Automated Data Item Consolidation Best Practices Evaluation Project

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Introduction

In January 2020 the Centers for Disease Control and Prevention (CDC) National Program of Cancer Registries (NPCR) initiated a project through the National Association of Chronic Disease Directors (NACDD) and the North American Association of Central Cancer Registries (NAACCR) to evaluate best practices in automated data consolidation within the Central Cancer Registry (CCR) setting and across several routinely collected cancer data items, comparing multiple automated consolidation methodologies. The goal of this effort was to undertake a systematic evaluation of multiple automated rules compared to manual consolidation for selected critical data items so that best practices could be identified based on real-world data. In so doing, a potential outcome included taking an initial step toward defining national standards for automated data item consolidation, which do not exist at this time.

Another potential outcome was the discovery that some data items do not lend themselves to automated consolidation, for example, because the items are new and require a better understanding prior to automation or are more challenging and require greater judgment.

Over the course of the project period, three CCRs—from Missouri (MO), North Carolina (NC), and Pennsylvania (PA)—were recruited to participate in the study, although one (PA) ended its participation prior to completion because of changing resource demands related to its response to the COVID-19 pandemic. The remaining two CCRs (MO and NC) completed the study; their results and experiences provide important advances in our understanding of the strengths and limitations for implementing automated data consolidation in the CCR setting.

Purpose and Goal

The purpose of the NPCR Automated Data Item Consolidation Evaluation project is to evaluate multiple automated consolidation methods across several registries to determine best practices for automated consolidation. This project will also allow the NPCR Registry Plus support team to assess whether the same consolidation method will be the optimal method for all participating registries.

The goal of this project is to determine the optimal automated consolidation methods using a data-driven approach to achieve the highest data quality for consolidated items reviewed in the evaluation. At the onset, we recognized that fully automated consolidation will never meet 100 percent accuracy. The goal is to determine the best value the majority of time, as well as the most optimal context for implementing automated consolidation to improve efficiencies and quality data.

Background

The goal of data item consolidation is the selection of the best value when multiple reporting sources report discrepant values for data items. The consolidated value becomes the value included in calls for data and used for analysis. Historically, the gold standard for consolidation has been manual review of coded values versus text by a trained cancer registrar performing best value selection. A trained registrar might have knowledge that is unknown to the computer system. However, many central registries find that manual consolidation is burdensome.

Many registries no longer have the resources to manually consolidate, given the volume of incoming cancer reports and increases in reporting sources. Automated decision-making can

vary widely based on the registries' purposes, philosophies, operational procedures, and available resources. In 2015, NAACCR published a Data Item Consolidation Manual, but consensus on best practices was not achieved.

At the national level, many challenges have emerged in developing best practices for data item consolidation including the following considerations:

- New types of source records
- Operational issues
- Balancing data quality and efficiency
- Workflow processing
- Data quality issues

Because CDC's software CRS Plus contains tools for writing and applying rules for automated consolidation, we will use these tools for the study. A description of consolidation follows.

Summary of Current Process in CRS Plus

Consolidation in CRS Plus is flexible in that data item consolidation can be automated as much each CCR desires. Several data items currently have fully automated consolidation rules. Manual intervention was the previous consensus to achieve the best possible consolidated value by comparing coded values against text for tumor information and staging. Registries have been encouraged to provide consolidation logic changes to the Registry Plus team for assistance in modifying consolidation directives. Validation of automatically consolidated data against manually consolidated data has been encouraged to ensure quality of data, but this step has not been completed because of lack of resources, delays, etc. Automated consolidation works best when editing and visual review have occurred to ensure the source record data are accurate. Differences in visual review procedures across registries could impact consolidation results.

In CRS Plus, data from incoming source records are compared to determine the "best consolidated value." If at any point automated data item consolidation fails—i.e., a single value has not been selected by the algorithm—the incoming abstract is sent to a pending system for manual review. The thought process behind sending records to pending is that the records will be reviewed prior to adding to the database and fully disposing the records. This can be especially important if the data are used for research. Once the data are added to the database, registries may not have the resources to go back and review cases. Data item consolidation is becoming more and more burdensome and registries are seeking enhanced automation. Testing is necessary to validate automated decisions to produce high-quality and reliable consolidated data and to convince registries that automation is effective and sufficiently accurate.

In CRS Plus, a default set of consolidation rules is defined for each NPCR-required data item. Registries have varying needs for automation, depending on caseload and staffing. The rules can be customized by the user to suit the needs of the registry. Some registries prefer to automate more than others because of several factors, including workload and availability of resources. The Tumor Linkage and Consolidation (TLC) module, TLC Plus, allows flexibility.

Rules to fully automate consolidation of all consolidated items are possible in TLC Plus; however, it is highly encouraged that registries adequately test any changes to consolidation rules to ensure quality of consolidated data prior to implementation.

Methods

CCRs that have staff with extensive experience in data item consolidation were selected to participate in the consolidation evaluation project. Once the participating registries were identified and confirmed, the NPCR Registry Plus support team hosted a kickoff call to discuss expectations, methods, timelines, and final products for the project. The CCRs participating in the NPCR Data Item Consolidation Evaluation Project were from Missouri, North Carolina, and Pennsylvania. Because of changing resources as a result of responding to the COVID-19 pandemic and unexpected staff changes, the PA CCR ended its participation in the study the first week of May 2020, prior to running any cases through the finalized data consolidation rules. The MO and NC CCRs completed all project activities.

During the first few months of the project, the NPCR Registry Plus support team conducted regular calls with the CCRs and sought their feedback and input for specific aspects of the study. For example, participating CCRs helped with identifying the six data items most useful for testing automated data consolidation. Additionally, the NPCR Registry Plus support team developed a tool that was distributed to participating registries for the evaluation. Prior to finalizing the tool, the NPCR Registry Plus support team provided consolidation prototypes to registries participating in the evaluation project so that they could give input to help finalize the rules tested in the evaluation.

