Warfarin Quality Metrics for Hospitalized Older Adults

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TH Open 2018;2:e242–e249.

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Keywords
► adverse drug events
► anticoagulants
► inpatients
► INR
► warfarin

Abstract

Background Warfarin’s adverse drug events are dangerous, common, and costly. While outpatient warfarin management tools exist, there is a dearth of guidance for inpatients.

Objectives We sought to describe a health system’s chronic warfarin quality metrics in older inpatients, defined by international normalized ratio (INR) control, explore associations between INR overshoots and clinical outcomes, and identify factors associated with overshoots.

Patients/Methods Data on patients 65 years and older who were prescribed chronic warfarin and admitted during January 1, 2014, to June 30, 2016, were extracted through retrospective chart review. We defined overshoots as INRs 5 or greater after 48 hours of hospitalization. Logistic regression modeling was used to determine risks for overshoots and multivariate analysis for overshoots’ association with length of stay (LOS), bleeding, and mortality.

Results Of the 12,107 older inpatients on chronic warfarin, most were 75 years or older (75.7%), female (51.2%), and white (70.0%). While 1,333 (11.0%) of patients had overshoots during the admission, 449 (33.7%) of these reached overshoots after 48 hours. When stratified by overshoots versus no overshoots, LOS more than doubled (15.6 vs. 6.8 days) and the bleed rate was significantly higher (27.4 vs. 8.3%) in the overshoot group. While overall mortality was small (0.4%), the overshoot group’s mortality was significantly higher (3.12 vs. 0.28%). Black race and weight were protective against overshoots; history of heart failure and antibiotic/amiodarone exposure were predictive of overshoots.

Conclusion This is the largest study examining warfarin quality metrics for hospitalized adults, specifically older inpatients. Our model may serve as the basis for identifying high-risk warfarin patients to target interventions to reduce adverse drug events.
Introduction

The Agency for Healthcare Research and Quality (AHRQ) labels anticoagulants such as warfarin a high-risk drug. Prior studies have shown that the majority of warfarin-associated bleeds result in serious outcomes, with fatal outcomes reported in up to 10%. Warfarin in particular accounts for the largest number of serious adverse event reports in the Food and Drug Administration’s (FDA’s) Adverse Event Reporting System for the 1990 and 2000 decades, especially in older patients. In a Medicare-specific population, 8.8% of adverse drug events during hospitalizations were attributed to warfarin. In teaching hospitals, one-third of preventable adverse drug events were related to warfarin. These warfarin-associated adverse drug events have a significant economic burden as well; a review of medical and pharmacy per patient and $40,586 per patient, respectively, compared to warfarin initiation.

We define INR overshoots as supratherapeutic INRs of greater than or equal to 5; it has previously been shown that the incidence of adverse events, specifically bleeding events, rises steeply with these INR values. To identify the quality of inpatient warfarin as a result of dosing during the acute hospitalization (rather than doses taken prior to admission), we limited our analysis to INRs after the initial 48 hours of the hospital stay. By hospital policy, warfarin dosing required checking daily INRs. To confirm that this policy was followed, we calculated the percentage of INR days as the number of days with INR values available per length of stay (LOS) for the groups with and without INR overshoots.

Methods

We conducted a retrospective chart review at a large health system operating in the New York metropolitan area, encompassing seven hospitals (three tertiary and four community hospitals). Data were extracted from electronic health records of patients 65 years and older who were admitted and treated with chronic warfarin between January 1, 2014, and June 30, 2016. For this study, we defined chronic warfarin as documentation of warfarin use as a home medication prior to admission (i.e., admission medication reconciliation). Our local institutional review board approved the study (IRB #16–642).

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Data points collected included all inpatient INR values, patient-related variables (age, height, weight, sex, race, marital status, smoking history), and presence of comorbid conditions (myocardial infarction [MI], congestive heart failure [CHF], peripheral vascular disease [PVD], cerebrovascular disease [CVD], dementia, chronic obstructive pulmonary disease [COPD], connective tissue disease, peptic ulcer disease [PUD], diabetes mellitus [DM], moderate or severe chronic kidney disease [CKD], hemiplegia/paraplegia, malignancies, HIV, and liver disease). Additional variables included medications administered during hospitalization (i.e., antibiotics, amiodarone, and statins) and organizational factors (i.e., tertiary vs. community hospital).

