UC San Diego

UC San Diego Previously Published Works

Title

Rate of Risk Factors for and Interventions to Reduce Hospital Readmission in Patients With Inflammatory Bowel Diseases

Permalink

https://escholarship.org/uc/item/1g30q321

Journal

Clinical Gastroenterology and Hepatology, 18(9)

ISSN

1542-3565

Authors

Nguyen, Nghia H
Koola, Jejo
Dulai, Parambir S
et al.

Publication Date

2020-08-01

DOI

10.1016/j.cgh.2019.08.042

Peer reviewed

eScholarship.org Powered by the California Digital Library
University of California

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

HHS Public Access

Author manuscript

Clin Gastroenterol Hepatol. Author manuscript; available in PMC 2021 August 01.

Published in final edited form as:

Clin Gastroenterol Hepatol. 2020 August ; 18(9): 1939–1948.e7. doi:10.1016/j.cgh.2019.08.042.

Rate of, Risk Factors for, and Interventions to Reduce Hospital Readmission in Patients with Inflammatory Bowel Diseases

Nghia H. Nguyen, MD, MAS[1], **Jejo Koola, MD**[2,3], **Parambir S. Dulai, MD**[1], **Larry J. Prokop, MLS**[4], **William J. Sandborn, MD**[1], **Siddharth Singh, MD, MS**[1,3]

[1]Division of Gastroenterology, Department of Medicine, University of California San Diego, La Jolla, California

[2]Division of Hospital Medicine, Department of Medicine, University of California San Diego, La Jolla, California

[3]Division of Biomedical Informatics, Department of Medicine, University of California San Diego, La Jolla, California

[4]Department of Library Services, Mayo Clinic, Rochester, Minnesota

Abstract

Background & Aims—We investigated 30- and 90-day rates and causes of, risk factors for, and interventions to reduce hospital readmission in patients who received medical treatment for inflammatory bowel diseases (IBD).

Methods—We performed a systematic search of publications through July 1, 2018 for studies of rates of hospital readmission and associated causes and risk factors in patients who received medical treatments for IBD. Our final analysis included 17 cohort studies (6324 patients) of hospitalized adults with IBD who had received medical treatment, along with reported readmission rates with detailed chart review. We performed random effects meta-analysis to estimate 30- and 90-day rates of readmission and identified causes and risk factors associated with readmission. We also performed qualitative analyses of studies that focused on interventions to reduce readmission.

Corresponding author: Siddharth Singh, MD, MS, Assistant Professor of Medicine, Division of Gastroenterology and Division of Biomedical Informatics, University of California San Diego, 9452 Medical Center Drive, ACTRI 1W501, La Jolla, CA 92093, U.S.A. sis040@ucsd.edu, Phone: 858-246-2352, Fax: 858-657-7259.

Author Contribution:

- Study concept and design: SS
- Acquisition of data: NHN, JDK, LJP, SS
- Analysis and interpretation of data: NHN, SS
- Drafting of the manuscript: NHN, SS
- Critical revision of the manuscript for important intellectual content: NHN, JDK, PSD, LJP, WJS
- Approval of the final manuscript: NHN, JDK, PSD, LJP, WJS, SS
- Guarantor of Article: SS

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Results—Overall, the 30-day rate of readmission was 18.1% (95% CI, 14.4–22.4) and the 90-day rate was 26.0% (95% CI, 22.7–29.6). On meta-regression, studies with higher proportions of patients with ulcerative colitis than Crohn's disease reported higher risks for readmission. Most common reasons for readmission were IBD flare, infection, or complications from unplanned surgeries during hospitalizations. Consistent risk factors for 30-day readmission were admission for pain control (odds ratio [OR], 2.27; 95% CI, 1.69–3.03), need for total parenteral nutrition on discharge (OR, 2.13; 95% CI, 1.36–3.35), and prior or unplanned surgery during admission (OR, 3.11; 95% CI, 2.27–4.25). Only one study focused on interventions (specialized inpatient IBD service) to reduce risk of readmission.

Conclusions—Overall 30- and 90-day rates of readmission for patients who received medical treatment for IBD are 18.1% and 26.0%, respectively. IBD flares and infections are common reasons for readmission, and inadequate pain control and need for parenteral nutrition were common risk factors. Interventional studies to reduce risk of readmission are needed.

Keywords

Burden; UC; CD; value-based care; population health

INTRODUCTION

Inflammatory bowel disease (IBD) is a chronic relapsing and remitting condition that affects approximately 2 million people in the United States (US) and places a heavy economic burden on the healthcare system.[1,2] IBD is one of the top 5 most expensive gastrointestinal conditions, with annual costs exceeding $10 billion in the US alone.[1,2] In population-based cohorts, approximately 50–80% of patients with IBD require hospitalization and these contribute a significant percentage of direct medical costs with approximately 30% of patients accounting for over 80% of total IBD-related healthcare costs.[3,4] In a nationally representative longitudinal cohort study, using the Nationwide Readmission Database, of 47,402 patients with IBD, our group estimated that medically-treated IBD patients spent a median 6 days in the hospital annually with a subset of high-need, high-cost patients spending over 45 days in the hospital annually with one hospitalization every 2 months, and a substantial number of these hospitalizations are preventable.[4]

It is imperative to identify patients at-risk for frequent readmissions, to implement population health management strategies to achieve the triple aim of improving quality and outcomes, and reducing costs of care.[5] Recent claims-based studies, for example, those utilizing Nationwide Readmissions Databases have relied on non-validated administrative claims codes to identify patients with IBD, are limited to 1 year, and provide limited information on outpatient management, medication use and other objective parameters that may significantly modify risk of readmission.[6–9] Moreover, these are typically encounter-based estimates, rather than individual patient-level estimates. Other large studies estimate rate and risk factors associated with surgically-treated IBD.[10,11]

Therefore, we sought to a perform systematic review with meta-analysis to estimate 30- and 90-day rates, causes and risk factors associated with readmission in medically-treated patients with IBD. We focused on electronic health record-based studies, with more granular

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

details surrounding readmissions. In addition, we qualitatively synthesized interventions that have been shown to reduce the risk of readmission.

