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eSleep_dHealth

Digital literacy enables up-to-date sleep medicine in inclusive healthcare

eSleep_dHealth

Document: eSleep_dHealth Curriculum

Developed by the ***University of Split (Activity 2.2. lead), E.C.H.R. Ltd. (NetHub), Reykjavik University, University of Crete, Mediterranean Economic Foresight Institute***

Summary

1. Introduction to the course

Sleep disorders impose a considerable burden on the worldwide population, contributing to a range of health complications. To create effective interventions, it is crucial to have a comprehensive understanding of their prevalence and the risk factors involved.

Education in sleep medicine and digital health research provides individuals with the necessary knowledge, resources, and tools to effectively prevent and identify sleep disorders.

This is relevant in the context of preventing other chronic health conditions, specifically cardiovascular disease, diabetes type 2, obesity, and mental health disorders that are closely linked to sleep disorders. By addressing sleep disorders at an early stage, it is possible to prevent or mitigate the development and progression of these conditions, thereby reducing the overall burden of disease.

Given the increasing prevalence of sleep disorders as people age and obesity and their correlation with age-related health conditions, this curriculum focuses on developing interdisciplinary expertise to implement preventive interventions that promote healthy lifestyles, especially sleep habits, and address sleep disorders among older adults. Developing interdisciplinary expertise will be possible by addressing unmet medical needs through innovation development that encourages a creative and entrepreneurial mindset while using digital technologies.

Finally, as sleep disorders with associated complications and comorbidities have a substantial impact on healthcare systems in terms of increased healthcare utilization, medication expenses, and lost productivity, implementing preventive measures like early detection and intervention can effectively decrease these healthcare costs.

Therefore, integrating sleep medicine into the education of healthcare professionals and those studying medicine, digital health, and other health-related technologies (including those interested in signal analysis, machine learning, etc) not only improves clinical care but also promotes preventive health practices and prepares healthcare professionals for the evolving landscape of digital healthcare technologies.

In our course, we will use open pedagogy, an approach to teaching and learning that emphasizes learner agency, collaboration, and the use of open educational resources (OER). Open pedagogy empowers learners to take ownership of their learning by actively participating in the creation and sharing of knowledge. It involves collaborative learning experiences where learners create, remix, and share knowledge. This approach fosters inclusion by providing opportunities for diverse perspectives to be heard and valued which is of extreme importance given the interdisciplinary nature

of the course. It can also create a sense of community among learners, which can be particularly beneficial for marginalized or underrepresented groups.

The course is organized in 3 modules, the first module Sleep Medicine reflects 6 ECTS (150 hours of student workload), while the second (Digital Health) and the third module (Entrepreneurship) each reflects 2 ECTS (54 hours of student workload). The concept of curriculum provides students of different backgrounds with the necessary knowledge and skills to identify and address unmet medical needs and create innovative solutions in the domain of digital health as well as to transform the innovative ideas into viable businesses.

2. Module 1 – Introduction to sleep. Digital innovation and implementation of Sleep Revolution results (6 ECTS, student workload - 150 hours)

Course Description

This course provides an introduction to the fundamentals of sleep medicine and sleep research. The course covers essential topics related to sleep physiology, sleep disorders, diagnostic techniques, and treatment modalities. Students will gain a comprehensive understanding of the importance of sleep for overall health and well-being, the role of circadian rhythm, sleep hygiene, and the skills necessary to assess and manage sleep-related issues.

2.1 PART 1 Sleep and Wakefulness, Sleep Research and Sleep Medicine (Student workload – 30 hours)

Lectures: Wakefulness and sleep, sleep physiology, sleep research and sleep medicine (4h)

Seminars: Regulation of sleep and wakefulness; two-process model (4h)

Practicals: Stages of sleep (2h)

Knowledge

- Theories on the functions of sleep
- Circadian rhythm of wakefulness and sleep
- Sleep homeostasis
- Acute and chronic sleep deprivation
- Species and gender differences in sleep
- The neurophysiology and neurobiology of wakefulness and sleep
- Sleep hygiene
- Sleep research overview

Research skills

- Acquire the knowledge and skills necessary to conduct a literature search.
- Conduct a critical literature review on specific topics in a group setting.

Life skills

- Engage in effective communication with students from diverse backgrounds.
- Implementation of assertiveness in communication.
- Effective time management for collaborative work.

Mindset and attitudes

- Valuing and appreciating the contributions of collaborators from various disciplines.
- Developing the resilience to navigate setbacks and challenges.
- Fostering a curious and critical mindset.

Learning outcomes

- Understand the foundational concepts of wakefulness and sleep, and scope of sleep research and sleep medicine.
- Define the sleep quality and its importance in healthcare.
- Describe the physiological processes involved in the regulation of wakefulness and NREM and REM sleep.
- Recount, discuss, and evaluate the outcomes of inadequate sleep hygiene and acute and chronic sleep deprivation.
- Understand and discuss the concept of sleep as an interdisciplinary area and explain possible collaborations of experts with different background in education and research in sleep and practice in sleep medicine.

Assessment: Concept Map (10h)

- **Description:** Students will create a concept map in small groups illustrating the interconnectedness of the foundational concepts introduced in the lecture and seminar. The concept map should include key terms, definitions, and relationships between topics such as sleep medicine, sleep physiology, and stages of sleep.

