**Supplementary Tables**

**Validating new coding algorithms to improve identification of alcohol- and non-alcohol-related cirrhosis hospital admissions in administrative databases.**

**Authors:** Liam A. Swain1 (liam.swain1@ucalgary.ca), Jenny Godley1,2 (jgodley@ucalgary.ca), Mayur Brahmania (mayur.brahmania@ucalgary.ca)3, Juan G. Abraldes4 (juan.g.abraldes@ualberta.ca), Karen L. Tang (klktang@ucalgary.ca)1,5, Jennifer Flemming (jennifer.flemming2@kingstonhsc.ca)6, and Abdel Aziz Shaheen1,3 (aashahee@ucalgary.ca).

**Affiliations:**

1. Department of Community Health Sciences, University of Calgary, Calgary, Alberta, Canada
2. Department of Sociology, University of Calgary, Calgary, Alberta, Canada
3. Division of Gastroenterology and Hepatology, Department of Medicine, Cumming School of Medicine, University of Calgary, Calgary, Alberta, Canada
4. Liver Unit, Division of Gastroenterology, Department of Medicine, University of Alberta, Edmonton, Alberta, Canada
5. Department of Medicine, Cumming School of Medicine, University of Calgary, Calgary, AB, Canada
6. Department of Medicine and Public Health Sciences, Queen’s University, Ontario, Canada

Table 1S. Alcohol-related cirrhosis (AC) and non-alcohol-related cirrhosis (NAC) standard administrative database identification methods

|  |  |  |
| --- | --- | --- |
| Condition | Algorithm | References |
| Alcohol-related cirrhosis | AC ICD-10 code alone | Hayward, 2020; Bengtsson, 2020; Ramrakhiani, 2021; Khalifa, 2023; Kramer, 2008; Nehra, 2013; Gu, 2022; Laswi, 2022; Axley, 2019; Sandahl, 2011; Termeie, 2022; Yang, 2008 1-12 |
| Alcohol-related cirrhosis | AUD codes and non-specific cirrhosis codes | Philip, 2020; Shirazi, 2021; Mellinger, 2018; Flemming, 2021; Dang, 2020; Beste, 2015; Ioannou, 2018; Pearson, 2021 13-20 |
| Non-alcohol-related cirrhosis etiologies | Viral, metabolic, and autoimmune etiology specific algorithms | Hayward, 2021; Husain, 2014; Philip, 2020; Myers, 2010; Molodecky, 2011; Niu, 2015; Kramer, 2008; Astrom, 2023; Pearson, 2021; Ioannou, 2018; Flemming, 2021 5, 13, 16, 19-26 |
| Non-alcohol-related cirrhosis as a group | NAC specific codes together | Mellinger, 2018; Ryu, 2022; Shaheen, 2022; Grønbaek, 2008; Nakitanda 2020 15, 27-30 |
| All cause cirrhosis | Individual cirrhosis codes or combinations of cirrhosis and decompensated cirrhosis-related condition codes | Hayward, 2020; Nehra, 2013; Kramer, 2008; Shearer, 2022; Bengtsson, 2020; Lapointe-Shaw, 2018; Mapakshi, 2018; Khalifa, 2023; Dahiya, 2022; Driver, 2019; Goldberg, 2022; Ramrakhiani, 2021; Astrom, 2023; Ioannou, 2018; Pearson, 2021 1-6, 19, 20, 25, 31-36 |