Outcomes included hospital LOS, mortality, and clinically significant bleeding. To capture clinically relevant bleeding, patients needed to meet at least two of the following three criteria: (1) an ICD9 code for bleeding (as a hospital diagnosis), (2) RBCs transfused during admission, and/or (3) receipt of a reversal agent during the admission (including any vitamin K, fresh frozen plasma, or prothrombin complex concentrates). The ICD9 bleeding codes used for analysis were derived from members of the New York State Anticoagulation Coalition and from Leonard et al (2008) and are listed in Appendix A. Appendix B clarifies the number of patients who met two or three criteria for bleeding.

Logistic regression modeling was used to determine the risk factors for INR overshoots. Additional multivariate
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analysis was employed to associate INR overshoots with LOS, bleeding, and mortality. Variability across the health system was evaluated with INR overshoots by type of hospital, tertiary care versus community facility. Additional analysis of the impact of patient weight (kg) on INR overshoots was done through chi square testing at 10-kg intervals to establish safety thresholds.

Results

There were 17,494 unique admissions across seven acute care facilities for patients 65 years and over on warfarin. Of these, 12,107 were on chronic warfarin with INR data available and 5,387 were initiated on warfarin during the hospitalization (not included in our target population). Of those on chronic warfarin, 1,020 (8.4%) discontinued warfarin on discharge from the hospital. Patients with INR overshoots were more likely to be discharged without warfarin than those without overshoots (24.3 vs. 7.8%, p < 0.0001). Table 1 describes the characteristics of patients on chronic warfarin during their acute hospitalization. The majority of patients (75.7%) were older than 75 years, female (51.2%), and white (70%). One-third had a history of smoking, with the most common comorbid conditions being CHF (46%), DM without chronic complications (31.4%), CVD (24%), COPD (22.9%), moderate/severe CKD (22.2%), and malignancy (22.1%).

The percentage of INR days was 96% of the total LOS for both the groups with and without INR overshoots. Table 2 presents supratherapeutic INR rates. Of the 12,107 patients, 5,829 (48.1%) became supratherapeutic with an INR greater than 3 during the admission, and 54.2% of these episodes occurred after the initial 48 hours of hospitalization. While 1,333 (11.0%) of chronic warfarin patients reached an INR greater than or equal to 5 after the initial 48 hours of hospitalization, 449 (33.7%) of these reached this maximum INR after the initial 48 hours of the hospital stay. Patients with INR overshoots remained over an INR of 5.0 for a mean of 1.9 days (SD: 1.2, range: 1–11 days).

Table 3 presents outcomes stratified by INR category after the initial 48 hours. When stratified by category (INR overshoots: INR ≥ 5 after initial 48 hours vs. no INR overshoots: INR < 5 after initial 48 hours), LOS more than doubled in the group with INR overshoots (6.8 vs. 15.6 days, <0.0001). Overall, the clinically significant bleed rate by our definition was 9%. The group with INR overshoots had a significantly higher bleed rate, compared with the group without INR overshoots (27.4 vs. 8.3%, adjusted odds ratio [OR]: 6.2, p < 0.0001). While the overall mortality rate for the chronic warfarin group was small (0.4%), there was a significantly higher mortality rate (3.12 vs. 0.28%, adjusted OR: 8.6, p < 0.0001) in the group with INR overshoots. There was no significant difference in either the 30- or 90-day readmission rates between groups.

In evaluating variability in the quality of warfarin management across the seven facilities, the rates of INRs over 5 after the first 48 hours ranged from 3.0 to 5.9%. While there was no significant difference between hospital types (community vs. tertiary) with regard to INR overshoots, admission to a tertiary hospital was found to be protective against bleeding (OR: 0.862, p < 0.0016).

Table 4 presents demographic, clinical, and organizational variables used in the prediction model for INR overshoots after the initial 48 hours of hospitalization. Using logistic regression, black race and weight were found to be protective against INR overshoots; conversely, history of CHF and antibiotic or amiodarone exposure was predictive of INR overshoots. Moderate or severe CKD trended toward predicting INR overshoots, but did not reach statistical significance (p < 0.068). When adding the variable for INR overshoots to the logistic regression model, we found that (in addition to controlling for age, gender, race, smoking status, ICU stay, heart failure, COPD, DM, CKD, malignancy, liver disease, weight, and antibiotic and amiodarone exposure) an INR greater than or equal to 5 was independently predictive of a longer LOS (p < 0.0001), higher bleed rate (p < 0.0001), and higher mortality (p < 0.0001).

