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RESEARCH ARTICLE

Integration of RES-Q-Compatible Stroke Documentation into the Hospital Information System: Evaluation of Stroke Center Indicators

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ABSTRACT

Objective: To integrate selected RES-Q-compatible quality indicators into the Hospital Information System (HIS) of a comprehensive stroke center and evaluate their impact on the completeness and consistency of structured clinical documentation.

Materials and Methods: A before-and-after observational study compared documentation completeness before and after RES-Q-compatible HIS integration. The pre-integration period covered November 2022–October 2023, and the post-integration period covered January–December 2024. November–December 2023 was considered the implementation phase and excluded from comparative analyses. The study was approved by the Institutional Review Board of Istinye University Human Research Ethics Committee (approval date: November 22, 2024; protocol number: 24-272) and was conducted in accordance with the principles of the Declaration of Helsinki. Structured documentation templates based on RES-Q quality indicators were incorporated into the HIS workflow.

Results: Documentation completeness improved significantly across almost all evaluated domains following HIS integration. Recording of symptom-onset time increased from 57.5% to 89.4%, and wake-up stroke from 46.6% to 85.3% (both p<0.001). Documentation of hypertension, coronary artery disease, diabetes mellitus, and atrial fibrillation increased from 78.8% to 93.6%, 61.1% to 92.6%, 67.0% to 91.9%, and 64.8% to 86.6%, respectively (all p<0.001). NIHSS documentation on admission improved from 47.9% to 91.9%, while INR documentation increased from 23.4% to 42.6% (both p<0.001). Overall, missing data were substantially reduced.

Conclusion: Integration of RES-Q-compatible structured documentation into the HIS significantly improved documentation completeness, data consistency, and workflow standardization in stroke care. Embedding structured data collection into routine clinical practice provides a sustainable framework for quality improvement and future registry-based performance evaluation.

Keywords: Data accuracy, electronic health records, hospital information systems, RES-Q, quality improvement, quality indicators, stroke, stroke registry

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INTRODUCTION

Stroke remains a major global public-health concern and a leading cause of mortality and long-term disability worldwide.[1] Its burden is projected to increase substantially over the coming decades, highlighting the need for systematic approaches to monitor and improve the quality of stroke care.[2] International organizations, including the European Stroke Organisation (ESO), have therefore promoted stan-

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dardized quality indicators and data-collection frameworks to support benchmarking, auditing, and continuous quality improvement across healthcare systems.[3,4]

Within health systems, every component of stroke care—from team composition and equipment standards to treatment protocols—is explicitly defined and periodically updated to align with new scientific developments. Ensuring the reliability of these evolving structures requires integration into quality-assurance frameworks that measure time-sensitive interventions, complication rates, and the implementation of secondary-prevention strategies. These standards cover acute treatment, post-acute care, and rehabilitation, enabling consistent performance monitoring over time.[5]

To address variations among regions and levels of resource availability, the ESO-EAST initiative launched the Registry of Stroke Care Quality (RES-Q) platform in 2015. This web-based data-collection system was designed to analyse healthcare quality indicators, provide hospital- and national-level feedback and benchmarking, and support healthcare systems in monitoring adherence to internationally accepted performance measures.[6] RES-Q therefore embodies a comprehensive and adaptable quality-assessment framework, optimized to accommodate diverse healthcare environments. For such systems to function effectively, certification and auditing mechanisms must rely on clearly defined, measurable performance criteria, assessed at regular intervals by independent evaluators. Infrastructure, clinical protocols, and workflow processes should all be encompassed within these evaluations. Collectively, these interlocking measures constitute a foundation for continuous quality improvement in stroke care worldwide.

Against this background, the {blinded} University Stroke Center integrated selected RES-Q-compatible documentation fields into its Hospital Information System (HIS) to establish a continuous, data-based quality assessment model. This study aims to evaluate the implementation of RES-Q-compatible structured documentation within the HIS, assess changes in documentation completeness for selected quality indicators, and provide insights into developing a sustainable quality-monitoring framework for stroke care in Turkey. The study was not designed as a full RES-Q registry validation project but rather as an assessment of HIS-based documentation quality and RES-Q compatibility.

MATERIALS and METHODS

Study Design

This single-center observational quality-improvement study used a before-and-after design to evaluate the completeness of selected RES-Q-compatible documentation fields before and after integration of structured electronic templates into the HIS. A retrospective pre-integration period (November 2022–October 2023) was compared with a prospective post-integration period (January–December 2024). November–December 2023 represented the implementation and system optimization period and was therefore excluded from comparative analyses.

