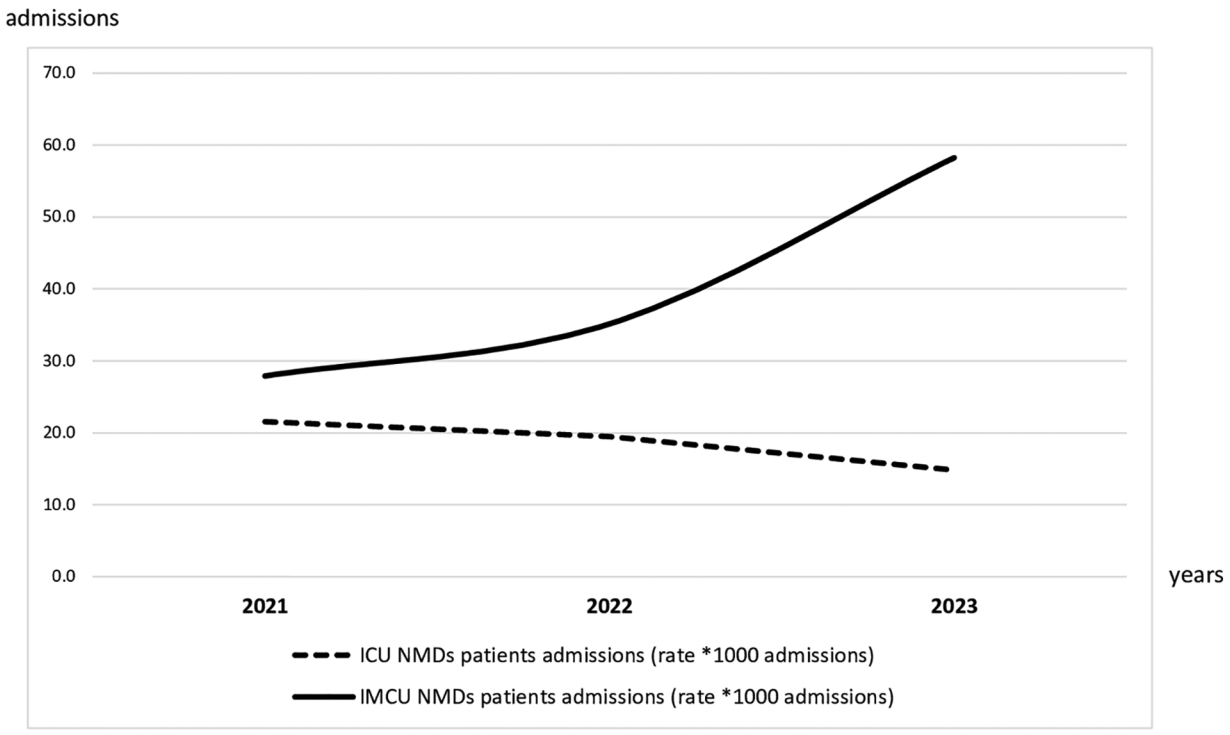

	2021	2022	June 2023
ICU total admissions	511	514	338
ICU NMDs patients admissions	11	10	5
ICU NMDs patients admissions (rate *1000 admissions)	21,5	19,5	14,8
IMCU total admissions	645	768	309
IMCU NMDs patients admissions	18	27	18
IMCU NMDs patients admissions (rate *1000 admissions)	27,9	35,2	58,3
ICU length of stay (days, median)	4	3	2

FIGURE 3
Trends of intensive care unit and intermediate care unit admissions over the study period of patients with NMDs. ICU, intensive care unit; NMD, neuromuscular disorders; IMCU, intermediate care unit.

decreased ICU bed use. However, we can preliminarily estimate that a 1-day stay in the IMCU, compared to the ICU, allows for an average saving of 840 euros per patient. We plan to properly evaluate this relevant aspect in a dedicated study. Moreover, the short period included in the study reduces the statistical power of our analysis. We were not able to carry out an adequate comparison with similar studies since research focusing on pediatric IMCU is very limited. In Italy, this likely depends on the lack of specific regulatory legislation which leads to a marked variability in terms of structuring, equipment, and staffing of pediatric IMCUs (36). Following this, the single-center nature of the study may also limit the generalizability of our findings because of site-specific practices and policies, including the availability of staff and equipment, and the hospital organization.

