

# Colonoscopy Screening for Colon Polyps: Can It Be Useful at an Earlier Age for Preventing Malignant Transformation?

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## Research

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# Abstract

**Background:** The aim of this study was to investigate whether colonoscopy screening should be performed at an earlier age than specified in the current guidelines.

**Methods:** Data of 1882 patients who presented to the gastroenterology clinic of our hospital and underwent colonoscopy were retrospectively evaluated. Polyps detected during colonoscopy were excised and sent to the pathology laboratory for histopathological examination. Patients were divided into two groups as <45 yo and  $\geq$ 45 yo and the data were compared between the groups.

**Results:** The most common indications for colonoscopy were found as abdominal pain in 40.6% of the patients, rectal bleeding in 18.6%, constipation in 14.2%, anemia in 10.5%, diarrhea in 3.1%, and other reasons in 6.8%. The rate of polyps was statistically significantly higher in  $\geq$ 45 yo patients (43.3%) compared to <45 yo patients (32.1%). The rate of neoplastic polyps was statistically significantly higher in the  $\geq$ 45 yo group compared to the <45 yo group. The most common localizations of polyps were rectum and sigmoid colon in all age groups.

**Conclusion:** Based on our findings, we believe that the onset age of screening for colon polyps should be 45 years as recommended by the updated guidelines. Also, colonoscopy screening should be performed in young adults without alarm symptoms who present with lower gastrointestinal complaints.

## Introduction

Colon polyps are considered a bridge to colorectal cancer (CRC) because of their potential for malignant transformation. Early detection and endoscopic removal are essential in the prevention of CRC. CRC is one of the most common cancer types in Western countries and 446,000 new cases are seen in Europe annually. Annual mortality from CRC is 214,000 for both sexes [1]. CRC cases are estimated to reach 1.36 million in men and 1.08 million in women worldwide by 2035 [2]. Recently, a change has been found in the incidence of polyps with increasing localization in the proximal colon in Western countries, which has been accompanied by an increased number of sessile serrated polyps (SSP).

Most polyps are asymptomatic and remain unrecognized but major clinical presentations in symptomatic cases include gastrointestinal bleeding, abdominal pain, intestinal obstruction, rectal prolapsus, and changes in bowel habits [3]. Polyps are histologically classified as neoplastic and non-neoplastic [4]. Non-neoplastic colon polyps may be inflammatory hyperplastic and cystic polyps, whereas neoplastic polyps can be benign such as tubular and tubulovillous adenomas or malignancies and these polyps are precursors of colon cancers. Recent studies have shown that hyperplastic polyps at the right side of the intestines may have malignant potential and should be closely followed up [5]. These polyps have adenomatous components; they show a serrated, sawtooth-like surface epithelium and have BRAF mutations [6].

Colon polyps are curable if excised. If left untreated, patients may develop complications such as bleeding and the condition may be fatal because of malignant transformation. Stycker et al. suggested that the risk of developing cancer because of sporadic colon polyps of 1 cm is 8% in 10 years and 24% in 20 years [7]. Therefore, removal of polyps is important to avoid the development of malignant polyps [8]. Interestingly, recent studies have reported an increase in the incidence of CRC in people younger than 40 years [9-12].

Colonoscopy is considered the best screening modality for colon cancer and adenomatous polyps by most gastroenterologists [13, 14]. Current guidelines recommend that colonoscopy screening begin at 50 years of age and should continue until 75 years [15]. Given the benefits of colonoscopy screening in adults and the increasing incidence of CRC in younger ages [16], there is a debate in the literature about whether colonoscopy screening for CRC should be started at an earlier age [17]. However, there is no empirical data on the effects of colonoscopy performed in patients <45 years of age.

The aim of this study was to investigate whether colonoscopy screening should be performed at an earlier age than specified in the guidelines.

## Materials And Methods

Data of patients who presented to the gastroenterology clinic of our hospital due to various reasons, had a positive stool screening test, and underwent colonoscopy from 2017 to 2019 were obtained from the hospital records and retrospectively evaluated. Patients with a severe cardiac or hepatic condition, respiratory failure, hemodynamic instability and serious systemic diseases, those at advanced stage of disease, patients with active gastrointestinal bleeding, and those with known colorectal cancer were excluded from the study.