Study Population

All consecutive stroke admissions recorded within the institutional stroke workflow during the study periods were included. No patient-level exclusion criteria were applied because the objective of the study was to evaluate documentation completeness rather than clinical outcomes. The unit of analysis was the documentation record associated with each stroke admission. No formal sample-size calculation was performed because all available stroke records during the study periods were included.

A total of 2,326 stroke admissions were available during the study periods, comprising 1,565 records from the pre-integration period and 761 records from the post-integration period.

Setting and Organization of Stroke Care

The İstinye University Stroke Center has been structured in accordance with comprehensive stroke center standards, providing the full continuum of care from emergency admission to post-stroke rehabilitation. The patient triage and management workflow is regulated by the institutional protocol entitled "Nörokod – Acute Stroke Diagnosis and Treatment Process," which ensures real-time coordination among vascular neurologists, the ward physician (stroke-floor physician), and the Nörokod nurse.

The stroke-floor physician is a general practitioner with a minimum of one year of experience in emergency medicine and specialized training in neurological examination, the National Institutes of Health Stroke Scale (NIHSS), hyperacute therapies, and stroke-specific imaging standards. This physician is responsible for the initial patient assessment, collection of medical history, initiation of emergency treatment, and documentation of all clinical actions.

The Nörokod nurse assists in recording vital signs, reporting critical values, facilitating intra-hospital transfers, and coordinating the diagnostic and treatment processes with the neurologist and ward physician. During radiological examinations, the nurse evaluates potential complications, measures critical time metrics, and records them in real time.

Data Sources and Measurement

Patient histories and clinical data are recorded using standardized electronic templates aligned with RES-Q quality indicators. Data entry is performed directly at the point of care by trained clinical staff to prevent retrospective input or secondary transcription errors, thereby reinforcing data reliability and enhancing quality assurance within the workflow.

The objective of the project was not to create a parallel RES-Q registry database or duplicate all RES-Q variables within a separate form. Instead, the project focused on embedding RES-Q-compatible structured documentation into routine clinical workflows. Variables already available in institutional systems, including many radiological, laboratory, and timestamp-related parameters, remained accessible through existing HIS, PACS, and laboratory information systems and therefore did not require duplicate manual registration.

The study was structured around two comparative periods separated by an implementation interval:

Pre-integration period – Retrospective evaluation (November 1, 2022–October 30, 2023): Retrospective records were analyzed to determine baseline documentation completeness for predefined RES-Q-compatible clinical indicators.

Implementation interval – System design and optimization (November–December 2023): RES-Q-compatible structured templates were developed, integrated into the HIS workflow, and optimized for routine clinical use. This interval was excluded from comparative analyses.

Post-integration period – Prospective evaluation (January 1, 2024–December 31, 2024): Following system refinement, prospective data collection was conducted to assess changes in documentation completeness after RES-Q-compatible HIS integration.

To minimize information bias, data were entered at the point of care using standardized electronic templates and predefined response options whenever applicable.

Scope of RES-Q Indicators Included in the Analysis

Although the RES-Q framework encompasses a broad spectrum of quality indicators across acute stroke management, imaging, reperfusion therapies, rehabilitation, complications, and secondary prevention, the purpose of the present study was not to evaluate the completeness of the entire RES-Q dataset.

The study specifically focused on clinical documentation domains in which structured recording by healthcare professionals was required and where improvements in documentation quality could be directly influenced by HIS integration. Several RES-Q-related variables, including many radiological findings, imaging timestamps, laboratory measurements, and other digitally generated parameters, were already available through institutional information systems and therefore were not included in the completeness analysis.

Consequently, the present study should be interpreted as an evaluation of RES-Q-compatible documentation quality within the HIS environment rather than a comprehensive assessment of all RES-Q registry variables.

System Integration and Data Handling

The project aimed to embed RES-Q quality indicators within the HIS architecture, allowing structured data capture from electronic templates without the need for a separate parallel RES-Q form. The HIS-based workflow encompassed every stage of care—from patient admission to discharge—ensuring data traceability and real-time quality monitoring.

