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Thematic Planning: The Role of the International Atomic Energy Agency in Promoting Education, Medical Research, and Technology Transfer Among Nuclear Medicine Communities of Developing Countries

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One of the major mechanisms of implementing the International Atomic Energy Agency's (IAEA) programs in nuclear medicine has been through coordinated research projects (CRPs). In recent years, the IAEA has initiated a new type of CRP, called Doctoral CRP, in an attempt to further improve the effectiveness of its programs. The structure of the Doctoral CRP has been built on the structure of the existing CRP concept, but with a broader "thematic" approach. The word "thematic" indicates that these CRPs should both have a fairly broad scope and be designed so that their outcome, in terms of practical applications, might readily fit into the selected nuclear applications that are offered to Member States under the IAEA's mechanism for thematic planning. The Nuclear Medicine Section of IAEA's Division of Human Health initiated the first Doctoral CRP of IAEA in the year 2000, entitled, "Management of Liver Cancer Using Radionuclide Methods with Special Emphasis on Trans-Arterial Radio-conjugate Therapy and Internal Dosimetry." Since then, the CRP has accomplished several milestones, including development of a new therapeutic radiopharmaceutical (¹⁸⁸Re lipiodol) and successfully carrying out Phase I and Phase II clinical trials on patients using the new therapeutic radiopharmaceutical.
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When The International Atomic Energy Agency (IAEA) was established in 1957 as an autonomous member of the United Nations family, one of its prominent mandates was to "seek to accelerate and enlarge the contributions of atomic energy to peace, health and prosperity throughout the world." The inclusion of health reflects the important fact that medical uses of radiation and radionuclides were among the first and most widespread applications of "atomic energy." Indeed, in the developed countries, it has been estimated that these applications now contribute, in some measure, to the diagnosis and treatment of one out of every three hospitalized

patients. Of even greater significance perhaps, is the role of ionizing radiation and radioactivity in biomedical research, helping to elucidate the very nature of health and disease.

Although nuclear medicine is considered high-tech, it is also essential for addressing important health problems of people living in developing countries. However, it is capital-intensive and requires considerable technical expertise and thus necessitates transfer of technology from developed to developing countries. The rapid development of nuclear medicine and of sophisticated instrumentation and radiopharmaceuticals has resulted in an enormous increase in costs creating an enormous challenge in promoting nuclear medicine globally and in developing countries in particular. No international organization except the IAEA has any specific mandate for application of nuclear energy in the area of human health. The IAEA, as already mentioned since its inception has given high priority to enhancing the awareness and capabilities of developing Member States in terms of employing nuclear technology for health care and medical research.

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The main objectives of IAEA's programs in nuclear medicine are to develop, evaluate, and disseminate nuclear and related technologies for application in public health programs. To achieve these objectives, the activities of the Agency are directed toward assisting developing Member States in integrating nuclear medicine into their health care systems. The Agency supports the establishment of effective and efficient health care programs in its Member States, using *in vitro*, *in vivo* and molecular radionuclide techniques. The Agency's assistance to Member States encompasses application of nuclear technology in diagnostic, therapeutic and preventive medicine, as well as in biomedical research, education and training and cost-effective supply of state of the art nuclear medicine equipment. Although the emphasis of the Agency originally was on infrastructure development, in recent years there has been a gradual shift toward clinical applications and specific problem-solving thematic projects.

Coordinated Research Project

One of the major mechanisms of implementing the IAEA's programs in nuclear medicine has been through coordinated research projects (CRPs). Most IAEA CRPs in the past have been very successful and indeed many active CRPs at present are effectively addressing relevant health problems of developing countries. More specifically, the purposes of the CRP are to derive new knowledge and better understanding or resolution of scientific and technical problems directly relevant to the attainment of the specific programmatic objectives outlined in the IAEA's program. The CRPs within the Research Contract Program are developed in relation to well-defined research topics on which an appropriate number of institutes are invited to collaborate and represent an effective means of bringing together researchers in both developing and industrialized countries to solve a problem of common interest. Once a CRP is created, research teams from an average of 10 to 12 institutes are normally selected for participation in the program, which lasts 3 to 5 years. Regardless of the field of research, each CRP involves certain common aspects. Institutes in developed countries work in close coordination with those in developing countries and all participants are encouraged to conduct work that will produce new research results and to apply these results to various needs and requirements in their respective countries. Cooperation among institutes is strongly encouraged and supported by Research Coordination Meetings (RCMs), which are financed by the IAEA for CRP participants (contractors and agreement holders) and held at appropriate intervals for each CRP. At these meetings, the progress of the CRP is reviewed in detail and the future direction of work is established. At the final RCM, results are reviewed and evaluated by all participants and, where appropriate, recommendations are made for future work in the field. The results of research supported under the program are shared by all Member States, and are disseminated through national, international and IAEA's scientific and technical publications and other communication media. Where feasible, the knowledge gained is also used to

enhance the quality of projects delivered to Member States through the IAEA's Technical Cooperation Program.

In terms of number of awards and degree of funding, the CRP program constitutes a significant activity within the general program of the IAEA. In the last 10 years the IAEA has financed from its regular budget research activities in Member States totaling several millions of dollars. For example, in 2005 research grants worth U.S. \$387,000 were awarded from the nuclear medicine section's regular budget to institutes in Member States under contractual arrangements and to fund RCMs. At the end of 2005, there were 111 active contractual arrangements (82 research contracts, 23 research agreements and 6 individual projects).