The final version of the tool used in the study applied multiple consolidation methods to existing central registry data by linking to the registry database. The results of the consolidation methods for a sample of records were written to an Excel file for viewing the results using the selected consolidation methods. The generated Excel file displayed the consolidation results for each consolidation method per patient and data item using the current abstract data, including real patient data, to determine consolidation best practices.

Selection of Data Items

When selecting the six data items for automated consolidation, multiple criteria were considered by participating CCRs and the NPCR Registry Plus support team. For example, some data items were considered inappropriate because CCRs would always want to complete a manual review of text when a discrepancy in the records emerged, because discrepancies are critical to understanding of the cancer case (e.g., primary site, laterality, behavior). The CCRs also reviewed sample cases to better understand the volume of discrepancies for given data items flagged for manual review evaluation to narrow down data items that would be strong candidates for study. The group discussed that it might be useful to target data items that have previously had less focus on automated consolidation to determine if they can be automated more easily than some of the data items that have already been consolidated less successfully.

The following six data items were **identified** for automated consolidation:

- ER Summary
- PSA Value
- Grade Clinical

- Histology Type ICDO3
- Rx Summ Surgery Primary Site
- SEER Summary Stage 2018

Selection of Cases for Evaluation

The MO registry used a simple convenience sample selection to determine which records would be included in the study, whereas the NC registry used case selection criteria to ensure its sample provided enough cases appropriate for the consolidation rules given the data items being evaluated. For example, NC oversampled prostate and female breast cancer cases to ensure there were enough to evaluate the Prostate Specific–Antigen (PSA) Value and Estrogen Receptor (ER) Summary automated consolidation rules, respectively. Additionally, only cases with more than one reporting source were considered by both participating CCRs.

Participating registries reviewed the subset of cases and performed manual consolidation to establish the gold standard value for each data item in the study for each record. The values determined by automated consolidation methods were then compared to the manually consolidated values to determine the method generating the highest quality.

Automated Data Consolidation Rules

All participating registries used the same consolidation method rules. When the same method for each item reviewed did not produce a similar result for a given case, differences were evaluated and documented. For the purposes of the automated data consolidation rules, “Silver Reporter” is defined as a reporting facility that is considered to have higher accuracy generally and is, therefore, given a higher degree of likelihood to provide the correct response for data items where there is a discrepancy between sources. For this automated data consolidation activity, CCRs were asked to identify the facilities to which they would like to assign Silver Reporter status, and they were not required to define Silver Reporters using the same criteria across CCRs, because no single criterion would be appropriate across CCRs nationally. The NC CCR used Commission on Cancer (CoC)-accredited facilities as a criterion for assigning Silver Reporter status, whereas the MO CCR asked the quality assurance staff to use their judgement to identify which facilities produced the highest quality data and assigned those facilities Silver Reporter status.

Five consolidation method rules were evaluated as follows:

- Rule 1 uses “the current method,” which employs a relatively small number of criteria to consolidate cases. Included in the rules are selecting known values over unknown values and selecting values from sources wherein other specific values are taken (such as Histology Type and Primary Site). Because several of the evaluated data items were new to the NAACCR record layout in version 18 and only basic edits were initially implemented, limited consolidation directives were initially applied, resulting in a higher percentage of manual review when differing values were reported by multiple reporting sources.

- Rule 2 builds on many of the same criteria as Rule 1, with some important differences. Included in the rules for method 2 are selecting values from sources identified as Silver Reporter along with known values over unknown values.

- Rule 3 builds upon many of the same criteria as Rule 1, with some important differences. Included in the rules applied for method 3 are selecting values from sources identified as "Analytic Sources" over "Nonanalytic sources," along with known values over unknown values.

- Rule 4 builds on many of the criteria of Rule 2, with some important differences. Included in the rules applied for method 4 are selecting values from sources identified as Silver Reporter, values taken based on hierarchy of class of case, along with known values over unknown values.

- Rule 5 builds on many of the criteria of Rule 1, with some important differences. Included in the rules applied for method 5 are selecting values based on the hierarchy of class of case, along with known values over unknown values.

In summary, the automated consolidation for Rule 1 is the most basic and often results in the consolidated record's being sent for manual review, while Rules 2–5 factor in additional layers of criteria that allow comparisons of selecting values based on such criteria as Silver Reporter, class of case, and analytic versus nonanalytic case to evaluate consolidation results to determine if any method produces a higher data quality.

Results

North Carolina

- 1,190 records were selected for evaluation. The selection criteria specified—
    - Breast and prostate cancer site to ensure enough cases available to evaluate ER Summary and PSA Site-Specific Data Items (SSDI)
    - Lung, colon, bladder, melanoma, and hematopoietic, which are top sites or have known issues with coding grade and histology
    - Remaining 30 percent of records came from all other sites
    - 67 records eliminated based on link to pre-2018 cancer diagnosis
- Silver reporters limited to CoC Cancer Programs as defined by the registry.
- Quality control (QC) staff (Certified Tumor Registrars) reviewed the remaining 1,123 records and manually selected data items for each record based on text.
- QC staff met and discussed each case where values did not agree with any auto-consolidated value to ensure accurate coding of that record.

Findings (NC)

Data Item	# of records evaluated (1,123 total)	% agreement to Certified Tumor Registrar review				
		Rule 1	Rule 2	Rule 3	Rule 4	Rule 5

ERSummary	30	70%	80%	83%	80%	73%
GradeClin	226	63%	72%	67%	71%	47%
HistTypeICDO3	171	37%	58%	63%	65%	64%
PSAValue	44	41%	82%	77%	73%	66%
RxSumSurgPSite	400	40%	77%	82%	74%	68%
SS2018	252	22%	71%	80%	71%	65%

Table 1. Percent agreement between automated consolidation rules and CTR review (North Carolina).

