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Variability of nursing complexity within medically homogeneous diagnosis-related groups: A retrospective analysis of pediatric electronic health records

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ABSTRACT

Background: This study examined variability in nursing complexity among pediatric patients within the same Diagnosis-related group (DRG) and assessed whether exceeding DRG-specific length-of-stay (LOS) thresholds was associated with higher nursing complexity.
Methods: A retrospective study analyzed electronic health records of pediatric inpatients admitted in 2022 to a tertiary hospital, focusing on the 20 most frequent DRGs. Nursing complexity was assessed using nursing diagnoses (NDs) recorded within 24 h of admission and nursing actions (NAs) documented during hospitalization. Group differences were assessed using independent-samples *t*-tests and Mann–Whitney *U* tests. Blockwise multivariable logistic regression estimated associations with LOS threshold exceedance: the first model included ND count adjusted for age, sex, DRG weight, and comorbidities, while the second additionally incorporated NA count.
Results: Among 1204 patients, 4247 NDs and 22014 NAs were recorded. NDs ranged 1–14 and NAs 5–59, with marked intra- and inter-DRG variability. Patients exceeding LOS thresholds (2.6%) had higher ND and NA counts (mean 6.29 vs 3.45 and median 27 vs 17, respectively; both $p < 0.001$). In the fully adjusted model, each additional ND increased the odds of LOS threshold exceedance by 25% (OR = 1.25, 95% CI 1.09–1.43, $p = 0.001$), and each additional NA by 9% (OR = 1.09, 95% CI 1.05–1.14, p < 0.001).
Conclusions: Nursing complexity varies within and across DRGs and is higher among patients exceeding LOS thresholds.
Implications to practice: Standardized nursing data may complement DRG classifications to better reflect nursing complexity and inform future reimbursement models.

Introduction

Two children with the same medical diagnosis, admitted to the same hospital unit, and classified under the same Diagnosis-related group (DRG), may appear comparable, with care that on paper seems standardized, predictable, and billable. But at the bedside, things often look very different, and their needs can differ substantially. One may require constant monitoring, extensive parental education, and emotional support; the other, a more linear, low-intensity care pathway. Despite this, both are formally classified and reimbursed as if they consumed the same nursing resources, with no distinction in reporting (Di Nitto et al., 2025; Pirson et al., 2013; Welton, Zone-Smith, & Fischer, 2006). Yet this variability is not merely descriptive: it reflects differences in nursing complexity that may predict the amount and type of nursing care required during hospitalization. In clinical practice, these

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differences have implications for nursing assignments, staffing needs, and, more broadly, nurse-to-patient configurations at the unit level, ultimately translating into differential resource consumption and associated costs of care. Prior research has shown that nursing complexity is associated with staffing patterns and nursing costs, while remaining insufficiently captured by DRG-based reimbursement systems (Fabrizi et al., 2024; Welton, Unruh, & Halloran, 2006).

This paradox brings a critical inquiry: does DRG-based classification accurately reflect the nursing care necessary to address patients' personalized, actual, and potential needs? If not, reimbursement models based exclusively on medical classification may fail to capture a critical component of hospital resource use.

In pediatric settings, where patient care is influenced not only by medical conditions but also by factors like age, developmental status, communication challenges, family involvement, and the child's and their caregivers' distinct responses and vulnerabilities (Herdman et al., 2024; Musselman et al., 2023; Navein et al., 2022), it becomes apparent that DRG groupings may not adequately capture nursing complexity. Indeed, while DRG assignment is based on medical diagnoses and procedures that reflect medical complexity, nursing complexity depends on the patient's specific responses, functional needs, and care intensity (Cesare, D'Agostino, Damiani, et al., 2025; Cesare, D'Agostino, Sebastiani, et al., 2025). This misalignment extends to hospital billing and reimbursement, where standardized DRG rates overlook nursing care, leaving the issue largely unexplored in reporting and funding frameworks (Welton & Longyear, 2024).

Background

DRGs are among the most widely used systems for classifying hospitalized patients with similar medical conditions. Initially developed at Yale University in the 1970s by Robert B. Fetter and John D. Thompson to improve care planning, monitor hospital performance, and align funding with expected resource use (Fetter et al., 1976; Fetter et al., 1977; Fetter et al., 1980; Thompson et al., 1979), DRGs have since become a cornerstone of reimbursement systems across many countries (Aragón et al., 2022; Fabrizi et al., 2024; Feng et al., 2020; Laport et al., 2008; Nonis et al., 2018). Over time, their role has progressively shifted from a classification tool to a financial lever, designed to standardize funding, incentivize efficiency, and contain costs within fixed payment schemes (Chen et al., 2023; Maniaci et al., 2023; Milstein & Schreyögg, 2024; Woo & Anderson, 2020).

In Italy, the Medicare DRG Version 24.0—adopted in 2009—remains the national standard for remunerating acute care services in public and accredited private hospitals (Ministero della Salute, 2025). Each hospitalization is assigned a DRG code, a relative weight (i.e., a numerical value reflecting the expected resource use associated with that DRG), and an associated cost (Mihailovic et al., 2016). To account for exceptional cases, length of stay (LOS) thresholds are also applied to flag outliers and adjust payments for unusually long hospitalizations (Felder, 2009).

Despite these advances in cost control and standardization, DRGs remain fundamentally centered on medical diagnoses and procedures. Within this paradigm, the DRG framework considers nursing care, as well as the contribution of other non-physician healthcare professionals, as a generic, undifferentiated cost item, collapsed under hospital services rather than recognized as a distinct and measurable component of care delivery (Cesare, D'Agostino, Sebastiani, et al., 2025; Fabrizi et al., 2024; Pirson et al., 2013; Welton, Zone-Smith, & Fischer, 2006). In practice, this structural reductionism assumes that patients within the same DRG consume similar care resources; however, this assumption does not reflect clinical reality, as it disregards variability in care needs, and nursing complexity (Bagnasco et al., 2025; Sanson et al., 2017; Sasso et al., 2017). The consequences are twofold: first, the actual contribution of nursing to patient care remains invisible in reimbursement logic; second, the variability of nursing complexity among medically similar patients is systematically underestimated. This gap becomes particularly evident when considering standardized nursing diagnoses (NDs), which are derived from patient assessment, and nursing actions (NAs), which are implemented during care delivery; together, these indicators provide a measure of nursing complexity (Cocchieri et al., 2025; Sanson, Welton, et al., 2019) but are still largely excluded from administrative records and policy frameworks (Cesare, D'Agostino, Sebastiani, et al., 2025; Spetz et al., 2019). In practical terms, NDs may include conditions such as fall risk, infection risk, acute pain, or breathing pattern impairment, whereas NAs may include safety monitoring, pain assessment, nutritional assessment, medication administration, and caregiver education. These data help make visible aspects of care demand that are often not represented in diagnosis- and procedure-based reimbursement systems. Conceptually, early NDs may support the prospective identification of nursing care needs, whereas aggregated NAs may better reflect the nursing care delivered and therefore inform ex-post evaluation of resource use; taken together, they contribute to a more comprehensive definition of nursing complexity (Cesare, D'Agostino, Sebastiani, et al., 2025).

