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Validity of different algorithmic methods to identify hospital readmissions from routinely coded medical data

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Abstract

Background: Hospital readmission rates are used for quality and pay-for-performance initiatives. To identify readmissions from administrative data, two commonly employed methods are focusing either on unplanned readmissions (used by the Centers for Medicare & Medicaid Services, CMS) or potentially avoidable readmissions (used by commercial vendors such as SQLape or 3 M). However, it is not known which of these methods has higher criterion validity and can more accurately identify actually avoidable readmissions.

Objectives: A manual record review based on data from seven hospitals was used to compare the validity of the methods by CMS and SQLape.

Methods: Seven independent reviewers reviewed 738 single inpatient stays. The sensitivity, specificity, positive predictive value (PPV), and F1 score were examined to characterize the ability of an original CMS method, an adapted version of the CMS method, and the SQLape method to identify unplanned, potentially avoidable, and actually avoidable readmissions.

Results: Both versions of the CMS method had greater sensitivity (92/86% vs. 62%) and a higher PPV (84/91% vs. 71%) than the SQLape method, in terms of identifying their outcomes of interest (unplanned vs. potentially avoidable readmissions, respectively). To distinguish actually avoidable readmissions, the two versions of the CMS method again displayed higher sensitivity (90/85% vs. 66%), although the PPV did not differ significantly between the different methods.

Conclusions: Thus, the CMS method has both higher criterion validity and greater sensitivity for identifying actually avoidable readmissions, compared with the SQLape method. Consequently, the CMS method should primarily be used for quality initiatives.

INTRODUCTION

Many countries use hospital readmission rates in quality monitoring programs and pay-for-performance initiatives.[1] However, different algorithmic methods can be chosen to identify relevant readmissions from the routinely coded medical data used in hospital administration. Two particularly established methods both focus on readmissions within 30 days of discharge but differ in defining readmissions as either "unplanned" or "potentially avoidable." The method used by the Centers for Medicare & Medicaid Services (CMS) distinguishes planned from unplanned readmissions,[2,3] whereas an alternative method used by several commercial vendors (such as SQLape or 3 M) attempts to further differentiate between unavoidable and potentially avoidable readmissions. The latter is achieved by making rule-based assumptions about which coded diagnoses and procedures are potentially avoidable (see below).[4–6]

Due to their use in the Hospital Readmission Reduction Program (HRRP) in the United States,[7] unplanned readmissions are more frequently discussed in the academic literature,[8] but the commercial vendors focusing on potentially avoidable readmissions argue that their method is more impactful in practice as it provides additional information on the preventability.[4,5] Previous studies (using the 3 M method for identifying potentially avoidable readmissions) have shown that the two methods produce different hospital quality rankings,[9–12] but to the best of our knowledge, their validity has never been directly compared. This creates an important research gap for policy makers, who must decide on quality programs based on one method or the other.

As part of a large initiative to adopt additional quality indicators in Switzerland (see below), we have compared the validity of an original version of the CMS method, an adapted version of the CMS method, and the SQLape method. Our primary objective was to assess which method shows higher criterion validity with respect to their outcomes of interest (i.e., identifying unplanned readmissions in the case of the CMS method and potentially avoidable readmissions in the case of the SQLape method). Our secondary objective was to examine the validity of the methods in identifying readmissions judged as actually avoidable by our reviewers to investigate whether the SQLape method offers an advantage in identifying actually avoidable readmissions.

METHODS

Study design and data

This study was part of a large collaborative research project funded by the Swiss Innovation Agency (Innosuisse) aiming to translate, examine, and adopt international quality indicators into the Swiss healthcare and medical coding system (research grant number 40160.1 IP-SBM). The results presented herein are from a retrospective manual record review using administrative and electronic medical record data for the fiscal years 2014–2018 from seven hospitals that participated in the study: three universities (i.e., academic teaching) hospitals, three private hospitals, and one regional cantonal hospital.

The administrative data set[13] contained all inpatient stays treated by the hospitals during the study period, with up to 50 diagnosis codes for each stay (from the International Statistical Classification of Diseases and Related Health Problems, 10th revision, German Modification, ICD-10-GM),[14] up to 100 procedure codes (from the Swiss classification of surgical interventions, CHOP),[14] the diagnosis-related group (from the SwissDRG system),[15] other clinically relevant variables such as admission and discharge conditions, and patients' demographic information. Electronic medical records were accessed directly by the reviewers at the hospitals and contained all available information from the patient documentation (e.g., discharge letters, surgery reports, charts, medications, as well as imaging, laboratory, and other results). The study was approved in a jurisdictional inquiry by the Ethics Committee Northwest- & Central Switzerland (January 27, 2021; ID: Req-2019–00624). Informed consent from patients was not required because the study was conducted as a quality control project within hospitals.

