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Teaching Workload Inequality and Temporal Patterns in Residency Training: A Gini Coefficient Analysis

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ABSTRACT

Introduction: Teaching workload inequality among clinical faculty is recognized but rarely quantified, and the temporal dimension of teaching remains largely unexplored. This study applied the Gini coefficient to quantify teaching workload and its association with temporal scheduling patterns.

Methods: We analyzed 3,177 speaker-activity pairs (356 faculty, 27 departments) from an electronic teaching platform at a tertiary hospital in Shenzhen, China (2022-2025). Activity counts served as a proxy for teaching workload; direct measures of preparation time, teaching complexity, and learner contact hours were unavailable. Gini coefficients with percentile-bootstrap 95% CIs quantified inequality; Spearman correlations (Benjamini-Hochberg corrected) and volume-adjusted partial correlations tested temporal associations; annual cross-sections and a core-cohort analysis distinguished compositional from within-group change.

Results: The hospital-wide Gini was 0.554 (95% CI: 0.514-0.590) among 356 participating faculty, a lower bound of true inequality; the top 20% delivered 57.8% of activities while the bottom 50% contributed 12.8%. Department-level Gini ranged from 0.000 to 0.702. Teaching methods showed temporal signatures (chi-square = 178.1, $p < 0.001$, Cramer's V = 0.17). Evening teaching correlated with inequality bivariately (rho = 0.547, q = 0.027) but not after controlling for volume (partial rho = 0.348, $p = 0.088$). Over four years, Gini declined from 0.531 to 0.439 with faculty expansion from 102 to 269, while a 41-faculty core cohort showed stable inequality (0.445-0.494), indicating compositional change.

Conclusions: Teaching workload among participating faculty was moderately to highly concentrated. The reported Gini is a lower bound; non-participating eligible faculty could not be enumerated. The Gini coefficient with temporal analysis offers a practical monitoring framework for residency training.

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Introduction

Clinical teaching is fundamental to medical education, yet the distribution of teaching responsibilities among faculty remains poorly understood. In academic medical centers, faculty typically allocate less than one-quarter of their professional effort to educational activities, with the remainder devoted to clinical care, research, and administration [1, 2]. Within this limited allocation, qualitative studies suggest that teaching workload is unevenly distributed, with a small subset of dedicated educators bearing a disproportionate share of the teaching burden [3, 4]. This concentration has potential consequences: overburdened faculty may experience burnout and reduced job satisfaction [5, 6], while limited participation by other faculty constrains the diversity of teaching perspectives available to trainees. Despite growing recognition of this problem, quantitative measurement of teaching workload inequality remains fragmented. Education value unit systems have been implemented at individual institutions, but a recent systematic review found marked variability in how educational effort is quantified, with no standardized metric emerging across settings [7].

The Gini coefficient, originally developed to measure income inequality [8], provides a well-established, single-number summary of distributional inequality ranging from 0 (perfect equality) to 1 (maximal concentration). Together with the Lorenz curve, this framework has been widely applied to assess inequalities in healthcare resource allocation, including physician workforce and nursing staff distribution [9, 10]. Investigators have also applied this metric to individual-level academic workload: pathologist clinical workload distribution (Gini = 0.05-0.23) [11], authorship concentration in medical journals (Gini = 0.49) [12], and residency interview distribution across specialties (Gini = 0.23-0.84) [13]. However, no prior studies have applied the Gini coefficient specifically to teaching workload distribution among clinical faculty.

Beyond the magnitude of individual teaching contributions, when teaching occurs may shape workload concentration. Clinical teaching is embedded within service schedules that vary by specialty and time of day: ward rounds typically occur in mornings, procedural skills training follows operative schedules, and some teaching extends into evenings or weekends when clinical demands allow [14, 15]. Faculty who teach across a wider range of time slots may carry a qualitatively different burden than those teaching exclusively during protected daytime hours. Yet the temporal dimension of teaching workload has received little systematic attention in the medical education literature.

China established its national standardized residency training system in 2014, mandating structured residency training for all new medical graduates [16, 17]. Teaching activity guidelines define categories of pedagogical activities, and electronic teaching management platforms have been widely adopted to document these activities [18-20]. These platforms capture not only who teaches but precisely when teaching occurs, enabling analysis of both distributional and temporal patterns. In this study, we analyzed administrative data from an electronic teaching platform at the Seventh Affiliated Hospital, Sun Yat-sen University, Shenzhen, China, to address four research questions: (1) What is the degree of teaching workload concentration at the hospital-wide and department levels? (2) What temporal patterns characterize teaching activities across methods and departments? (3) Is temporal scheduling flexibility associated with workload inequality? (4) How has teaching workload inequality changed over four annual cross-sections (2022-2025)? An important conceptual distinction is warranted. Borrowing from the health equity literature, we distinguish between inequality (distributional concentration, a descriptive property) and inequity (unfair or unjust distribution, a normative judgment). The Gini coefficient measures concentration but cannot, by itself, determine whether observed concentration reflects legitimate specialization, voluntary engagement by dedicated educators, or systemic barriers to participation. Without data on faculty rank, teaching qualifications, and individual preferences, our analysis characterizes the degree and patterns of concentration rather than rendering judgment on its fairness [3].

Methods

Study Design and Data Source

This was a retrospective repeated cross-sectional study conducted at the Seventh Affiliated Hospital, Sun Yat-sen University, Shenzhen, China, a tertiary teaching hospital accredited as a standardized residency training base. Teaching activity data from January 2022 to December 2025 were analyzed as pooled cross-sections (for hospital-wide and department-level estimates) and as annual cross-sections (for temporal trend analysis). Teaching activity records were extracted from the Cloud-based Clinical Medical Teaching and Visualization (CCMTV) platform, an internet-based teaching management system widely used in Chinese hospitals for scheduling, documenting, and evaluating residency training activities. Of 3,619 initially extracted records, 471 were excluded sequentially: 228 with incomplete activity status, 230 with dates outside the study period, 10 non-clinical or cross-departmental activities, and 3 records from a department with fewer than 10 total activities. The final analytical sample comprised 3,148 records from 27 clinical departments (Supplementary Figure S1). Department names were standardized by mapping 52 raw name variants to 27 canonical names.

