



Developing education in environmental health and medicine focusing on neurology: Initiatives in Sweden (the UPRISE model), France, and Turkey

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ABSTRACT

Background: The role of environmental factors in neurological disorders constitutes a topic of increasing importance. Teaching in European universities should expand and update this field gaining future health professionals including adjacent disciplines.

Aim: To describe recent efforts to create courses that cover crucial interdisciplinary content that we believe should be included in modern education, and to adapt modern pedagogic strategies.

Methods: In collaboration with RISE (Rencontres Internationales Santé Environnement), elective courses focused on Environmental Health and Medicine (EHM) were developed, in France, Sweden, and Turkey. The courses combined classic teaching methods and new pedagogic and digital solutions to create environment-related health awareness and facilitate future interprofessional collaboration in this field.

Results: UPRISE is an innovative elective course introduced in 2020 in Sweden's Uppsala University with the participation of lecturers from several countries and aim to recruit students from different universities. A total of 45, mainly female students (68%), participated in the course. In Strasbourg, France, a novel course on environmental medicine was held in 2019–2023 and examined 90 students, of which more than half were female. Nine graduate nurse students in Turkey attended ten seminar series focused on EHM. Overall, students expressed satisfaction with the courses.

Conclusions: This European project for courses in higher education arising from RISE was met with appreciation and challenges from academic institutions.

However, due to considerable efforts to introduce the EHM concept, a unique compulsory course for all medical students in the second year of training started in 2023 in all French medical faculties. In 2023, UPRISE was integrated into ENLIGHT, the European University Network to promote equitable quality of Life, sustainability, and Global engagement through Higher education Transformation.

1. Introduction

The scope of environmental medicine/neurology is always challenging to define. While our student audience is European/

Scandinavian, the subject is global in that environmental risks for low- and middle-income country (LMIC) populations may be greatest. Many investigators seek to separate the indoor and outdoor environment. Infectious agents constitute huge environmental human health threats.

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The key variable of nutritional state in determining the human response to environmental factors is often ignored. External heat is often over-emphasized over cold; light and darkness are commonly forgotten. Many, perhaps most, focus on manmade chemicals while minimizing key roles of botanical and other substances of natural origin linked to outbreaks of neurological disease. Chemicals such as carbon monoxide, nitric oxide, and hydrogen sulfide are often labeled neurotoxins when, in fact, this property is a dose-dependent phenomenon illustrated by the physiological use of very low concentrations of these substances as normal endogenous gaseous neurotransmitters. The plethora of medicines with neurotoxic potential (e.g. cancer chemotherapeutics) is often thought to be outside the subject of environmental medicine, and substance abuse may also be omitted yet both are major external causes of neurological disease. Warfare chemicals and ionizing radiation are rarely considered. Proposed environment-gene interactions in the etiology of especially neurodegenerative disease is a favorite topic of some, but sparse evidence is presently at hand to support the hypothesis. The contributions to neurologic disease of the gut microbiome – strictly part of the exterior environment of *Homo sapiens* – is gaining considerable interest among those studying the etiology of neurodegenerative disorders.

Reconnecting with Hippocratic concepts, Environmental Health and Medicine (EHM) re-emerged in the past century in response to increasing concerns regarding ecological awareness, environmental crises and disasters, global diffuse pollution, and these days climate change. Among the promoters and forerunners of environmental health was the important role of Rene Dubos (1901–1982), who considered human health related to the environment and emphasized the importance of the environment in disease occurrence [1]. He also co-authored with Barbara Ward the book famously titled “Only One Earth”, which served for the 1972 UN Conference on the Human Environment in Stockholm [2].

The historical role of institutional bodies, such as the 1989 meeting in Frankfurt-am-Main (Germany) that introduced the concept of environmental health to public policymakers, culminated in the adoption of the European Charter on Environment and Health [3] <https://iris.who.int/bitstream/handle/10665/347390/WHO-EURO-1989-3845-43604-61265-eng.pdf?>. The inception of environmental medicine stems from the description of Multiple Chemical Sensitivity syndrome, as presented by the pioneer Theron Randolph, an American allergologist. Randolph contributed to the establishment of the American Academy of Environmental Medicine in 1965 [4]. www.aemonline.org/about-us/. Publication in 1980 of a textbook on experimental and clinical neurotoxicology in the USA formalized this aspect of environmental neurology, with a later edition translated into Chinese and Russian languages [5]. In France, the concept of “Medicine of the Environment” was introduced in 1996 by professor Jean-François Mattéi in his report to the National Assembly [6] www.senat.fr/rap/r95-245-1/r95-245-11.pdf

This evolution helped to gain new visibility for EHM, which split from the disciplines of Environmental and Occupational Medicine and Public Health, although close relations and overlaps persist.