Patients' demographic data such as age and sex, smoking and alcohol consumption status, presence of alarm symptoms (weight loss, anemia, etc.), and family history were recorded. Besides, indications for colonoscopy, bowel cleanliness, pathologic findings, presence of polyps, localizations of polyps, type, number, and size of polyps, and presence of dysplasia were recorded and analyzed.

Data obtained were analyzed in detail. Colonoscopy procedures were performed by three experienced gastroenterologists. All polyps detected during colonoscopy were excised and sent to the pathology laboratory for histopathological examination. Polyp specimens were fixed in buffered formalin. Following staining with hematoxylin eosin, one or two sections of 4 µm were examined depending on the polyp size.

The patients were divided into two groups as <45 yo and ≥45 yo and data were compared between these two groups.

Before the study, ethics approval was received from the local ethics committee of the Sakarya University Training & Research Hospital with the 07/10/2020 dated and 71522473/050.01.04/402 numbered decision. The study was conducted in line with the ethical principles of the Declaration of Helsinki.

## Statistical Analysis

Statistical analysis was performed using the MedCalc Statistical Software version 12.7.7 (MedCalc Software bvba, Ostend, Belgium; <http://www.melcalc.org>; 2013). Continuous variables are expressed as descriptive statistics (mean and standard deviation). Categorical variables were evaluated using the Chi-Squared test and Fisher's Exact test when necessary and are expressed as frequency (n) and percentage (%).  $P < 0.05$  values were considered statistically significant.

## Results

### *Demographic Data*

A total of 1882 patients who underwent colonoscopy due to various reasons in the gastroenterology clinic of our hospital from 2017 to 2019 were included in the study. Of all patients, 990 (52.6%) were male and 892 (47.4%) were female. Demographic data of groups are given in Table 1. No significant difference was found between the groups in terms of age or sex ( $p > 0.05$ ).

**Table 1.** Demographic and Clinical Features of the Groups

<b>Demographic Features</b>	<b>&lt; 45 yo n=1078</b>	<b>≥ 45 yo n=804</b>	<b>All patients n=1882</b>
<b>Gender n (%)</b>			
Female	460 (42.7)	432 (53.7)	892 (52.6)
Male	618 (57.3)	372 (46.3)	990 (47.4)
<b>Mean age (mean±SD)</b>	34.5+5.8	54.7+6.5	43.1+11.7
<b>Smoking n (%)</b>			
Yes	162 (15)	112 (13.9)	274 (14.6)
No	916 (85)	692 (86.1)	1608 (85.4)
<b>Alcohol</b>			
Yes	42 (3.9)	20 (2.5)	62 (3.3)
No	1036 (96.1)	784 (97.5)	1820 (96.7)
<b>Family History</b>			
Yes	62 (5.8)	62 (7.7)	124 (6.6)
No	1016 (94.2)	742 (92.3)	1758 (93.4)
<b>Polyp localization</b>			
Rectum	216 (20)	144 (19.2)	370 (19.6)
Sigmoid colon	84 (7.8)	132 (16.4)	216 (11.5)
<b>Colonoscopy indications</b>			
Anemia	98 (9.1)	100 (12.4)	198 (10.5)
Abdominal pain	458 (42.5)	306 (38.1)	764 (40.5)
<b>Pathological finding in colonoscopy</b>			
Normal	482 (44.7)	352 (43.8)	834 (44.3)
Polyps	346 (32.1)	348 (43.3)	694 (36.9)
<b>Polyp types</b>			
Neoplastic	114 (10.6)	178 (22.1)	292 (15.5)
Nonneoplastic	232 (21.5)	170 (21.1)	402 (21.3)

The rate of smoking was found to be 13.9% in the ≥45 yo group and 15% in the <45 yo group. The rate of alcohol consumption was found to be 2.5% in the ≥45 yo group and 3.9% in the <45 yo group.

### ***Colonoscopy Data***

When data about colonoscopy procedures were examined, family history was found in 124 (6.6%) patients and 1870 (99.4%) patients underwent their first colonoscopy. Table 2 shows bowel cleanness status, family history, number of colonoscopies, and whether colonoscopy was completed for both groups.

