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THE INTERSECTION OF PHARMACY AND RADIOLOGY: ENHANCING PATIENT CARE THROUGH COLLABORATIVE PRACTICE

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ABSTRACT

In today's healthcare environment, it is essential that pharmacy and radiology work together to enhance patient care and improve the efficiency of their respective services in medical imaging. This article seeks to describe the collaborative practice initiatives that pharmacists have engaged in across various imaging departments. Interprofessional care models are designed to improve patient safety and outcomes. As a collaborative model for interprofessional education and practice, consultant pharmacists have been embedded in imaging departments to fill a variety of roles. These roles include pharmacist-involved indication checklist screening for prior authorization as well as patient care services designed to ensure medication safety. Pharmacist-led patient education services have also been established to address specific areas of public health interest. A collaborative pharmacy and radiology service is a model for enhancing patient care and translatable across medical imaging services.

Pharmacy practice and services have advanced in sophistication and complexity, particularly with drug-related devices. These devices interface with medical equipment, information systems, and the hospital formulary. Therefore other disciplines and departments, especially radiology, must partner to better service patients in this area. In addition, as the proportion of imaging patients on complex medication regimens increases, radiologists need the assurance that patient medications and drug compatibility with radiopharmaceuticals and media is safe. Pharmacist-involved patient safety initiatives in the imaging department are a solution. In addition, the time-consuming process of collecting prior authorization documentation that pertains to indications of imaging orders and medications for their indications is an ongoing challenge in the imaging department. Pharmacist-involved indication screening prior authorization is a solution.

It is with this understanding of the increasingly complex interactions between medication and imaging services, patient safety risks associated with medication in the imaging environment, and the inefficiencies of unmanaged prior authorization processes that collaborative opportunities between pharmacy and imaging departments have emerged. Pharmacists possess the clinical knowledge and technical skills to identify patient medication errors, guide improvements in patient safety, and audit compliance with safety measures, while radiologists have the medical expertise

and oversight to implement the required changes. Therefore pharmacist involvement in patient safety initiatives as collaborative practice with imaging departments is a logical next step in evolving pharmacy services.

1.2 Keywords

Interprofessional collaboration, Medication Management, Clinical Pharmacy, Radiology, Patient Care, Transition of Care, Technology Implementation, Preauthorization.

1.3 Aim of the study

Interprofessional collaboration between pharmacists and radiologists has the potential to enhance patient care and health outcomes through the collaborative practice of image quality improvement. To enhance the integration of collaborative practice within the pharmacy and radiology practice settings, it is important to better understand the perceptions of pharmacists and radiologists in regard to collaborative practice. Radiologists generally support collaborative practice initiatives with their pharmacist colleagues and perceive that collaborative practice has some clinical and operational benefits. While beneficial on both sides, pharmacists were less inclined to support the reciprocal involvement in prescriptions that may require radiological interpretations. Both groups felt their collaborative practice is impeded by factors such as poor interprofessional network, mixed understanding of each other's roles, time constraints and priorities on competing issues, as well as structural barriers (SAJIDAH ABDULQADER et al., 2017).

Interprofessional collaboration between pharmacists and radiologists on health care and professional development has been documented. However, research on the perceptions regarding collaborative practice between these two professional groups is lacking. Pharmacists and radiologists are both regulated health care professionals and play important roles in interpreting the data for optimizing the drug therapy process and radiation safety in diagnostic imaging respectively. The increase in the complexity of health care and professionals' task scopes has generated a pressing need for collaboration. The pharmaceutical care movement in the 1990s has led to functional changes in pharmacy practice from a traditional product-based focus to predominantly a patient-based one. A reciprocating change in the radiology domain has also occurred, e.g., radiology's participation in hospital ward rounds or collaborative on-call services.

1.4 1. Introduction

Within healthcare no single profession contains all the information necessary for the healthcare of a given patient. However, the value of the collective knowledge is only as good as the team's ability to share and synthesize that information for the good of the patient. Medical errors are most likely to occur when a patient is "handed off" from one professional to another, and solid methods of communication are essential to this handoff. Hands-on interaction among providers is a must in the IV pump room, where there are several different models of pumps in use. Anaphlaxis, especially when precipitated by medication errors, is a problem that often falls outside the purview of safety guards provided in computerized, automated systems (Hahn et al., 2014). A "fail safe" backup to computerized checks is essential in all computerized systems, and is vividly demonstrated in the IV pump room. While automation is no guarantee of safety, it affords a new opportunity for the pharmacist to practice in partnership with others on the healthcare team to

maximize its effectiveness and be a better protector of medications, patients and the institution. Hospitals operating with a "patient first" attitude and open to innovation are best positioned to take advantage of the value added by pharmacy in this new model of care.

Electronic health records (EHR) are creating valuable repositories of information accessible to any member of the patient team, at any time. This long-awaited tool is proving to offer exceptionally improved communication about a patient's status, medication administration and response to therapies. Importantly, the EHR contains a permanent record of the patient's care. These errors can take place with a failed read-back of a telephone order, and rushed notations in the EHR. An EHR neither forgets nor fails to hear important information. Likewise it records smoothly across disciplines. While still needing improvement, the EHR greatly enhances accountability. Electronic notations are associated with the user and the information chronicled seems more credible. Incoming data are reviewed and opportunities for intervention more readily identified.

Communication devices are also being integrated into the care continuum. Personal hand-held devices and smart phones are being used more often between professionals on a team as a means of direct communication. Beyond simple texting, these devices are also becoming the electronic eyes and ears of the profession in the hospital-wide alerting system. The faster and more ubiquitous the technology and communication device, the more likely things will go wrong. Speeding up the already rapid delivery of data is not necessarily the best thing for the team or the patient. Strategic communication and technology integration will greatly improve the continuum of care, but safeguarding privacy and avoiding public miscommunication is vital and necessary. Communication over these media must also be accurate and timely.

