# Effect of Aging on Healthcare Costs of Inflammatory Bowel Disease: A Glimpse into the Future

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**Background:** Population aging is expected to result in a substantial additional burden on healthcare resources in the near future. We aimed to assess the current and future impact of aging on direct healthcare costs (DHC) attributed to inflammatory bowel disease (IBD).

**Methods:** Patients with IBD from a Dutch multicenter cohort filled out 3-monthly questionnaires for 2 years. Elderly (≥60 yr) and younger patients (18–60 yr) IBD were analyzed for differences in 3-monthly DHC, productivity losses, and out-of-pocket costs. Prevalence rates were obtained from a health insurance database. Estimates of annual DHC and prevalence rates were applied to the total Dutch adult population in 2011 and then projected to 2040, using predicted changes in population demography, prices, and volume.

**Results:** IBD-attributable DHC were lower in elderly than in younger patients with IBD with respect to 3-monthly DHC (€359 versus €978, $P < 0.01$), productivity losses (€108 versus €456, $P < 0.01$), and out-of-pocket costs (€40 versus €57, $P < 0.01$). Between 2011 and 2040, the percentage of elderly IBD patients in the Netherlands has been projected to rise from 24% to 35%. Between 2011 and 2040, DHC of the total IBD population in the Netherlands are projected to increase from €161 to €661 million. Population aging accounted for 1% of this increase, next to rising prices (29%), and volume growth (70%).

**Conclusions:** Population aging has a negligible effect on IBD-attributable DHC of the IBD population in the near future, because the average costs incurred by elderly patients with IBD are considerably lower than those incurred by younger patients with IBD.

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**Key Words:** elderly persons, inflammatory bowel disease, healthcare costs, aging

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Inflammatory bowel disease (IBD), encompassing Crohn's disease (CD) and ulcerative colitis (UC), is one of the most prevalent chronic gastrointestinal diseases in the Western world.

Extrapolating the highest IBD prevalence rates to the populations of Europe and North America indicates that there were 3.7 million Europeans and 1.5 million North Americans diagnosed with IBD in 2011, accounting for €17.9 and €7.4 billion annual direct healthcare costs (DHC), respectively.[1–4]

Currently, 16% to 27% of patients with IBD are older than 60 years, hereafter referred to as "elderly patients with IBD."[5] This subpopulation will expand as a result of the aging of the baby boom generation.

Eurostat estimated that in Europe, the elderly population would increase by 50%, from 116 million in 2010 to 175 million in 2040.[6] According to a recent survey of U.S. hospital discharges, elderly patients with IBD accounted for a disproportionate number of hospitalizations and had a higher postoperative morbidity and mortality compared with younger patients.[7,8] Therefore, the growing subpopulation of elderly patients with IBD may increasingly burden healthcare resources.

In an era of budgetary constraints, more data on the economic impact of IBD are required for proper allocation of the limited healthcare resources. These data allow healthcare providers, policy makers, and clinicians to create a Pareto optimum that is defined in economics as a reallocation of resources for the benefit of all individuals.[9]

Previous cost-of-illness studies were mainly limited to single centers, reported only DHC, and were conducted in a prebiological era or relied on mathematic modeling.[10–16] Therefore, we initiated the "Costs of Inflammatory bowel disease in the Netherlands" or "COIN" study in 2010.[4] We used the COIN database to compare the IBD-attributable DHC (DHC-IBD) and productivity losses of elderly patients with IBD with those of younger patients with IBD. Based on these data, we estimated the 2011 DHC-IBD of the total adult IBD population in the Netherlands and projected those to 2040.

## MATERIALS AND METHODS

### Patient Population

Details on the patient population are available elsewhere.[4] Briefly, adult patients with both CD and UC from 7 general and 7 university hospitals were identified between 2007 and 2010, using Diagnosis-Treatment-Combination codes. Diagnosis-Treatment-Combination codes are based on the International Classification of Disease, Ninth Revision[17,18] and have been found to reliably identify patients with IBD.[19,20] In accordance with previous studies,[5,7] patients ≥60 years were defined as "elderly patients with IBD," whereas those <60 years were defined as "younger patients with IBD." The study was centrally approved by the Medical Ethics Committee of the University Medical Center Utrecht, Utrecht, the Netherlands.