Assessment: Writing white paper (10h)

- **Description:** Group work: students will conduct a research literature search and demonstrate comprehension of the research findings by summarizing research data, assessing the methods and validity of findings, and comparing research approaches across different studies. The topics will include mechanisms that regulate the different stages of sleep, differentiation among various stages of sleep using practical examples and observations, and outcomes of acute and chronic sleep deprivation. Each group will select one of the topics and summarize their findings in the form of a white paper. While writing white paper students will practice assertive communication. After the group project, each student will write their observations on the efficacy of time management during collaborative work.

Reading materials

- Andrillon T. How we sleep: From brain states to processes. Rev Neurol (Paris). 2023;179(7):649-657.
- Andrillon T, Oudiette D. What is sleep exactly? Global and local modulations of sleep oscillations all around the clock. Neurosci Biobehav Rev. 2023;155:105465.
- Cappadona R, De Giorgi A, Di Simone E, et al. Sleep, dreams, nightmares, and sex-related differences: a narrative review. Eur Rev Med Pharmacol Sci. 2021;25(7):3054-3065.
- Duhart JM, Inami S, Koh K. Many faces of sleep regulation: beyond the time of day and prior wake time. FEBS J. 2023;290(4):931-950.
- ESRS textbooks and research papers were found via students' literature search online.
- Urbanová L, Sebalo Vňuková M, Anders M, Ptáček R, Bušková J. The Updating and Individualizing of Sleep Hygiene Rules for Non-clinical Adult Populations. Prague Med Rep. 2023;124(4):329-343.

2.2 PART 2 Sleep diagnostics methodology and procedures (Student workload – 30 hours)

Lectures: Diagnostic techniques in sleep research and sleep medicine (2h)

Seminars: Polysomnography (PSG) and polygraphy (PG), actigraphy, questionnaires, sleep diary and consumer sleep technology; the Sleep Revolution project summary (3h)

Practicals: Sleep questionnaires and assessments; classical PSG vs. novel approach to sleep diagnostics (SAS) in the Sleep Revolution project (2h)

Knowledge

- Standard sleep diagnostic procedures
- Sleep history and examinations
- Measuring/monitoring sleep and wakefulness
- Sleep stages

Life skills

- Analytical skills to evaluate the strengths and limitations of different sleep measurements.
- Identifying and addressing challenges in the application of digital health and sleep medicine and research.

Mindset and attitudes

- Fostering an attitude that emphasizes the importance of patients' well-being and needs, and actively seeking their perspectives and experiences in shaping healthcare solutions.
- Encouraging patients to actively engage in their healthcare by fostering a mindset that emphasizes the use of digital health tools for empowerment.

Learning outcomes

- Identify sleep disorders belonging to different categories such as insomnia, sleep-related breathing disorders, central disorders of hypersomnolence, circadian rhythm sleep-wake disorders, parasomnias, sleep-related movement disorders, and other sleep disorders.
- Describe and explain diagnostic procedures such as questionnaires, sleep diaries, polysomnography, polygraphy (home sleep apnea testing), multiple sleep latency tests, maintenance of wakefulness tests, and actigraphy in assessment of different sleep disorders.
- Analyze the strengths and limitations of consumer sleep technology such as smartwatches.
- Describe, explain, and apply the key elements of sleep history (via interview).
- Apply the knowledge and demonstrate basic skills in human polysomnography scoring and interpretation.
- Comprehend the strengths and limitations of automatic and manual sleep scoring.
- Describe and differentiate the stages of sleep.
- Develop research questions and hypotheses relevant to sleep research and describe use of various data collection methods, such as questionnaires, interviews, and objective measurements.

Assessment: Report (5h)

- **Description:** Individual assignment: Students will write a short report with a measurement of their own normal sleep for 1 week, comparing different assessment tools such as an electronic sleep diary (Sleep Revolution app), standardized questionnaires, and a consumer sleep technology device. Students will also perform the different cognitive tests in the Sleep Revolution

digital management platform and the app (once when well alert and another time while sleepy/tired) and include those findings in the report.

Assessment: Polysomnography – sleep stages and arousals assessment (10h)

- **Description:** Demonstrate basic skills in human polysomnography scoring and interpretation. Comprehend the strengths and limitations of automatic and manual sleep scoring.

Assessment: Planning of research paper in IMRaD format (Introduction – Methods – Results – Discussion) (8h)

- **Description:** In groups, students will develop research questions and hypotheses relevant to sleep medicine and research. They will discuss the use of various data collection methods, such as questionnaires, interviews, and objective measurements to test the hypothesis. Students will be mentored in the process of assessing data accuracy, reliability, and validity. Finally, they will write a proposal for a short research paper in IMRaD format (Introduction – Methods – Results – Discussion).