Chi-square testing at 10-kg intervals for body weight found significant thresholds at both 50 and 90 kg: 7.7% of patients less than or equal to 50 kg experienced INR overshoots compared with 3.5% of those over 50 kg (p < 0.0001); 4.1% of patients less than or equal to 90 kg experienced INR overshoots compared with 2.5% of patients over 90 kg (p < 0.0001). At weights over 120 kg, there is no significant difference in incidence of INR overshoots between weight classes. Table 5 illustrates an overall downward trend of INR overshoots as weight classes increase, with 7.69% of those 50 kg and under experiencing overshoots, 3.78% of those between 50 and 90 kg, 2.35% between 90 and 120 kg, and 2.98% of those over 120 kg.

Discussion

This is the largest study to date examining warfarin quality metrics for older adults in the inpatient setting. More specifically, we sought to describe chronic warfarin quality metrics across multiple inpatient facilities, explore the association between inpatient INR overshoots and clinical outcomes, and identify intrinsic patient-related factors and extrinsic factors associated with INR overshoots. Warfarin has previously been described as a high-risk medication, and poor control defined by INR has been associated with negative outcomes; our research is novel in that it specifically investigates the clinical outcomes of INR overshoots in a large hospital-based health system and focuses on risk factors for such overshoots.

Approximately half of the patients on chronic warfarin reached supratherapeutic levels of INR greater than 3 during the admission, and approximately one-half of these occurred after the initial 48 hours of hospitalization. This time frame was used to focus on effects of inpatient, rather than outpatient, events including provider dosing and clinical conditions. Roughly 11% of patients reached supratherapeutic INRs at the clinically important threshold of INR ≥ 5.0, and one-third of these reached this level after the initial 48 hours, with inpatient dosing again likely responsible for these INR overshoots. While the overall bleed rate of 9% is comparable
Table 1 Patient characteristics: 12,107 chronic warfarin inpatients