Over several decades, studies have documented the weak correspondence between DRG weight and nursing complexity. Paradoxically, nursing complexity has even been suggested as a determinant of DRG weight, underscoring a structurally asymmetric relationship that exposes the conceptual and methodological limits of DRG-based reimbursement systems (Cesare, D'Agostino, Sebastiani, et al., 2025; Halloran & Kiley, 1987; Joya et al., 2022). In response, several scholars have called for the systematic inclusion of nursing data in hospital discharge registers (HDRs) to enhance the visibility of nursing contributions and to improve alignment between funding and care actually delivered (Bagnasco et al., 2025; Sanson et al., 2017; Welton, 2024; Welton & Halloran, 2005).

Yet, while this need is conceptually acknowledged, its empirical evidence remains scarce. In particular, no study has systematically examined variability in nursing complexity (i.e., NDs and NAs) within medically homogeneous DRGs in pediatrics—an area where variability could be intrinsic due to patient age, developmental stage, psychosocial context, family dynamics, and communication challenges (Hallman & Bellury, 2020; Härkönen et al., 2017; Navein et al., 2022; Verhage et al., 2020). Within this setting, standardized nursing languages (SNLs)—such as NDs and NAs—offer a promising approach to capture and quantify nursing complexity variations in pediatric patients grouped under the same DRG classification—where coding criteria assume similarity, but real-world patient care demands may differ considerably.

Building on this background, the present study aimed to explore the variability of NDs and NAs within the most representative pediatric DRGs in a hospital cohort. The specific objectives were to: (1) describe the prevalence and characteristics of the most frequent DRGs in the pediatric population over the study period; (2) examine intra-DRG variability in sociodemographic, clinical, and administrative characteristics; (3) analyze variability in patient care based on NDs and NAs among patients classified under these DRGs; and (4) evaluate differences in NDs and NAs between patients who exceeded the DRG LOS threshold and those who did not.

Hypotheses

Based on these objectives, we hypothesized that: (1) there is substantial intra-DRG variability in NDs and NAs, even among medically homogeneous patients; and (2) patients exceeding the DRG-specific LOS threshold would present a higher number of NDs and NAs compared to those within the expected LOS.

Methods

Design

Retrospective observational study. The study was reported according to the Reporting of Studies Conducted using Observational Routinely

Collected Health Data statement (Benchimol et al., 2015) (Supplementary File 1).

Sample, setting, and inclusion criteria

The present study was conducted in a pediatric department of one of the largest tertiary care centers in Italy (8 Departments, 259 Units, 1552 curative beds), and included patients under 18 years of age admitted in 2022. No restrictions were applied regarding the hospital unit of admission, as the aim was to capture a comprehensive overview of pediatric hospitalizations across clinical areas. Only admissions for which parental/legal guardian general consent for personal data processing and potential re-contact had been documented in the electronic health record (EHR) were considered eligible. For the purposes of this study, the research team reviewed the documented EHR consent status and subsequently contacted guardians by telephone to obtain study-specific informed consent for the use of routinely collected clinical and nursing data. Admissions for which study-specific consent was not confirmed were excluded from the analysis. This inclusion criterion was applied consistently to all eligible admissions in accordance with Ethics Committee requirements and local institutional regulations governing the secondary use of routinely collected pediatric clinical data (see Ethical Considerations section). To ensure analytical relevance and align with the study objectives, we focused our analyses on the 20 most frequent DRGs observed among all pediatric hospitalizations during the study period (Gluckman et al., 2020; Hennen et al., 1995).

Data sources and collection

Data were extracted from the hospital's EHR system, which includes standardized nursing documentation captured through the Neonatal and Pediatric Professional Assessment Instrument (PAI*ped*) (Cocchieri et al., 2018), a clinical nursing information system structured according to the Nursing Minimum Data Set framework. PAI*ped* is digitally embedded within the hospital EHR and designed to support standardized nursing assessment, diagnosis, and action planning in pediatric and neonatal settings. The system integrates the Clinical Care Classification (CCC) (Saba, 2012), a SNL translated into Italian (Zeffiro et al., 2021) for coding both NDs and NAs, which are entered as structured, coded fields within the EHR. At the operational level, NAs are also specified through the Italian Nomenclature of Nursing Care Performance (INNCP) (Cesare et al., 2024; Sanson, Alvaro, et al., 2019), a locally implemented SNL integrated into PAI*ped* and automatically cross-mapped with CCC codes. INNCP specifies NAs at a more detailed level, offering granular insights into the care process (Cesare, D'Agostino, Damiani, et al., 2025).

PAI*ped* is supported by a validated algorithm (Zega et al., 2014) that, based on the initial nursing assessment, suggests a set of relevant NDs. The nurse can choose to accept these suggestions, reject them, or add new NDs as deemed appropriate. Each selected ND activates a predefined set of standardized NAs from which nurses select the activities delivered during hospitalization and subsequently record them within the system. This structured linkage ensures consistent and standardized documentation of nursing care. The PAI*ped* was implemented at the study hospital in 2016, and annual audits are conducted to evaluate and improve the quality of nursing documentation (Cesare, Magliozzi, D'Agostino, et al., 2025).

For each eligible admission, demographic, clinical, administrative, and nursing data were extracted from the EHR by authorized personnel from the Information and Communication Technology service of the study hospital, using a structured query, and the resulting dataset was anonymized prior to analysis. The specific study variables are described in the following section.

Variables and measures

To address the study objectives, data were extracted from clinical, administrative, and nursing sources documented in the hospital's EHR. Variables were selected to capture patient characteristics, care delivery processes, and reimbursement-related metrics. The following were collected:

- Sociodemographic variables: patient age (years) and gender (male/female);
- Clinical variables: number of comorbidities and chronic conditions, and number of medical procedures performed during hospitalization;
- Administrative variables: DRG code, DRG category (medical/surgical), Major Diagnostic Category (MDC), DRG weight, LOS (days), and DRG-specific LOS threshold (days), according to Italian national regulation (Ministero della Salute, 2025);
- Nursing complexity variables:
  - NDs: standardized nursing judgements that describe actual or potential patient responses to health conditions or life processes and guide the planning and implementation of appropriate NAs. In this study, NDs were those documented within the first 24 h of hospital admission and validated by the responsible nurse; therefore, they were conceptualized as an early assessment-based measure of nursing complexity (Sanson, Welton, et al., 2019);
  - NAs: standardized nursing activities aimed at preventing, monitoring, or managing patient conditions as defined by the NDs. In this study, NAs referred to those documented throughout the entire patient hospitalization; therefore, they were conceptualized as a measure of nursing care delivered over time (Cesare, D'Agostino, Damiani, et al., 2025). Accordingly, NAs were interpreted as cumulative hospitalization-level measures reflecting overall care volume, rather than time-standardized measures of care intensity;
- Outcome variables: DRG-specific LOS threshold exceedance (yes/no), defined as whether the hospitalization LOS exceeded the DRG-specific LOS threshold (Ministero della Salute, 2025), directly addressing the fourth study objective.

Statistical analysis

Descriptive statistics were used to summarize the sociodemographic, clinical, and nursing complexity variables within each DRG. Categorical variables were reported as frequencies and percentages (e.g., DRGs prevalence), and continuous variables as means and standard deviations (SD) (e.g., age) or median values and interquartile ranges (IQR) (e.g., LOS), as appropriate and based on their distribution. The normality of continuous variables was assessed by examining skewness and kurtosis indices, with absolute values within ± 2 for skewness and $\pm$ 7 for kurtosis considered acceptable thresholds for approximate normality (Kim, 2013; Ryu, 2011).