Table 2S. Performance characteristics of previously validated individual ICD-9 and ICD-10 codes and algorithms for detection of cirrhosis and its complications.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Diagnostic Codes or Algorithms | **Diagnosis** | **PPV** | **NPV** | **Sensitivity** | **Specificity** | **Study** |
| ICD-9 Individual codes |  |  |  |  |  |  |
| * 571.2 | Alcoholic cirrhosis of liver | 90%  87.0% | 77%  46.3% | 52% | 84% | Kramer 5  Nehra 6 |
| * 571.5 | Cirrhosis of liver without mention of alcohol | 90%  79.8% | 87%  52.5% | 72% | 68% | Kramer 5  Nehra 6 |
| * 571.1 | Alcoholic hepatitis+labs | 86% | NR | NR | NR | Shaheen 28 |
| * 789.5 | Ascites | 63.3% | 29.6% | 44% | 48% | Nehra 6 |
| * 567.23 | Spontaneous bacterial peritonitis | 84.1% | 33.3% | 3% | 99% | Nehra 6 |
| * 572.2 | Hepatic encephalopathy | 91.5% | 36.1% | 52% | 84% | Nehra 6 |
| * 456.0 | Esophageal varices with bleed | 92.3% | 32.8% | 3% | 100% | Nehra 6 |
| * 456.21 | Secondary esophageal varices without bleed | 94.3% | 34.5% | 8% | 99% | Nehra 6 |
| * 456.2 | Esophageal varices in diseases classified elsewhere | 79% | 33% | 1% | 100% | Nehra 6 |
| * 572.4 | Hepatorenal syndrome | 92.1% | 33.2% | 2% | 100% | Nehra 6 |
| * 155.0 | Hepatocellular carcinoma | NR | NR | 83-96% | 85-95% | Flemming 32 |
| * 456.1 | Esophageal varices without bleed | 90.6% | 36.5% | 18% | 96% | Nehra 6 |
| * 572.3 | Portal hypertension | 91.8% | 40.1% | 31% | 94% | Nehra 6 |
| Algorithms |  |  |  |  |  |  |
| 571.2, 571.5, 571.6 | All cause cirrhosis | 90% | 87% | NR | NR | Kramer 5 |
| 571.0x, 571.1x, 571.3x, 571.2 | ALD cirrhosis | 90% | 77% | NR | NR | Kramer 5 |
| ALD: 571.0x, 571.1x, 571.3x, 571.2 + HCV: 070.41, 070.51, 070.54, V02.62 | All cause cirrhosis | 93% | 77% |  |  | Kramer 5 |
| 572.4, 456.2, 456.0, 456.21, 567.23, 572.2, 456.1, 572.3, 571.2, 571.5 | All cause cirrhosis | 78% | 91% | 98% | 43% | Nehra 6 |
| At least one chronic liver disease and cirrhosis code (571.2, 571.5, 571.6; 070.20, 070.21, 020.22, 070.23, 070.3, 070.31, 070.32, 070.33 070.40, 070.49, 070.59, 070.60, 070.70, 070.71, 070.90, 573.1 070.41, 070.44, 070.51, 070.54, 070.70, 070.71 070.42, 070.52, 273.4, 275.0, 275.1, 453.0, 571.0, 571.1, 571.1, 571.40, 571.41, 571.8, 571.9, 573.0, 573.3, 573.8, 573.9, 517.42, 576.1, and ≥ 8 code for decompensation 456.0, 456.20, 456.1, 456.21, 789.5, 789.59, 572.2, 567.0, 567.2, 567.21, 567.21, 567.29, 567.8, 567.89, 567.9, 572.4 | All cause cirrhosis | 95% | NR | NR | NR | Goldberg 2012 36 |
| One cirrhosis and one decompensated code: 571.2, 572.5 and 456.0, 456.1, 456.20, 456.21, 789.5, 567.23, 572.2, 070.44, 572.4 | All cause cirrhosis | 97% | NR | NR | NR | Ioannou 2018 19 |
| Hierarchical:  1. HCV RNA positive | Hepatitis C | 100% | 94-98% | 90-97% | 100% | Philip 2020 13 |
| 2. HBV surface antigen or HBV DNA positive | Hepatitis B | 86-96% | 99-100% | 92-96% | 99% | Philip 2020 13 |
| 3. 571.6, 576.1, 571.42 | Autoimmune | 90-91% | 96-98% | 56-83% | 99% | Philip 2020 13 |
| 4. 275.0 | hemochromatosis | 67% | 99% | 40% | 100% | Philip 2020 13 |
| 5. 305.0, 303, 291.0, 291, 571.0, 571.1, 571.2, 571.3, 535.3, 257.5, 425.5, 980.0, 980.9, 780.3, 760.71 | Alcohol-related cirrhosis | 40-82% | 98-100% | 80-90% | 96-97% | Philip 2020 13 |
| 6. None of the above | NAFLD/cryptogenic | 77-80% | 95% | 75-92% | 87-95% | Philip 2020 13 |
| ICD-10 Individual codes | **Diagnosis** | **PPV** | **NPV** | **Sensitivity** | **Specificity** | **Study** |
| * K70.3 | Alcoholic-related cirrhosis | 97%  100%  93%  98% | 35%  79%  NR  63% | 55%  7%  NR  24% | 93%  100%  NR  100% | Hayward 2020 1  Ramrakhiani 2020 3  Bengtsson 2020 2  Khalifa 2023 4 |
| * K71.7 | Toxic liver disease with cirrhosis | 100% | 78.1% | 0.3% | 100% | Ramrakhiani 2020 3 |
| * K74.6 | Other and unspecified cirrhosis | 90%  96%  89%  91%  93%  95% | NR  33%  89%  NR  81%  NR | NR    59%  NR  71%  NR | NR  98%  NR  96%  NR | Mapakshi 33  Hayward 2020 1  Ramrakhiani 2020 3  Bengtsson 20202  Khalifa 2023 4  Hayward 2021 26 |
| * K74.69 | Other cirrhosis of liver | 93%  93% | 83%  81% | 29%  71% | 99%  96% | Ramrakhiani 2020 3  Khalifa 2023 4 |
| * K70.1 | Alcoholic hepatitis+labs | 86% | NR | NR | NR | Shaheen 28 |
| * R18 | Ascites | 93%  97%  92% | N/A  76%  68% | NR  NR  43% | NR  NR  97% | Bengtsson2  Hayward 2020 1  Khalifa 2023 4 |
| * K65.9 | Peritonitis, unspecified | 87% | 95% | NR | NR | Hayward 2020 1 |
| * G93.4 | Hepatic encephalopathy | 75%  71% | 89%  77% | NR  NR | NR  NR | Tapper 37  Hayward 2020 1 |
| * K72.9 | Hepatic encephalopathy | 85-90% | 85-93% | NR | NR | Tapper 37 |
| * I85.0 | Esophageal varices | 90%  96%  91% | NR  NR  60% | NR  NR  18% | NR  NR  99% | Mapakshi 2018 33  Bengtsson 2  Khalifa 2023 4 |
| * I85.1/.11 | Secondary esophageal varices | 90.2%  92% | NR  57% | NR  6% | NR  100% | Mapakshi 2018 33  Khalifa 2023 4 |
| * I85.9 | Esophageal Varices without bleeding | 96% | NR | NR | NR | Bengtsson 2 |
| * I86.4 | Gastric varices | 90.2% | NR | NR | NR | Mapakshi 2018 33 |
| * I98.2 | Esophageal varices without bleeding in diseases classified elsewhere | 94% | 60% | NR | NR | Hayward 2020 1 |
| * I98.3 | Esophageal varices with bleeding in diseases classified elsewhere | 100% | 60% | NR | NR | Hayward 1 |
| * K76.7 | Hepatorenal syndrome | >80%  100% | NR  69% | NR  12% | NR  100% | Shearer 31  Khalifa 2023 4 |
| * C22.0 | Hepatocellular carcinoma | 84%  97% | NR  98% | NR  NR | NR  NR | Bengtsson2  Hayward 2020 1 |
| * K76.6 | Portal hypertension | 95%  95% | 84%  75% | 30%  58% | 100%  97% | Ramrakhiani 2020 3  Khalifa 2023 4 |
| * K74.4 | Secondary biliary cirrhosis | 100% | 24% | NR | NR | Hayward 2020 1 |
| * K74.5 | Biliary cirrhosis unspecified | 67% | 23% | NR | NR | Hayward 2020 1 |
| * K76.0 | NAFLD | 82% | NR | NR | NR | Astrom 2023 25 |
| * F10.1 | Harmful use of alcohol | 95% | 63% | 59% | 95% | Hayward 202126 |
| * K70.1 | Alcohol-related hepatitis | 100%  54% | 44%  NR | 5%  NR | 100%  NR | Hayward 202126  Pang 2015 38 |
| * K70.4 | Alcoholic hepatic failure | 95% | 53% | 35% | 98% | Hayward 202126 |
|  |  |  |  |  |  |  |
| Algorithms | **Diagnosis** | **PPV** | **NPV** | **Sensitivity** | **Specificity** | **Study** |
| Grouped alcohol codes: F10.1, K70.1, K70.2, K70.3, K70.4, K70.9 | Alcohol-related liver disease | 94% | 81% | 84% | 92% | Hayward 202126 |
| #6: K70.3, K74.4 K74.5, K74.6, C22.0, K70.4, K72.9, K76.6, K76.7, I85.0, I85.9, I86.4, I98.2, I98.3, K76.6 | All cause cirrhosis | 88% | 76% | 94% | 56% | Hayward 2020 1 |
| #1: K70.3, K74.4, K74.5, K74.6 | All cause cirrhosis | 96% | 69% | 81 | 90 | Hayward 2020 1 |
| K70.3, K70.31, K74.60, K73.69, K74.3, K74.4, K74.5 | All cause cirrhosis | 93% | NR | NR | NR | Mapakshi 2018 33 |
| K74.6, K76.6, K74.69, K70.30, K70.31, K71.7 | All cause cirrhosis | 88% | 90% | 60% | 100% | Ramrakhiani 2020 3 |
| K74.6, K70.3, I85.0, I85.9, I98.2, I98.3, K76.6, K72.9, K76.7 | All cause cirrhosis | 83-89% | NR | 61-100 | NR | Shearer 2022 31 |
| K70.3, K71.7, K74.5, K74.6, or I85.9, I98.2 | All cause cirrhosis | 88% | 98% | 99% | 79% | Lapointe-Shaw 2018 32 |
| Hierarchical:  1. HCV RNA positive | Hepatitis C | 100% | 94-98% | 90-97% | 100% | Philip 2020 13 |
| 2. HBV surface antigen or HBV DNA positive | Hepatitis B | 86-96% | 99-100% | 92-96% | 99% | Philip 2020 13 |
| 3. K74.3, K83.0, K75.4 | Autoimmune | 90-91% | 96-98% | 56-83% | 99% | Philip 2020 13 |
| 4. E83.10 | hemochromatosis | 67% | 99% | 40% | 100% | Philip 2020 13 |
| 5. F100-F109, X45, Y15, X65, K700-K702, K704, K709, K292, G312, G721, I426, K852, K860, E244, R780, T510, T519, O354, Q860, P043, K70.3, K70.1 | Alcohol-related cirrhosis | 40-82% | 98-100% | 80-90% | 96-97% | Philip 2020 13 |
| 6. None of the above | NAFLD/cryptogenic | 77-80% | 95% | 75-92% | 87-95% | Philip 2020 13 |
| K76.0, excluding coding for AUD (F10.0-F10.7W) and other liver diseases (K70.0-K70.9, B18, K75.4, K74.3, K83.0A, and no HCV RNA and HBV surface antigen) | NAFLD | 91% | NR | NR | NR | Astrom 2023 25 |
| K76.6, K70.31, K74.60, K74.69 | All cause cirrhosis | 92% | 93% | 90% | 94% | Khalifa 2023 4 |
| K70.3, K71.7, K72.1, K74.4, K74.5, K74.6, K76.6, K72.1, K72.9, I85.9, I86.4, I98.2, I85.0, I98.3 R18.X, J70.4, K70.9 | All cause cirrhosis | 99% | NR | 86% | 98% | Driver 2019 35 |