### Study Protocol and Measurements

A secured web-based questionnaire was developed to obtain baseline characteristics and 3-monthly cost data during 2 years of follow-up. Demographic characteristics included sex, age, age at diagnosis, education level, work status, family history, and smoking status. Clinical characteristics included subtype of IBD, disease duration and localization, penetrating disease course (perianal or other fistula), stoma or pouch, and clinical disease activity. Clinical disease activity was measured by the well-validated Short Crohn's Disease Activity Index[21] and the Modified Truelove and Witts Severity Index[22,23] for patients with CD and UC, respectively. Finally, quality of life was measured by the EQ-5D[23,24] and the IBDQ-32.[25,26]

### DHC-IBD, Productivity Losses, and Out-of-pocket Costs Attributable to IBD

DHC-IBD were obtained and classified as: (1) outpatient visits, including the number of outpatient physician consultations; (2) diagnostic procedures, including endoscopies and radiological examinations; (3) medication use, including IBD-specific drugs (mesalazine, steroids, immunosuppressants, and anti-TNFα antibodies); (4) stoma-related costs; (5) IBD-related hospitalizations, defined as the number of days hospitalized; and (6) IBD-related surgeries, including intestinal resections and perianal operations. In line with the Dutch guidelines for economic evaluations, patient's costs were calculated by multiplying self-reported units of resource utilization by their unit costs.[27]

To assess productivity losses, we used sick leave of patients and their caregivers from both paid and unpaid work as outcome measure (absenteeism). Employed patients, partially disabled patients with a paid job, and patients with an unpaid job (voluntary work) reported the number of sick leave days within the previous 3 months. In addition, patients were asked to report whether their caregivers were absent from paid work to take care of them, and if so, for how many days. Hours of work absence (paid and unpaid) of patients and caregivers were multiplied with the corresponding unit prices as reported previously.[4]

Patients reported IBD-related out-of-pocket costs within the previous 3 months, including patient's deductibles for healthcare insurance, over-the-counter drugs (vitamins, antidiarrheals, analgetics, probiotics, and minerals), travel costs, and subscriptions of patient organizations. More details on the calculation method are provided elsewhere.[4]

### Nonresponders

As reported previously,[4] there were no statistical differences between responders and nonresponders from 1 participating center with regard to demographic (age, sex) and clinical characteristics (disease duration, penetrating disease course, and abdominal surgery in the past).

### Projection of Prevalence Rates and DHC-IBD of IBD

The projections were made as follows. First, IBD prevalence rates and annual DHC-IBD per person were generated for each age- (18–39, 40–59, and ≥60 yr), sex-, and IBD subtype-specific group. The prevalence rate for each age-, sex-, and IBD subtype-specific group was estimated by dividing the number of patients with IBD by the total number of policy holders of the Agis Health Insurance Company[28] registered in July 1, 2011 and were conservatively assumed to remain constant between 2011 and 2040. Then, these prevalence rates were applied to the Census projections of population counts for the years 2011 to 2040 to generate the total IBD population for the years 2011 to 2040.[29] Finally, the DHC-IBD per person per 3 months were multiplied by 4 and by the corresponding number of patients with IBD of the above-mentioned groups to generate the total annual DHC-IBD of the IBD population for the years 2011 to 2040 (see Table, Supplemental Digital Content 1, http://links.lww.com/IBD/A404).

In our base-case analysis, we projected the DHC-IBD of the total IBD population from 2011 to 2040, taking into account the cumulative effects of population aging, rising prices, and volume growth (increased healthcare utilization) on the DHC-IBD. Prices and volume of overall healthcare expenditure were assumed to increase at the same rate for the next 30 years: averaging an annual rate of 4.9% (2.2% due prices; 2.7% due to volume). But as the increase in volume is debatable, we conducted a scenario analysis, in which we only accounted for the effects of population aging and rising prices (2.2%) on the DHC-IBD.[30,31]

Finally, one-way sensitivity analyses were performed, varying IBD prevalence rates and mean DHC-IBD of each age-, sex-, and IBD subtype-specific group, using the lower and upper ends of the 95% confidence interval (CI), to assess the uncertainty of the projected DHC-IBD between 2011 and 2040. The projection method is described in full detail in Data, Supplemental Digital Content 2, http://links.lww.com/IBD/A405.

