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The elderly population are more vulnerable for the management of colorectal cancer during the COVID-19 pandemic: a nationwide, population-based study

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Background/Aims: The impact of coronavirus disease 2019 (COVID-19) on the management of colorectal cancer (CRC) may worse in elderly population, as almost all COVID-19 deaths occurred in the elderly patients. This study aimed to evaluate the impact of COVID-19 on CRC management in the elderly population. **Methods:** The numbers of patients who underwent colonoscopy, who visited hospitals or operated for CRC in 2020 and 2021 (COVID-19 era) were compared with those in 2019, according to 3 age groups (≥ 70 years, 50–69 years, and ≤ 49 years), based on the nationwide, population-based database (2019–2021) in South Korea. **Results:** The annual volumes of colonoscopy and hospital visits for CRC in 2020 were more significantly declined in the old age group than in the young age group (both $P < 0.001$). In addition, the annual volume of patients operated for CRC numerically more declined in old age group than in young age group. During the first surge of COVID-19 (March and April 2020), old age patients showed statistically significant declines for the monthly number of colonoscopies (-46.5% vs. -39.3% , $P < 0.001$), hospital visits (-15.4% vs. -7.9% , $P < 0.001$), CRC operations (-33.8% vs. -0.7% , $P < 0.05$), and colonoscopic polypectomies (-41.8% vs. -38.0% , $P < 0.001$) than young age patients, compared with those of same months in 2019. **Conclusions:** Elderly population are more vulnerable for the management of CRC during the COVID-19 pandemic. Therefore, the elderly population are more carefully cared for in the management of CRC during the next pandemic. (Intest Res 2023;21:500-509)

Key Words: Age groups; Colonoscopy; Colorectal neoplasms; COVID-19; Mass screening

INTRODUCTION

In South Korea, the first case of novel coronavirus disease 2019 (COVID-19) was reported on January 20, 2020.¹ After the declaration of the COVID-19 pandemic by the World Health Organization on March 12, 2020, several outbreaks of the COVID-19 occurred in South Korea between 2020 and 2021. The American Gastroenterological Association recommended that all elective procedures, such as screening and surveillance colo-

noscopy, should be delayed in asymptomatic patients during the COVID-19 pandemic.² The Korean Cancer Association guidelines also recommended that colorectal cancer (CRC) screening should be determined according to the shortage of medical resources and the COVID-19 status of the region.³ Therefore, the COVID-19 pandemic has declined the number of screening and management of CRC in the world.^{4,5}

The impact of COVID-19 on the screening and management of CRC may worse in elderly population than in younger population, as almost all COVID-19 deaths occurred in elderly patients.^{6,7} In a systematic review and meta-analysis of 42 studies with 423,117 patients, elderly patients had increased mortality due to COVID-19 with a pooled odds ratio of 2.6, and a hazard ratio of 1.3.⁶ In other systematic review and meta-analysis of

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59 studies, elderly patients (≥ 70 years) had a higher infection risk with a relative risk (RR) of 1.7, a higher risk for severe COVID-19 disease with a RR of 2.1, an increased need for intensive care with a RR of 2.7, and a higher mortality with a RR of 3.6, compared with patients younger than 70 years.⁷ Currently, no population-based studies have quantified the negative effect of COVID-19 on the management of CRC in the elderly population. A better understanding of the impact of the COVID-19 pandemic on colonoscopy and CRC management in the elderly population may be the first step toward the successful rearrangement of medical resources for the elderly population.

This study aimed to evaluate the impact of the COVID-19 pandemic on colonoscopy and CRC management in the elderly population.

METHODS

1. Data Source

This was a nationwide population-based study using the Health Insurance Review and Assessment (HIRA) database of South Korea. In South Korea, the National Health Insurance (NHI) program covers approximately 98% of the total population with universal health coverage.^{8,9} All healthcare providers and all Koreans are required to be covered under the NHI program, which is based on fee-for-services.⁹ HIRA data is generated in the process of reimbursing providers under the NHI and contains comprehensive information on the relevant healthcare services, including various procedures, operations, examinations, treatments, and prescriptions.⁹ Procedure codes in physician claims databases had a very high level of agreement with data in medical charts. The index date for extracting the study data from the HIRA database was August 1, 2022.

2. Study Population

In this study, the COVID-19 era was defined as the period from January 1, 2020 to December 31, 2021, as the first case of COVID-19 was reported in January 2020 and several outbreaks had continued to December 2021. In South Korea, the first surge of COVID-19 was encountered at March and April 2020 with the implementation of social distancing. During the COVID-19 era, the Korean government offered guidance on changes in standard medical practices to minimize COVID-19 transmission. As a result, many Koreans postponed colonoscopy to avoid exposure to COVID-19,² and CRC patients also delayed their hospital visit and operations for the CRC during the CO-

VID-19 era.