- Rule 1 is the current rule (resulting in manual review the majority of the time thus not matching the value determined through the gold standard manual review).

- Cells marked in green reflect the rule giving the highest percent match to the preferred answer for each data item.

The NC team found that Rules 2, 3, and 4—which are based primarily on the Silver Reporter and/or class of case—had the highest accuracy. Rule 4 had the lowest overall accuracy but provided a significantly higher percentage of correct responses relative to the current rule. The NC team found that removing the hematopoietic cases from the evaluation did not improve the match percentage.

In 124 cases, manually coded correct values were not among the values selected by any of the automated data consolidation rule sets. A range of reasons explain why this occurred, including the following:

- 78 cases that had at least one abstract with the correct value, but none of the rules picked that value. This was especially true if the correct value was a 9 (e.g., grade,13 cases) or a lower code (e.g., surgery and SS2018, 23 cases). This creates some concern because at least one of the abstracts being consolidated contained the correct code, and none of the rules selected the code. Based on a manual review of the 78 cases, 13 had a correct code of “9 Unknown,” and the rules applied a preference for “Known” over “Unknown” logic. As a result, the rules worked as they should, but their logic resulted in an incorrect response recorded on automated consolidation because the unknown value was correct.

- 63 (2 PSA, 3 ER, 23 SS2018, 35 Grade) were related to new 2018 data items. As previously stated, new data items present some challenges for employing automated data consolidation rules. Most of the errors in this group were due to the incorrect use of new coding rules. There were also 16 records in which the correct choice was not selected because of new rules for Histology. The remaining records from this group included random issues, such as not coding the most specific code (e.g., 30 vs. 31 for surgery). Although not technically wrong, some of these selections were not the most specific, correct choice possible or the most specific, best code possible. Among these 124 cases, as abstractors become more proficient with new data items and rules, and as more robust edits are implemented, the automated data consolidation rules should work better.

In the analysis of the NC results that examines the accuracy of the selection based only on codes given in the abstract by dropping the 124 records discussed above wherein manually coded values were not among the values selected by the Rule Sets, Rules 2, 3, and 4 again had the most accurate selection, and the best rule for each data item did not change.

Data Item	# of records evaluated	Rule 1 # w/o NULL	Rule 1 % match	Rule 2 # w/o NULL	Rule 2 % match	Rule 3 # w/o NULL	Rule 3 % match	Rule 4 # w/o NULL	Rule 4 % match	Rule 5 # w/o NULL	Rule 5 % match
ERSummary	29	21	100%	28	86%	28	89%	28	86%	28	68%
GradeClin	225	197	73%	226	73%	197	77%	224	72%	225	47%
HistTypeICDO3	171	75	88%	148	68%	157	69%	168	67%	158	70%
PSAValue	44	18	100%	43	84%	43	79%	43	74%	43	67%
RxSumSurgPSite	400	200	79%	400	77%	400	83%	400	75%	400	69%
SS2018	252	73	78%	250	72%	252	81%	250	72%	252	65%

Table 2. Findings with NULL values removed (North Carolina)

- Cells marked in green reflect the rule giving the highest percent match to the preferred answer for each data item.

Although most of the current consolidation directives, especially for new data items, typically require manual review, it is also useful to see how each automated consolidation rule performs when no manual review is completed. When cases requiring manual review were included in the denominator, those cases counted as a non-match in the numerator because the rule was not able to determine the correct value. Including the nulls shows which rule gives the overall best match given all scenarios. However, when removing the nulls, some results were significantly different because the rule was not penalized for not being able to decide at all.

For example, for Histology, with the Nulls included, Rule 4 gave the highest percent match at 65 percent with the correct answer on 111/171 cases. When the nulls were removed, Rule 1 gave the highest percent match at 88 percent but only on 66/75 cases. Almost twice as many cases had the correct value with Rule 4, even though the overall percentage of accuracy is lower. Surgery of Primary Site and SS2018 were very similar in both scenarios.

Missouri

- 1,818 records were selected for evaluation by the MO team using a simple sampling strategy that did not oversample a particular site or data item.

- Silver reporters were assigned based on the MO CCR QA staff's identifying which facilities they considered to provide the highest quality data.

- QC staff (Certified Tumor Registrars) reviewed the records and manually coded selected data items for each record based on text to compare against resulting automated data consolidation values.

- QC staff provided feedback for each case wherein values did not agree with any auto-consolidated value to ensure accurate coding of that record.

Findings (MO)

Data Item	# of records evaluated (1,818 total)	% agreement to Certified Tumor Registrars review				
		Rule 1	Rule 2	Rule 3	Rule 4	Rule 5
ERSummary	18	56%	89%	89%	94%	89%
GradeClin	379	57%	65%	56%	64%	55%
HistTypeICDO3	280	18%	44%	56%	55%	55%
PSAValue	75	20%	63%	56%	61%	61%
RxSumSurgPSite	578	34%	75%	80%	68%	66%
SS2018	488	7%	76%	78%	69%	69%

Table 3. Percent agreement between automated consolidation rules and CTR review (Missouri).

- Rule 1 is the current rule (resulting in manual review the majority of the time thus not matching the value determined through the gold standard manual review).
- Cells marked in green reflect the rule giving the highest percent match to the preferred answer for each data item.

The MO team found that Rule 3 produced the greatest percentage agreement with three of the six variables evaluated (Histology, Surgery Primary Site, and SEER Summary Stage 2018). For the ER Summary field, Rule 4 produced the greatest percent agreement with the Certified Tumor Registrar (CTR) value and had the highest percent agreement for any of the fields evaluated. For Clinical Grade and PSA Value, Rule 2 produced the highest percent agreement with the value from the CTR. Rule 1, which is the current rule, did not have the highest percent agreement with the CTR value for any field. It actually was quite a bit lower in almost every field evaluated because the existing consolidation rules result in manual review for a range of reasons, including the fact that only basic edits were applied to new data items introduced in 2018. Rule 5 also did not produce the highest agreement with the CTR review for any of the fields reviewed, although it was relatively close to rules 2, 3, and 4 for most of the fields reviewed. For the specific fields reviewed, MO found the following overall trends when considering each of the rules used for automated data consolidation:

- For PSA value, none of the automated data consolidation rules were great at producing matches with what the CTR answered. Several reasons appeared to explain the differences, including rounding issues by abstractors. Additionally, a review of the cases determined that timing included in the text is the most important deciding factor when trying to resolve differences during consolidation, and that information was not factored

into the automation rules.