To explore the variability in NDs and NAs within each DRG, individual patient-level data were graphically represented using violin plots. These plots allow visual inspection of the dispersion of nursing care indicators within clinically homogeneous DRG groups. To compare the number of NDs between patients who exceeded the LOS threshold (outliers) and those with a normal LOS, an independent samples *t*-test was performed. The assumption of homogeneity of variances was assessed using Levene's test, and both the standard *t*-test (equal variances assumed) and Welch's correction (equal variances not assumed) were reported to ensure the robustness of results. The magnitude of between-group differences was assessed using Cohen's *d*, which quantifies the standardized mean difference; values of 0.2, 0.5, and 0.8 are conventionally interpreted as small, medium, and large effects, respectively (Cohen, 2013).

To compare the number of NAs between patients with normal LOS and outliers, a Mann–Whitney *U* test was performed due to the non-normal distribution of NAs. Alongside the *U* statistic, standardized *Z*-score, and two-tailed *p*-value, the Hodges–Lehmann estimator (interpreted as a pseudomedian when distributions are asymmetric) with its 95% CI was reported as a robust nonparametric measure of the median difference between groups (Staffa & Zurakowski, 2020). No correction for multiple testing was applied, as the comparisons were planned a priori and limited to the primary hypotheses of the study.

To further examine whether nursing complexity indicators were independently associated with LOS threshold exceedance, a two-step (blockwise) multivariable logistic regression approach was used. Given the low prevalence of LOS outliers, model complexity was deliberately restricted to a parsimonious set of clinically relevant covariates to reduce the risk of overfitting. In the first model, ND count was entered as the primary predictor and adjusted for age, sex, DRG weight, and total comorbidities. In the second model, NA count was additionally included to evaluate whether ND retained an independent association beyond overall NAs volume. Results were expressed as odds ratios (ORs) with 95% confidence intervals (CIs). Multicollinearity was assessed using variance inflation factors (VIFs). All analyses and visualizations were performed using IBM SPSS Statistics® for macOS (version 30) (Armonk, NY, USA: IBM Corp.) and R for macOS (version 4.5.1) with *ggplot2* package (version 3.5.2) (R Core Team, 2025; Wickham, 2016).

Ethical considerations

The study received approval from the Ethics Committee of the Catholic University of the Sacred Heart (Protocol no. 0012915/24, ID 6752; Approved on 16 May 2024). Although the study was retrospective, study-specific informed consent was required by the Ethics Committee for the secondary use of pediatric EHR data. In line with this requirement, general consent for personal data processing and potential recontact was routinely obtained from parents or legal guardians at admission and documented in a structured EHR module. When feasible, guardians were re-contacted by telephone—up to three attempts over a three-month period—to provide information on the study, confirm study-specific informed consent, and reiterate their right to withdraw at any time. Written consent was also obtained from healthcare professionals whose documentation was included. All data were anonymized and stored in a secure, password-protected database accessible only to the research team, in accordance with the Declaration of Helsinki, Good Clinical Practice guidelines, and applicable data protection regulations.

Results

Prevalence and characteristics of the top 20 DRGs in the pediatric cohort

During the study year, the 20 most frequent DRGs represented 57.7% of all pediatric hospitalizations and constituted the analytic sample ($N = 1204$). Before selection of the analytic sample, 62 otherwise eligible admissions were excluded because study-specific parent/legal guardian consent could not be confirmed, while an additional 73 admissions were excluded because parents or legal guardians could not be reached during the consent process.

The most frequent DRG was 26 (Seizure & Headache Age 0–17), representing 9.9% of cases. DRG 3 (Craniotomy Age 0–17) showed the highest DRG weight (2.3194) and the second-highest LOS threshold (40 days). DRG costs per episode also varied substantially across the DRGs, ranging from €588 for DRG 60 (Tonsillectomy &/Or Adenoidectomy Only, Age 0–17) to €8860 for DRG 3. The DRG characterized by the longest LOS threshold was DRG 430 (Psychoses), with 44 days. The lowest DRG weight was observed in DRG 422 (Viral Illness & Fever of Unknown Origin Age 0–17) at 0.3634, while the DRGs distinguished by the shortest LOS thresholds (4 days) were DRG 30 (Traumatic Stupor & Coma, Coma <1 Hr Age 0–17) and DRG 60 (Tonsillectomy and/or Adenoidectomy Only, Age 0–17). Overall, 60% of the top DRGs were medical, and 40% were surgical. The most represented Major Diagnostic Category (MDC) was MDC 01 (Diseases and Disorders of the Nervous System), which included 7 of the top 20 DRGs and accounted for over one-third of the cases (Table 1).

Sociodemographic, clinical, and administrative characteristics of patients within the analyzed DRGs

Among the analyzed DRGs, the mean age ranged from 2.5 years (DRG 98 – Bronchitis & Asthma) to 14.9 years (DRG 290 – Thyroid Procedures). The proportion of female patients varied widely, from 11.8% (DRG 430 – Psychoses) to 100% (DRG 359 – Uterine & Adnexa Procedures). The number of comorbidities and chronic conditions was

Table 1
Prevalence and characteristics of the top 20 DRGs in the pediatric cohort ($N = 1204$).

DRG characteristics							Descriptive Statistics	
Code	Description	Category	MDC	Weight	LOS threshold	DRG cost per episode (€)	N	%
26	Seizure & Headache Age 0–17	M	01	0.4853	10	1.729	207	9.9
3	Craniotomy Age 0–17	S	01	2.3194	40	8.860	159	7.6
35	Other Disorders Of Nervous System W/O Cc	M	01	0.6807	21	2.077	114	5.5
429	Organic Disturbances & Mental Retardation	M	19	0.7933	27	1.356	113	5.4
431	Childhood Mental Disorders	M	19	0.4865	21	1.118	81	3.9
422	Viral Illness & Fever Of Unknown Origin Age 0–17	M	18	0.3634	10	1.660	74	3.5
12	Degenerative Nervous System Disorders	M	01	0.9103	23	2.850	64	3.1
98	Bronchitis & Asthma Age 0–17	M	04	0.3816	10	1.538	63	3.0
167	Appendectomy W/O Complicated Principal Diagnosis W/O Cc	S	06	0.8102	8	2.560	41	2.0
430	Psychoses	M	19	0.7668	44	1.942	34	1.6
212	Hip & Femur Procedures Except Major Joint Age 0–17	S	08	1.5008	28	5.477	29	1.4
220	Lower Extremity & Humerus Proc Except Hip, Foot, Femur Age 0–17	S	08	1.0869	17	3.286	29	1.4
91	Simple Pneumonia & Pleurisy Age 0–17	M	04	0.4735	14	1.948	28	1.3
224	Shoulder, Elbow Or Forearm Proc, Excluding Major Joint Proc, W/O Cc	S	08	1.0375	13	4.391	27	1.3
290	Thyroid Procedures	S	10	0.9978	11	3.340	26	1.2
359	Uterine & Adnexa Proc For Non-Malignancy W/O Cc	S	13	0.9785	11	3.027	25	1.2
30	Traumatic Stupor & Coma, Coma <1 Hr Age 0–17	M	01	0.4185	4	1.409	24	1.2
63	Other Ear, Nose, Mouth & Throat O.R. Procedures	S	03	1.4586	13	4.378	23	1.1
60	Tonsillectomy &/Or Adenoidectomy Only, Age 0–17	S	03	0.3999	4	588	22	1.1
9	Spinal Disorders & Injuries	M	01	1.2757	24	3.589	21	1.0

Note: LOS threshold values reported in the table represent the official threshold assigned to each DRG by the Italian national regulation. DRG cost per episode (€) refers to the official reimbursement rate assigned to each DRG under the Italian hospital payment system.
Abbreviations: DRG, diagnosis-related group; MDC, major diagnostic category; W/O, without; Cc, complications; Proc, procedures; Hr, hour; O.R. operating room.

consistently higher in neurologic and psychiatric DRGs (e.g., DRG 9, 12, 429), while the mean number of medical procedures peaked in DRGs 429 (Organic Disturbances & Mental Retardation) and 35 (Other Disorders of Nervous System without Complications) (6.0 and 5.4 procedures, respectively).