As emphasized in prior literature, continuously updated patient registries provide key advantages by allowing expansion of sample size through ongoing case inclusion and longitudinal trend analyses across years.[1,5,6]

This study thus evaluates the applicability and effectiveness of RES-Q-based structured templates as fundamental components of the HIS, specifically assessing their capacity to enhance data integrity, standardize documentation, and facilitate non-neurologist stroke-team participation in high-quality registry-based recording aligned with international quality metrics.

Outcome Definition

The primary outcome was documentation completeness, defined as the proportion of eligible records containing a valid documented value for each selected RES-Q-compatible variable. Completeness rates were compared between the pre-integration and post-integration periods. The analysis assessed documentation completeness rather than clinical outcomes, treatment effectiveness, or patient prognosis.

The evaluated variables were selected RES-Q-compatible documentation fields grouped into four predefined domains: Stroke Circumstances, Previous Known History and Comorbidities, Pre-Admission Treatment, and Clinical Measures. For each variable, documentation completeness was assessed as the presence or absence of a valid recorded entry. For pre-admission treatment variables, a "filled" record indicated that medication status was explicitly documented in the corresponding structured field, irrespective of whether the patient was using the medication. Thus, medication-re-

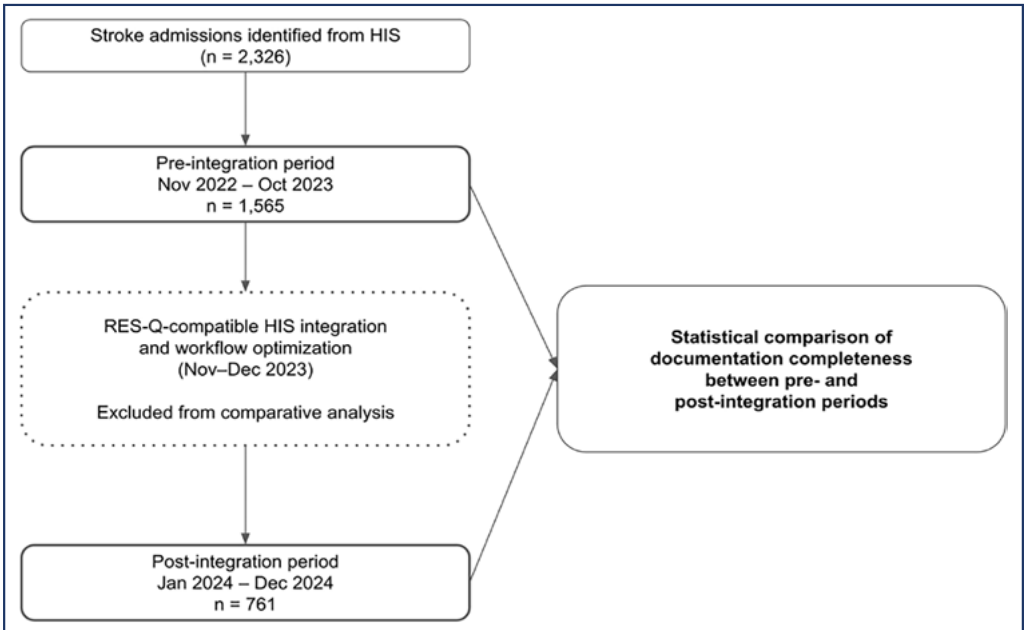

Figure 1. Study flow diagram

Flow diagram showing identification of stroke admissions, implementation of RES-Q-compatible structured documentation within the hospital information system (HIS), and comparative assessment of documentation completeness between the pre-integration (November 2022–October 2023) and post-integration (January–December 2024) periods. The implementation and system optimization phase (November–December 2023) was excluded from comparative analyses

lated completeness rates reflect the availability of documented medication-status information rather than the prevalence of medication use.

Missing Data

Missing values were not imputed. For each variable, completeness was calculated using the proportion of records containing a documented value relative to all eligible stroke records within the corresponding study period.

Statistical Analyses and Tools

Clinical data profiling was conducted using Wanalyzer v3.0 (WisdomEra Corp., Istanbul, Turkey), a platform integrated into the HIS (https://wisdomera.io). The application incorporates natural language processing (NLP) and expression management systems to extract, structure, and classify clinical information from unstructured electronic medical records. These features enabled the mapping of clinical narratives to standardized RES-Q-compatible quality indicators.

