IMPACT OF MULTIDISCIPLINARY CARE MANAGEMENT ON CLINICAL AND NUTRITIONAL OUTCOMES IN PATIENTS WITH COMPLEX GASTROINTESTINAL CONDITIONS

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A THESIS

Presented to the Graduate Programs in Human Nutrition
and the Oregon Health & Science University
School of Medicine
In partial fulfillment of
the requirements for the degree of

Master of Science in Human Nutrition

June 2019

School of Medicine

Oregon Health & Science University

CERTIFICATE OF APPROVAL

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Acknowledgements

Foremost, I would like to express my profound gratitude to my thesis mentor and advisor, Julie McGuire MS, RDN, LD. Her guidance throughout this process was invaluable and without her encouragement and advice, I would not have been able to complete this project. She leads by example, is extremely gifted at motivating her students and I consider myself blessed to have her as a mentor and friend. The Graduate Programs in Human Nutrition at OHSU is lucky to have such an exemplary mentor.

Second, I would like to thank Malissa Warren, RDN, CNSC, LD for sharing her profound knowledge of nutrition and allowing me to shadow her over the past two years. She went above and beyond to make herself available whenever possible to brainstorm research ideas, provide feedback on my work and support me in any way possible.

I also thank my committee members, Dr. Robert Martindale and Dr. Sarah Diamond for their time, dedication and the knowledge they imparted on me during this process. Both allowed me to shadow them in the clinic, and this enhanced my research by allowing me to connect with the population I studied.

Additionally, with the help of Elizabeth Dewey, MS, I was able to more fully understand how to conduct and interpret my statistical analyses and I am extremely thankful for the hours she spent meeting with me.

I must thank my family and friends. Without the support of my family, I would never have been able to pursue graduate school and their love kept me going even when I feared I would fail. My friends, Mallory Soares and Hannah Wilson were my life support these past two years and I am confident that without them, I would not have been able to complete this project. And finally, thank you to Quinn Sterling for lifting my spirits in hard times and for the steadfast support and love these past two years.

Abstract

Background: As improvements to the healthcare process are made, innovative treatment styles have emerged, one of which is the use of a multidisciplinary team (MDT) to manage patients with complex diseases. The MDT approach improves communication amongst practitioners, enhances education provided to the patient and stimulates more informed decision-making regarding patient care. In certain settings MDTs have been associated with increased overall patient survival and enhanced quality of life for the patient. Although there is large body of research on MDT management of conditions such as amyotrophic lateral sclerosis, renal disease, and various cancers, there are few studies on MDT management of patients with complex gastrointestinal (GI) conditions and this project aims to fill that gap.

Methods: Using existing data available in the OHSU Epic system, we conducted a pilot study involving a retrospective chart review of 41 patients to compare outcomes of providing MDT intervention. For purposes of this study, the difference between the MDT and non-MDT was the presence of a registered dietitian (RD). We hypothesized that the use of MDT care management would improve predetermined clinical and nutritional outcomes in patients cared for by a MDT. We also hypothesized that patient access to a RD would improve clinical and nutritional outcomes in patients with complex GI disorders and be associated with decreased clinic visits with the physicians.

Results: The MDT intervention group experienced significantly less weight loss than the non-MDT intervention group ($p=0.013$) and, the MDT intervention group had a median weight gain of 1.63 kg (IQR: -3.82 – 9.07) compared to the non-MDT intervention group, which had a median weight loss of -0.59 kg (IQR: -12.61 – 0). There was a significant decrease in number of

unplanned hospitalizations for nutrition-related complications after establishing care in the clinic for both groups combined (p=0.023), but this effect was not observed when comparing admissions before and after establishing care in the MDT intervention and non-MDT intervention groups (p=0.105, p=0.097, respectively). Regarding nutrition support, there was a suggestive but not statistically significant difference for time spent on enteral nutrition (EN), but not time spent on total parenteral nutrition (TPN) (p = 0.063 and p = 0.88, respectively). The non-MDT intervention group was weaned from EN and TPN faster than the MDT intervention group, but there was no correlation between time to wean with any nutritional or clinical outcomes such as unplanned hospitalizations. Additionally, access to a RD via phone or MyChart did not significantly decrease clinic visits with the physician and instead, there was a positive correlation observed in that as phone appointments and MyChart encounters with the RD increased, clinic visits with the physician increased.

Conclusions: While this study indicates that the RD is a well utilized member of the study team, the exact benefits of a MDT to the patient with complex GI conditions is still unclear. Further research featuring a larger sample size is needed to improve statistical power and elucidate results in this population.

Introduction and Specific Aims

The gastrointestinal (GI) system is vastly complex, and at a basic level functions to promote digestion and absorption of food to provide energy and nutrients to the host, excrete waste and provide protection.[1] A healthy, normal GI tract is also highly coordinated, a feature which is disrupted in the setting of GI disease.[1] GI diseases are those affecting any part of the GI tract, which extends from the esophagus to the rectum and the accessory organs including the liver, gallbladder, and pancreas.[2]

Multidisciplinary teams (MDTs) are more often used in the care of patients with complex disease because they foster more informed decision-making regarding patient care and result in better education provided to the patient, which ultimately, translates into improved overall patient care. [3-15] A MDT includes healthcare professionals from different disciplines with varying specialties depending on the type of disease being treated. MDT care was been associated with increased overall patient survival and better quality of life for the patient.[10]

Although there is substantial body of research on MDT management of conditions such as amyotrophic lateral sclerosis (ALS), [12,16] renal disease, [17] and various cancers [7,11,15], there are few studies on MDT management of patients with complex GI conditions and this project aims to fill that gap.

Specific Aims:

Aim 1: To investigate the impact of multidisciplinary care management of patients with complex GI disorders on clinical outcomes including number of encounters with physicians and incidence of unplanned hospital admissions.

We hypothesize the use of multidisciplinary care management will improve clinical outcomes in patients cared for by a MDT.

Aim 2: To investigate the impact of multidisciplinary care management on nutritional outcomes including time on nutrition support and weight status.

We hypothesize that nutrition outcomes will improve in patients cared for by a multidisciplinary team.

The primary goal of this investigation is to examine the relationship between MDT management of patients with complex GI conditions and relevant outcomes to provide evidence to support further development of MDTs in the healthcare setting.

Background

Obesity has become a major health problem both globally and in the United States (US), and it is estimated that over 39% of US adults have obesity.[18] The rising prevalence of this condition has spurred an increase in the incidence of bariatric surgery.[19] Although bariatric surgery can result in successful weight loss and reduced comorbidity burden, consequences may arise if the patient does not receive follow-up care or does not adhere to post-surgery recommendations, including vitamin and mineral supplementation.

A possible complication of bariatric surgery is short bowel syndrome (SBS). SBS is rare and estimates of prevalence indicate that out of 1 million Americans, four have SBS.[20] It is a serious condition that requires lifetime supplementation of vitamins and minerals and often results in dependence on artificial nutrition support.

Bariatric Surgery

Patients who meet the following criteria may be eligible for bariatric surgery: adults with a BMI > 40 kg/m^2 or with a BMI of > 35 kg/m^2 and who have one or more associated comorbid conditions, or who have been unable to achieve a healthy weight loss sustained for a period of time with prior weight loss efforts. Qualifying comorbid conditions include type II diabetes (T2DM), hypertension, respiratory diseases such as sleep apnea, non-alcoholic fatty liver disease, osteoarthritis, lipid abnormalities such as hyperlipidemia, gastrointestinal disorders and heart disease.[18,24] In addition to various pre-operative assessments including a review of medical history, physical examination and laboratory testing, those seeking bariatric surgery undergo a psychological assessment to identify patients who require additional preoperative interventions, or to disqualify patients for surgery.[18,24]

Historically, bariatric surgeries were considered to be restrictive, malabsorptive or a combination. Restrictive surgeries involve reduction in the size of the gastric pouch whereas malabsorptive surgeries elicit weight loss through inducing malabsorption either by reducing the functional length of the GI tract or reorganization of the GI anatomy.[18] More recently, bariatric surgeries are recognized as causing weight loss via restriction, malabsorption and metabolic changes as research indicates that alterations to the neural and endocrine signaling pathways responsible for appetite and satiety stimulation are affected.[18,25]

The most common types of bariatric surgery performed in the US include the Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG).[26] Less commonly performed procedures include the gastric band (GB), and the biliopancreatic diversion with duodenal switch (BDP/DS), although the latter has fallen out of favor due to significant nutrition-related risks associated with the length of bypassed small intestine.[18,24] According to the most recent data available from the American Society of Metabolic and Bariatric Surgery, 228,000 bariatric surgeries were performed in 2017. Of those, 59.39% were SG, 17.80% were RYGB, and 2.77% were GB surgeries. Interestingly, 14.14% of the total bariatric surgeries in 2017 were revisions of previously performed bariatric surgeries.