In 2007, two pivotal events launched the concept of Environmental Neurology (EN). These events were the World Federation of Neurology (WFN) agreement for the creation of the Environmental Neurology Research Group (ENRG) and the issue of the first article dedicated to EN [7]. Recently, we sought to define the discipline of Environmental Neurology, exemplifying Environmental Medicine, the scope of which serves our education programs [8].

Despite its status as a newly emerging discipline, EHM has only been included by medical faculties in a few academic courses for students in the medico-scientific community, and some countries lack such education, whatever the definition and scope of EHM [9–11].

In this article, we present our experiences with courses provided by the Department of Neurology of Uppsala University (Sweden), the Faculty of Medicine in Strasbourg (France), and lectures organized in

Turkey at the Istanbul University – Cerrahpasa, Florence Nightingale Faculty of Nursing.

2. History of UPRISE in Uppsala

The intersection of environmental health factors and medicine is complex and requires a multidisciplinary approach. Despite its importance, this junction remains largely unaddressed within existing health-related educational programs. An unpublished survey of students' opinions regarding their current education revealed a demand for courses covering this topic.

In response to this gap, we took the initiative to start an elective course - UPRISE. The name of the course refers to its location (Uppsala) and the RISE meetings held in Strasbourg since 2016 as part of the initiative of the French RISE Association [8]. The French acronym RISE stands for Rencontres Internationales Santé Environnement, addressing holistically environmental health and medical issues, including environmental changes (e.g., local or planetary), their impacts on the milieu (e.g., air, water), diseases related to chemical exposures, and intoxications.

Further insights were provided due to long-term involvement in WFN-ENRG and the optional teaching course launched in 2009 by the Faculty of Medicine in Strasbourg (France) [9,12,13].

In 2016 we initiated a lecture on *environmental factors in neurological disorders* in the 8th semester of medical school, covering central topics to understand basic science and medicine. Initially conducted as a one-hour lecture in English, it was later translated into Swedish and integrated into the curriculum, even as a video session (AT), offered to all medical programs nationwide. After a long period of preparation, involving the head and lecturers of the Neuroscience Department, the UPRISE course was launched at Uppsala University in 2020. The course was dedicated to general environmental medicine encompassing toxicology and endocrine disruptors, with a specific focus on neurology. Historically, the Department of Occupational and Environmental Medicine of Uppsala University had organized an elective course with similar content, which was incorporated into UPRISE.

3. Description of the UPRISE course

UPRISE, a 7.5-credit, 5-week-long course was given by the Department of Medical Sciences of Uppsala University between 2020 and 2021.

The Course established a teaching network at Uppsala University with guest lectures from other universities in Sweden, Norway, Russia, the USA, France, and Turkey. Lectures were given in English.

4. The aim of the course

The Course sought to provide basic information on all the factors that produce environment-associated health risks to the nervous system, together with possibilities/instruments to mitigate the risks in an interdisciplinary and multi-professional manner. One of the primary objectives was to develop transdisciplinary and interprofessional collaboration in a global and environmentally mediated context for the subject of neurology and to describe environmental factors that are essential for brain health both in low- and high-income populations. Another goal was to describe differences in global resources, the significance of poverty, and its current prevalence, including the impact of this in our local care, and identify environmental hazards affecting the nervous system including specific biological mechanisms in human and animal models. The subject of malnutrition was addressed, particularly undernutrition as a major risk factor for chemical-induced neurological disorders in low- and middle-income countries. Additionally, the Course aimed to describe the risks of short-term/delayed effects of modern warfare (psychological, nuclear, and chemical) and climate change from a medical perspective, and the principles of medical prioritization in major accidents affecting infrastructure. Lastly, the course aimed to give

examples of the implementation of the Course objectives in the form of local initiatives for sustainable development. The compulsory course literature included a couple of books and various articles [14–18].

