Catalogue of learning objectives in medical informatics for medical students

Developed by the working group “MI-Teaching in Medicine” (Headed by M. Dugas and J. Varghese)
of the German Society for Medical Informatics, Biometry and Epidemiology (GMDS)

No.	Subject	Objective: The student ...	Justification / Medical context / Medical competence	Competence context[1]	Competence level[2]	Competence role[3]	Comment
1	**Medical information management and communication**						
1.1	Goals of medical information management	can explain medical information management using clinical examples.	Documentation is a mandatory medical activity. Key objectives are: - Presentation of the course of the disease as the basis for treatment - Quality assurance - Communication - Patient safety - Medicolegal purposes - Proof of service provision - Economic efficiency/accounting/billing - Scientific purposes	A	2	2, 3, 4, 6	Documentation should be designed efficiently and allow the reuse of primary data for different documentation tasks.
1.2	Type and structure of medical documentation	knows the different types of medical documentation, their structure and areas of application, especially the basic documentation of hospitals and medical practices.	Physicians must be familiar with the different types of documentation in order to use them properly. Depending on the application context and objectives, different types of documentation are used, for example documentation in routine care or in the research context. The basic documentation provides a uniform, structured data of all service providers, which can be used within and across patient level.	B	2	1, 2, 3, 4, 5, 6, 7	Basic, disease-related and study documentation; documentation of progress, findings, measures, registries, reporting, patient-related and cross-patient documentation.

[1] Context of competence A: Covered particularly competently by Medical Informatics, B: Originally Medical Informatics, C: Compulsory elective subject. Learning objectives of Competence Context C are listed only as examples.
[2] Competence level 1: Factual knowledge/referenced knowledge, 2: Applied factual knowledge, 3: Practical knowledge
[3] Competence role (according to NKLM): 1=Medical expert, 2=Communicator, 3=Member of a team, 4=Responsible and manager, 5=Health advisor and advocate, 6=Professional, 7=Scientist

1.3	Electronic documentation	can name the advantages and disadvantages of different types of electronic documentation, their differences to paper documentation and the problems of media disruption.	Availability and reuse are important advantages of electronic documentation. When using electronic and paper-based documentation at the same time, clear organizational guidelines are required to avoid documentation and handling errors due to media disruption.	B	1	2, 3, 4, 6	Flexibility, readability, data quality, analysability, availability.
1.4	Item catalogue	can represent data items for a medical documentation procedure in a structured way.	Physicians should keep the standards of their documentation up to date. The selection of data items is based on the respective medical facts and is the basis for the development of databases. Structured documentation allows the reusability and evaluation of data elements.	B	2	4, 6, 7	Unambiguous definition of data items, avoidance of redundancy as a source of error. Differentiation of identification and medical description data with appropriate data types. Concept of a database.
1.5	Data management	knows measures to ensure high data quality and can plan and carry out database evaluations.	High data quality of medical data is a prerequisite for valid evaluations in studies and for legal quality assurance. Database queries with data evaluations are often used by physicians.	B	2	4, 6, 7	Quality criteria: Completeness, plausibility, validity. Avoidance of double entry. Regulatory requirements for data management.

2	**Medical classification systems and terminologies**						
2.1	Diagnostic coding, ICD-10	can code diagnoses using the nationally adapted and official ICD version, which is in use for inpatients and outpatients.	According to the German coding guidelines, the physician is responsible for documentation including diagnosis coding.	B	3	3, 4, 6	ICD-10 application areas: e.g. medical billing, quality assurance, health care research. ICD-10 structure, residual classes, cluster coding, diagnostic additives, principle of maximum specification, National coding guidelines and organizations (e.g. DIMDI in Germany).
2.2	Procedure coding	can explain and apply the coding of measures, interventions and procedures using national coding systems (e.g. OPS in Germany, ICD-10-PCS in United States).	According to the German coding guidelines, the physician is responsible for documentation including coding of measures according to the rules.	B	3	3, 4, 6	Structure of the procedure coding system, residual classes. Procedure definition, multiple procedures, bilateral procedures, procedures that are to be coded only once.
2.3	DRG	knows the DRG system, the information and tools required to determine a DRG, and key figures associated with the DRG system, and can explain these	The DRG system is a legally binding classification for billing in the inpatient sector. In order to be able to act in an economically responsible manner, physicians should know basics of the DRG system.	A	2	3, 4, 6	Definition of DRGs, determination of a DRG (grouper), base rate, MDC, CCL, case mix index, standard retention period, maximum retention period.
2.4	Further classifications and terminologies	knows other medical classifications and terminologies, understands their structure and field of application.	Physicians working in a research context or in quality management should be familiar with internationally established classifications and terminology to use them appropriately.	C	2	6, 7	UMLS, SNOMED-CT, LOINC, ICD-O, ICF.