Initiation of a PhD Education Within a New Kind of CRP

Despite the success of previous and currently active CRPs, the IAEA has initiated a new type of CRP in an attempt to further improve the effectiveness of its programs. The IAEA Program Coordination Committee's Subcommittee on Nuclear Applications approved in its meeting of August 25, 1999 that the concept of Thematic or Doctoral CRPs, as proposed by the Division of Human Health, be tested by the IAEA. The purpose of the Doctoral CRP is to further promote research on nuclear technologies in developing Member States through an optional kind of CRP based on a one to one relationship between research agreement holders and a research contract holder and including a PhD or other equivalent advanced degree and training program at the contract holder's institution. This educational component is the main difference between a thematic and a conventional CRP. An Advisory Group Meeting (AGM) was convened from November 27 to December 1, 2000 to discuss and finalize various aspects of the Doctoral CRP concept and to advise the IAEA on their implementation. The particular focus of the meeting was to elaborate the respective roles of Contract Holder Institutions, Agreement Holder Institutions, and the Fellows who would be conducting research with respect to the Doctoral CRP including enhancing his/her educational credentials by acquiring a Doctoral level degree. The representatives of the United Nations University and the United Nations Educational Scientific and Cultural Organization participated in the meeting and provided their inputs to the final document. Several aspects of Doctoral CRP were discussed, including the criteria for identification of Contract Holders, Agreement Holders, and Fellows; working conditions of the Fellow; the role of the IAEA/other relevant UN organizations, the Contract Holder, and the Agreement Holder; the syllabus and curriculum of the PhD education; and the type of agreement with national universities. The Advisory group Meeting appreciated the idea of introducing doctoral education linked to IAEA CRPs because it would enhance the quality and output of research and the human resources in developing countries. The AGM welcomed the new orientation of the CRPs to include a thematic focus, in addition to the existing format. The AGM also recommended that the CRP Fellow

should be a full-time doctoral student dedicated to the project, and hoped that the IAEA would explore the possibility of seeking extra-budgetary funding to enhance the capacity in developing countries. It further recommended that the training of the fellow would be in accordance with the regulations of the University at which the CRP fellow to be registered. The following is an outline to the Thematic or Doctoral CRP concept as defined by the AGM.

Main Framework

The CRP should be implemented within the following framework: (1) There should be an equal number of contract holders and agreement holders (mentors). (2) Each research contract holder (from a developing country) should be partnered with an agreement holder. (3) Each pair should work toward a well-defined scientific sub-goal. (4) Together, these sub-goals form the overall goal or theme of the CRP. (5) The overall goal should address needs of end users in developing Member States. (6) Finally, each pair should support the education of one PhD fellow at the contract holder's institution.

The PhD Education

Preferably, an entire 3- to 5-year PhD program for the fellow should be outlined. The research part of it should be offered at the contract holder's institute in a developing Member State and developed in cooperation between the contract holder and the agreement holder. The PhD program should be accepted by a national university in the contract holder's country. The fellow should be allowed to follow the standard PhD educational curriculum under that University at no cost to the IAEA (but rather as part of the contract holder's country's national commitment).

Expected Outcomes

It is expected that the Doctoral CRPs would produce a substantial contribution to the nuclear technology and knowledge for the theme covered, provide first-class scientific results suitable for publication in international peer-reviewed scientific journals, enhance impact resulting in the adoption of the developed technology, produce well-qualified scientists (PhDs) in the participating developing countries, adding to a sustainable infrastructure in participant Member States and thereby constituting an important element of technology transfer and cooperation.

The definition of the Doctoral CRPs along the same priority lines as the model project concept for Technical Cooperation projects of IAEA should make the applications that emerge from these CRPs particularly strong candidates for later inclusion in the thematic planning of the Department of Technical Cooperation of IAEA, and subsequent adoption of the result in many Member States. It was also anticipated that the Doctoral CRPs would be more expensive and therefore fewer in number than the normal CRPs. But the CRP program as such would be more focused and the quality of research activities co-ordinated by the Department of Nuclear Sciences and Applications would improve.

The Thematic Approach of the Doctoral CRP

The new kind of CRP, the Doctoral CRP, which was recommended by the AGM, has been developed as a response to the strategies outlined above. The structure of the Doctoral CRP has been built on the structure of the existing CRP concept, but with a broader "thematic" approach. The word "thematic" indicates that these CRPs should both have a fairly broad scope and be designed so that their outcome, in terms of practical applications, might readily fit into the selected nuclear applications that are offered to Member States under the IAEA's mechanism for thematic planning.

IAEA's First Doctoral CRP

The Nuclear Medicine Section of IAEA's Division of Human Health initiated the first Doctoral CRP of IAEA in the year 2000, entitled, "Management of Liver Cancer Using Radio-nuclide Methods with Special Emphasis on Trans-Arterial Radio-conjugate Therapy and Internal Dosimetry." Since then, the CRP has accomplished several milestones, formation of Research Pairs, enrolment of PhD students from developing countries, standardization of the labeling procedure of Re-188 (^{188}Re) with lipiodol, establishment of the quality control procedures for ^{188}Re -lipiodol, development of a Re-188 lipiodol internal dosimetry protocol and its successful application in patient-specific dosimetry, assessment of the safety and toxicity of ^{188}Re -lipiodol and assessment of its efficacy in the treatment of hepatocellular carcinoma through a multicenter Phase 2 study. The results of the safety, toxicity and efficacy of the new therapeutic radiopharmaceutical are presented in this special issue of *Seminars in Nuclear Medicine*.