Reading materials

- Abu K, Khraiche ML, Amatoury J. Obstructive sleep apnea diagnosis and beyond using portable monitors. Sleep Med. 2024;113:260-274.
- Arnardottir ES, Islind AS, Óskarsdóttir M. The Future of Sleep Measurements: A Review and Perspective. Sleep Med Clin. 2021 Sep;16(3):447-464. doi: 10.1016/j.jsmc.2021.05.004. Epub 2021 Jul 6. PMID: 34325822.
- Arnardittir ES et al The Sleep Revolution project: the concept and objectives https://onlinelibrary.wiley.com/doi/epdf/10.1111/jsr.13630
- Bazoukis G, Bollepalli SC, Chung CT, et al. Application of artificial intelligence in the diagnosis of sleep apnea. J Clin Sleep Med. 2023;19(7):1337-1363.
- ESRS textbook.
- Feltner C, Wallace IF, Aymes S, et al. Screening for Obstructive Sleep Apnea in Adults: Updated Evidence Report and Systematic Review for the US Preventive Services Task Force. JAMA. 2022;328(19):1951-1971.
- Lechat B, Scott H, Naik G, et al. New and Emerging Approaches to Better Define Sleep Disruption and Its Consequences [published correction appears in Front Neurosci. 2021 Nov 18;15:804589]. Front Neurosci. 2021;15:751730.
- Schiza S, Bouloukaki I. Screening for obstructive sleep apnoea in professional drivers. Breathe 2020;16: 29364; DOI: 10.1183/20734735.0364-2019

- Schiza S, Schwarz EI, Bonsignore MR, McNicholas WT, Pataka A, Bouloukaki I. Co-existence of OSA and respiratory diseases and the influence of gender. Expert Rev Respir Med. 2023;17(12):1221-1235.

2.3 PART 3 Insomnia and Circadian Rhythm Sleep Disorders (Student workload – 20 hours)

Lectures: Classifications, definitions and epidemiology of insomnia and circadian rhythm sleep disorders (2h)

Practicals: Use of sleep history, questionnaires, and objective measurements in diagnosing insomnia and circadian rhythm sleep disorders (2h)

Cognitive-behavioral therapy (CBT), bright light and melatonin in the treatment of insomnia and circadian rhythm sleep disorders (1h)

Knowledge

- Classifications, definitions and epidemiology of insomnia and circadian rhythm sleep disorders
- Advanced and delayed sleep phase syndrome
- Morningness/eveningness types
- Special populations and comorbidities
- Basics of CBT for insomnia (CBT-i), bright light, and pharmacological treatment

Research skills

- Actigraphy's role in monitoring wakefulness and sleep.
- Comparison of data obtained using questionnaires, actigraphy, and PSG/PG.

Life skills

- Keeping up with the rapid progress in technology and healthcare practices.
- Being proactive in projects related to digital health and sleep medicine.

Mindsets and attitudes

- Developing a solid ethical base and comprehending the ethical consequences of choices in the fields of digital health and sleep medicine, particularly in domains such as data privacy and security.

Learning outcomes

- Describe, identify and analyze types of insomnia and circadian rhythm sleep disorders
- Identify and discuss the pathophysiological mechanisms of insomnia and circadian rhythm sleep disorders and their relationship with clinical symptoms and possible comorbidities.

- Name and discuss the diagnostic and therapeutic procedures used in the diagnosis and treatment of insomnia and circadian rhythm disorders.

Assessment: Assessing insomnia and circadian rhythm sleep disorders in general population sample, group assignment (13h)

- **Description:** Obtain and analyze the Insomnia Severity Index questionnaire, sleep diary, and smartwatch (actigraphy) data in subjects with potential insomnia and circadian rhythms sleep disorders and discuss possible treatment plan.

Reading materials

- Baglioni C, Espie CA, Altena E, et al. Cognitive behavioural therapy for insomnia disorder: Extending the stepped care model. J Sleep Res. 2023;32(6):e14016.
- Crowther ME, Saunders WJ, Sletten TL, Drummond SPA, Bei B. Tailoring cognitive behavioural therapy for insomnia across contexts, conditions, and individuals: What do we know, where do we go?. J Sleep Res. 2023;32(6):e14023.
- Espie CA, Henry AL. Disseminating cognitive behavioural therapy (CBT) for insomnia at scale: capitalising on the potential of digital CBT to deliver clinical guideline care. J Sleep Res. 2023;32(6):e14025.
- ESRS textbook.
- Naha S, Sivaraman M, Sahota P. Insomnia: A Current Review. Mo Med. 2024;121(1):44-51.
- Riemann D, Espie CA, Altena E, et al. The European Insomnia Guideline: An update on the diagnosis and treatment of insomnia 2023. J Sleep Res. 2023;32(6):e14035.
- Riemann D et al. The European Insomnia Guideline: An update on the diagnosis and treatment of insomnia 2023. J Sleep Res. 2023 Dec;32(6):e14035. doi: 10.1111/jsr.14035. PMID: 38016484.
- Shaha DP. Insomnia Management: A Review and Update. J Fam Pract. 2023;72(6 Suppl):S31-S36.

- Sweetman A, Osman A, Lack L, Crawford M, Wallace D. Co-morbid insomnia and sleep apnea (COMISA): recent research and future directions. Curr Opin Pulm Med. 2023;29(6):567-573.

2.4 PART 4 Sleep-related breathing disorders (Student workload – 30 hours)

Lectures: Sleep disordered breathing (2h)

Seminars: Diagnostics and treatment modalities for obstructive sleep apnea (OSA) and other sleep-related breathing disorders. Sleep Revolution project - digital management of patients according to participatory medicine principles (5h).

