| **ALGORITHMS TO ENHANCE SPECIFICITY OF FRACTURE IDENTIFICATION** | | |
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| **Fracture site (“case” ICD-9 codes)** | **Additional case-qualifying requirements**1 | **Old CPT codes used by Baron (1986-1990 data) & Ray (1987 data)** |
| **Spine, Incident (substr3=805, 806, 73313)**  - Closed: substr4 in 8050, 8052, 8054, 8058, 73313  - Other: all other substr3=805, 806 | CQ = 1 Inpatient claim with **primary** diagnosis code  CQ = 3 Carrier claim or carrier line with diagnosis code **AND** carrier line with HCPCS in (22305, 22310, 22315, 22318, 22319, 22325, 22326, 22327, 22328, 22520, 22521, 22522, 22523, 22524, 22525, 76012, 76013, 72291, 72292, S2360-S2363)  OR Outpatient claim with diagnosis code **AND** outpatient revenue withHCPCS in (22305, 22310, 22315, 22318, 22319, 22325, 22326, 22327, 22328, 22520, 22521, 22522, 22523, 22524, 22525, 76012, 76013, 72291, 72292, S2360-S2363)  CQ = 4 Carrier claim or carrier line with diagnosis code  **AND** carrier line with HCPCS in (99024, 99058,  99499, 99201–99288, 99291–99292, 99301–99357,  99385–99387, 99395–99404) [Physician E&M codes]  plus, up to 10 days earlier (or on the same day), carrier  line or outpatient revenue with HCPCS in (72010-  72159, 72240-72285, 72295)  OR Outpatient claim with diagnosis code **AND** outpatient  revenue withHCPCS in (99024, 99058, 99499, 99201–  99288, 99291–99292, 99301–99357, 99385–99387,  99395–99404) [Physician E&M codes] plus, up to 10  Days earlier, carrier line or outpatient revenue with  HCPCS in (72010-72159, 72240-72285, 72295) | Not analyzed |
| **Pelvis (substr3=808)**  - Closed: substr4 in 8080, 8082, 8084, 8088  - Other: all other substr3=808 | CQ = 1 Inpatient claim with **primary** diagnosis code  CQ = 2 Inpatient claim with **secondary** diagnosis code  CQ = 3 Carrier claim or carrier line with diagnosis code **AND** carrier line with HCPCS in (27193-27194, 27215-27218, 27220, 27222, 27226-27228)  OR Outpatient claim with diagnosis code **AND**  outpatient revenue with HCPCS in (27193-27194,  27215-27218, 27220, 27222, 27226-27228) | Baron: 27210-27214  Ray: 27220, 27222, 27224, 27225 |
| **Clavicle (substr3=810)**  -Closed: substr4=8100  - Other: all other substr3=810 | CQ = 1 Inpatient claim with **primary** diagnosis code  CQ = 2 Inpatient claim with **secondary** diagnosis code  CQ = 3 Carrier claim or carrier line with diagnosis code **AND** carrier line with HCPCS in (23500, 23505, 23515)  OR Outpatient claim with diagnosis code **AND** outpatient  revenue with HCPCS in (23500, 23505, 23515) | Baron: not analyzed  Ray: 23500,05,10,15 |
| **Scapula (substr3=810)** | No CQ algorithm for this fracture site |  |