We compared the claims of colonoscopy, hospital visit for CRC, and operations for CRC during the COVID-19 era (2020–2021) and pre-COVID-19 era (2019) as a reference. In this study, 3 age groups were defined as follows: young age (≤ 49 years), middle age (50–69 years), and old age (≥ 70 years) population. The young and middle age cutoff was based on the official age (50 years) for CRC screening in guidelines.¹⁰ The middle age and old age cutoff were based on a systematic review and meta-analysis, which reported that patients aged ≥ 70 years had a higher rate of COVID-19 infection, severe COVID-19 disease, an increased need for intensive care, and higher mortality compared with patients younger than 70 years.⁷ As the information used in this study was related only to pseudonyms, the requirement for informed consent was waived. This study was approved by the Institutional Review Board of Kyung Hee University Hospital at Gangdong, Seoul, Republic of Korea (IRB number: KHNMC 2022-05-045).

3. Definition of Variables

Data in this study were extracted using the HIRA claim codes.¹¹ Colonoscopy was defined as colonoscopy without polypectomy (E7660). Colonoscopic polypectomies were defined as a single polypectomy (Q7701), 2 or more polypectomies (Q7702), endoscopic mucosal resection (Q7703), or endoscopic submucosal dissection (QX706). Colonoscopic procedures were analyzed per patient because some patients underwent multiple colonoscopic procedures. CRC was defined as C18 (malignant neoplasm of the colon), C19 (malignant neoplasm of the rectosigmoid junction), C20 (malignant neoplasm of the rectum), and carcinoma *in situ* of the colon and rectum (D010, D011, and D012) based on the major diagnostic codes of the International Classification of Diseases, ninth revision codes. CRC claim codes in South Korea are reliable, as they are strictly registered in the HIRA system because CRC patients pay only 5% of their medical costs for 5 years by co-payment policy. CRC operations were defined as colectomy (QA671, QA672, QA673, QA679, Q2671, Q2672, Q2673, Q2679, Q1261, or Q1262) and/or surgical resection of the rectum/sigmoid colon (QA921, QA922, QA923, QA924, Q2921, Q2922, Q2923, Q2924, Q2927, Q9292, QA928, or Q2928) in patients with CRC (Supplementary Table 1).

4. Statistical Analysis

The data during the COVID-19 era (2020–2021) were compared with the results of the same periods in 2019 for monthly

and annual comparisons. For the monthly comparison, monthly data of 2019 were compared with those in 2020 and 2021. Descriptive analysis was performed on the entire population during the study period. Annual or monthly comparative analysis between 2 groups were done using the chi-square tests. All statistical tests were two-sided, and a P -value of <0.05 was considered statistically significant. All statistical analyses were conducted using the R software package (R Foundation for Statistical Computing, Vienna, Austria; <http://www.R-project.org>).

RESULTS

1. Claim Data of Colonoscopy

The annual volumes of colonoscopies decreased by 8.7%, 7.0%, and 2.6% in the young age, middle age, and old age groups, respectively, in 2020 compared with those in 2019 (Table 1). The annual volumes of colonoscopies in 2020 significantly declined in middle and old age groups than those in young age group (both $P<0.001$). However, the annual volumes of colonoscopies in 2021 increased in all age groups compared with those

in 2019. During the first surge of COVID-19 (March–April 2020), the monthly number of colonoscopies decreased in all age groups compared with those in 2019, however, they declined more significantly in middle and old age groups than those in young age group (all $P<0.05$) (Fig. 1). After the first surge of COVID-19 in 2020, the monthly number of colonoscopies slowly recovered in all age groups compared with those in 2019 (Fig. 2).

2. Claim Data of Hospital Visit for CRC

The annual volume of hospital visit for CRC decreased by 1.8%, 2.5%, and 3.6% in the young age, middle age, and old age groups, respectively, in 2020 compared with those in 2019 (Table 2). The annual volumes of hospital visit for CRC significantly declined in 2020 in old age group than those in young age group ($P<0.05$). In 2021, the annual volume of hospital visit for CRC was significantly less recovered in old age group than young age group (2.4% vs. 11.6%, $P<0.05$), compared with those in 2019. During the first surge of COVID-19, the monthly number of hospital visit for CRC were more significantly declined in old age group than young age group ($-15.4%$ vs. $-7.9%$, $P<$

