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MONOGRAPH

Integration of Three Different Medical Research Projects for Medical Students in a Department of Pediatrics

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Abstract
At the Radboud University Nijmegen Medical Centre (RUNMC), all medical students perform one or more scientific studies. The Department of Pediatrics is involved in three different types of research projects: First, the Research Training Internship, which all medical students participate in during their Master program. This 12-week internship is considered an educational or learning activity and comprises general learning objectives as well as specific learning objectives. Second, the Radboud Honors Program Medical Sciences, a supplementary two-year program that gives exceptional Bachelor medical students the opportunity to train in medical research and to perform research at a host institute abroad. Finally, the Excellent Student Program that invites excellent students to participate in research projects in our pediatric clinic over a period of 2-6 years. The main goal of this program is to engage medical students in (clinical) science and translational research.
The three different student research projects have been highly productive over the past three years resulting in multiple scientific manuscripts and presentations as well as PhD applications and personal grants. Students are very positive about the programs. We believe these programs increase enthusiasm for medical research among medical students and challenge outstanding students.

Introduction
Medical specialists have to cope with a continually evolving field of medical knowledge. They must learn to integrate new insights and advanced technologies. One of the important skills required in this process of evaluating new knowledge is a critical attitude towards research methodologies. Furthermore, the medical specialists often lead research themselves. Therefore, medical research projects should be strongly embedded in the medical curriculum.[1] A number of studies have shown that medical student research programs increase interest in research and academic careers.[2-5]

At the Radboud University Nijmegen Medical Centre (RUNMC), all medical students perform one or more scientific studies (Figure 1). This research is performed in different Clinical Departments and Research Institutes. Research activities include: The 12-week Research Training Internship (RTI), which is a required component of the Master program of the medical curriculum; The Radboud Honors Program Medical Sciences (RHPMS), a supplementary 2-year program in the Bachelor's program that focuses at fundamental research and includes a research project abroad; and the Excellent Student Program (ESP) that matches excellent students to clinical investigators for 2 to 6 years. The RHPMS and ESP are also accessible for biomedical students.

Here, we report on the performance over the past three years of three different research programs from the Department of Pediatrics (34 full-time equivalent staff members) of the RUNMC.

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Figure 1. Overview of medical research projects for medical students.

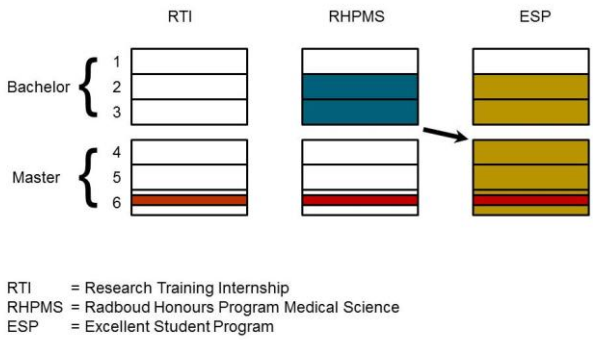

Figure 1. Overview of medical research projects for medical students.
The numbers 1 to 6 account for year 1 to 6 of medical school. The mandatory Research Training Internship (RTI) (red colour) is imbedded in the 6th year of medical school. The Radboud Honors Program Medical Sciences (RHPMS) (blue colour) is a two-year extracurricular program during the 2nd and 3rd year of medical school. The Excellent Student Program (ESP) (Yellow colour) starts in the second year of medical school en can be continued during the Masters'. The arrow indicates the possibility to continue the research activities in the ESP after finishing the RHPMS.

A. Research Training Internship (RTI)

The main objective of the RTI is to enhance the scientific understanding students gained during the Bachelor and Master programs. In the Bachelor program, students are educated in basic research methodology such as biostatistics and clinical epidemiology and are required to create at least one research protocol during this part of their medical curriculum. During the RTI, students expand their theoretical experience by applying their basic research skills in specific and more complex projects. The RTI is considered an educational and learning activity and it is intended as an exercise in performing research, not a test of researcher competences.

The RTI is scheduled deliberately in the final stages of the students' medical education (Figure 1), after completing rotations in various clinical departments. This design allows students to have clinical insight into the value of their research questions and helps to motivate and focus their efforts.