- For ER Summary, the MO team determined that considering positive over negative could significantly improve the effectiveness of the automation. This might apply for other SSDIs, as well. Additionally, they found that Rules 4 and 5 prioritizing class 21 over class 00 produced errors with clinical findings.

- A few interesting findings emerged that may make it more difficult to fully automate consolidating clinical grade. For example, within breast cancer cases, the automated data consolidation rules missed some of the correct values based on not accounting for in situ biopsy, but invasive at resection, as well as non-hierarchical low, intermediate, and high nuclear grade for in situ. Also, in some instances, unknown grade is an acceptable answer, but some of the automated data consolidation rules still favor the incorrect known value.

- For histology fields consolidation, the MO team also found that the automated data consolidation rules that favor most frequent value listed sometimes resulted in errors, potentially because the registry had duplicate submissions. Overall, the MO team considered that histology might not be a good candidate for automated data consolidation because of its complexity and the importance of ensuring the correct value is entered because other fields (e.g., grade) depend on a correct coding of histology.

Findings with NULL Values Removed (MO)

Data Item	# of records evaluated	Rule 1 # w/o NULL	Rule 1 % match	Rule 2 # w/o NULL	Rule 2 % match	Rule 3 # w/o NULL	Rule 3 % match	Rule 4 # w/o NULL	Rule 4 % match	Rule 5 # w/o NULL	Rule 5 % match
ERSummary	18	10	100%	18	89%	18	89%	18	94%	18	89%
GradeClin	376	296	73%	376	65%	296	72%	365	67%	375	55%
HistTypeICDO3	279	56	88%	181	68%	250	63%	262	59%	254	61%
PSAValue	74	15	100%	74	64%	74	57%	74	62%	71	65%
RxSumSurgPSite	567	204	96%	567	76%	567	81%	567	69%	567	68%
SS2018	475	39	82%	475	78%	475	80%	475	71%	475	71%

Table 4. Findings with NULL values removed (Missouri)

- Cells marked in lighter green reflect the rule giving the highest percent match to the preferred answer for each data item, which was Rule 1 for each of the data items in this analysis. Additionally, to highlight which rules other than Rule 1 had relatively high matches compared to the other rules, the darker green shows the rule giving the second highest percent match.

The MO team completed an analysis of its data excluding the null cases, as described above in the NC analysis. When MO ran the analysis for each data item removing the null cases from the calculation where manual review was required, Rule 1 produced the highest percent agreement

with what was considered the correct answer. Rule 1 also had the most cases dropped from the calculation given that it sends cases to manual review most often. However, as with the NC results, Rule 3 also performed quite well and gave the second-highest percent match and was quite close to Rule 1 for three of the data items.

Trade-Off: The Role of Manual Review and Achieving a Gold Standard

As standard setters and CCRs continue to evaluate their preferences for how much automation to include in the data consolidation process, a key consideration will be the trade-off between the often resource-intensive manual review and the ability of more automated methods to produce the preferred answer for a data item. The trade-off values will differ for data items, and CCRs will likely have different levels of tolerance for what they are willing to accept based on their resources and workload.

When the MO team looked at this specific issue, they found that Rule 1, which results in the most cases' going to manual review (on average 65% of cases going to manual review), also resulted in the preferred response much more often (between 73% and 100% of the time for the 6 data items tested) when a consolidated value could be determined by the consolidation rule. However, Rules 2–5 frequently came up with an automated response and less often sent a case to manual review (on average Rules 2–5 sent cases to manual review 5%, 6%, 2%, and 2%, respectively), but far less often result in a response that matched the preferred response. In fact, for the six data items tested the percentages of non-matches for Rule 2 were between 11 percent and 36 percent, Rule 3 were between 11 percent and 43 percent, Rule 4 were between 6 percent to 41 percent, and Rule 5 were between 11 percent to 45 percent. The trade-off for time saved by reducing manual review given the number of data items for which automated consolidation results in an incorrect answer will need to be carefully studied by CCRs and standard setters using "real world" data to ensure an informed decision is made when adopting automated data consolidation practices. The MO team has determined retaining Rule 1 is preferred because it provides the most accurate results even though it results in manual review more often. This supports evaluation of data at some point, either through visual review and upon manual review of differing values reported from multiple sources upon processing or after the data are added to the database if consolidating via automated rules and running data quality checks to achieve a higher threshold for data quality.

Conclusion

Many lessons were learned by the Registry Plus support team and CCRs in working through the automated data consolidation activities, including the following:

- When differences across data items are being reviewed, including Primary Site, Class of Case, and Reporting Source to better understand the case at initial review can help determine which of the responses are most accurate. Differences in any of those items can shed light immediately regarding differences across other items.

- As we consider how best to enhance automated data item consolidation, thinking through the hierarchical logic of rules will be critical to ensure that all the information needed to evaluate makes it through the full logic of the tool.

Abstractors are learning lessons regarding what variables are best suited for automated consolidation. For instance, newer data items in which we do not yet have expertise for application of abstracting rules or robust edits and how they work in the field may not be as well positioned for inclusion in automated data consolidation. Partial automation may be best for initial implementation of a new data item until data quality improves and edits are identified to improve the quality of the new data items that are consolidated.

- CCRs are learning more about the role of reporting sources and reliability of responses that could be customized across states as a factor considered in automation.

