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Enhancing Career Paths for Tomorrow's Radiation Oncologists

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Introduction[1] (NV, CRT, CNC)

The purpose for this manuscript is to enhance career opportunities for radiation oncologists (ROs) by expanding the scope of work as a prelude to re-defining the scope of our contributions at this critical inflection point in our history. The direct stimulus is the speculation and debate over the ROs' future, a logical issue in today's rapidly changing world of healthcare economics, cancer biology, artificial intelligence and global resource disparities (1–6). To be proactive and effective in adapting to – and with – these external factors, the data upon which decisions are based should be well understood. Yet accuracy of workforce forecasts for ROs are notoriously inconsistent, partly due to the imperfect assumptions inherent in such complex models (1–4). Nonetheless, over 50% of ROs are concerned about a future oversupply (5, 6), and the downstream effects already appear to have negatively impacted specialty choice among highly-talented and pragmatic medical students. Discussions of practitioner supply/demand imbalance often focus on the numerator – are there too many? Better solutions may reside in a broadening of the denominator – the talent and contributions that ROs bring to cancer care and greater society (7, 8). Regardless of how one views these complex issues, this is a critical juncture for exploring how to evolve ROs' skills and ensure that our contributions to cancer care remain critical to solving the challenges facing healthcare and patients.

Innovation and consideration of nontraditional paths should be a key part of the strategy to maintaining our relevance and proactively addressing transformational changes in healthcare delivery models, medical science and information technology. The "adoption life cycle" for innovation predicts a bell-curve distribution of uptake over time, innovators at one end, skeptics and phobics on the other (9). Healthcare adopts change judiciously, and appropriately so, pending establishment of safety and efficacy. ROs happen to represent a significant investment and subsequent revenue generator for healthcare enterprises...presently. Some may feel threatened by rapidly-evolving changes in systemic therapy, radiotherapy indications, and the fourth industrial revolution, where smart technologies are redefining, if not replacing, jobs requiring manual skill and human decision-making. But ROs could also benefit from some of these changes, which are inevitable and exponential; we must adapt creatively.

Clayton Christensen describes relevant concepts to manage (and thrive under) disruptive, catalytic and reverse innovation (10–13). Expanding radiation's therapeutic applications and technical capabilities are absolutely vital steps. This paper advocates for the parallel development of our workforce through opportunities in broader domains (Figure 1). Herein we review some underappreciated careers with colleagues who have successfully charted these paths, utilizing ROs' unique strengths to further diversify their skillsets, enrich our professional roadmap, and expand demand, i.e. that critical denominator. Far from exhaustive, this compendium provides a vision for how future ROs can do meaningful and influential work through activities that expand the definition of ROs' work-product, inspiring continued training, adaptation and evolution of our workforce[2].

[1]All authors were involved in the manuscript preparation. The title page lists individual sections with author initials to indicate the authors who had primary responsibility for that particular section.

Global Health (SG, MLY, TM, LNS, MKG)

ROs increasingly express interest in global medicine initiatives. Establishing cancer care in resource-constrained settings requires partnerships, resources, and sustainable training models. Remediating the situation wherein patients have no access to cancer care is a global imperative. Strong relationships between in-country leadership, care providers and paired organizations are requisite. Examples of how ROs can lead and significantly expand these critical initiatives include:

- The Asia-Pacific Special Interest Group of the Royal Australian (APROSIG) and New Zealand College of Radiologists (RANZCR) Faculty of RO aim to support provision of quality radiotherapy in low- and middle-income countries (LMICs). A key collaboration with the comprehensive Cambodian National Cancer Centre has enabled provision of radiotherapy services since April 2018 and funding for Cambodian oncology professionals to train in Australia and Australasian staff to volunteer in Cambodia.
- University of Pennsylvania (UPenn) has established an oncology collaboration with University of Botswana and the nation's Ministry of Health and Wellness. This partnership is developing programmatic initiatives including streamlined multidisciplinary care (14); guideline development; technical support for new radiation centers; timely chemotherapeutic drug delivery (15); and complementary research initiatives. Consequently, a robust framework for training and bidirectional exchange of oncology professionals has emerged (16), allowing U.S.-based trainees to gain experience in LMIC settings and further integrate global RO in their careers (17, 18).
- Not all LMIC nations have comprehensive radiotherapy training; Russian physicians can complete a two-year oncology residency program covering all aspects of cancer care, but this is mainly a self-learning process with no didactic curriculum. To achieve primary RO specialization, physicians receive additional training lasting 2.5–4 months but no practical exposure to structure contouring or treatment planning (19). In 2016, U.S. and Russian academic ROs piloted an in-person, expert-led contouring workshop (20); subsequently, 15 contouring workshops covering various disease sites were conducted in Russia with financial support from the Russian Society of Clinical Oncology.

The Lancet Oncology Commission report by the Global Task Force on Radiotherapy identified the lack of qualified human resources as a main barrier to providing adequate radiotherapy services in LMICs (21). They indicated a need to train 30,000 ROs, 22,100 medical physicists, and 78,300 radiation technologists over the next 20 years (21), numbers that cannot be achieved without a major paradigm shift in training pathways. Lack of universal acknowledgment of the legitimacy of a global health career is a roadblock to progress (22).

[2] Due to page limitations, a high-level discussion is presented here with additional details available in the references.

The push for innovation requires leadership by LMICs. Interested ROs can develop curricula and training materials with existing agencies: a) for guidance, the World Health Organization published a list of priority medical devices for cancer management (23); b) the International Atomic Energy Agency (IAEA) publishes how-to guides for establishing and maintaining high-quality radiotherapy departments (24, 25) and supports projects in over 130 countries, including radiotherapy education, randomized clinical trials, quality assurance activities, virtual tumor boards, in-person and online courses, and other resources.

Frontier Medicine (JL, GP)

One need not travel abroad to serve low-income and resource-strapped populations. Rural America's cancer patients and providers in geographically-isolated areas face unique challenges in receiving and delivering optimal care, similar to LMICs. System barriers in rural areas are well-documented; 19% of the U.S. population lives in census-designated rural areas yet only 6% of oncology providers practice there, with ROs especially concentrated in non-rural areas (26). Distance to cancer centers is a significant determinant of radiation receipt (27). Rural settings have lower cancer screening rates and delayed management of abnormal results (28–30). Further, rural cancer patients are under-represented in research initiatives (31) despite highly prevalent socioeconomic, demographic, and environmental risk factors that impact cancer development, treatment and mortality (tobacco/alcohol abuse; obesity; under-/lack of insurance) (32–35).

Northern Plains American Indians (NPAI) in particular experience among the highest U.S. cancer mortality rates (36). "Walking Forward" (WF) is a multi-faceted NCI-developed program helmed by a RO-trained principal investigator (DP). Its goal is to support community cancer centers (37) and provide innovation in healthcare delivery, including comprehensive patient navigation (PN), clinical trials access, and assessment of barriers to earlier diagnosis of screen-detectable cancers (38). Implementation of NPAI lay patient navigators resulted in improved patient satisfaction and identification of barriers to timely care (39–41), in turn earning WF cancer screening coordinators access to the Indian Health Service's centers (part of Department of Health and Human Services). This access facilitated ~2,000 screenings and allowed clinicians and scientists to complete genetic analyses in this highly vulnerable population (42), demonstrating importance of trust through responsible research that enhances understanding of normal tissue biology and enables future studies. WF's program is an example of important work to be done in these communities beyond radiation treatment delivery.

Our training programs could promote – even incentivize - rural clerkships, similar to what internal medicine programs offer. Creative, RO-specific solutions could be investigated. ROs are poised to offer pioneering approaches to healthcare delivery and unraveling of population-based cancer biology.

