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Original paper

Survey of postgraduate medical physics programmes in the Asia-Oceania region

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ABSTRACT

The increased use of medical imaging and radiation therapies has resulted in a high demand for medical physicists. Although medical physics programmes are well established in advanced countries, the same cannot be said for many low- and medium-income countries. In some countries, there may be huge variations in the graduates' skill and quality, which pose a problem in ensuring patient safety, providing quality assurance in treatments, optimisation of protocols and standardisation of quality. It also makes any yet-to-be-established regional peer recognition efforts problematic. In order to understand the depth of this problem, a survey was carried out as part of the home-based assignment under the RAS 6088 IAEA programme. A large diversity in terms of course content, duration, clinical training and student profile could be observed across the Asia-Oceania universities surveyed. Out of 25 programmes, only six received recognition from professional bodies, and they were mostly in Australia and New Zealand. Hence, to ensure quality education, a regional curriculum model needs to be developed to harmonise standards. And there is still a long way to go towards standardizing medical physics education and clinical training in the region.

1. Introduction

Historically, there is no established professional education or career pathway in medical physics because of the lack of standardised academic programmes and structured clinical training [1]. However, this scenario is changing as the field comes under heightened pressure to establish appropriate standards due to the increased use of radiation and complex techniques in medical imaging and radiation therapies. This has resulted in a high demand for medical physicists, who have obtained relevant qualifications and clinical competency training in one or more sub-specialities [2–5]. Surveys on the medical physics workforce worldwide and within the Asia-Pacific region also reported a growing need for competent and well-trained graduates [6,7]. In advanced countries, medical physics programmes and clinical training have been well established, but the scenario may not be the same in many low- and medium-income (LMI) countries [2,8].

It is said that there is a huge variation in the skills and quality of medical physics graduates produced by universities in different countries. This poses a problem in clinical practice, where they have to ensure patient safety, maintain quality assurance of treatments and optimise procedures for individual patients [8]. Standardising the practise of medical physics is difficult, especially in establishing international peer recognition.

In the last few years, several organisations in Europe and Asia-Pacific have looked into medical physics education, training and specialisation systems [2,7,9]. The International Atomic Energy Agency (IAEA) has initiated several technical cooperation programmes to establish academic courses in medical physics and conduct clinical training among member states [10]. In order to understand the challenges in medical physics education, a survey was conducted as part of the home-based assignment under the RAS 6088 IAEA programme.

Abbreviations: AFOMP, Asia Oceania Federation of Organizations of Medical Physics; ARASIA, Arab states in Asia who are members of the IAEA; ACPSEM, Australasian College of Physical Scientists and Engineers in Medicine; CAMPEP, Commission on Accreditation of Medical Physics Education Programs; EFOMP, European Federation of Organisations for Medical Physics; IAEA, International Atomic Energy Agency; IMPCB, International Medical Physics Certification Board; IOMP, International Organization of Medical Physics; IPEM, Institute of Physics and Engineering in Medicine; TEAP, Training, Education and Assessment Program

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2. Material & Methods:

The survey on postgraduate medical physics programmes was carried out from May to November 2018. The survey form was designed and sent out via email to selected universities in Asia and Oceania countries that offered postgraduate medical physics programmes. We also sent out survey forms to selected Arab countries which were members of IAEA (ARASIA).

The survey covered several aspects, including programme information, infrastructure, staffing, lecturers' qualifications, professional body accreditation, student profile, English language requirement, medical physics modules, methods of delivery and assessment, and clinical training.

3. Results

3.1. Programme demographics

A total of 25 recipients from 14 countries responded to this survey. The respondents represented 24 postgraduate medical physics programmes and one BSc course. This survey excluded doctoral/PhD programmes because they were usually carried out by research, which lacked coursework or a mixed-mode curriculum. Table 1 shows the list of programmes offered by responding universities. Each programme was given a unique ID label. The Vietnam programme (VN1) was an undergraduate course. That programme was unique because the Vietnamese national education policy required every master student to graduate with a bachelor degree of the same course that they were pursuing. In other words, a BSc. in Medical Physics had to be attained before a student could enrol in a postgraduate programme in medical physics. The names of the Master's were listed verbatim as provided in the survey form, hence, they were not standardised (eg. M.Sc. or M.S.).

Australian universities were the earliest in establishing postgraduate medical physics programmes in the region, going back as early as 1975 [AU1]. According to the respondent, the programme began part time in its first year, and transitioned to full time in 1976 [11]. While Indonesia also had a long-established programme [ID2], their's were broadly based on general physics with specialisation in medical applications (often as research groups).