| Characteristics                  | Total N (%) | No overshoots N (%) | Overshoots N (%) |
|----------------------------------|-------------|---------------------|------------------|
| **Age ≥75**                      | 9,172 (75.7)| 8,834 (75.8)        | 338 (75.3)       |
| Female                           | 6,203 (51.2)| 5,943 (51.0)        | 260 (57.9)       |
| **Race**                         |             |                     |                  |
| White                            | 8,472 (70.0)| 8,423 (72.2)        | 322 (71.7)       |
| Black                            | 1,593 (13.1)| 1,570 (13.5)        | 44 (9.8)         |
| Other                            | 880 (7.3)   | 1,219 (10.5)        | 61 (13.6)        |
| Hispanic                         | 704 (5.8)   | 676 (5.8)           | 28 (6.2)         |
| Asian                            | 461 (3.8)   | 449 (3.9)           | 22 (4.9)         |
| **Marital status**               |             |                     |                  |
| Married                          | 5,496 (45.4)| 5,296 (45.4)        | 200 (44.5)       |
| Widowed                          | 4,144 (34.2)| 3,993 (34.4)        | 151 (33.6)       |
| Single                           | 1,382 (11.4)| 1,333 (11.4)        | 49 (10.9)        |
| Divorced                         | 614 (5.1)   | 588 (5.0)           | 26 (5.8)         |
| Other                            | 409 (3.4)   | 390 (3.3)           | 19 (4.2)         |
| Separated                        | 65 (0.5)    | 61 (0.5)            | 4 (0.9)          |
| **Smoker (present/former)**      |             |                     |                  |
| CHF                              | 5,569 (46.0)| 5,377 (46.1)        | 192 (42.8)       |
| DM without chronic complication  | 3801 (31.4)| 3,668 (31.5)        | 133 (29.6)       |
| CVD                              | 2,906 (24.0)| 2,786 (23.9)        | 120 (26.7)       |
| COPD                             | 2,774 (22.9)| 2,658 (22.8)        | 116 (25.8)       |
| Moderate/Severe CKD              | 2,684 (22.2)| 2,571 (22.1)        | 113 (25.2)       |
| Malignancy                       | 2,675 (22.1)| 2,576 (22.1)        | 99 (22.1)        |
| MI                               | 1,656 (13.7)| 1,594 (13.7)        | 62 (13.8)        |
| PVD                              | 1,609 (13.3)| 1,542 (13.2)        | 67 (14.9)        |
| DM with chronic complication     | 677 (5.6)   | 647 (5.6)           | 30 (6.7)         |
| Connective tissue disease        | 575 (4.8)   | 551 (4.7)           | 24 (5.4)         |
| PUD                              | 458 (3.8)   | 441 (3.8)           | 17 (3.8)         |
| Liver disease (moderate/severe)  | 369 (3.1)   | 356 (3.1)           | 13 (2.9)         |
| Hemiplegia/Paraplegia            | 260 (2.2)   | 245 (2.1)           | 15 (3.3)         |
| Metastatic solid tumor           | 255 (2.1)   | 245 (2.1)           | 10 (2.2)         |
| Dementia                         | 135 (1.1)   | 132 (1.1)           | 3 (0.7)          |
| HIV                              | 9 (0.1)     | 9 (0.1)             | 0 (0)            |
| **Medications**                  |             |                     |                  |
| Statins                          | 7,514 (62.1)| 7,256 (62.2)        | 258 (57.5)       |
| Antiplatelets                    | 5,091 (42.0)| 4,910 (42.1)        | 181 (40.3)       |
| Antibiotics                      | 1941 (16.0)| 1,837 (15.8)        | 104 (23.2)       |
| Amiodarone                       | 968 (8.0)   | 919 (7.9)           | 49 (10.9)        |
| ICU admission                    | 1,974 (16.3)| 1,841 (15.8)        | 133 (29.6)       |
| First INR                        | 2.6 ± 1.6   | 2.6 ± 1.6           | 3.6 ± 2.6        |

Abbreviations: CHF, chronic heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CVD, cerebrovascular disease; DM, diabetes mellitus; ICU, intensive care unit; INR, international normalized ratio; MI, myocardial infarction; PUD, peptic ulcer disease; PVD, peripheral vascular disease.
to rates reported in Medicare patients on anticoagulation, the group with INR overshoots had significantly increased LOS, bleeding, and mortality. Given INR overshoots’ association with these adverse events, they may serve as potential surrogate markers for identifying such negative outcomes that health systems seek to avoid. By hospital policy, INRs are checked daily for patients presently treated with warfarin. Despite close monitoring with the rate of INR days being 96% in both the overshoot and no overshoot group, there was still poor control in the overshoot group suggesting that frequency of INR checking did not contribute to differences between adverse outcomes between the groups. Future studies should evaluate interventions to improve the safety of inpatient warfarin dosing and may use INR overshoots in addition to clinical outcomes to evaluate the effectiveness of such interventions.

We found that for older patients on chronic warfarin therapy during acute hospitalization, low weight, exposure to antibiotics/amiodarone, and heart failure were independently predictive of INR overshoots, while black race was protective. In additional weight analysis, the largest thresholds for correlation with INR overshoots were found at 50 and 90 kg. At weights above 120 kg, there were no longer associations with INR overshoots. While most of these factors have been identified as markers, or sensitivity classes for outpatient initiation algorithms, this is the first study to evaluate them in an older inpatient population. As examples, the initiation algorithms presented by the University of North Carolina and the University of Wisconsin both include heart failure, low body weight, antibiotics, and amiodarone as intrinsic and extrinsic factors making patients prone to higher warfarin sensitivity. In Kimmel’s

### Table 2 Supratherapeutic INRs

| INR values | No. of patients | %    |
|------------|----------------|------|
| INR > 3    | 5,829/12,107   | 48.1 |
| INR > 3 after 48 h | 3,157/9,873 | 32.0 |
| INR ≥ 5    | 1,333/12,107   | 11.0 |
| INR ≥ 5 after 48 h | 449/9,873   | 4.6  |

Abbreviation: INR, international normalized ratio.