1.5 2. Overview of Pharmacy and Radiology

Pharmacy is a health profession with the primary purpose of assuring safe and effective use of drugs (e.g. prescription and over-the-counter medications), and patient care services including managing the operation of the pharmacy services. All of these are accomplished through the provision of pharmaceutical care – the responsible provision of drug therapy for the purpose of achieving definite outcomes that improve a patient's quality of life.

The responsibility of providing pharmaceutical care requires sound knowledge of medicines and their use by patients (i.e. pharmacy practice), knowledge of T&T, and widespread collaborative practice with providers of those drugs including radiologists, physicians (doctors), dentists, pharmacists, nurses, social workers, laboratory technicians, and the support staff working with the drug producers and many others. The T&T of a drug includes consideration of its indications and contraindications, formulation and administration, distribution and formulation, biotransformation and elimination, stability and incompatibility, adverse effects, interactions, monitoring, and education.

Radiology is a branch of medicine and medical imaging that uses imaging to diagnose and treat diseases seen within the body. Radiology can be divided into two broad categories – diagnostic radiology, which uses non-invasive imaging modalities to diagnose disease, and interventional radiology, which uses minimally invasive image-guided procedures to treat diseases (Sorace et al., 2012). Many medications, such as contrast agents (either oral or injectable), will be ordered by a

radiologist for diagnostic imaging procedures to enhance visibility of internal bodily structures, but sometimes unforeseen complications can occur with the use of these medications, such as renal failure and anaphylactic reactions.

2.1. Historical Context

The profession of pharmacy is steeped in history, with roots dating back thousands of years. Since these early days, pharmacists have evolved into a profession-based healthcare entity, moving from a world steeped in tradition to one immersed in science and technology. This evolution has also occurred in parallel with the professions of medicine and nursing. It is argued that, much like other professions, the original intent of the pharmacist's role as a provider of patient-centered care has been interrupted, now being distorted into an alternate role. Specifically, the purpose of this input is to provide a historical context for where the profession of pharmacy has evolved from, and ultimately to set the stage for a discussion of where it is going.

In the times of ancient civilizations, the artisans practicing pharmacy were well regarded and perhaps even revered. Their role predated a profession of medicine, distinguished from physicians by the preparation of remedies. For centuries, pharmacy was almost exclusively a clerical profession, with the work primarily performing laborious manual processes such as compounding, measuring, and distributing medication. Indeed, this was pharmacy history for most of the world until the mid-19th century.

As a result of the resultant hue and cry resulting from the alleged bad medical practice, there was a movement toward professionalism, which means a rigid approach to defining standards and a license requirement for practice. As the upstarts were demanding admissions into the profession, physicians strenuously opposed such demands. After feigned compliance, they simply used the power of the state to define utter and exclusive control of the practice of medicine. There is, consequently, a switch to a new game with new rules and a new team in the adults' world of professionalism.

Around the turn of the 19th century, there was a huge influx of cheap medications flooding onto the market. The consequent widespread patent medicine scandal ultimately led to Federal legislation regulating drugs and medications. Rigid licensing requirements led to the demise of many apothecary shops and the wholesale end of pharmacy practice as it then existed. In the transition period, many independent pharmacists reinvented the pharmacy practice as the modern drug store pharmacies, which thrived into the late 1990s after a century of ad hoc retailing.

2.2. Current Practices

Radiologists are constantly being urged to change their practice models in order to improve quality, reduce costs, and therefore provide better patient care. Several subset models have emerged, from whole transformation to minor modifications and/or collaborations that still retain the independence of the doctor-patient relationship. Radiologists are known for being early adopters of technology, although technology is not the panacea that will once and for all solve the several investigations confronting the imaging specialty. However, the careful and clever use of technology will help survive and flourish in the transforming environment. Some changes purposely made for the future may be shocking and unpalatable to many, but it is impossible to

negate a reality. Any public, commercial, or academic entity knowingly ignoring these changes is probably inviting extinction. Despite the disruption, there are still plenty of opportunities for improvement, so much that images should be considered only a byproduct of the business. Actually, if the byproducts are well managed, the amount of work generated by them may dwarf the actual image workload multiplying revenues. Already, people in certain regions and fast developing nations had to sacrifice some of their medical service to make ends meet. The first step in this direction should be to provide at least one day per week when no examinations requiring radiographic interpretation are conducted. During these off-site days, radiology should be proactive implementing necessary transformations before demand exceeds supply. Redesign management of the radiological byproducts working together with the stakeholders generating the largest volume ones, the clinics. For instance, why not handle the overall workup of the investigations on behalf of the clinics, screening out those ones needing to be read by radiology in a text or worst-case scenario e-mail fashion. Educate clinicians, nurses and other personnel worldwide on the basics of radiology.

1.6 3. Collaborative Practice Models

Background: Interprofessional Team-Based Care (ITBC) is a collaborative process whereby health care professionals from different disciplines work together with patients, families, and caregivers to deliver higher quality care. ITBC is essential to providing patient-centered care for today's increasingly complex patient population. Technology can support pharmacy, radiology, and interprofessional collaborative practice, but it is only a small piece of the implementation puzzle. A combination of factors must be present for effective ITBC and to ensure sustainability. Objectives: This study examines the pharmacists' and radiologists' perspective on the interprofessional collaboration designs, competencies, or practice models within the PharmRad program to identify the factors essential for success. Methods: Focus groups and interviews were conducted to obtain the data of this study. Participant observations were performed to capture the participation of pharmacists and radiologists during the PharmRad sessions. Thematic analysis was used to identify themes related to the research questions. Member checking validity of the analysis was performed. Qualitative software was applied to code the transcript and identify themes. Results: The results of the analysis generated 4 key themes: (1) Remote collaboration situations create unique benefits; (2) Designers can enhance the effectiveness of the process through participant support; (3) Effective interprofessional collaboration requires established ground rules and responsibilities; (4) ITBC and initiation of implementation efforts should develop organically within the team. Discussion and Conclusion: The factors of collaboration at the levels of process design and group dynamics in interprofessional care are less widely studied than the factors focused on during the care delivery. The insights gained from this study provide unique perspectives on the design and implementation of interprofessional care.

