wrist POP	57/1.6	57/1.6	57/1.6	60/2	60/2	60/2	60/2
Forearm POP	57/2	57/2	57/2	60/2	60/2	60/2	60/2
Elbow POP	60/2	60/2	60/2	60/2.5	60/2.5	60/2.5	60/2.5
Foot POP	57/2	57/2	57/2	60/2	60/2.5	60/2.5	60/2.5
Ankle POP	57/2	57/2	57/2	60/2.5	60/2.5	60/2.5	60/2.5
Tib/fib/knee POP	60/2	60/2	60/2	60/2	60/2.5	63/2.5	63/2.5
Whole limb (not stitched)							
Whole limb upper	50/1.6	52/1.6	55/1.6		Do not X-ray distal extremities through table in emergency		
Whole limb lower	55/1.6	57/1.6	60/1.6				

Exposures shown in kilovoltage peak (kVp)/tube current time product/milli-ampere-seconds (mAs) format. 110 cm source image distance: no grid: no additional beam filtration.

AP, anterior–posterior; PA, posterior–anterior; DP, dorsi-plantar; POP, plaster of paris.

Figure: 1, Chart of average Radiation dose

Based on anatomical dissection, macroscopic assessment of internal organs, and samples forhistological testing and other ancillary investigations, an autopsy is still the gold standard for diagnosing the disease process underlying the cause of death. The weighing of internal organsis a standard autopsy method suggested in current recommendations for investigating Sudden Unexpected Death in Infancy. **[6].**

Digital Imaging

image projection. Both techniques include exposure to ionizing radiation and basic physical principles. The exposed film in traditional film screen radiography is the outcome of a tried-and-true process. A permanent record that cannot be altered is X-ray film. Data is captured by detectors in digital radiography and stored in a computer. Post-processing, both manual and automated, is required for the acquisition of data.

However, these tools present a new paradigm of projection radiology's possibilities and problems, which is unfamiliar to most users and prospective users. High detective quantum efficiency (D.Q.E.), a wide the dynamic range, options for post-processing archiving, and data transfer define digital radiography image quality. Because of the excellent quantum efficiency, pictures can be acquired at a lesser dose. Image post-processing has two disadvantages. On the one hand, it may increase image quality; on the other hand, it may reduce the rate and generate artefacts that could be mistaken as pathology if applied incorrectly **[1].** These essential distinctions from traditional film/screen demand the creation of fresh approaches to quality optimization.

Clinical planning

The most common radiographic procedure in hospitals and clinics is projection radiography of the chest, skeleton, and gastrointestinal system. It is now widely known that to reduce the pediatric C.T. dose when doctors frequently order pediatric computed tomography (C.T.) exams, the scanning parameters of the C.T. machine must be changed. Equal chances to lower patient dose for different exams in digital projection-radiography exist. The proper examination parameters must balance the radiation dose and the patient's clinical condition. The dose and image quality characteristics can be tailored to the clinical circumstances by the clinician due to the wide variety of imaging possibilities offered by digital radiography. A detailed inquiry method and clear goals are essential for effective patient management. The radiologist's primary goal is to deliver the necessary information to the referring practitioner. The test should be run with the least amount of dosage possible to accomplish this goal.

Two points can describe the strategy for using digital imaging devices:

1. Applying the ALARA principle (i.e., the dose to the patient should be as low as reasonably achievable).

2. Image quality should not be as good as the digital x-ray system is independent of dose value, but it should be adequate for diagnostic purposes. **[1].**

Measuring Radiation Dose:

Radiation that enters the body is absorbed in part. The image is created by using uninterested x-rays. The patient's previous radiation exposure is factored into the overall dosage. Radiation that enters the body does not affect this dose. The millisievert, often known as the "effective dose," is the scientific unit of measurement for whole-body radiation therapy (mSv). Other units used to determine radiation dose include rad, rem, roentgen, sievert, and grey. Doctors refer to the risk of radiation exposure to the complete body as the "effective dosage." A "risk" is the possibility of adverse side effects, such as acquiring cancer later in life. Various tissues' susceptibility to radiation is considered while determining the effective dosage. If the patients get an x-ray to examine radiation-sensitive tissues or organs, the effective dose will be higher. The physician can evaluate the risk by contrasting it with familiar, everyday radiation sources, such as ambient natural radiation **[7].**