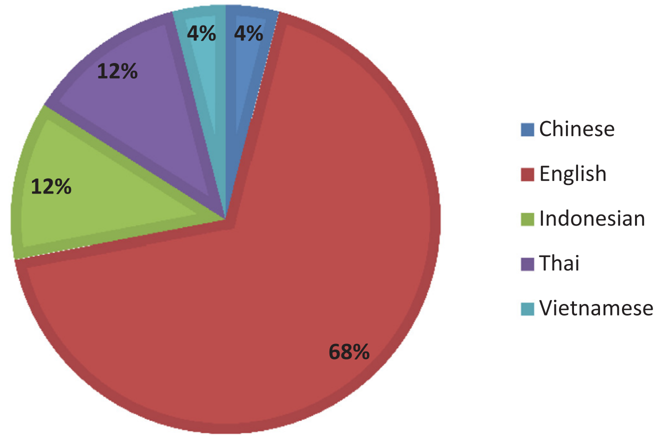

Fig. 1. Language of instruction.

A Thai university, HRH Princess Chulabhorn College of Medical Science [TH2], was the latest to introduce a medical physics programme and the first intake was expected in 2019. The median number of years that a programme had been conducted was 16 (range: 4 to 39 years).

The majority of programmes (76%) were conducted by the respective universities' School of Physics or Science Faculty, whereas only six (24%) were offered under a medical school. Average enrolment per intake was 10 ± 7 students per year (range: 2 to 26 students/ year). The mean number of graduates produced since a programme's establishment was 81 ± 59 (range: 5 to 200 graduates). The average number of graduates produced per year was 6 ± 4 (range: 2 to 12 graduates per year) and 68% of the programmes used English as the medium of instruction (Fig. 1). Thai, Indonesian and Chinese universities conducted their programmes in their respective national language.

Table 1
List of the country and programmes that was involved in this survey.

Country	ID	Programme name	University	Year established
Australia	AU1	M. App. Sc. (Medical Physics)	Queensland University of Technology	1975
	AU2	M. Phil.	University of Adelaide	Not available
	AU3	Graduate Certificate in Medical Physics	University of Adelaide	Not available
	AU4	M.Sc. (Medical Radiation Physics) (Course work 1603)	University of Wollongong	2009
Bangladesh	BD1	M. Sc. in Biomedical Physics and Technology (Specialisation: Medical Physics)	University of Dhaka	2014
	BD2	M.S. in Medical Physics	KhwajaYunus Ali University (KYAU)	2014
	BD3	M.Sc. in Medical Physics and Biomedical Engineering	Gono Bishwabidyalay (University)	2000
China	CH1	Master of Medical Technology (Medical Physics Direction)	Peking University	2017
India	IN1	M.Sc. Medical Physics	The Tamil Nadu Dr. MGR Medical University	2011
Indonesia	ID1	M.Sc. in Physics with specialisation in Medical Physics	Universitas Indonesia	2002
	ID2	M.Sc. in Physics with specialisation in Medical Physics	Bandung Institute of Technology	1979
	ID3	M.Sc. in Physics with specialisation in Medical Physics	Diponegoro University	2011
Jordan	JO1	M Sc. Program in Medical Physics	Jordan University	2007
Malaysia	MY1	Master of Medical Physics	University of Malaya	1998
	MY2	M.Sc. (Medical Physics)	Universiti Sains Malaysia	1995
New Zealand	NZ1	M.Sc. in Medical Physics	The University of Canterbury	2003
Pakistan	PK1	M.S. Medical Physics	Pakistan Institute of Engineering and Applied Sciences (PIEAS))	2001
Philippines	PH1	M.Sc. in Applied Physics, major in Medical Physics (1981 to present); Master in Medical Physics - non thesis option (2004–2016)	University of Santo Tomas	1981
Sri Lanka	LK1	M.Sc. in Medical Physics	University of Colombo	2013
	LK2	M.Sc. in Medical Physics	University of Peradeniya	1996
Syria	SY1	Master of Medical Physics	Damascus University	2013
Thailand	TH1	Medical Physics	Chulalongkorn University	2002
	TH2	M.Sc. Program in Medical Physics	HRH Princess Chulabhorn College of Medical Science	2019
	TH3	M.Sc. Program in Medical Physics	Mahidol University	1990
Vietnam	VN1	B.Sc. in Medical Physics degree	Nguyen Tat Thanh University	2015

Majority of the programmes (68%) were offered as a full-time mode of study. Seven programmes (28%) offered dual modes (full time and part time), while only one offered part-time study. For full-time programmes, more than half of them were conducted in a duration of two years. Only three programmes could be completed within one year [BD1, MY1 and MY2]. The maximum duration for a full-time programme was three years [CH1 and ID1]. In terms of credit hours, the reported figures ranged from 32 to 120 h per programme. However, with different programmes having different methods of calculating their equivalent credit hours, it was difficult to compare them across the board.