3.1. Interdisciplinary Teams

Inter-disciplinary teams, whether they be surgical, medical, or pharmacy practitioners, take on a significant role within the health-care system as they see the various health professionals become proficient at working and collaborating in teams. Learning to work in inter-disciplinary team

situations, and knowing the team approach to health-care is imperative for all future health-care professionals. In order to prepare these candidates for their future workplaces, and to improve health-care delivery to the patient, competency-based constructs or curricula with defined accounting of teamwork needs to be developed and integrated into the pharmacy curriculum ((J. Ascione, 2019)).

Pragmatic, competency-based curricula should focus on the science and art of teamwork in pharmacy, and pharmacy courses should be restructured to focus more on collaboration and teamwork fundamental competencies. Delivery of these curricula should include more active teaching methods such as integrated/discourse-based learning and simulation. Assessments of these curricula should be both formative and summative whilst aimed at accountability to ensure achievement of competency outcomes ((Hahn et al., 2014)).

The purpose of this paper is to consider the factors that influence interprofessional education and to outline a process of interprofessional care for academic centres or institutions engaged in health professions education. First, this paper defines interprofessional care as it relates to collaborative practice and then distinguishes and defines interprofessional education and interprofessional practice. Next, the need and benefits of promoting interprofessional education and more collaborative practice are discussed. Finally, a planning and action framework for interprofessional education is proposed, which includes objectives, strategies, resources, and evaluation processes for facilitating interprofessional care.

3.2. Communication Strategies

Several strategies may be employed to help facilitate communication between radiologists and other members of the healthcare team, both to enhance patient care in terms of safety and quality, and to minimize risks to the practice. Education on effective communication strategies may be incorporated into the training and induction of radiology staff, and may include aspects such as verbal communication strategies, written communication strategies, and teamwork/facilitation strategies.

Verbal communication strategies first begin with the social aspects of communication. Providers should ensure that they create an environment free from distractions with the appropriate chairs, lighting, and room temperature, while assuring privacy, access to the medical record, and reduced interruptions from external distractions. A good introduction is made by meeting patients and their families at their eye levels, stating their names and titles, and perhaps offering a handshake. Patients and their supporting families should be encouraged to voice their concerns, and should not be interrupted at the onset of the consultation. Health providers are encouraged to not only convey diagnoses, but also offer compassion. Finally, providers are encouraged to offer closure in appropriate fashion (Couto Otoni et al., 2018).

Written communication strategies focus on improving the radiology report itself, as it is often the only tangible part of the radiologist-patient encounter. Plans should be conveyed in such a way that misunderstandings are minimized. Language should be free of ambiguity and jargon, while also taking into account health literacy. Hospitals should also make sure non-English and hearing-impaired patients are catered to with qualified interpreters. The use of warnings in reports is a

poorly documented phenomenon in radiology departments, though any risks that may affect a patient's health should rightly be conveyed in unambiguous detail (M. DeBenedectis & P. Rosen, 2018).

The role of other medical staff is often overlooked in discussions on communication, yet many have more time to spend with patients and may be able to initiate dialogue when a radiologist otherwise cannot. The importance of this approach falls flat when radiology staff fail to collaborate or combat the culture of exclusivity found in many departments. Strong methodology and leadership is necessary to help change departmental culture for the better.

3.3. Role Definitions

Pharmacists can improve patient's care when integrated in patient care teams involving physicians and their diagnostic team. The teams can follow PDCA cycles by carefully defining, measuring, and monitoring the relevant processes and outcome criteria. Based upon regularly performed retrospectives, a continuous improvement approach can be taken to further optimize the collaboration. Mapping the patient care process starting with a vague referral, followed by imaging, diagnosis, and reporting is a next step in optimizing collaboration. Additional work focusing on patients integrated in teams of various healthcare professionals and pharmacists providing services is strongly recommended. Pharmacists could focus on the referral process by developing a search engine to assist them and physicians in defining the right clinical question. For radiology, it could develop and implement a unit operating on a region or even national level managing patient referrals.

When pharmacy services are less utilized by patients, radiology can implement or use a tool developed by pharmacy to monitor and assist in follow-up of abnormal/critical imaging findings. Cooperation and collaboration among healthcare professionals has many benefits for both patients and healthcare professionals. By being integrated in a team of healthcare professionals, a pharmacist can greatly improve patient care and is therefore an undeniable member of the care team. Various facets are important to take into account in establishing collaboration. Increased awareness about the role of a pharmacist in a multidisciplinary team, where it can provide additional services in both diagnostic imaging referral and follow-up, can be required. Healthcare institutions need a leadership and a policy aimed at cooperation and collaboration training among all healthcare professionals. To develop successfully, the pharmacist and the team needs to explore, define, and agree on tasks, responsibilities, and boundaries. Techniques from other professions could be applied in this regard and can be used as a starting point as well. Finally, good team dynamics, based upon mutual respect and trust, accountability, and confrontation in an assertive manner on the one hand, and willingness to be confronted, adjust, accept responsibility, and apologize when needed on the other hand, are crucial to be able to work together productively and enjoyably.