Outcomes and Policy (RDE, JAH, DR)

Examples of RO careers in outcomes and policy exist, but there remains a critical need to engage with healthcare legislation and economic stakeholders at local, national, and international levels to impact policy decisions involving the complex matrix of cancer care delivery systems. Understanding both the mechanisms impacting the relative costs of RO procedures and services and the tools used to determine physician performance and/or adherence to guidelines for reimbursement purposes is a vital skill set. Aside from ROs' opportunities to influence policy through medical society volunteer activities, another avenue is working with payer organizations either as employees or through grants/contracts to inform new policies. Blue Cross Blue Shield of Michigan supports the Michigan RO Quality Consortium, through which physician leaders have been instrumental in developing programs wherein centers meeting prespecified quality metrics and value-based goals can bypass prior authorization processes and receive increased provider reimbursement.

Opportunities also exist within the regulatory space for those with oncology expertise. In fact, the Chief Medical Officer position for Center for Medicare and Medicaid Innovation is presently occupied by a RO charged with directing development of alternative payment models across medical disciplines.

The U.S. Food and Drug Administration (FDA) and U.S. Nuclear Regulatory Commission have full- and part-time paid positions specifically for ROs given their unique and crucial perspective and training. Which technologies/devices will be approved and the circumstances in which they can be used is determined by the FDA, clearly impacting fields that utilize energy sources (e.g. ultrasound, hyperthermia) for clinical care. Beyond these specialty-dedicated positions, ROs are qualified for broader full-time positions in these two agencies, contributing expertise and gaining experience in cancer drug and equipment development and nuclear regulation.

ROs can also participate in policy processes at the global level. The IAEA, serving as the focal point for nuclear cooperation within the United Nations, has a Division of Human Health that employs ROs full-time and is focused on improving access, affordability and quality in radiation delivery (43). Non-governmental organizations (NGOs) provide career-defining or -enhancing opportunities to participate in global cancer policy and administration, including: the International Cancer Expert Corps (ICEC) which focuses on a systems approach to building capacity and capability for LMICs and geographically-isolated indigenous populations (44); Radiating Hope which assists with obtaining radiation equipment (brachytherapy); Chartrounds, providing case-based education; and Union for International Cancer Control which leads advocacy and capacity-building initiatives, collaborating with physicians, policymakers, and patient groups.

Government Service (JCB, BV, MAW, AHE, CNC)

Policy is often proposed by those in private and academic sectors prior to the drafting of legislation. Actual policy implementation - and to some extent interpretation - is conducted by those employed within the public sector. Government service offers unique opportunities for translating ROs' knowledge, skills, and abilities into a lever for influencing the health and well-being of individuals on a broad scale. This influence is manifest through a variety of functions, such as managing research programs, informing and interpreting policy decisions, regulating radiation-related pharmaceuticals and equipment, preparing for response to public health emergencies, and educating leaders at all governmental levels. The central theme uniting those who serve government is that public service is a public trust (45,

46) and offers the satisfaction that arises from knowing one's efforts may impact large segments of the population.

U.S. agencies offering unique and interesting opportunities for ROs include the NCI, National Institute of Allergy and Infectious Diseases and Department of Defense. While advanced degrees like MPH, PharmD, and PhDs are not requisite, ROs with this additional training may better realize the value of these skillsets in the government sector. ROs can participate as team members involved in pharmaceutical countermeasure discovery and development, formulation of clinical practice guidelines and doctrine, radiation/nuclear disaster preparedness and response, and national/international policy decisions. Practitioners wishing to remain closer to clinical medicine may find trials or grants management particularly rewarding roles, given their broad impact and influence.

Practically speaking, government careers carry numerous advantages. Many federal agencies allow dedicated time for practice to maintain clinical and technical skills without concerns of revenue generation. Despite the perception of prohibitive income differentials between public and private sectors, certain positions recognize ROs' competitive salaries and offer relatively generous government compensation and benefits packages along with significant job security.