- Reviewing data to determine the best value for Data Item Consolidation can help identify common errors in coding that could improve overall accuracy of auto consolidated values. For example, based on this project, both MO and NC are sending common errors to reporting facilities as part of an educational effort.

- Some factors seem to result consistently in issues that offer opportunities for improvement via edits, training, and/or education:

    - Grade for in situ breast: The priority code for breast differs based on behavior; the consolidation rules do not take this factor into consideration. This led to an incorrect decision when the abstractor did not apply the priority order for ductal carcinoma in situ (DCIS). They suggested potentially using edits or updated automated consolidation rules to apply this lesson.

    - For the surgery data items, the rules select 00 over 98, including for hematopoietic cases. But, if the edit is fixed to force a code of 98, automated data consolidation rules might work better.

    - The NC team suggested that a more in-depth evaluation looking at Histology for hematopoietic cases should be completed to better determine if these should be eliminated from the Histology consolidation rule.

- The MO and NC teams noted that on manual case review, class of case and reporting facility are key factors that help make coding decisions when there is no text. However, using different combinations of these factors with the automated data consolidation rules did not result in significant increases in the percent matches for correct values.

- The MO team found that when evaluating which rules work best for automated data consolidation activities, it may be important to consider which rules most often send the field to manual review, thus resulting in less automation.

- The MO and NC teams also used this study to guide them to the position that CCRs may fall into the habit of focusing too much on the red data items marked “For Review” in the CRS Plus software TLC window (manual decision required for consolidation). However, given that no rule can auto-consolidate at 100 percent, CCRs need to make sure the review process includes the green items as well (New value different from existing value—automated decision based on TLC Plus Directives).

- The MO team highlighted a few considerations that were unique to its CCR for this project but that could apply to more CCRs if automated data consolidation is rolled out on a more national scale. For example:

- Missouri has the most border states and two major cities on borders, which results in many consolidations where one submission is a consolidated record without text from another CCR.
- Additionally, Missouri has a large out-of-state NCI center with clinics on both sides of the border that reports to both the MO CCR and the other state's CCR. This may result in duplicate values coming to the MO CCR under different facility codes for the same patient. This can impact the consolidation rules by giving the false impression that results taken from identical patient encounters look like separate encounters and therefore seem to produce the same value with increased frequency. The consolidation rules that favor frequency of same responses for a data item would misread these identical encounters as separate and give them greater weight.
- Additionally, major cities sometimes have hospital systems that share abstracting software but send separate abstracts per facility. Thus, if they copy an existing abstract and do not apply adequate quality checks, the same hospital system may send duplicate erroneous values. This is an issue that the MO CCR has been working on with its hospital systems for some time and is an important consideration for automated consolidation.

- Some data items are considered so critical to the quality of the consolidated record that CCRs may feel reluctant to completely automate their consolidation and may insist that trained CTRs review any discrepancies to ensure the most correct choice is made for several reasons:
  - Resolving discrepancies for the same primary cancer requires the highest degree of confirmation that the correct value is selected to ensure cancer counts are accurate. For this reason, CCRs will also prefer that trained CTRs review the discrepancy and make the final decision.
    - An incorrect Primary Site impacts the Schema ID and several data items including Grade, Stage, SSDIs, and Treatment. The preference is to manually review the Primary Site when differing codes are reported by multiple sources, because determining the correct primary site is critical for schema selection.
  - For some conflicts, CCRs need CTRs to identify the case via manual review and follow back with facilities to provide education and training.
    - For example, Rules tying Grade to "Same as Histology" may not be advisable when there are misunderstandings of Histology and/or Grade rules, as seems to have been the case at this time point in 2018. Perhaps these fields are too complex for automation, or greater effort needs to be put into edits prior to these fields' coming to automated consolidation.
    - Also, Class of Case Hierarchy might need to be specific to a given use. Treatment items might benefit from a hierarchy that favors entries from a treating facility over a diagnosis-only facility.

The NC results demonstrated that CoC analytic cases do not necessarily hold a high enough level of accuracy that they can automatically be considered correct when discrepancies in codes exist. Although edits could be added to catch some obvious conflicts with the rules, every case

may need to be evaluated to identify why there was a discrepancy, followed by review of the text to determine the final code. This became obvious when contrasted with the non-CoC data sources to which additional scrutiny is automatically applied. The study showed no consistencies within reporting source or Class of Case to assign priority that would guarantee that the most accurate and specific code was selected via an automated data consolidation process. As a result, although using Silver Reporter and Class of Case appears to get states closer to more cases being auto consolidated, there still are not enough consistencies in these factors to guarantee accuracy. For this reason, many CCRs might still expect to manually verify any decisions determined via automated consolidation directives.

Data quality issues were identified upon review that were unexpected, further stressing the importance of data evaluation to identify data quality checks and training needs. Another factor to consider is the existing variation among registries in the volume and level of visual review conducted on source data.

Many registries are hampered by resource issues and not able to invest the resources they would like into visual review, which can directly impact the quality of the data. Through working on this project, participating CCRs also discussed the existence of opportunities to use well-designed and tested automated data consolidation rules to better focus CTRs and QC staff on high-priority consolidation activities that require more manual review. For example, the NC QC staff outlined two areas, Patient Linkage and Tumor Linkage, wherein advances in CRS Plus automation resulted in efficiencies based on focusing limited staff resources in an area of increased importance for manual review. Additionally, the MO team noted that the project activities were valuable for reinforcing that automated data consolidation rules can provide a more focused guide directing CTRs to what they should review, but they would not consider them a replacement for CTR evaluation.