1.7 4. Impact on Patient Outcomes

Creating an inclusive collaborative practice through the implementation of a pharmacy and radiology collaborative project can provide a multidisciplinary approach that enhances the quality of care and patient outcomes. Patients' health outcomes should always be measured through the

lens of quality and safety. Improving the quality of care means improving patient safety. Preventing events that have the potential to cause harm to patients and minimizing harm to patients requires consideration of systematic failures in healthcare processes. A multi-disciplinary approach within the healthcare system should include medical doctors, residents, pharmacists, pharmacy residents, pharmacy students, radiologists, and radiology technicians. A pharmacy and radiology collaborative practice model can enhance the quality of care by de-implementing the controversial medication, metformin, for patients on contrast media in the outpatient or inpatient setting. Maintaining clinical care networks between pharmacy and radiology can reduce the number of contrast-induced nephropathy incidences in patients receiving contrast media procedures. Directly assessing renal function before contrast media injection can improve efficiency and patient care during outpatient procedures, while the pharmacy resend order review process can help radiology add patient management orders. While questions about safety and quality measures remain, every quality and safety measure can be turned into practical metrics that are meaningful to providers. Implementation of pharmacy and radiology collaborative practice can be overtime, and significant quality improvement is expected to develop. By ensuring quality improvement throughout the process, the quality of care and patient safety can be guaranteed (Hahn et al., 2014). Implementation of interprofessional communication through pharmacy residency competencies can provide additional benefits to both pharmacy and radiology, while allowing pre-existing pharmacy residency experiences and skills to be adapted to pharmacy and radiology interprofessional needs. Collaborative healthcare is also an effective method to lower patient readmission rates and increase interprofessional collaboration in patients on polypharmacy. As safety events are re-evaluated near completion of the seven-step decision model, pharmacy could apply new data analysis to ensure that new evidence for efficiency is noted and maintained. Future directions include the enhancement of patient care through development and innovation of assessment and treatment opportunities. Ultimately, the philosophy of "No Health Without Mental Health" should always be considered.

4.1. Medication Management

As part of their involvement in the medication-use process, pharmacists engage in many activities surrounding medication selection, procurement, distribution, and monitoring. Through this broad scope of practice, pharmacists address complex medication-use needs in many specialties, including: older adults, pediatrics, psychiatry, infectious diseases, anticoagulation therapy, pain management, medication therapy management, transplants, and emergency medicine. This expanded service role for clinical pharmacy services enhances patient safety, decreases costs, and improves patient outcomes. Several of these services were recently implemented at the Massachusetts General Hospital and are currently being evaluated as part of the Patient Safety Research Laboratory.

Prescribing medications is reserved for licensed independent practitioners. For violation of state pharmacy laws, pharmacy technicians may face job suspension or dismissal and face an additional sanction. Pharmacists search for drug-related needs (problems) and goals. Pharmacists perform prospective Drug Utilization Evaluation (DUE) screening for current drug therapy, work to resolve

drug therapy problems and develop patient-specific therapeutic plans, and offer drug information regarding pharmaceuticals. Pharmacists collect and assess medication use data, assess drug therapy problems, follow implementable recommendation for patient monitoring, and evaluate the patient outcome.

Pharmacists are responsible for ordering medications and reviewing medication orders to avoid drug-use problems. They make reasonable recommendations to change drug therapy based on a review of a patient's drug therapy. Individualized pharmaceutical care plans are created based on adjusted patient information. Consequently, plans include drug therapy, patient education, monitoring parameters, and intended outcome for each drug prescribed. objectives, date of evaluation, responsibilities, and anticipated duration for implementation (Hahn et al., 2014).

4.2. Radiopharmaceuticals

Radiopharmaceuticals constitute an important family of drugs. The term radiopharmaceutical (or radioligand) is primarily used to designate a drug labeled with a radioactive tracer and employed as a pharmacologic means for therapeutic or diagnostic purposes. In recent decades, radiopharmaceuticals have also served as key research tools. The function of radiopharmaceuticals in therapy, diagnosis or research is similar to non-radiolabeled drugs. The drug binds to a target, be that DNA, RNA, protein or other types of macromolecules or receptors, and then exerts an action with therapeutic, diagnostic or investigative means that is suitable for the specific application. However, the efficacy of radiopharmaceuticals can be dramatically different from their non-radiolabeled homologues, because their radiation state coupled to the molecules adds a new action that directly leads to therapy or diagnostic outcome (Efferth & Langguth, 2011).

Nevertheless, the traditional definition of radiopharmaceutical can be extended further. Indeed, a more general definition of the term radiomodulator (or radiosensitizing drug) is suggested, designating a drug that sensitizes tumor cells towards all forms of radiation therapy, in a similar way that non-radiolabeled pharmaceuticals can render cells sensitive to inhibition or destruction by pharmacologic means. This sensitization is achieved by pharmacologic interactions with targets other than those of radiopharmaceuticals, and radiomodulators can be combined with standard external-beam radiation therapy with X- or γ-rays, β- or γ-eluting sources and many other forms of radiation therapy.

Finally, the evolution of current knowledge amongst radiopharmaceuticals is reviewed. First, the basic chemistry and design modalities of radiopharmaceuticals are introduced, such as the radiotracers, relevant radionuclides, filtering strategies, and labeling techniques. Next, the role of drugs in enhancing radiopharmaceuticals, such as cytotoxics, cytoprotective agents and drugs designed for other indications, such as antiviral, endocrine therapies etc., is documented. Thereafter, the newly emerged drugs in this field are illustrated in great detail. The chemical structures, molecular targets, mechanisms and consequences of a series of cellular and physical actions, radiation types, and the mode-of-action are all analyzed. This review ends with a brief overview of the future perspective of radiopharmaceuticals (Vidal et al., 2020).