4.1. Pedagogic strategy

To provide an optimal education on environmental health factors, we found it beneficial to combine students from different educational backgrounds with unique perspectives, as well as guest lecturers from various fields. The central pedagogic method was *problem-based learning* (PBL), designed to encourage students to pursue independent knowledge-seeking [19,20]. The students were given individual topics to research, which were later discussed in seminars culminating in final presentations on the last day. This followed a flipped-classroom model where students took responsibility for conducting the lectures. “Flipping the classroom”, a new pedagogical strategy means that the focus in education is switched from teacher-centered learning to learning-centered instructional strategies. Students are provided with key functional content prior to class that they need to prepare for in-class activities, called self-regulated learning. Different learning modalities such as commercial textbooks, videos or powerpoint presentations can be used to effectively learn the material and contents. Once the pre-class knowledge and concepts are acquired, students extend their learning during in-class activities by transition of simple concepts and ideas to critically and more complex ones to problem-solving. The role of teachers is to provide feedback to and answering or correcting questions raised by students. After-class work is focused on reinforcing the prior learning. The optimal goal of the flipped classroom is to introduce higher order thinking in students, to improve communication skills, and teamwork [21,22].

Another resource-efficient, student-centered teaching pedagogy that inspired the teaching was Team-Based Learning (TBL). Four key components of TBL include carefully formed and managed teams, frequent and timely feedback, problem-solving, and student peer evaluation [23]. UPRISE included an in-depth project based on the themes of the Course, and these were handled according to TBL in multi-professional groups. The work was based on 3 steps:

1. Preparation phase - based on defined material, students usually prepared themselves individually, e.g., by reading, or watching informative videos.
2. Readiness assurance – students grouped in teams and, under the guidance of the lecturer, carried out step by step a) individual test, b) group discussion, and c) team test.
3. Application phase – each team carried out application exercises covering key concepts in the field [24].

Depending on the scope of a study topic, the three steps could be extended e.g., over a week. Active Student Participation (ASP), a highlighted approach at Uppsala University, was encouraged during the entire Course [25].

4.2. Digital interface

The launch of UPRISE coincided with the COVID-19 Pandemic in 2020, necessitating the entire course to be conducted virtually via ZOOM. Consequently, this allowed students outside Uppsala to join the Course. The technological methods of digital teaching proved invaluable during the Pandemic, allowing for the geographical spread of the Course. Given the likelihood of future pandemics, there is a growing necessity for a long-term transition to digital learning formats, ensuring that there is always a digital equivalent for course elements to be taught and examined. In the case of UPRISE, a digitized form was very appropriate because the course content concerned environmental effects on neurological health with contributions from several international lecturers (Denmark, USA, Russia until 2021, France, Norway, and Turkey)

who could deliver the teaching without the need to travel to Uppsala. Other than ZOOM, the methods were digital platforms including streaming with the possibility for interaction, pre-recorded material (collaboration with the pedagogical IT hub *MedFarm DoIT*), and a flipped classroom in addition to pedagogical elements such as inventory with digital interactive tools, evaluation with feedback through chat or mail, and formative examination through the mail.

To further develop the digital pedagogics, a new form of visualized interaction was developed. Uppsala University’s Department of Game Design contributed specially designed software, *Gather Town* <https://game.speldesign.uu.se>, which allows the teacher and students to communicate, receive lectures and engage in social interaction on this digital platform.

The examination consisted of a written exam with mandatory participation on ZOOM, where the students were expected to have their cameras on. The final written exam was a 50:50 mixture of Multiple-Choice Questions (MCQ) and Modified Essay Questions (MEQ). During the exam, the students had the course material at their disposal, with the explicit aim that the examination was an additional form of learning. To pass the Course, a score $\leq 67\%$ on the final written exam was required.

In 2020, representatives from UPRISE took part in the meetings of ENLIGHT (enlight-eu.org), a European university Network to promote equitable quality of sustainability, global engagement through higher education and society projects, and to interact with groups interested in health and the environment.

5. Required skills achieved after completing the Course

The students were tasked with carrying out risk assessments and using decision models for environmental impacts on organisms define, calculating relative risks (RRs) of environmental factors in a four-field table, and describing relevant laboratory methods included in the course.

Furthermore, the course aimed to foster the development of (including one’s own) medical care and diagnostics to include aspects of global health and environmental impact, describing the influence of ethical and political issues in different social systems, and identifying economic drivers of risks and positive developments in modern society from a global perspective.