The NC CCR indicated its preference is to leave resolving complex conflicts among data values (those that the current, basic consolidation rules cannot resolve) to the manual review by CTRs. Other areas are in Pending, where workload can be reduced to allow more time for manual consolidation of data item conflicts in TLC. For NC, data item consolidation between two records for the same primary cancer is the core of its Pending Review. NC wants to make every effort to ensure that the most accurate value is selected. It is also important to know where these conflicts exist so the CCR can identify the cause and follow back to facilities with education and training. The QC issues identified through this project are good examples. The NC CCR may not have realized the issues if CRS Plus had auto consolidated these data items.

- Patient Linkage: The NPCR Registry Plus support team has developed a Patient Linkage tool for use with CRS Plus to assist registries in evaluating and determining the best algorithm for weights assigned to data items to determine patient match with a reasonable number of cases requiring review for patient linkage. NC and MO have implemented the Patient Linkage tool and both registries have found the enhancement has significantly increased their efficiency in processing. Based on that improvement, they evaluated all components of the scoring system and reduced the number going to Pending, from 45 percent to 33 percent overall for NC, and from 65 percent to 29 percent in MO; and those going in as a Patient Linkage status from 15 percent to less than 5 percent for NC, and from 27 percent to 2 percent for MO. These changes made a significant difference in the efficiencies for CTR staff. An important component of this improvement is that the NC team has a routine process (“safety net”) for identifying missed patient matches outside of CRS Plus for the rare situations that have so many unknowns or discrepancies that a high enough score could not be assigned. This allows

them to significantly reduce the patient non-matches in Pending but still have an effective means of identifying those rare situations.

This example provides an opportunity for the registry community to work together to develop consensus on how much automated data consolidation for patient linkage should be conducted to reduce the Pending workload. On the other hand, different states have different thresholds that work for their patient populations, so a firm, consistent threshold across all states may not be possible.

- Tumor Linkage: The latest CRS Plus upgrade included automated logic for 10 additional primary sites based on the SEER Solid Tumor Rules, which automatically dispose of cases that are a separate primary or link records identified to be the same tumor. The NC team found this approach has reduced Pending work even further and addressed another area where the QC staff felt they could spend less time.

The value of the automated data consolidation rules seems to lie in the ability to improve the registry workflow, take advantage of efficiencies within the process, and give trained staff the ability to better focus their energy on the core work of confirming final data value decisions, especially among the most critical and/or newer data items. Based on the acknowledgement that it is not possible to set up automated data consolidation in a way that establishes 100 percent accuracy on every case, its value in making preliminary decisions and highlighting important discrepancies is still quite valuable.

Before adopting any specific automated consolidation rules, it will be important that CCRs test the rules using actual registry data to determine which rule works best for specific data items. From this study, we have seen that the value of rules can differ from data item to data item, as well as CCR to CCR. We can build on this work to try to determine which items lend themselves more readily to automated data consolidation. For example, items that have been collected by CCRs longer with fewer rules changes may be better suited for automated data consolidation.

Over the course of working on this project, the CCRs also were able to identify QC improvements that could be completed to improve the quality of the records going into the automated data consolidation to improve the consolidated record output. For example, cases of Transrectal Biopsy (TRUS BX) were being coded in the Surgical Primary Site in error for prostate surgery, which could be addressed via an edit that looks for this issue. Based on what CCRs found in reviews during the automated data consolidation activities, they were able to add to their routine QC audits. Please see Appendix B *Supplement: The Role of Quality Control in Automated Data Consolidation* for more specific information related to the importance of QC in achieving optimal data consolidation results.

Clearly, this study highlights the critical role of routine QC checks and audits and shows that manual data item consolidation can provide another tool that highlights, by separating which cases require additional review, the areas wherein data items might benefit from additional edits and/or training to improve data quality. The lessons learned extend to other data items that have not been evaluated. The tool that was developed for this consolidation project can be used as a resource to CRS Plus users to evaluate other data items not considered for this project, and the consolidation methods and directives also can be modified and analyzed using registry production data by connecting to the CRS Plus database and generating comparison results for registries to review.

Additionally, different CCRs will have different preferences and acceptance of using automated

data consolidation depending upon many factors. For example, higher volume CCRs may be more willing to adopt full automation rules while lower- to mid-volume CCRs may prefer more moderate levels of automated data consolidation that send more cases to be pending for final manual review.

Reducing manual review in the initial steps of data flow for Patient Linkage and Tumor Linkage in conjunction with a combination of automated and manual methods for consolidation has significantly reduced the volume of records requiring manual review, leaving the decisions to CTRs to determine the best value when multiple sources report differing values. Focusing on automating processes that can be completed by a computer algorithm effectively and efficiently allows registries to focus resources on consolidation decisions that cannot easily be made through automation.

We would like to acknowledge the effort and valuable analysis provided by the Missouri Cancer Registry and Research Center and the North Carolina Central Cancer Registry. The thorough review by the participating registries identifies the need for consideration of data quality edits and checks as part of best practices for data item consolidation. Although identifying best practices for implementing fully automated data item consolidation was not the result of this project, this study did provide valuable information that needs to be considered as a first step by identifying data quality audits, checks, and edits, with the goal of improving incoming source data to have the best source information available to be considered for consolidation. It is our hope that understanding the challenges and data quality issues will help inform the registry community to determine next steps in identifying data item consolidation best practices and to enhance existing consolidation directives.

Next Steps and Recommendations

Several important next steps are recommended to involve the wider cancer registry community in the process of evaluating the role that automated data consolidation can play with improving efficiencies and quality of cancer registry reporting. Among the steps CDC, NAACCR, and national partners in the registry community can take are the following:

- Present the project summary to the Registry Plus Users Group.
- Provide recommended data quality checks to the Registry Plus Users Group.
- Review potential edit recommendations to determine whether edits can be added to the NAACCR Edit Metafile.
- Consider evaluation of other data items (long-standing NAACCR data items that have more robust multifield edits) and try to identify registries with resources to evaluate data using the tool created for this project.
- Work with national partners toward a common goal of developing best practices for data item consolidation that will include recommendations for data quality checks or edits to improve the quality of incoming data.