All programmes provided their students access to general academic support services, such as libraries, journals, computers, Internet connection and personal support, such as career counselling and networking. Generally, the support services were offered by the respective universities. Additional medical physics-related training and infrastructure, such as access to clinical equipment and facilities in hospital-based programmes, specialty laboratories (medical physics laboratories, quality control kit lab, treatment planning system laboratory, dosimetry laboratory, linear accelerator laboratory, Monte Carlo radiation simulation laboratory), and secondary dosimetry laboratories of additional value were offered where and when available.

3.2. Programme accreditation

Accreditation by professional medical physics organisations helped to ensure a certain standard in the delivery of a university's programme [12]. While all programmes in this study were recognised and accredited by their local education system, only six received recognition from professional bodies as listed in Table 2. The programmes were mostly offered by Australian and New Zealand universities, which were accredited by their local Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM). Only one university had its medical physics programme recognised by an overseas institute, which was the University of Malaya in Malaysia, and the accrediting professional body was the Institute of Physics and Engineering in Medicine (IPEM) based in the United Kingdom [22].

3.3. Staffing qualifications

There were 183 academics involved in the running of all 25 programmes surveyed. Of the total, 159 (87%) had a background in medical physics while 24 (13%) served in adjunct roles (Fig. 2). The adjunct academics mostly comprised clinicians, radiopharmacists and engineers. They were involved in teaching anatomy and physiology, radiopharmacology and instrumentation subjects.

Fig. 3 shows the overall distribution of the academics' position and qualification. Professors made up almost a quarter of the academics (21%), while associate professors made up 11%. The majority (61%) of the academics were senior lecturers, lecturers and medical physicists.

We acknowledged that there were inconsistencies across different countries in terms of academic positions. No attempt was made in this report to standardize this across the different programmes. A fairly high level of qualification was observed among the academics conducting the courses. Sixty-eight per cent of them had a PhD while 24% had a Master's (Fig. 4).

Table 2
Surveyed programmes that received accreditation from professional bodies.

Country	ID	Accreditor	Duration (years)
Australia	AU1	ACPSEM	1.5
	AU2	ACPSEM	2.0
	AU3	ACPSEM	Part time only
	AU4	ACPSEM	2.0
Malaysia	MY1	IPEM	1.0
New Zealand	NZ1	ACPSEM	2.0

Fig. 5 shows the distribution of the academics' position in all the programmes surveyed. Some academics were medical practitioners with a PhD. In these instances, their PhD was also counted in the statistics. Most programmes had at least one clinician involved, making up five per cent of the education workforce.

Fig. 6 shows the distribution of the academics' qualification in each programme. While it was common for educators in a postgraduate programme to have a minimum degree equivalent to the course that he/she is teaching, there were a few programmes that included staff with lower academic qualifications. Upon review, these academic staff were experienced/senior medical physicists and engineers, who were involved in teaching instrumentation. Their contributions were, hence, considered valuable in their programmes.

External examiners played a role in ensuring the quality of a postgraduate programmes from an independent point of view. These examiners were not bound to the university and did not have any particular conflict of interest. However, the appointment of external examiners would be dependent on the provisions of the respective universities since it involved costs and the networking strength of their academics.

Universities with "matured" programmes tended not to invite external examiners compared to those with "younger" courses. This could be seen in Australian and New Zealand universities, where the quality of their programmes was so established that they already had the knowledge and expertise to become a leader in the field.

However, half of the survey respondents said their universities did appoint external examiners. The median number of external examiners appointed was one per year. Some programmes appointed a few external examiners for several years. Hence, it was not surprising for some programmes to have up to five external examiners at any one time.

3.4. Student profile

Entry qualification of students from differing backgrounds were surveyed and shown in Table 3. All programmes enrolled students with physics background (eg. BSc. Physics, Applied Physics, Medical Physics, Radiation Physics). Only 66.7% of the programmes took in students with engineering background (BEng. Electrical & Electronic, Mechanical, Biomedical and Nuclear). Students with computer science (29.2%) and medical backgrounds (16.7%) were also enrolled, but they were a rarity. Around 58.3% of the programmes accepted students from other disciplines, namely health science, radiography and radiotherapy, medical imaging technology, biology and chemistry. Fig. 7 shows the student background in each postgraduate programme.

For the Vietnamese programme, the entry requirements were primarily based on their high school results. Students who had graduated with a bachelor degree in other fields but wished to study medical physics and eventually establish a career in the field would need to study from the beginning and obtain a second bachelor degree.

All programmes had English language requirements for foreign students who wish to enrol, while some allowed an exemption for local students. The minimum level of English language requirement varied between each programme. For some universities, an exemption was allowed if the students' first degree was obtained from a university where English is the medium of instruction. Otherwise, students might be required to pass an English proficiency test at the respective universities. Some programmes allowed students to take English courses provided by the respective universities to improve their command of the English language if the minimum requirement was not met at the point of entry.