**Table 2.** Colonoscopy data in ≥ 45 yo and < 45 yo patients

N(%)	< 45 N=1078	≥ 45 N=804	<u>AI Patients</u> <u>N=1882</u>
<b>Colon cleanness</b>			
Mild unclean	4(0,4)	20(2,5)	24(1,3)
Unclean	8(0,7)	18(2,2)	26(1,4)
Suboptimal	2(0,2)	2(0,2)	4(0,2)
Clean	1064(98,7)	764(95)	1828(97,1)
<b>Family history</b>			
Yes	62(5,8)	62(7,7)	128(6,6)
No	1016(94,2)	742(92,3)	1758(93,4)
<b>Number of colonoscopies</b>			
1	1068(99,1)	802(99,8)	1870(99,4)
2	8(0,7)	2(0,2)	10(0,5)
3	2(0,2)	0	2(0,1)
<b>Colonoscopy completed</b>			
Yes	1078(100)	804(100)	1882(100)

### ***Colonoscopy Findings***

Colonoscopy examination was normal in 834 of the patients (44.3%), while pathologic findings were found in 1048 (55.7%). When all patients were evaluated, the most common pathologic findings were found as polyps (36.9%) and hemorrhoids (9.9%). Distribution of pathologic findings is given in Table 3 for both groups.

**Table 3.** Pathologic findings in ≥ 45 yo and < 45 yo patients

Pathologic findings	< 45		≥ 45	
	N	%	N	%
<b>Anal fissure</b>	30	2.8	6	0.7
<b>Crohn</b>	86	8.0	18	2.2
<b>Crohn + polyp</b>	14	0.7	10	1.2
<b>Diverticular disease</b>	2	0.2	8	1.0
<b>Hemorrhoid</b>	90	8.3	58	7.2
<b>Hemorrhoid + polyp</b>	24	2.2	14	1.7
<b>Mass</b>	0	0	2	0.2
<b>Colon cancer</b>	1	0.2	2	0.2
<b>Polyp</b>	346	32.1	348	43.3
<b>Rectal ulcer</b>	0	0	2	0.2
<b>Ulcerative colitis</b>	42	3.9	10	1.2
<b>Ulcerative colitis + polyp</b>	2	0.2	0	0
<b>Normal</b>	482	44.7	352	43.8
<b>TOTAL</b>	1078	100	804	100

The localization of pathologic findings was found as rectum in 370 patients (19.6%), sigmoid colon in 216 (11.5%), descending colon in 136 (7.2%), transverse colon in 114 (6.1%), ascending colon in 104 (5.5%), and cecum in 62 (3.3%). Pathologic findings were observed in rectum in 19.2%, sigmoid colon in 16.4%, and descending colon in 10.2% of ≥45 yo patients. The localization of pathologic findings was found as rectum in 20% and sigmoid colon in 7.8% of <45 yo patients.

Colonic polyps were found in 36.9% of all patients included in this study. The rate of polyps was statistically significantly higher in ≥45 yo patients (43.3%) compared to <45 yo patients (32.1%) ( $p<0.001$ ).

Regarding the types of polyps detected during colonoscopy, in the ≥45 yo group, neoplastic polyps were found in 178 patients and non-neoplastic polyps were found in 170. In the <45 yo group, neoplastic polyps were found in 114 patients and hyperplastic polyps were found in 232. The rate of neoplastic polyps was statistically significantly higher in the ≥45 yo group compared to the <45 yo group ( $p<0.001$ ). No statistically significant difference was found between the two groups in terms of the rate of non-neoplastic polyps ( $p=0.309$ ).

Regarding the localizations of hyperplastic polyps, the most common polyp localizations were rectum and sigmoid colon in all age groups. In patients under 45 years of age, we observed 6 tubular polyps in

the rectum and sigmoid colon and 16 high-grade dysplasia polyps and 1 colon cancer in the ascending colon. In patients over 45 years of age, we found 34 high-grade dysplasia polyps and 2 colon cancers. The rate of having more than 3 polyps was found as 24.9% in  $\geq 45$  yo patients and 18.1% in  $< 45$  yo patients. The difference between the groups was statistically significant ( $p=0.002$ ).