## Statistical Analysis

Data analyses were performed using SPSS 20.0 and SAS 9.2. Descriptive statistics were used to characterize patients with both CD and UC according to their age. Mean and medians were reported with an SD and an interquartile range, respectively. Comparisons between elderly versus younger IBD were analyzed with Student's *t* test for continuous variables and $\chi^2$ or Fisher's exact test for dichotomous variables.

Costs were expressed as mean costs with 95% CI estimated using nonparametric bootstrap sampling. To identify cost drivers of high healthcare costs, we included demographic, clinical, and treatment-related characteristics into a 2-part mixed model. This model takes into account that cost data are right-skewed with a substantial proportion of zero values and consists of 2 parts: (1) a generalized linear mixed model assessing the odds of costs being positive and (2) a linear mixed model with log-normal link assessing the height of costs given that costs were actually incurred. To account for repeated measures within subjects, a random intercept was fitted to both parts of the model. Projections were modeled in MS Excel 2010.

# RESULTS

## Patient Population

In total, 3015 patients with IBD filled out the baseline questionnaire, including 1551 (51%) patients with CD, 1051 (35%) patients with UC, and 413 (14%) patients with either IBD-unspecified or "IBD-unknown". "IBD-unknown" included patients who did not know their IBD subtype, reported UC with ileal involvement or fistulas. As there were no significant differences between patients with IBD-unknown/-unspecified and UC regarding demographic (age, sex) and clinical characteristics (disease duration, abdominal surgery, stoma, pouch, and medication use), these groups were analyzed together (hereafter referred to as UC). Three hundred seven (20%) out of 1551 patients with CD and 354 (24%) out of 1464 patients with UC were older than 60 years.

The proportion of patients lost to follow-up was comparable between elderly and younger patients with IBD, namely 15.0% versus 15.4% ($P = 0.78$). Both elderly and younger patients with IBD who were lost to follow-up were more likely to be women ($P = 0.02$), smoker ($P < 0.01$), and had a lower education level ($P < 0.01$) than those patients with IBD who were not lost to follow-up.

Elderly patients with CD were more likely to be men ($P < 0.01$), had a higher probability of a positive history of abdominal surgery ($P < 0.01$), and a current stoma ($P < 0.01$) compared with younger patients with CD (Table 1). Younger patients with CD were more likely to be smoker ($P = 0.01$), had a higher incidence of clinical active disease ($P = 0.01$), and were more frequently treated with immunosuppressants ($P < 0.01$) and anti-TNFα antibodies ($P < 0.01$). Elderly patients with UC were more likely to be men ($P < 0.00$) compared with younger patients with UC (Table 2). Younger patients with UC had a higher incidence of clinical active disease ($P = 0.01$) and were more frequently treated with immunosuppressants ($P < 0.01$) and anti-TNFα antibodies ($P = 0.04$).

## DHC-IBD Costs in CD and UC

The mean DHC-IBD per patient per 3 months was lower in elderly patients than in younger patients with IBD, i.e., €982 versus €1428 ($P < 0.01$) in CD and €637 versus €995 ($P < 0.01$) in UC (Fig. 1). Medication use was the major cost driver in both elderly patients with CD and UC, accounting for 62% and 60% of total DHC, respectively. The costs attributable to anti-TNFα antibodies were consistently lower in elderly than in younger patients with IBD (€523 versus €962, $P < 0.01$ in CD and €287 versus €608, $P < 0.01$ in UC).

In elderly CD, the only significant predictor of high costs was anti-TNFα therapy (odds ratio [OR], 15.30; 95% CI, 12.61–18.56). Significant predictors of high costs in elderly UC were anti-TNFα therapy (OR, 18.70; 95% CI, 14.40–24.27), stoma use (OR, 9.30; 95% CI, 6.51–13.29), steroid therapy (OR, 1.28; 95% CI, 1.10–1.49), immunosuppressive therapy (OR, 1.25; 95% CI, 1.10–1.42), and current flares (OR, 1.17; 95% CI, 1.08–1.27).