METHODS

We conducted this systematic review and meta-analysis according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, and the process followed an *a priori* established protocol.[12]

Selection Criteria

We included cohort studies of patients with medically-treated IBD, diagnosed based on electronic health records, reporting 30- and/or 90-day rate of readmission, with or without causes and/or risk factors associated with readmission. In addition, we separately analyzed studies reporting interventions to reduce risk of readmission in patients with IBD. We excluded studies conducted in surgically-treated patients (patients admitted electively for surgery) and studies using large administrative databases due to lack of detailed clinical data.

Search Strategy

We conducted a comprehensive search of multiple electronic databases (Ovid MEDLINE, Ovid Embase, EBM Reviews, Scopus and Web of Science) from inception through November 30, 2017 with no language restrictions; the search was subsequently updated using PubMed on July 1, 2018. The search strategy was designed and conducted by an experienced medical librarian (L.J.P) with input from the study's investigators (N.N., J.K., S.S.), using controlled vocabulary supplemented with keywords, expanded terminology and varying algorithms for cohort studies. The details of the search strategy are included in the online supplement. Of note, our search encompassed patients with cirrhosis as part of a broader project on readmission risk. Two authors independently (N.N and J.K.) reviewed the title and abstract of studies identified in the search to exclude studies that did not meet the inclusion criteria as set forth *a priori* to address the research question of interest. After reviewing the title and abstracts of potential studies, we examined the remaining articles' full text to determine whether the study included relevant information. Next, the bibliographies of selected articles and review articles on the topic were manually searched for additional inclusion into our meta-analysis. Lastly, a manual search of conference proceedings of major gastroenterology conferences between 2013–2018 (Digestive Diseases Week, American College of Gastroenterology annual meeting, Crohn's and Colitis Congress) was reviewed to identify additional studies published only in abstract form. Disagreements regarding inclusion/exclusion of studies were resolved by a third author (S.S.).

Data Abstraction

We collected data on the following study-, hospitalization- and patient-related characteristics using a standardized form: (1) Study characteristics: primary author, time period of study/year of publication, location of the population studied, IBD subtypes; (2) Hospitalization characteristics: reasons for index admission and readmission (e.g., reasons for readmissions were categorized as cardiac, infections, genitourinary, gastrointestinal, IBD-specific,

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

endocrine/metabolic, psychiatric, hematological/neoplasms, and other), length of stay, ICU stay, surgery at index admission, total parenteral nutrition, medications (e.g. steroids/narcotics, immunomodulators, biologics), follow-up after discharge; (3) Patient characteristics: demographic data (e.g., age; proportion of males, Caucasians, private insurance, Crohn's disease (CD) vs. ulcerative colitis (UC), prior surgery, perianal disease, psychiatric comorbidity; disease duration, medications at time of index admission (e.g. steroids/narcotics, immunomodulators, biologics). We also collected data on prediction models for readmission where available.

Outcomes Assessed

Our primary outcome of interest was 30-day risk of readmission. Secondary outcomes of interest included 90-day risk of readmission, reasons for readmission, and risk factors associated with readmission. In studies reporting interventions to reduce risk of readmission, we sought to assess program structure and effectiveness. To ensure stability of association and identify factors associated with heterogeneity, we performed subgroup and/or sensitivity analysis based on geographical location of the centers included in the study, IBD disease phenotype, and publication type (full text vs. abstract). In addition, meta-regression was performed to analyze the effect of age, sex and IBD phenotype mix of cohorts.

Statistical Analysis

Pooled estimates, with accompanying 95% confidence intervals (CI), on readmissions rates were calculated using the DerSimonian and Laird random-effects model. For meta-analysis of risk factors associated with hospital readmissions, we reported odds ratio (OR) with accompanying 95% CI, if >2 studies reported that risk factor. Statistical heterogeneity was assessed using the I^2 statistic with a $I^2 \geq 50\%$ considered to be substantial heterogeneity. Due to high heterogeneity, formal assessment of publication bias was not conducted. Statistical significance was defined at the 0.05 level. All calculations were performed using Comprehensive Meta-analysis, version 2 (Biostat, Englewood, New Jersey, USA).

RESULTS

We identified 852 unique studies using our search strategy and reviewed 94 studies in detail and ultimately included 17 studies (6324 patients) in the quantitative analysis.[13–29] The study selection flowsheet is included in Figure 1. Of these 17 studies, 7 studies were full length articles and 10 were abstracts. Sixteen studies were conducted in the United States[13–15,17–29] and all[13–16,18–26,28,29] but two studies were conducted at single centers.[17,27]

Table 1 shows the study-level characteristics of included studies. Fourteen studies included both patients with CD and UC, and three studies focused only on patients with UC.[14,19,23] One study included both adults and pediatric patients.[24] Mean age of the patients ranged from 37 to 60 years of age, and proportion of males ranged from 38% to 96%. In studies that reported the medication history of patients who were admitted to the hospital, 21–89% of patients were on corticosteroids and 10–71% of patients were on immunomodulators.[15,19,20,23–28] Mean length of hospital stays ranged from 4 to 7 days. Overall, full-text articles

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

were deemed to be at low risk of bias, whereas abstracts were deemed to be at high risk of bias due to paucity of information reported.

Readmission rate

Overall, 30-day readmission rate (15 studies) was 18.1% (n=1077/5586; 95% CI 14.4–22.4), with considerable heterogeneity (I^2=93%) (Figure 2), while 90-day readmission rate (5 studies) was higher at 26.0% (n=368/1426; 95% CI 22.7–29.6) with moderate heterogeneity (I^2=54%). In studies with only patients with UC, 30-day readmission rate was similar (19.3%, 95% CI 6.8 – 43.8).

On subgroup analysis, no significant difference was observed in studies published in full text (18.4%; 95% CI, 13.8–24.1) vs. abstracts (19.8%; 95%C CI, 14.5–26.3) (p=0.73), or in studies from North America (16 studies; 19.6%; 95% CI, 15.9–24.0) vs. Australia (1 study; 12.9%; 95% CI, 8.5–19.2) (p=0.07). On meta-regression, risk of readmission was higher in studies in which proportion of patients with UC (vs. CD) was higher; study-level age and sex distribution did not significantly impact 30-day rates of readmission.

The most common reasons for readmissions were flare of underlying IBD, infections/sepsis, abdominal pain or surgical complications in patients who underwent unplanned surgery during hospitalizations (Table 1).