There was a statistically significant difference between  $\geq 45$  yo and  $< 45$  yo patients in terms of the number of polyps found by three examiners. Accordingly, the number of polyps found by the first examiner was significantly higher compared to the second and third examiners ( $p<0.001$ ). There was a statistical significance in the numbers of neoplastic and hyperplastic polyps found by the three examiners. The rate of detection of neoplastic and hyperplastic polyps was statistically significantly higher in the first examiner compared to the other examiners ( $p<0.001$  for all). Colonoscopy durations were evaluated by an independent nurse and the mean colonoscopy duration was found to be longer in the first examiner compared to the other examiners.

The numbers of polyps were evaluated according to the demographic data of the patients. No statistically significant difference was found between the sexes in terms of the number of polyps ( $p=0.088$ ). Also, no significant difference was found in polyp numbers according to smoking or alcohol use ( $p=0.874$  and  $p=0.488$ , respectively). Similarly, there was no significant difference in polyp numbers according to family history ( $p=0.222$ ). Again, no significant difference was found between patients with and without alarm symptoms in terms of polyp numbers ( $p=0.306$ ).

According to the results of ROC analysis performed to determine the critical age that can pose a risk for the number of polyps, A cut-off value of 29.5 years was found to create a risk for a high number of polyps with a sensitivity of 98.6% and a specificity of 91.4% ( $AUC=0.590$ ,  $p=0.018$ ) (Figure 3).

## Discussion

Colorectal cancer is becoming a life-threatening disease for young adults, because it is often diagnosed in an advanced stage. In this study, we investigated whether colonoscopy screening for colonic polyps should be made at an earlier age than reported in the current guidelines. Especially since neoplastic colon polyps have malignant potential, it is important to detect these polyps in a sufficiently early stage, when removal of these polyps with a simple procedure can prevent the development of colorectal cancer.

Most current international guidelines recommend the onset age of colonoscopy screening as 50 years of age in people with moderate risk. This is based on the increase of CRC incidence around 50 years of age. In 2009, the diagnosis of CRC was established in people aged 50 years and over by 90% [18]. In a study by Chen et al., one colonoscopy screening in unscreened 50-65 year-old population was expected to prevent mortality from CRC by 49% [19]. In the Canadian Task Force on Preventive Health Care (CTFPEC) guidelines (Canada), colonoscopy screening onset age is recommended as 50 years, allowing postponing of screening until 60 years of age [20].

In 2018, US Preventive Services Task Force (USPSTF) updated the onset age of colonoscopy screening as 45 years in patients with moderate risk [15]. In Saudi Arabia, the onset age of colonoscopy screening is recommended as 45 years, because the diagnosis of CRC is made in 55 years of age in Saudi women and 60 years of age in Saudi men [21]. Studies in the literature have reported that the incidence of CRC is increasing in parallel with the increasing incidences of sedentary lifestyle, obesity, and diabetes mellitus in young adults [22]. In 2013, 50310 people died from CRC in the USA and it has been reported that thousands of these people could be potentially saved with colonoscopy screening at an earlier age [23].

Studies from various countries have reported the incidence of CRC in people aged under 40 years. The incidence of CRC under 40 years of age was reported as 52% in a study from Pakistan [24], 39% in a study from India [25], 36% in a study from Iran [26], and 22% in a study from Korea [27]. In a study from Turkey, the incidence of early-onset CRC was reported as 20% in people aged under 40 years [28]. On the other hand, the incidence of CRC under 50 years of age was reported as 10% in a study from the USA [29], while this rate was reported as 5% in a study from the UK [30]. It is seen that the incidence of CRC in young adults is higher in developing countries compared to developed countries. We attribute this to colonoscopy screening programs being more common in developed countries.

The European Society of Gastrointestinal Endoscopy (ESGE) recommend to evaluate bowel cleanness during colonoscopy and appropriate or good cleanliness should be reported in at least 90% of screenings [31]. In our study, bowel cleanliness, which is among the factors affecting the quality of colonoscopy, was near 100% in all patients.