Practicals: Interdisciplinary collaboration in OSA patient education and counselling according to personalized and precision medicine principles. (3h)

Knowledge

- Sleep breathing disorders
- OSA and OSAS
- Screening tools for SBDs
- Diagnostics and treatment of OSA(S)
- OSA(S) and comorbidities
- Interdisciplinary approach to OSA
- OSA phenotypes
- Impact of OSA on life quality, health outcomes
- OSA and sleepiness behind a wheel

Research skills

- Engage in collaborative efforts to conduct interdisciplinary aproach to OSA.
- Develop the ability to effectively communicate with collaborators of diverse cultural backgrounds.
- Analysis of biomedical signals.
- Engage in the interpretation of qualitative and quantitative data to uncover significant insights.
- Combine both quantitative and qualitative methods to gain a thorough understanding of relevant clinical and research questions.
- Recognize research and academic articles with standard guidelines for sleep medicine approach to OSA.

Life skills

- Cultivate the ability to independently research and stay updated on the ever-changing trends sleep medicine and research with emphasis on new developments in digital health aimed to recognize, diagnose and treat OSA.

Mindset and attitudes

- Emphasize the significance of efficient teamwork and collaboration in accomplishing common goals, recognizing the collective power of interdisciplinary teams.
- Encourage a mindset that supports patient empowerment by utilizing digital health tools, motivating them to actively participate in their own healthcare.

Learning outcomes

- Classify and define OSA and other sleep-related breathing disorders.
- Understand the phenotypes of OSA.
- Define and discuss health and social implications and comorbidities of OSA.
- Understand the various treatment options available for obstructive sleep apnea.
- Understand and discuss the OSA-related health risks of elderly patients with suspected OSA.
- Apply the screening tools for OSA in general population.
- Explain the sleepiness behind a wheel in OSA and name the legal regulations for drivers with suspected or diagnosed OSA.

Assessment: Case Presentation (5h)

- **Description:** Students will work in small groups to prepare a case presentation on different sleep-related breathing disorders. Each group will present a hypothetical case, including the patient's history, diagnostic findings, and proposed treatment plan. This assessment will evaluate their understanding of the disease, treatment modalities, and ability to communicate effectively with peers.

Assessment: Score ESS, STOP and STOP-Bang questionnaires and a Home Sleep Apnea Testing study (15h)

- **Description:** Demonstrate basic skills in screening questionnaires Epworth sleepiness scale, STOP and STOP-Bang questionnaires and home sleep apnea testing/PG scoring and interpretation.

Reading materials

- Abbasi A, Gupta SS, Sabharwal N, et al. A comprehensive review of obstructive sleep apnea. Sleep Sci. 2021;14(2):142-154.Gomase VG, Deshmukh P,
- Bassetti CLA, Randerath W, Vignatelli L, et al. EAN/ERS/ESO/ESRS statement on the impact of sleep disorders on risk and outcome of stroke. Eur Respir J. 2020;55(4):1901104.
- Brunetti V, Rollo E, Broccolini A, Frisullo G, Scala I, Della Marca G. Sleep and Stroke: Opening Our Eyes to Current Knowledge of a Key Relationship. Curr Neurol Neurosci Rep. 2022;22(11):767-779.
- ESRS textbook
- Hirani R, Smiley A. A Scoping Review of Sleep Apnea: Where Do We Stand? Life (Basel). 2023;13(2):387.
- Lekurwale VY. Obstructive Sleep Apnea and Its Management: A Narrative Review. Cureus. 2023;15(4):e37359.
- Gleeson M, McNicholas W. Bidirectional relationships of comorbidity with obstructive sleep apnoea. European Respiratory Review. 2022;31:210256; DOI: 10.1183/16000617.0256-2021
- Osman AM, Carter SG, Carberry JC, Eckert DJ. Obstructive sleep apnea: current perspectives. Nat Sci Sleep. 2018;10:21-34.
- Riha R. Defining obstructive sleep apnoea syndrome: a failure of semantic rules Breathe. 2021;17:210082.
- Osorio R, Martínez-García MA, Rapoport D. Sleep apnoea in the elderly: a great challenge for the future. European Respiratory Journal. 2022;59:2101649.
- Shah NM, Shrimanker S, Kaltsakas G. Defining obesity hypoventilation syndrome. Breathe (Sheff). 2021;17(3):210089.

2.5 PART 5 Hypersomnias, parasomnias and movement disorders of sleep (Student workload – 10 hours)

Lecture: Different sleep disorders – hypersomnias of central origin, parasomnias, movement disorders (1h)

Seminar: Narcolepsy (2h)

Practicals: Use of questionnaires in recognizing the risk for sleep disorders in these groups (2h)

Knowledge

- Narcolepsy and other hypersomnias
- Parasomnias
- Sleep Walking
- REM sleep behavior disorder

- Restless legs syndrome (RLS) and Periodic limb movement disorder (PLMD)

Learning outcomes

- Describe the most important characteristics of primary and secondary hypersomnia, associated with excessive daytime sleepiness, hypersomnias of central origin, parasomnias, and sleep-related movement disorders.
- Describe the most prevalent parasomnias.
- Name and discuss the importance of sleep-related movement disorders such as restless legs syndrome (RLS) and periodic limb movement disorder (PLMD).
- Use acquired theoretical knowledge in recognizing sleep-related movement disorders in polysomnographic recordings.

Assessment: Online Quiz and Learning cards (5h)

- **Description:** Students will complete an online open-book quiz consisting of multiple-choice and true/false questions based on the lecture and seminar content.

Individual assignment: Students will use online tools to create learning cards covering the content of the module.