The emphasis was on the goal of primary prevention of neurological disease by identifying etiological environmental factors and ending/controlling their potential for human exposure. For example, we highlighted the effect of air pollution on the risk of stroke, water pollution resulting from waste from pharmaceutical and textile industries in developing countries, traces of sedatives and antidepressants in drinking water as well as in fish, *Pandemrix* influenza vaccination-associated risk of narcolepsy in children and adolescents.

6. Results

6.1. University of Uppsala

The first edition of UPRISE – the role of environmental factors in neurological health was held for three consecutive semesters between the fall of 2020 and 2021. During the three semesters of UPRISE in its original form, there was a total of 34 examined students. Participants came from diverse academic backgrounds including: medicine, nursing, pharmaceutical science, physiotherapy, and biomedicine. The percentage of foreign students varied. Overall, female students greatly outnumbered male participants (Table 1).

6.2. The thematic contents and concepts of the Course (Table 2)

- 1.) Social medicine and epidemiology (Introductory week together with Global Health in the medical program)

Table 1

The number and background of students attending the UPRISE courses during 2020–2021 in Uppsala.

Participants	Fall 2020	Spring 2021	Fall 2021	Total
No of students	14	18	13	45
Female/ Male	7/7	17/1	7/6	31/ 14
Medical students	6	6	6	26
Others	Nurse (1) Toxicologist (1) Neurologist (1) Oncologist (1) Psychologist (1) Medical Sciences (1) Physician (1) Physiotherapist (1)	Nurse (2) Physiotherapist (1) Pharmacist (1) Biology (2) Unknown (5)	Pharmaceutical (4) Physiotherapist (1) Global Health (1) PhD student in Neuroscience (1)	
Foreign students	The Azores (1)	Finland (2) Italy (1)	England (1) Greece (1) Netherlands (2) Portugal (1)	

Table 2

The course schedule is divided into five main areas (1/week).

1st week	Introduction			
Introduction Environment and Neurological Health Pollution from the textile industry (video) Introduction, Global Health	Methods of research, Group tasks for the students: Pregnancy/ environmental factors in neurodegenerative diseases (Four- fold tabl, Gather Town) Sustainable development- flipped classroom	What is the environment? The entity of disease historically: Psychogenic/somatic Environmental toxicology I The demographic and Epidemiologic transition	Introduction Occupational medicine Climate change, Physicians for the environment	Environmental toxicology II Exposures, principle of caution Risks in occupational medicine Exposures, metals, radiation Supervision Group task
2nd week	Exposures and effects Water Water pollution: PFASs Pharmaceuticals Wastewater-based epidemiology to assess human health Wastewater pollutants Visit to Vattenrenningsverket	Environmental chemicals, neurodevelopment, and Epigenetics Endocrine disruptors Neurotoxicology <i>Time for study/Flipped classroom</i>	EPIGENETICS, Fly lab Experimental models within pollutant research, <i>flipped class room</i> Fly lab	COVID-19 COVID-19 Pandemics, historical perspective The Corona pandemics (Neurological aspects on Corona (Uppsala case, vaccinations) Discussion <i>Time for study/Flipped classroom</i>
3rd week	Clinical Applications Risk patterns in chronic neurologic disease: MS MS and exposures to organic solvents <i>Time for study/ Flipped classroom</i>	Environmental factors in Parkinsonism Pharmacotherapy Environmental factors and brain tumors Logopedics from an international perspective Operation Smile (web material)	Pandemrix vaccination- narcolepsy Quality registers narcolepsy reg MS and air pollution Covid and air pollution <i>Time for study/Flipped classroom</i>	Literature seminar, <i>flipped classroom</i> : Sleep, environment and neuro-health Climate change and pediatrics
4th week	Environment/Society ROSLING SEMINAR Introduction Hans Rosling Rosling Seminar Konzo – Video Thorkild Tylleskär Discussion	Risk Calculation Four-fold table Muddy points Gamification Quality registers in neurology GATHER TOWN	Catastrophic events Example Fukushima, Chernobyl Psychiatric risks from environmental problems) Physicians against nuclear war. Panel discussion <i>Time for study/Flipped classroom</i>	Registers Training tasks in neurology policlinic (digital) Questionnaires, EIMS. Medical files Global perspectives blindness, <i>Flipped classroom</i> <i>Time for study/Flipped classroom</i>
5th week	Ethics, Justice, Economic drivers One health Ethics, law and environment Panel: Environment/the law: pharm. Companies Global transformations for health	Student presentations Group task Pregnancy Opposition Group task Neurodegenerative disease Opposition	Option: Questions on the examination	E-examination, <i>Inspira</i> (all study material allowed) Course evaluation (digital)

Principles of causality, complexity, big data, risk assessment, prevention, preventive principles, public health, global aspects, poverty, access to care, resources, rehabilitation, community development, and impact on care were highlighted.