Statistical analyses were performed using Wistats v3.0 (WisdomEra Corp., Istanbul, Turkey), which operates on the Python programming language and utilizes SciPy v1.2.3, scikit-learn v0.24.0, and statsmodels v0.9.0 (https://wistats.wisdomera.io). Age is presented as mean±standard deviation and was compared between study periods using the independent samples t-test. Categorical variables are presented as frequencies and percentages. Comparisons of documentation completeness between the pre-integration and post-integration periods were performed using the chi-square test or Fisher's exact test, when appropriate.

The primary analysis evaluated the proportion of completed documentation records for each selected RES-Q-compatible variable before and after HIS integration. Completeness rates were calculated as the percentage of records containing a valid entry among all eligible stroke admissions within the corresponding study period.

All statistical tests were two-sided, and a p value<0.05 was considered statistically significant.

RESULTS

Study Flow and Included Records

The study flow is presented in Figure 1. During the study period, a total of 2,326 stroke cases were documented in the RES-Q-compatible HIS. Of these, 1,565 records belonged to the retrospective pre-integration period (November 2022–October 2023), and

Table 1. Comparison of documentation completeness for stroke circumstances before and after res-q-compatible his integration

Variables	Before mean / %	After mean / %	p
Number of cases	1565 (100)	761 (100)	
Gender			0.059
Female	679 (43.4)	357 (46.9)	
Male	886 (56.6)	404 (53.1)	
Age	71.1	70.6	0.465
Stroke while already hospitalized			<0.001
Filled	1031 (65.9)	575 (75.6)	
Not-Filled	534 (34.1)	186 (24.4)	
Wake up stroke			<0.001
Filled	729 (46.6)	649 (85.3)	
Not-Filled	836 (53.4)	112 (14.7)	
Time of admission (hospital door)			
Filled	1565 (100.0)	761 (100.0)	
Not-Filled	0 (0.0)	0 (0.0)	
Date of onset of stroke symptoms			<0.001
Filled	900 (57.5)	680 (89.4)	
Not-Filled	665 (42.5)	81 (10.6)	
First assessment location			
Filled	1565 (100.0)	761 (100.0)	
Not-Filled	0 (0.0)	0 (0.0)	
Arrival Source			<0.001
Filled	1199 (76.6)	702 (92.2)	
Not-Filled	366 (23.4)	59 (7.8)	
Name of first hospita of admission			<0.001
Filled	1176 (75.1)	647 (85.0)	
Not-Filled	389 (24.9)	114 (15.0)	
Patient hospitalized in Day 1			
Filled	1565 (100.0)	761 (100.0)	
Not-Filled	0 (0.0)	0 (0.0)	
Admitted under department			
Filled	1565 (100.0)	761 (100.0)	
Not-Filled	0 (0.0)	0 (0.0)	

Values are presented as n (%) or mean values. Documentation completeness represents the proportion of records containing a valid documented value for each variable. Comparisons were performed between the pre-integration period (November 2022–October 2023) and the post-integration period (January–December 2024). The implementation interval (November–December 2023) was excluded from analysis. Categorical variables were compared using the Chi-square test or Fisher's exact test, and continuous variables using the Independent Samples t-test. HIS: Hospital information system; RES-Q: Registry of stroke care quality

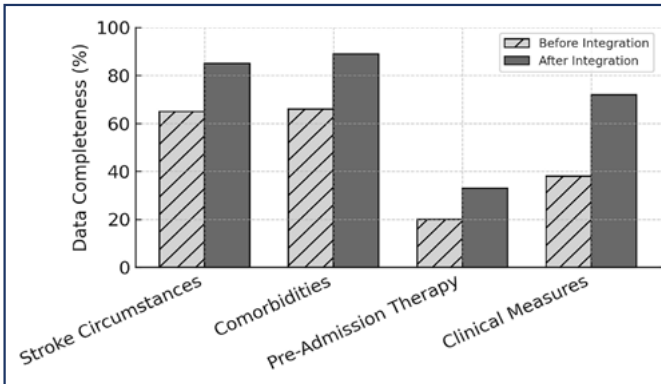

Figure 2. Overall trend in data completeness (before vs after integration)

This figure illustrates the improvement in data completeness across four analyzed RES-Q-compatible documentation domains—Stroke Circumstances, Comorbidities, Pre-Admission Therapy, and Clinical Measures—before and after integration of selected RES-Q-compatible templates into the hospital information system (HIS)

761 records were captured during the prospective post-integration period (January–December 2024). The implementation and system optimization interval (November–December 2023) was excluded from comparative analyses. All available entries from both periods were included in the analysis without exclusions. Because the study focused on documentation completeness rather than patient follow-up or clinical outcomes, no eligibility screening or attrition stages were applicable.