MY1 grants an exemption to local candidates on the requirement of scoring a cumulative grade point average of 3.0 and above in their bachelor's degree if they had relevant working experience. CH1 waived the entry requirement for outstanding students who were highly recommended by their supervisors/lecturers from their undergraduate

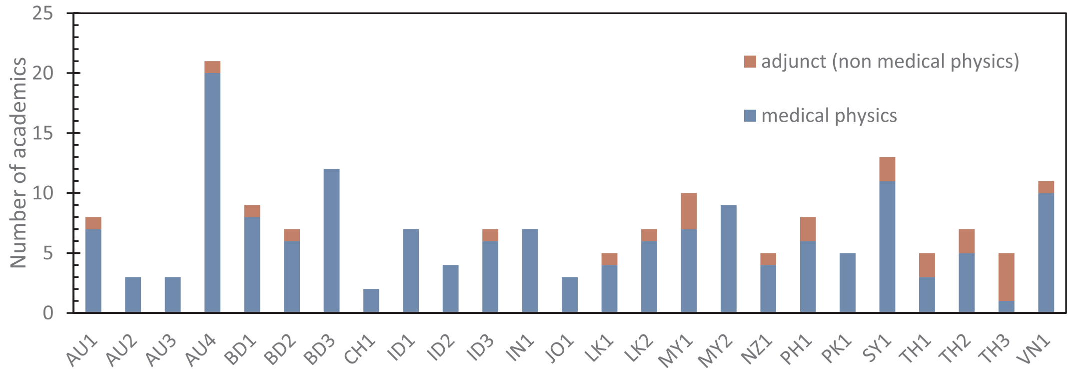

Fig. 2. Number medical physics academics versus adjuncts in each programme.

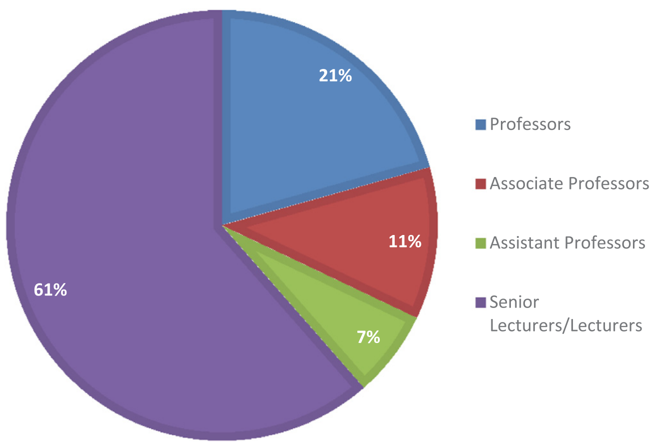

Fig. 3. Distribution of academics' in all programmes.

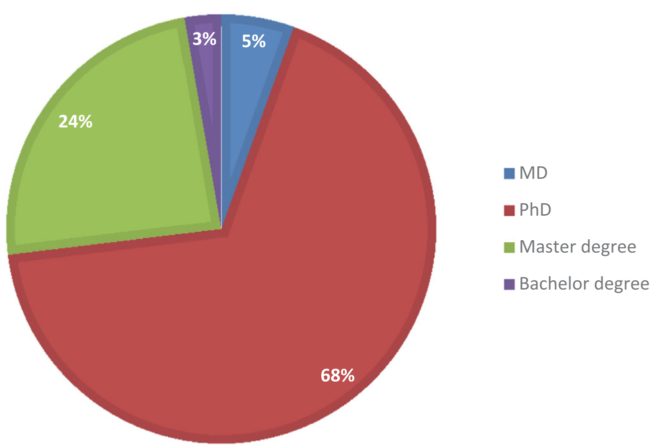

Fig. 4. Distribution of teaching staff qualification in all programmes.

universities. Most other programmes did not have provisions for waiving entry requirements.

3.5. Medical physics modules

Medical physics modules considered here are based on IAEA training course series (TCS 56) report [13].

- Anatomy and Physiology as applied to Medical Physics
- Radiobiology
- Radiation Protection
- Radiation Physics & Dosimetry
- Professional and Scientific Development
- Research Project
- Medical Imaging Fundamentals
- Physics of Radiation Oncology
- Physics of Nuclear Medicine
- Physics of Diagnostic and Interventional Radiology
- Practical sessions

Fig. 8 shows the relative weightage of the medical physics modules within each programme. Since there were variations in the naming of the modules as well as its content, this figure was generated based on the best assumption of the module content reflected by the modules' name. In many cases, two modules might be combined within one course. The credit hours/points for the courses were divided equally between the modules that reflected the content.