We are also aware that a multicenter study comparing our populations with NMD patients admitted to hospitals without IMCU would be desirable as it would provide even more accurate data on the impact of the introduction of IMCU in a hospital's operation.

Finally, patients with NMDs are affected by different diseases with heterogeneous pathophysiology. Given that, the reasons for hospitalization and the received treatments (i.e., steroids) may vary from one another thus limiting the possibility of drawing definite conclusions.

Multi-center and prospective studies accompanied by the implementation of the development process of pediatric IMCUs and their homogenization may contribute to overcoming these limitations.

Conclusions

While the concept of a pediatric IMCU is still evolving, with variations across healthcare systems, our exploratory findings advocate for its crucial role in the nuanced care of children with NMDs. Future studies should aim to evaluate the broader impacts on hospital costs, pediatric critical care, and both clinical and psychological outcomes for patients.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Regione Liguria Ethical Board (RCR-2022-23682290). The studies were conducted in accordance with the local legislation and institutional requirements. The ethics committee/institutional review board waived the requirement of written informed consent for participation from the participants or the participants' legal guardians/next of kin because of the retrospective nature of the study. In any case, consent to completely anonymous use of clinical data for research/epidemiological purposes is requested by the clinical routine at the time of admission/diagnostic procedure in our hospital.

Author contributions

GB: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Writing – original draft, Writing – review & editing, Methodology. MS: Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. FC: Data curation, Investigation, Writing – original draft, Writing – review & editing. MM: Data curation, Formal analysis, Investigation, Methodology, Resources, Writing – original draft, Writing – review & editing. DP: Investigation, Supervision, Validation, Writing – original draft, Writing – review & editing. MR: Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. GT: Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. NB: Data curation, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. SB: Supervision, Validation, Writing – original draft, Writing – review & editing. MP: Conceptualization, Investigation, Resources, Validation, Writing – original draft, Writing – review & editing. CF: Funding acquisition, Supervision, Validation, Writing – original draft, Writing – review & editing, Conceptualization, Data curation. PS: Conceptualization, Funding acquisition, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. CB: Conceptualization, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. AM: Funding acquisition, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

Generative AI statement

The author(s) declare that no Generative AI was used in the creation of this manuscript.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fped.2025.1539540/full#supplementary-material

References

1. Racca F, Sansone VA, Ricci F, Filosto M, Pedroni S, Mazzone E, et al. Emergencies cards for neuromuscular disorders. 1st consensus meeting from UILDM - Italian muscular dystrophy association. Workshop report. *Acta Myol*. (2022) 41:135–77. doi: 10.36185/2532-1900-081

2. Darras BT, Jones HR Jr. Neuromuscular problems of the critically ill neonate and child. *Semin Pediatr Neurol*. (2004) 11(2):147–68. doi: 10.1016/j.spen.2004.04.003

3. Harrar DB, Darras BT, Ghosh PS. Acute neuromuscular disorders in the pediatric intensive care unit. *J Child Neurol*. (2020) 35(1):17–24. doi: 10.1177/0883073819871437

4. Deenen JC, Horlings CG, Verschuuren JJ, Verbeek AL, van Engelen BG. The epidemiology of neuromuscular disorders: a comprehensive overview of the literature. *J Neuromuscul Dis*. (2015) 2(1):73–85. doi: 10.3233/JND-140045

5. Ricci G, Torri F, Bianchi F, Fontanelli L, Schirinzi E, Gualdani E, et al. Frailties and critical issues in neuromuscular diseases highlighted by SARS-CoV-2 pandemic: how many patients are still "invisible"? *Acta Myol*. (2022) 41(1):24–9. doi: 10.36185/2532-1900-065

6. Kao WT, Tseng YH, Jong YJ, Chen TH. Emergency room visits and admission rates of children with neuromuscular disorders: a 10-year experience in a medical center in Taiwan. *Pediatr Neonatol*. (2019) 60(4):405–10. doi: 10.1016/j.pedneo.2018.09.008