**TABLE 1.** Main Baseline Characteristics of Younger (<60 yr) Versus Elderly Patients (≥60 yr) with CD

| | Younger CD, n = 1244 | Elderly CD, n = 307 | *P* |
|---|---|---|---|
| Demographic characteristics | | | |
| Male gender (%) | 408 (32.8) | 164 (53.4) | 0.00 |
| Age (±SD), yr | 42.2 (10.8) | 66.0 (5.0) | 0.00 |
| Age at diagnosis (±SD), yr | 26.7 (9.8) | 40.2 (14.9) | 0.00 |
| Low education (%) | 777 (62.5) | 223 (72.6) | 0.00 |
| Positive family history (%) | 265 (21.3) | 71 (23.1) | 0.50 |
| Current smoker | 279 (22.4) | 49 (16.0) | 0.01 |
| Employment status (%) | | | |
| Employed | 706 (56.8) | 31 (10.0) | 0.00 |
| Fully work disabled | 153 (12.3) | 22 (7.2) | 0.01 |
| Partially work disabled | 208 (16.7) | 55 (17.9) | 0.62 |
| Retired | 7 (0.6) | 173 (56.4) | 0.00 |
| Homemaker | 108 (8.7) | 26 (8.5) | 0.91 |
| Student | 62 (5.0) | — | 0.00 |
| Clinical characteristics | | | |
| Disease duration, median (IQR) | 13.9 (6.9–22.8) | 24.9 (13.9–37.5) | 0.00 |
| Disease localization (%) | | | |
| Large bowel | 335 (26.9) | 92 (30.0) | 0.29 |
| Small bowel | 241 (19.4) | 66 (21.5) | 0.40 |
| Both large and small bowel | 630 (50.6) | 134 (44.6) | 0.03 |
| Unknown | 38 (3.1) | 15 (4.9) | 0.11 |
| Clinical disease activity, mean score on short-CDAI | 146.5 (85.2) | 119.5 (69.7) | 0.01 |
| IBDQ total, median (IQR) | 177 (153–196) | 176 (155–198) | 0.48 |
| EQ-5D Visual Analogue Scale, median (IQR) | 71 (61–80) | 70 (60–80) | 0.46 |
| Penetrating disease course (%) | 658 (52.9) | 150 (48.9) | 0.21 |
| Stoma (%) | 137 (11.0) | 54 (17.6) | 0.00 |
| Pouch (%) | 21 (1.7) | 7 (2.3) | 0.49 |
| Treatment-related characteristics | | | |
| Type of abdominal surgery in the past (%) | 713 (57.3) | 233 (75.9) | 0.00 |
| Ileocecal resection | 281 (22.6) | 79 (25.7) | 0.17 |
| Resection neo-terminal ileum | 82 (6.6) | 35 (11.4) | 0.00 |
| Partial small bowel resection | 118 (9.5) | 43 (14.0) | 0.02 |
| Partial large bowel resection | 136 (10.9) | 41 (13.4) | 0.28 |
| Subtotal resection | 96 (7.7) | 35 (11.4) | 0.04 |
| Medication use (%)[a] | | | |
| Mesalazine | 221 (21.4) | 67 (25.1) | 0.20 |
| Steroids | 81 (7.8) | 26 (9.7) | 0.32 |
| Immunosuppressants | 359 (34.6) | 59 (22.1) | 0.00 |
| Anti-TNFα antibodies | 262 (25.3) | 35 (13.1) | 0.00 |

[a]Medication use was obtained 3 months after inclusion. In total, 1035 younger patients with CD and 267 elderly patients with CD reported their medication use.

## Productivity Losses and Out-of-pocket Costs in CD and UC

Productivity losses due to sick leave of paid work were lower in elderly patients than in younger patients with CD and UC (€97 versus €420 [$P = 0.04$] and €54 versus €392 [$P < 0.01$], respectively). Productivity losses due to sick leave of unpaid work were higher in elderly than in younger CD, but comparable between elderly and younger patients with UC (€25 versus €14 [$P < 0.01$] and €22 versus €20 [$P = 0.69$], respectively). Out-of-pocket costs were lower in elderly than in younger patients with CD and UC (€48 versus €75 [$P < 0.01$] and €4 versus €37 [$P < 0.01$],