The BPD/DS procedure is associated with the greatest weight loss because it produces malabsorption of nutrients while restricting the volume of nutrients ingested.[27-30] Due to the disruption to normal GI anatomy, ingested nutrients do not mix with pancreatic enzymes or bile until further down the intestinal tract and a significant portion of the small intestine is bypassed, thus decreasing the absorptive surface area for calories and nutrients.[18,31] While this malabsorptive state does promote significant weight loss, up to 90% of patients with the surgery develop a micronutrient deficiency within three years after surgery.[32] Micronutrients include substances required in trace amounts to promote normal growth and development, and include the vitamins and minerals.[32] Furthermore, this surgery is associated with higher rates of malnutrition, anemia, mortality and greater rate of complications compared to other types of surgery such as a RYGB.[19,28]

Despite the existence of bariatric surgical techniques, which have proven successful, there are cases of rare and unorthodox procedures. One example is the Salmon procedure, a technique that has not officially been described in published literature. The Salmon procedure is both restrictive and malabsorptive. This surgical technique was developed by P.A. Salmon in the late 1980's and involves a vertical banded gastroplasty with horizontal stomach stapling and a RYGB.[33] Sparse research exists on this technique and due to the high rate of complications and failure, the technique was not widely adopted.

Complications after bariatric surgery

While bariatric surgery can be a highly effective treatment for patients with severe obesity, there are significant risks associated with these procedures with rates of post-surgical complications ranging from 5% to 30%.[34] Complications vary based on the type of surgery performed. In the setting of RYGB, ulcerations at the gastro-jejunal anastomosis occur in up to 16% of patients.[35] These ulcerations can lead to stenosis and rarely, perforation.[35] Gastro-gastric fistulas, an abnormal connection between the gastric pouch and excluded stomach, may also occur, resulting in weight regain, pain, nausea and emesis.[35] Surgical leaks are a serious complication that most often present rapidly following the RYGB procedure, but may also arise further out from the date of surgery.[35,36] Indications of a leak include tachycardia, leukocytosis and an elevated C-reactive protein.[35,36] Ventral incisional hernias, internal hernias, adhesions and intussusceptions may also occur following surgery, resulting in intestinal obstruction that, if left untreated, may result in massive bowel necrosis requiring bowel resection.[35] Depending on the amount of necrotic tissue removed, iatrogenic short bowel syndrome may arise, which will be discussed in the later sections. Of complications that may arise following a GB procedure, the most serious is band erosion, which may occur within weeks or years following surgery and triggers sepsis.[35] The BPD/DS procedure is associated with the highest rate of and most serious complications including anastomotic leak, anastomotic stenosis, and GI abdominal hemorrhage.[36] Complications that may arise later include small bowel obstruction, severe protein-calorie malnutrition, severe micronutrient deficiencies and incisional hernias.[27,36]

Malnutrition

A simple definition of malnutrition is proposed by Jensen et al. and states it is “a decline in lean body mass with the potential for functional impairment.”[37] However, the condition is more complex and in 2009, the Academy of Nutrition and Dietetics (AND) along with the American Society for Enteral and Parenteral Nutrition (ASPEN) developed a well-rounded definition to aid in the recognition and diagnosis of malnutrition.[38] Diagnosis is based on the patient having at least two of the following characteristics: insufficient energy intake, weight loss, loss of muscle mass, loss of subcutaneous fat, localized or generalized fluid accumulation that may mask weight loss, and diminished functional capacity as measured by hand grip strength.[38]

The opinion that people with obesity are adequately nourished is pervasive yet false as an energy dense diet does not always correlate with a nutrient rich diet. Reports indicate that at least 15-20% of obese patients may be deficient in one or more micronutrients.[39] Furthermore, a recent and large retrospective chart review of patients who underwent bariatric surgery indicates that more than 6% of patients with obesity were malnourished prior to surgery.[34]

There is robust evidence rationalizing the need to address malnutrition prior to surgery. Research has established a clear relationship between preoperative nutritional status, risk of malnutrition and postoperative surgical outcomes. Malnutrition results in longer length of stay, a higher incidence and severity of complications, greater healthcare associated costs, higher rates of readmission and reoperations and increased mortality and morbidity.[39,40]

Depending on how it is defined and the population being studied, prevalence of malnutrition ranges from 24% to 88%.[40] Prevalence of malnutrition in patients undergoing GI surgery is estimated to be as high as 65%, and almost the same amount (66.67%) lose weight while hospitalized.[40] Although the negative outcomes of malnutrition have been recognized since 1936 by Studyley et al., malnutrition is still under recognized, especially in the population with obesity.[40] The serious negative impacts of malnutrition justify increasing efforts towards maintaining proper nutritional status in hospitalized patients and the role of the RD is key in achieving this goal.[41] RDs are trained in weight loss counseling but also provide motivational interviewing and are experts in recognizing and providing interventions related to malnutrition.

Micronutrient deficiencies

The disruption to normal GI anatomy and physiology inherent to bariatric surgery requires patients who have had bariatric surgery, regardless of type, to supplement micronutrients. Supplementation is often a lifetime requirement, especially in the setting of RYGB, SG, and BDP/DS.[42-44] Although prevalence and severity of nutrient deficiencies varies by type of surgery, bariatric surgery can exacerbate existing nutrient deficiencies or instigate new nutrient deficiencies.[18,28,29,31,45-48] Micronutrients include the fat soluble vitamins, water soluble vitamins and minerals.[49] Fat soluble vitamins include vitamins A, E, D and K and the water-soluble vitamins include vitamin C and the B vitamins.[49]

Deficiency of the fat-soluble vitamins most often occurs in RYGB and BPD/DS as a result of bypass and/or removal of all or part of the jejunum and ileum, the principal sites of absorption for these vitamins.[49-51] The highest prevalence of deficiency among the fat soluble vitamins is observed with vitamin D, and rates are reported to be as high as 100% after bariatric surgery.[46] Calcium absorption is most problematic for patients who have had RYGB, SG and BPD/DS due to decreased surface area for gastric acid secretion and bypass of the duodenum and proximal jejunum, which feature the highest concentration of calcium transporters in the intestines.[50] Although passive absorption occurs along the entire GI tract, the segments where the greatest intestinal absorption may occur are bypassed in the RYGB and BPD/DS surgeries.[49,50] Finally, calcium absorption can be upregulated but requires adequate vitamin D as this process occurs through genomic action of the active form of vitamin D, $1,25(OH)_2D$.[49] Therefore, calcium deficiency can be precipitated by vitamin D deficiency.[49] The mechanisms responsible for intestinal vitamin D absorption are not fully clear, however it is understood that as it is fat soluble, absorption of vitamin D is enhanced with fat absorption and hindered by fat malabsorption.[49]

Another common micronutrient deficiency following bariatric surgery, particularly RYGB, SG and BDP/DS, is vitamin B12 deficiency. More than one third of patients may develop vitamin B12 deficiency following RYGB.[52,53] Absorption of zinc, vitamin B1 (thiamine), and selenium primarily take place in the duodenum and the proximal jejunum.[50] Therefore, any surgery that disrupts these segments of the intestines may result in deficiencies of these nutrients. Although absorption of zinc is not limited to these areas as it can be absorbed in the ileum and large intestine, zinc absorption is dependent on the action of pancreatic enzymes on dietary zinc.[54,55] In the setting of procedures such as BPD/DS, pancreatic enzymes delivery is disrupted, which causes decreased absorption of nutrients that require enzymatic action prior to absorption.[54,55] The few studies on selenium deficiency in this population indicate it is uncommon, but more likely to occur in the setting of RYGB and BPD/DS.[50] Thiamine is of particular concern due to the neurological deficits resulting from a deficiency of this vitamin.[56] Absorption of thiamine takes place in the duodenum and proximal jejunum, thus patients who have undergone RYGB and BDP/DS face a higher risk of deficiency as their alimentary path bypasses these sites.[57] Folate deficiency can occur following RYGB and BDP/DS but is less likely because folate is absorbed along the entire small intestine.[50]

Microcytic anemia caused by iron deficiency is also common following bariatric surgery.[50] Similar to thiamine, iron absorption takes place in the duodenum and proximal jejunum and operations that bypass or alter the anatomy of these segments, including RYGB and BPD/DS, frequently result in iron deficiency.[48,50] Additionally, the form of dietary iron, Fe^{3+}, must be converted to Fe^{2+} for optimal absorption and this is accomplished through the action of hydrochloric acid (HCl) present in gastric secretions.[50] This becomes problematic in the setting of surgeries where HCl acid secretion is decreased, disrupting normal iron absorption.[52]

Copper absorption takes place in the stomach and proximal duodenum and although deficiencies are uncommon, studies have demonstrated patients who have had RYGB and BPD/DS operations may develop deficiency without adequate supplementation.[58]