Reading materials

- Anguizola E SS, Botta P LM, Castro-Villacañas A, Garcia-Borreguero D. The Clinical Evaluation of Sleep-Related Movement Disorders. Sleep Med Clin. 2021;16(2):223-231.
- Avidan AY. The Clinical Spectrum of the Parasomnias. Sleep Med Clin. 2024;19(1):1-19.
- Bruni O, DelRosso LM, Melegari MG, Ferri R. The Parasomnias. Psychiatr Clin North Am. 2024;47(1):135-146.
- ESRS textbook.
- Iranzo A. Parasomnias and Sleep-Related Movement Disorders in Older Adults. Sleep Med Clin. 2022;17(2):295-305.
- Khan M. Restless Legs Syndrome and Other Common Sleep-Related Movement Disorders. Continuum (Minneap Minn). 2023;29(4):1130-1148..
- Lopez R, Dauvilliers Y. Challenges in diagnosing NREM parasomnias: Implications for future diagnostic classifications. Sleep Med Rev. 2024;73:101888.
- Mainieri G, Loddo G, Provini F, Nobili L, Manconi M, Castelnovo A. Diagnosis and Management of NREM Sleep Parasomnias in Children and Adults. Diagnostics (Basel). 2023;13(7):1261.
- Malkani R. REM Sleep Behavior Disorder and Other REM Parasomnias. Continuum (Minneap Minn). 2023;29(4):1092-1116.

- Pizza F, Filardi M, Moresco M, et al. Excessive daytime sleepiness in narcolepsy and central nervous system hypersomnias. Sleep Breath. 2020;24(2):605-614.

2.6 PART 6 Societal, economic, organizational, and research aspects (Student workload – 30 hours)

Lectures: Importance of sleep and negative impact of sleep disorders on health and well-being, demographic and socioeconomic aspects of sleep; Sleep as a pillar in the lifestyle medicine (2h)

Seminars: Prevention and early assessment of risk for sleep disorders. Personalized and precision medicine approach to patients with sleep disorders (2h)

Practicals: Sleep hygiene education. Sleep in the lifestyle medicine (1h)

Knowledge

- European sleep societies, ESRS, ANSS, ERS, EAN, etc.
- Standard European guidelines in sleep and sleep medicine
- European education in sleep and sleep medicine
- Sleep research in Europe
- Reimbursement of sleep diagnostics and treatment in Europe

Research skills

- Engage in collaborative efforts to conduct interdisciplinary research projects.
- Develop the ability to effectively communicate with researchers of diverse cultural backgrounds.
- Develop academic articles that meet the standards for publishing in peer-reviewed journals.
- Gain a clear understanding of how peer review works and how to handle feedback from reviewers.

Life skills

- Cultivate the ability to independently research and stay updated on the ever-changing trends in digital health and sleep medicine and research.
- Being able to comprehend and control one's own emotions and showing empathy towards the experiences of patients and colleagues.

Mindset and attitudes

- Emphasize the significance of efficient teamwork and collaboration in accomplishing common goals, recognizing the collective power of interdisciplinary teams.

- Encourage a mindset that supports patient empowerment by utilizing digital health tools, motivating them to actively participate in their own healthcare.

Learning outcomes

- Explore the broader health implications of sleep disorders beyond individual conditions.
- Discuss the importance of sleep for overall health and well-being.
- Identify early signs and risk factors for different sleep disorders.
- Discuss strategies for early detection and intervention to prevent or minimize the impact of sleep disorders.
- Describe and discuss the European organizational (expert societies), educational and research aspects in sleep, as well as standard guidelines for practice in sleep medicine.
- Develop strategies to promote healthy sleep habits and optimize sleep environments.
- Design and execute a research study in a group setting and write up the results.

Assessment: Research paper in IMRaD format (Introduction – Methods – Results – Discussion) (25h)

- **Description:** In assigned groups in Part 1, students will work on developed research questions and hypotheses relevant to sleep medicine and research. They will use various data collection methods, such as questionnaires, interviews, and objective measurements to test the hypotheses. Students will be mentored in the process of collecting data, assessing data accuracy, reliability, and validity. Finally, they will write a short research paper in IMRaD format (Introduction – Methods – Results – Discussion) under supervision.
- They will also evaluate research papers from other student groups using the provided templates and examples of good and bad peer review.
- Upon revision, the revised research paper will be assessed and graded, as well as the quality of peer review for each students group.

Reading materials

- Billings ME, Cohen RT, Baldwin CM, et al. Disparities in Sleep Health and Potential Intervention Models: A Focused Review. Chest. 2021;159(3):1232-1240.
- Bonsignore MR, Randerath W, Schiza S, et al. European Respiratory Society statement on sleep apnoea, sleepiness and driving risk. Eur Respir J. 2021;57(2):2001272.
- ESRS textbook.

- Lajunen T, Gaygısız E, Wang W. Sleep and happiness: socio-economic, population and cultural correlates of sleep duration and subjective well-being in 52 countries. Front. Sleep. 2023;2:1118384.
- Papadopoulos D, Etindele Sosso FA. Socioeconomic status and sleep health: a narrative synthesis of 3 decades of empirical research. J Clin Sleep Med. 2023;19(3):605-620.
- Yang E, Ismail A, Kim Y, et al. Multidimensional Environmental Factors and Sleep Health for Aging Adults: A Focused Narrative Review. Int J Environ Res Public Health. 2022;19(23):15481.

3. MODULE 2 - Digital health (2 ECTS, student workload - 54 hours)

Mandatory – to include diagnostic and digital management approach in Sleep Revolution (it is obligatory to include the general knowledge in digital health and the approach in Sleep revolution, so both modules are covered).