Some postgraduate programmes that were largely based on general physics with specialisation in medical physics would have additional modules that included non-medical subjects. These modules were grouped as "OTHERS". They included biophysics, health & occupational physics, modern physics, biomedical/clinical engineering & instrumentation/ research tools, total quality management, physics subjects (Quantum Orbital Theory, Quantum Field Theory, Spectroscopy, Plasma of Laser, Optoelectronics, Advanced Modern Physics, Differential Equation, Electromagnetism, Quantum Mechanics), independent study and public courses.

Table 4 summarizes the various methods for imparting knowledge to students. Most programmes used similar methods. A few programmes featured novel methods of teaching, such as blended learning, taking advantage of pre-recorded lectures and virtual learning experiences.

Assessment methods and weightage varied across different programmes. All programmes applied a mixture of formative and summative assessments in the modules. For example, the most common weightage was 40% continuous assessment and 60% final examination for theoretical modules. The research project assessments were also always divided between written project reports/dissertation and final presentation/viva voce.

Most programmes set the passing mark at 50% or an equivalent cumulative grade point average (CGPA). The highest passing mark was quoted by ID1, with 75% or an equivalent CGPA of 3.0 to 4.0. Before granting of the Master's degree, two programmes [TH2 and TH3] required the student to produce at least one publication.

Plagiarism, defined as the submission of another person's work as one's own and copying of intellectual properties without acknowledgement, was regarded as highly unethical by all programmes. Most programmes required the students to use some form of online checking tool like Turnitin to avoid large-scale plagiarisation of the work of others. Some programmes stated a maximum acceptable level of similarity for a Master's dissertation/research report at $<$ 30%. Additional measures to prevent plagiarism included changing the topics of assignments annually by lecturers. In addition, many programmes also incorporated a research ethics course/seminar to educate students on

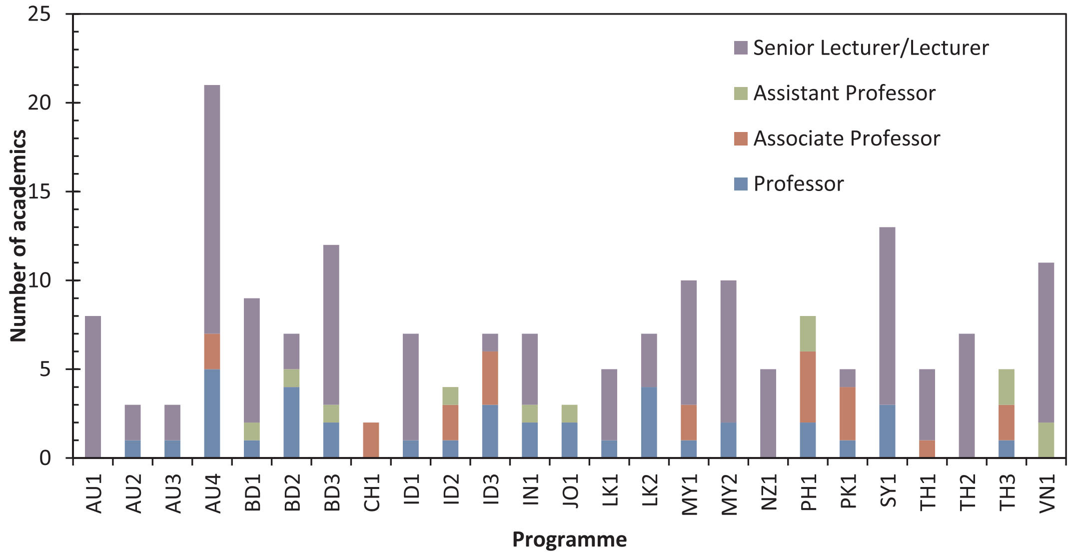

Fig. 5. Number academics and their positions in medical physics programmes offered by various universities.

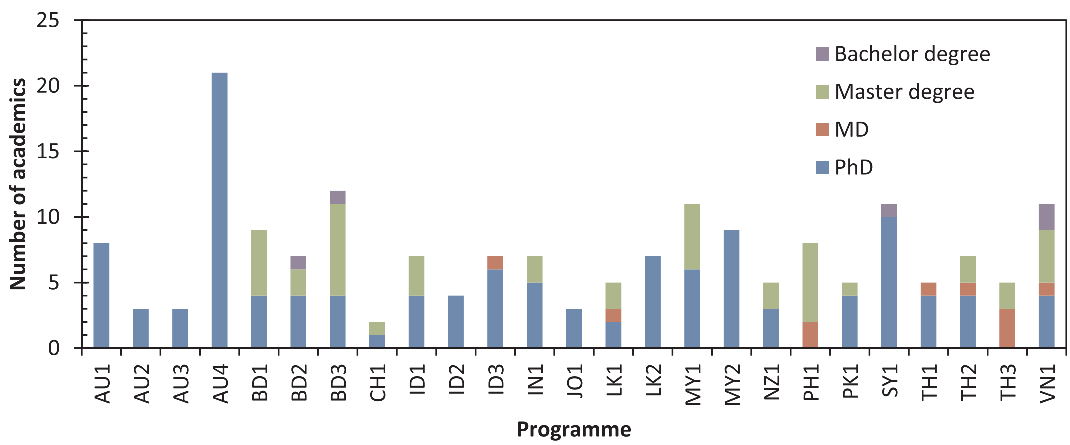

Fig. 6. Teaching staff qualification in medical physics programmes.