Nutrition is clearly a key component to achieving success with bariatric surgery and the RD can play a critical role in both pre- and post-operative care of the patient including providing dietary education, consulting on eating patterns, reinforcing the importance of adherence to micronutrient supplementation and identifying the signs of malnutrition. While there are studies that characterize the benefits of the RD in promoting weight loss[59,60] for the bariatric population, there few that address other benefits the RD may provide to these patients. As part of the MDT, the RD may alleviate burdens for other care team members, including physicians, by addressing supplement form and dosage-related concerns, addressing any barriers to food tolerance and providing interventions to treat malnutrition.[26]

Potential contributing factors to post-surgical complications

There are many factors that may be responsible for the complications that arise following bariatric surgery. These include surgical error, development or worsening of comorbid conditions, lack of adherence to post-surgery diet and lifestyle recommendations and lack of follow-up by a practitioner or preferably, a team with bariatric surgery expertise.[61] The latter two are most pertinent to the complications of malnutrition and micronutrient deficiencies. Research describing long-term compliance to micronutrient supplementation recommendations is sparse as is research focused on the rates of long-term follow-up in this population. However, it is worthwhile to consider available research regarding adherence to post-surgery recommendations, both short-term and long-term, because it is unlikely that patients will follow recommendations long-term if they are not doing so within six months to one year following surgery. A study evaluating micronutrient regimen adherence 50 days following surgery found patients exhibited a mean adherence rate of only 58% in the first week following surgery and 39% at the last week of follow-up, indicating that even in the short-term compliance rates are low .[62] Another study evaluating adherence post-surgery found that while 90% of patients reported compliance with recommendations five months after surgery, only 50% were compliant one year after the surgery. [63] Similarly, Welch et al. found a mean adherence rate to micronutrient supplementation of 57.6% in laparoscopic gastric bypass patients two to three years after surgery.[64] Welch et al. also conducted a literature review to investigate rates of follow-up in the bariatric surgery population and found that on average, 71% of patients are lost to follow-up within two years of surgery and 69% within three years of surgery.[64] When patients are lost to follow-up they may not receive the level of care needed or care specific to their altered GI anatomy placing them at higher risk for nutrition-related complications and micronutrient deficiencies. MDT management of patients with bariatric surgery may be crucial to maintain long-term nutritional status and prevent nutrition-related complications.

Short Bowel Syndrome

Short bowel syndrome (SBS) is a type of intestinal failure (IF) characterized by the inability to maintain normal protein-energy, electrolyte, micronutrient and fluid balance with a normal, standard diet.[65,66] The condition arises from the loss of small bowel due to surgery or a congenital abnormality, and results in decreased surface area for the absorption of macronutrients, micronutrients, water and electrolytes.[20,65]

Surgical SBS occurs as a complication of procedures such as laparoscopic fundoplication, gastric bypasses, cholecystectomies, and appendectomies. The incidence of post-surgical SBS has increased by up to 20% since 2005.[67] In a 10-year follow-up study of patients who underwent a RYBG, up to 16% of patients developed an internal hernia, which is a protrusion of visceral tissue into the abdominal cavity.[68] Internal hernias can precipitate massive bowel necrosis, which requires surgical removal of the necrotic tissue and eventually results in SBS.[68,69] McBride et al. reviewed medical records of 175 adult patients who developed SBS as a postoperative complication. Of procedures completed, SBS was most commonly associated with laparoscopic gastric bypass and cholecystectomy procedures.[67] Furthermore, patients undergoing laparoscopic gastric bypass are found to experience increased incidence of intestinal obstruction, placing them at higher risk for SBS.[67,70] The most common specific mechanism in the development of post-surgical SBS is adhesive obstruction, followed by volvulus, ischemia and post-operative hypoperfusion.[67,70] SBS may also occur in up to 15% of adult patients undergoing massive intestinal resection and in 25% of patients with multiple resections.[70]

Complications associated with SBS may be divided into those associated with the underlying pathophysiology of the disease and those resulting from treatment. The underlying pathophysiology causes severe malnutrition, hepatobiliary, metabolic, renal and gastrointestinal complications, whereas the loss of intestinal absorptive area and increased intestinal transport can cause other complications including chronic diarrhea, dehydration, electrolyte imbalances, small bowel bacterial overgrowth and renal failure.[70,71] Additionally, patients with SBS experience higher incidence of cholelithiasis, gastric hypersecretion, nephrolithiasis and liver disease.[70] Diseases associated with SBS as a complication include inflammatory bowel disease (IBD) and necrotizing enterocolitis in infants.[20,70] Treatment-related complications include catheter related infections (CRI), difficulties with vascular access, refeeding syndrome and sepsis.[70]

Survival with SBS is influenced by the amount, location and function of the remaining bowel. Other factors influencing the outcome of SBS include patient age, presence of comorbidities, further occurrences of intestinal obstruction and lastly, the efforts of the care management team.[72] However, the primary determinant of outcome in SBS is intestinal remnant length.[70] Resection of up to one half of the small intestine is often well tolerated, but SBS may result when less than 180 centimeters of small intestine is left.[70] Total parenteral nutrition (TPN) support is often necessary in patients with less than 120 centimeters of remaining intestine with colonic discontinuity and in patients with less than 60 centimeters of small intestine with the colon in continuity.[70] Location of the remnant is also important due to the different physiologic responsibilities associated with the various segments of the intestine.[70] Patients left with an ileal remnant have better clinical outcomes compared to those with a jejunal remnant because of the specialized nature of the ileum, which is the site of absorption of vitamin B12 and bile salts, features different hormones and is generally more adaptable than the jejunum. [70]

Treatment goals for SBS include promoting enteral independence and improving quality of life through both surgical and medical methods.[71] Home parenteral nutrition (HPN) has been integral to management of SBS since its development in 1970. Significant advances have been made regarding the treatment of SBS, with intestinal rehabilitation emerging as a primary form of treatment.[70] Intestinal rehabilitation describes the restoration of intestinal function to increase macronutrient, micronutrient and fluid absorption, thus enhancing autonomy of the patient by decreasing reliance on TPN.[73] The specific improvements to intestinal function and absorption are achieved through provision of a modified diet, nutrition support, oral rehydration solutions, motility and anti-secretory agents, antibiotics, and heterotrophic medications.[70] Intestinal transplant was once considered a standard treatment for patients with SBS, however it has fallen out of favor due to significant complications and the decrease in quality of life following the procedure.[74]

Patients with SBS may be TPN dependent for life, but are likely to transition to enteral or oral feeding.[66] TPN dependency should be avoided as it is associated with a high risk of complications, high costs, and disturbances to quality of life.[75] Dependency on TPN at one, two, and five years was reported in 74%, 64%, and 48% of patients, respectively.[66] The overall five year survival rate after leaving the hospital with a diagnosis of SBS is 75%, and is vastly influenced by the ability to provide long-term nutrition support.[70]

Until recently, a validated quality of life (QOL) survey for the SBS population did not exist. In 2010, Baxter and colleagues developed and administered a questionnaire to 100 adult patients on HPN, all of whom where highly compliant. [76] Results of this study revealed that patients on HPN experienced significant grief, depression, drug dependency and body image issues compared to the group not on HPN.[70,76] Other published data on QOL for patients with SBS requiring continuous TPN indicates it is lowest in the first year on TPN and gradually improves, with higher QOL scores being reported after four to five years of therapy.[70,75,77] Patients receiving this treatment may require anywhere from 12-18 hours of continuous TPN, which puts significant strains on travel, social and professional life.[70] Furthermore, TPN poses a financial burden to the patient and healthcare system, and prolonged TPN is expensive due to the cost of the treatment itself, but also because of recurrent clinic visits and hospital readmissions for treatment-related complications.[70] The costs of the treatment range from $75,000 to $150,000 per year, excluding the indirect costs of travel to appointments and payment to caregivers.[75]

The complex nature of SBS management necessitates the need for multidisciplinary care, including surgical and medical rehabilitation, and provision of nutrition support.[8,67,70,71,73,78,79] Nutrition provision is more accurate when nutrition status is monitored as a team by the physicians, nurses, pharmacists, and RDs.[70,71] Several reports have highlighted the benefits of the multidisciplinary approach to manage patients with SBS including reduced episodes of sepsis, earlier initiation of nutrition support and increased overall patient survival.[20,70,78,79]

Multidisciplinary Team Management of Disease

MDT management of complex conditions has been used in oncology, ALS, and liver disease and is associated with improved clinical, nutritional and financial outcomes.[3-15] A MDT may include various healthcare professionals from a wide variety of disciplines and the type of practitioners involved often depends on the disease.[80] In general, the MDT approach streamlines communication, enhances proactive management of the patient's symptoms, and depending on the protocol of the MDT, the patient may not have to visit with each provider separately, thus saving time and money.[81] The MDT approach is beneficial as it fosters increased evidenced-based decision making, faster initiation of treatment and improved quality of life for the patient.[7,82] Moreover, issues related to nutrition, including identification of malnutrition, are often addressed earlier by MDTs.[5,10] This is especially important considering the evidence connecting preoperative malnutrition with poor post-operative outcomes in patients undergoing surgery.[7]