4.3. Patient Safety

Safety must include adherence to radiation protection measures, equipment maintenance and quality control procedures, control of medication once they are received by the facility, and the use of proper form to ensure that the right medication is administered at the right route to the right patient (Lau, 2007). Pharmacists play a key role in assuring the safe and quality use of radiopharmaceuticals. In this regard, radiopharmaceuticals and radioisotopes must be procured from licensed and reliable suppliers with accredited quality, tracking and distribution systems. In addition to vigilance in the transport and storage of radioisotopes, pharmacists must also ensure that accurate information on product quality, including expiry date, is consistently communicated to all users. At the point of sale, pharmacists should focus on confirming proper product use and suitability, providing updated product quality information, providing information on management of trained personnel and handling precautions, archive record keeping, and devising procedures for accident reporting and communication.

Two well-documented aspects of safety management are the "Reporting of Incidents and Accidents" and the "Error Prevention" strategies. A structured, non-punitive incident reporting system, with independent error investigations must exist to identify the weaknesses of the system. System changes must be implemented to minimize the chances of recurrence. Error prevention strategies can include the use of workflow maps, redundant rational checks, the use of pre-fills, colour-coded syringes and labels, and even medication reconciliation processes that transcend workflow and staff switches. Control principles in the reduction of risk must also apply. In particular, both physical checks and checking systems must be established, whereupon an initial detection check for the administration of radiation products, and systematic daily checks for the presence of unaccounted for products are implemented.

1.8 5. Challenges and Barriers

The vast potential for collaboration between pharmacists and radiologists remains unrealized in many locations and practice settings. A number of intrinsic and extrinsic issues currently frustrate efforts to bridge this gap. Education, practice change, and increased patient interaction between pharmacists and radiologists can help identify opportunities for improvement and optimize patient real estate. Pharmacists possess the qualifications, expertise, and tools to assist radiologists and other healthcare providers in improving patient care. The breadth of clinical taxonomy likely contributes to a lack of understanding of radiology practice by outside professionals. This knowledge deficits may ultimately restrict pharmacist involvement in routine practice or limit their ability to contribute to the pharmacy profession overall (D. Hager et al., 2015). During initial efforts to expand pharmacist involvement, it is likely to first focus on those with limited engagement by pharmacy professionals. Identification of new opportunities may necessitate pharmacist and pharmacy technician devotion of additional time resources or data extraction/management capabilities. The rapid increase in availability of external radiology systems and the potential for internal efficiency issues will also contribute to stagnant practice quality improvement. Both of these concerns might ultimately impact how well pharmacists are

able to identify opportunities for integration with current pharmacy services or variable external systems.

Another substantial barrier is skepticism regarding the need for pharmacist involvement. Depending on the location and practice setting, this practice change may be viewed as an unneeded addition to the current process (Al-Salloum et al., 2020). Previous research on practice change projects in radiology is limited, especially within the pharmacy realm. Interest in exploring this avenue may initially be met with indifference. A lack of belief in the relevance or utility of practice enhancements aimed at improving care is common across many disciplines. Within the pharmacy field, efforts to assess competency have gained favor, and this focus has also infiltrated radiology practice. During initial attempts at interprofessional collaboration radiology exposures are often understood mostly through clinical roles and not from involved technical evaluations or enhancements. As passive involvement is not consistent with the proactive stance taken upstream for prescription medications, this understanding gap creates the potential for collaboration with pharmacy directly.

5.1. Professional Silos

Professional silos can decrease successful collaborative practice in pharmacy and radiology. Differing education and training experiences' profession-specific perspectives can hinder dialogue despite professionals' common commitment to patient-centered care (Hahn et al., 2014). Differences in jargon, abbreviations, and methods of conduct, in turn, make it difficult for RPM professionals to communicate across disciplines. Organizational silos include departments assigned to build elevators, supply vents, and safety showers hardware/software in each space. Old-school changes have resulted in defaulted design principles that include three “stations” in each space. Pharmacy, nursing, and radiology departments in silo spaces follow the same workflow model, further reinforcing departmental boundaries. Previous design efforts diminished the response to indirect workflow if one was ruled out or automated, and rapid introduction of new technologies was disruptive, difficult to reinduce, and hard to test. Further siloing followed, seriously hampering a coordinated response to defects, as each department adjusted independently and creatively to maintain the ebbing of care. A risk of similar isolation and mechanical tinkering also exists, which would only conceal ongoing curator problems. Such highly couplable systems can show bad design without sufficient crowding, reinforcement, and cultivating efforts. In a feedback loop, the need for crowding could lead to fake collaboration. Faulty interventions could mask actual care. Further deterioration can threaten losing control over radiopharmacies, outsourcing compounding to nonlicensed out-of-state pharmacies, lack of procedures, gaps in responsibilities and accountabilities, staffing shortages and regulatory stress, and pen-driven mergers.

5.2. Regulatory Issues

The regulatory framework that exists in regard to pharmacy and radiology practice varies between the two professions. Radiologists must pursue licensure through passing a national certifying exam after graduating from medical school. Pharmacists similarly must graduate from a pharmacy school offering a Doctor of Pharmacy (Pharm.D.) degree before taking a national Pharmacy

Licensure Exam in addition to any state-specific examinations a Board of Pharmacy may conduct (Adams & Weaver, 2019). Regulatory experience for pharmacists has also been unique across the U.S., with states making practice model changes throughout the years including expanded immunization provision, direct-to-pharmacist medication therapy management avenues, and pharmacist prescriptive authority for a variety of medications to name a few. Currently, there is a nationwide push for pharmacy practice regulations to allow pharmacists to enter into collaborative practice agreements (CPAs) with other healthcare providers (primarily physicians) so that patient care can be more efficiently and effectively coordinated between pharmacy and other health services.