Table 3
Academic background of students enrolling in postgraduate medical physics programmes.

Student background	No. of programmes	%
Physical Sciences	24	100.0
Engineering	16	66.7
Computer Science	7	29.2
Medicine	4	16.7
Others	14	58.3

research misconduct, conflicts of interest, and security and protection of personal information.

3.6. Clinical training module

Eight programmes were linked to clinical training modules. Table 5 shows details of the clinical training modules. These programmes required a longer time to complete (two to three years) with the exception of the Vietnamese programme, which would take five years because students had to begin from a basic degree. Nine programmes reported not having a clinical training link and another nine did not provide information on their clinical training links. The faculty/department conducting the programmes appeared to weigh in on clinical training links. Programmes offered by a medical faculty were more likely to incorporate clinical training.

A short note on the competency-based structured clinical training for medical physicists in Australia and New Zealand, which was established about 15 years ago: Their Master's were not directly linked to a clinical training programme, and graduates must complete a training stint at a hospital as a registrar, just like their medical peers. The Training, Education and Assessment Programme (TEAP) in Australia only required a physics degree or equivalent to train as a registrar. However, to graduate from TEAP, an ACPSEM-accredited postgraduate degree in medical physics was highly recommended. ACPSEM would also monitor other postgraduate medical physics degrees, such as a research-based MSc or PhD, and provide them with an equivalent recognition on a case-by-case basis. But the registrars must also complete the core coursework components of the relevant medical physics programme to become a certified medical physics specialist.

The required core modules were well aligned with the recommendations of the IAEA TCS 56 report [13]. MSc graduates would normally take three years to complete their training. Registrars were allowed up to five years to complete their clinical training and obtain their certification. TEAP certification also required a publication in a peer-reviewed journal and conference presentation. These requirements could be fulfilled by registrars during their studies or clinical training.

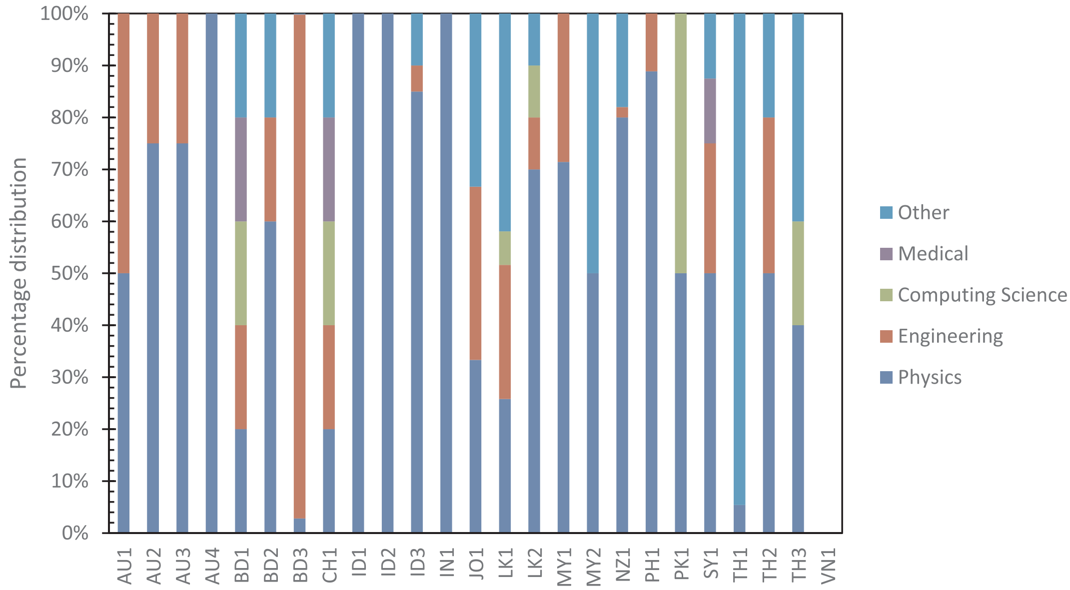

Fig. 7. Background of students enrolled in each university's programme.