In an oncology setting, management of patients with GI cancer by a MDT increased the accuracy of cancer staging, thereby influencing treatment decisions, which ultimately translates into improved clinical outcomes.[83] A randomized clinical trial of MDT management of advanced recurrent breast and hematologic cancer found the psychological, physical and patient care needs were decreased in the group treated with a MDT compared to the group treated in a more standard manner by individual practitioners.[82] MDT management of patients with esophageal cancer resulted in improved nutritional status, decreased complications such as infections, decreased length of hospital stay and reduced patient care-related costs.[6] The use of a peri-operative MDT for radical esophagectomy improved patient outcomes including shortened duration of fevers, earlier initiation of post-operative oral intake and decreased length of post-operative stay.[15] Multidisciplinary care has also become common in treatment of ALS and results in significantly increased survival and improved quality of life for the patient.[12,16]

Multidisciplinary care in the setting of bariatric surgery has been the recommended approach by the National Institutes of Health since 1992 and the team should include providers with specialties in medical, clinical, dietetic and psychosocial fields.[84] Current consensus statements from the American Society of Metabolic and Bariatric Surgery (ASMBS) and the Endocrine Society indicate that bariatric surgery patients are best served with care from a MDT.[3,44] More recently, MDTs are being incorporated into the management programs of other conditions, including IF and SBS.[10] A large systematic review and meta-analysis of MDT management in GI rehabilitation of pediatric patients with IF demonstrated the use of a MDT significantly reduced septic episodes and increased overall patient survival.[10] Other improvements included decreased relative risk of liver transplant, decreased IF-associated liver disease, reduced calories provided by TPN and overall improved coordination of care.[10] The use of a MDT in the setting of SBS may also shorten TPN duration and reduce CRIs.[8,85] In many studies, MDT management resulted in earlier initiation of feeding, whether oral, enteral or parenteral, which is associated with reduced mortality, though the exact mechanisms for this relationship remain unclear.[5,14,15]

Another type of MDT, the nutrition support team (NST), has emerged and is frequently used to manage patients with diseases featuring significant nutrition-related complications. NSTs have been vital to safe and effective administration of nutrition support, including EN and

TPN, since the 1980's.[4] A NST commonly includes physicians, nurses, RDs, and specially trained pharmacists.[4] The team functions to provide nutrition assessments, determine nutrient needs, recommend and manage appropriate TPN or EN regimens, and train support staff.[4] When compared to management by single providers, patients managed by NSTs have improved nutritional status, better clinical outcomes, reduced mortality and lower healthcare-associated costs.[9,86-88] There is little research on the exact mechanisms related to cost savings attributable to NSTs, but Kennedy and Nightingale demonstrated the addition of a nutrition nurse specialist and a senior dietitian to the NST resulted in tangible cost savings through decreased TPN episodes and decreased incidence of catheter-related sepsis.[9] Other studies have demonstrated this approach results in decreased length of stay, shortened time on nutrition support and reduced infections, all of which decreases the financial burden of disease. [3-15]

The role of the GI system in maintaining a healthy nutritional status makes nutrition a crucial focal point of treatment for any GI condition. Likewise, the complex nature of GI conditions requires intensive, coordinated, and comprehensive medical and surgical management. Previous studies have demonstrated that MDTs provide a higher level of integrated care and confer significant benefits to the patient.[8,10,16,17,85] However, there is very little research on the use of MDTs in the setting of GI disease, especially in the outpatient setting.[17] The purpose of this study is to investigate the impact of multidisciplinary care management on clinical and nutritional outcomes in patients with complex GI conditions. Identifying benefits of the use of MDT in management of this population will inform future clinical practices and may foster improved clinical and nutritional outcomes for patients with complex GI conditions.

Methods

Study Design

This was a retrospective chart review comparing clinical and nutritional-related data from patients with complex GI conditions seen at the Digestive Health Clinic (DHC) at Oregon Health & Science University (OHSU). Study data were obtained through review of electronic medical records in EPIC and included data obtained in the process of routine clinical care. There was no patient contact as a result of being included in this study and all analyses were done through the exclusive use of EPIC-derived data. This study was approved by the Institutional Review Board at OHSU.

Setting and Study Population

This study included subjects who were seen at the OHSU DHC between December 1, 2008 – December 1, 2017 and included subjects who met the inclusion and exclusion criteria outlined below. A total of 41 patients met inclusion criteria (Table 1) for this study. Additionally, participants were divided into two groups based on whether they were seen by the MDT.

Inclusion and Exclusion Criteria

Table 1. Study Criteria

Inclusion	Exclusion
• Age 18-95 • Diagnosis of complex gastrointestinal disease including inflammatory bowel disease, post-operative short bowel syndrome, complications of bariatric procedure • Established care at the Digestive Health Clinic after December 1, 2008 and before December 1, 2017.	• Any other concurrent condition which, in the opinion of the investigator, would preclude participation

Multidisciplinary Team (MDT)

For this study, the MDT was comprised of two physicians, a RD, and supportive staff including medical assistants and medical scribes. The MDT intervention group received care from this team and the non-MDT intervention group received care from either or both physicians and supportive staff, but did not receive care from the RD.

Study Procedures

Eligible study participants were queried through the OHSU EPIC Cohort Discovery system and identified by the principal investigator. Using EPIC, the study team collected baseline data including age, gender, race/ethnicity, number of clinic and phone appointments, number of MyChart encounters, GI related diagnoses, mental health related diagnoses, previous GI reconstruction procedures, previous GI related procedures, relevant comorbidities, laboratory data, weight (kg), and body mass index (kg/m^2). Outcome measurements included weight change, time on and time to wean from nutrition support, incidence of unplanned hospital admissions before and after establishing care at the DHC and change in the number of clinic, phone and MyChart encounters with physicians and RD. Comorbidities were described using the age-adjusted Charlson Comorbidity Index (ACCI), a validated method of assessing comorbidity burden and mortality risk.[89]

Weight change

All patient weights (kg) obtained during course of treatment at the clinic were documented. Absolute weight change (kg) was calculated with the weight obtained at first clinic visit and either the weight at the patients last clinic visit or, if the patient was still receiving care, the weight from the date closest to December 1, 2017. Percent weight loss was calculated using the same two weight measurements for all patients.

Unplanned hospital admissions

The number of patients admitted, total number of admissions, and reasons for unplanned hospital admission were collected. Unplanned hospital admissions were grouped as either being related to GI disturbances (nausea, vomiting, diarrhea), related to metabolic disturbance (dehydration, electrolyte abnormality) or related to nutrition (malnutrition, PICC line infection, PICC line blockage, enteral tube blockage or accidental removal).

Time to return to oral feeding

Patients who had feeding tube or lines placed while receiving care at the clinic were included in this analysis. If a patient had a feeding tube or line placed prior to establishing care with the clinic, the date the patient established care at the clinic was used as the date of nutrition support initiation in the sub-analysis. The documented date of feeding tube or line removal was used to determine the length of time for a subject to return to oral feeding.

Laboratory data

All pertinent laboratory data, including albumin, prealbumin, C-reactive protein, zinc, copper, vitamin D, while the patient received care at this clinic were collected.

Data Collection and Management

All data were stored electronically on the OHSU-approved Box secure cloud storage. Study folders were only shared with and accessed by study staff. After procurement, the data was de-identified, and the patient identifiers were kept separate from the data during storage, use and transfer. Each subject was given a 4-digit identifier (starting with 1001 and continuing up sequentially by one) upon review for use on the research documents. The patient's name and identifier were recorded on a separate document and were destroyed at the completion of the data analysis. The end point for data collection was either the date of the last clinic visit or, if the patient was still receiving care from the clinic, the end point was the appointment date closest to December 1, 2017.

Statistical Analysis

Primary outcomes of this study were weight change, time to wean from nutrition support, incidence of and reason for unplanned hospital admissions before and after establishing care at the DHC, and number of clinic, phone and MyChart encounters.

Data analysis was performed by the study team using JMP version 14.2.0. All data was assessed for normality via the Shapiro-Wilk test and data with non-normal distribution was treated accordingly. Statistical significance was set at $p = < 0.05$ for all statistical analyses. Descriptive statistics were used to determine if there were any baseline differences in patient characteristics between the two groups including age, gender, anthropometrics, comorbidities and GI-related diagnoses and procedures. Categorical variables were reported as counts and percentages. Continuous data with normal distribution were summarized as means with standard deviations and continuous data with non-normal distribution were summarized as medians with interquartile range. Patients in the MDT intervention and non-MDT intervention groups were compared via chi squared test or Fisher exact test for categorical data, and Students t-test for normally distributed continuous variables or Wilcoxon rank-sum test (Mann-Whitney U) for non-normal data.

A paired t-test was conducted to explore the differences between unplanned hospital admissions for nutrition-related complications before and after establishing care at the DHC. Only patients with Care Everywhere data were included in this analysis. Unplanned hospital admissions for nutrition-related complications included admissions for GI disturbances (nausea, vomiting, diarrhea), dehydration, electrolyte abnormality, malnutrition and/or failure to thrive, PICC line infection, PICC line blockage/problem, or feeding tube problems (clogged tube, accidental removal of tube). Six patients were removed from this analysis: five did not have Care Everywhere data and one patient was an outlier that significantly skewed the data.