Risk factors associated with 30-day readmission

Supplementary Table 1 details differences in demographic-, clinical-, index hospitalization- and discharge characteristics of patients who were vs. were not readmitted. Eight studies reported data on predictors for 30- day readmission rate (Table 2).[19,21–23,25–28] Patients who were admitted for pain control (OR, 2.26; 95% CI, 1.66 – 3.07), required total parenteral nutrition on discharge (OR, 2.13; 95% CI, 1.36 – 3.35) and either had prior surgery or underwent unplanned surgery during admission (OR, 3.11; 95% CI 2.27 – 4.25) were more likely to be readmitted within 30 days (Table 3). Seven studies included data on patient-level characteristics in patients who were readmitted to the hospital compared to those who were not.[13,23–28] In one study, patients with readmission were significantly older as compared to patients who were not readmitted.[26] Sex, race/ethnicity and insurance status was not consistently different between those who were readmitted vs. not readmitted. Studies did not report information on outpatient/interval evaluation and management of patients after discharge from index hospitalization, to ascertain potential impact of transitional care on risk of readmission.

One study by Hazratjee and colleagues developed a prediction model to ascertain risk of readmission.[25] Five factors were associated with risk of readmission: benzodiazepines given during admission (HR 3.0, 95% CI 1.7–5.1), pain control on admission (HR 2.2, 95% CI 1.4–3.6), lack of narcotic prescription on discharge (HR 2.2, 95% CI 1.3–3.7), abscess drainage (HR 3.4, 95% 1.9–6.3), and discharge to assisted home care or assisted-care facility (HR 3.2, 95% CI 1.8–5.7). Performance of this prediction model, based on the bias-correct *c*-statistic was 0.757, which is the same as the area under the receiver operator curve (AUC) metric.

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Interventions to reduce readmission

There were very few studies focusing on interventions to reduce readmission. Law *et al* reported on impact of a specialized IBD service on post-discharge outcomes in a time-interrupted cohort with lower rates of readmission at 90 days for all IBD-related hospitalizations.[24] The authors found that implementation of a specialized IBD team may allow for optimization of medical therapy on discharge, facilitated closer follow-up with outpatient providers and allowed earlier recognition of the need for surgical intervention and increased multidisciplinary collaboration leading to lower readmission rates.

DISCUSSION

In this systematic review and meta-analysis of 17 cohort studies in medically-treated patients with IBD, we observed a 30-day and 90-day readmission rate of 18.1% (95% CI 14.4–22.4) and 26.0% (95% CI 22.7–29.6), respectively. Most common reasons for readmission were related to flare of underlying IBD, infections/sepsis, abdominal pain and surgical complications in patients who underwent unplanned surgery during hospitalizations. Most consistent risk factors associated with 30-day readmission include initial hospitalization for pain control, need for total parenteral nutrition on discharge, and patients who had prior surgery or underwent unplanned surgery during admission. Very few studies have evaluated interventions to reduce risk of readmission, with one study evaluating role of an inpatient IBD specialist service. No studies have evaluated the role of post-discharge transitional care on risk of readmission. Overall, these findings demonstrate high risk of short-term readmission in patients with IBD, and provide impetus to study interventions, particularly post-discharge transitional care coordination, to reduce readmission in patients with IBD.

Our short-term readmission risk estimates are similar to estimates from national claims-based analyses, using Nationwide Readmissions Databases, which reported 30- and 90-d readmission rates of 10–20%[9,30] and 24%,[6] respectively. These nationally representative studies used single administrative claims codes for IBD to identify patients hospitalized with IBD, and hence were unable to adequately verify IBD diagnosis or provide details of disease phenotype and complications.

Current studies are limited in comprehensive assessment of risk factors associated with readmission, and none of the studies account for impact of evaluation and management post-discharge on risk of readmission. Only one study developed a prediction model predicting short-term readmission in hospitalized patients with IBD, using patient-level covariates – Hazratjee and colleagues identified pain management in IBD as one of the major drivers of readmission while infection control with abscess drainage and being discharged to another facility as other risk factors for readmission; interestingly, lack of narcotic prescription on discharge was associated with higher risk of readmission, potentially related to inadequate pain control post-discharge.[25] With the advent of the Electronic Health Record (EHR) and its deluge of data and novel analytic approaches such as machine learning, higher fidelity risk models are becoming more common. Using the national Veterans Administration database, Waljee and colleagues observed that a random forest machine learning prediction model incorporating longitudinal data readily available in electronic medical records, outperforms traditional logistic regression in predicting risk of hospitalization and

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

corticosteroid use within 6 months; risk of readmission was not studied.[31] More importantly the EHR allows automated risk calculation and integration of predictive analytics into the clinical workflow for decision support, which eliminates the need for manual data entry for risk score calculation. Several studies have shown improved outcomes embedding more complicated prediction models, automatically calculated by the EHR, within routine care.[32–34]

Several electronic health interventions have recently demonstrated potential benefit in decreasing risk of readmission. In a community practice-based, insurance-supported, smartphone-based application for patient engagement, integrated with clinical decision support, Project Sonar has demonstrated decline in rates of hospitalization, especially in engaged patients. In a randomized trial of telemedicine-based patient engagement and monitoring, Cross and colleagues demonstrated decrease in rate of hospitalization, though cost-benefit may be offset by the increase in non-invasive diagnostic tests, telephone calls and electronic encounters.[35] These interventions may be particularly effective in a subset of patients hospitalized with IBD, particularly those identified to be at high risk of readmission. Specific assessment for modifiable risk factors for re-admission prior to hospital discharge could be undertaken to facilitate early outpatient follow-up and reduce readmission.

While our study was the first of its kind to synthesize and summarize the available data on rates, reasons and risk factors for short-term readmissions in patients with IBD, there are several limitations. First, most of the included cohort studies were from single centers, in the United States, and may not be representative of the general population; however, nationally representative cohort studies have also observed similarly high rates of readmission. Second, studies were unable to account for hospitalization outside of the index health system. Fragmentation of care (readmission to a non-index hospital) may occur in 26–33% patients with IBD and contributes to inferior patient outcomes.[36] Due to this, our estimates on readmission risk may be underestimated. Third, there is limited information on potentially modifiable risk factors for readmission, without details of post-discharge interventions in hospitalized patients that may modify risk of readmission.