Quality Assurance:

To produce acceptable picture quality with a reasonable radiation dose, radiography equipment must be approved and operated by national standards. Technical details might be found in national or international standards. Technical phantoms are used to examine the imaging apparatus's image quality periodically. For this purpose, a typical ghost consists of a copper step wedge for dynamic range adjustment, a lead bar pattern for low contrast resolution measurement, and numerous low contrast objects for spatial resolution assessment.

Comprehensive quality assurance (Q.A.) testing was performed on the X-ray machine before the patient dosage experiments started. In addition, for two years, the Q.A. tests were repeated quarterly while gathering data for this study's patient dosage data. This study routinely assessed several X-ray machine performance metrics, including kVp accuracy, mA and timer linearity, output consistency, beam alignment, optical and radiation field congruence, half value layer (H.V.L.), and spatial picture resolution **[3,8].**

Deterministic Effect and Stochastic Effect:

A threshold dose means exposure to radiation below this level hasno effect. In contrast, exposure to radiation over this level has consequences and is one of the distinguishing features of deterministic effects (tissue reactions). Exposure to radiation that exceeds the threshold dose causes many cells to die or degenerate all at once, and the incidence rate keeps rising. Users can get information from modern X-ray equipment on how much patient exposure occurs during procedures. The standard amounts are the dose area product, also known as the "Air Kerma area product" (K.A.P.), which is typically reported in Gy.cm2 (or cGy.cm2 or Gy.m2, both of which yield the exact numerical values), and the "cumulative Air Kerma" at the "patient entrance reference point," which is reported in 23 milli-grey. In addition to the fluoroscopy time, these figures are frequently stated for fluoroscopy and cine acquisition (F.T.). All dose values must be constantly calibrated on the imaging apparatus. A medical physicist must perform additional calculations to determine a "peak skin dosage." **[8].** Digital treatments can use the same best practices for traditional radiography, such as ideal collimation, source-to-image distance (S.I.D.), focal spot size, and patient position. This is especially important in settings where several parameters are manually set, for example, a critical care unit or an emergency room. Unfortunately, there is a propensity to less strictly enforcing these standards. Because digital technology is more forgiving to dose variations and offers more opportunities for retroactively recovering image quality through processing. Inadequate images were simple to spot in conventional screen-film radiography. Most of these photos were subsequently captured again. But with digital methods, image processing may make up for mistakes in acquisition. In some cases, the source of the error is not evident on the radiograph after processing. Electronic shutters, in particular, can conceal excessively large collimation. In a DR/CR situation, proper X-ray beam collimation is crucial for radiation protection and image quality **[9].** The radiographer is responsiblefor determining the best collimation area for each patient, considering the patient's body size, the diagnostic query, and the examination type's specific criteria. This is especially crucial when employing large-area detectors and systems that aren't cassette-based (some C.R. systems, all D.R. systems) **[10].**

Optimization of Tube Voltage and Beam Filtration

Due to the limited dynamic range of conventional film-screen systems, high kilovoltage settings were previously required to penetrate highly attenuating regions such as the mediastinum while maintaining an adequate level of visual contrast in the lungs. Digital images are frequently made with the same kVp settings as film-screen images. However, this method has recently come under fire. Because image processing allows for independent modulation of an image's contrast and density, digital systems have reinterpreted the traditional relationship between tube potential and picture contrast. All digital detector mediums have increased dose efficacy (D.Q.E.) to varying degrees, depending on their absorption characteristics, which presents a challenge to the classic high kVp method for digital systems at lower Kvp ranges.**[3].** Maintain the universal interpretation option and support the typical features gainedduring radiology training.