A Kaplan Meier analysis was used to examine the between group relationship for time to wean from EN and TPN. For this study, time to wean from TPN or EN includes only days on the support method, but not days between nutrition support treatment periods when nutrition support may have been stopped but restarted once malnutrition reoccurred. In this analysis, the observational unit was the event which was initiation of nutrition support. In cases where one patient had multiple rounds of TPN or EN initiated, each round was treated as separate event. EN or TPN start date was either the actual date the feeding tube or line was placed if the patient had already established care at the DHC or the date of the first clinic appointment if the patient had a previously placed feeding tube or line. EN or TPN end date was either the true date the tube or line was removed, and nutrition support ceased or the end of the study collection period (December 1, 2017) if the patient was still on TPN or EN. Patients deemed lifetime TPN- or EN-dependent by the principal investigator were removed from the survival analysis. For patients on EN, the specific type of feeding tube was also collected.

Specific Aim 1: A Fisher's exact test was used to investigate differences in the number of clinic visits with physicians between both groups. A two-sample unpaired t-test or Wilcoxon rank-sum test was used to compare differences between the two groups for number of patients admitted for unplanned hospitalizations, number of unplanned hospitalizations and reasons for unplanned hospital admissions. Two-sample paired t-test's (matched pair analyses) were conducted to compare differences in number of unplanned hospital admissions before and after establishing care with the clinic for the whole study population, and individually for the two groups.

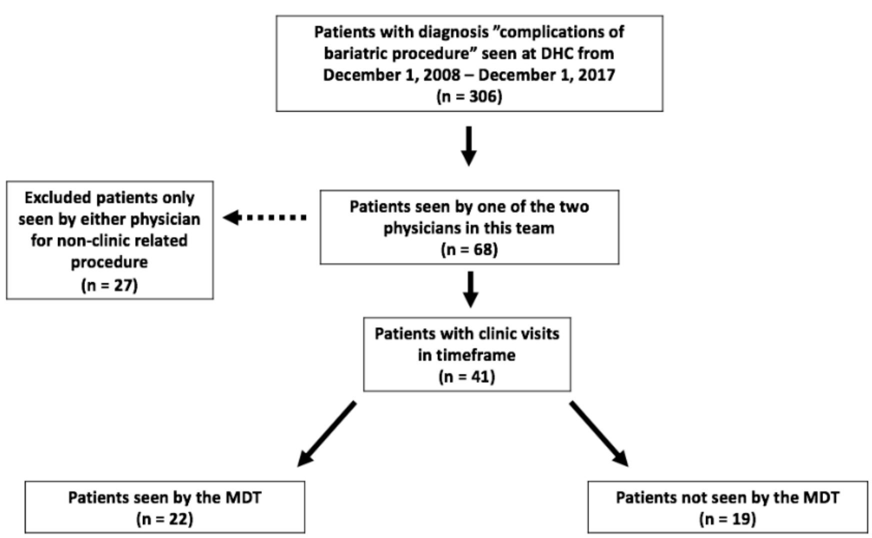
Specific Aim 2: A two-sample unpaired t-test or Wilcoxon rank-sum test was used to compare differences between the two groups for weight change. A Kaplan-Meier analysis was used to compare time to return to oral feeding from EN and TPN between the two groups and the difference was calculated with a log-rank test.

Results:

Patient Characteristics

Between December 1, 2008 and December 1, 2017, a total of 306 patients with a diagnosis of "complications of bariatric procedure" were seen at the DHC (Figure 1). After identifying patients seen only by either or both providers of interest, the number of patients decreased to 68. Of the 68 that initially met inclusion criteria, 27 were only seen by a provider for a non-bariatric related procedure (colonoscopy or esophagogastroduodenoscopy) and were not affiliated with the DHC for any care beyond the procedure conducted. Therefore, those patients were eliminated from data collection and the final number of patients included in the data collection and analysis was 41. Of the 41 patients included in this study, 22 were seen by both the RD and physician and were included in the MDT intervention group and 19 patients were only seen by the physician and were included in the non-MDT intervention group.

Figure 1. Patient Enrollment



There were no significant between group differences in age (p=0.45, unpaired t-test), gender (p= 0.61, Fisher's exact), or ACCI at baseline (p=0.97, unpaired t-test (Table 2). For the ACCI score, a score of ≤ 2 describes participants who are younger than 60 or have few comorbidities present. A score of 3-5 describes older participants with few comorbidities or younger subjects with many comorbidities. A score > 5 describes subjects who are older and have many comorbidities. The average comorbidity score across both groups was 3.53 ± 1.88. Baseline weight and BMI were significantly higher in the MDT intervention group (p=0.0004, Wilcoxon rank-sum test) compared to non-MDT intervention group. The median BMI (kg/m^2) at initial clinic visit was 23.48 kg/m^2 in the MDT intervention group and 31.28 kg/m^2 in the non-MDT intervention group. The MDT intervention group had a maximum BMI of 33.89 kg/m^2 compared to the non-MDT intervention group, which had a maximum BMI of 57.34 kg/m^2.

Table 2. Patient Characteristics

Characteristics	All Patients (n=41)	MDT Intervention (n=22)	Non-MDT Intervention (n=19)	*p-value*
	Mean ± SD or Median (IQR)			
Age, year	60.36 ± 11.11	61.59 ± 11.17	58.94 ± 11.16	0.4545[a]
Initial weight, kg	73.43 (62.05 - 96.70)	68.10 (54.35 - 75.96)	89.812 (72.12 - 110.85)	0.0004[b]
BMI, kg/m^2	26.72 (22.71 - 32.63)	23.482 (18.92 - 28.45)	31.285 (26.45 - 45.28)	0.0004[b]
Age-Adjusted Charlson Score	3.54 ± 1.88	3.54 ± 1.92	3.53± 1.89	0.9746[a]
	n (%)			
Score ≤ 2	10 (24)	6 (27)	4 (21)	
Score 3-5	24 (59)	11 (50)	13 (68)	
Score > 5	7 (17)	5 (23)	2 (11)	
Gender				0.6099[c]
Male	4 (10)	3 (14)	1 (5)	
Female	37 (90)	19 (86)	18 (95)	

[a] Student's t-test

[b] Wilcoxon rank-sum test

[c] Fishers exact test

SD, standard deviation; IQR, interquartile range; BMI, body mass index as kg per meter squared; kg, kilogram

GI Medical Diagnoses and Surgery

There were no significant between group differences for type of bariatric surgery when considering RYGB vs other (including SG, BPD/DS, gastric band, gastric stapling, jejunoileal bypass, Billroth-II, Salmon procedure) ($p=0.2155$, Fisher's exact test) (Table 3). There were no between group differences regarding IBD diagnosis ($p=0.2354$, Fisher's exact test), fistula diagnosis ($p=0.51$, Fisher's exact test), or SBS diagnosis ($p=0.4192$, Fisher's exact test). There was a significant difference in the number of patients who had one bariatric revision surgery between the two groups with the MDT intervention group having more patients with a history of one revision ($p=0.0044$, Fisher's exact test). This effect was not observed in the case of two or more bariatric revision surgeries ($p=0.6388$, Pearson's chi squared). Additionally, there was a significant difference in the number of patients with a history of one bowel resection with the MDT intervention group having more patients with a history of one bowel resection ($p=0.0013$, Fisher's exact test). However, there was no significant difference in the case of two or more bowel resections ($p=0.1146$, Pearson's chi squared). Finally, there were no significant between group differences for history of one fistula takedown ($p=0.3757$, Pearson's chi squared) or history of two or more fistula takedowns ($p=0.6388$, Pearson's chi squared). The majority of patients (73%) had at least one mental health diagnosis (Table 4). However, there were no significant differences between the two groups regarding the number of patients with one or more mental health diagnoses ($p=0.9450$, Pearson's chi squared).

