Guest Editorial AIoPT (Artificial Intelligence of Paediatric Things): Informatics in Meeting Paediatric Needs and Patient Monitoring

MEDICAL (health) informatics broadly encompasses the cognitive, information processing, and communication tasks inherent in medical practice, education, and research, with a particular emphasis on the development of computer-based patient records, decision support systems, information standards, data aggregation systems, communication systems, and educational programs for patients and health providers. In addition, this rapidly growing area is confronted with developing technological solutions sensitive to special populations' specific requirements, i.e., **Preventive, Assistive, and Medical Children Health Informatics**. First, children have distinct physiology, come from diverse backgrounds, and are disproportionately affected by illnesses. Thus, children are not little adults, as a famous adage among child health experts. These distinctions have been extensively discussed and are frequently called the four D's. Second, children depend on their parents and extended relatives to access necessary health care. Thus, plans must include gathering and distributing information to many patients. Third, childhood is defined by a developmental trajectory marked by fast change and the emergence of capacities for health information utilization. Fourth, children's health is defined by distinct epidemiology characterized by fewer significant chronic diseases, a high prevalence of acute illnesses, and reliance on preventative interventions. Finally, since children are the poorest and most varied in our society, they exhibit distinct demographic trends.

Pediatrics concerns the health and development of newborns, children, and adolescents and their ability to reach their full potential as adults. Pediatricians must be concerned with specific organ systems, biological processes, and environmental and societal factors that significantly affect children's physical, emotional, and mental health and social well-being. Pediatricians have diagnostic tools, medicines, and vaccinations at their disposal to improve health, but most importantly, they know children and their diseases, as well as data generated from their treatment [1]. Informatics and information technology have the potential to enhance health outcomes by using clinical data significantly. These characteristics contribute to their uniqueness and complexity as patients with complicated health information requirements. Despite demands for pediatric-specific health tools, little research on pediatric informatics and much less on children's unique requirements has been published. For example, children are an extensive and diverse group with different healthcare requirements from adults [2]. Numerous features of this group and the health care system that serves them need particular attention when designing and deploying improved information technology solutions. Explicitly defining children's specific health requirements concerning the healthcare community in which they get treatment can assist in explaining why "one size fits all" solutions do not apply to children's health. Thus, the health service research issues linked to the application of AIoPT (Artificial Intelligence of Paediatric Things) in Informatics in Meeting Paediatric are investigated and would be the focus of the present special issue.

Children Health Informatics (CHI) must develop into a major theme and technique for healthcare, childcare, and community health, including high-dimensional modeling and understanding of patients from preterm infants to children. The subject is fundamentally multidisciplinary, relying on conventional biological sciences, data science, biostatistics, epidemiology, decision theory, omics, implementation science, and health care policy and management [3], [4], [5]. The AIoPT faculty is deficient in the research literature, which complements the specialized medical, data science, computer science, mathematics, and epidemiology necessary for developing Preventive and Assistive Children's Health Informatics. Technologies that assist pediatric care must address problems such as growth and development, children's changing physiology, and children's specific illnesses and treatments. Connectivity and data integration are critical issues for child healthcare professionals. Consumer health information requirements for this group extend beyond the individual to the family level. With all of this in mind, this special issue aims to briefly overview some of the most recent developments in the study and use of AIoPT for Preventive, Assistive, and Medical Children's Health Informatics.

The first paper by Lachlan et al. [A1] performs research for the care of neonatal infants, and abdominal auscultation, and this research is considered a safe, convenient, and inexpensive method to monitor bowel conditions. With the help of early automated detection of bowel dysfunction, neonatologists could create a diagnosis plan for early intervention. The research evaluates the proposed method on abdominal sounds collected from 49 newborn infants admitted to our tertiary Neonatal

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Intensive Care Unit (NICU). The results of leave-one-patient-out cross-validation show that the proposed method provides an accuracy of 95.1% and an Area Under Curve (AUC) of 85.6%, outperforming both the baselines and the recent works significantly. These encouraging results show that the proposed Ensemble-based Deep Learning model is helpful for neonatologists to facilitate telehealth applications.