Table 1. Number of Patients Who Underwent Colonoscopy^a

Group	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Young age													
2019	46,502	37,854	41,126	41,725	40,790	39,623	46,073	48,838	41,409	51,223	61,418	66,936	563,517
2020	43,474	36,606	24,972	28,983	35,736	41,383	44,894	45,751	45,371	45,104	59,437	62,914	514,625
Change (%) ^b	-6.5	-3.3	-39.3	-30.5	-12.4	+4.4	-2.6	-6.3	+9.6	-11.9	-3.2	-6.0	-8.7
2021	45,815	39,894	45,818	47,349	44,327	55,123	53,006	51,858	42,190	47,982	62,119	70,987	606,468
Change (%) ^b	-1.5	+5.4	+11.4	+13.5	+8.7	+39.1	+15.0	+6.2	+1.9	-6.3	+1.1	+6.1	+7.6
Middle age													
2019	76,230	63,451	80,500	80,814	79,534	74,638	87,650	89,389	71,612	94,330	103,402	105,251	1,006,801
2020	68,986	61,109	44,025	53,374	70,139	81,469	90,216	88,460	80,006	87,673	106,584	104,237	936,278
Change (%) ^b	-9.5 ^d	-3.7 ^e	-45.3 ^d	-34.0 ^d	-11.8 ^e	+9.2 ^d	+2.9 ^d	-1.0 ^d	+11.7 ^c	-7.1 ^d	+3.1 ^d	-1.0 ^d	-7.0 ^d
2021	75,182	65,260	91,606	93,098	85,321	91,612	93,734	84,013	72,135	97,644	114,145	117,154	1,080,904
Change (%) ^b	-1.4 ^e	+2.9 ^c	+13.8 ^e	+15.2 ^e	+7.3 ^e	+22.7 ^d	+6.9 ^d	-6.0 ^d	+0.7 ^e	+3.5 ^d	+10.4 ^d	+11.3 ^d	+7.4 ^e
Old age													
2019	18,712	15,713	23,306	24,160	22,904	20,338	22,196	18,593	17,319	22,693	21,205	20,082	247,221
2020	17,626	15,398	12,480	16,277	21,761	25,378	24,776	19,896	18,895	21,852	24,442	22,054	240,835
Change (%) ^b	-5.8 ^e	-2.0 ^e	-46.5 ^d	-32.6 ^e	-5.0 ^d	+24.8 ^d	+11.6 ^d	+7.0 ^d	+9.1 ^e	+3.7 ^d	+15.3 ^d	+9.8 ^d	-2.6 ^d
2021	19,065	16,486	27,805	27,301	22,566	22,914	24,086	20,047	19,610	25,788	26,121	24,024	275,813
Change (%) ^b	+1.9 ^c	+4.9 ^e	+19.3 ^d	+13.0 ^e	-1.5 ^d	+12.7 ^d	+8.5 ^d	+7.8 ^e	+13.2 ^d	+13.6 ^d	+23.2 ^d	+19.6 ^d	+11.6 ^d

^aColonoscopy was defined as colonoscopy without any therapeutic interventions (E7660).

^bChange (%) means the percentage of change in 2020 or 2021 compared to that of 2019.

^{c-c}Statistical significance was expressed with ^c $P<0.05$, ^d $P<0.001$, ^e $P\geq 0.05$ (no significance).

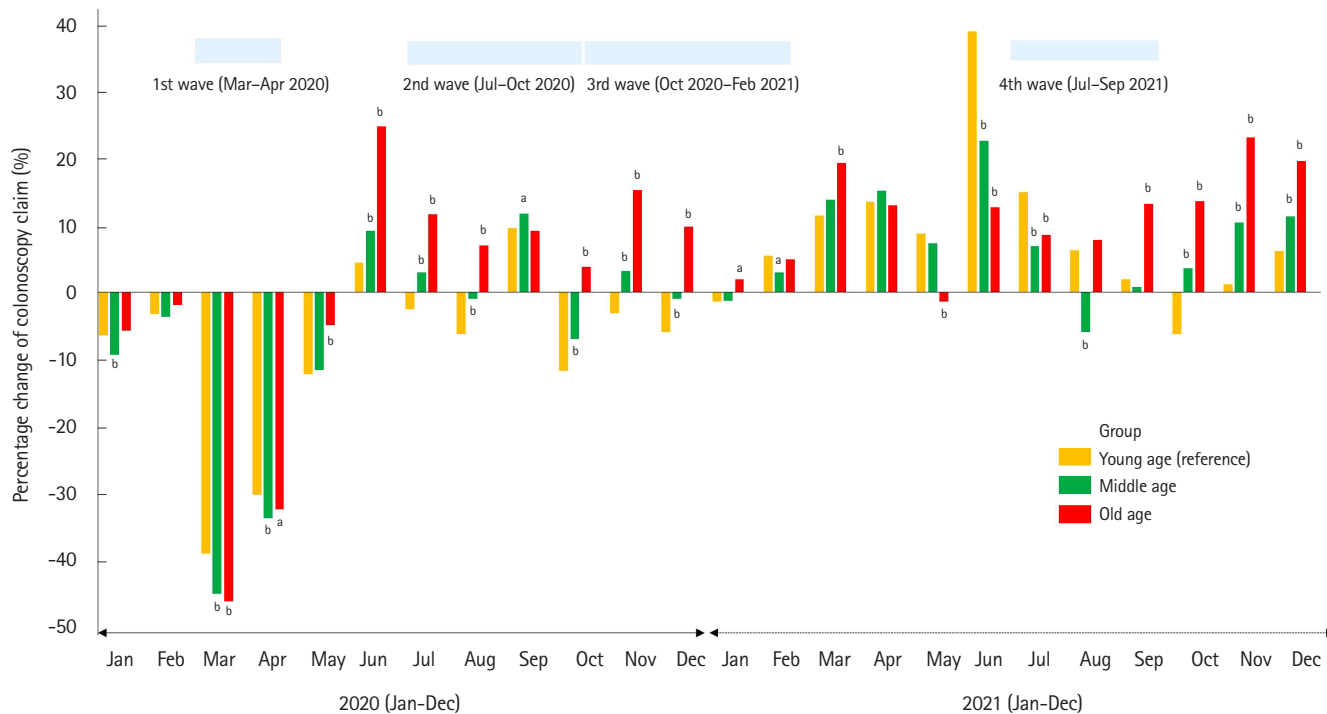


Fig. 1. The monthly change (%) of colonoscopy, hospital visit for colorectal cancer (CRC) and operation for CRC during the first surge of coronavirus disease 2019 (March and April of 2020), compared with those in 2019, more significantly declined in middle and old age groups than young age group (reference). Their statistical significance was expressed with $^aP < 0.05$, $^bP < 0.001$.