Median LOS ranged from 2 to 7 days, with the longest observed in DRG 430 (Psychoses), despite no patient in this group exceeding the LOS threshold. Only a few DRGs showed a notable proportion of patients exceeding the expected LOS, particularly DRG 30 (Traumatic Stupor & Coma), with 16.7% of patients above threshold, and DRG 60 (Tonsillectomy and/or Adenoidectomy), with 9.1%. Overall, 31 patients (2.6%) exceeded the DRG-specific LOS threshold across the 20 DRGs (Table 2).

Prevalence and variability of NDs and NAs within the analyzed DRGs

Among the analyzed DRGs, a total of 4247 NDs and 22014 NAs were identified, corresponding to a mean of 3.53 NDs (SD: 2.46) and a median of 17.00 NAs (IQR: 7) per patient. The most frequently recorded ND was *Fall Risk* (23.1%), followed by *Infection Risk* (17.4%) and *Acute Pain* (12.1%). Regarding NAs, *Perform Individual Safety* was the most common intervention (5.0%), closely followed by *Assess Sleep Pattern Control* (5.0%) and *Assess Nutrition Care* (4.7%). The detailed prevalence of the NDs and NAs across the 20 most frequent DRGs is presented in Table 3.

The number of NDs ranged from 1 to 14 and NAs from 5 to 59, showing considerable variability across DRGs. The highest mean number of NDs was observed in DRG 98 (Bronchitis & Asthma) (mean = 5.6, SD = 2.3), followed by DRG 12 (Degenerative Nervous System Disorders) (mean = 4.6, SD = 2.9). DRG 98 (Bronchitis & Asthma) and DRG 91 (Simple Pneumonia & Pleurisy) showed the highest median number of NAs, at 24 (IQR = 8) and 23 (IQR = 6), respectively. Considering both range and IQR, the highest intra-DRG variability was observed in DRG 3 (Craniotomy) and DRG 26 (Seizure & Headache), with NDs spanning 1–14 and NAs 10–59 and 9–53, respectively. DRG 212 (Hip & Femur Procedures) also showed marked variability (NDs: 1–13; NAs: 11–53), while DRG 430 (Psychoses) exhibited wide NA dispersion (11–51) despite lower mean values (Table 4). Despite clinical homogeneity within DRG groupings, patients exhibited wide intra-DRG variability in NDs and NAs. Violin plots illustrating their distribution across DRGs revealed substantial dispersion (Fig. 1).

NDs and NAs according to DRG LOS threshold

Patients exceeding the DRG LOS threshold ($N = 31$) showed higher numbers of NDs and higher cumulative numbers of NAs compared to those within the threshold. Specifically, patients exceeding the threshold had a higher number of NDs (mean = 6.29, SD = 2.83) compared to their counterpart (mean = 3.45, SD = 2.41), with a mean difference of 2.84 (95% CI [1.97–3.70]). This difference was statistically significant ($t(1202) = 6.45$, $p < 0.001$), with Levene's test confirming homogeneity of variances ($p = 0.537$). Welch's correction yielded consistent results ($t(31.16) = 5.53$, $p < 0.001$). The effect size was large (Cohen's $d = 1.18$), indicating a clinically relevant difference.

Patients exceeding the threshold also showed a higher number of NAs (median = 27, IQR = 14) compared to those within the threshold (median = 17, IQR = 7). The Mann–Whitney U test confirmed statistical significance ($U = 7057.5$, $Z = -5.83$, $p < 0.001$), with a Hodges–Lehmann estimated median difference of +9 NAs (95% CI [6–12]) between groups (Fig. 2).

Table 2
Sociodemographic, clinical, and administrative characteristics of patients within the analyzed DRGs.

DRG data		Descriptive Statistics						
DRG code	DRG description	Female (*N*; %)	Age (mean, SD)	Comorbidities (mean, SD)	Chronic conditions (mean, SD)	Medical procedures (mean, SD)	LOS (median, IQR)	Patients Exceeding LOS Threshold (*N*; %)
26	Seizure & Headache Age 0–17	99 (47.8)	6.60 (5.28)	1.61 (0.84)	0.99 (0.91)	5.29 (1.57)	5.00 (4)	11 (5.3)
3	Craniotomy Age 0–17	54 (34.0)	4.51 (5.57)	1.31 (0.75)	1.14 (0.66)	4.29 (2.35)	6.00 (2)	4 (2.5)
35	Other Disorders Of Nervous System W/O Cc	34 (29.8)	8.68 (4.75)	1.96 (1.03)	1.70 (0.99)	5.40 (1.87)	4.00 (3)	1 (0.9)
429	Organic Disturbances & Mental Retardation	36 (31.9)	7.38 (4.26)	1.99 (0.97)	1.83 (0.87)	6.01 (1.16)	5.00 (2)	0 (0)
431	Childhood Mental Disorders	22 (27.2)	4.91 (3.78)	1.77 (0.73)	1.60 (0.65)	5.70 (1.24)	4.00 (3)	0 (0)
422	Viral Illness & Fever Of Unknown Origin Age 0–17	29 (39.2)	4.84 (5.98)	2.04 (0.94)	0.20 (0.47)	3.58 (1.55)	3.00 (3)	3 (4.1)
12	Degenerative Nervous System Disorders	36 (56.3)	7.50 (5.67)	2.22 (1.06)	2.00 (0.96)	5.81 (1.42)	3.00 (5)	0 (0)
98	Bronchitis & Asthma Age 0–17	30 (47.6)	2.48 (3.50)	1.46 (0.76)	0.52 (0.56)	4.44 (1.60)	5.00 (3)	3 (4.8)
167	Appendectomy W/O Complicated Principal Diagnosis W/O Cc	12 (29.3)	11.32 (3.37)	1.12 (0.40)	0 (0)	1.51 (0.52)	2.00 (1)	1 (2.4)
430	Psychoses	4 (11.8)	14.59 (1.62)	2.18 (1.00)	1.91 (0.83)	5.76 (1.30)	7.00 (6)	0 (0)
212	Hip & Femur Procedures Except Major Joint Age 0–17	16 (55.2)	11.52 (5.03)	1.48 (0.87)	0.66 (0.90)	4.14 (1.96)	4.00 (3)	0 (0)
220	Lower Extremity & Humerus Proc Except Hip, Foot, Femur Age 0–17	9 (31.0)	12.90 (3.54)	1.24 (0.58)	0.24 (0.51)	3.31 (1.80)	4.00 (4)	0 (0)
91	Simple Pneumonia & Pleurisy Age 0–17	12 (42.9)	4.46 (4.92)	1.96 (1.00)	0.32 (0.61)	4.64 (1.64)	5.00 (3)	1 (3.6)
224	Shoulder, Elbow Or Forearm Proc, Excluding Major Joint Proc, W/O Cc	4 (14.8)	12.15 (2.69)	1.19 (0.56)	0.04 (0.19)	2.81 (1.64)	2.00 (2)	1 (3.7)
290	Thyroid Procedures	19 (73.1)	14.85 (1.95)	1.46 (0.58)	1.31 (0.68)	2.62 (1.06)	2.00 (1)	0 (0)
359	Uterine & Adnexa Proc For Non-Malignancy W/O Cc	25 (100)	14.24 (3.37)	1.40 (0.65)	0.24 (0.52)	3.00 (1.73)	2.00 (1)	0 (0)
30	Traumatic Stupor & Coma, Coma <1 Hr Age 0–17	7 (29.2)	7.00 (5.82)	1.33 (0.57)	0.08 (0.28)	2.00 (2.06)	3.00 (2)	4 (16.7)
63	Other Ear, Nose, Mouth & Throat O.R. Procedures	8 (34.8)	13.87 (2.70)	1.30 (0.56)	0.04 (0.21)	2.17 (0.98)	3.00 (2)	0 (0)
60	Tonsillectomy &/Or Adenoidectomy Only, Age 0–17	7 (31.8)	6.73 (3.04)	1.18 (0.59)	1.14 (0.47)	2.00 (0.98)	2.00 (1)	2 (9.1)
9	Spinal Disorders & Injuries	10 (47.6)	7.57 (5.07)	2.52 (1.25)	2.24 (1.14)	5.57 (1.72)	5.00 (3)	0 (0)