| **Humerus (substr3=812; 73311)**  - Closed: substr4 in 8120, 8122, 8124, 73311  - Other: all other substr3=812 | CQ = 1 Inpatient claim with **primary** diagnosis code  CQ = 2 Inpatient claim with **secondary** diagnosis code  CQ = 3 Carrier claim or carrier line with diagnosis code **AND** carrier line with HCPCS in (23600, 23605, 23615, 23616, 23620, 23625, 23630, 23665, 24500, 24505, 24515, 24516, 24530, 24535, 24538, 24545, 24546, 24560, 24565, 24566, 24575, 24576, 24577, 24579, 24582)  OR Outpatient claim with diagnosis code **AND** outpatient  revenue with HCPCS in (23600, 23605, 23615, 23616,  23620, 23625, 23630, 23665, 24500, 24505, 24515,  24516, 24530, 24535, 24538, 24545, 24546, 24560,  24565, 24566, 24575, 24576, 24577, 24579, 24582) | Baron: 23600-23630, 23665-23680, 24500-24588  Ray: 23600,05,10,15,20,25,30,65, 70,75,80, 24500,05,06,10,15,30,31, 35,36,38,40,42,45,60,65,70, 75-81,83,85-88 |
| **Radius\_ulna**2 **(substr3=813; 73312)**  **-** Distal radius/ulna (forearm): substr4 in 8134, 8135, 73312 | CQ = 1 Inpatient claim with **primary** diagnosis code  CQ = 2 Inpatient claim with **secondary** diagnosis code  CQ = 3 Carrier claim or carrier line with diagnosis code **AND** carrier line with HCPCS in (25600, 25605, 25606, 25607, 25608, 25609, 25611, 25620, (25650, 25651, 25652 - includes ulnar styloid)  OR Outpatient claim with diagnosis code **AND**  outpatient revenue with HCPCS in (25600, 25605,  25606, 25607, 25608, 25609, 25611, 25620, (25650,  25651, 25652 - includes ulnar styloid) | Baron: 25600-20  Ray: 25600-20 |
| -Radius/ulna-other: after excluding substr4 in 8134, 8135, all substr3=813 | CQ = 1 Inpatient claim with **primary** diagnosis code  CQ = 2 Inpatient claim with **secondary** diagnosis code  CQ = 3 Carrier claim or carrier line with diagnosis code **AND** carrier line with HCPCS in (24650, 24655, 24665, 24666, 24670, 24675, 24685, 25500, 25505, 25515, 25520, 25525, 25526, 25530, 25535, 25545, 25560, 25565, 25574, 25575)  OR Outpatient claim with diagnosis code **AND**  outpatient revenue with HCPCS in (24650, 24655,  24665, 24666, 24670, 24675, 24685, 25500, 25505,  25515, 25520, 25525, 25526, 25530, 25535, 25545,  25560, 25565, 25574, 25575) | Baron: 24620-35 (elbow), 24650-85, 25500-75  Ray: 24650,55,60,65,66,70, 75,80,85; 25500,05,10,15, 30,35,40,45,60,65,70,75 |
| **Carpal (substr3=814)** | CQ = 1 Inpatient claim with **primary** diagnosis code  CQ = 2 Inpatient claim with **secondary** diagnosis code  CQ = 3 Carrier claim or carrier line with diagnosis code **AND** carrier line with HCPCS in (25622, 25624, 25628, 25630, 25635, 25645, 25680, 25685)  OR Outpatient claim with diagnosis code **AND** outpatient  revenue with HCPCS in (25622, 25624, 25628, 25630,  25635, 25645, 25680, 25685) | Baron: not analyzed  Ray: 25622,24,26,28,30,35, 40,45,80,85 |
| **Hip (substr3=820; 73314)**  - Closed: substr4 in 8200, 8202, 8208, 73314  - Other: all other substr3=820 | CQ = 1 Inpatient claim with **primary** diagnosis code  CQ = 2 Inpatient claim with **secondary** diagnosis code  CQ = 3 Carrier claim or carrier line with diagnosis code **AND** carrier line with HCPCS in (27230-27248)  OR Outpatient claim with diagnosis code **AND**  outpatient revenue with HCPCS in (27230-27248)  OR Carrier claim or carrier line with diagnosis code **AND** carrier line with HCPCS in (27130, 27125) [Hip replacement]  OR Outpatient claim with diagnosis code **AND** outpatient revenue with HCPCS in (27130, 27125) [Hip replacement]  OR Outpatient claim with diagnosis code **AND** ICD9 Procedure Code in (8151, 8152) [Hip replacement]  OR Outpatient claim with diagnosis code **AND** ICD9  Procedure Code in (7855, 7905, 7915, 7925, 7935,  7965) [Femur Repair] | Baron: 27230-27248  Ray: 27125-27127, 27230-38, 27240-48 |