7. Yates K, Festa M, Gillis J, Waters K, North K. Outcome of children with neuromuscular disease admitted to paediatric intensive care. *Arch Dis Child*. (2004) 89(2):170–5. doi: 10.1136/adc.2002.019562

8. Noritz G, Naprawa J, Apkon SD, Kinnett K, Racca F, Vroom E, et al. Primary care and emergency department management of the patient with duchenne muscular dystrophy. *Pediatrics*. (2018) 142(Suppl 2):S90–8. doi: 10.1542/peds.2018-0333K

9. Josef F. The spectrum of neuromuscular disorders admitted to a pediatric intensive care unit is broader than anticipated. *J Child Neurol*. (2020) 35(4):300–1. doi: 10.1177/0883073819894852

10. Simonds AK. Respiratory support for the severely handicapped child with neuromuscular disease: ethics and practicality. *Semin Respir Crit Care Med*. (2007) 28(3):342–54. doi: 10.1055/s-2007-981655

11. Flandreau G, Bourdin G, Leray V, Bayle F, Wallet F, Delannoy B, et al. Management and long-term outcome of patients with chronic neuromuscular disease admitted to the intensive care unit for acute respiratory failure: a single-center retrospective study. *Respir Care*. (2011) 56(7):953–60. doi: 10.4187/respcare.00862

12. Ko MSM, Poh PF, Heng KYC, Sultana R, Murphy B, Ng RWL, et al. Assessment of long-term psychological outcomes after pediatric intensive care unit admission: a systematic review and meta-analysis. *JAMA Pediatr*. (2022) 176(3):e215767. doi: 10.1001/jamapediatrics.2021.5767

13. Pryce P, Gangopadhyay M, Edwards JD. Parental adverse childhood experiences and post-PICU stress in children and parents. *Pediatr Crit Care Med*. (2023) 24(12):1022–32. doi: 10.1097/PCC.0000000000003339

14. Jaimovich DG, Committee on Hospital Care and Section on Critical Care. Admission and discharge guidelines for the pediatric patient requiring intermediate care. *Crit Care Med*. (2004) 32(5):1215–8. doi: 10.1097/01.CCM.0000126001.23141.4F

15. Plate JDJ, Leenen LPH, Houwert M, Hietbrink F. Utilisation of intermediate care units: a systematic review. *Crit Care Res Pract*. (2017) 2017:8038460. doi: 10.1155/2017/8038460

16. Capuzzo M, Volta C, Tassinati T, Moreno R, Valentin A, Guidet B, et al. Hospital mortality of adults admitted to intensive care units in hospitals with and without intermediate care units: a multicentre European cohort study. *Crit Care*. (2014) 18(5):551. doi: 10.1186/s13054-014-0551-8

17. Solberg BC, Dirksen CD, Nieman FH, van Merode G, Ramsay G, Roekaerts P, et al. Introducing an integrated intermediate care unit improves ICU utilization: a prospective intervention study. *BMC Anesthesiol*. (2014) 14:76. doi: 10.1186/1471-2253-14-76

18. Bertolini G, Confalonieri M, Rossi C, Rossi G, Simini B, Gorini M, et al. Costs of the COPD. Differences between intensive care unit and respiratory intermediate care unit. *Respir Med*. (2005) 99(7):894–900. doi: 10.1016/j.rmed.2004.11.014

19. Cheng DR, Hui C, Langrish K, Beck CE. Anticipating pediatric patient transfers from intermediate to intensive care. *Hosp Pediatr*. (2020) 10(4):347–52. doi: 10.1542/hpeds.2019-0260

20. Brisca G, Tardini G, Pirlo D, Romanengo M, Buffoni I, Mallamaci M, et al. Learning from the COVID-19 pandemic: IMCU as a more efficient model of pediatric critical care organization. *Am J Emerg Med*. (2023) 64:169–73. doi: 10.1016/j.ajem.2022.12.009

21. Ettinger NA, Hill VL, Russ CM, Rakoczy KJ, Fallat ME, Wright TN, et al. Guidance for structuring a pediatric intermediate care unit. *Pediatrics*. (2022) 149(5):e2022057009. doi: 10.1542/peds.2022-057009

22. The Jamovi Project. Jamovi. (Version 2.4) [Computer Software] (2023). Available online at: https://www.jamovi.org (accessed August 10, 2023).