PPV: Positive predictive value

NPV: Negative predictive value

NR: Not reported

ICD: International classification of diseases

Table 3S. International classification of diseases tenth revision codes (ICD-10) used for case definitions and admission selection.

|  |  |
| --- | --- |
| Condition | ICD-10 Codes |
| Alcohol-related cirrhosis | K70.3 |
| Non-alcohol-related cirrhosis: |  |
| * *Toxic liver disease with fibrosis and cirrhosis of liver* | K71.7 |
| * *Secondary biliary cirrhosis* | K74.4 |
| * *Biliary cirrhosis, unspecified* | K74.5 |
| * *Other and unspecified cirrhosis of liver* | K74.6 |
| Decompensated cirrhosis-related conditions |  |
| * *Ascites* | R18 |
| * *Unspecified encephalopathy* | G93.4 |
| * *Hepatic failure, unspecified* | K72.9 |
| * *Portal hypertension* | K76.6 |
| * *Esophageal varices* | I85.0 |
| * *Secondary esophageal varices* | I85.1 |
| * *Esophageal varices without bleeding* | I85.9 |
| * *Gastric varices* | I86.4 |
| * *Esophageal varices without bleeding in diseases classified elsewhere* | I98.2 |
| * *Esophageal varices with bleeding in diseases classified elsewhere* | I98.3 |
| * *Hepatorenal syndrome* | K76.7 |
| * *Hepatocellular carcinoma* | C22.0 |
| Additional decompensated cirrhosis-related conditions: |  |
| * *Acute/subacute hepatic failure* | K72.0 |
| * *Chronic hepatic failure* | K72.1 |
| * *Unspecified peritonitis* | K65.9 |
| Alcohol use disorder-related conditions: |  |
| * *Acute Intoxication* | F10.0 |
| * *Harmful Alcohol Use* | F10.1 |
| * *Alcohol dependence* | F10.2 |
| * *Alcohol withdrawal* | F10.3, F10.4 |
| * *Other alcohol-related psychoses* | F10.5-F10.9 |
| * *Accidental or intentional Alcohol Poisoning* | X45, Y15, X65 |
| * *Alcoholic fatty liver* | K70.0 |
| * *Alcohol-related hepatitis* | K70.1 |
| * *Alcoholic fibrosis and sclerosis of liver* | K70.2 |
| * *Alcohol-related cirrhosis* | K70.3 |
| * *Alcoholic hepatic failure* | K70.4 |
| * *Alcoholic liver disease, unspecified* | K70.9 |
| * *Alcoholic gastritis* | K29.2 |
| * *Degeneration of nervous system due to alcohol* | G31.2 |
| * *Alcoholic polyneuropathy* | G62.1 |
| * *Alcoholic myopathy* | G72.1 |
| * *Alcoholic cardiomyopathy* | I42.6 |
| * *Alcohol-induced pancreatitis* | K85.2, K86.0 |
| * *Alcohol-induced pseudo Crushing’s syndrome* | E24.4 |
| * *Maternal care for (suspected) damage to fetus from alcohol* | O35.4, Q86.0, P04.3 |
| * *Alcohol in blood* | R78.0 |
| * *Toxic effect of alcohol* | T51.0, T51.9 |