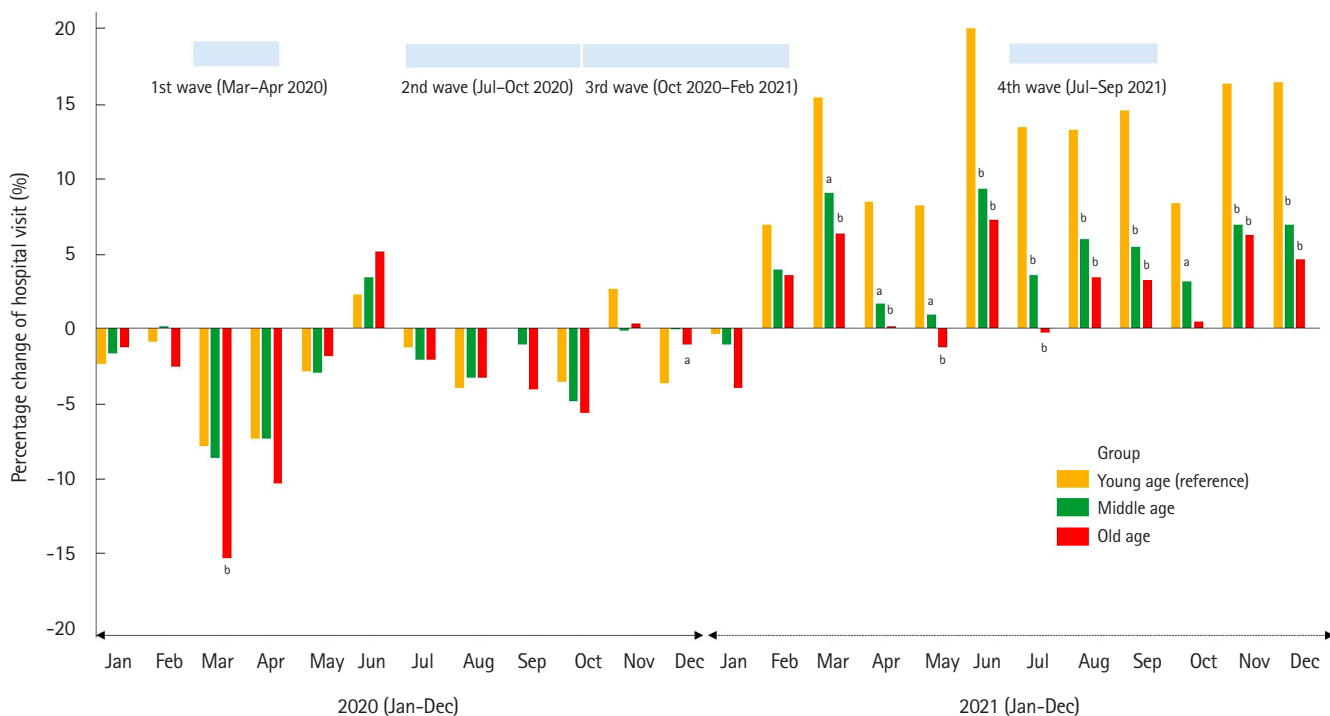


Fig. 2. The percentage change of colonoscopy claim in 2020 and 2021, compared to those of 2019, were more significantly declined in middle and old age groups than those in young age group in the first epidemic wave, but slowly recovered in all age groups even in the 2nd-4th epidemic waves. Statistical significance was expressed with $^aP < 0.05$, $^bP < 0.001$.