In conclusion, in this systematic review and meta-analysis of medically treated IBD patients, we observed approximately 1 in 5 medically-treated patients with IBD may be readmitted within 30 days of index hospitalization. Disease-(IBD flare) and treatment-related (infections, surgical complications) factors are the most common reasons for readmission. Development of population health management strategies focusing on identification of high-risk patients and development and implementation of multi-dimensional post-discharge transitional care interventions is warranted to improve quality of care, population health outcomes and reduce costs of care.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Acknowledgments

Disclosures: Dr. Singh is supported by the National Institute of Diabetes and Digestive and Kidney Diseases of the National Institutes of Health under award number K23DK117058, the American College of Gastroenterology Junior Faculty Development Award and the Crohn's and Colitis Foundation Career Development Award (#404614). Dr. Nguyen is supported by the National Institute of Diabetes and Digestive and Kidney Diseases of the National Institutes of Health under award number T32DK007202. Dr. Dulai is supported by the American Gastroenterology Association Research Scholar Award.

Conflicts of Interest:

NHN – None to declare.

JDK – None to declare.

PSD – Research support Takeda, Abbvie, Pfizer, Janssen, Buhlmann, ALPCO, Polymedco, Prometheus; Consulting fees Takeda, Abbvie, Pfizer, Janssen, Robarts Clinical Trials.

LJP – None to declare.

WJS – Research grants from Atlantic Healthcare Limited, Amgen, Genentech, Gilead Sciences, Abbvie, Janssen, Takeda, Lilly, Celgene/Receptos,Pfizer, Prometheus Laboratories; consulting fees from Abbvie, Allergan, Amgen, Arena Pharmaceuticals, Avexegen Therapeutics, BeiGene, Boehringer Ingelheim, Celgene, Celltrion, Conatus, Cosmo, Escalier Biosciences, Ferring, Forbion, Genentech, Gilead Sciences, Gossamer Bio, Incyte, Janssen, Kyowa Kirin Pharmaceutical Research, Landos Biopharma, Lilly, Oppilan Pharma, Otsuka, Pfizer, Precision IBD, Progenity, Prometheus Laboratories, Reistone, Ritter Pharmaceuticals, Robarts Clinical Trials (owned by Health Academic Research Trust, HART), Series Therapeutics, Shire, Sienna Biopharmaceuticals, Sigmoid Biotechnologies, Sterna Biologicals, Sublimity Therapeutics, Takeda, Theravance Biopharma, Tigenix, Tillotts Pharma, UCB Pharma, Ventyx Biosciences, Vimalan Biosciences, Vivelix Pharmaceuticals; and stock or stock options from BeiGene, Escalier Biosciences, Gossamer Bio, Oppilan Pharma, Precision IBD, Progenity, Ritter Pharmaceuticals, Ventyx Biosciences, Vimalan Biosciences. Spouse: Opthotech - consultant, stock options; Progenity - consultant, stock; Oppilan Pharma - employee, stock options; Escalier Biosciences - employee, stock options; Precision IBD - employee, stock options; Ventyx Biosciences – employee, stock options; Vimalan Biosciences – employee, stock options.

SS – Research grants from AbbVie, Consulting fees from AbbVie, Takeda, Pfizer, AMAG Pharmaceuticals.

REFERENCES

1. Mehta F Report: economic implications of inflammatory bowel disease and its management. Am J Manag Care 2016;22:s51–60. [PubMed: 27269903]
2. Molodecky NA, Soon IS, Rabi DM, et al. Increasing incidence and prevalence of the inflammatory bowel diseases with time, based on systematic review. Gastroenterology 2012;142:46–54 e42; quiz e30. [PubMed: 22001864]
3. Singh S, Brill JV, Proudfoot JA, et al. Project Sonar: A Community Practice-based Intensive Medical Home for Patients With Inflammatory Bowel Diseases. Clin Gastroenterol Hepatol 2018;16:1847–50 e1. [PubMed: 30149146]
4. Nguyen NH, Khera R, Ohno-Machado L, Sandborn WJ, Singh S. Annual Burden and Costs of Hospitalization for High-Need, High-Cost Patients With Chronic Gastrointestinal and Liver Diseases. Clin Gastroenterol Hepatol 2018;16:1284–92 e30. [PubMed: 29474966]
5. Dulai PS, Singh S, Ohno-Machado L, Sandborn WJ. Population Health Management for Inflammatory Bowel Disease. Gastroenterology 2018;154:37–45. [PubMed: 29122544]
6. Barnes EL, Kochar B, Long MD, et al. Modifiable Risk Factors for Hospital Readmission Among Patients with Inflammatory Bowel Disease in a Nationwide Database. Inflammatory Bowel Diseases 2017;23:875–81. [PubMed: 28426473]
7. Dotson JL, Kappelman MD, Chisolm DJ, Crandall WV. Racial disparities in readmission, complications, and procedures in children with Crohn's disease. Inflammatory Bowel Diseases 2015;21:801–8. [PubMed: 25742396]