Abbreviations: DRG, diagnosis-related group; SD, standard deviation; LOS, length of stay; IQR, interquartile range; MDC, major diagnostic category; W/O, without; Cc, complications; Proc, procedures; Hr, hour; O.R. operating room.

Table 3
Prevalence of NDs and NAs within the analyzed DRGs.

NDs (CCC) ($N = 4247$)			Descriptive Statistics N (%)
Fall Risk			980 (23.0)
Infection Risk			737 (17.4)
Acute Pain			512 (12.1)
Sleep Pattern Disturbance			393 (9.3)
Injury Risk			216 (5.1)
Skin Integrity Impairment Risk			185 (4.4)
Feeding Deficit			177 (4.2)
Anxiety			170 (4.0)
Fluid Volume Deficit			157 (3.7)
Breathing Pattern Impairment			119 (2.8)
Physical Mobility Impairment			93 (2.2)
Others			508 (12.0)
NA code (CCC) ($N = 22014$)	**NA description (CCC)**	**INNCP**	**N (%)**
N42.3.2	Perform Individual Safety	Application and use of a hospital patient identification wristband	1109 (5.0)
A04.0.1	Assess Sleep Pattern Control	Assessment of sleep/rest length and quality	1102 (5.0)
J29.0.1	Assess Nutrition Care	Assessment and monitoring of nutritional/hydration conditions	1037 (4.7)
G.20.0.2	Perform Physician Contact	Nurse-physician collaboration	1013 (4.6)
G17.1.4	Teach Adult Day Center	Reception and orientation of the patient	958 (4.4)
K32.1.2	Perform Blood Specimen Care	Venous blood sampling for blood chemistry tests	823 (3.7)
N42.0.2	Perform Safety Precautions	Use of devices to reduce hazards	803 (3.6)
K33.0.2	Perform Vital Signs	Vital signs measurement	708 (3.2)
K31.3.1	Assess Physical Examination	Assessment of patient dependency levels through physical examination	560 (2.5)
H23.4.2	Perform Medication Treatment	Enteral medication administration	551 (2.5)
E12.1.2	Perform Coping Support	Relationship of help and psychological support	515 (2.3)
D78.0.1	Assess Neurological System Care	Assess and monitor consciousness	500 (2.3)
Q48.0.2	Perform Comfort Care	Provide comfort measures	473 (2.1)
C08.0.2	Perform Cardiac Care	Performing an electrocardiogram (ECG)	462 (2.1)
N42.3.1	Assess Individual Safety	Fall risk assessment (e.g., Humpty-Dumpty scale)	458 (2.1)
H24.4.2	Perform Medication Treatment	Parenteral medication administration	443 (2.0)
H24.0.2	Perform Medication Care	Intravenous infusion management	443 (2.0)
Q47.0.1	Assess Pain Control	Comprehensive pain assessment	433 (2.0)
Others	Others	Others	9623 (43.7)

Note: Only NDs and NAs with a frequency greater than 2% in the total sample are shown; all remaining NDs and NAs are grouped under Others.
Abbreviations: DRG, diagnosis-related group; NDs, nursing diagnoses; CCC, Clinical Care Classification; NAs, nursing actions; INNCP, Italian Nomenclature of Nursing Care Performance.

Table 4
Descriptive statistics and intra-DRG variability of NDs and NAs.

DRG data		Nursing Data			
		NDs		NAs	
DRG code	DRG description	Mean (SD)	Range (min–max)	Median (IQR)	Range (min–max)
26	Seizure & Headache Age 0–17 ($N = 207$)	3.10 (2.56)	1–14	16.00 (5)	9–53
3	Craniotomy Age 0–17 ($N = 159$)	4.41 (2.34)	1–14	20.00 (9)	10–59
35	Other Disorders Of Nervous System W/O Cc ($N = 114$)	2.61 (2.24)	1–13	15.00 (4)	8–36
429	Organic Disturbances & Mental Retardation ($N = 113$)	2.07 (1.96)	1–10	15.00 (4)	10–24
431	Childhood Mental Disorders ($N = 81$)	1.78 (1.67)	1–9	14.00 (4)	9–25
422	Viral Illness & Fever Of Unknown Origin Age 0–17 ($N = 74$)	3.99 (1.98)	1–11	19.50 (7)	10–45
12	Degenerative Nervous System Disorders ($N = 64$)	4.58 (2.94)	1–13	16.00 (5)	10–30
98	Bronchitis & Asthma Age 0–17 ($N = 63$)	5.59 (2.28)	2–13	24.00 (8)	15–44
167	Appendectomy W/O Complicated Principal Diagnosis W/O Cc ($N = 41$)	4.46 (1.86)	1–9	19.00 (5)	13–30
430	Psychoses ($N = 34$)	2.32 (1.68)	1–7	17.00 (5)	11–51
212	Hip & Femur Procedures Except Major Joint Age 0–17 ($N = 29$)	5.07 (3.04)	1–13	20.00 (11)	11–53
220	Lower Extremity & Humerus Proc Except Hip, Foot, Femur Age 0–17 ($N = 29$)	4.66 (1.95)	1–9	20.00 (7)	13–33
91	Simple Pneumonia & Pleurisy Age 0–17 ($N = 28$)	5.57 (2.22)	1–10	23.00 (6)	17–36
224	Shoulder, Elbow Or Forearm Proc, Excluding Major Joint Proc, W/O Cc ($N = 27$)	4.37 (1.36)	2–7	19.00 (8)	5–30
290	Thyroid Procedures ($N = 26$)	4.12 (1.45)	2–8	16.00 (2)	11–22
359	Uterine & Adnexa Proc For Non-Malignancy W/O Cc ($N = 25$)	3.68 (1.63)	1–8	22.00 (9)	10–33
30	Traumatic Stupor & Coma, Coma <1 Hr Age 0–17 ($N = 24$)	3.50 (1.75)	1–7	14.50 (10)	6–43
63	Other Ear, Nose, Mouth & Throat O.R. Procedures ($N = 23$)	3.00 (1.68)	1–6	16.00 (7)	8–22
60	Tonsillectomy &/Or Adenoidectomy Only, Age 0–17 ($N = 22$)	2.77 (1.23)	1–6	13.00 (4)	9–26
9	Spinal Disorders & Injuries ($N = 21$)	2.71 (2.76)	1–10	14.00 (5)	10–24

Abbreviations: DRG, diagnosis-related group; NDs, nursing diagnoses; NAs, nursing actions; SD, standard deviation; IQR, interquartile range; W/O, without; Cc, complications; Proc, procedures.