| **Other femur (substr3=821; 73315)**  - Closed: substr4 in 8210, 8212, 73315  - Other: all other substr3=821 | CQ = 1 Inpatient claim with **primary** diagnosis code  CQ = 2 Inpatient claim with **secondary** diagnosis code  CQ = 3 Carrier claim or carrier line with diagnosis code **AND** carrier line with HCPCS in (27500-27514)  OR Outpatient claim with diagnosis code **AND** outpatient revenue with HCPCS in (27500-27514)  OR Outpatient claim with diagnosis code **AND** ICD9  Procedure Code in (7855, 7905, 7915, 7925, 7935,  7965) [Femur Repair] | Baron: 27500-14  Ray: 27500,02,04,06,08, 10,12,14 |
| **Patella (substr3=822)** | No CQ algorithm for this fracture site |  |
| **Tibia/fibula (substr3=823; 73316)**  - Closed (*not including knee or ankle):* substr4 in 8230, 8232, 8238, 73316  - Other (*not including knee or ankle)*: all other substr3=823 | CQ = 1 Inpatient claim with **primary** diagnosis code  CQ = 2 Inpatient claim with **secondary** diagnosis code  CQ = 3 Carrier claim or carrier line with diagnosis code **AND** carrier line with HCPCS in (27530-27536, 27750-27759, 27780-27784, 27824-27828)  OR Outpatient claim with diagnosis code **AND**  outpatient revenue with HCPCS in (27530-27536, 27750-27759, 27780-27784, 27824-27828) | Baron: 27530-40, 27750-58, 27780-84, 27800-06  Ray: 27530,32,34,36-38,40, 27750,52,54,56,58,80-82, 84, 27800,02,04,06 |
| **Ankle (824)**  substr3 in 824 | CQ = 1 Inpatient claim with **primary** diagnosis code  CQ = 2 Inpatient claim with **secondary** diagnosis code  CQ = 3 Carrier claim or carrier line with diagnosis code **AND** carrier line with HCPCS in (27760, 27762, 27766, 27786, 27788, 27792, 27808, 27810, 27814, 27816, 27818, 27822, 27823, (28430, 28435, 28436, 28445 - includes talus)  OR Outpatient claim with diagnosis code **AND**  outpatient revenue with HCPCS in (27760, 27762, 27766, 27786, 27788, 27792, 27808, 27810, 27814, 27816, 27818, 27822, 27823, (28430, 28435, 28436, 28445 - includes talus) | Baron: 27760-66, 27786-92, 27808-23  Ray: 27760,62,64,66,86,88, 90,92; 27810,12,14,16,18, 20,22,23 |

1Each carrier claim record will have at least one, but potentially multiple carrier line records. Each outpatient claim record will have at least one, but potentially multiple outpatient revenue records. Case-qualifying definitions including carrier claim/carrier line or outpatient claim/outpatient revenue combinations are linked by beneficiary id and claim id.

2HCPCS repair codes for Distal radius/ulna (forearm) and Radius/ulna-other subcategories are shown separately, but all codes map to the Radius\_ulna fracture site and to both subcategories.