The primary unit of analysis was the speaker-activity pair. The speaker (speakers_name field) was identified as the faculty member who delivered the teaching session, distinguished from the data-entry organizer (realname field). Twenty-eight records (0.9%) listed two co-speakers and were counted once per speaker, yielding 3,177 speaker-activity pairs from 356 unique faculty members. These represent faculty who delivered at least one recorded teaching activity; the total number of eligible faculty was not available. All inequality measures, therefore, reflect the distribution among participating faculty, not among all potentially eligible faculty. Departments were classified as medical (n = 13), surgical (n = 8), or other (n = 6) based on the hospital's residency training rotation structure.

Measures of Inequality

Teaching workload was operationalized as the count of recorded teaching activities per faculty member (speaker-activity pairs). We use the term "workload" throughout this manuscript in this restricted, operational sense: we do not claim to capture preparation time, teaching complexity, learner contact hours, or educational impact. To evaluate the robustness of count-based workload as a proxy for time-weighted workload, we pre-specified a duration-weighted sensitivity analysis using method-level average session durations (Supplementary Table S1); the duration-weighted Gini of 0.559 differed from the count-based Gini of 0.554 by 0.005 (0.9%), supporting the empirical adequacy of the count-based proxy within this dataset.

The Gini coefficient was calculated using the standard plug-in (sample) estimator based on ordered teaching counts: $G = [2 \times \Sigma_{i=1}^{n} (i \times x_i) - (n + 1) \times \Sigma_{i=1}^{n} x_i] / [n \times \Sigma_{i=1}^{n} x_i]$, where $x_1 \le x_2 \le \ldots \le x_n$ are the sorted teaching counts across the n participating faculty [8, 21]. The Lorenz curve was constructed by plotting the cumulative proportion of teaching activities against the cumulative proportion of faculty ranked from lowest to highest contribution. Ninety-five percent confidence intervals were estimated using the non-parametric percentile bootstrap method with 2,000 resamples (random seed = 42) [31]; bias-corrected accelerated (BCa) intervals were not used. The small-sample bias-corrected estimator $G^* = G \times n/(n - 1)$ was reported as a sensitivity analysis (Supplementary Table S3). Hospital-wide and department-level Gini coefficients were calculated using pooled (2022-2025) data. The Mann-Whitney U test compared medical versus surgical department Gini coefficients, and Spearman's rank correlation assessed the association between departmental teaching volume and Gini coefficients.

Temporal Pattern Analysis

Teaching activities were categorized by time of day based on recorded start times: morning (06:00-11:59), afternoon (12:00-17:59), and evening (18:00-23:59); three overnight activities (00:00–05:59) were excluded. Weekend activities were identified by day of the week. The chi-square test of independence assessed the association between teaching method (four major types) and time-of-day category, with Cramer's V as the effect size.

Inequality-Temporal Association Analysis

At the department level (n = 26, excluding Emergency Medicine with a single faculty member), seven temporal features were computed for each department: morning, evening, and weekend teaching proportions; hour spread (standard deviation of teaching hours); temporal entropy (Shannon entropy $H = -\text{sum}[p(h) \times \log_2(p(h))]$ over 18 hourly bins, where p(h) is the proportion of activities starting in hour h); peak hour concentration (maximum p(h)); and weekday entropy (Shannon entropy over 7 weekdays). Spearman correlations between each temporal feature and the department Gini coefficient were calculated, with Benjamini-Hochberg false discovery rate correction applied across seven tests. To assess whether these associations were independent of teaching volume, partial Spearman correlations were computed: variables were first converted to ranks, then each ranked variable was regressed on the control variable (departmental teaching volume), and the Pearson correlation between residuals served as the partial rank correlation coefficient, with p-values derived from the t-distribution approximation with n-3 degrees of freedom. At the individual level, among speakers with three or more activities (n = 247), Spearman correlations between teaching volume and four temporal flexibility measures were computed with BH-FDR correction. Speakers in the top 20% by volume were compared with those in the bottom 50% on temporal characteristics.

Temporal Trends and Sensitivity Analyses

Annual Gini coefficients were calculated for each year (2022-2025). Because only four non-independent time points were available, the trend is reported descriptively. Faculty were classified as "new" or "returning," and a core cohort of 41 faculty participating in all four years was identified. Six sensitivity analyses assessed robustness: (1) alternative speaker identification using the organizer field (Gini = 0.726 from 168 individuals); (2) fractional counting for multi-speaker records (Gini = 0.557); (3) excluding departments with fewer than 20 activities (Gini = 0.546); (4) duration weighting using method-level average durations (Gini = 0.559); (5) small-sample Gini correction G* = G x N/(N-1); and (6) alternative evening thresholds (17:00 and 19:00). Across speaker-based analyses, the Gini remained in the narrow range of 0.546-0.557.

Ethics and Statistical Analysis

This study was approved by the Ethics Committee of the Seventh Affiliated Hospital of Sun Yat-sen University (Approval No. KY-2026-111-01, dated March 25, 2026). The study used de-identified administrative data with no patient involvement. Informed consent was waived due to the retrospective use of de-identified administrative records. All analyses were performed using Python 3.13 with NumPy, SciPy, and Matplotlib. Statistical significance was set at alpha = 0.05. This study is reported according to the STROBE guidelines for observational studies.

Results

Study Sample

A total of 3,148 teaching activity records from 27 clinical departments were retained for analysis, yielding 3,177 speaker-activity pairs from 356 unique faculty members (Supplementary Figure S1). The four most common activity types accounted for 97.5% of all records: mini-lectures (n = 1,249, 39.7%), skills practice (n = 629, 20.0%), case discussions (n = 607, 19.3%), and teaching rounds (n = 583, 18.5%) (Table 2). Teaching volume increased substantially over the study period, from 443 activities delivered by 102 faculty in 2022 to 1,339 activities by 269 faculty in 2025.