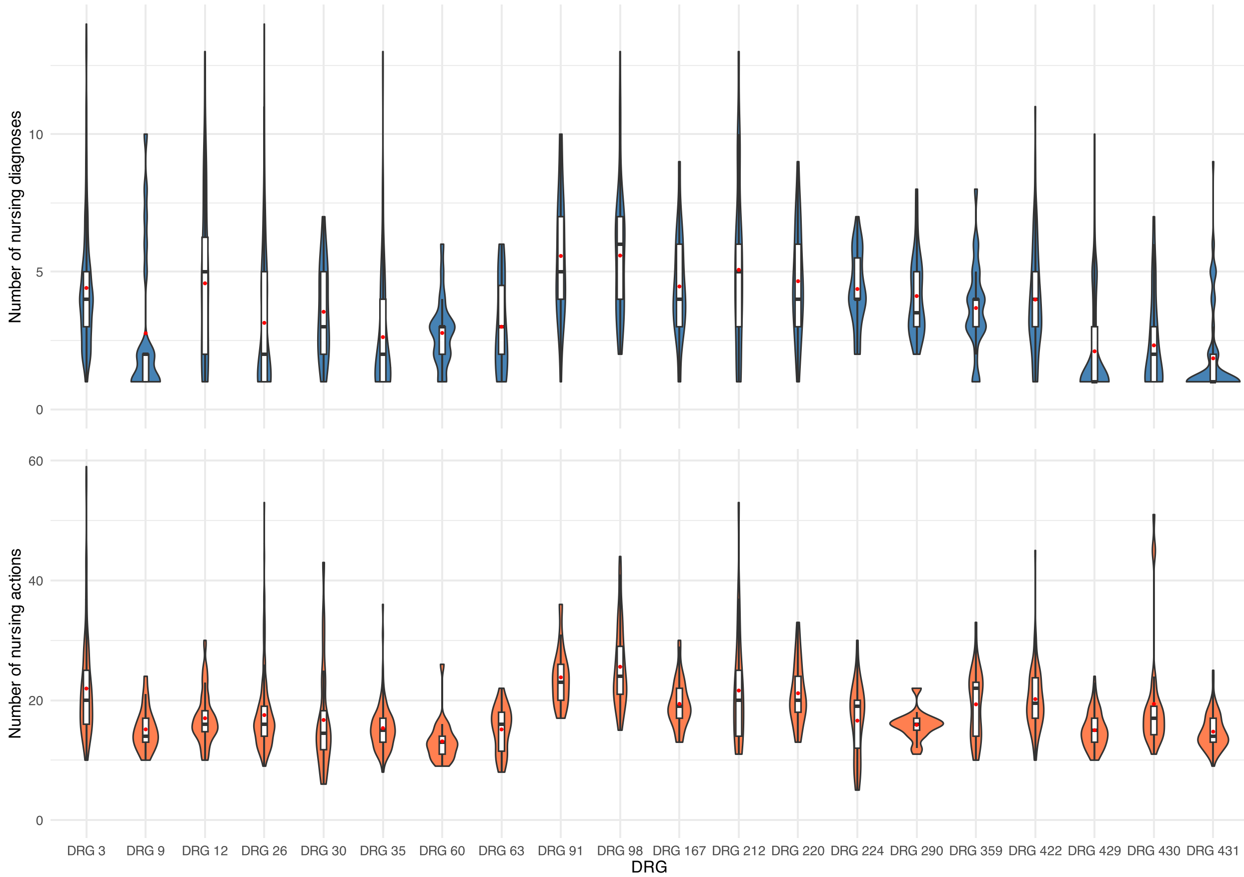

Fig. 1. Violin plots of intra-DRG variability in NDs and NAs.
Note: Violin plots display the full distribution of NDs (top panel) and NAs (bottom panel) per patient within each DRG category, allowing visualization of dispersion, skewness, and potential multimodal patterns. DRGs are arranged on the x-axis in ascending numerical order. The width of each violin reflects the distribution density estimated through kernel density estimation (KDE) function. Red dots indicate the median, while the embedded boxplots represent the interquartile range.
DRG legend: DRG 3, Craniotomy Age 0–17; DRG 9, Spinal Disorders & Injuries; DRG 12, Degenerative Nervous System Disorders; DRG 26, Seizure & Headache Age 0–17; DRG 30, Traumatic Stupor & Coma, Coma <1 Hr Age 0–17; DRG 35, Other Disorders of Nervous System W/O Cc; DRG 60, Tonsillectomy &/Or Adenoidectomy Only, Age 0–17; DRG 63, Other Ear, Nose, Mouth & Throat O.R. Procedures; DRG 91, Simple Pneumonia & Pleurisy Age 0–17; DRG 98, Bronchitis & Asthma Age 0–17; DRG 167, Appendectomy W/O Complicated Principal Diagnosis W/O Cc; DRG 212, Hip & Femur Procedures Except Major Joint Age 0–17; DRG 220, Lower Extremity & Humerus Proc Except Hip, Foot, Femur Age 0–17; DRG 224, Shoulder, Elbow or Forearm Proc, Excluding Major Joint Proc, W/O Cc; DRG 290, Thyroid Procedures; DRG 359, Uterine & Adnexa Procedures for Non-Malignancy without Cc; DRG 422, Viral Illness & Fever of Unknown Origin Age 0–17; DRG 429, Organic Disturbances & Mental Retardation; DRG 430, Psychoses; DRG 431, Childhood Mental Disorders.
Abbreviations: DRG, diagnosis-related group; W/O, without; Cc, complications; Proc, procedures.

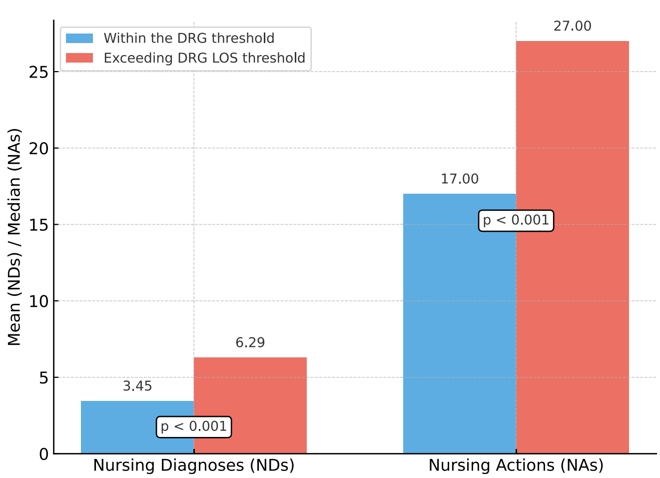

Fig. 2. NDs and NAs according to DRG LOS threshold.
Note: Reported *p*-values indicate statistically significant differences in NDs (independent-samples *t*-test) and NAs (Mann-Whitney *U* test) between patients within and exceeding the DRG-specific LOS threshold.
Abbreviations: DRG, diagnosis-related group; LOS, length of stay; NDs, nursing diagnoses; NAs, nursing actions

Multivariable association between ND and NA counts and DRG-specific LOS threshold exceedance

To evaluate the independent association between ND and NA counts and DRG-specific LOS threshold exceedance, a two-step (blockwise) multivariable logistic regression approach was used, estimating two sequential models (Model 1 and Model 2) (see the Methods section).