1. Image processing should be consistent with identifying whether something is normal andanalyzing studies longitudinally.
2. Picture contrast is enhanced differently in different anatomic locations and for distinct imagestructures thanks to modern multi-frequency processing capabilities. Reader studies show thatphotographs altered using sophisticated processing technologies are much favored **[3-18].**

It remains unknown if a processing-related increase in image quality can be leveraged to reduce the dosage. The fact that image processing can increase and decrease image noise makes the connection between picture processing and the necessary dose evident **[19-25].** It is possible to modify the framerate on each device from 25 to 30 frames per second (fps) to 12 or 6 fps. Some systems permit lower speeds and even E.C.G. (or pacing impulse) triggering. Frame rates might vary from three to one per second (fps) (which, in the case of starting, is also in sync with the cardiac rhythm). The relationship between the framerate and the exposure of the patient, the operator, and the other employees is virtually linear. Determining the imaging system's dosage/pulse adjustment algorithms, and reducing the frame rate from 25 fps (many systems' default option) to 3 fps, which is still enjoyable during E.P. procedures, could lead to an 8-fold reduction in radiation dose [8]. Even though 3D NFM equipment is readily available, fluoroscopic guidance is still necessary for many EP procedures. Therefore, utilizing non-fluoroscopic technology shouldn't result in radiation dose reduction complacency. The only radiation source for patients is the primary beam. The main source of exposure for the operator and other staff members is dispersed radiation from the patient, which is directly correlated with the patient's D.A.P. value. As a result, the patient's state significantly influences the dosage rate for everyone in the room. Reducing the patient's exposure will also reduce the cath lab staff's exposure **[26-30].** Physicians must balance radiation exposure and imaging requirements. The primary focus of X-ray equipment makers is image quality, and their systems are typically designed for coronary angiography and PCIs. As a result, electrophysiologists should demand changes to the workflow from their team, (ii) specific fluoroscopy system settings to restrict exposure, and (iii) appropriate protection during the procedure. The combined measures described below can lower the effective patient dose and scatter radiation toward cath lab employees by up to 95% or greater during catheter ablation treatments **[31-34].**

References:

1. Busch HP, Faulkner K. Image quality and dose management in digital radiography: a new paradigm for optimization. Radiation protection dosimetry. 2005 Dec 1;117(1-3):143-7.

2. Faulkner K. Mammography screening. Qua1ity Assurance Reference Centre, Unit.;9.

3. Uffmann M, Schaefer-Prokop C. Digital radiography: the balance between image quality and required radiation dose. European journal of radiology. 2009 Nov 1;72(2):202-8.

4. Perisinakis K, Damilakis J, Theocharopoulos N, Manios E, Vardas P, Gourtsoyiannis N. Accurate assessment of patient effective radiation dose and associated detriment risk from radiofrequency catheter ablation procedures. Circulation. 2001 Jul 3;104(1):58-62.

5. Auxier JA, Dickson HW. Guest editorial: Concern over recent use of the ALARA philosophy. InEPA Radon and Radionuclide Emission Standards: Hearing Before the Procurement and Military Nuclear Systems Subcommittee of the Committee on Armed Services, House of Representatives, Ninety-eighth Congress, First Session, October 6, 1983 1983 (p. 117). US Government Printing Office.

6. Hui SC, Pialasse JP, Wong JY, Lam T, Ng BK, Cheng JC. Radiation dose of digital radiography (DR) versus microdose x-ray (EOS) on patients with adolescent idiopathic scoliosis: 2016 SOSORT-IRSSD “John Sevastic Award” Winner in Imaging Research. Scoliosis Spinal Disord. 2016; 11: 46.

7. Safety P. Radiation Dose in X-Ray and CT Exams. American College of Radiology and Radiological Society of North America (April 2012). 2012.

8. Heidbuchel H, Wittkampf FH, Vano E, Ernst S, Schilling R, Picano E, Mont L. & ESC Scientific Document Group Jais Pierre 1 de Bono Joseph 2 Piorkowski Christopher 3 Saad Eduardo 4 Femenia Francisco 5.(2014). Practical ways to reduce radiation dose for patients and staff during device implantations and electrophysiological procedures. Europace.;16(7):946-64.

9. Farhan AL. The modern X-ray imaging manners for diagnosis of the dental diseases. Eurasian Journal of Physics, Chemistry and Mathematics. 2022 Jul 1;7:138-48.