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

8. Micic D, Gaetano JN, Rubin JN, et al. Factors associated with readmission to the hospital within 30 days in patients with inflammatory bowel disease. PLoS ONE [Electronic Resource] 2017;12:e0182900.
9. Poojary P, Saha A, Chauhan K, et al. Predictors of Hospital Readmissions for Ulcerative Colitis in the United States: A National Database Study. Inflammatory Bowel Diseases 2017;23:347–56. [PubMed: 28221246]
10. Gu J, Stocchi L, Remzi F, Kiran RP. Factors associated with postoperative morbidity, reoperation and readmission rates after laparoscopic total abdominal colectomy for ulcerative colitis. Colorectal Dis 2013;15:1123–9. [PubMed: 23627886]
11. Hanzlik TP, Tevis SE, Suwanabol PA, et al. Characterizing readmission in ulcerative colitis patients undergoing restorative proctocolectomy. Journal of Gastrointestinal Surgery 2015;19:564–9. [PubMed: 25560185]
12. Hutton B, Salanti G, Caldwell DM, et al. The PRISMA extension statement for reporting of systematic reviews incorporating network meta-analyses of health care interventions: checklist and explanations. Ann Intern Med 2015;162:777–84. [PubMed: 26030634]
13. Malhotra A, Mandip KC, Shaukat A, Rector T. All-cause hospitalizations for inflammatory bowel diseases: Can the reason for admission provide information on inpatient resource use? A study from a large veteran affairs hospital. Military Medical Research 2016;3.
14. Picardo S, Porritt A, So K, Venugopal K. Predictors of hospital length of stay and 30day readmission in patients with inflammatory bowel disease admitted with a flare. Journal of Gastroenterology and Hepatology (Australia) 2017;32:141.
15. Naik AS, Zadvornova Y, Stein D, et al. Factors associated with 30 day re-admission in inflammatory bowel disease. Gastroenterology 2013;1):S642.
16. Israel A, Bokhary MI, Grabowski J, Shanmuganathan S, Roffey D, Sy RG. Predictors of 30 day readmission rates in inflammatory bowel disease patients after hospital discharge. Gastroenterology 2015;1):S452.
17. Hudesman D, Chang S, Malter L, Kimmel J, Rolston VS, Bosworth BP. Patients cared for in an integrated academic IBD practice have lower readmission rates: A key quality indicator. Gastroenterology 2017;152 (5 Supplement 1):S218.
18. Blonski W, Synnestvedt MB, Tierney A, Marchioni RM, Buchner A, Lichtenstein GR. Factors associated with hospital readmissions in patients with inflammatory bowel disease (IBD). Gastroenterology 2012;1):S788.
19. Feuerstein JD, Martinez-Vazquez M, Belkin E, Singla A, Cheifetz AS. 30 day readmissions rate and predictors of readmission in hospitalized patients with ulcerative colitis. Gastroenterology 2014;1:S–375.
20. George L, Martin B, Gupta N, Shastri N, Venu M, Naik AS. Predicting 30-day readmission rate in inflammatory bowel disease (IBD) patients: Performance of lace index. Gastroenterology 2017;152 (5 Supplement 1):S790–S1.
21. Syal G, Murphy SJ, Duarte-Rojo A. Racial disparities in readmission rates, procedures and complications among adults with inflammatory bowel diseases. Gastroenterology 2017;152 (5 Supplement 1):S372–S3.
22. Rizk M, Boules M, Michael M, Lopez R. Creation of a novel prospectively based inflammatory bowel disease readmission index. American Journal of Gastroenterology 2016;111:S265–S6.
23. Tinsley A, Naymagon S, Mathers B, Kingsley M, Sands BE, Ullman TA. Early readmission in patients hospitalized for ulcerative colitis: incidence and risk factors. Scand J Gastroenterol 2015;50:1103–9. [PubMed: 25866237]
24. Law CCY, Sasidharan S, Rodrigues R, et al. Impact of Specialized Inpatient IBD Care on Outcomes of IBD Hospitalizations: A Cohort Study. Inflammatory Bowel Diseases 2016;22:2149–57. [PubMed: 27482978]
25. Hazratjee N, Agito M, Lopez R, Lashner B, Rizk MK. Hospital readmissions in patients with inflammatory bowel disease. American Journal of Gastroenterology 2013;108:1024–32. [PubMed: 23820989]

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

26. Christian KE, Jambaulikar GD, Hagan MN, et al. Predictors of Early Readmission in Hospitalized Patients with Inflammatory Bowel Disease. Inflammatory Bowel Diseases 2017;23:1891–7. [PubMed: 28837523]
27. Mudireddy P, Scott F, Feathers A, Lichtenstein GR. Inflammatory Bowel Disease: Predictors and Causes of Early and Late Hospital Readmissions. Inflammatory Bowel Diseases 2017;23:1832–9. [PubMed: 28858068]
28. Allegretti JR, Borges L, Lucci M, et al. Risk Factors for Rehospitalization Within 90 Days in Patients with Inflammatory Bowel Disease. Inflammatory Bowel Diseases 2015;21:2583–9. [PubMed: 26244647]
29. Chan L, Wood E, Fang L, Limdi J. Hospital readmissions in patients with inflammatory bowel disease: A UK single centre experience. Journal of Crohn's and Colitis 2015;9:S354–S5.
30. Kruger AJ, Hinton A, Afzali A. Index Severity Score and Early Readmission Predicts Increased Mortality in Ulcerative Colitis Patients. Inflamm Bowel Dis 2018.
31. Waljee AK, Lipson R, Wiitala WL, et al. Predicting Hospitalization and Outpatient Corticosteroid Use in Inflammatory Bowel Disease Patients Using Machine Learning. Inflamm Bowel Dis 2017;24:45–53. [PubMed: 29272474]
32. Amarasingham R, Patel PC, Toto K, et al. Allocating scarce resources in real-time to reduce heart failure readmissions: a prospective, controlled study. BMJ Qual Saf 2013;22:998–1005.
33. Cronin PR, Greenwald JL, Crevensten GC, Chueh HC, Zai AH. Development and implementation of a real-time 30-day readmission predictive model. AMIA Annu Symp Proc 2014;2014:424–31. [PubMed: 25954346]
34. Kuzniewicz MW, Puopolo KM, Fischer A, et al. A Quantitative, Risk-Based Approach to the Management of Neonatal Early-Onset Sepsis. JAMA Pediatr 2017;171:365–71. [PubMed: 28241253]
35. Cross RK, Langenberg P, Regueiro M, et al. A Randomized Controlled Trial of TELEmedicine for Patients with Inflammatory Bowel Disease (TELE-IBD). Am J Gastroenterol 2019;114:472–82. [PubMed: 30410041]
36. Cohen-Mekelburg S, Rosenblatt R, Gold S, et al. Fragmented Care is Prevalent Among Inflammatory Bowel Disease Readmissions and is Associated With Worse Outcomes. Am J Gastroenterol 2019;114:276–90. [PubMed: 30420634]