In Model 1, ND count was included as the main predictor and adjusted for age, sex, DRG weight, and total comorbidities. The model was statistically significant ($\chi^2(5) = 49.80$, $p < 0.001$), with a Nagelkerke R^2 of 0.190, indicating modest model fit. Each additional ND was associated with a 36% increase in the odds of exceedance (OR = 1.36, 95% CI 1.21–1.53, $p < 0.001$). Total comorbidities were also positively associated (OR = 1.75, 95% CI 1.29–2.37, $p < 0.001$), whereas age and sex were not significant. DRG weight showed an inverse, though non-significant, association (OR = 0.49, 95% CI 0.22–1.10, $p = 0.082$).

In Model 2, which additionally included NA count, both ND and NA counts remained independently associated with LOS threshold exceedance after adjustment for demographic and clinical covariates. Each additional ND increased the odds by 25% (OR = 1.25, 95% CI 1.09–1.43, $p = 0.001$), and each additional NA by 9% (OR = 1.09, 95% CI 1.05–1.14, $p < 0.001$). In this fully adjusted model, DRG weight was

Table 5
Adjusted multivariable logistic regression models for DRG-specific LOS threshold exceedance.

Variable	B	SE	OR (Exp(B))	95% CI	*p*-value
Model 1. ND adjusted for demographic and clinical covariates					
Age	−0.033	0.035	0.968	0.904–1.037	0.352
Female sex	0.244	0.383	1.276	0.602–2.704	0.524
DRG weight	−0.722	0.415	0.486	0.215–1.095	0.082
Total comorbidities	0.557	0.155	1.746	1.287–2.368	<0.001
Total NDs	0.307	0.060	1.360	1.210–1.528	<0.001
Intercept	−5.501	0.631	–	–	<0.001
Model fit: $\chi^2(5) = 49.797$, $p < 0.001$; Nagelkerke $R^2 = 0.190$					
Model 2. ND and NAs adjusted for demographic and clinical covariates					
Age	−0.007	0.035	0.993	0.927–1.064	0.848
Female sex	0.218	0.392	1.243	0.577–2.679	0.579
DRG weight	−0.913	0.412	0.401	0.179–0.899	0.027
Total comorbidities	0.620	0.159	1.858	1.361–2.537	<0.001
Total NDs	0.224	0.069	1.251	1.092–1.434	0.001
Total NAs	0.090	0.021	1.094	1.050–1.140	<0.001
Intercept	−7.226	0.791	–	–	<0.001
Model fit: $\chi^2(6) = 66.266$, $p < 0.001$; Nagelkerke $R^2 = 0.252$					

Note: Outcome: exceeding the DRG-specific LOS threshold (yes/no). A two-step (blockwise) strategy was used. Model 1 included total NDs adjusted for age, sex, DRG weight, and total comorbidities. Model 2 additionally included total NAs.
Abbreviations: LOS, length of stay; B, unstandardized regression coefficient; SE, standard error; OR, odds ratio; CI, confidence interval; DRG, diagnosis-related group; NAs, nursing actions; NDs, nursing diagnoses; χ^2, chi-square statistic, R^2, pseudo coefficient of determination.

significantly inversely associated with LOS threshold exceedance (OR = 0.40, 95% CI 0.18–0.90, $p = 0.027$), whereas total comorbidities remained positively associated. The model was statistically significant ($\chi^2(6) = 66.27$, $p < 0.001$), with a Nagelkerke R^2 of 0.252, indicating improved model fit compared with Model 1. No relevant multicollinearity was detected (all VIF values <1.4) (Table 5).

Discussion

This study assessed variability in NDs and NAs within the most frequent pediatric DRGs and showed substantial differences in care needs among clinically homogeneous groups. These findings confirm our first hypothesis: even within medically homogeneous DRGs, nursing complexity varies considerably. Our second hypothesis was also confirmed: patients exceeding the LOS threshold had significantly higher ND and NA counts than those within expected LOS. Together, these results provide robust evidence that DRG classifications, while effective in clustering medical diagnoses and procedures, systematically fail to capture the variability of nursing complexity. In other words, patients formally classified and reimbursed as having comparable medical and economic resource use (Cesare, D'Agostino, Sebastiani, et al., 2025; Liu et al., 2024) can require very different levels of nursing care. This divergence confirms that DRG categories do not adequately represent the measure of nursing care required at the bedside (Di Nitto et al., 2025; Sanson et al., 2017).

The variability in NDs and NAs observed in this study is clinically meaningful. Patients exceeding the DRG-specific LOS thresholds had significantly higher ND and NA counts than those within the expected LOS. Taken together, these findings support the interpretation of nursing complexity as a potential driver of prolonged hospitalization rather than merely a correlate (Cesare, D'Agostino, Nurchis, et al., 2025). Specifically, patients whose LOS exceeded the expected thresholds had, on average, more than two additional NDs and approximately ten additional NAs compared with non-outliers.

Beyond these descriptive differences, the multivariable analysis confirmed that both ND and NA counts remained independently associated with LOS threshold exceedance after adjustment for age, sex, DRG weight, and total comorbidities, indicating that nursing complexity contributed explanatory value beyond traditional medical case-mix indicators. Notably, in the fully adjusted model including both NDs and NAs, DRG weight showed a significant inverse association with LOS threshold exceedance, suggesting that higher administratively assigned medical severity did not independently explain LOS threshold exceedance after accounting for nursing complexity. This pattern suggests that nursing complexity captures clinically relevant variability in resource use that is not adequately represented within DRG-based reimbursement logic.

These findings further support the interpretation that the observed association is not fully explained by longer exposure time alone. NDs were identified within the first 24 h of admission (Cesare, D'Agostino, Nurchis, et al., 2025) and are therefore temporally antecedent to LOS, making a purely reverse interpretation less likely. This temporal ordering suggests that higher nursing complexity is already present early in hospitalization and may contribute to later deviations from expected LOS patterns, rather than being a by-product of prolonged stay. This interpretation aligns with prior evidence showing that the number of NDs was a significant predictor of LOS longer than expected according to the DRG, whereas the APR-DRG weight was not (D'Agostino et al., 2019). At the same time, because NAs were measured as cumulative counts over the entire hospitalization, they may partly reflect exposure time rather than time-standardized care intensity; accordingly, their role should be interpreted as supportive rather than explanatory. Nevertheless, their consistency with ND patterns provides convergent support for the observed association. Moreover, previous research suggests that hospitalization duration and care intensity do not necessarily overlap; for example, Cho et al. (2014) reported that shorter LOS may be associated with higher work demands and work pace at the unit level. Taken together, by quantifying ND/NA variability—particularly among LOS outliers—our study reinforces the view that nursing complexity represents an important and still underrecognized component of hospital resource use, thereby strengthening the case for reimbursement reform (Cesare, D'Agostino, Sebastiani, et al., 2025; Garcia & Jenkins, 2018; Welton & Harper, 2016).

From a methodological perspective, SNLs allowed us to measure nursing complexity in a reproducible way. NDs and NAs, documented through PAI*ped*, provided a structured proxy for nursing input that is currently invisible in hospital cost accounting. In our cohort, the most frequent NDs were related to risk diagnoses that are not routinely captured in the medical record. This underlines how nursing data complement medical information and may contribute to preventing adverse outcomes directly under nurses' responsibility—such as falls, pressure injuries, and infections (Cordina et al., 2025; Ojo & Thiamwong, 2022; Teixeira et al., 2025; Todo Bom et al., 2025).