Table 3. GI Medical Diagnoses and Surgery			
Characteristics	**MDT Intervention (n=22)**	**Non-MDT Intervention (n=19)**	***p-value***
		n (%)	
History of Bariatric Surgery	22 (100)	19 (100)	
Bariatric Surgery Type			
RYGB	16 (61.5)	10 (38.4)	.2115[a]
Other	6 (4)	9 (6)	.2115[a]
SG	2 (33)	4 (66)	
BPD/DS	3 (75)	1 (25)	
Gastric Band	0	1 (100)	
Gastric Stapling	0	1 (100)	
Jejunoileal Bypass	0	1 (100)	
Billroth-II	0	1 (100)	
Salmon Procedure	1 (100)	0	
IBD Diagnosis	3 (100)	0	0.2354[a]
CD	1 (100)	0	
UC	1 (100)	0	
CD and UC	1 (100)	0	
Fistula Diagnosis	9 (64)	5 (35)	0.51[a]
Gastrocutaneous	0	2 (100)	
Enterocutaneous	6 (85)	1(14)	
Retrovaginal	2 (100)	0	
Gastrocolic	0	1 (100)	
Gastrogastric	1 (50)	1 (100)	
SBS Diagnosis	5 (71)	2 (28)	0.4192[a]
History of 1 Bariatric Revision	15 (78)	4 (21)	0.0044[a]
History of 2+ Bariatric Revisions	2 (66)	1 (33)	0.6388[b]
History of Bowel Resection	15 (83)	3 (37.5)	0.0013[a]
History of 2+ Bowel Resections	5 (83)	1 (16)	0.1146[b]
History of Fistula Takedown	6 (66)	3 (33)	0.3757[b]
History of 2+ Fistula Takedowns	2 (66)	1 (33)	0.6388[b]

[a] Fishers exact test

[b] Pearson's chi squared test

RYGB, Roux-en-Y gastric bypass; SG, sleeve gastrectomy; BDP/DS, biliopancreatic diversion with duodenal switch; IBD, inflammatory bowel disease; CD, Crohn's disease; UC, ulcerative colitis

Table 4. Mental Health Diagnoses				
Characteristics	**All Patients (n=41)**	**MDT Intervention (n=22)**	**Non-MDT Intervention (n=19)**	***p-value***
		n (%)		
No. of patients with one or more mental health diagnoses	30 (73)	16 (72.7)	14 (73.6)	0.9450[a]
		n		
Total no. of mental health diagnoses	55	29	26	0.9450[a]

[a] Pearson's chi squared test

Clinic Visits with Physicians:

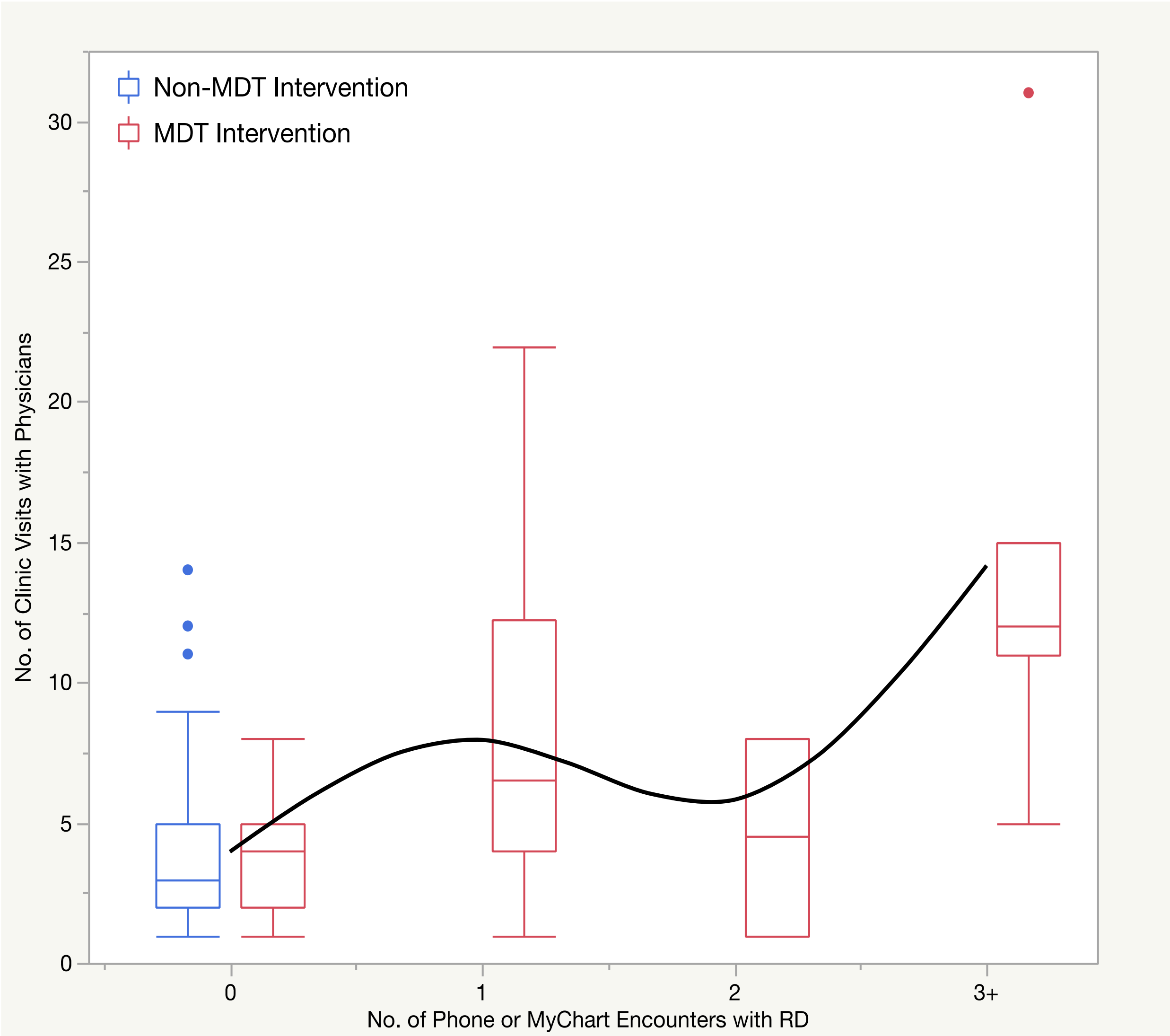
The MDT intervention group had significantly more visits with the physicians than did the non-MDT intervention group (6.5 visits, IQR [3.75-11.25] vs 3 visits, IQR [2-5], p=0.0253) (Table 5, Figure 2). In the MDT intervention group, there was a positive correlation between the number of phone consults with the RD and number of office visits with the physician (Figure 2).

Table 5. Clinic Visits with Physicians			
Characteristics	**MDT Intervention (n=22)**	**No MDT Intervention (n=19)**	***p-value***
		Median (IQR)	
Office visits with physician	6.5 (3.75-11.25)	3 (2.0-5.0)	0.0253[a]

[a] Fishers exact test

IQR, interquartile range

Figure 1. Impact of MyChart and Phone Encounters with RD on Clinic Visits with Physicians



Weight Change:

Seven patients (two from the MDT intervention group and five from the non-MDT intervention group) who only had one clinic visit were excluded from this analysis.

The groups differed significantly by weight (kg) at the last clinic visit or end of study collection period (p=0.0034, unpaired t-test) (Table 6). The MDT intervention group experienced significantly less weight loss than the non-MDT intervention group (p=0.0128, unpaired t test) and the MDT intervention group had a median weight gain of 1.63 kg (IQR: -3.82 – 9.07) compared to the non-MDT intervention group, which had a median weight loss of -0.59 kg (IQR: -12.61 – 0).

Table 6. Absolute weight change (kg)			
Characteristics	**MDT Intervention (n=20)**	**Non-MDT Intervention (n=14)**	***p-value***
		Median (IQR)	
Initial weight, kg	68.10 (54.35 - 75.96)	89.812 (72.12 - 110.85)	0.0004[a]
End weight, kg	70.62 (55.89 - 79.73)	85.27 (73.48 - 107.73)	0.0034[a]
Weight difference, kg	1.63 (-3.82 - 9.07)	-0.59 (-12.16 - 0)	0.0128[a]

[a] Wilcoxon Rank Sum test

kg, kilograms; IQR, interquartile range

Similar to the absolute weight change, there was a significant difference in percentage of weight change between the MDT intervention and non-MDT intervention groups (6.02% ± 14.01 vs -5.97% ± 13.53, p value = 0.0181, unpaired t-test) (Table 7). Patients in the MDT intervention group had a lower baseline BMI and on average, and experienced positive weight change compared to patients in the non-MDT intervention group who had a higher baseline BMI and on average, experienced weight loss (Table 6).

Table 7. Percent weight change over study period			
Characteristic	**MDT Intervention (n=20)**	**Non-MDT Intervention (n=14)**	***p-value***
		Mean ± SD	
Weight change, %	6.02 ± 14.01	-5.97 ± 13.53	0.0181[a]

[a] Student's t-test

SD, standard deviation

Unplanned Hospital Admissions:

Six patients were removed from this analysis with five not having Care Everywhere data and one being an outlier due to the high number of readmissions (number of hospitalizations after first clinic visit = 27). There was a significant decrease in number of unplanned hospitalizations for nutrition-related complications after establishing care in the clinic for both groups combined (p=0.0233, paired t-test/matched pair analysis) (Table 8), but this effect was not observed across groups when comparing number of unplanned admissions before and after establishing care for the MDT intervention and non-MDT intervention groups (p=0.1049 and p=0.0965, respectively, paired t-test/matched pair analysis) (Table 8).