ICD-10: International classification of diseases 10th revision

Table 4S. Non-alcohol-related cirrhosis (NAC) identification performance characteristics of individual decompensated cirrhosis-related condition ICD-10 codes in any diagnostic position.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Condition | ICD-10 | PPV %  (95% CI) (n/n) | NPV %  (95% CI) (n/n) | Sensitivity %  (95% CI) (n/n) | Specificity % (95% CI) (n/n) | AUROC (95% CI) |
| * *Ascites* | R18 | 25.8 (19.7-32.7)  (48/186) | 69.7 (65.4-73.8) (338/485) | 24.6 (18.7-31.3)  (48/195) | 71.0 (66.7-75.0)  (338/485) | 0.48 (0.44-0.51) |
| * *Unspecified encephalopathy* | G93.4 | 21.1 (6.1-45.6)(4/19) | 70.7 (67.0-74.2)(461/652) | 2.1 (0.6-5.2)(4/195) | 96.8 (94.9-98.2)(461/476) | 0.49 (0.48-0.51) |
| * *Hepatic failure, unspecified* | K72.9 | 44.2 (35.1-53.5) (53/120) | 74.2 (70.4-77.8)  (409/551) | 27.2 (21.1-34.0)  (53/195) | 85.9 (82.5-88.9)  (409/476) | 0.57 (0.53-0.60) |
| * *Portal hypertension* | K76.6 | 41.5 (26.3-57.9)  (17/41) | 71.7 (68.1-75.2)  (452/630) | 8.7 (5.2-13.6)  (17/195) | 95.0 (92.6-96.7)  (452/476) | 0.52 (0.50-0.54) |
| * *Esophageal varices* | I85.0 | 46.7 (21.3-73.4)  (7/15) | 71.3 (67.7-74.8)  (468/656) | 3.6 (1.5-7.3)  (7/195) | 98.3 (96.7-99.3)  (468/476) | 0.51 (0.50-0.52) |
| * *Secondary esophageal varices* | I85.1 | 0 | 70.9 (67.3-74.4)  (476/671) | 0 | 100% | 0.50 |
| * *Esophageal varices without bleeding* | I85.9 | 33.3 (4.3-77.7)  (2/6) | 71.0 (67.4-74.4)  (472/665) | 1.0 (0.1-3.7)  (2/195) | 99.2 (97.9-99.8)  (472/476) | 0.50 (0.49-0.51) |
| * *Gastric varices* | I86.4 | 5.0 (0.1-24.9)  (1/20) | 70.2 (66.5-73.7)  (457/651) | 0.5 (0.0-2.8)  (1/195) | 96.0 (93.8-97.6)  (457/476) | 0.48 (0.47-0.49) |
| * *Esophageal varices without bleeding in diseases classified elsewhere* | I98.2 | 23.7 (11.4-40.2)  (9/38) | 70.6 (66.9-74.1)  (447/633) | 4.6 (2.1-8.6)  (9/195) | 93.9 (91.4-95.9)  (447/476) | 0.49 (0.47-0.51) |
| * *Esophageal varices with bleeding in diseases classified elsewhere* | I98.3 | 21.2 (12.1-33.0)  (14/66) | 70.1 (66.3-73.7)  (424/605) | 7.2 (4.0-11.8)  (14/195) | 89.1 (85.9-91.7)  (424/476) | 0.48 (0.46-0.50) |
| * *Hepatorenal syndrome* | K76.7 | 36.8 (16.3-61.6)(7/19) | 71.2 (67.5-74.6)(464/652) | 3.6 (1.5-7.3)(7/195) | 97.5 (95.6-98.7)(464/476) | 0.51 (0.49-0.52) |
| * *Hepatocellular carcinoma* | C22.0 | 51.8 (43.1-60.4)  (71/137) | 76.8 (73.0-80.3)  (410/534) | 36.4 (29.7-43.6)  (71/195) | 86.1 (82.7-89.1)  (410/476) | 0.61 (0.58-0.65) |
| * *Acute/subacute hepatic failure* | K72.0 | 14.0 (5.8-26.7)(7/50) | 69.7 (65.9-73.3)(433/621) | 3.6 (1.5-7.3)(7/195) | 91.0 (88.0-93.4)(433/476) | 0.47 (0.45-0.49) |
| * *Chronic hepatic failure* | K72.1 | 48.8 (33.3-64.5)(21/43) | 72.6 (69.0-76.1)(454/625) | 10.9 (6.9-16.2)(21/195) | 95.4 (93.1-97.1)(454/476) | 0.53 (0.51-0.56) |
| * *Unspecified peritonitis* | K65.9 | 14.6 (6.1-27.8)(7/48) | 69.8 (66.1-73.4)(435/623) | 3.6 (1.5-7.3)(7/195) | 91.4 (88.5-93.7)(435/476) | 0.47 (0.46-0.49) |