As a tribute to the late Hans Rosling, Professor of Global Health, a seminar was held by Professor Thorkild Tylleskär from Bergen, Norway, focusing on Professor Rosling's research in Mozambique and several other African countries. The main subject of his field research was "Konzo" (cassavism), an epidemic of disabling spastic paraparesis primarily among women and children due to the consumption of improperly detoxified cassava roots that contain cyanogens. Professor Rosling took an interdisciplinary approach in his research, combining disciplines such as molecular anthropology, medicine, chemistry, and agriculture. He also is the father of a perfect statistical tool, the *Gapminder*, which we evoked during these seminars (<https://www.gapminder.org/about/about-gapminder/history/>). *Concept: Tools to analyze and monitor environmental health risks in your own local/regional surrounding.*

2. Basic science

Including health anthro-zoonosis, medical entomology, basic and clinical toxicology, ionizing and non-ionizing radiation, noise, water and air pollution, endocrine disruptors, chemical effects in the environment, and risks in occupational settings. *Concept: Multiple, interactive*

threats to brain health.

3. Environmental factors

The following environmental risk factors were included in the course plan: external/internal, local/global. Genetics, epigenetics, environmental medicine, water circle, nutritional state, physiology, adaptation, metabolic biorhythms, ecology, climate change, evolutionary biology (CNS), anthropology. *Concept: critical window in ontogenesis.*

4. Neurological disease

Fetal development and environmental threats, autism, stroke risks globally, the impact of air pollution, brain tumors, endocrine disruptors, obesity, diabetes risk, drug-induced neurological diseases, for example, narcolepsy after *Pandemrix* vaccination, environmental factors in multiple sclerosis, neurodegenerative diseases, psychiatric problems, infectious diseases such as HIV, trauma, post-traumatic stress syndrome, tropical diseases vs. climate change, and extreme events. *Concept: critical window infant, child and adult health/disease prevention.*

5. Economic and ethical aspects

Economic drivers of social development in terms of sustainable development: Millennium goals. Warfare: weapons, nuclear weapons, chemicals released by bomb explosion. Combined approaches: the new diseases, obesity. New threats: pharmaceuticals in the environment. Decision-making under uncertainty. Critical assessment of alternative medicine, and hypersensitivity was the focus of this part of the course—*concept: drivers behind multiple, interactive threats to brain health.*

Overall, students expressed satisfaction with the course; however, the course evaluation revealed some weaknesses: Firstly, many students found it challenging to grasp the full scope of the topic, despite it being divided into subtopics to facilitate comprehension. Some students found it difficult to adjust to the complexities of topics with which their respective education had not previously engaged. The new concept of flipped classrooms placed a significant amount of added responsibility on the students.

The time needed for preparation before the lectures was not considered when creating the schedule. This should be addressed in the design of future courses.

A high percentage of the students passed the exam, and the overall impression was that the students were ambitious and interested. Students who did not appreciate the course opted not to take the examination.

After an organizational change in the Department of Neuroscience, the UPRISE course was put on hold in Spring 2022. Upon reflection, it became apparent that the weak support from the medical program and the cost of the teacher time did not balance the relatively small amount of examined students per year. Eventually, in August 2023, the Course was reintroduced in the Department of Medical Sciences due to a collaboration with the ENLIGHT group as part of their initiative to promote a challenge-based transformation of European higher education.

6.3. UPRISE student perspectives in Uppsala

Following the Active Student Participation model [25], the student representative for the UPRISE course (V.S.) played a vital role in creating the curriculum and improving the Course based on student feedback. Inspired by UPRISE, V.S. applied for grants from Uppsala University for climate initiatives and subsequently launched a series of lectures on UPRISE topics. These lectures, open to all students and also the public, had the vision to create a platform for an interdisciplinary approach to understanding and solving human health challenges related to climate change.

6.4. Development of student projects

Directly involving the students by encouraging independent knowledge-seeking and flipped classroom approaches would also be shown to have positive downstream effects in later iterations of UPRISE. In one case, a female medical student (Y.N.) conducted research on patients with Parkinson's disease, examining the regularity with which treating neurologists and physicians in the Neurology ward asked questions about environmental factors; she presented an early version of the research in an UPRISE group task in the first semester of the Course. Subsequently, as a practicing doctor, Y.N. was invited as a lecturer in a later UPRISE course on environmental aspects of neurological health, where she presented her research results.