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

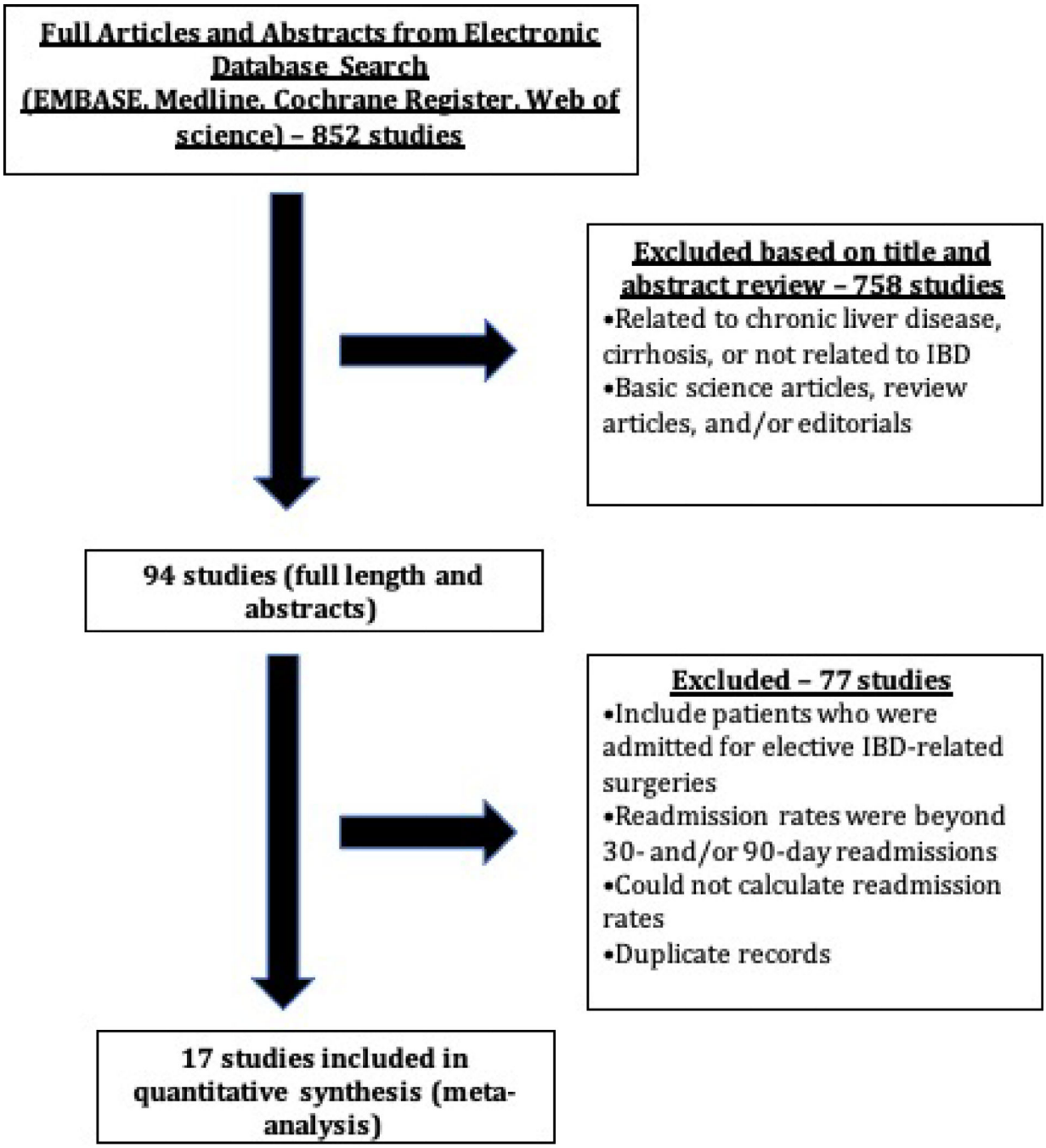

Figure 1.
Flow Diagram summarizing study identification and selection

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

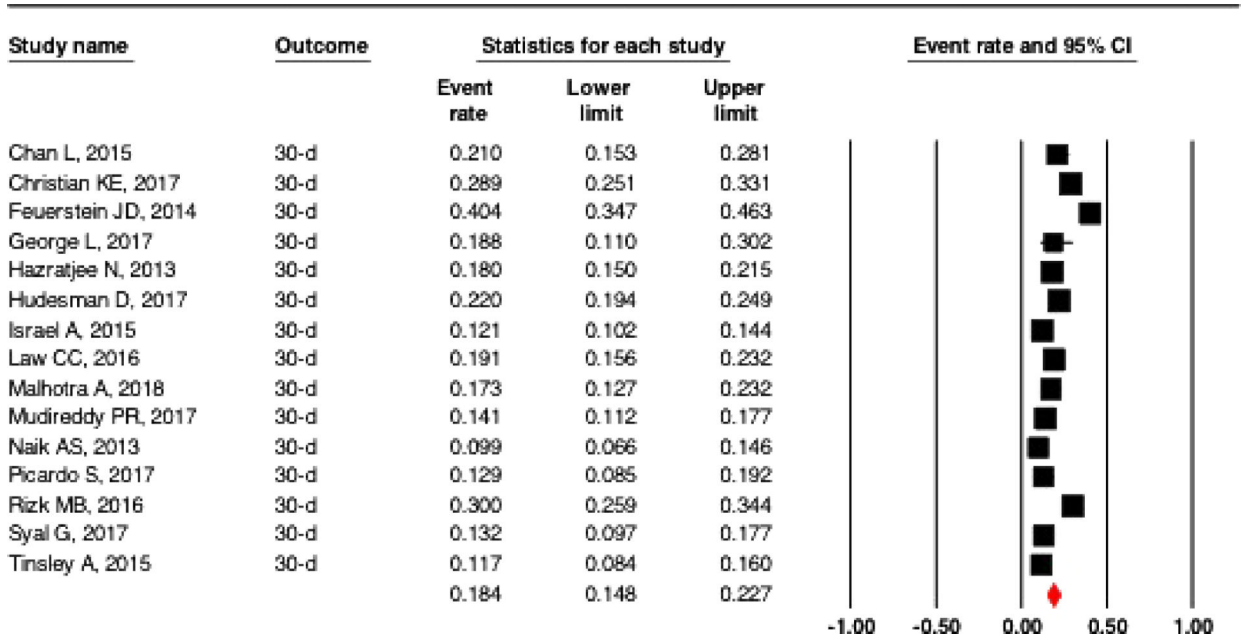

Figure 2.

Forest plot showing 30-day readmission rate in adult medically-treated patients hospitalized with IBD

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Table 1.