Table 2. Number of Patients Who Visited Hospital for Colorectal Cancers^a

Group	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Young age													
2019	4,779	4,249	4,310	4,482	4,316	4,294	4,535	4,448	4,303	4,576	4,491	4,590	53,373
2020	4,663	4,212	3,969	4,149	4,191	4,388	4,476	4,271	4,301	4,410	4,609	4,759	52,398
Change (%) ^b	-2.4	-0.9	-7.9	-7.4	-2.9	+2.2	-1.3	-4.0	0.0	-3.6	+2.6	-3.7	-1.8
2021	4,759	4,541	4,973	4,860	4,671	5,155	5,141	5,034	4,927	4,957	5,221	5,341	59,580
Change (%) ^b	-0.4	+6.9	+15.4	+8.4	+8.2	+20.1	+13.4	+13.2	+14.5	+8.3	+16.3	+16.4	+11.6
Middle age													
2019	25,931	23,214	24,638	24,965	24,592	24,011	25,455	24,158	23,841	25,323	24,951	25,553	296,632
2020	25,487	23,242	22,487	23,122	23,842	24,835	24,908	23,354	23,575	24,071	24,893	25,534	289,350
Change (%) ^b	-1.7 ^c	+0.1 ^c	-8.7 ^c	-7.4 ^c	-3.0 ^c	+3.4 ^c	-2.1 ^c	-3.3 ^c	-1.1 ^c	-4.9 ^c	-0.2 ^c	-0.1 ^c	-2.5 ^c
2021	25,634	24,117	26,846	25,367	24,813	26,250	26,338	25,573	25,118	26,103	26,673	27,322	310,154
Change (%) ^b	-1.1 ^c	+3.9 ^c	+9.0 ^c	+1.6 ^c	+0.9 ^c	+9.3 ^d	+3.5 ^d	+5.9 ^c	+5.4 ^d	+3.1 ^c	+6.9 ^d	+6.9 ^d	+4.6 ^d
Old age													
2019	19,475	17,473	19,205	19,825	19,272	18,810	19,987	18,745	18,653	20,035	18,984	19,199	229,663
2020	19,220	17,027	16,244	17,757	18,906	19,760	19,577	18,120	17,890	18,891	19,044	18,986	221,422
Change (%) ^b	-1.3 ^c	-2.6 ^c	-15.4 ^d	-10.4 ^e	-1.9 ^c	+5.1 ^c	-2.1 ^c	-3.3 ^c	-4.1 ^c	-5.7 ^c	+0.3 ^c	-1.1 ^c	-3.6 ^c
2021	18,700	18,093	20,415	19,841	19,021	20,156	19,936	19,391	19,256	20,117	20,162	20,080	235,168
Change (%) ^b	-4.0 ^c	+3.5 ^e	+6.3 ^d	+0.1 ^d	-1.3 ^d	+7.2 ^d	-0.3 ^d	+3.4 ^d	+3.2 ^d	+0.4 ^d	+6.2 ^d	+4.6 ^d	+2.4 ^d

^aColorectal cancer was defined as colorectal cancers (C18, C19, C20) including carcinoma in situ of colon and rectum (D010, D011, D012).

^bChange (%) means the percentage of change in 2020 or 2021 compared to that of 2019.

^c $P < 0.05$, ^d $P < 0.001$, ^e $P \geq 0.05$ (no significance).

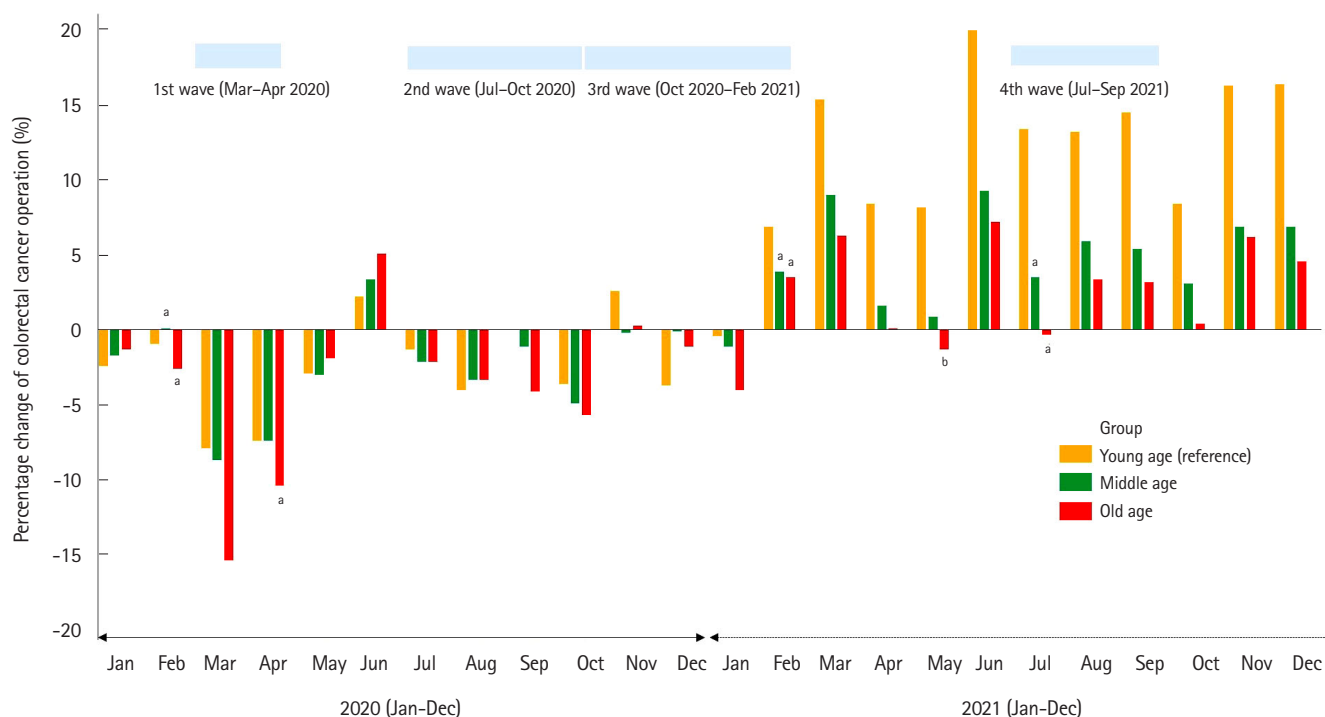


Fig. 3. The percentage change of hospital visit in 2020 and 2021, compared to those of 2019, were significantly declined in old age group than those in young age group in the first epidemic wave, but slowly recovered in all age groups even in the 2nd-4th epidemic waves. Statistical significance was expressed with ^a $P < 0.05$, ^b $P < 0.001$.