Case identification

The definitions of unplanned 30-day readmissions from CMS (version 2020)[2,3,16–18] and the commercially available method for potentially avoidable 30-day readmissions from SQLape[5,19] were used to flag unplanned and potentially avoidable readmissions, respectively. SQLape uses the term "potentially avoidable readmissions," which is why we have adopted this terminology throughout the manuscript. However, a similar methodology used by 3 M terms these readmissions "potentially preventable."[6,20] The SQLape method was originally developed with data using the Swiss medical coding systems, whereas the CMS definitions of unplanned readmissions had to first be translated into the Swiss coding systems. This was done by the authors in close collaboration with medical coding experts from the participating hospitals, subsequently checked by two independent medical coders, and validated as part of this study. See Part A of the Supporting Information for a brief comparison of the methods used by CMS and SQLape.

The original version of the CMS method (as per the CMS guidelines) was additionally modified to generate an adapted version of the CMS method (conceptually proposed elsewhere).[21] Here, we included the hospitals' own (routinely coded) assessment of whether readmissions were emergent or elective to improve the distinction between planned and unplanned readmissions. The specifics of this adapted version of the CMS method are described in more detail in Part A of the Supporting Information. Subsequently, the original method will be referred to as "original CMS method," whereas the adapted version will be referred to as "adapted CMS method."

Sampling and record review

A random sample of pairs of inpatient stays was drawn (each comprising an index hospitalization and readmission) from all hospitalizations that

were considered as eligible cases by both the CMS and SQLape methods. The stays were selected across all patient cohorts, as well as the diagnosis- and procedure-specific patient populations defined by CMS (see Table 1). Part B of the Supporting Information provides a more detailed description of the sampling strategy.

In total, 738 single stays, or 369 pairs consisting of index hospitalization and readmission (within the same hospital), were reviewed by seven independent reviewers based at the different hospitals: five medical doctors and two quality managers with a background in nursing and health sciences. Of the 369 case pairs, 55 (15%) were duplicates that were reviewed by two independent reviewers to assess the inter-rater reliability (IRR). All reviewers underwent standardized training to familiarize themselves with the definitions of unplanned, potentially avoidable, and actually avoidable readmissions, and to learn the structured review process. Their assessments were collected using a standardized online questionnaire specifically designed for this research in a previous pilot study (see Part C of the Supporting Information).

For each case pair, the reviewer assessed whether the readmission was planned or unplanned, unavoidable or potentially avoidable, and potentially avoidable or really avoidable. The definitions of unplanned and potentially avoidable readmissions followed the specifications of CMS and SQLape, respectively. A readmission was defined as "unplanned" if it arose from acute clinical events requiring urgent rehospitalization (i.e., was not foreseen during the index hospitalization)[2] and as "potentially avoidable" if it was related to any condition treated during the index hospitalization.[4] "Actually avoidable" readmissions were those judged by the reviewers as possible to avoid.

For potentially or actually avoidable readmissions, the reviewers assessed the cause of readmission according to a previously developed systematic classification framework.[4] In addition, the reviewers were asked to provide their level of subjective certainty with regard to each question they answered (e.g., "How certain are you about this decision?") based on a Likert scale ranging from 1 ("very uncertain") to 10 ("very certain").

Analysis

As part of our statistical analyses, we first determined the frequency of readmissions that were judged by the reviewers to be unplanned, potentially avoidable, and actually avoidable across the various patient

TABLE 1 Sample sizes, along with the frequency of cases assessed by the reviewers as unplanned, potentially avoidable, and actually avoidable.[a]

	Cases[b]	Unplanned[c]	(%)	Pot. avoid.[d]	(%)	Act. avoid.[e]	(%)
AMI	20	12	60%	10	50%	3	15%
HF	22	15	68%	13	59%	3	14%
COPD	23	16	73%	15	65%	4	18%
PN	27	25	93%	16	59%	6	23%
STR	26	17	65%	14	54%	5	19%
CABG	14	14	100%	11	79%	8	67%
THATKA	19	17	89%	14	78%	10	56%
Cv	28	10	36%	8	29%	2	7%
Cr	29	22	76%	17	59%	3	10%
Neu	21	16	76%	9	45%	4	19%
Med	53	40	75%	28	53%	10	19%
Surg	22	16	73%	15	71%	7	33%
HWR	10	9	90%	8	80%	3	30%
Total sample	314	229	73%	178	57%	68	22%