Students can find descriptions or suggestions for RTI projects on the RUNMC website, developed by staff to link with the research interests of the department. Sometimes, the proposals have been fully developed, allowing students to make an immediate start. More commonly, a proposal describes a research theme or research methodology in broad terms relaying on the student and his/her supervisor to formulate a concrete research plan that is feasible within the 12-week period. International internships can be facilitated if the projects are sufficiently integrated into the RTI program (Box 1).

A senior staff member with a PhD qualification supervises the RTI. To maintain a high quality level of RTI, an RTI professionalization course (8 hours) is offered to medical staff involved in supervising RTI projects. The RTIs are imbedded in the Master's program and the Clinical Departments receive financial compensation from RUNMC for each accepted student.

The RTI comprises both general and personal learning objectives. General learning objectives include that the student is able to:

1. Specify the motive for the study, the interests it serves, and the medical and scientific context in which it fits.
2. Design a definitive research proposal using the following skills:
    a. Retrieve, critically appraise, and systematically review relevant literature.
    b. Provide greater precision or depth to the research question based on the literature.
    c. Design a study that fits the definitive research question.
3. Organize and conduct the proposed study.
4. Systematically analyze the generated data.
5. Provide clear descriptions of results with informative summaries documented in tables and figures.
6. Identify limitations and errors in the data collected.
7. Critically reflect on the study design and the results.
8. Produce a written report that conforms to requirements in terms of both content (justification of the study design, clear description, analysis, critical reflection) and form (carefully edited, trim layout, clear language, references).
9. Deliver a concise oral presentation to the department where the study was performed and engage in productive discussion of the research results.

In addition to the general learning objectives, RTIs include specific personal learning objectives relating to the particular type of RTI. Example objects are

composing a questionnaire, learning how to use a pipette, learning how to work with experimental animals or with laboratory samples that have already been collected.

Before starting the RTI, students write a project plan in which they describe the general learning objectives and at least three personal learning objectives. This plan is the first quality control step in the RTI program. It is important that students and their supervisors agree on both the general learning objectives as well as the personal learning objectives. Furthermore, the project plan should include a time line that shows sufficient opportunity for achieving the learning objectives in a 12-week period.

After approval of the project plan, students first enter a two-week Central Clinical Education program. During this clinical education program, students are educated to prepare a Plan of Work. For example, students are taught how to define their main research question, how to choose a proper study design, and how to organize and analyze data. After completing this training course, students are able to conduct their internship following the proposed Plan of Work.

The Plan of Work is the final product of this phase, and is assessed by the course lecturer on a pass-fail basis. In case of a fail, the course coordinator will ask the student to revise his/her plan. Final approval of the Plan of Work is obligatory to continue with the RTI.

In the next phase of the RTI, the research project is implemented and the students are coached and frequently evaluated by the supervisor. After the 12-week program, the RTI is assessed by means of two assessment protocols. The first assessment protocol is used by the daily research supervisor. This protocol distinguishes between assessment of students' overall performance (*process aspects*) and their achievements (*learning outcomes*), i.e. the degree to which they have accomplished the general internship learning objectives. The protocol also records personal learning objectives, which, however, do not contribute towards the final grade.

For the second assessment protocol, an independent second reviewer is asked to assess the RTI report (*product aspects*). If the first assessment is biased through process aspects – for example the project-based collaboration or relationship between students and supervisors – the independent assessment of the written report by a second reviewer may restore that balance. As the written report (*product*) may be considered an account of the students' learning, it may indirectly and implicitly reveal something about the general learning objectives of the internship. This independent second reviewer can assess the report objectively as he/she is unaware of students' and supervisors' day-to-day progress activities throughout the internship. The final grade of the internship is calculated as follows: (the overall performance grade + the general learning objectives grade + 2 x the written report grade) / 4.

Results of RTI at the Department of Pediatrics

From January 2010 to December 2012, more than 500 medical students at the RUN Medical School have successfully completed the RTI. Of these students, 46 participated through the Department of Pediatrics, with a diversity of research topics as shown in Table 1. Seven of these 46 students, performed their RTI abroad (China, Suriname, USA, Germany, Canada), and two students performed their RTI at another Dutch university in collaboration with the RUNMC. All students passed for the internship.