Industry **(PO, JG, PK, JBW)**

Historically, physicians have not been encouraged to consider careers in industry. Over recent decades, technical advances in radiotherapy treatment planning, imaging and delivery have led to development of novel techniques such as intensity modulation, image guided therapy and radiosurgery. These techniques are associated with lower toxicity and greater efficacy; this improved therapeutic ratio has consequently driven expansion of clinical indications for radiation, demand that is anticipated to build as imaging, treatment delivery, and allied technologies advance in parallel. Compared to other specialties, however, ROs could play a greater role in development of molecularly targeted agents and diagnostics.

Innovation in these domains depends on close collaborations with - and possible employment within - industry. Corporate partners can help identify and focus on high-priority needs and have both ability and relative agility to create, test, commercialize, and rapidly propagate technology. Areas ripe for industry-practitioner projects include improved targeting, application of artificial intelligence, development of radiation modifying systemic agents and biomarkers of tissue injury and tumor response.

Collaborations can be particularly fruitful when industrial partners have internal competence that helps bridge the gap between business and medicine. Most major RO technology vendors have "Medical Affairs" teams as it will become increasingly critical – perhaps mandatory - to formally assess therapeutic improvements in conjunction with increased costs before products can enter routine clinical practice. This domain could be a natural fit for ROs with (or seeking) MBA or JD degrees – a RO phenotype poised for industry leadership. Critical to radiation oncology's growth is a concerted effort to engage similar teams with pharmaceutical companies, focusing on radiation interactions with systemic agents. Our future will be profoundly impacted by drug and molecular diagnostics that synergize with radiation and ROs who know how to develop them.

Radiation Epidemiology **(MAT, JDB)**

Radiation epidemiology (RE) is a collaborative discipline comprising experts in epidemiology, statistics, dosimetry and radiation medicine, investigating the environmental, occupational and medical/therapeutic effects of radiation on human health (47). For radiological and nuclear incidents, including terrorism-related, RE provides a framework of cancer risk and normal tissue injury to help determine the source of injury and means to mitigate acute and late effects (48, 49). Nuclear detonations and the aftermath of radiophobia have been engrained in the public since 1945. Over the past 30 years, RE has guided design and conduct of major population studies following nuclear power plant accidents like Chernobyl and Fukushima (50–54). Knowledge regarding long-term effects of radiation exposure derives predominantly from epidemiologic study of atomic bomb survivors (55) and medically-exposed patients (56).

As a powerful and cost-effective cancer treatment (57), radiation's successes can incur tissue damage and associated latent risks of subsequent malignancies or organ impairment (58–61). ROs are trained to recognize unusual outcomes or tissue injury within or near the radiation field, important observations to document especially with relatively newer modalities like stereotactic radiation and proton therapy (62–64). RE promotes systematic comparison of outcomes to those from previous radiation techniques, especially effective in centralized high-volume radiation facilities and large multi-national studies. As radiation therapy becomes increasingly available in less-resourced environments (21), it will be vital for ROs to develop low- or no-cost web-based common data collection structures to track irradiated individuals across different geographic areas. A cadre of RE-focused ROs can apply their expertise in both clinical medicine and molecular mechanisms underlying disease and radiation injury to interpret big data, address "radiophobia", and guide risk/benefit approaches to diagnostic and therapeutic use of radiation.

The National Council for Radiation Protection and Measurements program, "Where are the Radiation Professionals (WARP)?", emphasizes the need and opportunities for professionals with the requisite education and experience (65–67). ROs formally trained in epidemiologic methodology and hands-on laboratory experience could pursue novel translational science and policy career paths in academia and national/international government agencies.

Informatics **(CDF, RFT, ADT, CRT)**

As RO enters the "Big Data" (68–71) and genomics (72) era, direct and formal informatics competency among general practitioners will be increasingly important. Already, our professional engagement with patients depends upon digital engagement (73) through treatment (74), research (75), documentation (76–78), safety (79–81), and decision-support tools (69, 82–90). Furthermore, informatics expertise is already required as noted in ASTRO-NIH-AAPM's 2015 symposium report (91) and. A "Technology for Innovation in RO" panel report (92).