Stroke Circumstances

In the Stroke Circumstances domain, the proportion of completed records increased significantly for nearly all analyzed parameters. Documentation of stroke occurring during hospitalization improved from 65.9% to 75.6%, wake-up stroke from 46.6% to 85.3%, and symptom-onset time from 57.5% to 89.4% (all p<0.001; Table 1). Similarly, completeness for arrival source increased from 76.6% to 92.2%, and first hospital of admission from 75.1% to 85.0% (both p<0.001; Table 1). Overall domain-level improvement is summarized in Figure 2.

Previous Medical History and Comorbidities

Completeness of previous medical history and comorbidity documentation improved substantially after RES-Q-compatible HIS integration. Filled records increased for hypertension from 78.8% to 93.6%, coronary artery disease or myocardial infarction from 61.1% to 92.6%, diabetes mellitus from 67.0% to 91.9%, congestive heart failure from 56.9% to 83.7%, and atrial fibrillation or flutter from 64.8% to 86.6%

Table 2. Comparison of documentation completeness for previous medical history and comorbidities before and After RES-Q-compatible HIS integration

Variables	Before n (%)	After n (%)	p
Number of cases	1565 (100)	761 (100)	
Hypertension			<0.001
Filled	1234 (78.8)	712 (93.6)	
Not-filled	331 (21.2)	49 (6.4)	
Coronary artery disease			<0.001
Filled	956 (61.1)	705 (92.6)	
Not-filled	609 (38.9)	56 (7.4)	
Diabetes			<0.001
Filled	1049 (67.0)	699 (91.9)	
Not-filled	516 (33.0)	62 (8.1)	
Congestive heart failure			<0.001
Filled	891 (56.9)	637 (83.7)	
Not-filled	674 (43.1)	124 (16.3)	
Hormonal contraception			
Filled	0 (0.0)	0 (0.0)	
Not-filled	1565 (100.0)	761 (100.0)	
Smoking			<0.001
Filled	475 (30.4)	20 (2.6)	
Not-filled	1090 (69.6)	741 (97.4)	
HIV			<0.001
Filled	745 (47.6)	230 (30.2)	
Not-filled	820 (52.4)	531 (69.8)	
Previous hemorrhagic stroke			<0.001
Filled	862 (55.1)	236 (31.0)	
Not-filled	703 (44.9)	525 (69.0)	
Atrial fibrillation/flutter			<0.001
Filled	1014 (64.8)	659 (86.6)	
Not-filled	551 (35.2)	102 (13.4)	

Data are presented as n (%). Documentation completeness represents the proportion of records containing a valid documented value for each comorbidity variable. Comparisons were performed between the pre-integration period (November 2022–October 2023) and the post-integration period (January–December 2024). The implementation interval (November–December 2023) was excluded from analysis. P values were calculated using the Chi-square test or Fisher's exact test, as appropriate. RES-: Registry of stroke care quality; HIS: Hospital information system; MI: Myocardial infarction; HIV: Human immunodeficiency virus

(all p<0.001; Table 2). In contrast, completeness declined for smoking status from 30.4% to 2.6%, HIV history from 47.6% to 30.2%, and previous hemorrhagic stroke from 55.1% to 31.0% (all p<0.001; Table 2). Parameter-specific changes are illustrated in Figure 3.

Pre-Admission Treatment

Documentation completeness also improved in the Pre-Admission Treatment domain. Recording of antihypertensive use increased from 25.5% to 38.6%, antidiabetic medication from 11.7% to 19.7%, and statin therapy from 4.9% to 9.5% (all p<0.001; Table 3). Completeness for apixaban increased from 2.2% to 3.7%, edoxaban from 0.6% to 1.4%, and cilostazol from 0.1% to 0.5% (all p<0.05; Table 3).