10. Niemann T, Reisinger C, Rau P, Schwarz J, Ruis-Lopez L, Bongartz G. Image quality in conventional chest radiography. Evaluation using the postprocessing tool Diamond View®. European journal of radiology. 2010 Mar 1;73(3):555-9.

11. Chhabadia, Gazal. “COVID-19 Pandemic: Health Impact and Social Responsibility.” Journal of Pharmaceutical Research International, July 21, 2021, 68–74. https://doi.org/10.9734/jpri/2021/v33i38A32061.

12. Chimurkar, Vilas K., Vaibhav Anjankar, Prajakta Ghewade, and Anil J. Anjankar. “Morphometric Study of Cadaveric Spleen in Vidarbha Region.” Journal of Pharmaceutical Research International, December 9, 2021, 132–37. https://doi.org/10.9734/jpri/2021/v33i54A33728.

13. Chintalwar, Kunal, and Swaroopa Chakole. “COVID-19 Mutation and Impact on Various Organs.” Journal of Pharmaceutical Research International, July 14, 2021, 85–91. https://doi.org/10.9734/jpri/2021/v33i37A31983.

14. Chitale, Neha, Deepali Patil, and Pratik Phansopkar. “Efficacy of Integrated Neuromuscular Inhibition Technique Versus Mulligan Mobilization on Pain and Functional Disability in Subjects with Non-Specific Low Back Pain –A Research Protocol.” Journal of Pharmaceutical Research International, September 28, 2021, 99–104. https://doi.org/10.9734/jpri/2021/v33i45A32719.

15. Chitale, Neha Vinay, and Mitushi Kishorrao Deshmukh. “Tethering of the Spinal Cord in Cervical Region in Adult Male Patient.” Pan African Medical Journal 40 (2021). https://doi.org/10.11604/pamj.2021.40.20.31405.

16. Chitale, Neha Vinay, and Pratik Arun Phansopkar. “A Complicated Case of Open Wound Managed by Platelet Rich Plasma.” Pan African Medical Journal 39 (2021). https://doi.org/10.11604/pamj.2021.39.238.29867.

17. Chitalkar, Pratiksha, Rakesh Kumar Jha, and Dhruba Hari Chandi. “Case Study of Polycystic Ovary Syndrome -An Overview.” Journal of Pharmaceutical Research International, July 29, 2021, 56–60. https://doi.org/10.9734/jpri/2021/v33i39A32141.

18. Choubisa, Chitrakshi A., Vishnu Vardhan G. D., and Ashish Bele. “Impact of Therapeutic Ultrasound and Myofascial Release Technique on Quality of Life of Students Having Neck Pain Following Virtual Learning.” Journal of Pharmaceutical Research International, September 25, 2021, 466–73. https://doi.org/10.9734/jpri/2021/v33i44B32698.

19. Choudhari, Sonali G., Abhay M. Gaidhane, Priti Desai, Tripti Srivastava, Vedprakash Mishra, and Syed Quazi Zahiruddin. “Applying Visual Mapping Techniques to Promote Learning in Community-Based Medical Education Activities.” BMC Medical Education 21, no. 1 (December 2021): 210. https://doi.org/10.1186/s12909-021-02646-3.

20. Choudhary, Amruta. “Adolescent Clinic—Need of the Era.” Bioscience Biotechnology Research Communications 14, no. 6 (June 15, 2021): 41–44. https://doi.org/10.21786/bbrc/14.6.9.

21. Choudhary, Srishti. “A Review on Measures for Prevention of Community Transmission of COVID-19.” Bioscience Biotechnology Research Communications 14, no. 6 (June 15, 2021): 214–19. https://doi.org/10.21786/bbrc/14.6.45.

22. Chowdhury, Debolina, P. S. Patil, and P. B. Behere. “A Preliminary Report on Relationship between the Subtypes of Early Life Stressor and Clinical Depression.” Journal of Pharmaceutical Research International, July 17, 2021, 16–22. https://doi.org/10.9734/jpri/2021/v33i37B32015.