6.5. The Faculty of Medicine, Strasbourg

The Faculty of Medicine in Strasbourg initiated an annual Course called "Enseignement complémentaire, médecine environnementale" dedicated to environmental medicine; this began in October 2009 and terminated in June 2014 [12]. After several changes, a second version of the Course was launched in 2018 and remained unchanged for 5 years until 2023. This elective course covered the entire scope of the EHM [13].

Designed from an anthropocentric perspective, the Course aimed to address the question, "What are the effects of the environment on man and his health?" It explored various disciplines ranging from earth and life sciences to social, legal, and economic sciences, addressing, for example, urban climate and air pollution, the Precautionary Principle, and the use of big data sets. Biology and physiology, as well as bio-anthropology, considered adaptation and vulnerability. Several pathologies related to environmental factors were addressed: medical toxicology and poisoning, infections, neuropsychiatric diseases, and cancer. Students were also introduced to health-risk analysis in Occupational Medicine, considering, for example, the health effects of ionization and noise. The lecture concerning the emergency medical management of disasters was praised by the students.

Across the years of its operation, namely 2018–2023, the Course involved approximately 30 teachers. For the 2021–22 academic years, the teachers' affiliations were either academic (Strasbourg University and Centre National de la Recherche Scientifique, 38%), belonging to the Faculty of Medicine (35%), or independent (27%). Almost a third of the lectures were given by specialists, without any attachment to the University of Strasbourg who had agreed to teach for free. No doubt that EHM issues must be addressed holistically, with an interprofessional approach. The language used in the Course was French.

Only medical and midwifery students with a two-year education background could apply in a limited number (around twenty) due to the final evaluation procedure. Notably, during the second phase, significant improvements were made to the evaluation rules. Considering the students' workload imposed by the pure medical part, the mandatory courses were de facto conferences without any control over the subjects that were taught. The final evaluation comprised an oral 20-min team presentation and a personal short report. Each team (two or three students) had freely chosen an environmental topic; each member was required to write a short report concerning what s/he had presented orally. The valuation results were remarkable; students demonstrated a high level of engagement and presented exciting approaches to environmental health. All students passed the exam. During these five years, we proposed an evaluation by the students, concerning both the pertinence of the chosen topics and the pedagogic performance of the lecturers.

Over the five-year duration of the Course, a total of 90 students opted to participate. Notably, female medical students were greatly interested in this elective course: The sex ratio (F/M) of 45/23 was around 2, compared to the sex ratio among medical students during three years (same academic year, named DFGSM 3) which was around 1.6 (Table 3).

Table 3

The total number of students registered in the courses at Strasbourg University between 2018 and 2023.

Participants	2018–2019	2019–2020	2020–2021	2021–2022	2022–2023	Total
Number of students	8	11	24	29	18	90
Medical students	5	10	14	21	18	68
Female/ Male	6/2	6/5	20/4	20/9	15/3	67/23
Midwifery students	3	1	10	8	0	22
Female/Male	3/0	1/0	9/1	7/1	0	20/2

6.6. Student perspectives in Strasbourg

A survey to assess student satisfaction was conducted in 2021 by one of the authors (M.I.) among the 42 students who attended the Course in 2018–19, 2019–20, and 2020–21. The survey comprised two steps: The first involved a prospective collection of data addressing the participants' motivation for this elective course. The second was a retrospective collection of the students' opinions after completing the course and final examinations.

The prospective study (40 questionnaires completed) showed that the main motivation for choosing this course (37/40) was its topicality, which indicated interest and curiosity among the students. In addition, they appreciated the opportunity to develop their critical thinking, the variety of teaching, the oral assessment, and the opportunity to work in a group and limited numbers.

The retrospective study also collected quantitative data. Each speaker was rated for their pedagogical qualities and the relevance of the conference topic.

The average satisfaction index was 7.90/10 (CI (95%) = [7.38;8.42]). Clinical interest was the lowest-rated item, with an average of 6.87/10 (CI (95) = [6.09;7.65]). Although the students seemed very satisfied with the Course, its clinical and practical relevance was considered low. One possible interpretation is that medical students may be more accustomed to being taught medicine from a curative rather than a preventive perspective. This is a key point – when students were asked whether they wanted to treat and cure people or prevent people from getting a disease – the former ended up in medical school, the latter in a research laboratory. Rarely, a student will indicate both interests such that, if available, they opt for a Medical Scientist (MD/PhD) training program.