The main objectives of the module will be to set the stage for digital health, in general, and to design, develop and use digital tools within healthcare settings for optimization purposes, in particular. By the end of the module, the students will be able to illustrate introductory knowledge of digital health, encompassing design, development and utilization of digital tools in healthcare settings as demonstrated by their assignment where the focus is to design a mobile application for a specific case.

3.1 PART 1 Designing Digital Health and Utilizing Cutting-Edge Emerging Technologies (Student workload – 22 hours)

Lecture: Digital Health (2h)

Seminar: Design and development of emerging technologies (2h)

Workshop: Working on a project related to the design of a digital health mobile application (2h)

Knowledge

- Core concepts of digital health and the role of emerging technologies in healthcare.
- Overview of design principles for digital health applications.

Research skills

- Ability to assess the viability and effectiveness of digital health technologies through user-centred design and feedback.

Life skills

- Enhancing digital literacy and technical skills relevant to healthcare.
- Effective communication and teamwork in a digital-first environment.

Mindset and attitudes

- Embrace innovation and continuous improvement in healthcare technologies.
- Ethical considerations in the design and implementation of digital health solutions.

Learning outcomes

- Define digital health and distinguish when emerging technologies can prove revolutionary.
- For a given digital health application discuss potential helpful, as well as harmful aspects.
- Evaluate the effectiveness and appropriateness of different manual processes that can be digitalized and use that to write a one-page project proposal.
- Demonstrate skills in carving out a digital health application from a complex case on an individual basis.
- Summarize conclusions according to their importance after peer-to-peer discussions of how digital health applications can be designed for healthcare purposes.
- Demonstrate the ability to communicate ideas and information clearly and respectfully across disciplinary boundaries.

Assessment: An individual project on the design of digital health (16h)

- **Description:** Students will work individually to come up with an initial design of a digital health mobile application based on a case presented to them. They work on their design through a co-design approach through a problem-based learning approach, where the case is theirs to interpret.

Reading materials

- Fitzpatrick G, Ellingsen G. A Review of 25 Years of CSCW Research in Healthcare: Contributions, Challenges and Future Agendas. Computer Supported Cooperative Work. 2013;22:609–665.
- Johansson V, Islind AS, Lindroth T, Angenete E, Gellerstedt M. Online communities as a driver for patient empowerment: systematic review. Journal of medical Internet research. 2021;23(2):e19910.
- Lupton, D. Digital Health: Critical and Cross-Disciplinary Perspectives (1st ed.). 2017. https://doi.org/10.4324/9781315648835

3.2 PART 2 Ethics and Artificial Intelligence of the Future (Student workload – 16 hours)

Lecture: Understanding the ethics, drawbacks, and potentials of digital health and artificial intelligence (2h)

Seminar: Digital platforms and data-driven decision-making (2h)

Workshop: Working on a project on digital platforms, data-driven decision-making, and the future of artificial intelligence in healthcare setting (2h)

Knowledge

- Understanding ethical implications and the potential impacts of AI in healthcare.
- Awareness of data privacy laws and regulations relevant to digital health.

Research skills

- Critical evaluation of AI technologies for biases and ethical concerns.

Life skills

- Navigating ethical dilemmas in the use of artificial intelligence.
- Decision-making skills in complex, technologically driven environments.

Mindset and attitudes

- Commitment to uphold ethical standards in the use of digital health.
- Responsiveness to emerging ethical challenges in technology applications.

Learning outcomes

- Define digital platforms and data-driven decision-making.
- Give examples of ways in which artificial intelligence can be helpful and when it can be harmful to healthcare of the future.
- Summarize conclusions according to their importance after peer discussions on AI in digital health with a focus on ethics, drawbacks, and its potential.
- Foster an ethical and responsible perspective in using digital tools within healthcare, emphasizing patient dignity and self-care.
- Evaluate the effectiveness and appropriateness of artificial intelligence and data-driven decision-making.
- Turn narrative descriptions into numerical data that can be the basis for enhanced decision-making in a healthcare setting.

Assessment: Team written research report (10h)

- **Description:** Students will work in teams on writing a research report with incorporated reflections on the ethics, potentials and drawbacks of artificial intelligence and data-driven decision-making in healthcare settings and hand that in.

Reading materials

- Kearns M, Roth A. The ethical algorithm: The science of socially aware algorithm design. 2019.

- Topol E. The patient will see you now: the future of medicine is in your hands. 2015.
- Zuboff, S. The age of surveillance capitalism. In Social theory re-wired. 2023;203-213.

3.3 PART 3 Machine Learning (Student workload – 16 hours)

Lecture: Machine learning and an introduction to Python (2h)

Seminar: Working with medical data (2h)

Workshop: Working on a project related to data analysis of objective data from wearable devices for measuring sleep and subjective data from a digital health mobile application (2h).

Knowledge

- Fundamentals of machine learning and its applications in sleep data analysis.
- Techniques for managing and analyzing large datasets.

Research skills

- Use of statistical tools and software for data analysis in healthcare research.

Life skills

- Analytical thinking and problem-solving using quantitative data.
- Adaptability to new tools and methodologies in data science.

Mindset and attitudes

- Advocating for data-driven decision making in healthcare.
- Openness to learning and applying new analytical techniques.