Responsive initiatives such as the recently launched NCI-FDA INFORMED (93) Data Science Fellowship (94) and MD Anderson National Institute of Biomedical Imaging and Bioengineering-supported Fellow/Resident RO iNtensive Training in Imaging and Informatics to Empower Research Careers (FRONTI2ER) (95) seek to develop a cadre of ROs with focal domain expertise. Clinical informatics has been recognized as a formal American Board of Medical Specialties' subspecialty certification since 2013 (96–98). ROs have become more aware of clinical and bioinformatics/computational biology specialization options through recent professional society meetings, but lack of clarity remains regarding existing pathways to gain expertise in this rapidly evolving field. The sub-discipline of informatics must not be constrained to clinicians with a knack for computational coding, nor divested entirely to our historically more-engaged physics colleagues (99, 100) who have thus far been visionary in informatics development (101), data standardization and nomenclature specification (102). Instead, ROs as a whole must enthusiastically engage within the larger field of informatics, otherwise clinicians will continue being "frustrated with increasing burden of documentation across disparate systems and the associated risks to patient care" (73). Programmatic efforts like Oregon Health & Science University's Fellowship in Informatics-RO Track (103), patterned partly from UPenn's model and incorporating eligibility for the clinical informatics subspecialty certification within an academic RO department, serves as a model for directly incorporating clinical informatics as a formal medical discipline into all aspects of trainee education.

Biology **(MBH, SF)**

Careers in laboratory and translational biology are already well recognized, but the explosion in biology, immunology and molecular oncology requires stronger RO representation. Successful integration of ROs within modern cancer biology research first necessitates commitments to prepare and support new leaders, such as the Holman pathway mechanism to foster physician-scientists. Recent commitments (i.e., ASTRO Research Grants program) seek to address this gap via novel partnerships with scientific foundations (104).

Personalized medicine is a rapidly evolving approach to cancer treatment, linking knowledge of individual tumor biology with available therapies to optimize benefit. Describing these opportunities are well beyond the scope of this paper but to note a few rapidly-emerging research areas are DNA damage response and immunotherapy. DNA damage repair deficits (DDRD) represent an exploitable vulnerability of cancer (105), and potential basis for treatment selection, leading to the concept of synthetic lethality (106–111)

Likewise, successful immunotherapy interventions (IO) overcome specific mechanisms by which tumors evade host immune rejection. The type, density and location of immune cells within human tumors are strongly associated with prognosis (112–115) and consistent, durable response to immune checkpoint blockade (ICB). The latter is achieved in less than one-third of treated patients; considerable efforts focus on enhancing this proportion (121). Immune response elicited by standard cytotoxic therapies contribute to efficacy (116, 117). Ionizing radiation, the classic example of a DNA damage agent, can also elicit systemic responses (abscopal effect) in conjunction with IO in settings where IO alone was ineffective

(118–120). ROs performed the seminal work introducing the concept that radiotherapy can elicit an ‘in situ vaccination’, and have since demonstrated fundamental features of irradiated tumors that can synergize with IO (121–123).

ROs’ involvement in the delivery of systemic therapy is essential to recapture our scope as oncologists and can serve as a “denominator-expander”. Indeed, globally, “clinical oncologists” are trained in both radiotherapy and medical oncology. As of January 2019, there are ~800 cancer immunotherapy trials in the U.S. (www.clinicaltrials.gov), of which ~25% are testing radiation as an immune adjuvant. It’s not possible to imagine a successful future for our specialty without having leaders with combined expertise in radiation oncology, cancer biology and immunobiology linking the laboratory and clinic. Rather than disease site-focused sub-specialization, ROs could forge medical oncology- or immunology-focused pathways for cross-training to gain expertise in these novel sub-disciplines.