PPV: Positive predictive value

NPV: Negative predictive value

AUROC: Area under receiver operating characteristic curve

95% CI: 95% confidence intervals

n/n: Estimate ratio

ICD-10: International classification of diseases 10th revision

Table 5S: Calculation of true and false positives and negatives for AC and NAC algorithms using electronic medical record review as reference standard.

|  |  |  |  |
| --- | --- | --- | --- |
|  | | Reference standard: EMR validation | |
| Validated condition\* | No validated condition |
| AC ICD-10 coding algorithm | Meets AC algorithm | AC True positive | AC False positive |
| Does not meet AC algorithm | AC False negative | AC True negative |
| NAC ICD-10 coding algorithm | Meets NAC algorithm | NAC True positive | NAC False positive |
| Does not meet NAC algorithm | NAC False negative | NAC True negative |

\* Validated condition is AC for AC ICD-10 coding algorithms and NAC for NAC ICD-10 coding algorithms

AC: alcohol-related cirrhosis

NAC: non-alcohol-related cirrhosis

EMR: electronic medical record

ICD-10: International Classification of Diseases 10th revision

Table 6S. Calculation of positive negative predictive value (PPV), negative predictive value (NPV), sensitivity, and specificity.

|  |  |
| --- | --- |
| Estimate | \*Calculation |
| PPV | True positive / (true positive + false positive) |
| NPV | True negative / (true negative + false negative |
| Sensitivity | True positive / (true positive + false negative) |
| Specificity | True negative / (true negative + false positive) |

\*Calculation is specific to AC or NAC. For example, PPV for AC would be AC true positive / (AC true positive + AC false positive).

PPV: positive predictive value

NPV: negative predictive value

Table 7S. Characteristics of patients with missing laboratory data compared to admissions who successfully linked to laboratory data.

|  |  |  |  |
| --- | --- | --- | --- |
| Characteristics | Linked to lab data  N=426 | Not linked to lab data  N=245 | p-value |
| Age, median (IQR) | 61 (52-70) | 58 (50-69) | p=0.018 |
| Hospitalization year, median (IQR) | 2017 (2014-2019) | 2011 (2009-2015) | p<0.001 |
| Sex, n (%) |  |  |  |
| 1. Male | 259 (60.7%) | (64.5%%) | p=0.90 |

IQR: Interquartile range

Table 8S. Demographic and clinical characteristics of patients with missing EMRs compared to patients with available EMRs.

|  |  |  |  |
| --- | --- | --- | --- |
| Characteristics | Linked to EMR  N=671 | Not linked to EMR  N=29 | p-value |
| Age, median (IQR) | 60 (51-70) | 64 (55-72) | p=0.23 |
| Hospitalization year, median (IQR) | 2015 (2011-2019) | 2011 (2009-2014) | p=0.07 |
| Sex, n (%) |  |  |  |
| 1. Male | 417 (62.2%) | 21 (72.4%) | p=0.33 |
| 1. Female | 254 (37.9%) | 8 (27.4%) |  |
| AST (U/L), median (IQR) | 65.5 (40-117) | 82 (51-133) | p=0.55 |
| ALT (U/L), median (IQR) | 31 (19-65) | 43 (36-49) | p=0.19 |
| Albumin (g/L), median (IQR) | 25 (21-30) | 26 (25-35) | p=0.42 |
| Total bilirubin (µmol/L), median (IQR) | 28 (13-81) | 23 (17-36) | p=0.71 |
| Creatinine (µmol/L), median (IQR) | 84 (62-132.5) | 101.5 (77-126) | p=0.34 |
| INR, median (IQR) | 1.4 (1.2-1.7) | 1.2 (1.1-1.3) | p=0.18 |
| Sodium (mEq/L), median (IQR) | 136 (132-137) | 137 (135-137) | p=0.49 |
| MELD, median (IQR) | 15.4 (10.0-21.2) | 11.7 (10.0-16.9) | p=0.37 |
| MELD sodium, median (IQR) | 17.4 (11.6-24.6) | 13.2 (11.0-18.8) | P=0.25 |
| Has AC ICD-10 code any position, n (%) | 167 (24.9%) | 4 (13.8%) | p=0.27 |
| Has NAC ICD-10 code any position, n (%) | 142 (21.2%) | 6 (20.7%) | p=1.00 |
| Has AUD ICD-10 code in any position, n (%) | 194 (29.9%) | 4 (13.8%) | p=0.09 |
| Has decompensated cirrhosis code in any position, n (%) | 511 (76.2%) | 22 (75.9) | p=1.00 |

Note: only 10 of the individuals missing EMR have available lab data.