4. Discussion

The survey showed a large variability in the curricula and implementation of post-graduate medical physics educational programme across the region. Efforts towards harmonisation of the standards of the programmes could be enhanced by seeking accreditation from professional bodies such as IPEM, ACPSEM, CAMPEP and the International Organization for Medical Physics (IOMP). The International Medical Physics Certification Board (IMPCB) runs a certification programme in accordance with IOMP guidelines. They mainly focused on accreditation of national certification bodies and certify individual medical physicist, which can also be a useful platform

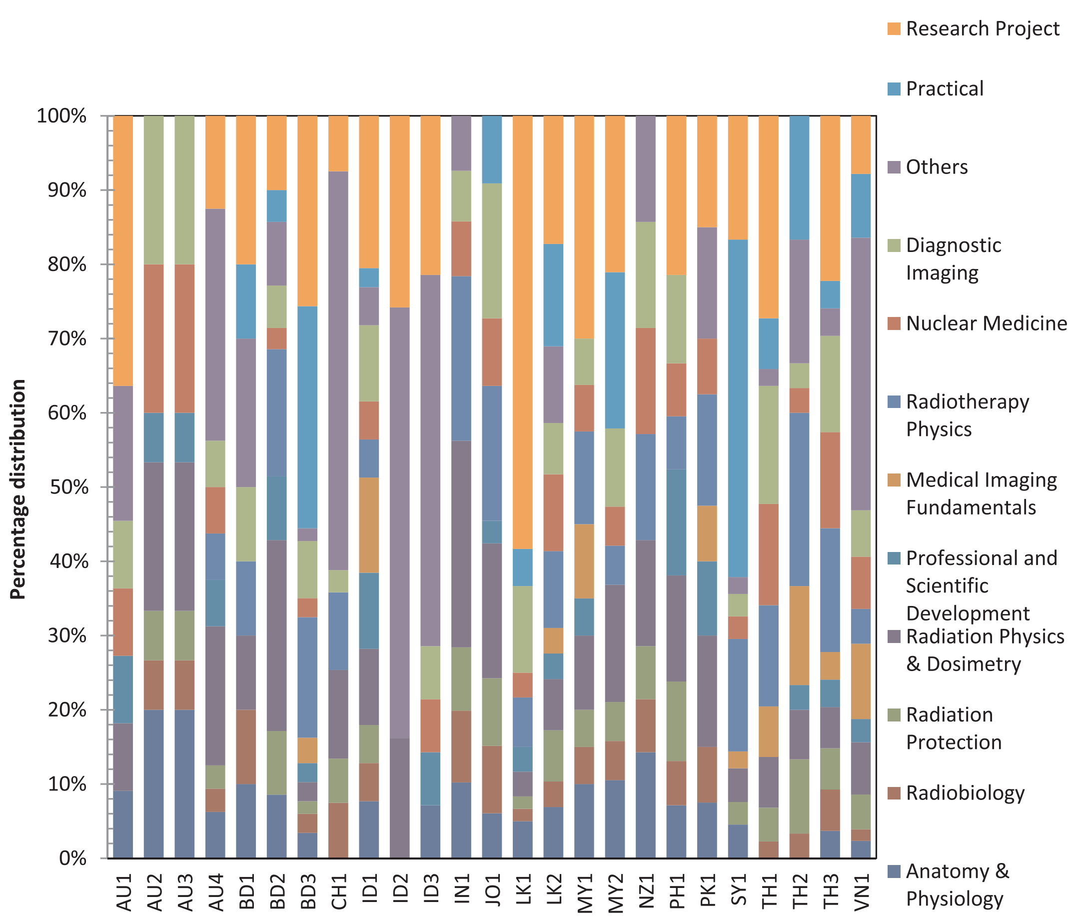

Fig. 8. Relative weightage of the medical physics modules in each programme. However, different programmes may have different names to the module and the module contents may vary. This figure was generated based on the best assumption of the module contents reflected by the module names.

Table 4
Methods for imparting knowledge.

Modules	Example of methods
Theoretical modules	• Face-to-face lectures • Assignments • Tests • Quizzes • Extra online reading materials • IAEA teaching resources • Small group discussions
Practical modules	• Clinical hands-on sessions • Hospital visits • Clinical attachments • Field work • Demonstrations • Case studies
Research projects	• Written reports • Oral presentations • Viva voce • Poster presentations • Periodic meetings with supervisors • Project-based learning • Seminar/conference presentations • Journal publications
Novel methods	• Blended learning • Recorded lectures • Self-directed learning • Guided learning • Immersive virtual reality technology (VERT) radiotherapy simulator • Online videos of clinical practice • Inquiry-based teaching strategy • Collaborative learning

towards achieving harmonisation of medical physics programme and continuous education.

In terms of student profiles, there should also be stricter control of students enrolling in these postgraduate programmes. It was noted that the Australian and New Zealand programmes only admitted students with a basic degree in physics or engineering, while this is not so for the other countries. These students tended to have more exposure to physics and mathematics, which are important knowledge and foundation for better understanding and appreciation of medical physics.