Learning outcomes

- Define machine learning and distinguish it from generic artificial intelligence.
- Understand ways in which machine learning and advanced data analysis techniques can prove impactful in healthcare.
- Discuss ways in which data analysis can be carried out when data is collected through novel emerging technologies.
- Evaluate the effectiveness and appropriateness of machine learning and advanced data analysis techniques compared to simpler traditional techniques.

- Demonstrate skills in data analysis of medical data, both objective data and subjective data.

Assessment: A teamwork data analysis project (10h)

- **Description:** Students will work in teams on data analysis of medical data (both objective and subjective), specifically from emerging technologies such as wearable devices and a digital health mobile application. Students will work with the programming language Python and use high-level machine learning in their data analysis to gain introductory knowledge on advanced data analysis through machine learning.

These course aims to equip students with a broad understanding of digital health, emphasizing not only technical skills but also ethical considerations and critical thinking when implementing digital solutions in healthcare settings.

Reading materials

- Biedebach L, Óskarsdóttir M, Arnardottir ES, Islind, AS. Two Sides of the Same Pillow: Unfolding the Relationship between Objective and Subjective Sleep Quality with Unsupervised Learning. International Conference on Information Systems. 2023.
- Biedebach L, Óskarsdóttir M, Arnardóttir, ES, Sigurdardóttir S, Clausen MV, Sigurdardóttir SÞ, ... & Islind AS. Anomaly detection in sleep: detecting mouth breathing in children. Data Mining and Knowledge Discovery. 2023;1-30.
- Lee P, Goldberg C, Kohane I. The AI revolution in medicine: GPT-4 and beyond. 2023.
- Topol E. Deep medicine: how artificial intelligence can make healthcare human again. 2019.

4. MODULE 3 - Entrepreneurship (2 ECTS, Student workload – 54 hours)

This module is designed to bridge the gap between different mindsets of students from medical and digital backgrounds to enable digital innovation development in the field of sleep medicine. Students will learn how to transform scientific insights and digital health technologies into viable business models in the field of healthcare and life sciences. The module will cover fundamental entrepreneurial concepts, opportunity recognition / unmet medical challenges, ideation, startup creation, intellectual property rights, and strategies for innovation in healthcare. Students will engage with the principles of entrepreneurship through the lens of health tech. They will learn to identify market needs, ideate challenge-based innovations, develop business plans, understand regulatory environments, and explore funding opportunities for startups in healthcare and life sciences.

4.1 PART 1 Entrepreneurial Mindset in Healthtech (Student workload – 15 hours)

Lecture: Introduction to Entrepreneurial thinking (1h)

- Exploring the significance of entrepreneurship in healthcare.
- Characteristics and mindset of successful health tech entrepreneurs (best practices examples).

Seminar: Opportunity Recognition in Sleep Medicine (2h)

- Techniques to identify unmet needs and opportunities in the field of sleep medicine.
- Engaging with user experience and feedback to spot innovation opportunities.

Workshop: identification of the unmet medical need in the field of sleep medicine – talks with HCPs (2h)

Knowledge:

- Understanding of entrepreneurial mindset and its relevance in health tech.
- Methods for recognizing business opportunities in healthcare.
- Basic principles of entrepreneurship within the context of health technology.
- Methods for opportunity recognition and validation in the health sector.

Research skills

- Market analysis and identification of target customer needs.

Life skills

- Strategic thinking and planning for new business initiatives.
- Communication and negotiation skills in entrepreneurial settings.

Mindset and attitudes

- Encouraging creativity and innovative thinking in identifying business opportunities.
- Resilience and adaptability in the face of entrepreneurial challenges.

Learning Outcomes

- Identify and evaluate opportunities for innovation in sleep medicine.
- Understand the entrepreneurial mindset necessary to drive health tech advancements.

Assessment: A teamwork Opportunity Analysis Report (10h)

- **Description:** students will be assigned the task of creating a document named Opportunity Analysis Report. The document will have the structure of the State-of-the-art/Market Analysis Report giving the overview of the existing solutions that target the selected unmet medical need, but enriched with the conclusion that provides an overview of the existing market gaps and opportunities for innovations related to the selected unmet medical need.

Reading materials:

- Cohen D, Hung A, Weinberg E, Zhu D. Healthtech in the fast lane: What is fueling investors excitement? 2020.
- Diandra D, Azmy A. Understanding Definition of Entrepreneurship. Journal of Management Accounting and Economics. 2020;7(5):235-241.
- Enderavor Insight. Innovation and Entrepreneurship in Healthcare. The Impact of Successful Founders and How Decision Makers Can Support Them. 2020.
- Hernandez D, Carrion D, Perotte A, Fulilove R. Public Health Entrepreneurs: Training the Next Generation of Public Health Innovators. Public Health Reports. 2014;129(6):477-481.
- Kulkov I, Ivanova-Gongance M, Bertello A, Makkonen H, Kulkova J, Rohrbeck R, Ferraris A. Technology Entrepreneurship in Healthcare: Challenges and

Opportunities for Value Creation. Journal of Innovation & Knowledge. 2023; 8(2):100365.
- Mazurek Melnyk B, Raderstorf T (ed.). Evidence-based Leadership, Innovation, and Entrepreneurship in Nursing and Healthcare. 2024.
- Widen R, Garbuio M, Angeli F, Mascia D. Healthcare Entrepreneurship. 2018.