Abbreviations: AMI, acute myocardial infarction; CABG, coronary artery bypass graft; COPD, chronic obstructive pulmonary disease; Cr, cardiorespiratory; Cv, cardiovascular; HWR, hospital-wide readmissions; HF, heart failure; Med, medical; Neu, neurological; PN, pneumonia; STR, stroke; Surg, surgical; THATKA, total hip or total knee arthroplasty.

[a]There was one case where the distinction between planned and unplanned could not be made by the reviewers due to missing or insufficient patient documentation, three cases where potential avoidability could not be assessed, and six cases where actual avoidability could not be judged; these were excluded from the respective results (see also the footnotes of the other tables).

[b]Cases = reviewed cases.

[c]Unplanned = unplanned readmissions (number of cases and % of cases).

[d]Pot. avoid. = potentially avoidable readmissions (number of cases and % of cases).

[e]Act. avoid. = actually avoidable readmissions (number of cases and % of cases). Left-hand column lists patient populations.

populations defined by CMS (i.e., the cardiovascular, cardiorespiratory, neurological, medical, and surgical cohorts; patients with acute myocardial infarction, chronic obstructive pulmonary disease (COPD), heart failure, pneumonia, and stroke; and patients undergoing coronary artery bypass graft, as well as total hip or knee arthroplasty). Second, we compared the underlying readmission causes. Third, we compared the true positives (TPs), false positives (FPs), true negatives (TNs), and false negatives (FNs), as well as the sensitivity (=TPs/(FNs + TPs)), specificity (=TNs/(TNs + FPs)), positive predictive value (PPV = TPs/(TPs + FPs)), and F1 score (=2 × (PPV × sensitivity)/(PPV + sensitivity)) of the original CMS, the adapted CMS, and the SQLape methods, with regard to identifying their outcomes of interest. Since the PPV and F1 score are influenced by the underlying prevalence (i.e., the frequency of unplanned vs. potentially avoidable readmissions, see Table 1), we have provided a sensitivity analysis in Supporting Information S1: Table 3S. Here, the PPV and F1 score of the SQLape method were recalculated using the formula: Adjusted PPV = (sensitivity × prevalence)/[(sensitivity × prevalence) + ((1 – specificity) × (1 – prevalence))] by assuming a prevalence identical to the frequency of unplanned readmissions.

Fourth, we compared the TPs, FPs, TNs, FNs, sensitivity, specificity, PPV, and F1 score of the original CMS, the adapted CMS, and the SQLape methods in identifying actually avoidable readmissions. For this comparison, no sensitivity analysis (i.e., adjustment of the PPV and F1 score) was required because the prevalence of the actually avoidable readmissions is identical for all investigated methods. Finally, IRR (=$N_{agreement}/N_{total}$) was measured separately as the percentage of agreement between reviewers across the different distinctions of planned versus unplanned, unavoidable versus potentially avoidable, and potentially avoidable versus actually avoidable readmissions.

To provide comparisons of the frequencies of unplanned and actually avoidable readmissions across the patient populations, we used Fisher's exact test (with calculated odds ratios [ORs] and 95% confidence intervals [CI]), comparing each patient population with the rest of the populations combined (i.e., imagine a separate 2 × 2 contingency table for each comparison). To investigate potential differences in the frequency of TPs and FPs (underlying the PPV), and of TPs and FNs (underlying the sensitivity), between the original CMS, the adapted CMS, and the SQLape methods, we used Chi-square (χ^2) tests with Yates' correction. All statistical analyses were performed in Python (version 3.8.8) and results were considered statistically significant if $p < 0.05$ (with Bonferroni correction for multiple comparisons across the different patient populations).[22]

RESULTS

Of 314 unique case pairs (i.e., 369 pairs excluding the 55 duplicates used to assess IRR), 250 (80%) were flagged as unplanned according to the original CMS method, 218 (69%) were flagged as unplanned according to the adapted CMS method, and 157 (50%) were flagged as potentially avoidable by the SQLape method. Cohen's kappa indicated slight to fair agreement ($\kappa = 0.242$) between unplanned

readmissions flagged by the original CMS method and those flagged by the SQLape method as potentially avoidable.