6.7. Nursing school in Istanbul

The Istanbul project aimed to raise awareness of environmental neurology among nurses, an important part of the healthcare team and in close contact with patients. For this purpose, a webinar on the impact of environmental factors on human health was first organized in September 2021. The webinar highlighted practical concerns for nurses and midwives, in particular the health impact of indoor air pollution and endocrine-disrupting chemicals. The seminar was attended by 77 nurses from various institutions, which led to the organization of a series of seminars scheduled online every 2–3 weeks. Participation was voluntary: the participants were nine Masters and PhD students who were also registered nurses. The seminar series on an introduction to environmental neurology and medicine was held in ten online sessions of 45 to 60 min duration. There was no examination. After defining the specific approaches used in environmental medicine with a comparison with environmental health, the courses addressed in detail the main concepts involved in EHM, in particular causality, level of proof, and evidence-based medicine, the different meanings of the term risk, considering both danger, hazard, and probability, as well as criticality (the combination of probability and severity of a hazard's occurrence) and risk management. Addressing complexity as well as certainty (determinism) versus uncertainty and doubt completed these theoretical bases of EHM. Examples drawn from neurological diseases and the health consequences of climate change illustrated the contemporary relevance and

importance of these concepts. Although the course took place on Sunday evenings, the participants remained engaged and were satisfied with the increase in knowledge in this new area, which has yet to be included in the nursing school curriculum. Suggestions were made to include more specific neurology topics in subsequent seminars. It was suggested that the program be enriched with more concrete and practical recommendations on the role of nurses in environmental health. Building on this initiative, the aim is to increase the interest of nurses and midwives in this new area of EHM, following the example of the American Alliance of Nurses for Healthy Environments (<https://envirn.org>).

7. Discussion

The establishment of these elective courses originated in personal initiatives (J.R., A.M.L., Z.T.); they were encouraged by the respective deans and needed local advocacy. We had considered (J.R., A.M.L., Z.T.) whether teaching EHM to our students should be mandatory, hoping that these courses might meet the interests and needs of the students in the medico-scientific community. In Uppsala, for example, in the medical degree program, this elective course was challenged by other elective courses covering important topics, e.g., emergency and therapeutics. The relatively low number of medical students attending UPRISE was explained by this course targeting students in a later stage of their training.

Despite targeting students with different backgrounds and education levels, we observed a more extensive interest from female students in these teaching courses. The average sex ratio was 75% female vs. 25% male in Strasbourg and 68% female vs. 32% male in Uppsala. A possible explanation is that female students are overrepresented in medicine (females represent >60% of all medical students in France) [26].

The fact that only female students attended the conferences in Istanbul is consistent with the continuing female dominance in the nursing field in Turkey.

Another plausible explanation might be that females have more pro-environmental concerns. A report from 1983 provided modest support for women being more concerned about the environment than men: a Chinese study based on self-reports also reported a higher level of environmentalism among women [27,28].

These first initiatives of teaching EHM in Uppsala and Strasbourg have now been completed. UPRISE has been integrated into ENLIGHT, a project that fosters collaboration between European universities and promotes a broader perspective on the impact of environmental factors on our health. In France, following the conference of the deans of the medical faculties, a compulsory course for all second-year medical students in the second year of training was introduced in 2023, thus bringing the unique Strasbourg experiment to an end. Numerous initiatives are currently underway to educate medical students about EHM. For instance, the Faculty of Medicine of the University of Luxembourg offers all medical students an introduction to environmental health with a classical approach focusing on environmental milieu and exogenous agents. In addition, this university provides an introduction to environmental neurology to students engaged in neurology (J.R.).

Another interesting aspect of these courses is the involvement of faculty members at the local level, both in Uppsala and Strasbourg, with lecturers drawn from many disciplines. During course development, we advocated and recruited researchers from many specialties, e.g.,

researchers from the Agricultural University in Uppsala and neuroscientists in Uppsala University. This inclusive and holistic approach was also evident in the course in Strasbourg. Some of our colleagues realized that the environmental issues impacted the field of their specialty. For example, one ophthalmologist recognizing that the lack of exposure to outdoor light is a major risk factor for myopia, did not spontaneously classify light exposure as a relevant environmental factor.