In a recent study, it was reported that at least 1 polyp was detected in 34.3% of patients undergoing colonoscopy screening [32]. Similarly, in our study, we found at least 1 polyp in 36.9% of patients undergoing colonoscopy.

In our study, the most common indications of colonoscopy in <45 yo patients were found as abdominal pain in 43%, changed bowel habits in 21%, rectal bleeding in 20%, and anemia in 10%. In a study by Mikaeel et al. on colorectal cancer in young adults, indications of colonoscopy in patients aged under 50 years were found as rectal bleeding in 51%, abdominal pain in 16%, anemia in 16%, and changes in bowel habits in 13% [33]. We believe that although the indications in our study were similar to those of the mentioned study, the differences between the rates might have resulted from different sociocultural characteristics and lifestyles between the countries.

Based on the updated recommendations in recent guidelines for performing colonoscopy at an earlier age, we divided our patients into two groups as  $\geq 45$  yo and <45 yo and evaluated the data again between these two groups. The presence of polyps and neoplastic polyps was statistically significantly higher in the  $\geq 45$  yo group compared to the <45 yo group. However, colonoscopy was performed in 1078 patients in the <45 yo group (52.3%) and pathologic findings were detected in 55.3% of these patients. In a study by Peñaloza et al. in 2017, a total of 411 colonoscopies were analyzed and pathologic findings were observed in 44% of cases. The highest rate of pathologic findings was found in the 41-50-year-old age group [34].

In our study, the most common localization of pathologic findings was rectum (19.6%), followed by sigmoid colon (11.5%). In study of Peñaloza et al., the most common localization was found as sigmoid colon as well [34]. Given that serrated adenomas are more common on the right side, the rate of pathologic findings detected in sigmoid colon was remarkable. Also, recent studies have shown that hyperplastic polyps at the right side of the intestines may have malignant potential and should be closely followed up [5]. In our study, more than 5% of the hyperplastic polyps were localized in the cecum, ascending colon, and transverse colon at the right side.

Overall, no statistically significant difference was found between patients with and without alarm symptoms (weight loss, anemia, etc.). This indicates that performing colonoscopy screening only in patients with alarm symptoms brought the possibility of missing polyps in other patient groups. Therefore, we think that colonoscopy screening should be performed not only in patients with alarm symptoms, but in all patients presenting with lower gastrointestinal complaints.

In our study, there was a significant difference between the numbers of polyps detected by the three examiners. Accordingly, the first examiner found a higher number of polyps than the other examiners. We believe this was resulted from longer colonoscopy durations.

A ROC analysis was performed to determine the cut-off value for the age that creates a risk for a high number of polyps. As a result of this analysis, a cut-off value of 29.5 years was found to create a risk for a high number of polyps with a sensitivity of 98.6% and a specificity of 91.4%. We think that this result suggests the importance of colonoscopy screening at an earlier age.

## Conclusions

Given the increasing incidence of early-onset CRC worldwide, colonoscopy screening should be performed in young adults without alarm symptoms who present with lower gastrointestinal complaints. The current guidelines recommend the age of starting colonoscopy screening as 50 years. However, as seen in our study, polyps can be found at an earlier age. Therefore, based on our findings, we believe that colonoscopy screening should be started at 45 years of age, given the increasing incidence of early-onset colorectal cancer. In order to update the current guidelines and to set an earlier age for colonoscopy screening for polyps, sufficient evidence should be accumulated in the literature on this subject. We believe that our paper will contribute to further comprehensive research on the matter.

## Declarations

**Ethics approval and consent to participate:** Before the beginning of the study, necessary approval was received from the local ethics committee of the Sakarya University Training & Research Hospital.

**Consent for publication:** N/A

**Availability of data and materials:** Data used in this study are included within the text.

**Competing Interests:** The authors declare no conflict of interest to declare

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**Authors' Contributions:** MFA designed, executed the study, analyzed the results, MAA performed interpretation and supervision of the study.