An inventory of the scientific topics shows that the majority of the projects can be classified as applied medical research. These studies provide quantitative evidence on the effect of medical interventions, and on the diagnosis, aetiology and prognosis of disease. The remainder are mechanism studies (how diseases develop) and health care evaluations.

Since 2010, RTI students claimed 5 co-authorships and 2 first authorships. In addition, the RTI has resulted in more than fifteen presentations and posters at national and international congresses.

B. Radboud Honors Program Medical Sciences (RHPMS)

The RHPMS is a supplementary two-year program that gives Bachelor students in biomedical sciences and dentistry the opportunity to get acquainted with and be actively involved in medical research. In their first Bachelor year, students with the best grades (top 25%) are invited to apply. They are then selected on the basis of their grades, motivation and enthusiasm for research, and also, of course, on their ability to handle 10 hours of extracurricular study a week. The RHPMS is financially supported by the RUN.

The students start with an English Proficiency Course in which they are taught scientific writing and presentation skills. After this course, they are introduced to the six different research institutes

associated with the RUN, through lectures, clinical visits and hands-on laboratory experiences. After this introduction the students start their own research project at one of the six research institutes, assigned to a principal investigator. In this phase, students are able to do their first scientific experiments under the guidance of well-established and skilled scientists. There they are trained and prepared for their internship at a research institute abroad where they will conduct their own research for at least three months on a full-time base. After the RHPMS, students are encouraged to continue their research work in the ESP (see Figure 1).

Results of RHPMS at the Department of Pediatrics

The RHPMS program started in 2009. Every year around 25 students are selected, so far, two groups have finished the RHPMS (inception cohorts 2009 and 2010). Of these two groups, ten students (seven medical students and three biomedical sciences students) were assigned to a principle investigator from our Department of Pediatrics. This department is affiliated with several RUN research institutes e.g. the Institute for Genetic and Metabolic Diseases (IGMD), the Research Institute for Oncology (RIO) and the Nijmegen Institute for Infection and Inflammation (N4i). For an overview of the Honors projects initiated by the Department of Pediatrics, see Table 2.

The internships abroad were mostly arranged by the staff members of our pediatric department. In a few cases however, the students were able to secure an internship themselves. The research abroad took place all over the globe (Table 2).

Of the 10 RHPMS students in our department, two have published at least one article so far, and two students have been accepted to a highly competitive, selective master (Molecular Mechanisms of Disease at the RUN and a Research Master at the University of Maastricht, the Netherlands).

C. Excellent Student Program (ESP)

The ESP is linked to the RUNMC research Institute for Inherited Genetic and Metabolic Diseases (IGMD), but also non-IGMD projects can be qualified for the ESP. The program is not funded. The main goal of the ESP is to involve medical students into science and to give them the opportunity to perform translational research. The ESP is usually more clinically orientated as compared to the RHPMS. The student's responsibilities include 20 hours a month of research time in addition to the regular study activities.

In contrast to the RHPMS program, the application procedure is open to all (bio)medical students rather than only to top students in class. Other factors, like motivation, as well as social and organizational skills, contribute to the excellent student profile. In addition, ESP is a longitudinal program that continues into the Master program. (Junior) principal investigators or (junior) principal lecturers can sign up for the ESP by writing a project proposal. Students can rank their preferences for a specific topic or mentor and then, mentors and students are matched by using a series of brief interviews.

Coaching of the students plays a central role in the ESP and implies not only training in how to perform medical research and presentation skills, but also career guidance and coaching in professional attitude and behavior. The learning objectives and goals are individually determined and regularly evaluated.

Once a year, the students present their work at the ESP symposium. All students are required to write an abstract for an oral or poster presentation at the symposium. This enables them to practice their presentation skills and become familiar with scientific meetings.