The underrepresentation of nursing in reimbursement systems is not a recent issue. More than forty years ago, John Thompson—a nurse and one of the DRG developers—recognized the absence of precise measures for capturing nursing care within the DRG framework and urged the development of more accurate methods to quantify nursing's contribution (Thompson, 1984). Earlier evidence from adult populations has repeatedly documented substantial within-DRG variability in nursing workload and costs (Fosbinder, 1986; Mowry & Korpman, 1985; Wilson et al., 1988), reinforcing that DRGs alone cannot capture the value of nursing care.

Our study provides the first pediatric evidence of this issue, highlighting a care context where complexity is especially pronounced (Cesare, D'Agostino, Damiani, et al., 2025). In our sample, conditions such as bronchitis and asthma or pneumonia (i.e., DRG 98 and DRG 91), despite being assigned relatively low DRG weights, were associated with high nursing complexity. This is consistent with pediatric literature showing that respiratory diseases demand disproportionate nursing resources due to continuous monitoring, symptom management, and extensive parental education (Alexandre-Sousa et al., 2024; Chiang & Amin, 2017; Tao et al., 2023; Xue et al., 2022). This finding has a critical implication: unless nursing is integrated into reimbursement frameworks, hospitals delivering more intensive care may face financial disincentives, while the real value of nursing remains hidden—still treated as an undifferentiated component of hospital "room and board" costs (Welton & Longyear, 2024). Such omission not only obscures nursing's unique contribution to patient outcomes but also prevents alignment between financial models and the actual care delivery.

From a policy and practice perspective, these findings highlight a clear opportunity. Standardized ND/NA data, already available through routine electronic documentation, can be aggregated and used as a nursing-specific case-mix adjustment alongside DRG weights. Such integration could enable the development of hybrid reimbursement models combining medical and nursing case-mix indicators. This would support the recognition of nursing as a distinct, measurable, and potentially billable component of care, rather than an undifferentiated element of daily hospital cost. Developing and testing a Nursing Case-Mix Index based on ND/NA data—and, prospectively, hybrid models integrating standardized nursing data with direct care time—should be a priority for future reimbursement research. This perspective is fully aligned with the American Commission for Nurse Reimbursement (CNR)'s call to explicitly recognize the value of nursing care and move beyond its treatment as an indivisible cost component (Commission for Nurse Reimbursement, 2025).

This study has some limitations. First, it was conducted in a single tertiary pediatric hospital with a distinctive subspecialty case-mix, particularly in neurological and neurosurgical care. This organizational profile likely influenced the frequency distribution of the most represented DRGs in the sample, which may not reflect general pediatric hospitalization patterns and may limit the generalizability of the observed nursing complexity patterns to other pediatric settings. Second, the retrospective design relied on routinely collected data, making the analysis dependent on the completeness and accuracy of nursing documentation in the EHR. Nurses at the study hospital have been using the PAI*ped* system for over a decade and receive continuous training in its application, which supports the reliability and consistency of the recorded data; notably, no missing data were observed. However, formal inter-rater reliability testing was not performed, and nurse-level sociodemographic and professional characteristics (e.g., years of experience or documentation expertise) were not collected as part of the study design. Therefore, potential variability in documentation practices between novice and experienced nurses using PAI*ped* cannot be excluded. Prior analyses conducted at the study hospital have nevertheless demonstrated satisfactory levels of documentation accuracy and internal consistency in PAI-derived nursing data, supporting the reliability of the information used in the present study (Cesare, Magliozzi, D'Agostino, et al., 2025). Third, the consent-based inclusion procedure required by the Ethics Committee may have introduced selection bias. Because only admissions for which study-specific parent/legal guardian consent could be confirmed were included, some otherwise eligible hospitalizations may not have been represented in the final sample, particularly when parents or legal guardians were not reachable during follow-up or when consent confirmation could not be obtained. Therefore, families with greater logistical or communication barriers may have been less likely to be included. This consent-based inclusion process may therefore have resulted in a non-random analytic sample, potentially affecting the representativeness of the findings. Fourth, while nursing complexity was measured through the number of standardized NDs and NAs, other relevant dimensions—such as time spent per action or time-standardized indicators of care intensity (e.g., NAs per day)—were not available in the dataset. Because NAs were extracted as cumulative episode-level counts, their association with LOS may partly reflect a time-exposure effect. Fifth, the low prevalence of LOS outliers constrained multivariable modeling, yielding an events-per-variable ratio of approximately 5:1. Although the traditional 10-event rule is frequently cited, model performance depends on multiple factors beyond this threshold, and lower ratios may still be acceptable in parsimonious models with low multicollinearity (Riley et al., 2019; Vittinghoff & McCulloch, 2007). Nonetheless, effect estimates may be sensitive to small-sample variability and should be interpreted cautiously and replicated in larger cohorts with more outcome events. The findings should therefore be interpreted as hypothesis-generating.

Future research should address these limitations through multicenter and cross-national studies to enhance generalizability and examine variability across different reimbursement systems. Larger sample sizes with a higher prevalence of LOS outliers would allow more robust multivariable modeling and more comprehensive adjustment for potential confounders. Additional nursing input measures—such as direct care time, workload indices, and staffing variables—should be integrated to refine the measurement of nursing complexity. Prospective studies are needed to link ND and NA counts with direct nursing care time and day-level documentation in order to distinguish cumulative care volume from care intensity, validate time-standardized indicators (e.g., NAs per day), and inform the development of nursing-sensitive case-mix adjustments within DRG-based reimbursement systems. Future investigations should also incorporate nurse-level variables (e.g., years of professional experience and documentation expertise) to assess potential variability in documentation practices and to formally evaluate inter-rater reliability within clinical nursing information systems. Moreover, the growing integration of AI-assisted documentation tools warrants dedicated methodological research to examine how digital augmentation may influence the structure, consistency, and interpretability of nursing data. Longitudinal designs should also examine how variability in nursing complexity influences patient outcomes and resource utilization over time, ensuring that nursing contributions are appropriately represented in future reimbursement models.

Conclusions

This study demonstrates that DRG-based classification does not capture the variability in NDs and NAs among medically homogeneous pediatric patients, particularly among patients exceeding the LOS threshold, who show significantly higher nursing complexity. Because ND and NA counts quantify nursing complexity, nursing should be included in DRG systems as a distinct, quantifiable, billable, and accountable component. Embedding patient-level ND and NA data into national reporting would improve reimbursement accuracy, recognize nursing's contribution to outcomes, and increase funding transparency. In pediatrics—where care needs are intrinsically variable (Cesare, D'Agostino, Damiani, et al., 2025)—such integration is essential to align payment with the care delivered and to fully acknowledge nursing within health systems.

CRediT authorship contribution statement

Manuele Cesare: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Mario Cesare Nurchis:** Writing – review & editing, Investigation, Formal analysis, Data curation, Conceptualization. **Fabio D'Agostino:** Writing – review & editing, Funding acquisition. **John Michael Welton:** Writing – review & editing, Supervision, Conceptualization. **Emanuele Sebastiani:** Writing – review & editing. **Gianfranco Damiani:** Writing – review & editing. **Antonello Cocchieri:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pedn.2026.07.002.

Data availability

Data are available on reasonable request from the corresponding author. The data are not publicly available due to privacy and ethical restrictions.

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