Additionally, psychiatrists who agreed to teach discovered the overlooked role of environmental factors in their discipline. Often the medical community does not attribute to health and disease many risk factors that have been identified to the environment. This local involvement of faculty members involved in EHM teaching in several French universities was unfortunately not taken into account during the elaboration of the new compulsory education module launched in France in 2023 for all medical students, a typical top-down production that ignored the contribution of local initiatives and faculty members involvement.

On a broader scale, teaching environmental medicine is becoming increasingly imperative because it corresponds to a demand from physicians, students, and socio-politic awareness organizations. In the USA, physicians including neurologists have recently underlined the need for education addressing the health consequences of climate change [29,30]. For the neurological community, Environmental Neurology can greatly contribute to strengthening and promoting the emerging concept of Brain Health, supported by the World Health Organization and many neurological professional associations (e.g., World Federation of Neurology, European Academy of Neurology) [31 Lancet N]. This *Brain Health Strategy* launches a statement for the future: “One brain, one life, one approach”. The crucial role of neurologic health for all human activities now and in new generations is highlighted as well as the vulnerability that has been proven in terms of risks from environmental factors [32].

8. Summary

These innovative courses presented both challenges and successes. The first problem was to define the broad topic. The Course in Uppsala was greatly facilitated by the infrastructure of the department that organized UPRISE -the Department of Neuroscience- which had both preclinical and clinical expertise. Almost all professors had a personal interest in covering the specific fields of environmental effects and consequently took part in teaching. However, organizing such a complex subject is demanding, and even though efforts were made to link the different topics, for example by using a unifying heading for each of the five weeks, students nevertheless reported some frustration with the difficulties in understanding the scope of subjects derived from different disciplines that are usually separated, such as toxicology and epidemiology. The extensive content of the course made some fragmentation necessary, which is a limitation and may have contributed to the confusion felt by some students. We aimed to create a basic knowledge of environmental medicine in neurology by adding information and training on useful theoretical and practical strategies, such as how to proceed when faced with a health issue where environmental effects cannot be excluded. It is evident that health professionals are usually trained to manage diseases but are less inclined to explore causation and act preventively after identifying a potential environmental health risk. This is a key feature of the courses described in this article: the awareness to adapt to a protective attitude, according to The Precautionary Principle, in the sense that the mere suspicion of a risk should be taken into account instead of the current evidence-based medicine Axiom where statistically significant risk estimates are required. <https://www.sciencedirect.com/topics/earth-and-planetary-sciences/precautionary-principle>.

Initially, we found it surprising that medical students were underrepresented - rather it was pharmacology students who showed interest.

The UPRISE course and the Turkish one were inspired and

intellectually supported by RISE, especially Dr. Reis who personally followed the developments. In addition, the participants of RISE contributed with lectures.

In Turkey, the course was only available to nurses, which is a general limitation, but it should be considered a first attempt to introduce this topic. The French course was eventually closed but turned into a short mandatory course for all second-year medical students. The Swedish UPRISE course has started a collaboration with the ENLIGHT network with a promising potential for internalization and outreach.

CRedit authorship contribution statement

Shala Ghaderi Berntsson: Conceptualization, Data curation, Formal analysis, Methodology, Supervision, Validation, Visualization, Writing – original draft. **J. Reis:** Conceptualization, Formal analysis, Methodology, Supervision, Writing – original draft, Writing – review & editing. **Z. Tulek:** Conceptualization, Formal analysis, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. **P.S. Spencer:** Conceptualization, Data curation, Methodology, Supervision, Writing – original draft, Writing – review & editing. **M. Imhoff:** Conceptualization, Data curation, Writing – original draft. **Moniz Joao:** Conceptualization, Data curation, Formal analysis, Methodology, Visualization, Writing – original draft. **Muataz S. Lafta:** Conceptualization, Data curation, Writing – original draft. **Y. Najjar:** Data curation, Methodology, Writing – original draft. **A. Tolf:** Conceptualization, Methodology, Writing – original draft. **V. Selander:** Conceptualization, Formal analysis, Methodology, Writing – original draft. **Y. Söderfeldt:** Conceptualization, Methodology, Supervision, Writing – review & editing. **A.M. Landtblom:** Conceptualization, Data curation, Formal analysis, Methodology, Supervision, Validation, Visualization, Writing-review & editing

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