Hospital-Wide and Department-Level Workload Inequality (RQ1)

The distribution of teaching activities across 356 participating faculty was markedly unequal. The hospital-wide Gini coefficient using pooled (2022-2025) data was 0.554 (95% CI: 0.514-0.590), indicating moderate-to-high concentration. Because the denominator comprised only faculty who delivered at least one recorded activity, this estimate reflects inequality among participating faculty and represents a lower bound of the true hospital-wide inequality; the same qualification applies to the department-level estimates presented below. The Lorenz curve (Figure 1) showed substantial departure from the line of equality: the top 10% of faculty (n = 35) delivered 39.0% of all activities, the top 20% (n = 71) delivered 57.8%, while the bottom 50% (n = 178) contributed only 12.8%. Individual teaching loads were right-skewed (MEAN = 8.9, median = 5, SD = 11.6, IQR: 2-12, range: 1-97).

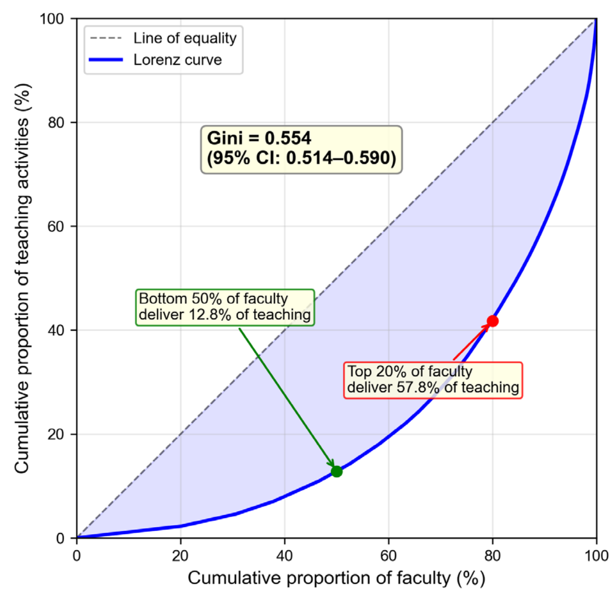


Figure 1. Lorenz Curve of Hospital-Wide Teaching Workload Distribution (Pooled 2022-2025)
Lorenz curve depicting the cumulative distribution of teaching activities across 356 participating faculty members. The diagonal dashed line represents perfect equality. The bottom 50% of faculty contributed 12.8% of all teaching activities, while the top 20% delivered 57.8%. The hospital-wide Gini coefficient was 0.554 (95% CI: 0.514-0.590).

Department-level Gini coefficients varied widely across the 27 departments, ranging from 0.000 to 0.702; among departments with at least five participating faculty, the range was 0.133-0.702 (Figure 2, Table 1). The highest inequality was observed in Obstetrics and Gynecology (Gini = 0.702, 33 faculty), Emergency Surgery (0.609, 8 faculty), and Ultrasound (0.599, 19 faculty). Conversely, several departments showed relatively equitable distributions: Neurology (0.193, 24 faculty), Cardiology (0.207, 9 faculty), and Pediatrics (0.133, 10 faculty). Surgical departments (n = 8) had a numerically higher median Gini (0.401) than medical departments (n = 13, median = 0.370), but this difference was not statistically significant (Mann-Whitney U = 36.0, $p = 0.269$). Teaching activity volume was positively correlated with departmental workload inequality (Spearman rho = 0.607, $p < 0.001$), suggesting that larger teaching programs were more susceptible to workload concentration.

Table 1. Department-Level Workload Inequality and Temporal Patterns (n = 27 Departments)

Department	Cat.	Faculty	Pairs	Gini (95% CI)	Morning %	Afternoon %	Evening %	Peak
Obstetrics & Gynecology	Oth	33	506	0.702 (0.597-0.751)	39.7	43.5	16.6	09:00
Emergency Surgery	Sur	8	139	0.609 (0.326-0.710)	61.3	28.5	10.2	10:00
Ultrasound	Oth	19	214	0.599 (0.432-0.695)	8.5	89.1	2.4	16:00
GI Surgery	Sur	28	236	0.565 (0.452-0.622)	25.5	68.5	6.0	17:00
Reproductive Med.[a]	Oth	4	39	0.558 (0.000-0.625)	38.5	59.0	2.6	16:00
Nephrology	Med	43	154	0.504 (0.416-0.561)	52.5	46.1	1.4	15:00
Pulm. & Crit. Care	Med	14	109	0.488 (0.294-0.599)	76.1	22.9	0.9	11:00
Orthopedics	Sur	26	199	0.446 (0.332-0.523)	35.7	56.8	7.5	15:00
Urology	Sur	14	206	0.439 (0.257-0.536)	64.1	32.5	3.4	09:00
General Practice	Med	7	31	0.433 (0.190-0.492)	12.9	83.9	3.2	15:00
Rheumatology[a]	Med	4	38	0.421 (0.050-0.462)	76.3	23.7	0.0	10:00
Gastroenter-ology	Med	16	117	0.380 (0.231-0.485)	66.7	32.5	0.9	11:00
ICU	Med	14	145	0.377 (0.229-0.486)	75.0	24.3	0.0	10:00
Hematology	Med	8	54	0.370 (0.178-0.481)	44.4	55.6	0.0	16:00
General Surgery	Sur	21	233	0.363 (0.255-0.439)	58.1	36.7	4.8	10:00
Infectious Disease	Med	6	60	0.356 (0.136-0.391)	53.3	46.7	0.0	16:00
Anesthesiol-ogy	Sur	17	158	0.334 (0.182-0.463)	2.5	96.2	1.3	15:00
CV Surgery[a]	Sur	3	36	0.315 (0.000-0.493)	72.2	27.8	0.0	08:00
Endocrinology	Med	14	37	0.315 (0.202-0.362)	62.2	37.8	0.0	10:00
Thoracic Surgery	Sur	12	158	0.302 (0.164-0.413)	70.9	27.8	1.3	09:00
Radiology	Oth	11	48	0.288 (0.145-0.391)	6.2	93.8	0.0	16:00
Neonatology	Oth	6	10	0.233 (0.076-0.267)	40.0	60.0	0.0	15:00
Cardiology	Med	9	130	0.207 (0.084-0.272)	58.5	39.2	2.3	10:00
Neurology	Med	24	69	0.193 (0.121-0.251)	88.4	11.6	0.0	11:00
Pediatrics	Oth	10	12	0.133 (0.000-0.171)	50.0	41.7	8.3	10:00