Regulatory barriers and unknowns exist depending on the design of a CPA and the workings of interprofessional collaboration between pharmacy and other fields of practice. These barriers prevent pharmacy practice models from being fully utilized to improve patient care in all applicable areas. It is necessary for pharmacy stakeholders including organizations, pharmacists, and individual pharmacy locations to work together to push for and establish clearer regulations across the U.S. such that any pharmacy practice models to be developed in the future can immediately begin improving patient care with no loss in time, productivity, or collaborative potential. Significant strides to allow CPAs have already been made as laws to allow CPAs and specific models have been established in many other states, but much work remains to develop sufficiently clear guidelines and regulations to representively allow CPAs in all states and ensure they can be deployed. It is critical that pharmacy stakeholders work together in the months and years to come to take the next steps towards full state representation of practice models that utilize CPAs.

5.3. Resource Limitations

Before a collaborative practice model is initiated, a consideration of the infrastructure that has to be put in place to support the model, the knowledge of who will be providing the services, and the expectations of the service has to happen. Between pharmacy and radiology, all of the described components would be important to review as they relate to radiology technicians or radiology physicians providing medication services. While protocol treatment plans, documentation, and recommendations of medications can still be delivered for the imaging contrast, the knowledge the interprofessional team gains and the opportunity for education for non-pharmacist providers is lost without a pharmacy presence directly involved in the collaborative service (Hahn et al., 2014). Patients requesting radiology services cannot be directly approached by radiology pharmacists regarding medication needs and/or preferences without the presence of a physician or technician. This is a frustrating limitation to the practice for the pharmacists involved, as well as the teams that want pharmacy's input on hospitalist admissions and sub-specialty consults. Limitations exist for pharmacy with the inability to verify a patient's history of medication use due to regulations with medical records. The nurse's knowledge of patient medications can be pooled for services where pharmacy is not represented. As with anything new, collaboration takes time. New collaborative practice models take more time for development than anticipated. Delays can happen

due to other higher priority projects undertaken by the pharmacy and radiology services or due to regulatory issues impeding timely completion.

Time zone differences play a major role in the timeliness of inclusive meetings from the perspective of New Zealand seeking to close gaps between St Louis and New Zealand. There is great potential for hospitals outside elsewhere in the world to be better engaged. As with any new practice, there should be established quality metrics early in the collaboration to ensure quality remains consistently high (R. Reid, 2022).

1.9 6. Case Studies

Understanding the analytical nature of the study, the following section presents interesting information via individual case studies on joint actions of pharmacy and radiology in daily practice. Unique models across the globe are reported below.

1. Join and See (JAS) in Blanchard Valley Hospital

In 2016, Managers of the Diagnostic Imaging and Pharmacy services collaborated and implemented a project called ”Join and See” (JAS). The main purpose was improving patient care by optimizing the imaging order process and medication use. Initially, high utilization of CT and radiography imaging modalities and concerns about prescribed medication practice were observed. By searching collaborative practice models involving radiology and pharmacy, the JAS was established as a new interprofessional collaborative practice in the area of imaging ordering medications. In this practice, all imaging orders are automatically checked for corresponding medications, and the pharmacist calls the ordering physician to discuss and promote the clarity of prescription. This practice was designed to resolve the confusion on who should respond when medication-related issues are raised. Initially, JAS was implemented in the CT and radiography departments, at 12 hours per week musculoskeletal specialists’ site visit. After 7 months, it was expanded to the MR and ultrasound departments, and 16 hours per week. The imaging order was JIRA-ed to indicate whether it was handled by a pharmacist. After 3 months, physicians’ rating on the appropriate information reflected by a higher average score from JAS was significantly improved (Dugas et al., 2001).

2. Time-Out Protocol After Ordering a Diagnostic Imaging Test for a New Inpatient

Aimed at enhancing safety in a large hospital with more than 1,000 beds, a joint action with recommendation of phasing-out unnecessary imaging study was initiated in 2018. For reducing a continuation and inadequate pre-examination preparation on patient safety and performance, a “time-out protocol after ordering a diagnostic imaging test for a new inpatient” (TOP) was innovated. The most important mechanism was providing information confirming a no-change period, which means scheduling a diagnostic imaging test was innovative to a new inpatient with an appropriate indication. Such education was spread to the National Congress of Research, Productivity and Health Policy in Japan. Implemented joint action was led by the Head of Department of Diagnostic Radiology and Director of the Hospital Pharmacy. Both introduced and reported verified data (Jessome, 2020).

6.1. Successful Collaborations

Considerable collaboration to connect radiographers and pharmacists in providing holistic patient care focused on the prescribing and administering of radiopharmaceuticals was visible in some cases. Radiopharmaceuticals are a special form of medication, yet their use in practice frequently goes unnoticed by pharmacy departments. Pharmacists have a thorough understanding of pharmacology, patient care, and the medication use process in addition to other critical responsibilities. To the general public, the protection of patients and staff within golden shields of protection in the pharmacy is apparent; even wider golden shields are formed in most accredited medical facilities through the combined performance of the pharmacy and radiology departments. Medication use procedures are obligatory in both departments, yet their explicit application for the safety use of newly prescribed radiopharmaceuticals as required by the laws of medicine and pharmacy has been noted to be inadequate.

Successful collaborations were visible across pharmacy and radiology departments with sophisticated systems in place for other radiopharmaceuticals and cross-discipline support in various forms informing a way forward for successful implementation in hospitals considering a collaborative approach. It is hoped that a Plan–Do–Study–Act cycle of analyzing an identified problem, producing tested solutions, and then engaging in continuous monitoring will embed new working practices that ultimately will be enhanced over time. However, successful collaborative working was noted to be a lengthy process requiring initial analysis of the current situation. While work may need to be completed beforehand to raise awareness of the shared objectives of protecting the patient and optimizing the medication use process leading to a better quality and efficiency of care, initial engagement could not be undertaken alone.