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## References

1. <https://ecis.jrc.ec.europa.eu/> (Access date: 17/11/2019).
2. Ferlay J, Soerjomataram I, Dikshit R, et al. Cancer incidence and mortality worldwide: sources, methods and major patterns in GLOBOCAN 2012. *Int J Cancer*. 2015;136:E359-E386.
3. Gonzales-Peralta RP, Anderson JM: Polyps and polyposis syndromes; in Wyllie R (ed): *Pediatric Gastrointestinal Disease: Pathophysiology, Diagnosis and Management*, ed 2. Philadelphia, Saunders, 1999, pp 443– 453.
4. Cooper HS: Intestinal neoplasms; in Sternberg SS (ed): *Diagnostic Surgical Pathology*, ed 3. Philadelphia, Lippincott Williams & Wilkins, 1999, pp 1413–1436.
5. Baran B, Mert Ozupek N, Yerli Tetik N, Acar E, Bekcioglu O, Baskin Y. Difference Between Left-Sided and Right-Sided Colorectal Cancer: A Focused Review of Literature. *Gastroenterology Res*. 2018 Aug;11(4):264-273.
6. Spring KJ, Zhao ZZ, Karamatic R, et al. High prevalence of sessile serrated adenomas with BRAF mutations: a prospective study of patients undergoing colonoscopy. *Gastroenterology*. 2006 Nov. 131(5):1400-7.
7. Stryker SJ, Wolff BG, Culp CE, et al. Natural history of untreated colonic polyps. *Gastroenterology*. 1987 Nov. 93(5):1009-13.
8. Acheson AG, Scholefield JH. Colorectal cancer: screening and surveillance. In: Hawkey CJ, Bosch J, Richter JE, García-Tsá G, Chan FKL, editors. *Textbook of Clinical Gastroenterology and hepatology*. 2nd ed. Oxford: Wiley-Blackwell; 2012. p. 438-443.
9. Bailey CE, Hu C-Y, You YN, Bednarski BK, RodriguezBigas MA, Skibber JM, Cantor SB and Chang GJ (2015). Increasing disparities in the age-related incidences of colon and rectal cancers in the United States, 1975-2010. *JAMA Surg* 150, 17 –22.
10. Bleyer A, Barr R, Ries L, Whelan J and Ferrari A, eds (2017) *Cancer in Adolescents and Young Adults*. Cham: Springer International Publishing.
11. Hessami Arani S and Kerachian MA (2017). Rising rates of colorectal cancer among younger Iranians: is diet to blame? *Curr Oncol* 24, e131–e137.
12. Troeung L, Sodhi-Berry N, Martini A, Malacova E, Ee H, O'Leary P, Lansdorp-Vogelaar I and Preen DB (2017) Increasing incidence of colorectal cancer in adolescents and young adults aged 15-39 years