Results of ESP at the Department of Pediatrics

Since the start of the program in 2010, 55 students were participated through our Department of Pediatrics. Seven students (12.7%) quit the program prematurely, mostly because of the high workload. So far, sixteen of the remaining 48 students finished their medical school and therefore discontinued the program. Currently, 32 students are participating in the ESP. Nineteen of these students are linked to an IGMD-project, four students to the N4i and one to the RIO. The other students are working with more clinically orientated medical specialists.

Thirteen of the 48 students from the ESP have published 34 peer-reviewed papers. They were first authors on 22 publications and co-author 32 times. Four students presented their work at international conferences and four students received a personal research grant. One student received a national prize for most talented medical student in biomedical research. Five ESP students (9%) continued their ESP research as a PhD student.

Discussion

Education in scientific skills and competences is essential for the medical curriculum since all medical specialists should be able to interpret and critically evaluate medical research. For an optimal understanding of the process of medical research, education needs to be focused on both theoretical knowledge and practical experience.[1] Besides the theoretical goals of medical research projects for medical students, an important aim of these projects should be to give the medical students a positive experience performing research. This may be even more important as there is a global need to increase recruitment of young clinical academic researchers.[6] In the United Kingdom clinical academics make up only 6% of the medical workforce and this number is falling. Similar trends are documented in the United States an other countries of Europe.[7,8] For this reason Lawson McLean et al. identified 12 tips to encourage student engagement in academic aspects of medicine and foster participation in research during their undergraduate training period.6 These 12 tips are based on an extensive review of the international literature and their personal experience of students' research-related activities.

At the RUN, we offer students a very broad scientific research program that includes basic research training (RTI) for all students as well as advanced, long-term research programs for exceptional students (RHPMS and ESP). The embedding of a RTI into the Master program of the medical curriculum encourages students to choose a project of their specific interest and facilitates valuation of the research project in its context. A structured preparation phase, before the actual start of the research internship, enables students to perform the research project more fluently, which prevents frustration and drop-out.

In contrast to the universal RTIs, that usually concern applied medical research projects, the RHPMS is focused on fundamental research, that is imbedded in the RUN research institutes. The RHPMS includes a well-structured selective research education program that forms a solid base for a further career in medical science. The opportunity to conduct their own research at an internationally renowned university develops students' English language as well as provides experience in medical research in an international setting. Individual coaching during the RHPMS ends with Bachelor completion. Therefore, students are encouraged to continue their scientific career by participating in the ESP.

In contrast to the RHPMS, the ESP is a long-term individual coaching project for outstanding students. By means of a teacher-companion relationship, students are mentored regarding careers, professional behavior and medical research. This approach has been advocated by others as well.[9] The research projects of the ESP overlap with the RHPMS, but the topics are less fixed and generally more clinical in focus.

Our approach to research activities in medical school training is unique since it includes mandatory as well as elective and extracurricular programs. The programs generally cover eleven of the twelve tips for teachers to enhance medical student exposure to research at medical school.[6] The only tip not incorporated in these programs includes promotion of teaching initiatives and developing teaching skills.[6] Implementation of this training could further improve the students' academic skills and thus be a valuable contribution to our programs.

The output of the different research programs at our clinic is high as measured by the number of peer-reviewed papers, presentations at (inter)national congresses, PhD applications and personal grants. More importantly, the evaluation of the students is overwhelmingly positive. In general, students develop a more realistic and positive view of medical research and academically outstanding students feel more challenged, appreciated and mentored. So far, we do not have quantitative information about the student evaluation of the programs, but we are prospectively collecting these data.

In conclusion, we believe that our programs increase the enthusiasm for scientific work in medical students and foster their critical evaluation of medical research. For the excellent students, our goal is to encourage them to continue to pursue medical research throughout their professional careers.