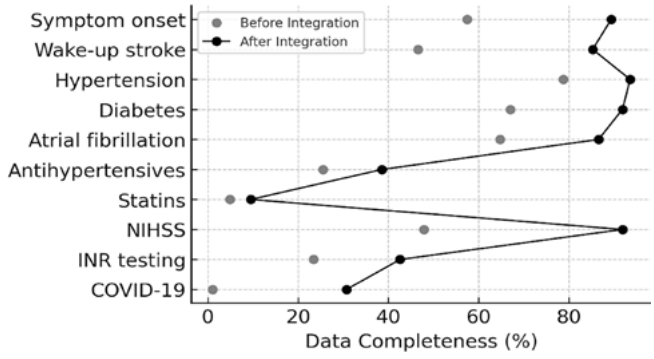

Figure 3. Parameter-specific changes in data completeness

Parameter-level trends in completeness are shown for representative RES-Q variables. Gray circles indicate values before, and black circles indicate values after integration. Consistent upward shifts demonstrate improved documentation for critical measures such as symptom-onset time (57.5 %)

Clinical Measures

The Clinical Measures domain demonstrated the most pronounced gains. Documentation of NIHSS on admission increased from 47.9% to 91.9%, INR testing from 23.4% to 42.6%, and COVID-19 status from 1.0% to 30.7% (all p<0.001; Table 4). In contrast, documentation completeness for pre-admission modified Rankin Scale (mRS) declined from 5.4% to 0.4% (p<0.001; Table 4). The distribution of completeness improvements across analyzed parameters is shown in Figure 4.

Overall Documentation Completeness

Overall, post-integration analyses showed a statistically significant enhancement in documentation completeness across nearly all analyzed RES-Q-compatible documentation domains. These findings support the effectiveness of RES-Q-compatible structured electronic templates for improving documentation quality and data reliability within the HIS workflow.

DISCUSSION

This study demonstrates that embedding selected RES-Q-compatible documentation fields into the institutional workflow of the Stroke Center was associated with measurable improvements in data completeness and documentation quality across multiple domains of stroke care. Following the

Table 3. Comparison of documentation completeness for pre-admission treatment before and after RES-Q-compatible HIS integration

Variables	Before n (%)	After n (%)	p	Variables	Before n (%)	After n (%)	p
Number of cases	1565 (100)	761 (100)		Dipyridamol			
Anti-hypertensives			<0.001	Filled	0 (0.0)	0 (0.0)	
Filled	399 (25.5)	294 (38.6)		Not-filled	1565 (100.0)	761 (100.0)	
Not-filled	1166 (74.5)	467 (61.4)		Warfarin			0.408
Anti-diabetics			<0.001	Filled	37 (2.4)	16 (2.1)	
Filled	183 (11.7)	150 (19.7)		Not-filled	1528 (97.6)	745 (97.9)	
Not-filled	1382 (88.3)	611 (80.3)		LMWH/Heparin			0.223
Aspirin (ASA)			0.068	Filled	17 (1.1)	5 (0.7)	
Filled	439 (28.1)	237 (31.1)		Not-filled	1548 (98.9)	756 (99.3)	
Not-filled	1126 (71.9)	524 (68.9)		Dabigatran			0.415
Cilostazol			0.024	Filled	4 (0.3)	3 (0.4)	
Filled	1 (0.1)	4 (0.5)		Not-filled	1561 (99.7)	758 (99.6)	
Not-filled	1564 (99.9)	757 (99.5)		Rivaroxaban			0.055
Clopidogrel			0.070	Filled	53 (3.4)	37 (4.9)	
Filled	98 (6.3)	61 (8.0)		Not-filled	1512 (96.6)	724 (95.1)	
Not-filled	1467 (93.7)	700 (92.0)		Apixaban			0.032
Ticagrelor				Filled	35 (2.2)	28 (3.7)	
Filled	0 (0.0)	0 (0.0)		Not-filled	1530 (97.8)	733 (96.3)	
Not-filled	1565 (100.0)	761 (100.0)		Edoxaban			0.032
Ticlopidine				Filled	9 (0.6)	11 (1.4)	
Filled	0 (0.0)	0 (0.0)		Not-filled	1556 (99.4)	750 (98.6)	
Not-filled	1565 (100.0)	761 (100.0)		Statin			<0.001
Prasugrel				Filled	76 (4.9)	72 (9.5)	
Filled	0 (0.0)	0 (0.0)		Not-filled	1489 (95.1)	689 (90.5)	
Not-filled	1565 (100.0)	761 (100.0)					