- in Western Australia 1982-2007: examination of colonoscopy history. *Front Public Health* 5, 179.
13. Levin B, Lieberman DA, McFarland B, Smith RA, Brooks D, Andrews KS et al. Screening and surveillance for the early detection of colorectal cancer and adenomatous polyps, 2008: a joint guideline from the American Cancer Society, the US Multi-Society Task Force on Colorectal Cancer, and the American College of Radiology. *CA Cancer J Clin.* 2008 May-Jun;58(3):130-60.
  14. Lieberman DA, Rex DK, Winawer SJ, Giardiello FM, Johnson DA, Levin TR. Guidelines for colonoscopy surveillance after screening and polypectomy: a consensus update by the US Multi-Society Task Force on Colorectal Cancer. *Gastroenterology.* 2012 Sep;143(3):844-857.
  15. <https://www.uspreventiveservicestaskforce.org/Page/Document/UpdateSummaryFinal/colorectal-cancer-screening> (Access date: 17/11/2019).
  16. Austin H, Henley SJ, King J, Richardson LC, Ehemann C. Changes in colorectal cancer incidence rates in young and older adults in the United States: what does it tell us about screening. *Cancer Causes Control* (2014) 25(2):191–201.
  17. Ahnen DJ, Wade SW, Jones WF, Sifri R, Silveiras JM, Greenamyre J, et al., editors. The increasing incidence of young-onset colorectal cancer: a call to action. *Mayo Clinic Proceedings.* Denver: Elsevier (2014).
  18. Hagggar FA, Boushey RP. Colorectal cancer epidemiology: incidence, mortality, survival, and risk factors. *Clin Colon Rectal Surg* 2009; 22: 191-197.
  19. Chen C, Stock C, Hoffmeister M, Brenner H. Optimal age for screening colonoscopy: a modeling study. *Gastrointest Endosc.* 2019 May;89(5):1017-1025.
  20. Canadian Task Force on Preventive Health Care, Bacchus CM, Dunfield L, Gorber SC, Holmes NM, Birtwhistle R, Dickinson JA, Lewin G, Singh H, Klarenbach S, Mai V, Tonelli M. Recommendations on screening for colorectal cancer in primary care. *CMAJ* 2016; 188: 340-348.
  21. Alsanea N, Almadi MA, Abduljabbar AS, Alhomoud S, Alshaban TA et al. National Guidelines for Colorectal Cancer Screening in Saudi Arabia with strength of recommendations and quality of evidence. *Ann Saudi Med* 2015; 35: 189-195
  22. Dennis J. et al. The Increasing Incidence of Young-Onset Colorectal Cancer: A Call to Action. *Mayo Clinic Proceedings* 2014 Feb; 89(2): 216 – 224.
  23. Colditz GA, Atwood KA, Emmons K, Monson RR, Willett WC, Trichopoulos D et al. Harvard report on cancer prevention volume 4: Harvard Cancer Risk Index. Risk Index Working Group, Harvard Center for Cancer Prevention. *Cancer Causes Control.* 2000 Jul;11(6):477-88.
  24. Amini AQ, Samo KA and Memon AS. (2013). Colorectal cancer in younger population: our experience. *J Pak Med Assoc.* 63(10): 1275-1277.
  25. Gupta S, Bhattacharya D, Acharya A, Majumdar S, et al. (2010). Colorectal carcinoma in young adults: a retrospective study on Indian patients: 2000–2008. *Colorectal Dis.* 12(10 Online): e182-e189.
  26. Fazeli MS, Adel MG and Lebaschi AH. (2007). Colorectal carcinoma: a retrospective, descriptive study of age, gender, subsite, stage, and differentiation in Iran from 1995 to 2001 as observed in

Tehran University. Dis Colon Rectum. 50(7): 990-995.

27. Chung SJ, Kim YS, Yang SY, Song JH, et al. (2010). Prevalence and risk of colorectal adenoma in asymptomatic Koreans aged 40-49 years undergoing screening colonoscopy. J Gastroenterol Hepatol. 25(3): 519-525.
28. Zorluoglu A, Yilmazlar T, Ozguc H, Bagcivan E, et al. (2004). Colorectal cancers under 45 years of age. Hepatogastroenterology. 51(55): 118-120.
29. Crosbie AB, Roche LM, Johnson LM, Pawlish KS, et al. (2018). Trends in colorectal cancer incidence among younger adults-Disparities by age, sex, race, ethnicity, and subsite. Cancer Med. 7(8): 4077-4086.
30. <https://bowelcancerorguk.s3.amazonaws.com/Test%20images/NeverTooYoungreport2015.pdf> (Access Date: 19/11/2019).
31. Burke CA, Church JM. Enhancing the quality of colonoscopy:the importance of bowel purgatives.Gastrointest Endosc 2007; 66:565–573
32. Reinhart K, Bannert C, Dunkler D et al. Prevalence of flat lesions in a large screening population and their role in colonoscopy quality improvement. Endoscopy 2013;45:350–56.
33. Mikaeel RR. (2019). Colorectal Cancer in Australian Young Adults. Mathews J Cancer Sci. 4(1): 1-18
34. Melo-Peñaloza MA. Results of total colonoscopy in the diagnosis of polyps. Case studies in Villavicencio, Colombia. Rev. Fac. Med. 2017;65(3):433-9.