Table 8. Unplanned Hospitalizations Before and After Establishing Care at DHC

Characteristics	Before Establishing Care	After Establishing Care	*p-value*
		n	
Total no. of admissions for both groups	83	42	0.0232[a]
		n (%)	
No. of admissions for MDT intervention group	34 (40)	20 (47)	0.1049[a]
No. of admissions for non-MDT intervention group	49 (59)	22 (52)	0.0965[a]

[a] Paired t-test

Additionally, there were no significant between group differences regarding the number of patients in each group ever admitted (p=1.0, Fisher's exact test) (Table 9). Unplanned hospitalizations for GI disturbances (nausea, vomiting, diarrhea), metabolic abnormalities (dehydration, electrolyte abnormality) or nutrition-related complications (malnutrition, PICC line infection, PICC line blockage, feeding tube blockage, accidental feeding tube removal) did not differ significantly between the two groups (p=0.1334, p=0.1217, p=0.1320, respectively, Wilcoxon rank-sum test) (Table 9).

Table 9. Reasons for Unplanned Hospitalizations				
Characteristics	**All Patients (n=35)**	**MDT Intervention (n=20)**	**Non-MDT Intervention (n=15)**	***p-value***
		n (%)		
No. of patients ever admitted	32 (91)	18 (90)	14 (93)	1.0[a]
		n		
Total no. of admissions	129	58	71	
Reasons for admission				
GI Disturbances	68	22	46	0.1334[b]
Metabolic Abnormalities	22	7	15	0.1217[b]
Dehydration	9	3	6	
Electrolyte Abnormality	13	4	9	
Nutrition Related	39	29	10	0.1320[b]
Malnutrition	8	6	2	
PICC line infection	7	6	1	
PICC line blockage/problem	5	5	0	
Feeding tube problem	19	12	7	

[a] Fisher's exact test

[b] Wilcoxon rank sum test

Finally, there was a decreased relative risk of experiencing an unplanned hospital admission for nutrition-related complications if seen by an RD, but this finding was not statistically significant (RR 0.928, 95% CI: 0.56 – 1.51) (Table 10).

Table 10. Risk of Unplanned Hospitalization				
Characteristic	**MDT Intervention**	**Non-MDT Intervention**	**RR**	**95% CI**
No. of admissions after first clinic visit	42	20	0.928	0.56 - 1.51

RR, relative risk

Nutrition Support

Fifteen patients had nutrition support initiated during their course of care at the DHC with nine being on EN and nine being on TPN (Table 11). For both groups combined, the median number of days spent on any nutrition support was 112 days (IQR 56 -300), median number of days spent on EN was 56 days (IQR 6 – 154), and median number of days spent on TPN was 171 days (80 – 133). Of those on EN, six patients were in the MDT intervention group and three were in the non-MDT intervention group. Those in the non-MDT group had a median of six days (IQR 6-56) on EN compared to a median of 109.5 days (IQR16.75-265) for those in the MDT intervention group. Of the patients on TPN, only one was in the non-MDT intervention group and TPN was initiated at two separate time intervals with a total of 294 days on TPN. The median number of days on TPN in the MDT intervention group was 171 days (IQR 80-333). Three of the patients were on both TPN and EN at separate intervals in their treatment period, two from the MDT intervention group and one patient from the non-MDT intervention group. There was no significant difference between time spent on either EN or TPN between the two groups ($p = 0.1948$, $p = 0.4367$, respectively, Wilcoxon rank test) (Table 11). There was also no significant between group difference for time spent on either form of nutrition support ($p=.3865$, Wilcoxon rank-sum).

Table 11. Days on Nutrition Support

Characteristics	All Patients (n=15)	MDT Intervention (n=12)	Non-MDT Intervention (n=3)	*p-value*
		Median (IQR)		
Days on Nutrition Support	112 (56 - 300)	141.5 (71.5 - 348.5)	56 (6 - 300)	0.3865[a]
Days on EN	56 (6 - 154)	109.5 (16.75 - 265)	6 (6 - 56)	0.1948[a]
Days on TPN	171 (80 - 333)	138.5 (71.5 - 321.75)	294*	0.4367[a]

[a] Wilcoxon rank sum test.

IQR, interquartile range

** n=1, interquartile range not applicable*

Kaplan Meier analyses were used to compare the time to wean from EN (Figure 4) or TPN (Figure 5). There was a suggestive difference between the MDT and non-MDT groups for the time to wean from EN (p = 0.0631, log rank test) (Figure 4), but not for time to wean from TPN (p = 0.8856, log rank test) (Figure 5). For EN, the non-MDT intervention group was weaned faster than the MDT intervention group (22.67 days vs 130.29 days, respectively). For TPN, the non-MDT intervention group was also weaned faster than the MDT intervention group (147 days vs. 175.33 days, respectively).

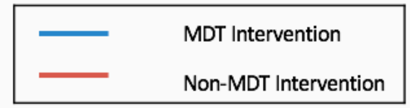


Figure 3. Time to Return to Oral Feeding from EN

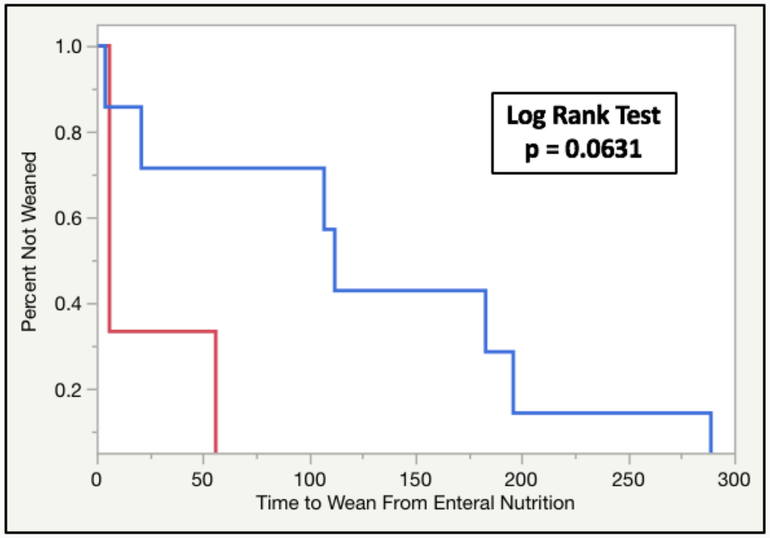


Figure includes 9 patients with 10 events. Each event represents initiation of EN.

Figure 4. Time to Return to Oral Feeding from TPN

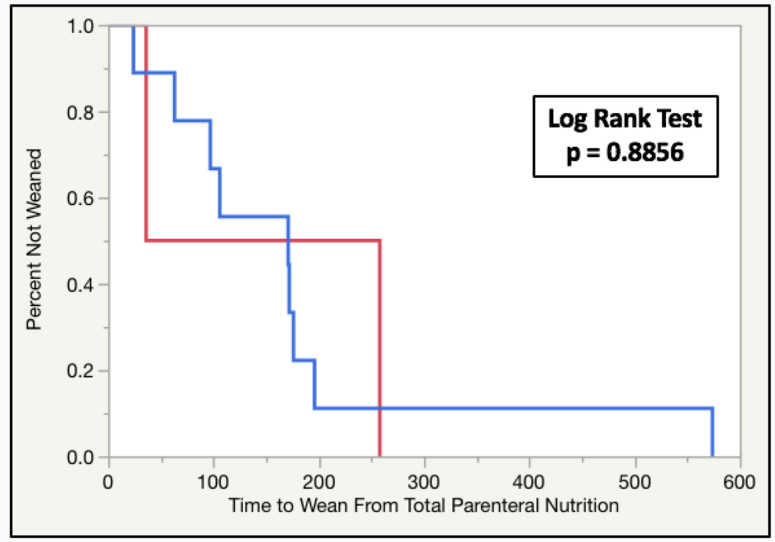


Figure includes 9 patients with 11 events. Each event represents initiation of TPN.

Prevalence of Micronutrient Deficiencies

At the initial clinic visit, 32 patients had labs drawn including 22 patients from the MDT intervention group and 10 from the non-MDT intervention group (Table 12). Among all patients with labs drawn at baseline, 88% had low albumin, 78% had low prealbumin, 67% were deficient in zinc, 50% were deficient in copper and 56% were deficient in vitamin D. Of patients in the MDT intervention group who received lab draws at first visit, 88% had low albumin, 86% had low prealbumin, 71% were deficient in zinc, 67% were deficient in copper, and 60% were deficient in vitamin D. Of patients in the non-MDT intervention group who received lab draws at first visit, 89% had low albumin, 50% had low prealbumin, 50% were deficient in zinc, none were deficient in copper and 50% were deficient in vitamin D (Table 12).

Table 12. Prevalence of Micronutrient Deficiencies

Characteristics	MDT Intervention (n=22)	Non-MDT Intervention (n=19)
	n (%)	
Patients with lab drawn at visit 1	22 (100)	10 (52.6)
Patients deficient at visit 1:		
Albumin	15 (88)	2 (89)
Prealbumin	12 (86)	8 (50)
Zinc	5 (71)	1 (50)
Copper	4 (67)	0
Vitamin D	6 (60)	3 (50)

****Percentages were calculated based on the number of patients who had that specific lab drawn and not calculated based on the total number of patients with labs drawn in each cohort***

Discussion

The present study examined the clinical and nutritional outcomes in patients with complex GI conditions who were or were not treated by a MDT. When considering the MDT vs non-MDT interventions, the main difference was presence or absence of a RD in the group with the MDT including the RD.