Palliative Care **(JJ, KVD)**

The history of radiotherapy and oncologic palliative care is intricately intertwined (116, 117). From the discovery of Roentgen rays in 1896 until the first use of chemotherapy in the 1940s, radiotherapy was the primary modality for palliation of symptoms from advanced cancer, augmenting surgery and supportive medicines. In 1964, the distinction between palliative and curative radiotherapy was highlighted in *JAMA* by Parker, emphasizing relief of suffering as the primary endpoint of palliative radiotherapy (124). The 1970s and 1980s saw much progress (125), focusing on optimizing palliative radiation outcomes and tolerability.. As systemic therapies improved, the locus of care for these patients shifted from surgeons and ROs to hematologists/oncologists as primary care providers (126) with the ROs’ role shifting from one primary to consultative management.

The hospice movement of the late 20th-century grew out of pioneering work in the UK by Dame Cicely Saunders (117, 126, 127). This movement provided holistic care for patients with advanced illness and their families, caring for physical, emotional, spiritual and psycho-social needs. It became a funded component of the U.S. healthcare system with the creation of the Medicare hospice benefit in 1982 (117). Hospice and Palliative Medicine was formally recognized as a medical subspecialty by nine member boards of the American Board of Medical Specialties in 2006, with active support of the American Board of Radiology (128). ROs were encouraged to participate in board certification. By the early 2010s, the field of palliative medicine further cemented its place in early oncology care with: 1) publication of several randomized clinical trials demonstrating improvements in mood, symptom control, quality of life, and overall survival with early initiation (129–132), and 2) ASCO-issued formal statements recommending the integration of palliative care into standard oncology practice (133, 134).

More recently, our role has re-expanded as a growing number of ROs have achieved dual board-certification in palliative medicine. ROs have also increasingly taken leadership roles in palliative radiation by:

- Developing policy guidelines (135, 136)
- Chairing national meetings (137)

- Identifying ROs' educational gaps (138–142)
- Creating a palliation subspecialty within RO, resulting in growth of dedicated palliative radiotherapy services

Furthermore, a number of innovative clinics have demonstrated the power of integrating palliative care and radiation to improve collaboration and clinical outcomes for advanced cancer patients (143–146). Canada's rapid access bone metastasis radiotherapy clinics (144) provided insights into the use of single-fraction radiotherapy for bone metastases with high levels of pain relief and minimal side effects. Similar benefit has been demonstrated for patients with brain and spine metastases (147, 148). ROs must continue to assume more active roles in palliative medicine areas of clinical care, research, advocacy and policy so that our voices will gain new strength during multidisciplinary discussions while caring for the sickest patients, teaching the next generation the true value and scope of our field.

Training Considerations **(ALZ, NV)**

Given these opportunities for expanding ROs' future scope of practice, how do we impart the requisite skills to our workforce? Formal training and board certification requirements for specialized apprentices vary by country and jurisdiction; not all expertise requires lengthy training and credentialing. For U.S. trainees, the Accreditation Council for Graduate Medical Education residency review committee requires 36-months minimum (27 for Holman scholars) of clinical RO rotations during a 48-month residency. There is no mandatory structure during the remaining 12 months, thus tremendous opportunity exists to strategically augment trainees' skillsets.

Some may use elective time towards degree and certificate programs. Briefer targeted clinical exposures could instill comfort with prescribing certain medical therapies and managing predictable side effects in the acute and follow-up setting. Working in under-resourced environments requires cultural adjustment, not necessarily formal certification. While opportunities to acquire new skills are more accessible during post-graduate training, practicing ROs interested in expanding their toolbox and credentials can also partake. We envision a robust spectrum with options that do not universally require marked investments of time or money:

- on-line or live seminars/coursework
- certificates/Masters degrees (i.e., epidemiology, informatics)
- clinical rotations (i.e., frontier medicine, global health)
- brief internships/externships (i.e., industry, government)
- procedural training (i.e., needle biopsy, flexible sigmoidoscopy or cystoscopy)
- fellowships (i.e., immunology, palliative care).