Appendix B: Automated Data Item Consolidation Best Practices Evaluation Project Final Report Supplement

The Role of Quality Control in Automated Data Consolidation

The critical role that quality control plays in decisions related to the use of automated data consolidation was again reinforced by the work that the Missouri and North Carolina central cancer registries (CCRs) completed on this project. Both CCRs provided feedback and specific examples of ways in which improved quality control on data items could change their decision on the appropriateness of using automated data consolidation. For example, through this project, there were examples in which the following activities done before automated data consolidation likely would have improved matches with the correct value:

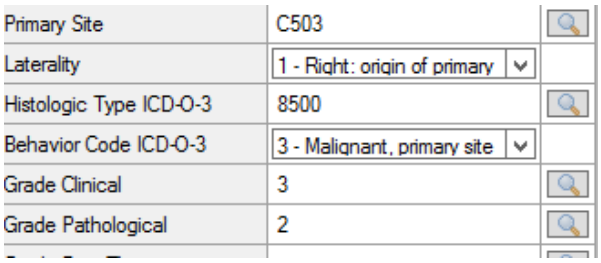
- Increased training for Certified Tumor Registrars (CTRs) on new data items or abstraction rules so that the quality of the records brought into the automated data consolidation process more often contained the correct value
- Improved edits on data fields prior to their processing via automated data consolidation so that incorrect values are weeded out
- Improved record process flow to CCRs from in-state health systems and bordering states to minimize the duplicate patient records found within the CCR database

Additionally, we received specific feedback from the CCRs regarding updates to edits or rules on data items or primary cancer sites that might result in improved matching with correct values during the automated data consolidation process. It is important that as the cancer community considers the optimal role for automated data consolidation at CCRs, the necessary steps be taken to increase the likelihood that the highest quality records are being brought into the consolidation process. It is only when high-quality individual records are used for input that a high-quality consolidated record can be the output.

Data Item and Cancer Site Edits To Consider

Data Item: Grade

- The highest grade is being coded in Clinical Grade without taking into consideration the timeframe allowed, especially for prostate bx vs trans-urethral resection of the prostate (TURP).
- (EDIT OPPORTUNITY) Pathological grade was less than clinical grade. Many records do not reflect the grade rule change for 2018 in circumstances when the clinical grade is higher than the pathological grade.



Note 1: Pathological grade must not be blank.

Note 2: Assign the highest grade from the primary tumor. If clinical grade is highest grade identified, use grade that was identified during the clinical timeframe for both clinical grade and pathological grade. This follows the American Joint Committee on Cancer (AJCC) rule that pathological timeframe includes all of the clinical timeframe plus information from the resected specimen.

- If a resection is done of a primary tumor and there is no grade documented from the surgical resection, use the grade from clinical workup.
- If a resection is done of a primary tumor and there is no residual cancer, use the grade from clinical workup.
    - The correct codes for in situ cases and applying the priority order are not being used. For example, for breast, the grade for ductal carcinoma in situ (DCIS) incorrectly used codes for numerical grades 1-3 instead of L, M, and H.“High grade” DCIS = H, not 3.

Rationale from the Surveillance, Epidemiology, and End Results (SEER)*Educate Breast case scenarios: Codes 1-3 are the preferred grading system codes for invasive cancers and **do not apply to in situ cancers**.

Grade Coding Instructions and Tables manual (page 71), Note 3 states the priority order for the breast:

- Invasive cancers: codes 1-3 take priority over A-D.
- In situ cancers: codes L, M, H take priority over A-D

How to code various references to grade (grade 2/3, Grade 1 [NG 5]), etc.

- (EDIT OPPORTUNITY) **Prostate:** Most errors occurred when there was a Gleason Score 7. The pattern equation has to be according to the table. IE 3+4 and 4+3.
- **Colon:** Grade from polypectomy is pathologic grade only.
- (AUDIT) Just a biopsy of LN or distant site. Often, grade from these is used to code clinical grade. Run report where stage is not local and there was surgery of a site other than the primary. Check text to verify clinical grade is not coded from other than primary site.

(EDIT OPPORTUNITY) Melanoma: C44.9 and grade not 9.

Data Item: SEER Summary Stage 2018

- **Prostate:** Coded as 9-unknown when it could've been coded more definitively according to the text fields and review of the Summary Stage 2018 manual. Review of film studies and path text was usually able to determine summary stage.

- **Prostate:** Ext to perivesical soft tissue + regional LN but no metastasis. Code 4, not 3 or 7.

- **Lung:** Incorrectly coded to 3 - Regional to Lymph nodes when Supraclavicular Nodes were positive. Supraclavicular node involvement should be coded to 7 - Distant. Supraclavicular LN involvement is staged differently for TNM. It is considered a regional node and coded as N3.

For Supraclavicular nodes specifically, these are considered "regional" as far as coding the FNA/biopsy in the treatment fields of abstract.

Data Item: Surgery

- **Melanoma:** Need overall review of surgical codes. Margins from path report not being included in text. STORE manual pg. 466 CCARM pgs. 294–298. "Shave/punch bx followed by re-excision" and margins for re-exc.

- **Breast:** "Partial mastectomy" versus "lumpectomy"; it appears that some abstractors use these terms and codes interchangeably, but the STORE Appendix B has clear definitions for both.

- **Breast:** Modified radical mastectomy codes require LN surgery code beyond SLN.