Table 1 shows the sample distribution across patient populations, along with the frequency of cases assessed by the reviewers as unplanned, potentially avoidable, and actually avoidable. On a scale from 1 to 10, reviewers expressed a mean certainty in their decisions of 9.59 (SD = 0.91) for planned versus unplanned, 8.79 (SD = 1.74) for unavoidable versus potentially avoidable, and 7.14 (SD = 2.22) for potentially versus actually avoidable readmissions. The IRR results for these distinctions were 98% (planned vs. unplanned), 95% (unavoidable vs. potentially avoidable), and 87% (potentially vs. actually avoidable).

Comparing unplanned readmission frequencies across patient populations revealed that patients with cardiovascular diseases experienced significantly fewer unplanned readmissions (OR = 0.17, CI = 0.07–0.38; $p < 0.001$), relative to the other patient populations. Examining the frequencies of actually avoidable readmissions showed that patients undergoing coronary artery bypass graft (OR = 7.87, CI = 2.29–27.00; $p < 0.001$) and total hip or knee arthroplasty (OR = 5.0, CI = 1.90–13.23; $p = 0.001$) had significantly more avoidable versus unavoidable readmissions compared with other patient populations. Table 2 illustrates the causes of readmission (as assessed by the reviewers) for cases judged as either potentially or actually avoidable during review. The most frequent reason for readmission was relapse or aggravation of the disease, which was never judged as actually avoidable. However, of the 178 cases with potentially avoidable readmissions, 68 (39%) were deemed actually avoidable by the reviewers. Inappropriate therapy and failure of postdischarge follow-up care were rare (three and four cases, respectively), but were always considered actually avoidable (100%). On the other hand, two comparatively frequent causes often judged as actually avoidable were complications of surgical care (29 cases, 79% avoidability) and premature discharge (11 cases, 82% avoidability).

Table 3 presents the criterion validity results for the original CMS, adapted CMS, and SQLape methods, comparing their ability to correctly identify unplanned readmissions (in the case of the two CMS methods) and potentially avoidable readmissions (in the case of the SQLape method) according to their own definitions. The significantly higher frequency of TPs relative to FPs for the original and adapted CMS method, relative to the SQLape method, underlies the higher PPV of both versions of the CMS method compared to the SQLape method ($\chi^2(1,313) = 9.04$, $p = 0.003$; and $\chi^2(1,313) = 22.50$, $p < 0.001$, respectively). Similarly, comparing the frequency of TPs and FNs (underlying the sensitivity) between the original and adapted CMS method and the SQLape method explains the greater sensitivity of both variations of the CMS method compared with the SQLape method ($\chi^2(1,313) = 53.52$, $p < 0.001$; and $\chi^2(1,313) = 31.77$, $p < 0.001$, respectively). In the sensitivity analysis in Supporting Information S1: Table 3S, the recalculation of the PPV and the F1 score in favor of the SQLape method confirmed these findings (see also Section 2).

Lastly, Table 4 shows the validity of the original CMS, the adapted CMS, and the SQLape methods in identifying actually avoidable readmissions. In contrast to the results in Table 3, all

TABLE 2 Causes of readmission among potentially and actually avoidable readmissions (as assessed by the reviewers).[a]

	Pot. avoid.[b]	(in %)	Act. avoid.[c]	(in %)	Avoidability[d] (%)
Complication of surgical care	29	16	23	34	79
Drug-related adverse event	15	9	4	6	27
Complication of nonsurgical care	15	9	6	9	40
Missing or erroneous diagnosis	9	5	6	9	67
Inappropriate therapy	3	2	3	4	100
Premature discharge	11	6	9	13	82
Other inadequate discharge	8	5	7	10	88
Failure of postdischarge follow-up care	4	2	4	6	100
Inadequate patient behavior	8	5	1	1	13
Relapse or aggravation of disease	46	26	0	0	0
Readmission was not justified	3	2	1	1	33
Other reasons	19	11	4	6	21
Reason could not be identified	6	3	0	0	0
Sample	176	100	68	100	39

[a]Cases assessed as actually avoidable were a subset of those assessed as potentially avoidable. Two cases with missing information concerning the cause of potentially avoidable readmission were excluded. This explains the difference between the 176 potentially avoidable cases displayed here and the 178 cases reported in Table 1.