Data are presented as n (%). Documentation completeness represents the proportion of records containing a valid documented value for each pre-admission medication variable. Comparisons were performed between the pre-integration period (November 2022–October 2023) and the post-integration period (January–December 2024). The implementation interval (November–December 2023) was excluded from analysis. P values were calculated using the Chi-square test or Fisher's exact test, as appropriate. RES-Q: Registry of stroke care quality; HIS: Hospital information system; ASA: Acetylsalicylic acid; LMWH: Low-molecular-weight heparin

implementation of structured electronic templates and direct point-of-care entry, we observed substantial gains in domains such as stroke circumstances (e.g., symptom-onset time, arrival source), comorbidities and pre-admission treatments, and key clinical measures (e.g., NIHSS on admission). These findings align with prior evidence indicating that well-designed registries and focused quality systems can enhance both data fidelity and, by extension, care performance.[7,8]

Importantly, our objective was not to replicate the complete RES-Q registry structure within a separate data-entry environment. Instead, we sought to improve the completeness of clinical information that requires active documentation by the stroke team. Many radiological, laboratory, and system-generated quality indicators already existed within the institutional digital infrastructure and therefore did not require additional manual registration. This distinction is important when interpreting the scope of the reported completeness analyses.

These improvements in documentation—for example, increasing the recording of NIHSS on admission from 47.9% to 91.9%—suggest that embedding process measures into routine care can lead to meaningful workflow change. This is consistent with the notion that adherence to performance indicators is linked to better patient outcomes.[9] In other words, enhanced data completeness is not simply a technical achievement but may reflect deeper changes in care culture, from "optional documentation" to "care-system-integrated documentation."

The results also reflect broader insights from the epidemiology of stroke and the evolving need for quality improvement. Globally, despite declining age-standardized rates in some settings, the absolute burden of stroke continues to rise.[10,11] Thus, establishing robust quality-monitoring systems such as RES-Q is a critical response. Additionally, as De Cola et al.[12] highlight, quality indicators need to span not only acute care but also rehabilitation and follow-up phases to ensure

Table 4. Comparison of documentation completeness for clinical measures before and after RES-Q-compatible HIS integration

Variables	Before n (%)	After n (%)	p
Number of cases	1565 (100)	761 (100)	
NIHSS on admission			<0.001
Filled	750 (47.9)	699 (91.9)	
Not-filled	815 (52.1)	62 (8.1)	
Glasgow coma scale			<0.001
Filled	121 (7.7)	701 (92.1)	
Not-filled	1444 (92.3)	60 (7.9)	
mRS			<0.001
Filled	85 (5.4)	3 (0.4)	
Not-filled	1480 (94.6)	758 (99.6)	
COVID-19 status			<0.001
Filled	16 (1.0)	234 (30.7)	
Not-filled	1549 (99.0)	527 (69.3)	
INR testing			<0.001
Filled	366 (23.4)	324 (42.6)	
Not-filled	1199 (76.6)	437 (57.4)	

Data are presented as n (%). Documentation completeness represents the proportion of records containing a valid documented value for each clinical measure. Comparisons were performed between the pre-integration period (November 2022–October 2023) and the post-integration period (January–December 2024). The implementation interval (November–December 2023) was excluded from analysis. P values were calculated using the Chi-square test or Fisher's exact test, as appropriate. RES-Q: Registry of stroke care quality; NIHSS: National institutes of health stroke scale; INR: International normalized ratio; mRS: Modified rankin scale; COVID-19: Coronavirus disease 2019

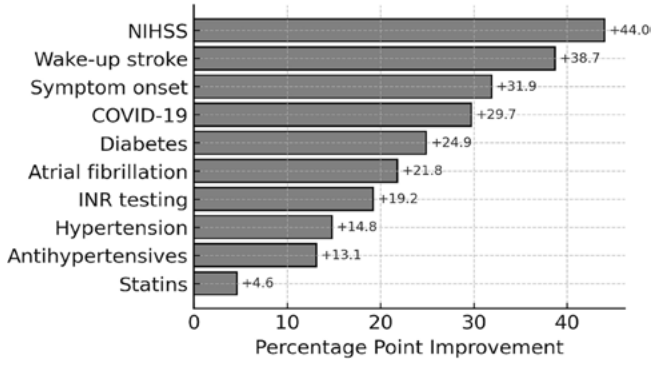

Figure 4. Completeness improvement distribution (after–before)

This horizontal bar graph displays the percentage-point change (Δ %) in data completeness for all analyzed parameters, ranked from greatest to smallest improvement. The most pronounced gains were observed in NIHSS on admission (+44 pp), symptom-onset documentation (+32 pp), wake-up stroke (+39 pp), and diabetes mellitus (+25 pp). Gray gradient bars highlight the magnitude of improvement for each metric, demonstrating the overall enhancement in data recording performance following RES-Q-compatible HIS integration

that the full stroke-care continuum is captured. Our HIS template structure was designed to reflect this broad continuum; however, the present analysis focused on selected clinical documentation domains.