**TABLE 2.** Main Baseline Characteristics of Younger Patients (<60 yr) Versus Elderly Patients (≥60 yr) with UC

| | Younger UC[a], n = 1110 | Elderly UC[a], n = 354 | *P* |
|---|---|---|---|
| Demographic characteristics | | | |
| Male gender (%) | 503 (45.3) | 245 (69.2) | 0.00 |
| Age (±SD), yr | 44.1 (10.3) | 66.7 (5.6) | 0.00 |
| Age at diagnosis (±SD), yr | 30.8 (10.8) | 48.2 (14.0) | 0.00 |
| Low education (%) | 647 (58.3) | 239 (67.5) | 0.02 |
| Positive family history (%) | 224 (20.2) | 76 (21.5) | 0.44 |
| Current smoker | 127 (11.4) | 28 (7.9) | 0.06 |
| Employment status (%) | | | |
| Employed | 755 (68.0) | 57 (16.1) | 0.00 |
| Fully work disabled | 128 (11.5) | 16 (4.5) | 0.00 |
| Partially work disabled | 93 (8.4) | 48 (13.6) | 0.00 |
| Retired | 15 (1.4) | 212 (59.9) | 0.00 |
| Homemaker | 95 (8.6) | 21 (5.9) | 0.12 |
| Student | 24 (2.2) | — | 0.00 |
| Clinical characteristics | | | |
| Disease duration, median (IQR) | 11.2 (5.9–19.9) | 16.3 (6.9–28.9) | 0.00 |
| Clinical disease activity, mean score on MTWSI (±SD) | 4.2 (2.8) | 3.8 (2.4) | 0.01 |
| IBDQ total, median (IQR) | 184 (160–202) | 189 (166–204) | 0.01 |
| EQ-5D Visual Analogue Scale, median (IQR) | 74 (65–81) | 73 (65–80) | 0.71 |
| Stoma (%) | 80 (7.2) | 27 (7.6) | 0.82 |
| Pouch (%) | 119 (10.7) | 19 (5.4) | 0.00 |
| Treatment-related characteristics | | | |
| Subtotal colectomy in the past (%) | 126 (11.4) | 23 (6.5) | 0.01 |
| Medication use (%)[b] | | | |
| Mesalazine | 551 (59.3) | 197 (62.5) | 0.35 |
| Steroids | 44 (4.7) | 18 (5.7) | 0.59 |
| Immunosuppressants | 205 (22.1) | 47 (14.9) | 0.00 |
| Anti-TNFα antibodies | 49 (5.3) | 7 (2.2) | 0.04 |

[a]Including patients with UC and patients with IBD-unspecified/"IBD-unknown."
[b]Medication use was obtained 3 months after inclusion. In total, 929 younger UC patients and 315 elderly UC patients reported their medication use.

respectively) (Fig. 2; see Tables, Supplemental Digital Content 3 and 4, http://links.lww.com/IBD/A406 and http://links.lww.com/IBD/A407).

## DHC-IBD Costs in 2011

Costs were lower in elderly versus younger patients with IBD with respect to 3-monthly DHC-IBD (€359 versus €978, $P < 0.01$), productivity losses (€108 versus €456, $P < 0.01$), and out-of-pocket costs (€40 versus €57, $P < 0.01$). Within elderly patients with IBD, costs were higher in patients aged 60 to 70 years versus patients aged 70 years or older with respect to DHC-IBD (€432 versus €241, $P = 0.000$), productivity losses (€119 versus €14, $P = 0.001$), and out-of-pocket costs (€46 versus €19, $P = 0.001$).

## Projections of IBD Population and DHC-IBD

The total IBD population in the Netherlands is expected to increase from 43,953 in 2011 to 46,894 individuals in 2040, an increase of 7%. The total number of elderly patients with IBD will increase from 10,658 in 2011 to 16,323 in 2040, a growth of 53% (see Table, Supplemental Digital Content 1, http://links.lww.com/IBD/A404).

According to our base-case analysis (population aging + rising prizes + volume), the DHC-IBD of the total adult IBD projection are projected to increase from €161 million to €661 million in 2040, a 4.1-fold increase. The contributions of population aging, price inflation, and volume to this increase were respectively 1%, 29%, and 70% (Fig. 3).