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| **METHODS**  *FRACTURE DIAGNOSIS FILE*  Claims containing diagnosis codes for non-pathologic fractures (ICD-9 800-829), pathologic fractures (ICD-9 7331x), and fracture aftercare (V541x, V542x) are extracted from Medicare files. The Medicare file types may vary, and fracture claims from Home Health, Hospice, Skilled Nursing Facility, and Durable Medical Equipment files may or may not be extracted depending upon study aims. Each extracted fracture claim is assigned a fracture site (the anatomic location of the fracture) based on 3-digit ICD-9 diagnosis code (plus 5-digit pathologic fracture ICD-9 code, in some cases). Fracture sites are **bolded** in the table above and include “Closed” and “Other” subcategories, where applicable. Claims containing fracture aftercare codes that map to more than one fracture site are cloned so that each relevant fracture site can be assigned to the claim.  Relevant Variables: Beneficiary ID, Claim ID, Claim Date, Medicare File Type, Diagnosis Code, Position, Fracture Site  *FRACTURE REPAIR FILE*  Claims containing procedure codes for fracture repair are extracted from Medicare files. Each fracture repair claim is assigned a fracture site based on the location of treatment indicated by the repair code.  Relevant Variables: Beneficiary ID, Claim ID, Procedure Date, Medicare File Type, Procedure Code, Fracture Site  *FRACTURE AGGREGATE FILE*  The Fracture Diagnosis File and the Fracture Repair File are sorted and linked on Beneficiary ID, Claim ID, and Fracture Site. All claims from the Fracture Diagnosis File are retained in the Fracture Aggregate File, while unlinked claims from the Fracture Repair File are dropped.  *CASE-QUALIFYING ALGORITHM*  The “case-qualifying” (CQ) Algorithm is applied to claims in the Fracture Aggregate File. The CQ Algorithm assigns “Closed” and “Other” subcategories for each fracture site using exact ICD-9 diagnoses, and also assigns CQ values (see table above). The CQ algorithm first looks for inpatient fracture diagnosis claims and anatomic site-specific fracture repair claims to derive the CQvariable. For fractures other than spine, CQ values of 1 and 2 are assigned if the fracture diagnosis in the claim is an inpatient file primary or secondary diagnosis, respectively, and a CQ value of 3 is assigned if there is a fracture repair code from carrier line or outpatient revenue that can be linked to a matching fracture diagnosis by beneficiary id and claim id. Spine fracture claims that have only a physician diagnosis (i.e., they are not assigned CQ values of 1 or 3) are then linked by claim date to spine imaging records to assign CQ value 4 (Physician Evaluation & Management + Imaging). As noted previously, spine imaging can occur up to 10 days prior to the Physician Evaluation & Management HCPCS code.  *EPISODE ALGORITHM*  The episode algorithm is applied using the fracture site variable. Fracture sites include subcategories (i.e., “Closed”, “Other”) but the algorithm works on the more general location of the fracture (**bolded in the table above**). Using the Fracture Aggregate File, fracture episodes are created using beneficiary claims for the same fracture site where none of the consecutive claims are separated by more than 90 days. Fracture episodes include claims with a nonblank CQ value as well as those with a blank CQ value. Nonblank CQ values are intended to distinguish diagnoses pertaining to true fractures from rule-out diagnoses that occur in claims data when a patient receives services to determine if a suspected fracture is a real fracture and when that patient does not actually have a fracture. Additionally, claims with fracture aftercare codes (V541x, V542x), while not included in case-qualifying definitions, can potentially extend episodes for certain fracture sites (see table below). The episode algorithm identifies the beginning and end dates of each fracture episode and creates three episode-level indicators that can be used for subsequent analyses: 1) presence of at least one inpatient claim, 2) presence of at least one CQ claim, and 3) presence of at least one trauma claim within 14 days of the episode start date.  The episode algorithm works by sorting the Fracture Aggregate File by beneficiary, fracture site, and claim date. When there is more than one claim for the same fracture site on the same date, the claims are consolidated into a single record, with preference being given to a CQ claim. Each consolidated record has CQ indicators (CQ 1-3 for fractures other than spine and CQ 1, 3, and 4 for spine fractures); if there are multiple CQ claims on the same day, each CQ indicator will be set accordingly. Next, the time periods between claims for each beneficiary are assessed by fracture site. Consecutive claims that occur within 90 days of a previous claim for the same fracture site are included in a single episode. That is, a beneficiary is not at risk for a new fracture **at that site** until a 90 day ‘clean period’ has passed where there is no fracture claim for that specific site. If the next claim date for the same fracture site occurs more than 90 days after the previous claim date, a new episode (and clean period) begins. Because the episode algorithm uses the fracture site variable, it permits a beneficiary to have fracture episodes that overlap in calendar time when there are fractures occurring at different anatomical locations.  Claims belonging to each distinct episode are then assigned a sequence number that enables the derivation of episode beginning and end dates and indicators for inpatient claims, CQ claims, and trauma claims for each fracture episode. | |