23. R Core Team. R: a language and environment for statistical computing. (Version 4.1) [Computer software] (2022). Available online at: https://cran.r-project.org (R packages retrieved from CRAN snapshot 2023-04-07) (accessed August 10, 2023).

24. Russ CM, Agus M. Triage of intermediate-care patients in pediatric hospitals. *Hosp Pediatr*. (2015) 5(10):542–7. doi: 10.1542/hpeds.2014-0144

25. Fuller C, Wineland AM, Richter GT. Update on pediatric tracheostomy: indications, technique, education, and decannulation. *Curr Otorhinolaryngol Rep*. (2021) 9(2):188–99. doi: 10.1007/s40136-021-00340-y

26. Volsko TA, Parker SW, Deakins K, Walsh BK, Fedor KL, Valika T, et al. AARC clinical practice guideline: management of pediatric patients with tracheostomy in the acute care setting. *Respir Care*. (2021) 66(1):144–55. doi: 10.4187/respcare.08137

27. Yehya N, Servaes S, Thomas NJ, Nadkarni VM, Srinivasan V. Corticosteroid exposure in pediatric acute respiratory distress syndrome. *Intensive Care Med*. (2015) 41(9):1658–66. doi: 10.1007/s00134-015-3953-4

28. Jacobs A, Derese I, Vander Perre S, Wouters PJ, Verbruggen S, Billen J, et al. Dynamics and prognostic value of the hypothalamus-pituitary-adrenal axis responses to pediatric critical illness and association with corticosteroid treatment: a prospective observational study. *Intensive Care Med*. (2020) 46(1):70–81. doi: 10.1007/s00134-019-05854-0

29. Menon K, McNally JD, Choong K, Lawson ML, Ramsay T, Hutchison JS, et al. A cohort study of pediatric shock: frequency of corticosteriod use and association with clinical outcomes. *Shock*. (2015) 44(5):402–9. doi: 10.1097/SHK.0000000000000355.

30. Birnkrant DJ, Pope JF, Eiben RM. Management of the respiratory complications of neuromuscular diseases in the pediatric intensive care unit. *J Child Neurol*. (1999) 14(3):139–43. doi: 10.1177/088307389901400301

31. Arslan Ş, Yorulmaz A, Sert A, Akin F. Management of acute mitochondriopathy and encephalopathy syndrome in pediatric intensive care unit: a new clinical entity. *Acta Neurol Belg*. (2020) 120(5):1115–21. doi: 10.1007/s13760-019-01125-3

32. Gregoretti C, Ottonello G, Chiarini Testa MB, Mastella C, Ravà L, Bignamini E, et al. Survival of patients with spinal muscular atrophy type 1. *Pediatrics*. (2013) 131(5):e1509–14. doi: 10.1542/peds.2012-2278

33. Simonds AK. Home ventilation. *Eur Respir J Suppl*. (2003) 47:38S–46. doi: 10.1183/09031936.03.00029803

34. Khirani S, Bersanini C, Aubertin G, Bachy M, Vialle R, Fauroux B. Non-invasive positive pressure ventilation to facilitate the post-operative respiratory outcome of spine surgery in neuromuscular children. *Eur Spine J*. (2014) 23(Suppl 4):S406–11. doi: 10.1007/s00586-014-3335-6

35. Smith A, Kelly DP, Hurlbut J, Melvin P, Russ CM. Initiation of noninvasive ventilation for acute respiratory failure in a pediatric intermediate care unit. *Hosp Pediatr*. (2019) 9(7):538–44. doi: 10.1542/hpeds.2019-0034

36. Sfriso F, Biban P, Paglietti MG, Giuntini L, Rufini E, Mondardini MC, et al. Distribution and characteristics of Italian paediatric intermediate care units in Italy: a national survey. *Acta Paediatr*. (2020) 109(5):1062–3. doi: 10.1111/apa.15091