### Table 3 Outcomes stratified by INR overshoots

|                  | Overshoots | No overshoots | Adjusted OR | p-Value  |
|------------------|------------|---------------|-------------|----------|
| Length of stay (d) | 15.60      | 6.81          | n/a         | <0.0001  |
| Mortality        | 3.12%      | 0.28%         | 8.6         | <0.0001  |
| Readmissions     |            |               |             |          |
| 30 d             | 18.35%     | 20.71%        | n/a         | 0.1856   |
| 90 d             | 33.28%     | 31.63%        | n/a         | 0.4647   |
| Bleeding         | 27.39%     | 8.27%         | 6.2         | <0.0001  |

Abbreviation: INR, international normalized ratio.

### Table 4 Prediction model for INR overshoots: analysis of maximum likelihood estimates

| Parameter                    | Estimate | p-Value |
|------------------------------|----------|---------|
| Intercept                    | -1.00    | 0.35    |
| Tertiary hospital            | -0.01    | 0.93    |
| Age: years                   | -0.01    | 0.14    |
| Gender: male                 | -0.22    | 0.10    |
| Race                         |          |         |
| Asian                        | -0.16    | 0.55    |
| White                        | -0.27    | 0.11    |
| Black                        | -0.59    | 0.01    |
| Ethnicity: Hispanic          | -0.38    | 0.12    |
| Marital status               |          |         |
| Widowed                      | -0.27    | 0.32    |
| Divorced                     | -0.03    | 0.92    |
| Married                      | -0.12    | 0.64    |
| Separated                    | 0.17     | 0.79    |
| Single                       | -0.17    | 0.56    |
| Smoker                       | -0.10    | 0.37    |
| Comorbid conditions          |          |         |
| MI                           | -0.03    | 0.82    |
| CHF                          | -0.22    | 0.04    |
| PVD                          | 0.10     | 0.52    |
| CVD                          | 0.14     | 0.23    |
| Dementia                     | -1.00    | 0.16    |
| COPD                         | 0.19     | 0.11    |
| Connective tissue disease    | 0.02     | 0.94    |
| PUD                          | -0.09    | 0.74    |
| DM without chronic complication | -0.04  | 0.72    |
| DM with chronic complication | 0.16     | 0.46    |
| Moderate/Severe CKD          | 0.23     | 0.07    |
| Hemiplegia/Paraplegia        | 0.39     | 0.19    |
| Malignancy                   | -0.03    | 0.79    |
| Metastatic solid tumor       | 0.03     | 0.93    |
| Moderate/Severe liver disease| -0.17    | 0.57    |
| Height                       | 0.00     | 0.91    |
| Weight                       | -0.01    | <0.01   |
| Medications                  |          |         |
| Statins                      | -0.19    | 0.07    |
| Antibiotics                  | 0.43     | 0.00    |
| Amiodarone                   | 0.38     | 0.02    |

Abbreviations: CHF, chronic heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CVD, cerebrovascular disease; DM, diabetes mellitus; ICU, intensive care unit; INR, international normalized ratio; MI, myocardial infarction; PUD, peptic ulcer disease; PVD, peripheral vascular disease.
pharmacogenetics studies, the clinical dose-revision algorithm that was used as a comparison to pharmacogenetics dosing, black race and body surface area were included as factors increasing the recommended warfarin dose, and amiodarone use as a factor lowering the dose.\textsuperscript{22}

There were several limitations to our study. This was a retrospective chart review, and predictors of INR overshoots were limited by documentation available from the electronic health record with incomplete information, and difficulty establishing cause and effect. Comorbid conditions were identified through an electronic data pull of ICD9 codes alone, and thus we were unable to differentiate between acute, chronic, and past conditions or to establish temporal associations between such comorbid conditions and INR overshoots. Bleeding events during hospitalization could not be time correlated with INR overshoots, again highlighting the lack of ability to establish cause and effect. We do hope to have improved accuracy of bleeding events by requiring a minimum of two bleed-related orders or coding but were unable to verify this through individual chart analysis. Furthermore, this definition of bleeding may have impacted the finding that admission to a tertiary hospital was associated with a lower risk of bleeding due to differences in transfusion management such as evidence-based, higher thresholds for transfusions. Additionally, while ICU admission was more prevalent in the INR overshoot group, we were unable to assess whether such admissions were due to a concurrent illness causing the overshoot, severe bleeding caused by the overshoot, or poor dosing within the ICU. We also did not assess for scenarios when warfarin was intentionally held (i.e., for procedures) or the need for reversal due to bleeding. To overcome this barrier, our focus for poor control was on supratherapeutic INRs known to be high risk for acute bleeding episodes rather than on subtherapeutic INRs. On the inpatient setting, the risk of subtherapeutic INRs was impacted by using heparin-bridging therapies when appropriate. We did not separate surgical and medical patients who may have different risk factors for adverse events. A final limitation was that the use of antibiotics or amiodarone was not correlated in its timing with the administration of warfarin.