[b]Pot. avoid. = potentially avoidable readmissions (number of cases and % of cases judged as potentially avoidable).

[c]Act. avoid. = actually avoidable readmissions (number of cases and % of cases judged as actually avoidable).

[d]Avoidability = percentage of cases judged as actually avoidable among the potentially avoidable cases.

methods were compared here with respect to how many of their flagged readmissions were judged as actually avoidable by the reviewers. Doing so revealed that the three methods did not differ significantly in their ability to identify actually avoidable readmissions ($\chi^2(1,308) = 0.72$, $p = 0.400$; and $\chi^2(1,308) = 0.14$, $p = 0.710$, respectively). However, the comparison showed that both versions of the CMS method displayed a significantly higher frequency of TPs to FNs leading to higher sensitivity in identifying actually avoidable readmissions, relative to the SQLape method ($\chi^2(1,308) = 9.62$, $p = 0.002$; and $\chi^2(1,308) = 5.76$, $p = 0.016$, respectively).

DISCUSSION

Previous research has shown that hospital quality rankings differ depending on the utilized method to flag readmissions,[12] which may have important financial consequences for hospitals participating in pay-for-performance programs. However, to the best of our knowledge, this is the first study to compare the validity of different methods in identifying unplanned, potentially avoidable, and actually avoidable readmissions. We found that the original CMS method, and our adapted version thereof, had greater sensitivity and a higher PPV than the SQLape method, in terms of identifying their outcomes of interest (i.e., unplanned readmissions in the case of the CMS methods

and potentially avoidable readmissions in the case of the SQLape method). In terms of identifying readmissions that are judged as actually avoidable by the reviewers, both versions of the CMS method displayed higher sensitivity than the SQLape method, although the PPV did not differ significantly across the three methods.

Our results have confirmed previous findings of only moderate correlation between rates for hospital readmissions from CMS, and those for potentially avoidable readmissions from 3 M.[11,12] However, we went beyond the scope of those previous studies by answering the remaining question concerning the validity of the different methods.[10,12] We demonstrated that both versions of the CMS method have higher criterion validity than the SQLape method. In addition, we found that the lower criterion validity of the SQLape method cannot be offset by an improved ability to identify actually avoidable readmissions. Although the SQLape method makes certain assumptions regarding which coded diagnoses and procedures in hospitals' administrative datasets could potentially be avoided (see Part A of the Supporting Information), our findings indicate that these assumptions do not confer any advantage in identifying actually avoidable readmissions over the CMS method that focuses on unplanned readmissions. In fact, the SQLape method excluded more actually avoidable readmissions, leading in turn to a lower sensitivity in identifying actually avoidable readmissions compared with the two variants of the CMS method. These results are consistent with a prior

TABLE 3 Unplanned readmissions flagged by the original and adapted CMS methods (n = 313) and potentially avoidable readmissions flagged by the SQLape method (n = 311).[a]

	Unplanned from original CMS method[b]	Unplanned from adapted CMS method[c]	Potentially avoidable from SQLape method[d]
TPs	211	198	110
FPs	39	20	44
TNs	45	64	89
FNs	18	31	68
Sensitivity	92%	86%	62%
Specificity	54%	76%	67%
PPV	84%	91%	71%
F1 score	88%	89%	66%

Abbreviations: FNs, false negatives; FPs, false positives; PPV, positive predictive value; TPs, true positives, TNs, true negatives.

[a]The total number of flagged cases per method is indicated in the main text, while the totals for unplanned and potentially avoidable readmissions (assessed by the reviewers) are presented in Table 1. One case where the distinction between planned and unplanned and three cases where the potential avoidability could not be assessed by the reviewers were excluded. This explains the difference between the total number of cases presented in Table 1 (n = 314) and here (n = 313 and 311, respectively).

[b]Unplanned from original CMS method = unplanned readmissions flagged according to the original CMS method.

[c]Unplanned from adapted CMS method = unplanned readmissions flagged according to the adapted CMS method.

[d]Potentially avoidable from SQLape method = potentially avoidable readmissions flagged according to the SQLape method.