3	**Health information systems**						
3.1	Hospital Information System (HIS) function	knows tasks and function of a HIS and can explain them.	Physicians work with a HIS in inpatient care.	B	2	2, 3, 4	HIS is a socio-technical system. Need for management of a HIS. Role of evaluation functions in the HIS (Data Warehouse function).
3.2	HIS components	can name and explain the most important components of a HIS (RIS/PACS, LIS, PDMS/Anaesthesia Information System, Surgery administration, EMR system)	Systems designed for specialty departments are of central importance for the respective medical disciplines. Clinical documentation and reporting requires an understanding of the functionality and role of these departmental systems.	B	2	2, 3, 4	
3.3	HIS requirements	can formulate requirements for departmental systems and provide feedback to existing systems. - Requirement specifications, performance and functional specifications - Procurement processes, tendering procedures, role of the physician	Physicians should be able to give medical guidelines for the selection of new departmental systems, as well as to collaborate in the customization of departmental systems and the adaptation to their own conditions and work processes. They should be able to assess which of these tasks they can perform independently and which they can only perform with expert advice.	B	2	4, 6	Participation in the creation of service specifications, requirement and functional specifications within the framework of procurement processes. Cooperation in project organisation/management.
3.4	Electronic Health Record (EHR) system	can request examinations in the EHR system, document findings and create a medication prescription and a discharge letter.	All physicians must be able to carry out the daily routine activities in an EHR system in inpatient care.	B	3	2, 3, 4	
3.5	EHR function	knows CPOE (computerized physician order entry) procedure, its advantages and disadvantages as well as the necessary framework conditions and can explain it.	CPOE and CDSS (clinical decision support system) are becoming increasingly common in hospitals and medical practices. Since the systems can both improve patient safety and induce treatment errors when used incorrectly, physicians should know the principles, potential benefits, but also the risks and requirements for use.	B	2	1, 2, 3, 4, 6	CPOE: for example requesting a CT. CDSS: for example, drug interaction testing for prescription of medicinal products.

3.6	Personal health record (PHR)	knows tasks and function of the different types of electronic patient records (initiated by health professional, equipment-related or inter-institutional) and PHR (initiated by patients).	Patient records are incomplete and heterogeneous due to the variety of healthcare institutions and legal or technical framework-conditions. This may impact patient-safety. Physicians should know possibilities and limitations of different record types.	B	2	1, 2, 3, 4, 6	Explanation of different patient record types: electronic health record (EHR), electronic patient record, personal health record (PHR). Case number vs patient identification number
3.7	Patient safety	knows possible errors/risks regarding IT systems in the public health sector and actions to minimize these risks.	Physicians must take into account limitations and error possibilities (handling errors, malfunctions) of IT systems in order to to prevent damage to the patient.	B	2	1, 3, 4, 6	Liability, the need for training actions/instruction, systematic tests, software risk classes, reporting requirements. National and/or international regulations and standards, e.g. medical device regulation.
3.8	Cohorts & register/ study data	knows requirements for Information processing in studies and registers and the term EDC (Electronic Data Capture) and can explain it.	Use of prospective data capture in registers is necessary for inpatient and outpatient setting (e.g. cancer registry). Registers are an essential instrument for health services research.	B	2	2, 4, 6, 7	Information systems in health care are a central data source for health services research. Register studies, importance of data quality.
3.9	Medical Practice Software	knows tasks and functions of information systems for outpatient care and medical responsibilities in the operation of these systems and can explain it.	Systems for medical routine in outpatient care. Medical responsibility regarding confidentiality, data protection/data security in these systems.	B	2	1, 2, 3, 4, 6	

4	**Apps, decision support and artificial intelligence**						
4.1	Clinical Decision Support Systems (CDSS)	knows different types of knowledge-based systems and medical applications of CDSS to optimize patient care.	The amount of relevant biomedical content is increasing rapidly. CDSS are knowledge-based systems. These systems represent, filter and process medical knowledge such that clinical processes can be optimized in patient care. Successful application of knowledge-based systems requires high data quality and benefits from highly structured data.	B	2	1,3,4,6	Possibilities and limitations of CDSS; knowledge-based systems: e.g. rule-based systems, Bayes networks, machine learning and neural networks.
4.2	Machine Learning and Neural Networks	knows examples of machine learning approaches and can explain the basic principles for their evaluation using the example of artificial neural networks.	The increasing digitization in the health care system and availability of powerful computer architectures facilitate applications of machine learning systems, e.g. in imaging procedures. Physicians should understand the basic principles how these systems work and how to evaluate them in order to assess its possibilities and limitations in medical applications.	B	2	1,7	Examples for machine learning: Decision trees, case-based reasoning, neural networks. Evaluation of neural networks: Use of training/test data, overfitting, hyper-parameters, cross validation.
4.3	Personalized Medicine, medical applications of CDSS or AI systems	knows the term Personalised Medicine or Precision Medicine and medical applications of machine learning methods or AI systems, especially in the context of the Medical Device regulation.	AI-based pattern recognition contributes significantly to Personalized Medicine in a number of medical application areas. Physicians should be familiar with these applications in order to assess the potential in their own research or routine work in the context of regulatory requirements.	A	2	1,4,6	Exemplary AI applications: Pattern recognition of skin tumors in image data, analysis of radiology images. Rule-based systems with HIS/CPOE integration: Thromboembolism prophylaxis, antiobiotic stewardship, diabetes management.
4.4	Patient apps	understands patient empowerment: the possibilities of patients to take an active role in health care, e.g. through patient apps.	Physicians should be informed about information processing procedures for patients in the context of prevention, diagnostics and therapy, in order to provide competent advice to patients.	B	2	5	Health-related internet research, IT-supported self-documentation by the patient (course of disease, quality of life), prevention.