**Summary and Conclusion**

Our study findings indicated that (1) INR overshoots are prevalent in the inpatient setting in an older population across our health system and associated with poor outcomes and (2) INR overshoots are independently associated with low weight, heart failure, non-black race, and antibiotic or amiodarone exposure. In the outpatient setting, both intrinsic patient-related and extrinsic factors are integrated into warfarin dosing algorithms. We found that similar factors are also associated with inpatient INR metrics. Yet, no such tool exists in the inpatient setting to determine appropriate warfarin dosing, especially for more frequent (than weekly) assessments. Our model may serve as the basis for identifying high-risk patients and developing interventions for inpatient warfarin dosing strategies. Future studies should focus on the impact of the rate of change of the INR (the delta INR) on predicting INR overshoots when combined with clinical factors identified by our prediction model.\textsuperscript{17}

Conflict of Interest

None declared.

Acknowledgments

The authors would like to acknowledge the Center for Health Innovations and Outcomes Research at Northwell Health for their support.

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**Table 5 INR overshoots by weight classes**

| Weight (kg) | No overshoots n (%) | Overshoots n (%) | Chi-square |
|------------|---------------------|-----------------|------------|
| ≤50        | 708 (92.31)         | 59 (7.69)       | <0.001     |
| 50.01–90   | 8,116 (96.22)       | 319 (3.78)      | <0.001     |
| 90.01–120  | 2,283 (97.65)       | 55 (2.35)       | <0.001     |
| >120       | 489 (97.02)         | 15 (2.98)       | <0.001     |

Abbreviation: INR, international normalized ratio.
Appendix A ICD9 codes bleeding

| ICD 9 Code | Definition                                      |
|-----------|------------------------------------------------|
| 2463      | Hemorrhage and infarction of thyroid           |
| 2554      | Corticoadrenal insufficiency                   |
| 2851      | Acute posthemorrhagic anemia                   |
| 2865      | Hemorrhagic disorder due to circulating anticoagulants |
| 2867      | Acquired coagulation factor deficiency         |
| 2869      | Other and unspecified coagulation defect       |
| 3361      | Vascular myelopathies                          |
| 36281     | Retinal hemorrhage                             |
| 3636      | Choroidal hemorrhage and rupture               |
| 36441     | Hyphema of iris and ciliary body               |
| 3688      | Other specified visual disturbances            |
| 37272     | Conjunctival hemorrhage                        |
| 37481     | Hemorrhage of eyelid                           |
| 37632     | Orbital hemorrhage                             |
| 37742     | Hemorrhage in optic nerve sheaths              |
| 37923     | Vitreous hemorrhage                            |
| 38869     | Other otorrrhea                                |
| 4230      | Hemopericardium                                |
| 430       | Subarachnoid hemorrhage                        |
| 431       | Intracerebral hemorrhage                       |
| 432       | Other and unspecified intracerebral hemorrhage |
| 436       | Ill-defined cerebrovascular disease            |
| 458       | Hypotension                                    |
| 4590      | Hemorrhage unspecified                         |