Keywords
Research training, (Bio)medical students, excellent student program

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References
1. Report of the AAMC-HHMI committee. Scientific foundations for future physicians. Association of American Medical Colleges; 2009.
2. Solomon SS, Tom SC, Pichert J, Wasserman D, Powers AC. Impact of medical student research in the development of physician-scientists. *J Investig Med*. 2003: 51(3): 149-156.
3. Brancati FL, Mead LA, Levine DM, Martin D, Margolis S, Klag MJ. Early predictors of career achievement in academic medicine. *J Am Med Assoc*. 1992; 267: 1372-1376.
4. Dyrbye LN, Davidson LW, Cook DA. Publications and presentations resulting from required research by students at Mayo medical school, 1976-2003. *Acad Med*. 2008; 83 (6): 604-610.
5. Reinders JJ, Thomas JB, Kropmans JB, Cohen-Schotanus J. Extracurricular research experience of medical students and their scientific output after graduation. *Med Educ*. 2005; 39: 237.
6. Lawson McLean A, Saunders C, Palani Velu P, Iredale J, Hor, K, Russell, CD. Twelve tips for teachers to encourage student engagement in academic medicine. *Med Teach*. 2013; 1-6.
7. Ley TJ, rosenberg LE. The physician-scientist career pipe-line in 2005: Build it, and they will come. *JAMA* 2005; 294:1343-51.
8. Sheridan DJ. Reversing the decline of academic medicine in Europe. *Lancet* 2006; 367:1698-1701.
9. Van Bodegom D, Hafkamp M, Westendorp RGJ. Using the Master-apprentice relationship when teaching medical students academic skills: the Young excellence class. *Med Sci Educ*. 2013; 23 (1S): 80-83.

APPENDIX

Box 1. Case report medical student.

May 2009. David is an 18-year old, enthusiastic medical student who would like to become a pediatrician but also has research ambitions. After the first year of medical school, he was selected for the Radboud Honors Program Medical Sciences (RHPMS). Following the introduction at the Research Institute of Genetic and Metabolic Diseases he decided to do his internship on the subject of Cutis Laxa Syndrome ('old skin'). For the internship abroad, he worked with the Charité University of Berlin, Germany where he was invited to continue his research for an additional three months for his master Research Training Internship (RTI). His supervisors were very satisfied with the results and rewarded him with the highest credits. After having finished his RHPMS and RTI, David returned to the Netherlands where he continued his Master program and his research work into Cutis Laxa Syndrome. He continued in the Excellent Student Program. At this moment, David has co-published 4 peer-reviewed articles and wrote 1 paper as first author.*

**the name David is a pseudonym*

Topic	**Number of RTI students**
General Pediatrics	6
Endocrinology	3
Metabolic Diseases	7
Gastroenterology	2
Infectious Diseases	4
Intensive Care Medicine	1
Pulmonology	5
Oncology	6
Nephrology	6
Neonatology	4
Pediatric Surgery	2
Total	**46**

Table 1: *Research Teaching Internship (RTI) in the Department of Pediatrics: Cohort January 2010 - December 2012*

Research institute	Project	International internship
Cohort 2009		
IGMD	Clinical presentation and molecular-genetic aspects of patients with one heterozygous POLG mutation	Institute of Genetic Medicine , Newcastle, UK
N4i	Pneumococcal infections: a new approach?	University of Sienna, Sienna, Italy
IGMD	Investigations into the localization of PYCR1	Charité Univeristy Hospital Berlin, Germany
RIO	Investigating the role of Evi1 in murine Acute Myeloid Leukemia (AML)	Pediatric Oncology Lab, USFC San, Francisco, USA
N4i	Attachment and Entry Receptors for Influenza A Viruses	University of Melbourne Melbourne, Australia
Cohort 2010		
RIO	Mechanisms of action of GATA1s in Down syndrome leukaemia	Institute of Molecular Medicine Oxford, UK
IGMD	The role of ATAD3-B in mitochondrial DNA metabolism	Mitochondrial Biology Unit Cambridge, UK
N4i	Detection of membrane damage and implication for autophagy induction	Lab. of Medicine and Pathology, Toronto, Canada
N4i	In search of novel antibiotics against resistant bacteria	Baltimore School of Medicine Maryland, USA
RIO	A novel subgroup in B-cell precursor acute lymphoblastic leukaemia	North. Inst. for Cancer Research, Newcastle University, UK

Table 2*: Honors projects in the Radboud Honors Program Medical Sciences for the Department of Pediatrics: Cohort 2009 and 2010 Institute for Genetic and Metabolic Diseases (IGMD), the Research Institute for Oncology (RIO) and the Nijmegen Institute for Infection and Inflammation (N4i).*