AC: Alcohol-related cirrhosis

NAC: Non-alcohol-related cirrhosis

AUD: Alcohol use disorder

EMR: Electronic medical records

AST: Aspartate transaminase

ALT: Alanine transaminase

INR: International Normalized Ratio

MELD: Model-for-End-Stage Liver Disease

IQR: Interquartile range

Table 9S. Performance characteristics of alcohol-related cirrhosis (AC) admission identification algorithms in the cohort of 671 hospitalized patients.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| AC identification number and ICD-10 algorithm: | PPV %  (95% CI) (n/n) | NPV %  (95% CI) (n/n) | Sensitivity %  (95% CI) (n/n) | Specificity % (95% CI) (n/n) | AUROC (95% CI) |
| AC algorithm 1 derivations: AC code in different diagnostic positions | | | | | |
| AC#1: *K70.3 primary position* | 99.0 (94.6-100) (100/101) | 73.3 (69.5-76.9) (418/570) | 39.7 (33.6-46.0) (100/252) | 99.8 (98.7-100) (418/419) | 0.70 (0.67-0.73) |
| AC #1.1*: K70.3 secondary position* | 89.4 (79.4-95.6) (59/66) | 68.1 (64.2-71.8) (412/605) | 23.4 (18.3-29.1) (59/252) | 98.3 (96.6-99.3) (412/419) | 0.61 (0.58-0.64) |
| AC #1.2: *K70.3 any position* | 95.2 (90.8-97.9) (159/167) | 81.5 (77.9-84.8) (411/504) | 63.1 (56.8-69.1) (159/252) | 98.1 (96.3-99.2) (411/419) | 0.81 (0.78-0.84) |
| AC algorithm 2 derivations: NAC + AUD codes together | | | | | |
| AC #2*: Primary K71.7, K74.6, K74.4, or K74.5 + secondary AUD code* | 100 (29.2-100) (3/3) | 62.7 (58.9-66.4) (419/668) | 1.2 (0.2.1-3.4) (3/252) | 100 (99.1-100) (419/419) | 0.51 (0.50-0.51) |
| AC #2.1*: Primary AUD code + secondary K71.7, K74.6, K74.4, or K74.5* | 0 (0/0) | 62.4 (58.7-66.1) (419/671) | 0 (0/252) | 100 (99.1-100) (419/419) | 0.50 (0.50-0.50) |
| AC #2.2*: AUD code + K71.7, K74.6, K74.4, or K74.5 in any position* | 90 (55.5-99.7) (9/10) | 63.2 (59.4-66.9) (418/661) | 3.6 (1.6-6.7) (9/252) | 99.8 (98.7-100) (418/419) | 0.52 (0.50-0.53) |
| AC algorithm 3 derivations: AUD + decompensation codes together | | | | | |
| AC #3: *Primary decompensation code + secondary AUD code* | 94.4 (81.3-99.3)  (34/36) | 65.7 (61.8-69.4)  (417/635) | 13.5 (9.5-18.3) (34/252) | 99.5 (98.3-99.9) (417/419) | 0.57 (0.54-0.59) |
| AC #3.1*: Primary AUD code + secondary decompensation code* | 94.8 (89.0-98.1) (109/115) | 74.3 (70.4-77.9) (413/556) | 43.3 (37.1-49.6) (109/252) | 98.6 (96.9-99.5) (413/419) | 0.71 (0.68-0.74) |
| AC #3.2: *AUD code + decompensation code in any position* | 92.3 (87.4-95.7) (167/181) | 82.7 (79.0-85.9) (405/490) | 66.3 (60.1-72.1) (167/252) | 96.7 (94.5-98.2) (405/419) | 0.81 (0.78-0.85) |
| AC algorithm 4 derivations: AC + decompensation + AUD + NAC codes | | | | | |
| AC #4: *AC #1.2 or AC #3.2* | 92.8 (88.4-95.9) (194/209) | 87.4 (84.1-90.3) (404/462) | 77.0 (71.3-82.0) (194/252) | 96.4 (94.2-98.0) (404/419) | 0.87 (0.84-0.89) |
| AC #4.1: *AC #4 or AC #2.2* | 92.9 (88.6-96.0)  (197/212) | 88.0 (84.7-90.8)  (404/459) | 78.2 (72.6-83.1)  (197/252) | 96.4 (94.2-98.0)  (404/459) | 0.87 (0.85-0.90) |
| AC #4.2*: AC #4.1 and K72.0 + AUD code together* | 91.7 (87.1-95.0)  (198/216) | 88.1 (84.8-91.0)  (401/455) | 78.6 (73.0-83.5)  (198/216) | 95.7 (93.3-97.4)  (401/419) | 0.87 (0.84-0.90) |
| AC #4.3: *AC #4.2 and K72.1 + AUD code together* | 91.7 (87.1-95.0)  (198/216) | 88.1 (84.8-91.0)  (401/455) | 78.6 (73.0-83.5)  (198/252) | 95.7 (93.3-97.4)  (401/419) | 0.87 (0.84-0.90) |
| AC #4.4: *AC #4.3 and K65.9 + AUD code together* | 91.7 (87.1-95.0)  (198/216) | 88.1 (84.8-91.0)  (401/455) | 78.6 (73.0-83.5)  (198/252) | 95.7 (93.3-97.4)  (401/419) | 0.87 (0.84-0.90) |
| AC algorithm 5 derivations: AC #4.1 + alcohol-related hepatic failure and unspecified alcohol-related liver disease codes | | | | | |
| AC #5: *AC #4.1 + K70.4 in any position* | 91.1 (86.5-94.5)  (204/224) | 89.3 (86.0-92.0)  (399/447) | 81.0 (75.6-85.6)  (204/252) | 95.2 (92.7-97.1)  (399/419) | 0.88 (0.85-0.91) |
| AC #5.1: *AC #5 + K70.9 in any position* | 81.8 (76.5-86.3)  (211/258) | 90.1 (86.8-92.8)  (372/413) | 83.7 (78.6-88.1)  (211/252) | 88.8 (85.4-91.6)  (372/419) | 0.86 (0.84-0.89) |