Department	Cat.	Faculty	Pairs	Gini (95% CI)	Morning %	Afternoon %	Evening %	Peak
Geriatrics[a]	Med	3	16	0.083 (0.000-0.095)	62.5	37.5	0.0	10:00
Emergency Med.[a]	Med	1	23	0.000 (0.000-0.000)	30.4	13.0	56.5	18:00
Medical (n = 13)				**Median: 0.370**				
Surgical (n = 8)				**Median: 0.401**				
Mann-Whitney U				**U = 36.0, p = 0.269**				

Notes: Cat. = Category: Med = Medical, Sur = Surgical, Oth = Other. Pairs = speaker-activity pairs. Morning = 06:00-11:59, Afternoon = 12:00-17:59, Evening = 18:00-23:59. Peak = modal teaching hour. Departments ranked by Gini coefficient (descending). 95% CIs estimated by 2,000 bootstrap resamples. [a] Departments with fewer than five participating faculty; Gini coefficients may be unstable and were excluded from group comparisons.

Table 2. Teaching Method Distribution and Temporal Signatures

Method	N (%)	Morning %	Afternoon %	Evening %	Peak Hour
Mini-lecture	1,249 (39.7)	39.2	51.8	9.0	16:00
Skills Practice	629 (20.0)	40.1	56.9	2.7	15:00
Case Discussion	607 (19.3)	50.2	45.6	4.1	10:00
Teaching Round	583 (18.5)	67.2	30.4	2.2	09:00
Other[a]	80 (2.5)	–	–	–	–
Total	**3,148 (100.0)**	**46.9**	**47.4**	**5.6**	**16:00**

Notes: Morning = 06:00-11:59, Afternoon = 12:00-17:59, Evening = 18:00-23:59. Chi-square test for method x time-of-day (top 4 methods): chi-square = 178.1, df = 6, $p < 0.001$, Cramer's V = 0.17. [a] Includes complex case discussions (n = 46), outpatient teaching (n = 13), radiology teaching (n = 10), faculty-student meetings (n = 5), literature review sessions (n = 5), and surgical skills instruction (n = 1).

Figure 2. Department-Level Gini Coefficients for Teaching Workload Distribution
Cleveland dot plot showing Gini coefficients with bootstrap 95% CIs for 27 departments, ranked by inequality. Departments are color-coded by category: medical (blue), surgical (red), and other (green). Departments with fewer than five faculty are marked with open symbols. The vertical dashed line indicates the hospital-wide Gini of 0.554.