5	**Health telematics and telemedicine**						
5.1	Electronic Health Insurance Card	knows tasks and functions of electronic health insurance cards and health professional cards as well as the principle of the telematics infrastructure and can explain it.	electronic health insurance card, health professional card and telematics infrastructure are the basis for networking in the health care system.	B	2	4, 6	
5.2	Interoperability	knows the term interoperability and its necessity, levels and requirements and can explain these using a clinical example.	Physicians determine the content structure of clinical documentation. They therefore need to understand the implications of this for electronic exchange of patient data within a hospital and between different healthcare institutions.	B	2	4,7	Health telematics refers to an IT infrastructure, among other things, to ensure secure communication via networks and syntactic and semantic interoperability of the applications involved.
5.3	Telematics standards	can name important international standards of medical informatics.	Physicians are involved in the selection of IT systems for hospitals and medical practices and therefore need a basic understanding of these standards. They should know that electronic data exchange between the many IT systems and medical devices in the hospital/health care system is problematic and that appropriate standards for communication are needed.	B	1	4,7	xDT, CDA, DICOM, HL7, IHE.
5.4	Telemedicine	knows use cases for telemedicine applications and can explain their basic conditions.	The importance of telemedical applications for patient care is continuously increasing due to increasing specialization and lack of qualified personnel. Physicians should therefore be informed about possible applications and their framework conditions in order to be able to decide for the benefit of patients.	B	2	1,4	Teleradiology, telepathology, teleconsultation, patient monitoring at home, Ambient Assisted Living (AAL)

6	Data protection and regulatory requirements						
6.1	Ethical and legal foundations	can identify and apply fundamental principles of data protection.	Physicians, as special persons of trust and bearers of secrets, should handle the information entrusted to them competently and carefully. Acting ethically and in accordance with the law requires appropriate expertise.	B	3	1, 3, 4, 6, 7	Medical confidentiality, basic right of informational self-determination, national or international data protection regulation as the European General Data Protection Regulation, prohibition with reservation, principal of data economy. Organisational and technical data protection measures, handling of molecular genetic data.
6.2	Pseudonymisation/ Anonymisation	can explain and differentiate pseudonymised and anonymised patient data	Physicians should be able to assess whether patient data is sufficiently anonymised for processing outside the treatment context.	B	2	4, 6, 7	Definition of anonymisation and pseudonymisation, risk of re-identification.
6.3	Data security	can explain technical and organisational measures for the secure handling of patient data.	Transmission and auditable storage of patient data is required in the context of patient treatment .	B	2	1, 4	Federal institutions of information security, ISO 27001, Critical Infrastructure Protection, virus protection, symmetric/asymmetric cryptography, digital signature, authentication, backups, auditable storage/archiving of patient data.
6.4	Further legal aspects	knows legal principles in the context of medical documentation or information systems and can explain it	Physicians must know legal principles of medical documentation in order to apply it lege artis. In particular, it must be possible to answer the following questions: - Who has to document? - What is to be documented? - When is documentation required? - How is it to be documented? - Who may view the documentation? - How and how long is the documentation to be kept?	A	2	2, 3, 4, 6	Reversal of the burden of proof. Notification requirements. Examples of laws and regulations from which documentation requirements are derived, e.g. in Germany: Patient Rights Act §§630a ff BGB, SGB V, Transfusion Act, Radiation Protection Ordinance, X-ray Ordinance, Infection Protection Act, Professional Code of Conduct for Physicians, Medical Device Law (MPG), MDR-EU-V 745/2017.

6.5	MI in medical research	can specify regulatory requirements and data standards for medical research.	Physicians working in research should know regulatory requirements and standards (GCP) in order to be able to apply these in the planning and conduct of studies.	C	2	4, 5, 6, 7	Central role of IT systems and methods of medical informatics in health services research. CDISC, SDTM, MedDRA. Declaration of Helsiniki, Informed consent, GCP. Requirements for archiving of research data.