23. Chunchuwar, Manasi D., Bharat Rathi, Anita Wanjari, and Renu Rathi. “Pharmaceutical Standardization and Drug Dosage Modification of Laghu Sudarshan Churna with Comparative Assessment of Its Antipyretic and Analgesic Activities in Albino Rats.” Journal of Pharmaceutical Research International, October 5, 2021, 130–37. https://doi.org/10.9734/jpri/2021/v33i45B32789.

24. Chutia, Happy, Tripti Srivastava, and Himashree Bhattacharyya. “Introduction of Class.Room Quality Circles among 1 st Year MBBS Students and Its Effect on Students Learning.” Journal of Education and Health Promotion 10, no. 1 (2021): 20. https://doi.org/10.4103/jehp.jehp_412_20.

25. “COVID-19: Lessons from the Pandemic.” Bioscience Biotechnology Research Communications 14, no. 6 (June 15, 2021): 130–33. https://doi.org/10.21786/bbrc/14.6.30.

26. Dabhekar, Praful R., and Rupali Naik. “Study on Work Safety for Employees in Radiology Department.” Journal of Pharmaceutical Research International, December 15, 2021, 353–58. https://doi.org/10.9734/jpri/2021/v33i58A34126.

27. Dadlani, Mohit, Ankit Jaiswal, Kiran Saoji, and Gajanan Pisulkar. “An Unusual Presentation of Foreign Body Granuloma of Ankle Mimicking a Neoplastic Lesion.” Journal of Evolution of Medical and Dental Sciences 10, no. 20 (May 17, 2021): 1547–50. https://doi.org/10.14260/jemds/2021/322.

28. Dafal, Akshay, Sunil Kumar, Sachin Agrawal, Sourya Acharya, and Apoorva Nirmal. “Admission Anion Gap Metabolic Acidosis and Its Impact on Patients in Medical Intensive Care Unit.” Journal of Laboratory Physicians 13, no. 02 (June 2021): 107–11. https://doi.org/10.1055/s-0041-1726568.

29. Daga, Shreya, Rashmi Walke, Pallavi R. Bhakaney, . Vishnuvardhan, Ruhi Kumbhare, and Moli Jain. “Effectual Physiotherapy Treatment in a 16 Year Old Case of Atrial Septal Defect- A Single Case Study.” Journal of Pharmaceutical Research International, December 14, 2021, 161–65. https://doi.org/10.9734/jpri/2021/v33i57B34041.

30. Dagadkar, Arundhatee. “Management and Outcomes of Pregnancy with Gestational Hypertension and Hyperthyroidism: A Case Report.” Journal of Pharmaceutical Research International, July 28, 2021, 295–99. https://doi.org/10.9734/jpri/2021/v33i38B32126.

31. Dahake, Sampada, Priyanka Paul Madhu, Amit Reche, Kumar Gaurav Chhabra, Simran Kriplani, Rutuja Ubhale, and Barkha Adwani. “Determine the Effectiveness of Anacardic Acid and Stannous Fluoride as an Anti-Erosive Agent.” Journal of Pharmaceutical Research International, October 16, 2021, 495–99. https://doi.org/10.9734/jpri/2021/v33i46A32892.

32. Dahane, Arya. “Myasthenia Gravis.” Bioscience Biotechnology Research Communications 14, no. 6 (June 15, 2021): 52–54. https://doi.org/10.21786/bbrc/14.6.12.

33. Dahane, Trupti M., Rupali Mukesh Patel, Surekha Godbole Dubey, and Kashish Mangal. “Awareness & Knowledge of Maxillofacial Prosthodontics as a Dental Specialty amongst Medical Practitioners.” Journal of Evolution of Medical and Dental Sciences 10, no. 9 (March 1, 2021): 608–12. https://doi.org/10.14260/jemds/2021/131.

34. Dahiwele, Akshay, Shailesh Patil, Sarju Zilate, Harsh Salankar, and Sonali Rode. “Effective Response to DPP-4 Inhibitors in Patients of COVID – 19 Triggered Uncontrolled Type 2 DM – A Case Report.” Journal of Pharmaceutical Research International, December 13, 2021, 34–38. https://doi.org/10.9734/jpri/2021/v33i55A33803.