Established systems in larger facilities along with the engagement of senior management informed early understanding of current capabilities before spreading interest and discussing lower-level imperatives and promotions to agents of change within departments. The application of potent forms of networking was detailed in a collaborative model demonstrating improvements arising from capabilities associated with being employed by a larger facility. New processes to transfer information and approval despite remote working locations were also required. For others in similar positions attempting to begin this journey, picking the right starting point and agents of change was viewed as fundamental to achieving success with future application.

6.2. Lessons Learned

Despite the interest in pharmacy and radiology collaboration, the described outreach and practice development options were all familiar to the pharmacy team. Acknowledging that despite having no prior experience working with radiology, ideas regarding potential initiatives came easily raises the question: Are laboratory and radiology work groups so similar that the ideas could be easily translated from one to the other? The laboratory department was well-versed in working with pharmacy to advance care and safety processes, and the latter had found success modeling initiatives that addressed those same departmental needs. If so, there may be opportunities for departments that have not typically collaborated to do so, as a majority of the suggestions generated by the pharmacy work group had also been effective in the laboratory setting. If not,

there may be something unique about the pharmacy and radiology work groups, health system, or pharmacy practice workload changes that made that group more readily productive. Additional exploration into how to leverage the synergy created by the intersection of pharmacy and radiology added complexity to the data interpretation but could also enhance the efforts' impact.

Beyond exploring the observations generated in the context of outward-facing initiatives, the pharmacy work group was left with the question of how to apply them to their department's day-to-day operations. Each idea presented multiple angles for departmental improvements, with each proposal containing multiple discrete tasks. The pharmacy team had a wealth of ideas for enhancing pharmacy care provided to patients while simultaneously enhancing department safety and patient care processes. However, the pharmacy team was also cognizant of the limitations of available time and resources. Over the next few months, the work group adopted the approach of reviewing suggestions and determining which tended to fall into a category that was already being addressed. It was decided that the group also needed input from the pharmacy team focused on each section of pharmacy practice, as initial proposals had been developed with radiology-focused practice in mind.

The inherent power of collaboration became clear during practice development discussions; using collaborative discussions to learn about a topic broadly enhanced understanding and generated ideas for specific initiatives. It was also informative for the effort's organizing team to better understand the practice development workload taking place in the pharmacy section, providing opportunities to reinforce those efforts and identify additional needs. Recommendations for future planning efforts born from that discussion include managing scope as feasibly as possible and discussing general topics with individual sections before attempting to broaden discussions.

1.10 7. Future Directions

The new heath system environment provides many opportunities for pharmacy and radiology to work together to meet their common goals of improving patient care and lowering overall cost of care. Pharmaceutical care services encompass many different practice areas that are aligned with radiology's mission to deliver quality services and enhance patient safety. Automated and semiautomated technologies can assist pharmacies in safely and efficiently preparing medications used in procedural areas. Standard order sets, order screening and drug utilization review programs can help to avoid delays in patient care. Clinical decision support programs can ensure the safe use of medications in radiology. This is the future of pharmacy and radiology working together, bringing pharmacy to health system regions that do not employ them and improving patient and workflow safety through the combined effects of computer-centered pharmacy and radiology systems (Hahn et al., 2014).

The expanded pharmacy practice model entails a greater role in managing pharmacotherapy services and systems of scheduled medications. These services are highly securitized environments and more pharmacy need to be employed on a 24/7 basis in this region as it concerns patient well being and safety. Rad/Onc and clinical assistance of pharmacist systems have a new pharmacy work design. Orders are now screened by systems in synergy with an EHR and are automatically interpreted, with pharmacy flagging certain CT orders for protocols not validated in

the system. Both successful recommendations by pharmacy in preventing delays in care and new orders have been flagged and communicated to radiology.

The cooperative effort and recognition of groups of systems that incorporated this new pharmacy model under separate cases is also future wish. Systems can be utilized in other hospitals to improve care and workflow. Newly employed hospitals have an incentive to hire pharmacy who have successfully developed and administered these systems. Hospitals can use websites to demonstrate which automated systems or innovations can be constructed with order objectives. Each hospital can meet independently for these regions interested in utilizing cooperative systems. Participating hospitals must agree to open their systems to pharmacy in order for regions to successfully work together. It is also the potential for worldwide pharmacy.

7.1. Innovative Technologies

Historically, prescription information, when communicated, left little room for error. Today, wireless transmission, electronic prescribing, and computerized physician order entry allow for a far more integrated approach. Digital imaging carries the potential to enhance patient understanding and pharmacy function (Hahn et al., 2014). An integrated imaging and management system has been developed to allow diagnosis and treatment planning on both sides of the pharmacy-radiology interface.

Innovative technologies model cooperative behavior. Digital images may be shared in either direction, with the pharmacist acting as or consulting with the radiologist when scanning is performed on the pharmacy side. In patient care, either the pharmacy or the radiology side may image the patient without the limitation of mussing the hair. This technology is an advancement beyond the past experience of either party “hiding” under the traditional bath-light systems used in analogue film processing. Integration allows the use of the same console for all imaging details, and key technologies are patented inventions. There is direct observability of technology operations.

Innovative technologies elicit situational trust. Transparency and public awareness of processes performed help to foster understanding and assurance that functions are being performed appropriately. No redundant or overlapping procedures are included in both the pharmacy and the radiology sides, eliminating one potential criticism. Return on investment, though unquantifiable and far longer-term than other operations, should be far in excess of the costs of failed expectations. Enduring, sustainable, cooperative modeling is hence developed.