7	**Access to medical knowledge**						
7.1	Literature search	can conduct medical literature searches, apply search syntax correctly and assess the quality of knowledge sources.	Physicians need access to the current medical literature in order to retrieve the relevant knowledge for patient treatment and research.	A	3	1, 5, 7	Boolean operators. Quality assessment of the sources, stored queries, systematic procedure.
7.2	Controlled vocabulary	can explain the meaning of controlled vocabulary in medicine and use it in literature search.	Controlled vocabularies, especially Medical Subject Headings (MeSH), are necessary for efficient medical literature searches. Physicians should therefore be able to use it.	B	3	1, 5, 7	Use of MeSH descriptors to optimize recall and precision of a search query.
7.3	Recall and precision	knows the importance of recall and precision when searching in databases and can explain it.	Physicians should know quality criteria for evaluation of search results in order to to assess query results, especially for large databases.	B	2	1, 5, 7	
7.4	Medical databases	knows drug information systems and can apply them.	Drug information systems are essential for patient care, especially with regard to thera-peutic safety.	A	2	2, 3, 6	Contraindications, side effects and interactions.
7.5	Guidelines	knows quality and development stages of guidelines and can explain them	Physicians should be able to apply guidelines in patient care appropriately.	A	2	1, 2, 3, 6	Levels of evidence, level of recommendation. Role of knowledge-based decision support systems.

8	**Medical signal and image processing**						
8.1	Biosignal Processing	can name examples of medical biosignals, knows filter procedures for biosignals and can explain them.	Physicians work with various medical biosignals (e.g. ECG, EEG, EMG) in the context of diagnostics and therapy. They should therefore know the characteristics of these signals in order to be able to interpret them appropriately.	B	2	1	
8.2	Imaging methods	knows examples of medical images and can name their properties.	analogous to 7.1.	A	2	1	E.g. X-ray images, ultrasound images, microscopic and macroscopic images. DICOM standard.
8.3	Image processing	knows procedures for image processing and can explain and apply them.	Within the scope of imaging diagnostics, physicians should be able to apply basic procedures such as windowing, contrast/brightness control and simple filter procedures in order to avoid false diagnoses.	B	3	1	Windowing, Histogram spread/equalization (bone/ soft tissue window), edge and contrast enhancement.
8.4	Image evaluation	can explain and apply registration and segmentation of medical images	Physicians should be able to use image evaluation procedures in order to use them safely in diagnostics and therapy with imaging techniques.	B	3	1	Data- and model-driven procedures, diagnostic support systems.
8.5	Visualization	knows different visualization methods as well as their properties and characteristics (artifacts) and can explain them.	Physicians specialising in imaging procedures (radiology, cardiology, etc.) should be able to apply and assess visualisation procedures appropriately.	C	2	1	Data and model driven, direct and indirect visualization.

9	**Further topics**						
9.1	Quality and risk management	knows basic terms and methods of quality and risk management and can explain them	Physicians should know the most important terms and methods of quality and risk management to actively contribute to patient safety.	A	2	4, 5, 6	Structural/process/outcome quality, quality indicators, statutory external quality assurance, PDCA cycle, Critical Incident Reporting System (CIRS)
9.2	Internet for medical professionals	knows the rules for presentation of practices and clinics on the Internet as well as general conditions for medical consultations via the Internet.	Physicians are obliged to implement professional codes of conduct.	B	1	5, 6	Media literacy. Quality rules for websites with health-related content.
9.3	Medical teaching and learning systems	knows examples of medical teaching and learning systems and has experience in their use.	Physicians should be able to use simulators for medical skills in the context of education and training. They should also be familiar with teaching and learning systems for patients, so that they can advise them accordingly.	C	2	5, 7	
9.4	Bioinformatics in medical research	knows gene and protein databases and corresponding search methods and can explain them.	Physicians in basic research should be able to carry out appropriate database queries. Advances in personalised medicine are expected to lead to the use of such databases for routine care.	C	2	5, 6, 7	

List of abbreviations

AAL	ambient assisted living
CDA	clinical document architecture
CIRS	critical incident reporting system
DICOM	Digital Imaging and Communications in Medicine
DRG	Diagnosis Related Groups
EDC	electronic data capture
EMR	Electronic Medical Record
HL7	Health Level 7
ICD	International Classification of Diseases
IS	Information system
HIS	Hospital Information System
LIS	Laboratory Information System
LOINC	Logical Observation Identifiers Names and Codes
MeSH	medical subject headings
MI	Medical Informatics
PACS	Picture Archiving and Communication System
PDMS	Patient data management system (intensive care medicine)
RIS	Radiology Information System
SNOMED	Systematized nomenclature of medicine
UMLS	Unified Medical Language System
xDT	Data exchange formats for outpatient physicians