We observed that unplanned hospitalization admissions did significantly decrease after establishing care at the DHC and found a reduced risk of unplanned hospital admission after visiting with the RD, although the latter finding was not statistically significant and likely limited by the small sample size. While we did not observe a statistically significant decrease in unplanned readmissions after establishing care with the MDT intervention group, perhaps more importantly, we were able to show a significant decrease in unplanned admissions in a clinically and nutritionally unstable population. A study focused on the Metabolic and Bariatric Surgery Accreditation Quality Improvement Program (MBSAQIP) which stemmed from a collaboration between the American College of Surgeons (ACS) and the American Society for Metabolic and Bariatric Surgery (ASMBS), [55] found a significant decrease in 30-day readmission rates in hospitals featuring this program. This program includes RD involvement and multidisciplinary team care. While there is research focused on 30-day readmission rates in the bariatric surgery population, there is limited research on long-term readmission rates and unplanned readmission characteristics in this population. In contrast to the study focused on the MBSAQIP, our study focused on long-term and overall readmission rates a.

We also found that patients in the MDT intervention group had significantly more visits with physicians than those in the non-MDT intervention group. While there are many possible reasons for this observation, we hypothesize the MDT intervention group had more patients with severely compromised nutritional status and more clinically complex cases, justifying the need for more visits with physicians. Patients in the MDT intervention group started and ended treatment at a significantly lower BMI, had significantly more patients with a history of bariatric revision or GI resection surgeries and had more patients with a SBS, IBD or fistula diagnosis. Moreover, there were more patients in the MDT intervention group on nutrition support and there was a greater prevalence of micronutrient deficiencies in the MDT intervention group. Again, all together, this suggests a more complex and unstable population in the MDT intervention group.

Ultimately, we hoped that having an RD on the team would alleviate the need for the patient to come into clinic as frequently, either through phone appointments with the RD or by addressing patient needs with MyChart messaging. However, we observed the opposite effect in that patients with more phone appointments and MyChart interactions with the RD had more clinic visits with the physicians. While this does not indicate that RD intervention reduces clinic visits with the MD, it does indicate that the RD is a well utilized member of the team. While we did not specifically investigate cost savings as part of this study, we can infer that the presence of the RD on this MDT did free up physician time and thus, allow the physicians to see more patients. The RD was able to spend more time with each patient and answer nutrition-related questions that, without the presence of the RD, would have had to be addressed by the physician.

Our findings related to weight change must be interpreted with caution as, unlike the typical population seeking bariatric surgery, patients treated at the DHC are not always given a goal of weight loss. In fact, many patients in the MDT intervention group were nutritionally or clinically compromised as evidenced by their baseline, clinical and nutritional characteristics. As a possible result of not receiving bariatric-related care, not following recommendations or being unable to absorb the nutrients consumed due to malabsorption induced by surgery, some of the patients in our study experienced negative health consequences leading to excessive weight loss, malnutrition and ultimately, resulting in a referral to this clinic. Thus, weight regain, or presence of excessive weight was not always an issue for patients in this study, particularly those treated by the MDT. Favorable weight changes occurred in both groups when considering the average BMI or weight of each group at baseline. The MDT intervention group started at a significantly lower weight and had more patients with a low normal or underweight BMI but experienced weight gain overall. In contrast, the non-MDT intervention group started at a significantly higher weight and had more patients with an overweight or obese BMI but experienced weight loss overall. Thus, the MDT and specifically, the RD more often saw patients who started off at either a low or normal BMI and the MDT was able to elicit a positive outcome evidenced by weight gain. While there was a significant difference between the two groups in terms of weight change, the groups also started out at significantly different BMIs, which could have impacted the weight change. Additionally, there are many other factors that contribute to weight change that we did not assess in this study including genetics, metabolism, level of physical activity and dietary habits.

With regards to nutrition support, although we did not find any statistically significant improvements in nutrition support-related outcomes, our finding that more patients in the MDT intervention group were on nutrition support is similar to other findings in relevant literature. Specifically, a study by Jo et al. on MDT care in the MICU also found more patients cared for by the MDT were placed on EN.[56] These findings are expected when considering that most times when a patient is on any form of nutrition support, either as an inpatient or an outpatient, a RD, nutrition support team or other MDT is involved.

Finally, we must consider how the characteristics of the patients in these cohorts have changed over the course of the study period from 2008 to 2017. More specifically, how the average ambulatory patient may present with more complications and significantly more compromised nutritional and clinical status in the later years of this study due to improvements in healthcare provision. These improvements include the ability to provide nutrition support, administers IV medications and provide IV rehydration from the home as well as opportunities for patients to have their medication- or care-related issues addressed from the home via phone and MyChart messaging. Due to these improvements, the patients who were treated in the later years, from 2013 – 2017, may have been more nutritionally and clinically compromised further adding to the heterogeneity of the patients in these cohorts. We predicted that the MDT had seen patients with a higher comorbidity burden and more complications. While there was no statistically significant difference in comorbidity burden as defined by the ACCI, the MDT did treat patients with more bowel resections, bariatric revisions, and a greater prevalence of micronutrient deficiencies, indicating that the MDT team did see patients who may have had more clinical and nutritional needs.

An unexpected finding was that no patients with a BMI of greater than 35 kg/m^2 were seen by the MDT and while the reason for this is unknown, it could indicate presence of the perception that patients with obesity did not require care from the MDT. However, research demonstrates that people with obesity can be malnourished and thus, benefit from the same consideration as persons of normal weight.[34] Furthermore, of patients in both groups with obesity and who had lab data available at the initial consult, 100% had hypoalbuminemia, 100% were deficient in zinc and 75% were deficient in vitamin D. This prevalence of micronutrient deficiency exceeds micronutrient deficiency rates reported in the literature which indicate that at least 15-20% of patients with obesity are found to be deficient in at least one micronutrient. This provides further evidence that weight status does not necessarily correlate with nutrition status.

Strengths. To our knowledge, there are no studies that investigate the impact of MDT management, which includes a RD, for care of patients with complex GI conditions outside the setting of an intensive care unit.[5,91] Our study provides insight into how MDT management of this population influences predetermined patient outcomes. An additional strength of this study is the access to multiple years of data and records beyond our institution through the use of the Care Everywhere network in EPIC. Most importantly, this study demonstrated that we were able to decrease unplanned hospital admissions in a sick population through establishing care at the DHC, although we cannot say that care provided by the MDT at the DHC is responsible for this decrease.

Limitations. One limitation of this study is that it is retrospective and therefore we cannot determine casual effects.[92] Retrospective patient chart reviews may also be inherently bias regarding patient selection.[8] In particular, there is unintended selection bias regarding patients who were referred to the RD in this study. The RD is a limited resource as this MDT clinic has only one RD. Therefore, the physicians select and refer patients who are most in need of the nutrition expertise the dietitian can provide. Additionally, the relatively small sample size and heterogeneity of patients may have resulted in selection bias and most certainly resulted in weak statistical power for many analyses.[92,93] Specifically, regarding the non-statistically significant findings, there is a possibility of Type II error occurring due to the small sample size of this study. Future studies should include a larger patient population to more thoroughly investigate possible relationships between outcome improvements based on MDT versus non-MDT intervention.

Prospective studies are warranted to determine the impact of MDT management of this population in both the inpatient and outpatient setting as these findings do indicate possible trends towards outcome improvement with MDT management. While RD intervention is not standard of care for many clinics, future research featuring a prospective design should carefully consider the ethical implications of limiting access to a RD to one cohort given the possible benefit of providing MDT care for patients with complex conditions. Additionally, future studies whether prospective or retrospective should recruit a larger sample size to provide more statistical power.

Regarding the significance and clinical application of this study, it is first important to note that there were outcome improvements with the MDT model. This study also provided an opportunity for quality improvement for the team. First, developing TPN and EN weaning protocols to provide a standard of practice may improve or clarify nutrition support-related care. Second, protocolizing laboratory procedures to follow ASMBS guidelines would be beneficial as the guidelines were recently updated and represent best practice relative to bariatric-related care. Finally, providing more referrals to the RD for patients with higher BMIs is important. Sarcopenic obesity is becoming increasingly more prevalent and weight is not an adequate indicator of nutrition status.

Conclusion

Although we were unable to accept our hypothesis that MDT care of patients with complex GI conditions would result in improved nutritional and clinical-related outcomes, there is research demonstrating significant improvements to nutritional and clinical outcomes and reduced cost with the use of an MDT in certain settings.[4,5,9,88,91] This study provides valuable insights that may be applied to this clinic to further improve the care provided to patients with complex GI disorders.

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