Extending this concept, "hybrid residencies" could be creatively designed to enable ROs to crosstrain in medical oncology or nuclear medicine. An example initiative aimed to regain our specialty's foray into theranostic fields was the successful application and approval of a modified track allowing trainees to extend training by 12–18 months and be board-eligible in both radiation oncology and nuclear medicine.

Curricula-driven programs have established objectives and competency criteria. How does one gauge adequacy of acquired knowledge from less formal instruction? What constitutes an acceptable level of exposure to a discipline or technique? The key endpoint is competence to practice in an area not presently covered during routine training. Balancing standardized assessments of acceptable competency with independent instruction and self-regulation will be a challenge, but not insurmountable. Professional responsibility mandates one be able to comprehensively manage the consequences and complications of an activity, procedure or administration prior to undertaking it. Ensuring medico-legal compliance will require input from all relevant stakeholders to establish ground rules within reason and within the law.

Another issue to anticipate will be challenges from other specialists to ROs' attempts at expanding current scope of practice, leading to potential denial of access and limited growth. This need not be a deterrent, as recent history is rife with examples of redefined medical specialty borders. Cardiothoracic surgeons have battled cardiologists over trans-catheter procedures, interventional radiologists have sparred with vascular surgeons over arterial stents, and urologists and neurosurgeons have co-opted a share of our IMRT and radiosurgery cases. Nonetheless, political savvy, compromise and competence will be important to enable more peaceful expansion. Involving other specialties in our training process early and often may help to reduce mistrust and defuse perceived threats that ROs are seeking to practice outside their abilities. To broaden our trainees' horizons – and promote exposure of other specialists to us – elective time could be committed to extra-departmental "modules" at the cancer center/institution rather than department-limited or specialty-focused activities.

It's essential to gain cross-table support for these initiatives and convince our colleagues that ROs can create new frontiers for everyone. "Microinterventions" to educate our primary care and oncology colleagues and promote our visibility at grassroots community initiatives could help improve extra-disciplinary understanding of ROs' roles. Practitioners can enhance visibility and enable hospital-based providers to better understand our expertise by seeing in-patients. An immediate recommendation would be for recent and upcoming graduates to not only contemplate classic positions advertising for ROs, but also jobs requiring broader skill sets not exclusive to our specialty. There are notable job opportunities for practitioners with expertise in palliative care, informatics, global cancer medicine, etc. (Figure 1), but employers and prospective applicants may assume these are intended or best-suited for medical oncologists or primary care specialists. We believe that ROs with appropriately expanded skillsets should proactively consider these positions, which could lead to creation of novel hybrid positions incorporating both the advertised job responsibilities and more conventional radiation oncology practice. As such, we believe there is tremendous opportunity yet to be realized once we re-imagine the scope of work for our specialty.

Ultimately, to establish reliable, flexible, personalized pathways to training in the domains described herein, legal credentialing bodies, relevant professional societies and our non-RO colleagues will all need to engage in the conversation. Furthermore, we as a specialty must initiate and sustain the process of innovation and not wait for others to reinvent our story. We posit that our specialty is at an inflection point; the imperative is on us to determine which direction we are headed.

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Fig. 1.

Expanding the scope of radiation oncology careers. The circles each represent existing careers considered in this paper that are evolving and carry potential for new dimensions. They are a mixture of hybrid positions that can be additive to clinical radiation oncology practice (eg, outcomes and policy), positions that could require additional formal training (eg, epidemiology or palliative care), and full-time opportunities (eg, government service and industry). The number of opportunities per year are estimates based on current experience and ongoing early expansion; creation (ie, new positions that need to be filled) of even 20 full-time equivalents annually (10%–15% of graduates) could have a substantial impact on radiation oncology. Some areas, such as global health, could require many more individuals per year and offer the opportunity for fully or partially retired radiation oncologists to increase years of work, serving as mentors for program building in underserved communities globally and domestically and opening or accelerating opportunities for those earlier in their career.