Note: Table 3S shows all used ICD-10 codes

AC: Alcohol-related cirrhosis

PPV: Positive predictive value

NPV: Negative predictive value

AUROC: Area under receiver operating characteristic curve

95% CI: 95% confidence interval

n/n: Estimate ratio

ICD-10: International classification of diseases 10th revision

NAC: Non-alcohol-associated cirrhosis

AUD: Alcohol use disorder

Table 10S. Performance characteristics of non-alcohol-related cirrhosis (NAC) admission identification algorithms in the cohort of 671 hospitalized patients.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| NAC identification number and ICD-10 algorithm: | PPV %  (95% CI) (n/n) | NPV %  (95% CI) (n/n) | Sensitivity  (95% CI) (n/n) | Specificity (95% CI) (n/n) | AUROC (95% CI) |
| NAC algorithm 1 derivations: NAC ICD-10 codes alone | | | | | |
| NAC #1: *K71.7, K74.6, K74.4, or K74.5 in any position (not excluding AUD codes)* | 78.9 (71.2-85.3) (112/142) | 84.3 (80.9-87.3)  (446/529) | 57.4 (50.2- 64.5)  (112/195) | 93.7 (91.1-95.7)  (446/476) | 0.76 (0.72-0.79 |
| NAC #1.1*: K71.7, K74.6, K74.4, or K74.5 in primary position (not excluding AUD codes)* | 76.1 (61.2-87.4)  (35/46) | 74.4 (70.8-77.8)  (465/625) | 17.9 (12.8-24.1)  (35/195) | 97.7 (95.9-98.8)  (465/476) | 0.58 (0.55-0.61) |
| NAC #1.2: *K71.7, K74.6, K74.4, or K74.5 in secondary position (not excluding AUD codes)* | 80.2 (70.8-87.6)  (77/96) | 79.5 (75.9-82.7)  (457/575) | 39.5 (32.6-46.7)  (77/195) | 96.0 (93.8-97.6)  (457/575) | 0.68 (0.64-0.71) |
| NAC algorithm 2: NAC ICD-10 codes alone, excluding AUD codes | | | | | |
| NAC #2: NAC #1 + excluding all AUD codes | 84.1 (76.7-89.9) (111/132) | 84.4 (81.1-87.4) (455/538) | 56.9 (49.7-64.0) (111/195) | 95.6 (93.3-97.2) (455/476) | 0.76 (0.73-0.80) |
| NAC algorithms 3-17 derivations: Stepwise inclusion of decompensation codes to NAC coding algorithms | | | | | |
| NAC #3: *NAC #2 + C22.0 in any diagnostic position* | 69.2 (62.5-75.4)  (144/208) | 89.0 (85.8-91.7)  (412/463) | 73.8 (67.1-79.9)  (144/195) | 86.6 (83.2-89.5)  (412/476) | 0.80 (0.77-0.84) |
| NAC #3.1: *NAC #2 + C22.0 in primary position* | 69.8 (63.0-76.0) (143/205) | 88.8 (85.6-91.6)  (414/466) | 73.3 (66.5-79.4)  (143/195) | 87.0 (83.6-89.9)  (414/476) | 0.80 (0.77-0.84) |
| NAC #4: *NAC #3 + K72.9 in any position* | 63.4 (57.3-69.2)  (168/265) | 93.3 (90.5-95.6)  (379/406) | 86.2 (80.5-90.7)  (168/195) | 79.6 (75.7-83.2)  (379/476) | 0.83 (0.80-0.86) |
| NAC #4.1: *NAC #3.1 + K72.9 in primary position* | 67.6 (61.3-73.5)  (163/241) | 92.6 (89.7-94.9)  (398/430) | 83.6 (77.6-88.5)  (163/195) | 83.6 (80.0-86.8)  (398/476) | 0.84 (0.81-0.87) |
| NAC #5: *NAC #4 + K72.1 in any position* | 62.8 (56.9-68.4)  (179/285) | 95.9 (93.4-97.6)  (370/386) | 91.8 (87.0-95.2)  (179/195) | 77.7 (73.7-81.4)  (370/476) | 0.85 (0.82-0.87) |
| NAC #5.1: *NAC #4.1 + K72.1 in primary position* | 68.3 (62.1-74.0) (172/250) | 94.5 (91.9-96.5)  (396/419) | 88.2 (82.8-92.4) (172/195) | 83.2 (79.5-86.4)  (396/476) | 0.86 (0.83-0.89) |
| NAC #6: *NAC #5 + K76.6 in any position* | 62.6 (56.8-68.2)  (181/289) | 96.3 (93.9-98.0)  (368/382) | 92.8 (88.2-96.0)  (181/195) | 77.3 (73.3-81.0)  (368/476) | 0.85 (0.82-0.88) |
| \*NAC #6.1: *NAC #5.1 + K76.6 in primary position* | 68.3 (62.1-74.0)  (172/252) | 94.5 (91.9-96.5)  (396/419) | 88.2 (82.8-92.4)  (172/195) | 83.2 (79.5-86.4)  (396/476) | 0.86 (0.83-0.89) |
| NAC #7: *NAC #6 + I85.0 in any position* | 62.6 (56.8-68.1)  (184/294) | 97.1 (94.8-98.5)  (366/377) | 94.4 (90.1-97.2)  (184/195) | 76.9 (72.8-80.6)  (366/476) | 0.86 (0.83-0.88) |
| NAC #7.1: *NAC #5.1 + I85.0 in primary position* | 68.1 (62.0-73.7)  (177/260) | 95.6 (93.2-97.4)  (393/411) | 90.8 (85.8-94.4)  (177/195) | 82.6 (78.8-85.9)  (393/476) | 0.87 (0.84-0.89) |
| NAC #8: *NAC #7 + K76.7 in any position* | 62.3 (56.5-67.8)  (185/297) | 97.3 (95.1-98.7)  (364/374) | 94.9 (90.8-97.5)  (185/195) | 76.5 (72.4-80.2)  (364/476) | 0.86 (0.83-0.88) |
| NAC #8.1: *NAC #7.1 + K76.7 in primary position* | 68.2 (62.2-73.8)  (178/261) | 95.9 (93.4-97.6)  (393/410) | 91.3 (86.4-94.8)  (178/195) | 82.6 (78.8-85.9)  (393/476) | 0.87 (0.84-0.90) |