7.2. Education and Training

Interprofessional Education (IPE) is essential for training health care professionals who work in teams. Successful IPE helps health care disciplines better utilize each other’s strengths in a team-based collaboration that improves patient care, ultimately leading to stronger health care systems (Boland et al., 2018). Designing and implementing training for diverse health care professions is challenging. While most health disciplines recognize the importance of IPE, many professional training programs struggle with grind implementation. Interprofessional discussions on policy, research, and practice have grown as the collaboration between pharmacy and radiology has advanced. All talk attracts attention, breeds interest, and rattles minds. Most importantly, talk leads

to action. Still chambers are needed for candid discussion where professions can freely express public views, private concerns, and common interests. Electronic avenues such as editorials, blogs, and social media need to be utilized to disseminate news and mount campaigns. All communication and educational platforms that radiologists, pharmacists, and students access can be vehicles for outreach. Educational opportunities such as these may be available to different extents at different institutions, but they bear the promise of one thing: Change.

After recognition of both the collective belief regarding the value of this collaboration, and awareness of the existing barriers, there followed the most important agenda: how best to move forward in developing collaborative practice in pharmacy and radiology. To this end, the committee consulted peer-reviewed literature first and foremost. Credible guidance from other professionals who have effectively undertaken the march toward collaborative practice was sought. Guidelines and barriers published by other health disciplines were considered during the committee's deliberation. Collaborative practice was defined as "when multiple health workers from different professional backgrounds work together with patients, families, caregivers, and communities to deliver high-quality health care." It is a coordinated model of care that blends the efforts from several disciplines, each bringing its own specialized skills as part of a team, and interprofessional providers communicate frequently and work with one another to achieve mutual goals. It is imperative to spell out what collaborative practice is before addressing how best to achieve it.

7.3. Policy Recommendations

Interprofessional collaboration between pharmacists and radiologists is comparatively rare; however, it offers a unique opportunity to enhance patient care through improved imaging appropriateness and improved access to imaging examinations. The focus of this article is to discuss the utilization of collaborative practice agreements, specifically within radiology, to enhance care using the skills and expertise from the pharmacy profession. One collaborative pharmacy collaborative practice agreement was identified. The agreement was adapted for practice in the pharmacy profession in Arizona and approved by the Arizona State Legislature during the 2022 legislative session. From this experience, recommendations and considerations are provided for future agreements between pharmacists and radiologists.

In 1984, clinical pharmacy was defined as "the area of pharmacy concerned with the science and practice of rational medication use." In 2004, the practice of clinical pharmacy was reinforced, describing it as "the health science discipline in which pharmacists provide patient care that optimizes medication therapy and promotes health, wellness, and disease prevention." Unfortunately, the overlap between the practice of clinical pharmacy and radiology is not often recognized. While radiology provides imaging services, pharmacists provide medications and drug therapy. Imaging services utilize enormous energy signatures in conjunction with contrast agents to produce "imaging." Pharmacists optimize and provide drug therapy using smaller energy signatures often in conjunction with contrast agents. With only a 1 hour overlap in the pharmacy and radiology curriculum, the association between the two professions is commonly not

recognized by other members of the health care team; however, it offers a unique opportunity to greatly enhance patient care (Hahn et al., 2014).

1.11 8. Conclusion

This article reviews how the rapid growth of the pharmacy profession, and its evolution towards patient-focused pharmaceutical care, can be integrated into the activities of radiology departments. It showcases the collaborative practice of pharmacists who specialize in radiology pharmaceuticals. The roles of pharmacists working in radiology are constantly evolving with the strong shift towards consolidation of healthcare systems, further complexity of the technological environment in modality, and the increased recognition of the roles of pharmacists themselves. With the increasing number of opportunities, a major challenge remains in education, training, and recruitment, as well as the demand for integration of these processes. Globally, the term radiopharmacy can refer to pharmacists working in the field of nuclear medicine, as well as pharmacy services supporting interventional radiology. Academic training varies; however, it often concentrates on pre-formulation, radiolabeling, and quality assurance of radiopharmaceuticals (Hahn et al., 2014). This development should be embraced by radiology departments and universities to ensure future workforce demands in this field (Al-Salloum et al., 2020).

Licensed pharmacists working in radiology have a province of responsibility pertaining to pharmacy practice in the department formalized as a practice standards document. Furthermore, specialty training in residency/clinical fellowships is required for practice today. Radiology pharmacy is entering a new phase similar to radiopharmacy in terms of growth, complexity, and public awareness. Three groups of opportunities will be elaborated: growth of practice; change in practice standards; and recognition of radiology pharmacists. With the creation of the Integrated Practice Model through the American College of Clinical Pharmacy visioning process, management of radiopharmaceuticals in an imaging department is likely to be part of pharmacy practice in the future. In this scenario, a dedicated pharmacist specializing in radiopharmaceuticals will need to be employed at the imaging department; as regards protocols and interventions, it may be similar to that needed to support current guidelines for nuclear pharmacies and PET centers. As there is a need for customized protocols and standardized education and training, new developments in the field of controlled drug pharmacy may provide valuable input. The growth of the discipline of radiology pharmacy is an exciting development that is now beginning to gain recognition around the world. For this opportunity to continue to flourish, products that stimulate and promote specialty training and practice standards will need to be embraced globally.

In this new phase for radiology pharmacy, there are challenges ahead. With the increasing number of opportunities, a major challenge remains in education, training, and recruitment, as well as the demand for integration of these processes. Currently, there is a lack of academic programs and continuing professional education to train pharmaceutics, quality assurance, and regulatory aspects for radiopharmaceuticals destined for PET-MRI, and a need to integrate practical and education elements for novel/complex tracers. Entry-level degrees and specialist board certification focus on nuclear medicine, and not on integration of these knowledge areas; yet, there are no entry-level

credentials available for pharmacists practicing locally or globally. With the rapid advancement of technology and increased recognition of pharmacists, initial and other educational programs and processes will need to be developed as priority, locally as well as globally. Radiologists and radiology department management should embrace and endorse the discipline of radiology pharmacy to avoid drifting through unplanned processes and unrealistic developments of technology.

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