NeoCam, an open-source hardware-software platform for video-based monitoring of preterm newborns in Neonatal Intensive Care Units, is introduced in the second publication by Angel et al. ([A2]). (NICUs). The edge computing component of NEOCAM enables real-time video processing and acquisition. By conducting the majority of the processing on the device, including suitable anonymization for better compliance with privacy standards, it offers the advantage of handling data more efficiently compared to other proposed solutions. Additionally, it enables the simultaneous execution of numerous clinically relevant video analysis tasks at speeds between 20 and 30 frames per second. It introduced algorithms to measure the infants' body posture, motor activity, respiration rate, and emotional status without making physical contact. As long as there are enough light and ideal imaging conditions, the suggested approach agrees well with existing methods for measuring breathing rate. NeoCam has undergone preterm infant testing in the NICU of the University Hospital Puerta del Mar (Cádiz, Spain), and it has reported the findings from this trial.

Neonatal admitted to neonatal intensive care units (NICUs) are at risk for respiratory decompensation and may need endotracheal intubation, as shown in the third publication by Juengeun et al. [A3]. In particular, urgent unplanned intubation is connected with delayed intubation's higher morbidity and death. The safety margins can be increased by avoiding high-risk late intubation by correctly forecasting the need for intubation in real-time and allocating more time for preparation. This study used a deep neural network to forecast the likelihood of intubation in neonatal patients with respiratory issues. A multimodal transformer model was created to assess numeric data, such as preliminary clinical data and time-series data (1–3 h of vital signs and Fi$textO 2$ setting value). The proposed model successfully predicted the need for intubation three h in advance over a dataset containing data on 128 neonatal patients who underwent noninvasive ventilation (area under the receiver operator characteristic curve = 0.880 0.051, F1-score = 0.864 0.031, sensitivity = 0.886 0.041, specificity = 0.849 0.035, and accuracy = 0.857 0.032). The suggested model also showed strong generalization ability by obtaining AUROC 0.890, F1-score 0.893, specificity 0.871, sensitivity 0.745, and accuracy 0.864 using an additional 91 dataset for testing.

The fourth publication by Ethan et al. [A4] focuses on the possibility of remote cardio-respiratory health monitoring of newborns using stethoscope-recorded chest sounds. However, excellent heart and lung sounds are necessary for trustworthy monitoring. This research introduces new artificial intelligence-based Non-negative Matrix Factorization (NMF) and Non-negative Matrix Co-Factorization (NMCF) approaches to separate newborn chest sounds. An artificial mixed dataset of heart, lung, and noise sounds was created to evaluate these methods and contrast them with currently used single-source separation techniques. Then, signal-to-noise ratios for these synthetic combinations were computed.

Additionally, these approaches were evaluated using the signal quality score of 1–5, generated in their prior research, and real-world noisy newborn chest sounds. Each approach's computing efficiency was also evaluated to identify which was best for real-time processing. Overall, the proposed NMF and NMCF approaches exceed the next-best current method for the artificial dataset by 2.7 dB to 11.6 dB and for the real-world dataset by 0.40 dB to 1.12 dB, respectively. A 10 second recording's median processing time for the sound separation was found to be 28.3 seconds for NMCF and 342 milliseconds for NMF. The proposed approaches can be used to denoise neonatal heart and lung sounds in a real-world setting due to their steady and reliable performance.