Characteristics of studies included in the systematic review

Study, Year of Publication	Location, time-period, # centers	# patients; 30-d readmission; 90-d readmission	Age, % males, % with CD	Reason for index admission	Reasons for readmission	Medications at time of index admission		
						Steroids/ Narcotics	Immunomodulators	Biologics
Full Length Articles								
Hazratjee, 2013[25]	Cleveland, Ohio, USA; 2008–10; single center	429 (539 index admissions; per hospitalization analysis); 97/539 (18.0%) [per patient: 69/429, 16.1%]; NR	42 (16); 43; 74	1. IBD flare (46%), 2. Pain control (27%), 3. Infection (16%)	1. Pain control (50%), 2. IBD flare requiring steroids (28%), 3. Infection (28%)	63; 77	10	2
Tinsley, 2015[23]	New York, NY, USA; 2007–11; single center	229 (274 index admissions; per hospitalization analysis); 32/274 (11.7%), 53/259 (20.5%)	37 (15); 52; 0	'Symptomatic' UC based on chart review	1. IBD flare, medically managed (47), 2. IBD flare requiring surgery (47), 3. Unrelated to IBD (6)	61/NR	32	9
Allegretti, 2015[28]	Boston, MA, USA; 2011–12; single center	356 (375 index admissions; per hospitalization analysis); NR; 125/356 (35%)	42 (17); 38; 59	Unplanned IBD-related reason	1. IBD flare (31%), 2. Planned IBD operation (17%), 3. IBD medication-related complication (12%), 4. Not related to gastrointestinal disease (6%)	87	41	NR
Law, 2016[24]	Boston, MA, USA; 2013–15; single center	306 (408 index admissions; per hospitalization analysis); 78/408 (19.1%), 112/408 (27.5%) Pre-IBD service: 27/196 (14%), 47/196 (22%) Post-IBD service: 51/212 (26%), 61/212 (29%)	Pre-IBD service: 41 (18); 53; 67 Post-IBD service: 40 (17); 48; 66	NR	NR	Pre-IBD service: 45/NR Post-IBD service: 45	Pre-IBD service: 19; Post-IBD service: 27	Pre-IBD service: 30; Post-IBD service: 39
Christian, 2017[26]	Baltimore, MD, USA; 2004–13; single center	498 (1213 index admissions; per hospitalization analysis); 232/1213 (19.1%))	39 (14); 40; 68	NR	NR	89	71	66
Mudireddy, 2017[27]	Philadelphia, PA, USA; 2007–10; multi-center	439 (439 index admissions; per hospitalization analysis); 62/439 (14.1%); 104/439 (23.6%))	38 (15); 45; 67	NR	1. IBD (44%), 2. Infection (17%), 3. Abdominal pain (6%), 4. Gastrointestinal bleeds (3%)	21/62	10	10
Malhotra, 2018[13]	Minneapolis, MN, USA; 2007–13	130 (202 index admissions; per hospitalization analysis); 35/202 (17.3%); 59/202 (29.2%)	60 (15); 96; 57	'Symptomatic" based on chart review	1. IBD-related problems (71%), 2. Non-gastrointestinal conditions (25%), 3. Scheduled surgery (3%)	25/NR	27	12
Abstracts								

Study, Year of Publication	Location, time-period, # centers	# patients; 30-d readmission; 90-d readmission	Age, % males, % with CD	Reason for index admission	Reasons for readmission	Medications at time of index admission		
						Steroids/ Narcotics	Immunomodulators	Biologics
Blonski W, 2012[18]	Adults, United States; 2010; single center	899 (899 index admissions; per hospitalization analysis); NR; 198/899 (22%)	38 (no SD); 54; 70	NR	NR	NR	NR	NR
Naik AS, 2013[15]	Adults, United States, unknown; single center	222 (222 index admissions; per hospitalization analysis); 25/222 (11%); NR	41 (1); 44; 65	IBD-related hospitalizations	NR	NR	44	36
Feuerstein JD, 2014[19]	Adults, United States, 2002–2012; single center	720 (720 index admissions; per hospitalization analysis); 109/720 (15.1%); NR	41 (no SD); 52; 0	UC-related admission	1. Recurrence UC flare or related symptoms (38%), 2. UC surgery on initial admission (45%), 3. Planned readmission (3%)	42/NR	14	7
Chan L, 2015[29]	Adults, United States; 2011–2013; single center	157 (157 index admissions; per hospitalization analysis); 33/155 (21%); NR	44 (no SD); 42; 47	Exacerbation of IBD	1. Dehydration/anemia (27.3%), 2. Surgery or surgical complications (12.2%), 3. Pain control (6.1%), 4. Obstruction (6.1.%), 5. Venous thromboembolism (3.0%), 6. Other/unknown (39.2%)	NR	NR	NR
Israel A, 2015[16]	Adults, Canada; 2008–2013; single center	941 (941 index admissions; per hospitalization analysis); 114/941 (12%); NR	NR	NR	NR	NR	NR	NR
Rizk MB, 2016[22]	Adults, United States; 2012–2014; single center	450 (450 index admissions; per hospitalization analysis); 135/450 (30%); NR	NR	NR	NR	NR	NR	NR
Picardo S, 2017[14]	Adults, Australia; 2011–2016; single center	155 (155 index admissions; per hospitalization analysis); 20/155 (14.8%); NR	41 (no SD); 37; 0	IBD-related indication	NR	NR	NR	NR
Hudesman D, 2017[17]	Adults, United States, 2015–2016; multi-center	899 (899 index admissions; per hospitalization analysis); 198/899 (22%); NR	NR	NR	NR	NR	NR	NR
George L, 2017[20]	Adults, United States; 2014–2016; single center	64 (64 index admissions; per hospitalization analysis); 12/64 (19%); NR	NR	NR	1. Disease flare (67%), 2. Infection (19%), 3. Partial small bowel obstruction (14%)	NR	47	42
Syal G, 2017[21]	Adults, United States; 2011–2015; single center	280 (280 index admissions; per hospitalization	NR	NR	NR	NR	NR	NR

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Study, Year of Publication	Location, time-period, # centers	# patients; 30-d readmission; 90-d readmission	Age, % males, % with CD	Reason for index admission	Reasons for readmission	Medications at time of index admission		
						Steroids/ Narcotics	Immunomodulators	Biologics
		analysis); 37/280 (13.2%); NR						

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Table 2.