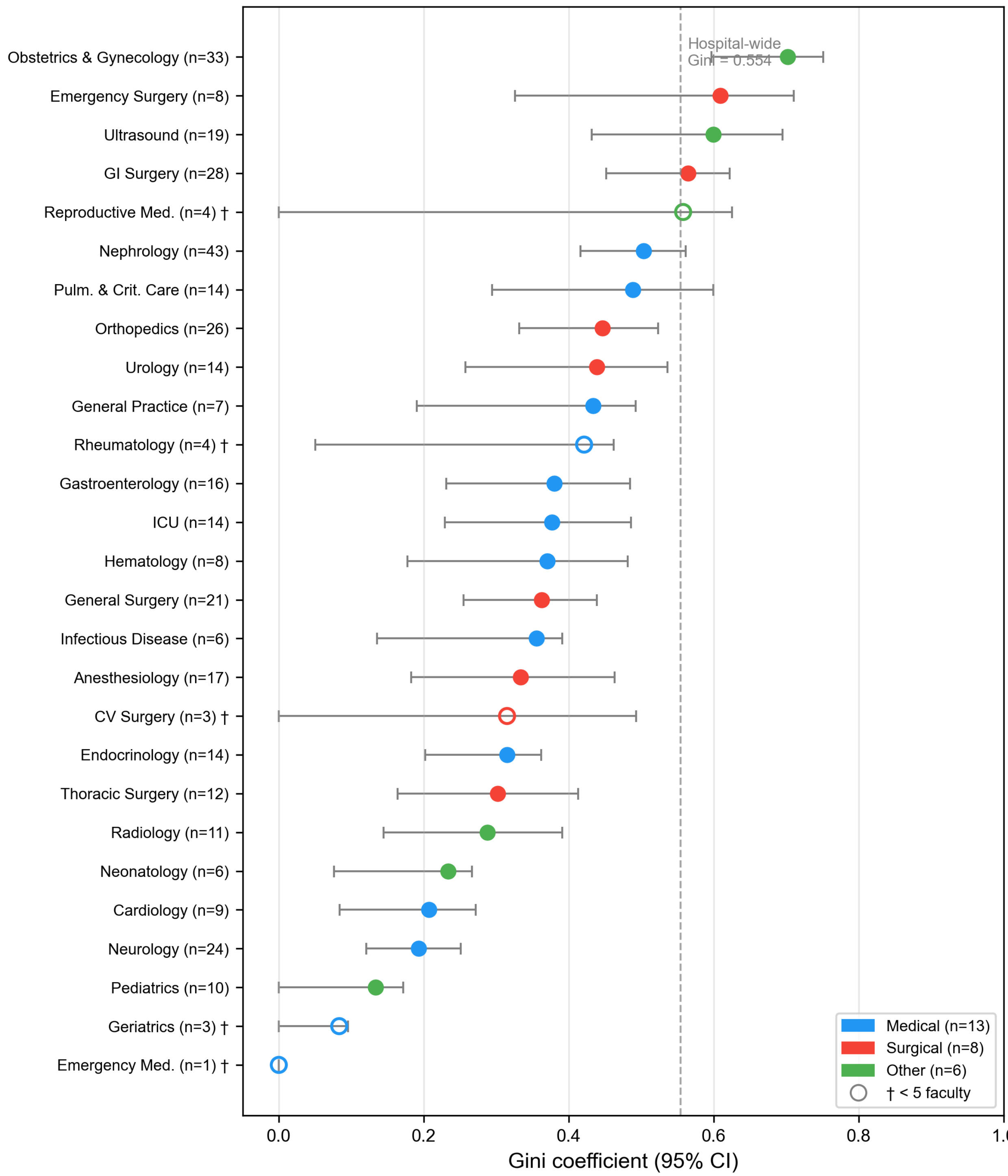
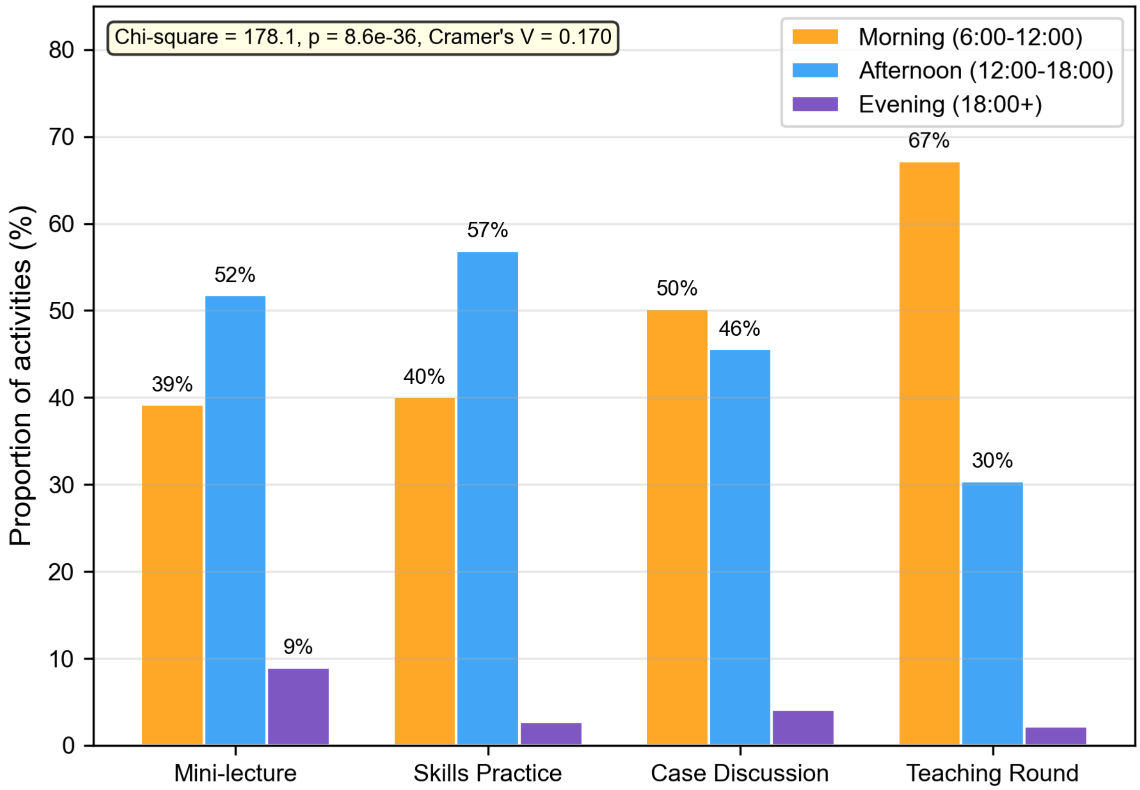


Figure 3. Teaching Method Distribution by Time of Day
Grouped bar chart showing morning, afternoon, and evening proportions for four major teaching methods. Teaching rounds were predominantly morning activities (67.2%), while mini-lectures clustered in the afternoon (51.8%), with the highest evening proportion (9.0%). Chi-square = 178.1, df = 6, $p < 0.001$, Cramer's V = 0.17.



Temporal Patterns of Teaching Activities (RQ2)

Hospital-wide, teaching activities were nearly evenly split between morning (n = 1,476, 46.9%) and afternoon (n = 1,493, 47.4%) sessions, with a smaller proportion in the evening (n = 176, 5.6%) and on weekends (n = 70, 2.2%). Teaching methods exhibited distinct temporal signatures (chi-square = 178.1, df = 6, $p < 0.001$, Cramer's V = 0.17; Figure 3). Teaching rounds were predominantly morning activities (67.2% morning), reflecting integration with early ward-based clinical workflows. Mini-lectures showed the opposite pattern, clustering in the afternoon (51.8%) with the highest evening proportion (9.0%). Skills practice sessions were primarily afternoon-based (56.9%), consistent with scheduling after morning clinical duties (Table 2).

Department-level temporal profiles varied dramatically (Table 1, Supplementary Figure S2). Emergency Medicine was an extreme outlier, with 56.5% of teaching occurring in the evening, reflecting the department's around-the-clock clinical rhythm. Obstetrics and Gynecology had the second-highest evening proportion (16.6%). At the other extreme, Anesthesiology concentrated 96.2% of activities in the afternoon, Radiology 93.8% in the afternoon, and Neurology 88.4% in the morning.

Inequality-Temporal Association (RQ3)

At the department level (n = 26), evening teaching proportion (rho = 0.547, q = 0.027) and temporal entropy of teaching hours (rho = 0.499, q = 0.033) showed significant positive associations with the Gini coefficient after BH-FDR correction (Table 3, Figure 4). These findings indicate that departments with more evening teaching and greater temporal dispersion tended to have higher workload inequality. However, because teaching volume was independently correlated with inequality (rho = 0.607, $p < 0.001$), partial Spearman correlations controlling for volume were conducted: the evening teaching association declined from rho = 0.547 to partial rho = 0.348 (a 36% reduction, $p = 0.088$) and temporal entropy from rho = 0.499 to partial rho = 0.284 (a 43% reduction, $p = 0.168$), neither reaching statistical significance.