Nevertheless, some limitations and key challenges remain. In this study, certain parameters, including smoking status, HIV history, previous hemorrhagic stroke, and pre-admission mRS, showed declining completeness after implementation. This suggests that even when systems are optimized, certain data fields remain vulnerable—likely those that are not directly tied to immediate acute-care workflow or whose documentation responsibilities are less clearly owned by the stroke team. This observation mirrors the findings of Purvis et al.[13] that many process indicators, especially those related to early rehabilitation or non-immediate care phases, are underused or misaligned with guideline-derived sets. The decline in mRS completeness, for example, may reflect difficulties in capturing functional outcomes in real time within busy stroke units.

Moreover, while data completeness is a prerequisite for outcome monitoring and benchmarking, it is not in itself a guarantee of care quality improvement or better patient outcomes. For example, documentation improvements do not directly equate to faster door-to-needle times, shorter lengths of stay, or lower recurrence rates; these downstream endpoints require separate measurement and may lag behind documentation changes. In this respect, our study should be interpreted as an intermediate outcome (i.e., documentation quality) rather than a patient-outcome study. Future work should link improved documentation to actual clinical outcomes and process times (e.g., reperfusion delays, complication rates) to complete the "quality-improvement loop."

From a systems perspective, our experience reinforces three major enablers for success: (1) integration of selected RES-Q-compatible templates into the HIS such that data entry is seamless, (2) training and empowerment of multidisciplinary team members (including non-neurologist physicians, nurses, and information-system staff) to adopt the new workflow, and (3) feedback loops and periodic auditing to sustain performance. Our institution's before-and-after approach, with a defined implementation interval between retrospective baseline assessment and prospective monitoring, may provide a replicable model for other centers seeking to operationalize registry-based quality improvement.

Another important consideration is that the study evaluated selected RES-Q-compatible documentation domains rather

than the entire spectrum of RES-Q indicators. This approach was intentional because numerous imaging- and laboratory-related parameters were already routinely captured by existing hospital systems. Therefore, the findings should be interpreted as reflecting improvements in structured clinical documentation rather than completeness of every variable included in the RES-Q framework.

Despite these strengths, several limitations should be acknowledged. Although the integration of selected RES-Q-compatible documentation fields into the HIS significantly improved documentation completeness, this study has several limitations. First, data quality in the pre-integration period depended on retrospective documentation, which may introduce information bias and limit the accuracy of baseline completeness estimates. Second, while the structured templates enhanced standardization, variations in clinician engagement and workflow intensity could still influence data entry reliability, leading to differential completeness across indicators. Third, the study evaluated documentation quality rather than clinical outcomes; thus, improvements in completeness cannot be directly linked to better patient care or functional recovery. Additionally, the findings reflect the experience of a single stroke center, which may limit generalizability to other institutions with different staffing models or HIS infrastructures. Finally, the study did not assess the long-term sustainability of improvements, and further follow-up is required to determine whether documentation gains persist over time.

In the context of the Turkish healthcare environment, where stroke center certification and systematic registries are less uniformly established than in some high-income countries, our findings may have broader implications. Implementing the RES-Q template structure may help bridge regional disparities, support benchmarking, and foster continuous data-driven improvement in stroke care. Given the rising stroke burden projected globally and in middle-income settings, such infrastructures are timely and necessary.[14]

CONCLUSION

In conclusion, while documentation completeness is one component of care quality, the substantial gains observed in our center following the integration of selected RES-Q-compatible templates into the daily workflow suggest that systematically applied quality-registry frameworks can materially improve data capture. Sustaining gains will require ongoing training, performance feedback, integration across the full stroke pathway (including rehabilitation), and measurement of whether improved documentation translates into improved clinical outcomes.

Disclosures

Ethics Committee Approval: The study was approved by the Istinye University Human Research Ethics Committee (No: 24-272, Date: 22/11/2024).

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