Appendix A (Continued)

| ICD 9 Code | Definition                                      |
|-----------|------------------------------------------------|
| 5238      | Other specified periodontal diseases           |
| 4560      | Gastrointestinal hemorrhage of some sort       |
| 45520     | Gastrointestinal hemorrhage of some sort       |
| 45550     | Gastrointestinal hemorrhage of some sort       |
| 45580     | Gastrointestinal hemorrhage of some sort       |
| 45620     | Gastrointestinal hemorrhage of some sort       |
| 53021     | Gastrointestinal hemorrhage of some sort       |
| 5310      | Gastrointestinal hemorrhage of some sort       |
| 5312      | Gastrointestinal hemorrhage of some sort       |
| 5314      | Gastrointestinal hemorrhage of some sort       |
| 53140     | Gastrointestinal hemorrhage of some sort       |
| 5316      | Gastrointestinal hemorrhage of some sort       |
| 532       | Gastrointestinal hemorrhage of some sort       |
| 5330      | Gastrointestinal hemorrhage of some sort       |
| 5332      | Gastrointestinal hemorrhage of some sort       |
| 5334      | Gastrointestinal hemorrhage of some sort       |
| 5336      | Gastrointestinal hemorrhage of some sort       |
| 5340      | Gastrointestinal hemorrhage of some sort       |
| 5342      | Gastrointestinal hemorrhage of some sort       |
| 5344      | Gastrointestinal hemorrhage of some sort       |
| 5346      | Gastrointestinal hemorrhage of some sort       |
| 53511     | Gastrointestinal hemorrhage of some sort       |
| 53521     | Gastrointestinal hemorrhage of some sort       |
| 53531     | Gastrointestinal hemorrhage of some sort       |
| 53541     | Gastrointestinal hemorrhage of some sort       |
Appendix A (Continued)

| ICD 9 Code | Definition                                      |
|------------|------------------------------------------------|
| 5351       | Gastrointestinal hemorrhage of some sort       |
| 53561      | Gastrointestinal hemorrhage of some sort       |
| 56202      | Gastrointestinal hemorrhage of some sort       |
| 56203      | Gastrointestinal hemorrhage of some sort       |
| 56212      | Gastrointestinal hemorrhage of some sort       |
| 56213      | Gastrointestinal hemorrhage of some sort       |
| 56881      | Gastrointestinal hemorrhage of some sort       |
| 56935      | Gastrointestinal hemorrhage of some sort       |
| 5789       | Gastrointestinal hemorrhage of some sort       |
| 5780       | Gastrointestinal hemorrhage of some sort       |
| 56985      | Gastrointestinal hemorrhage of some sort       |
| 5351       | Atrophic gastritis                             |
| 5368       | Dyspepsia and other specified disorders of function of stomach |
| 53783      | Angiodysplasia of stomach and duodenum with hemorrhage |
| 5582       | Toxic gastroenteritis and colitis              |
| 5738       | Other specified disorders of liver             |
| 5967       | Hemorrhage into bladder wall                  |
| 5968       | Other specified disorders of bladder           |
| 5997       | Hematuria                                      |
| 59989      | Other specified disorders of the urinary tract |
| 6021       | Congestion or hemorrhage of prostate           |
| 6201       | Corpus luteum cyst or hematoma                 |
| 6228       | Other specified noninflammatory disorders of cervix |
| 6238       | Other specified noninflammatory disorders of vagina |
| 6262       | Excessive or frequent menstruation             |
| 6268       | Other disorders of menstruation and other abnormal bleeding from female |
| 6269       | Unspecified disorders of menstruation and other abnormal bleeding from female |
| 719        | Hemarthrosis                                   |
| 7802       | Syncope and collapse                           |
| 7804       | Dizziness and giddiness                        |
| 7807       | Malaise and fatigue                            |
| 78079      | Other malaise and fatigue                      |
| 7827       | Spontaneous ecchymoses                         |
| 7847       | Epistaxis                                      |
| 7848       | Hemorrhage from throat                         |
| 7855       | Shock without mention of trauma                |
| 7863       | Hemothypsis                                    |
| 7870       | Nausea and vomiting                            |

Notes: These codes were derived from members of the New York State Anticoagulation Coalition and primarily from Leonard et al (2008).20

Appendix B

| Bleeding count | Frequency | Percent | Cumulative frequency | Cumulative percent |
|----------------|-----------|---------|----------------------|--------------------|
| 0              | 11,646    | 66.57%  | 11,646               | 66.57%             |
| 1              | 4,225     | 24.15%  | 15,871               | 90.72%             |
| 2              | 1,423     | 8.13%   | 17,294               | 98.86%             |
| 3              | 200       | 1.14%   | 17,494               | 100.00%            |