Table 3. Inequality-Temporal Association Analysis

Panel A: Department-Level Associations (n = 26 Departments)

Temporal Feature	rho	*p*	*q* (BH-FDR)	Sig.
Evening teaching %	0.547	0.004	0.027	*
Temporal entropy (hours)	0.499	0.010	0.033	*
Weekend teaching %	0.395	0.046	0.081	
Peak hour concentration	-0.405	0.040	0.081	
Weekday entropy	0.317	0.115	0.161	
Morning teaching %	-0.236	0.247	0.288	
Hour spread (SD)	0.192	0.348	0.348	

Spearman correlations between the department Gini coefficient and temporal features. BH-FDR correction across 7 tests. Emergency Medicine excluded (single faculty member).

Panel B: Teaching Volume and Temporal Characteristics of Individual Faculty (n = 247 Active Speakers, ≥3 Activities)

Temporal Flexibility Measure	rho	*p*	*q* (BH-FDR)	Sig.
Unique hours used	0.771	<0.001	<0.001	**
Method type diversity	0.627	<0.001	<0.001	**
Hour spread (SD)	0.386	<0.001	<0.001	**
Evening teaching %	0.348	<0.001	<0.001	**

Spearman correlations between individual teaching volume and temporal flexibility. BH-FDR correction across 4 tests. * $q < 0.05$; ** $q < 0.001$.

Figure 4. Association Between Evening Teaching Proportion and Department-Level Workload Inequality
Scatter plot of evening teaching proportion versus Gini coefficient for 26 departments. Point size is proportional to teaching volume. Spearman rho = 0.547 ($q = 0.027$). Emergency Medicine was excluded (single faculty member).

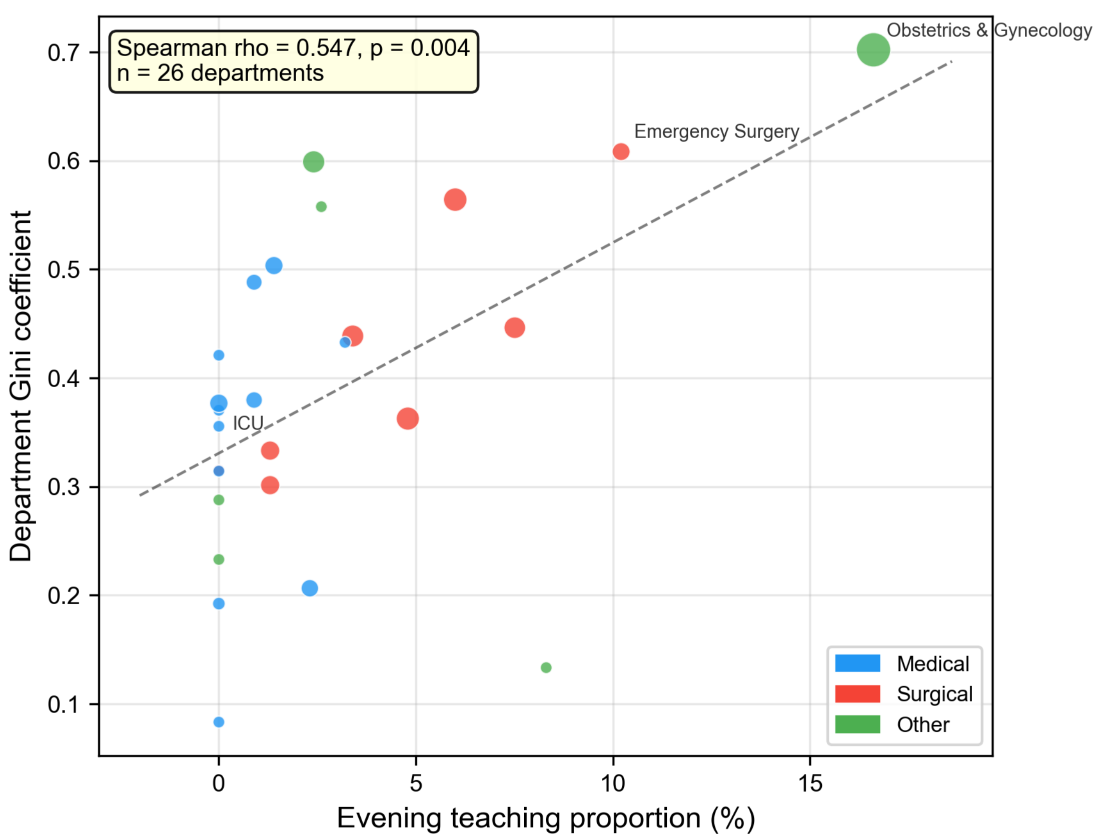
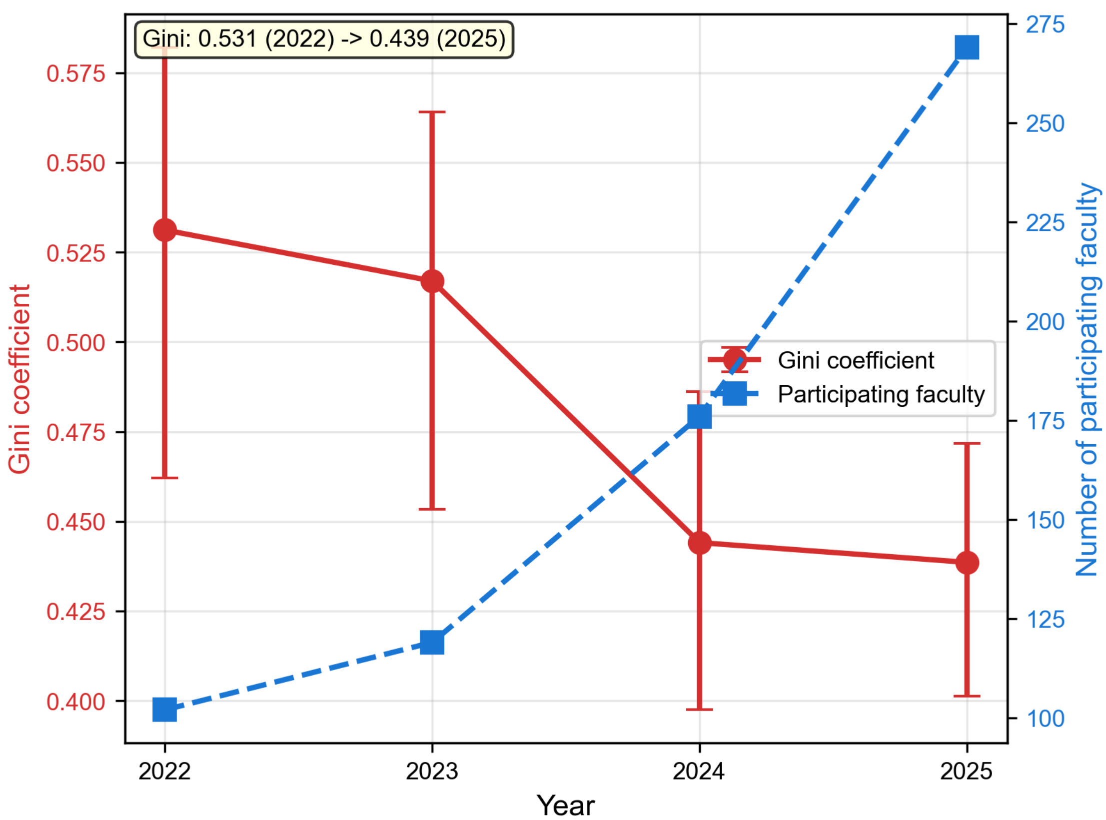