Table 3. Number of Patients Who Underwent Operations for Colorectal Cancers^a

Group	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Young age													
2019	192	161	157	147	167	162	152	175	159	146	160	154	1,932
2020	168	145	164	146	177	167	166	154	162	164	149	154	1,916
Change (%) ^b	-12.5	-9.9	+4.5	-0.7	+6.0	+3.1	+9.2	-12.0	+1.9	+12.3	-6.9	0.0	-0.8
2021	197	118	197	156	160	157	180	168	153	160	164	148	1,958
Change (%) ^b	2.6	-26.7	+25.5	+6.1	-4.2	-3.1	+18.4	-4.0	-3.8	+9.6	+2.5	-3.9	+1.3
Middle age													
2019	1,030	773	928	814	803	734	878	734	770	707	797	825	9,793
2020	956	949	893	660	708	760	759	690	700	745	821	809	9,450
Change (%) ^b	-7.2 ^c	+22.8 ^c	-3.8 ^c	-18.9 ^c	-11.8 ^c	+3.5 ^c	-13.6 ^c	-6.0 ^c	-9.1 ^c	+5.4 ^c	+3.0 ^c	-1.9 ^c	-3.5 ^c
2021	972	828	938	807	777	822	787	828	689	843	873	827	9,991
Change (%) ^b	-5.6 ^c	+7.1 ^c	+1.1 ^c	-0.9 ^c	-3.2 ^c	+12.0 ^c	-10.4 ^c	+12.8 ^c	-10.5 ^c	+19.2 ^c	+9.5 ^c	+0.2 ^c	+2.0 ^c
Old age													
2019	789	608	766	773	757	666	765	661	585	621	641	628	8,260
2020	643	709	658	512	683	736	685	585	631	649	661	626	7,778
Change (%) ^b	-18.5 ^c	+16.6 ^c	-14.1 ^c	-33.8 ^c	-9.8 ^c	+10.5 ^c	-10.5 ^c	-11.5 ^c	+7.9 ^c	+4.5 ^c	+3.1 ^c	-0.3 ^c	-5.8 ^c
2021	755	607	809	726	707	722	702	771	628	711	682	664	8,484
Change (%) ^b	-4.3 ^c	-0.2 ^c	+5.6 ^c	-6.1 ^c	-6.6 ^d	+8.4 ^c	-8.2 ^c	+16.6 ^c	+7.4 ^c	+14.5 ^c	+6.4 ^c	+5.7 ^c	+2.7 ^c

^aOperations for colorectal cancer was defined as colectomy (QA671, QA672, QA673, QA679, Q2671, Q2672, Q2673, Q2679, Q1261, Q1262) and/or surgical resection of rectum/sigmoid colon (QA921, QA922, QA923, QA924, Q2921, Q2922, Q2923, Q2924, Q2927, Q9292, QA928, Q2928) in patients with colorectal cancer.

^bChange (%) means the percentage of change in 2020 or 2021 compared to that of 2019.

^{c-c}Statistical significance was expressed with ^c $P < 0.05$, ^d $P < 0.001$, ^e $P \geq 0.05$ (no significance).

0.001 in March) (Fig. 1). After the first surge of COVID-19 in 2020, the monthly number of hospital visits slowly recovered in all age groups compared with those in 2019 (Fig. 3).

3. Claim Data of Operation for CRC

The annual volume of patients operated for CRC decreased by 0.8%, 3.5%, and 5.8% in the young age, middle age, and old age groups, respectively, in 2020 compared with those in 2019 (Table 3). The annual volume of patients operated for CRC numerically more declined in old age groups than those in young age group, however, did not reach statistical significance. The annual volumes of patients operated for CRC in 2021 increased in all age groups compared with those in 2019. During the first surge of COVID-19, the monthly number of patients operated for CRC in 2020 decreased in all age groups, compared with those in 2019. However, they declined more significantly in old age group than those in young age group (-33.8% vs. -0.7%, $P < 0.05$ in April) (Fig. 1). After the first surge of COVID-19 in 2020, the monthly number of patients operat-

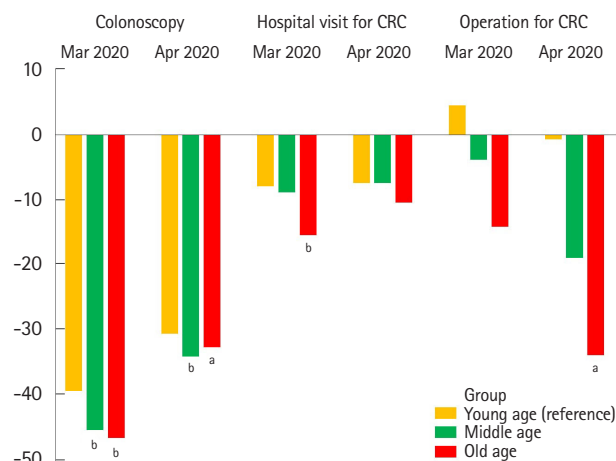


Fig. 4. The percentage change of colorectal cancer (CRC) operation in 2020 and 2021, compared to those of 2019, were significantly declined in old age group than those in young age group in the first epidemic wave, but slowly recovered in all age groups even in the 2nd-4th epidemic waves. Statistical significance was expressed with ^a $P < 0.05$, ^b $P < 0.001$.