## Figures

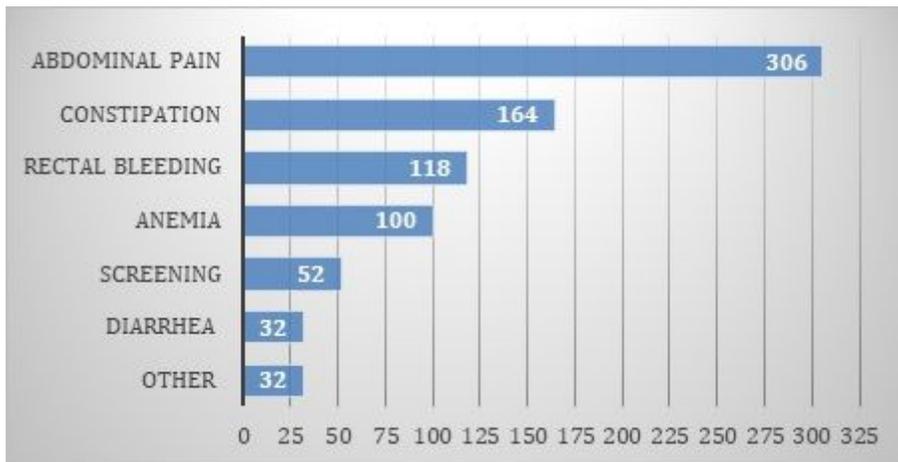
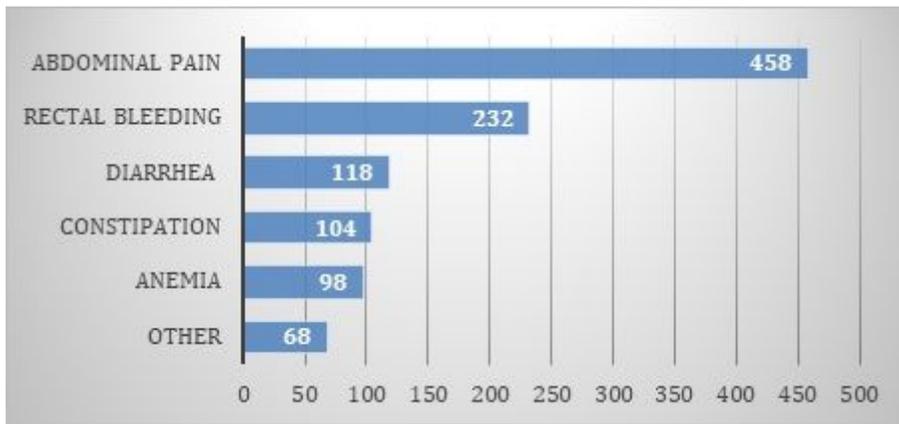


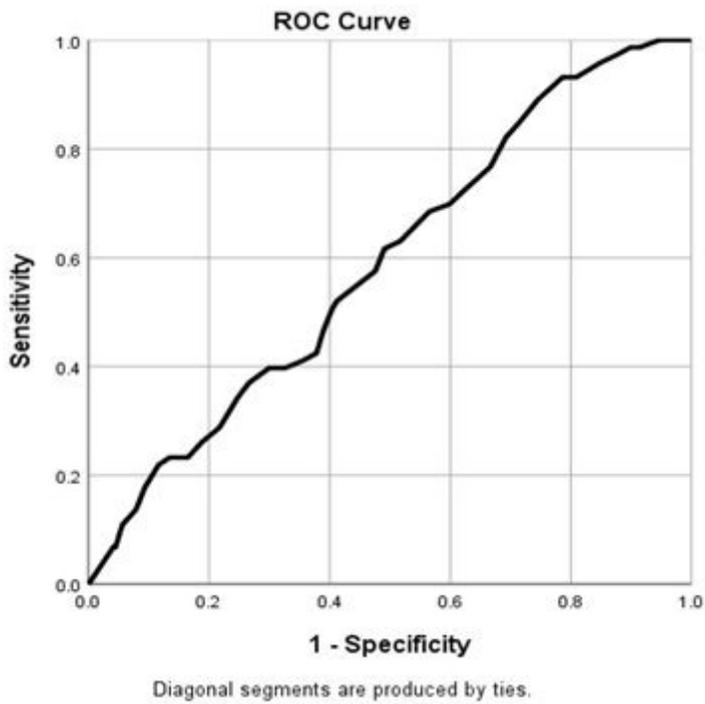
Figure 1

Colonoscopy indications in  $\geq 45$  yo patients



**Figure 2**

Colonoscopy indications in < 45 yo patients



**Figure 3**

ROC analysis performed to determine age cut-off that creates a risk for high number of polyps.