Figure 5. Temporal Trends in Teaching Workload Inequality and Faculty Participation, 2022-2025
Dual-axis line plot showing annual Gini coefficient (left axis) and participating faculty count (right axis). Gini declined from 0.531 to 0.439 while faculty increased from 102 to 269. Error bars represent bootstrap 95% CIs.



Leave-one-out analysis confirmed that no single department drove the bivariate associations.

At the individual level (n = 247 active speakers), evening teaching proportion (rho = 0.348, $q < 0.001$) and hour spread (rho = 0.386, $q < 0.001$) showed moderate positive correlations with teaching volume, providing evidence that higher-volume teachers extend into non-standard hours. High-volume teachers (top 20%, ≥17 activities, n = 51) had a higher proportion of evening teaching (7.9%) compared with low-volume teachers (bottom 50%, ≤ 8 activities, n = 125; 3.5%) and lower morning teaching (45.6% vs. 54.7%) (Supplementary Table S2). However, the average teaching hour did not differ significantly between groups (Mann-Whitney U = 3,562, $p = 0.223$), suggesting temporal extension rather than temporal shifting.

Temporal Trends (RQ4)

The hospital-wide Gini coefficient showed a decline over four years: 0.531 (95% CI: 0.462-0.582) in 2022, 0.517 (0.453-0.564) in 2023, 0.444 (0.398-0.486) in 2024, and 0.439 (0.401-0.472) in 2025 (Figure 5). The confidence intervals for 2022-2023 overlapped substantially with each other, as did those for 2024-2025, while the intervals for 2022-2023 and 2024-2025 showed minimal overlap, suggesting a step-change between 2023 and 2024 rather than a gradual decline. This decline was concurrent with a 2.6-fold increase in participating faculty (102 to 269) and a 3.0-fold increase in total activities (443 to 1,339). Among a core cohort of 41 faculty who participated in all four years, Gini coefficients were relatively stable (range: 0.445-0.494), a trajectory that contrasts with the overall hospital-wide decline and reinforces the interpretation that the hospital-wide trend was driven by compositional change – new, lower-volume faculty entering the pool – rather than redistribution among established faculty. The hospital-wide Gini was robust across sensitivity analyses (Supplementary Tables S1 and S3): a duration-weighted Gini using method-level average durations yielded 0.559, and the small-sample corrected Gini G* was 0.556 (difference = 0.002).

Discussion

This study applied the Gini coefficient to quantify teaching workload distribution among clinical faculty and examined the association between temporal scheduling patterns and workload inequality. Our analysis of 3,177 speaker-activity pairs from 356 faculty across 27 departments revealed moderate-to-high concentration (Gini = 0.554), with substantial departmental variation. Teaching methods showed distinct temporal signatures, and departments with more evening teaching had higher workload inequality, though this association was attenuated after controlling for teaching volume.

The hospital-wide teaching Gini of 0.554 is substantially higher than clinical workload Gini values (0.05–0.23) reported by Bonert et al. for pathologist caseload distribution [11] and comparable to the authorship inequality measured by Hart and Perlis across medical journals (Gini = 0.49) [12]. An important caveat is that our denominator included only 356 faculty who delivered at least one teaching activity; incorporating non-participating eligible faculty would increase the Gini substantially, making our estimate a lower bound of the true inequality. The higher inequality in teaching likely reflects fundamental differences in allocation mechanisms: clinical duties are typically assigned through structured schedules, whereas teaching participation is often voluntary and driven by intrinsic motivation.[22, 23] Faculty who find personal meaning in education may self-select into a "teaching champion" role [24], creating concentration dynamics that do not arise in scheduled clinical work.

The wide range of department-level Gini coefficients (0.133-0.702 among departments with ≥ 5 faculty) underscores the heterogeneity of teaching cultures across clinical specialties. The positive correlation between teaching volume and inequality (rho = 0.607) suggests that larger programs are more susceptible to workload concentration, potentially through diffusion of responsibility in larger groups or cumulative advantage dynamics whereby productive individuals attract further responsibilities. The absence of a significant medical-surgical divide ($p = 0.269$) suggests that teaching inequality is shaped more by department-specific organizational factors – faculty size, leadership priorities, and the availability of protected teaching time – than by broad disciplinary categories [25].