Risk factors independently associated with readmission in individual studies

Author, Year	30- and 90- day readmission rate	Multivariate predictors included in study
Feuerstein JD, 2014[19]	15.1%; NR	30-day readmission • Systemic steroids prior to admission: OR 1.55 (1.00 – 2.39) • Surgery during admission: OR 3.33 (2.10 – 5.29) • CT abdomen/pelvis during admission: 1.82 (OR 1.14 – 2.92) • Elevated creatinine on admission: 1.06 (1.02 – 1.11) • Weekend discharge: OR 0.60 (0.35 – 1.05) • Disease location (proctosigmoiditis): 0.65 (0.13 – 3.3) • Disease location (left sided colitis): 2.10 (0.57 – 7.80) • Disease location (extensive colitis): OR 1.28 (0.36 – 4.56) • Abdominal x-ray: OR 1.18 (0.73 – 1.92)
Hazratjee N, 2013[25]	20%; NR	30-day readmission • No narcotics given during admission: HR 2.2 (1.3 – 3.7) • Benzodiazepines given during admission HR 3.0 (1.7 – 5.1) • Pain control on admission: HR 2.2 (1.4 – 3.6) • Abscess drainage: HR 3.4 (1.9 – 6.3) • Discharged to assisted home care or assisted-care facility: HR 3.2 (1.8 – 5.7)
Tinsley A, 2015[23]	11.7%; 20.5%	30-day readmission • Extensive colitis: OR 3.59 (1.41 – 9.13) • Married: OR 1.94 (0.79 – 4.72) • Weekend discharge: OR 2.35 (0.93 – 5.90) • Outside hospital transfer: OR 2.38 (0.76 – 7.43) 90-day readmission • Albumin on admission: OR 0.56 (0.31 – 0.99) • Extensive colitis: OR 3.09 (1.33 – 7.08) • Comorbidity: OR 3.14 (0.69 – 14.27) • Admitted to a teaching service: OR 2.87 (1.14 – 6.54)
Allegretti JR, 2015[28]	N/A; 35%	90-day readmission • Depression: HR 1.99 (1.33 – 3) • Chronic pain: HR 1.88 (1.14 – 3.10) • Steroids in the previous 6 months: HR 1.33 (0.92 – 2.04)
Rizk M, 2016[22]	30%; NR	30-day readmission • Admitted for pain control: OR 2.3 (1.5 – 3.4) • Admitted for documented flare: OR 0.61 (0.43 – 0.87) • Any current medications on admission: OR 2.4 (1.6 – 3.4) • CTE/CT imaging done on admission: OR 0.55 (0.39 – 0.76) • Colonoscopy during admission: OR 0.39 (0.27 – 0.56) • Narcotics given during admission: OR 0.59 (0.37 – 0.93) • Length of stay (linear component): OR 1.6 (1.2 – 2.3) • Pain control plan on discharge: OR 2.0 (1.3 – 3.0)
Syal G, 2017[21]	13.2%; NR	30-day readmission • Race (black vs white): OR 2.11 (0.95 – 4.67) • Perianal disease: OR 2.70 (1.13 – 6.40) • Prior surgery: OR 2.58 (1.15 – 5.79) • Insurance status: OR 1.84 (1.28 – 2.64)

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Author, Year	30- and 90- day readmission rate	Multivariate predictors included in study
Christian KE, 2017[26]	28.9%; NR	30-day readmission • History of congestive heart failure: OR 4.06 (1.45 – 11.35) • History of chronic obstructive pulmonary disease: OR 2.86 (1.32 – 6.23) • BMI ○ Underweight: OR 1.81 (1.04 – 3.46) ○ Obese: OR 1.72 (1.20 – 2.47) • Previous use of systemic steroids: OR 1.90 (1.04 – 3.46) • Diverting ileostomy during index admission: OR 2.04 (1.11 – 3.73) • Subtotal colectomy during index admission: OR 2.45 (0.98 – 6.15) • Diagnosis of deep venous thrombosis/pulmonary embolus during index admission: OR 3.46 (0.98 – 12.23) • Antibiotics at discharge ○ Oral: OR 1.13 (0.80 – 1.61) ○ Intravenous: OR 1.81 (0.81 – 1.02) • Diet at discharge ○ Restricted oral: OR 1.59 (0.97 – 2.60) ○ Enteral feeds: OR 2.59 (0.70 – 9.52) ○ Total parenteral nutrition: OR 1.97 (1.03 – 3.75)
Mudireddy PR, 2017[27]	14.1%; 23.7%	30-day readmission • Steroids at admissions: 0.52 (0.23 – 1.15) • TPN: 2.30 (1.22 – 4.30) • ICU stay: 3.61 (1.38 – 9.46) 90-day readmission • Mesalamine at admission: • TPN: 1.66 (0.94 – 2.93) • ICU stay: 3.61 (1.38 – 9.46) • Biologics at discharge: 0.44 (0.19 – 1.02)

*All confidence intervals are 95%.

Author Manuscript Author Manuscript Author Manuscript Author Manuscript

Table 3.

Factors associated with 30-day risk of readmission

Variable	Pooled 30-day readmission rate	Number of studies included	Odds ratio	95% CI	Heterogeneity
Steroids on admission	315/1657	3	1.23	0.64 – 2.36	71.48%
Admitted for pain control	**239/989**	**2**	**2.26**	**1.66 – 3.07**	**0%**
Total parenteral nutrition on discharge	**206/937**	**2**	**2.13**	**1.36 – 3.35**	**0%**
Weekend discharge	141/994	2	1.13	0.30 – 4.28	83.87%
Extensive colitis	141/994	2	2.35	0.87 – 6.36	39.20%
Transfer to outside facility after initial discharge	**129/813**	**2**	**3.01**	**1.80 – 5.04**	**0%**
Abdominal imaging during admission	244/1170	2	0.99	0.31 – 3.19	93.96%
Prior surgery and/or surgery during admission	**387/2037**	**4**	**3.11**	**2.27 – 4.25**	**0%**

Clin Gastroenterol Hepatol. Author manuscript; available in PMC 2021 August 01.