| **FRACTURE AFTERCARE CODES** | |
| **Fracture site** | **Codes** |
| Spine (incident) | V5417, V5427 |
| Pelvis | None |
| Clavicle | None |
| Scapula | None |
| Humerus | V5410, V5420, V5411, V5421 |
| Distal radius/ulna (forearm) | V5410, V5420, V5412, V5422 |
| Radius/ulna-other | V5410, V5420, V5412, V5422 |
| Carpal | V5412, V5422 |
| Hip | V5413, V5423, V5414, V5424, V5415, V5425 |
| Other femur | V5414, V5424, V5415, V5425 |
| Patella | V5414, V5424, V5415, V5425, V5416, V5426 |
| Tibia/fibula | V5414, V5424, V5416, V5426 |
| Ankle | V5414, V5424, V5416, V5426 |
| **TRAUMA CODES**  If a trauma-related diagnosis code is found in a claim dated within +/- 14 days of the fracture episode start date, the trauma indicator is set on the fracture claim. This enables the subsequent derivation of an episode-level trauma indicator. | |
| 'E800' <= dgns4 <= 'E848'; 'E881' <= dgns4 <= 'E884'; 'E908' <= dgns4 <= 'E909'; 'E916' <= dgns4 <= 'E928' | |

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| **Potential algorithm variants, changes over time, and considerations to implementing fracture episode algorithms** |
| * Skull/face, hand/fingers, foot/phalanges, and multiple fractures are excluded as are other fracture sites that are unrelated to osteoporosis. * Fracture aftercare codes (V541x, V542x) may be used in case definitions, or to extend episodes, or may not be used at all. * Pathologic fracture diagnosis codes are included for many fracture sites; however, exclusions for certain conditions (e.g., cancer, Paget’s) may need to be made. * In older populations, the concept of traumatic fracture is debated; therefore, fracture episodes that include trauma codes may be included or excluded. * For **Hip** fractures, HCPCS and ICD9 procedure codes for hip replacement may not be included in the CQ = 3 definition. However, if they are included, ICD9 procedure codes for hip replacement must have a diagnosis code for hip fracture on the same claim id. ICD9 procedure codes for femur repair may not be included in the CQ = 3 definition. However, if they are included, ICD9 procedure codes for femur repair must have a diagnosis code for hip fracture on the same claim id. * For **Other femur** fractures, ICD9 procedure codes for femur repair may not be included in the CQ = 3 definition. However, if they are included, ICD9 procedure codes for femur repair must have a diagnosis code for femur fracture on the same claim id. * For **Spine** fractures, CQ = 4 requires a diagnosis code and a Physician E&M code, plus, up to 10 days earlier, a HCPCS fracture imaging code. This 10 day window may be insufficient to capture some spine fractures and may need to be extended to 30 or 90 days. * For **All** fractures, CQ = 3 requires a diagnosis code AND a HCPCS repair code (linked by beneficiary id and claim id). Claims with a repair code but without a matching diagnosis on the same claim (i.e., orphan claims) may be accepted as CQ = 3. Including orphan repair claims outright or including them if a matching diagnosis can be found within +**/-** 30 days of the procedure date for the repair code may capture additional CQ claims. * For **All** **fractures except Spine**, consider the implications of requiring an inpatient claim (primary or secondary) or a repair code for CQ definitions. Fractures that do not typically need hospitalization or surgical repair procedures (i.e., non-operatively repaired) are potentially being missed by our algorithms. Rib fractures would be an example of this type of fracture. * If looking for “wrist” fractures, combine distal radius/ulna and carpal fracture claims. * If looking for “hip” fractures, consider combining hip and femur fractures together. Anatomically, a hip fracture is a fracture of the femoral neck, but it can also extend inferiorly and involve another portion of the femur. * These algorithms intentionally favor specificity over sensitivity. Some fracture sites can be non-operatively managed and these will be missed by this algorithm, by intent. For that reason, specificity will be higher, but sensitivity lower, and for population-based fracture epidemiology, one may wish to relax the requirement for CQ=3 claims to have a coupled repair procedure at some sites. Wrist fracture is a relevant example. |