The bivariate evening teaching–inequality association (rho = 0.547) was substantially attenuated after controlling for teaching volume (partial rho = 0.348, a 36% reduction) and no longer statistically significant ($p = 0.088$). This indicates that departmental teaching volume is a major confounder: larger-volume departments simultaneously tend toward both higher inequality and more evening teaching. At the individual level, the correlation between teaching volume and evening teaching proportion (rho = 0.348) provides evidence that higher-volume teachers extend into non-standard hours, and the average teaching hour did not differ between high- and low-volume teachers ($p = 0.223$), indicating temporal extension rather than shifting. These findings suggest that while temporal scheduling patterns may accompany workload concentration, the current evidence does not support an independent association after accounting for volume. Notably, the department-level analysis (n = 26) has limited statistical power to detect moderate partial correlations, and the ecological design means that department-level patterns may not reflect individual-level mechanisms. Scheduling-based interventions alone are therefore unlikely to address the root causes of concentration.

The Gini coefficient declined from 0.531 to 0.439 over four years among platform-recorded faculty, concurrent with a 2.6-fold expansion of participating faculty. The overlapping confidence intervals suggest a step-change between 2023 and 2024 rather than a gradual trend, and with only four non-independent time points, random fluctuation or changes in platform documentation coverage cannot be excluded. The relative stability of inequality within the 41-member core cohort (Gini range: 0.445-0.494) suggests that the hospital-wide decline reflected compositional change – new, lower-volume faculty entering the pool – rather than behavioral redistribution among established educators. However, this core cohort is a highly selected subset (faculty who participated in all four years), and its stability may partly reflect a ceiling effect among the most consistently engaged teachers. This compositional mechanism mirrors findings in healthcare resource distribution studies where workforce expansion was associated with declining Gini coefficients [26]. The electronic teaching platform may have facilitated broader participation by making teaching contributions visible and creating institutional accountability. However, platform documentation coverage may have changed over the study period, and disentangling the effects of platform adoption, institutional growth, and policy changes requires further investigation.

This study has several limitations. First, this was a single-center study at a relatively young tertiary hospital, and findings may not generalize to institutions with different organizational structures. Second, only participating faculty were included in the denominator; incorporating non-participants would increase the Gini. As a rough sensitivity estimate, if the total eligible faculty pool were 500, 600, or 700, the hospital-wide Gini would rise to approximately 0.68, 0.74, or 0.77, respectively, underscoring that our estimate of 0.554 represents a lower bound of the true concentration among all eligible faculty. The annual trends should also be interpreted with this caveat: the declining Gini reflects patterns among platform-recorded participants, and expanding documentation coverage may contribute to the observed decline independently of any true redistribution. Third, the count-based measure treats all sessions equally regardless of preparation time or complexity, though a duration-weighted sensitivity analysis produced a nearly identical Gini (0.559 vs. 0.554). Because this study measures activity counts as a proxy for workload, the direction of any bias depends on whether high-volume teachers disproportionately engage in activities with greater or lesser preparation burden; if high-volume teachers favor mini-lectures (which require substantial preparation) over teaching rounds (embedded in clinical workflows), the count-based Gini may underestimate true workload concentration. Fourth, only formal, platform-recorded activities were captured; informal teaching and invisible educational labor [27] may be distributed differently. Fifth, we lacked data on faculty rank and teaching qualifications that could help distinguish between inequality and inequity. Finally, the temporal-inequality associations are cross-sectional and correlational; causal directionality cannot be established.

These findings have practical implications for teaching workload management. The Gini coefficient and Lorenz curve can serve as monitoring tools for program administrators, enabling comparisons across departments and over time. The temporal analysis adds a diagnostic dimension: departments combining high teaching volume with evening teaching proportions may benefit from protected teaching time during standard working hours. Integration of workload equity metrics with scheduling data in institutional dashboards [28] and temporal weighting in education value unit systems [29,30] could support more equitable distribution of teaching responsibilities. Future research should extend this approach to multi-center settings and investigate whether targeted scheduling interventions can reduce workload concentration.

Conclusion

Teaching workload among participating clinical faculty at this tertiary hospital was moderately to highly concentrated (Gini = 0.554), with the top 20% of faculty delivering 57.8% of all recorded teaching activities; this estimate should be interpreted as a lower bound, as incorporating non-participating eligible faculty would substantially increase concentration (sensitivity estimates reach 0.68-0.77 at plausible eligible-pool sizes of 500-700 faculty). Workload concentration varied widely across 27 departments (Gini: 0.133-0.702 among departments with ≥ 5 faculty). Teaching methods exhibited distinct temporal signatures, but the bivariate evening teaching – inequality association did not remain significant after controlling for teaching volume. Over four annual cross-sections, the Gini declined concurrently with broader faculty participation, consistent with compositional change rather than redistribution among established faculty. The Gini coefficient and Lorenz curve provide a practical framework for monitoring teaching workload concentration in residency training programs.

Abbreviations

BH-FDR, Benjamini-Hochberg false discovery rate; CCMTV, Cloud-based Clinical Medical Teaching and Visualization; CI, confidence interval; IQR, interquartile range; RQ, research question; SD, standard deviation.

Data Availability

The datasets analyzed during the current study are not publicly available due to institutional data governance policies, but are available from the corresponding author on reasonable request.

Ethics Approval and Informed Consent

This study was approved by the Ethics Committee of the Seventh Affiliated Hospital of Sun Yat-sen University (Approval No. KY-2026-111-01, dated March 25, 2026). The study used de-identified administrative data with no patient involvement. Informed consent was waived due to the retrospective use of de-identified administrative records. This study was conducted in accordance with the Declaration of Helsinki.

Consent for Publication
Not applicable. This study used de-identified administrative records with no patient involvement.

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Conflict of Interest
The authors declare that they have no competing interests.

Author Contributions

- **Zhen Zhang**: Conceptualization, Data curation, Formal analysis, Writing – original draft.
- **Chujie Chen**: Conceptualization, Methodology, Supervision, Writing – review & editing.

Both authors have reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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Supplementary Materials

Supplementary material is available as a separate file, including Supplementary Figures S1–S2 and Supplementary Tables S1-S3.