TABLE 4 Actually avoidable readmissions among the unplanned readmissions flagged by the original and adapted CMS methods and among the potentially avoidable readmissions flagged by the SQLape method (n = 308).[a]

	Act. avoid. from original CMS method[b]	Act. avoid. from adapted CMS method[c]	Act. avoid. from SQLape method[d]
TPs	61	58	45
FPs	183	156	108
TNs	57	84	132
FNs	7	10	23
Sensitivity	90%	85%	66%
Specificity	24%	35%	55%
PPV	25%	27%	29%
F1 Score	39%	41%	41%

Abbreviations: FNs, false negatives; FPs, false positives; PPV, positive predictive value; TNs, true negatives; TPs, true positives.

[a]The total number of flagged cases per method is indicated in the main text, while the totals for actually avoidable readmissions (assessed by the reviewers) are provided in Table 1. Six cases where actual avoidability could not be assessed by the reviewers were excluded. This explains the difference between the total number of cases presented in Table 1 (n = 314) and here (n = 308).

[b]Act. avoid. from original CMS method = actually avoidable readmissions within readmissions flagged as unplanned by the original CMS method.

[c]Act. avoid. from adapted CMS method = actually avoidable readmissions within readmissions flagged as unplanned by the adapted CMS method.

[d]Act. avoid. from SQLape method = actually avoidable readmissions within readmissions flagged as potentially avoidable by the SQLape method.

study using a pediatric sample to compare 3 M's potentially avoidable readmission method against a time-flag-based version of what the authors determined to be unplanned readmissions. They found poor sensitivity, specificity, and PPV for the 3 M method in identifying preventable readmissions.[9]

From a practical perspective, the higher PPV of the CMS method in identifying such readmissions means that hospital quality managers who check the flagged readmissions will find a higher percentage of correctly flagged cases compared with the SQLape method. Furthermore, the higher sensitivity of the CMS method in identifying actually avoidable readmissions means that during quality monitoring, a lower percentage of actually avoidable readmissions are missed because they were not flagged compared with the SQLape method. Consequently, our results suggest that the CMS method is preferable to assess hospital quality, in terms of readmissions for individual hospitals as well as in national quality initiatives.

Beyond this primary research question, we investigated the validity of an adapted CMS method in identifying unplanned readmissions from coded medical data, by additionally including the hospitals' assessment of which readmissions were emergent versus elective (based on a suggestion made elsewhere[21]). This modification further improved the validity metrics of the original CMS method for identifying both unplanned and actually avoidable readmissions. In addition to comparing the validity of these three methods, we also presented results on the most frequent causes of readmission. Consistent with previous findings,[4] we observed that the most frequent reason for readmission was a relapse or aggravation of the patient's condition. Similarly, our finding that complications of surgical care and premature discharge were both frequent and often judged as avoidable are in line with previous research[4,23] and could aid hospital managers in deciding how to prioritize quality initiatives targeted at readmissions.

This study has several limitations. For instance, our results were generated using the two specific implementations of the algorithmic methods by CMS and SQLape, making it possible that different (software) implementations of these methods may alter the results. In addition, our findings relate to only one country (Switzerland), which may limit their generalizability to different healthcare settings in other nations, particularly given our specific translation of the definitions of unplanned readmissions into the Swiss coding system. For instance, readmission rates have been found to be lower in Switzerland compared with the United States (around 6.1% compared with 8.7%, which could be related to differences in the healthcare system and/or healthcare delivery).[7,24] In addition, we

deliberately focused on the patient populations defined by CMS as part of their quality monitoring program in the United States. This allowed us to compare our results across different patient populations. However, it may also limit the generalizability of our findings to other patient populations. Thus, future research should elucidate whether the present findings can be confirmed in other healthcare settings and other patient populations.

CONCLUSION

In conclusion, we have shown that the CMS method has both higher criterion validity and greater sensitivity in identifying actually avoidable readmissions, compared with the SQLape method. Consequently, the CMS method should primarily be used in provider comparisons and quality initiatives. In addition, by including hospitals' assessments on readmission urgency as an additional input in the CMS method, its validity may be further improved.

CONFLICT OF INTEREST STATEMENT
MH provides consulting and analysis services regarding quality indicators for the Swiss National Association for Quality Development in Hospitals and Clinics (ANQ), and their software partner INMED GmbH. However, these organizations were not involved in either the design, conduction, analysis, and interpretation of the study or the writing and publication of this manuscript. The remaining authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT
The administrative data that support the findings of this study are available from the Swiss Federal Office of Statistics (contactable via gesundheit@bfs.admin.ch). However, the electronic medical records belong to the participating hospitals.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.