The last publication by Yamei et al. [A5] demonstrates that the demand for automatic pediatric sleep staging has increased as a result of the prevalence and awareness of children's sleep disorders continuing to rise. Algorithms for recognizing stages of supervised sleep, however, frequently encounter difficulties including the scarcity of pediatric sleep doctors and data heterogeneity. Researchers suggested a multi-task contrastive learning technique for semi-supervised pediatric sleep stage detection, known as MtCLSS, by combining two domains that are rapidly developing: semi-supervised learning and self-supervised contrastive learning. Electroencephalogram (EEG) recordings of the complete night polysomnogram are specifically subjected to signal-adapted transformations, which enables the network to enhance its representational capability by recognizing the transformations. Additionally, the proposed study added an extension to the contrastive loss function, modifying contrastive learning for the semi-supervised environment. In this way, the proposed methodology increases the robustness of the model by learning broad characteristics from signal transformations in addition to task-specific features from a modest quantity of supervised data. A real-world paediatric sleep dataset is used to evaluate MtCLSS, and the results are encouraging (0.80 accuracy, 0.78 F1-score and 0.74 kappa). A well-known public dataset was used to test the generality of the proposed research work. The experimental findings show that the MtCLSS architecture is effective for EEG-based automatic pediatric sleep staging in situations with relatively little labeled data.

Each of the five papers focuses on a distinct but crucial domain vector of the medical, preventive, and assistive children's health informatics (PAMCHI). We believe this Special Issue will increase awareness in the scientific community by presenting and emphasizing the most recent unique and emerging technologies, implementations, and applications on the Informatics in Meeting Paediatric Needs. Finally, we would like to express our gratitude to all the authors who contributed their research to this special issue. We also want to thank the many subject-matter experts who participated in the review process and gave the authors valuable feedback on how to make the articles' contents and presentations better. We would also like to express our gratitude to Professor Dimitrios I. Fotiadis, the Editor-in-Chief, and the publishing team for their assistance and suggestions and comments, which were extremely useful during the challenging stages of finishing the special issue.

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APPENDIX
RELATED ARTICLES

[A1] L. Burne et al., "Ensemble approach on deep and hand-crafted features for neonatal bowel sound detection," *IEEE J. Biomed. Health Inform.*, early access, Oct. 27, 2022, doi: 10.1109/JBHI.2022.3217559.

[A2] A. Ruiz-Zafra et al., "NeoCam: An edge-cloud platform for non-invasive real-time monitoring in neonatal intensive care units," *IEEE J. Biomed. Health Inform.*, early access, Feb. 01, 2023, doi: 10.1109/JBHI.2023.3240245.

[A3] J.-E. Im, S.-A. Yoon, Y. M. Shin, and S. Park, "Real-time prediction for neonatal endotracheal intubation using multimodal transformer network," *IEEE J. Biomed. Health Inform.*, early access, Apr. 17, 2023, doi: 10.1109/JBHI.2023.3267521.

[A4] E. Grooby et al., "Noisy neonatal chest sound separation for high-quality heart and lung sounds," *IEEE J. Biomed. Health Inform.*, early access, Oct. 20, 2022, doi: 10.1109/JBHI.2022.3215995.

[A5] Y. Li, S. Luo, H. Zhang, Y. Zhang, Y. Zhang, and B. Lo, "MtCLSS: Multi-task contrastive learning for semi-supervised pediatric sleep staging," *IEEE J. Biomed. Health Inform.*, early access, Oct. 10, 2022, doi: 10.1109/JBHI.2022.3213171.

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[2] J. Oliveira et al., "The CirCor DigiScope dataset: From murmur detection to murmur classification," *IEEE J. Biomed. Health Inform.*, vol. 26, no. 6, pp. 2524–2535, Jun. 2022.

[3] F. Ma, L. Yu, L. Ye, D. D. Yao, and W. Zhuang, "Length-of-stay prediction for pediatric patients with respiratory diseases using decision tree methods," *IEEE J. Biomed. Health Inform.*, vol. 24, no. 9, pp. 2651–2662, Sep. 2020.

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[5] M. Piriyajitakonkij et al., "SleepPoseNet: Multi-view learning for sleep postural transition recognition using UWB," *IEEE J. Biomed. Health Inform.*, vol. 25, no. 4, pp. 1305–1314, Apr. 2021.