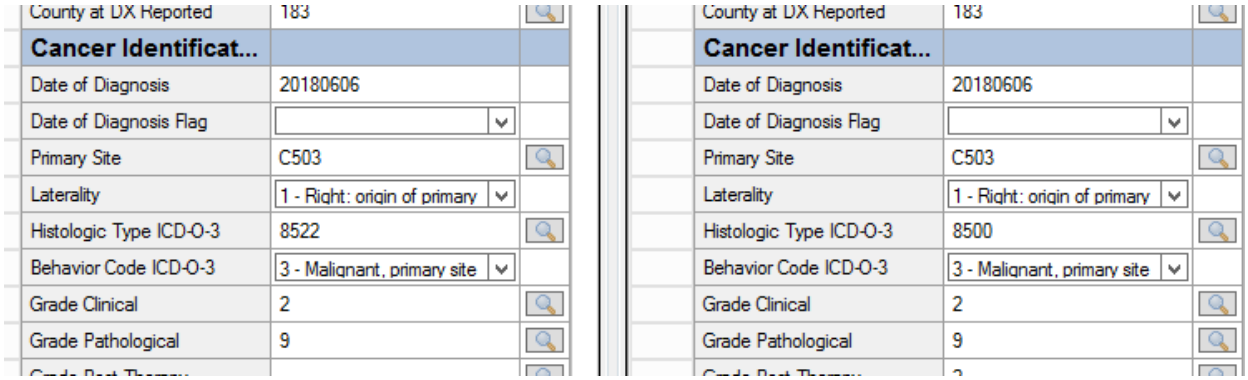
- (EDIT OPPORTUNITY—Reported to the North American Association of Central Cancer Registries [NAACCR] **Hemat:** Site code C421. Surg Prim Site MUST be 98. No edit! Same with Scope Reg LN.

- (AUDIT) **Regional lymph node biopsies:** FNA and/or biopsy of regional nodes should be coded in the Scope of Regional LN Surgery data item as a code 1. It is not coded in the Diagnostic and/or Staging Procedure. Run report on stage and these two surgery data items.

Data Item: Histology

- **Melanoma:** When Lentigo maligna melanoma is used with a different specific term, use the other term, STR H7.

- **Breast:** Although some breast cases have involved histology details, we still get varying histology codesfor more common text. For example, both abstracts have the exact same text that states, "Ductal Carcinoma w/lobular features." Reviewing STR for both DCIS and Invasive primaries would be beneficial.



County at DX Reported	183
Cancer Identificat...	
Date of Diagnosis	20180606
Date of Diagnosis Flag	
Primary Site	C503
Laterality	1 - Right: origin of primary
Histologic Type ICD-O-3	8522
Behavior Code ICD-O-3	3 - Malignant, primary site
Grade Clinical	2
Grade Pathological	9

County at DX Reported	183
Cancer Identificat...	
Date of Diagnosis	20180606
Date of Diagnosis Flag	
Primary Site	C503
Laterality	1 - Right: origin of primary
Histologic Type ICD-O-3	8500
Behavior Code ICD-O-3	3 - Malignant, primary site
Grade Clinical	2
Grade Pathological	9

Another histology check might be the use of code 8522 for invasive duct and lobular cases. The College of American Pathologists statement may have changed or been updated but it is definitely a rule in the 2018 STR—because it uses the word “features,” abstractors may be still using the 8500 code. There have been a few cases withthe text exactly stating “invasive carcinoma w/ductal and lobular features.”

Rule H23 Code **8522** when carcinoma NST and lobular are present in multiple tumors.

- DCIS and in situ lobular **8522/2**
- Carcinoma NST/duct carcinoma and invasive lobular **8522/3**

Note 1: CAP uses the term Invasive carcinoma with ductal and lobular features (“mixed type carcinoma”) as a synonym for duct carcinoma/carcinoma NST AND invasive lobular carcinoma 8522/3.

- **Lung:** Non-Small Cell Carcinoma (NSCLC) was incorrectly coded to 8010/3 (Carcinoma, NOS) insteadof 8046/3 so that the case was eligible for AJCC TNM staging.

SEER inquiry System #20180112 states, “You should not change a histology to assign TNM to the case; AJCC does not determine histology coding. And while pathologists are not encouraged to use NSCLC,the code is not obsolete and should be used if there is no other specific histology.”

The 2018 Solid Tumor Rules for Lung, Rule H3 state:

Rule H3 Code the specific histology when the diagnosis is **non-small cell lung carcinoma** (NSCLC) **consistent with** (or any other ambiguous term) **a specific carcinoma** (such as adenocarcinoma, squamous cell carcinoma, etc.) when:

- The histology is clinically confirmed by a physician (attending, pathologist, oncologist, pulmonologist, etc.)
- The patient is treated for the histology described by an ambiguous term
- The case is accessioned (added to your database) based on a single histology described by ambiguous terminology and no other histology information is available/documented

Note: If the case does not meet the criteria in the first two bullets, code non-small cell lung cancer (NSCLC) **8046**.

Primary Site: Bladder

- **Behavior:** There was no mention of involvement or invasion of tissues in the text, but the behavior was coded as invasive. Referred back to the SEER Training Bladder Module Abstracting Keys and the general instructions in the SS2018 (Bladder Schema page 8–12 and the Notes 3–6) to determine whether the tumor was in situ or invasive. This information had to be corrected/investigated before being able to appropriately code the summary stage. “No stromal invasion” is common.

Primary Site: Prostate

- **PSA Site-Specific Data Items (SSDI)**
    - **Rounding:** If 0–4, round down. If 5–9, round up. Record to the nearest tenth in ng/mm.

      Incorrect rounding could affect the stage group. Be sure to review the General Rules for Entering Lab Values at the beginning on the SSDI Manual (page 18).

    - Use the LAST PSA value prior to biopsy. Old rules used the highest value. NEW RULES SAY USE THE LAST!

      Be sure text includes DATE AND VALUE. Without the date, it is difficult to validate that this was the LAST PSA prior to diagnostic biopsy or treatment.

Primary Site: Head and Neck: HPV Positive

Check sites of C100-C109; C090-C099; C111 with histology coded to 8070/3. Is there information in the text about human papilloma virus (HPV) (virus) +/- where the histology could be recoded to 8085 or 8086? In this audit, there were cases where histology was coded to 8070/3 and the text had information about HPV.