Students with a degree in medicine, biology, chemistry and computing might have some knowledge in either one of the subjects, but they would not have strong foundation in both mathematics and physics. This might affect the students' suitability to enrol in the course and compromise its delivery. As students find it difficult to cope with unfamiliar subjects, the educators might reduce the depth of physics and mathematics in the curriculum to cater to the students' level of understanding, hence affecting the quality of graduates.

In Southeast Asian universities, it was quite common to see students with technologist background, i.e. radiation therapist and radiographers. The prominence of this trend was predominantly due to historical reasons and the local country's regulation, whereby, these two professions had been in existence much earlier than medical physicists.

With respect to course content and syllabus of the postgraduate programmes, it was recommended that they follow the IAEA TCS 56 document as a minimum standard. After that, it would be up to the universities to strengthen their programmes based on their countries' regulation and local industry demand. It is imperative for universities in developing countries to benchmark their postgraduate medical physics programmes with those offered by their counterparts in developed countries. Recommendations as detailed in several publications and policy documents by the Asia Oceania Federation of Organizations of Medical Physics (AFOMP), European Federation of Organisations for Medical Physics (EFOMP) and IAEA could serve as good guides towards harmonisation of medical physics postgraduate programmes in this region [3–5,8,13–20]. The EFOMP policy statement 12.1 in particular,

Table 5
Description of clinical programme linkages.

ID	Modes of clinical training	Requirements	Parallel with /post programme	Duration (months)	System adopted	Areas	Clinical supervisor experience	Assessments
BD3	Internship programme at hospitals with MoU	None	Parallel	6[a]	None	RT, NM, DX & IR	Hospital physicist with MSc in medical physics and had worked for 7 to 8 years in Bangladesh. Also training supervisor of other foreign developed countries under international qualification.	Oral exams, reports
TH1		MSc. (Medical Physics) and working as medical physicist	Parallel	12 to 24	IAEA	RT, NM, DX & IR	2 years' clinical experience	Logbook, oral and written exams, and report required
TH2		Achieve 1st coursework (must pass 80% of all modules)	Parallel	240 h		RT only	PhD or more than 5 years of clinical experience	Log book, oral and written exams, and report
CH1	Hospital based programme		Parallel	18		RT only	Associate professor and above, academic board interviewed	Report
JO1	2 days per week			6				Report
IN1	One-year internship	Pass university examination	Parallel			RT, NM, DX & IR	MSc Medical Physics/MSc DipRp with 3 years' experience	Logbook, oral and written exams, and report required
LK2	Hospital based internship	Part 1 course work exam	Parallel	06–12 months		RT, NM & DR	MSc Medical Physics with 10 years' experience	Logbook, written , report and Oral
VN1	2-year training			24 months		RT, NM, DX & IR		

[a] RT - radiotherapy, NM - nuclear medicine, DX - diagnostic imaging, and IR - interventional radiology.

had laid out a systematic attempt in harmonisation of medical physics education and training across Europe and is a model that is very useful for consideration in the Asia Oceania region [20]. Many of these documents recommended having an appropriate education and qualification framework for medical physicists and providing accredited clinical training in hospitals with continuous professional development programmes [20,21].

There were several limitations in this survey. First, the postgraduate programmes and universities listed in this survey were by no means exhaustive. Only the programmes that responded to this survey and follow-up questions by providing adequate information were included in this study. Second, there was large variation in the respondents' understanding of the questionaire. It would, perhaps, require a more detailed follow-up questionnaire to standardize the response. Each respondent might have a different understanding of what "linkage with a clinical training programme" meant, which could either be a structured component incorporated as part of the postgraduate programme, or as an attachment or posting.

5. Conclusion

A survey was carried out to evaluate postgraduate medical physics programmes in the Asia-Oceania region. Despite the limitations, we feel that this survey is instructive and provides information that is not available elsewhere. There is large diversity across different programmes, particularly in staff qualification, student profile, entry requirements, course modules, duration, clinical exposure and accreditation by national or international bodies. Out of 25 programmes surveyed, only eight provided clinical training and assessment as part of the programme. Even in that, the definition of "clinical training" in medical physics also differed greatly among the respondents. Hence, there is a long way to go towards unifying or harmonising medical physics education and clinical training in this region.

Furthermore, a survey such as this would generate a baseline overview regarding the educational aspects in the Asia-Oceania region (including ARASIA), and that this could lead to the design of more rigorous comprehensive surveys in future. In summary, we have provided a brief overview of post-graduate medical physics education aspects in this region, which will be useful to stakeholders who are interested to initiate, enhance and harmonise their medical physics programmes.

Acknowledgement

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