| \*NAC #9: *NAC #8 + I85.9 in any position* | 62.1 (56.3-67.6)  (185/298) | 97.3 (95.1-98.7)  (363/373) | 94.9 (90.8-97.5)  (185/195) | 76.3 (72.2-80.0)  (363/476) | 0.86 (0.83-0.88) |
| NAC #9.1: NAC #8.1 + I85.9 in primary position | 68.1 (62.1-73.7)  (179/263) | 96.1 (93.7-97.7)  (392/408) | 91.8 (87.0-95.2)  (179/195) | 82.4 (78.6-85.7)  (392/476) | 0.87 (0.84-0.90) |
| \*NAC #10: *NAC #8 + I98.2 in any position* | 62.3 (56.5-67.8)  (185/297) | 97.3 (95.1-98.7)  (364/374) | 94.9 (90.8-97.5)  (185/195) | 76.5 (72.4-80.2)  (364/476) | 0.86 (0.83-0.88) |
| \*NAC #10.1: *NAC #9.1 + I98.2 in primary position* | 68.1 (62.1-73.7)  (179/263) | 96.1 (93.7-97.7)  (392/408) | 91.8 (87.0-95.2)  (179/195) | 82.4 (78.6-85.7)  (392/476) | 0.87 (0.84-0.90) |
| ^NAC #11: *NAC #8 + G93.4 in any position* | 59.9 (54.2-65.4)  (185/309) | 97.2 (95.0-98.7)  (352/362) | 94.9 (90.8-97.5)  (185/195) | 73.9 (69.8-77.8)  (352/476) | 0.84 (0.82-0.87) |
| ^NAC #11.1: *NAC #9.1 + G93.4 in primary* *position* | 65.5 (59.5 71.1)  (180/275) | 96.2 (93.8-97.9)  (381/396) | 92.3 (87.6-95.6)  (180/195) | 80.0 (76.2-83.5)  (381/476) | 0.86 (0.84-0.89) |
| ^NAC #12: *NAC #8 + R18 in any position* | 56.8 (51.3-62.2)  (188/331) | 97.9 (95.8-99.2)  (333/340) | 96.4 (92.7-98.5)  (188/195) | 70.0 (65.6-74.0)  (333/476) | 0.83 (0.81-0.86) |
| ^NAC #12.1: *NAC #9.1 + R18 in primary position* | 61.4 (55.6-67.0)  (183/298) | 96.8 (94.4-98.3)  (361/373) | 93.8 (89.5-96.8)  (183/195) | 75.8 (71.7-79.6)  (361/476) | 0.85 (0.82-0.87) |
| \*NAC #13: *NAC #8 + I98.3 in any position* | 62.3 (56.5-67.8)  (185/297) | 97.3 (95.1-98.7)  (364/374) | 94.9 (90.8-97.5)  (185/195) | 76.5 (72.4-80.2)  (364/476) | 0.86 (0.83-0.88) |
| \*NAC #13.1:  *NAC #9.1 + I98.3 in primary position* | 68.1 (62.1-73.7)  (179/263) | 96.1 (93.7-97.7)  (392/408) | 91.8 (87.0-95.2)  (179/195) | 82.4 (78.6-85.7)  (392/476) | 0.87 (0.84-0.90) |
| ^NAC #14: *NAC #8 + K65.9 in any position* | 56.6 (51.1-62.0)  (188/332) | 97.9 (95.8-99.2)  (332/339) | 96.4 (92.7-98.5)  (188/195) | 69.7 (65.4-73.8)  (332/476) | 0.83 (0.81-0.86) |
| \*NAC #14.1: *NAC #9.1 + K65.9 in primary position* | 64.5 (58.6-70.1)  (182/282) | 96.7 (94.4-98.2)  (376/389) | 93.3 (88.9-96.4)  (182/195) | 79.0 (75.1-82.6)  (376/476) | 0.86 (0.84-0.89) |
| ^NAC #15: *NAC #8 + K72.0 in any position* | 57.1 (51.5-62.6)  (185/324) | 97.1 (94.8-98.6) (337/347) | 94.9 (90.8-97.5)  (185/195) | 70.8 (66.5-74.8)  (337/476) | 0.83 (0.80-0.85) |
| ^NAC #15.1: *NAC #9.1 + K72.0 in primary position* | 65.1 (59.1-70.7)  (179/275) | 96.0 (93.5-97.7)  (380/396) | 91.8 (87.0-95.2)  (179/195) | 79.8 (75.9-83.3)  (380/476) | 0.86 (0.83-0.88) |
| ^NAC #16: *NAC #8 + I86.4 in any position* | 60.9 (55.1-66.4)  (185/304) | 97.3 (95.0-98.7)  (357/367) | 94.9 (90.8-97.5)  (185/195) | 75.0 (70.9-78.8)  (357/476) | 0.85 (0.82-0.87) |
| ^NAC #16.1: *NAC #9.1 + I86.4 in primary position* | 66.1 (60.1-71.7)  (179/271) | 96.0 (93.6-97.7)  (384/400) | 91.8 (87.0-95.2)  (179/195) | 80.7 (76.8-84.1)  (384/476) | 0.86 (0.84-0.89) |
| ^NAC #17: *NAC #2 + any decompensation code in any position* | 46.7 (41.8-51.7)  (191/409) | 98.5 (96.1-99.6)  (258/262) | 97.9 (94.8-99.4)  (191/195) | 54.2 (49.6-58.7)  (258/476) | 0.76 (0.74-0.79) |
| ^NAC #17.1: *NAC #2 + any decompensation code in primary position* | 53.6 (48.2-58.9)  (187/349) | 97.5 (95.2-98.9)  (314/322) | 95.9 (92.1-98.2)  (187/195) | 66.0 (61.5-70.2)  (314/476) | 0.81 (0.78-0.83) |

\* Addition of code produced lower or the exact same performance characteristics; therefore, the code was excluded in subsequent algorithms

^ Addition of code significantly decreased AUROC; therefore, the code was excluded in subsequent algorithms

Table 3S has all ICD-10 codes used

PPV: Positive predictive value

NPV: Negative predictive value

AUROC: Area under receiver operating characteristic curve

95% CI: 95% confidence intervals

n/n: Estimate ratio

ICD-10: International classification of diseases 10th revision

NAC: Non-alcohol-associated cirrhosis

AUD: Alcohol use disorder (includes AC and AH)

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