Table 4. Number of Patients Who Underwent Colonoscopic Polypectomies^a

Group	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Young age													
2019	19,667	16,193	19,183	20,776	21,170	21,095	23,714	24,635	21,204	27,841	34,673	38,087	288,238
2020	20,669	18,578	13,000	15,836	19,726	24,052	26,861	27,022	28,507	29,829	40,072	43,074	307,226
Change (%) ^b	+5.1	+14.7	-32.2	-23.8	-6.8	14.0	13.3	9.7	34.4	7.1	15.6	13.1	+6.6
2021	27,176	23,032	28,545	31,424	30,679	38,345	36,220	36,182	30,651	36,415	47,912	54,991	421,572
Change (%) ^b	+38.2	+42.2	+48.8	+51.3	+44.9	+81.8	+52.7	+46.9	+44.6	+30.8	+38.2	+44.4	+46.3
Middle age													
2019	58,085	42,727	54,794	55,730	54,953	51,426	61,076	62,322	50,040	66,360	75,486	79,342	712,341
2020	58,234	45,538	33,979	41,481	54,486	63,656	71,353	70,216	63,989	70,351	86,738	89,946	749,967
Change (%) ^b	+0.3 ^d	+6.6 ^d	-38.0 ^d	-25.6 ^e	-0.8 ^d	+23.8 ^d	+16.8 ^c	+12.7 ^c	+27.9 ^d	+6.0 ^c	+14.9 ^c	+13.4 ^e	+5.3 ^d
2021	71,854	53,705	77,830	80,429	75,125	80,172	83,025	73,438	66,140	88,403	103,484	110,378	963,983
Change (%) ^b	+23.7 ^d	+25.7 ^d	+42.0 ^d	+44.3 ^d	+36.7 ^d	+55.9 ^d	+35.9 ^d	+17.8 ^d	+32.2 ^d	+33.2 ^c	+37.1 ^c	+39.1 ^d	+35.3 ^d
Old age													
2019	14,307	10,901	16,887	17,485	16,366	14,729	16,227	13,111	12,111	16,619	16,260	15,567	180,570
2020	14,649	11,804	9,836	12,992	17,295	19,807	19,740	15,618	15,525	17,476	20,182	19,053	193,977
Change (%) ^b	+2.4 ^e	+8.3 ^d	-41.8 ^d	-25.7 ^e	+5.7 ^d	+34.5 ^d	+21.6 ^d	+19.1 ^d	+28.2 ^c	+5.2 ^c	+24.1 ^d	+22.4 ^d	+7.4 ^c
2021	17,856	13,490	23,705	23,719	19,366	19,426	20,761	16,569	16,663	22,881	23,643	22,208	240,287
Change (%) ^b	+24.8 ^d	+23.8 ^d	+40.4 ^d	+35.7 ^d	+18.3 ^d	+31.9 ^d	+27.9 ^d	+6.4 ^d	+37.6 ^d	+37.7 ^d	+45.4 ^d	+42.7 ^c	+33.1 ^d

^aColonoscopic polypectomy was defined as single colonoscopic polypectomy (Q7701), multiple colonoscopic polypectomy (Q7702), endoscopic mucosal resection (Q7703) and endoscopic submucosal dissection (QX706).

^bChange (%) means the percentage of change in 2020 or 2021 compared to that of 2019.

^{c-c}Statistical significance was expressed with ^c $P < 0.05$, ^d $P < 0.001$, ^e $P \geq 0.05$ (no significance).

ed for CRC slowly recovered in all age groups compared with those in 2019 (Fig. 4).

4. Claim Data of Colonoscopic Polypectomy

The annual volumes of colonoscopic polypectomies increased in all age groups in 2020 and 2021 compared with those in 2019 (Table 4). During the first surge of COVID-19, the monthly number of colonoscopic polypectomies declined in all age groups compared with those in 2019, however, more significantly declined in middle and old age groups than young age group (both $P < 0.001$). After the first surge of COVID-19 in 2020, the monthly number of colonoscopic polypectomies rapidly recovered in all age groups compared with those in 2019.