4.2 PART 2 Innovation Design Methodologies (Student workload – 19 hours)

Lecture: Design Thinking Approach (1h)

- Fundamentals of the Design Thinking as a problem-solving approach.
- Overview of the five stages of the Design Sprint: Empathize, Diverge, Ideate, Prototype and Test.

Seminar: Applying Design Sprints to Health Tech challenges (2h)

- Introduction to the design sprint methodology: a five-day process for answering critical business questions through design, prototyping, and testing ideas with customers.
- Case studies of design sprints in the health tech industry.

Workshop: practical use of qualitative and/or quantitative methods in the validation of the unmet medical need with end-users/patients (2h).

Knowledge

- In-depth understanding of design thinking and sprint methodologies.
- Application of these methodologies to create viable health tech solutions.

Research skills

- Empirical testing and validation of product ideas through prototyping and user feedback.

Life skills

- Collaborative skills in multidisciplinary teams.
- Project management and execution of design sprints.

Mindset and attitudes

- A proactive approach to problem-solving.
- Commitment to user-centered design and continuous refinement.

Learning Outcomes

- Apply design thinking methods to develop innovative solutions to complex health challenges.
- Utilize design sprint techniques to rapidly prototype and test new ideas in the context of sleep medicine.

Assessment: A teamwork Design Thinking Project (14h)

- **Description:** Students will apply design thinking principles to identify an unmet need in sleep medicine and develop a conceptual solution. This project involves creating a portfolio of the design thinking stages they utilized, showcasing how they empathized with users, defined the problem, ideated solutions, built a prototype, and planned tests.

Reading materials:

- Banfield R, Lombardo CT, Wax T. Design Sprint: A Practical Guidebook for Building Great Digital Products. 2015.
- Dorst K. The Core of Design Thinking and Its Application. 2011;32(6):521-532.
- Knapp J. Sprint: How to Solve Big Problems and Test New Ideas in Just Five Dayss. 2016.
- Oliveira M, Zancul E, Leme Fleury A. Design Thinking as an Approach for Innovation in Healthcare: Systematic Review and Research Avenues. BMJ Innovations. 2021;7:491-498.
- Razzouk R, Shute V. What is Design Thinking and Why is It Important? Sage Journals. 2012;82(3):330-348.
- Sandars J, Goh P-S. Design Thinking in Medical Education: The Key Features and Practical Application. Journal of Medical Education and Curricular Development. 2020;7.

4.3 PART 3 Turning ideas into successful businesses (Student workload – 20 hours)

Lecture: From Prototype to Market (2h)

- Steps to take a health tech product from concept to market.
- Understanding product development lifecycle in health technologies.
- Intellectual property rights: patents, trademarks, copyrights

Seminar: Funding and Investment (2h)

- Overview of funding sources for startups: venture capital, angel investors, grants.

- Pitching to investors: key elements of a successful pitch.

Workshop: How to create a good Pitch Presentation (2h)

- Workshop on creating a pitch presentation (In small groups, students will create and pitch their business plan to a panel of potential investors (role-played by faculty and industry experts). This will test their ability to present their idea and demonstrate its viability.)

Knowledge

- Insight into the process of taking a product from prototype to market.
- Understanding of intellectual property and funding strategies for startups.

Research skills

- Financial forecasting and business model testing.

Life skills

- Leadership and management skills necessary for startup success.
- Effective pitching and presentation skills for securing investment.

Mindset and attitudes

- Entrepreneurial spirit with a focus on innovation and market disruption.
- Ethical considerations in business practices, particularly in the health tech field.

Learning Outcomes

- Navigate the funding landscape for health tech innovations.
- Understand intellectual property rights.
- Prepare and deliver an effective pitch to potential investors.

Assessment: A teamwork Business Plan Development (14h)

- **Description:** Students will develop a comprehensive business plan for an innovative solution in sleep medicine. This plan will include a brief market analysis, a business model and marketing strategies.

Reading materials:

- Association of Universities in the Netherlands, The Netherlands Federation of University Medical Centres, The Royal Netherlands Academy of Arts and

Science, The Netherlands Organisation for Scientific Research. Set of Guidelines with Intellectual Property Rights (IPR) for academic start-ups. 2016.

- Baehr E., Loomis E. Get Backed. The Handbook for Creating Your Pitch Deck, Raising Money, and Launching the Venture of Your Dreams. 2010.
- Blank S, Dorf B. The Startup Owner's Manual. The Step-By-Step Guide for Building a Great Company. 2012.
- Berezekina E. Developing A Roadmap How to Bring New Products to the Market. A Low Risk Medical Device. 2022.
- Dushin M, Doston Cornell S, Richards D. Developing Your Social Enterprise Pitch Deck. 2019.
- European Court of Auditors. EU Intellectual Property Rights. Protection Not Fully Waterproof. 2022.
- Harvard Business School. New Venture Competition. Pitch Deck Example.
- IJzerman MJ, Koffijberg H, Fenwick E, Krahn M. Emerging Use of Early Health Technology Assessment in Medical Product Development: A Scoping Review of the Literature. PharmaEconomics. 2017;35:727-740
- IJzerman M, Steuten LMG. Early Assessment of Medical Technologies to Inform Product Development and Market Access. Applied Health Economics and Health Policy. 2011;9(5):331-47.
- Klačmer Čalopa M, Horvat J, Lalić M. Analysis of Financing Sources for Start-up Companies. Management. 2014;19(2):19-44.