DISCUSSION

This population-based study quantify the impact of the COVID-19 pandemic on colonoscopy and CRC management in elderly population. The annual volumes of colonoscopy and hos-

pital visits for CRC in 2020 were more significantly declined in old age group than in young age group. In addition, the annual volume of patients operated for CRC numerically more declined in old age group than in young age group. During the first surge of COVID-19 (March–April 2020), elderly subjects showed statistically significant declines for the monthly number of colonoscopies, hospital visits, CRC operations, and colonoscopic polypectomies than young age patients, compared with those in same month of 2019. Our study results were consistent with those of Western studies,^{12,13} in that the annual volume of colonoscopy and CRC management markedly decreased during the COVID-19. But, our notable finding was that elderly patients are more vulnerable for the management of CRC during the first surge of COVID-19 pandemic. In South Korea, the first surge of COVID-19 in March and April 2020 was followed by 2nd epidemic wave in July to October 2020, 3rd epidemic wave from November 2020 to February 2021 and 4th epidemic wave from July to September 2021.¹⁴ Despite several epidemic waves of COVID-19, colonoscopy and management of CRC were gradually unaffected by COVID-19 epidemic chang-

es after the first surge of COVID-19 in South Korea.

In recent studies,^{7,15-17} old age was an independent risk factor for COVID-19 mortality. In a UK-based study, elderly patients aged ≥ 75 years showed a 13-fold higher COVID-19 mortality risk compared with those aged < 65 years.¹⁵ In a systematic review and meta-analysis, individuals aged ≥ 75 years had a 3.4-fold higher risk for COVID-19 mortality.¹⁶ Based on 178,568 COVID-19 deaths from approximately 2.4 billion U.S. population, elderly patients aged ≥ 65 years had significantly higher COVID-19 mortality rates compared with younger individuals.¹⁷ In a recent meta-analysis including 59 studies comprising 36,470 patients, elderly patients aged ≥ 70 years had a higher rate of COVID-19 mortality, COVID-19 infection, severe COVID-19 disease, and need for intensive care compared with patients younger than 70 years.⁷ Due to the higher risk of COVID-19 transmission and mortality among elderly patients, the screening and management of CRC may be more decreased in the elderly patients than in young age group during the COVID-19 pandemic.

Therefore, efforts are needed to close the gap of colonoscopy and CRC management in the elderly population during the first surge of COVID-19. The gap of CRC management may be reduced by converting contact treatment to non-contact treatment for the elderly population. In the United States, for example, hospital visits decreased by 68%, but, telemedicine visits increased by 41% during COVID-19.¹⁸ In addition, colonoscopy may be converted to fecal immunochemical test (FIT) to reduce the backlog of elderly subjects who need to be screened for CRC.¹⁹ FIT is a relatively non-contact and safe procedure, therefore, FIT could be an alternative to colonoscopy to elderly subjects, who are hesitant of hospital visits during COVID-19.²⁰ However, colonoscopy is still preferred over FIT due to higher diagnostic yield of CRC. So, stool DNA-based test with a high diagnostic yield for CRC may be promising option for elderly subjects during COVID-19. A recent study showed that stool DNA-based methylated syndecan-2 test has increased sensitivity (90.2%) and specificity (90.2%) for detection of CRC as compared to FIT.²¹ This test could be done entirely from home with no special preparation during COVID-19.

Temporary interruption of CRC screening and management during the COVID-19 pandemic may lead to additional deaths from CRC. In Canada, 6-month interruptions in CRC screening due to COVID-19 will lead to increase of CRC incidence until 2200 with more CRC deaths over the lifetime.²² In the United Kingdom, a 12-month delay of CRC diagnosis due to COVID-19 was estimated to decrease in 6.4% of 5-year surviv-

al rate of CRC.¹⁸ In addition, they expected to take 3–6 months for the return to pre-pandemic levels even after lifting all restrictions on CRC screenings.²³ Therefore, a substantial increase in the number of avoidable CRC deaths may be expected as a result of diagnostic delays of CRC during COVID-19. In our study, the volume of colonoscopies declined during only the first surge of COVID-19 (March–May 2020), which may little impact on the oncological outcomes of CRC. However, oncological outcomes of CRC affected by COVID-19 pandemic should be further evaluated in South Korea, especially for the elderly population.

The use of the HIRA database enabled us to perform the first Asian study to date that assessed the worse impact on the elderly population for the colonoscopy and CRC management during COVID-19. Our findings are virtually free from referral bias and are readily generalizable owing to the population-based design. However, this study has some limitations. One of the limitations of our study is the secondary data with uncertainty regarding the accuracy of the diagnosis. However, previous studies using the HIRA database have shown that procedures and diagnoses are accurately coded. No specific details regarding the indications of colonoscopy and detailed clinical information of each patient were recorded in the HIRA. In addition, it is challenging to generalize our findings to other countries, as the COVID-19 status and healthcare systems differ in each country. Finally, our population-based data included only 3 years of data, so they are not timely enough, but most timely available. Furthermore, there is a growing body of evidence to suggest similar findings observed internationally.

In conclusion, elderly population are more vulnerable for the colonoscopy and CRC management during the first surge of COVID-19 pandemic. Therefore, elderly population are more carefully cared for the colonoscopy and CRC management during the next pandemic.

ADDITIONAL INFORMATION

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Data Availability Statement

Not applicable.

Author Contributions

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Supplementary Materials

Supplementary materials are available at the Intestinal Research website (<https://www.irjournal.org>).

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