According to our scenario analysis (population aging + rising prizes), the DHC-IBD of the total adult IBD projection

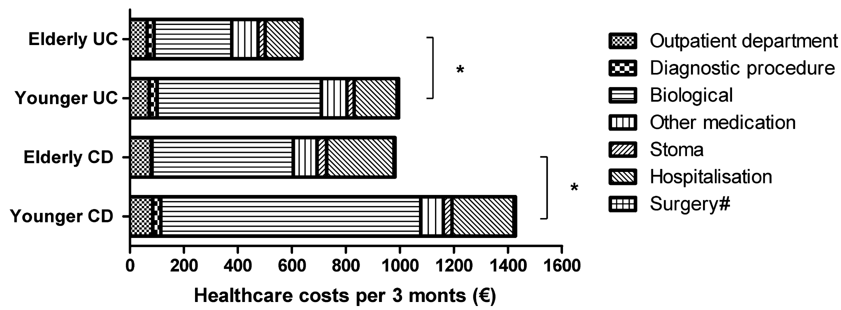


FIGURE 1. Mean DHCs per 3 months in 2011 and cost drivers of both elderly and younger patients with both CD and UC. *$P < 0.00$, #Mean costs per 3 months related to surgery were €2, €6, €4, and €6 for elderly patients with UC, younger patients with UC, elderly patients with CD, and younger patients with CD, respectively.

are projected to increase from €161 million to €310 million in 2040, a 1.9-fold increase.

When using the low and high boundaries of the estimated DHC-IBD and the IBD prevalence rates in our base-case analysis, the projected DHC-IBD of the adult IBD population in 2040 varied between €559 and €763 million (Fig. 3) and between €580 and €741 million, respectively.

## DISCUSSION

Healthcare costs have significantly increased over the recent years. This has been attributed to an overall increase in prices of healthcare expenditure, volume growth, and population aging. The latter contributes to higher healthcare costs because of the increasing likelihood of chronic illness with age and a general increased healthcare utilization. In IBD, however, we found that the impact of population aging on the DHC-IBD of the total adult IBD population, presuming status quo in treatment, is mitigated by 2 factors: (1) the relatively low healthcare utilization by elderly patients with IBD and (2) a reduced proportion of relatively expensive middle-aged (40–60 yr) patients with IBD due to the declining birth rate since the baby boom.

### COIN Cohort

Several reasons may explain the lower healthcare utilization, productivity losses, and out-of-pocket costs in elderly patients with IBD as compared with younger patients with IBD.

Consistent with previous studies, expensive anti-TNFα antibodies were less frequently prescribed for elderly than for younger patients with IBD,[4,32–34] which may suggest a milder disease course in elderly IBD patients. Accordingly, in our study, elderly patients with IBD reported a lower disease activity at baseline and a higher quality of life at baseline and during follow-up than younger IBD patients (see Table, Supplemental Digital Content 5, http://links.lww.com/IBD/A408). A milder disease course, when aged, has been reported by other authors showing lower requirements of immunosuppressants and anti-TNFα antibodies,[33,35] reduced rates of hospitalization,[36,37] and disease progression,[35,38] and better treatment response.[39] Additionally, clinicians may hesitate to prescribe anti-TNFα antibodies in elderly patients, because of doubts related to the efficacy or the demonstrated increased risk of potential side effects of these compounds in elderly, such as (opportunistic) infections[40,41] and cancer.[42]

Second, overall productivity losses were lower in elderly than in younger patients with IBD, obviously because most elderly patients with IBD were retired.

Third, most elderly patients with IBD were captured at a later stage of their disease as reflected by the long median disease duration and were therefore exempted from high costs that are usually incurred in the first years after diagnosis.[43,44]

### Projection of IBD-attributable DHC Until 2040

Productivity losses could not reliably be extrapolated due to ongoing policy changes with respect to retirement age and were therefore excluded. However, according to previous and current

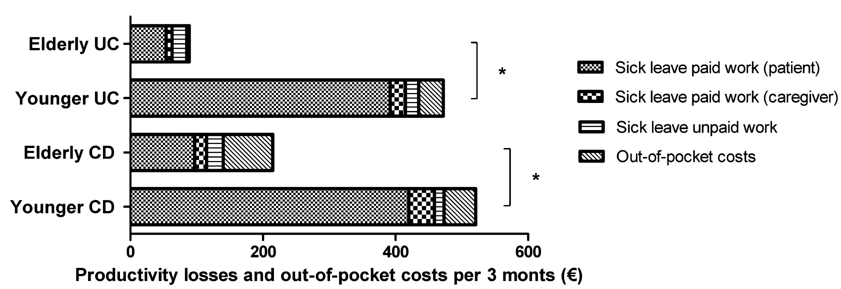


FIGURE 2. Mean productivity losses and mean out-of-pocket costs per 3 months in 2011 of both elderly and younger patients with CD and UC. *$P < 0.00$.

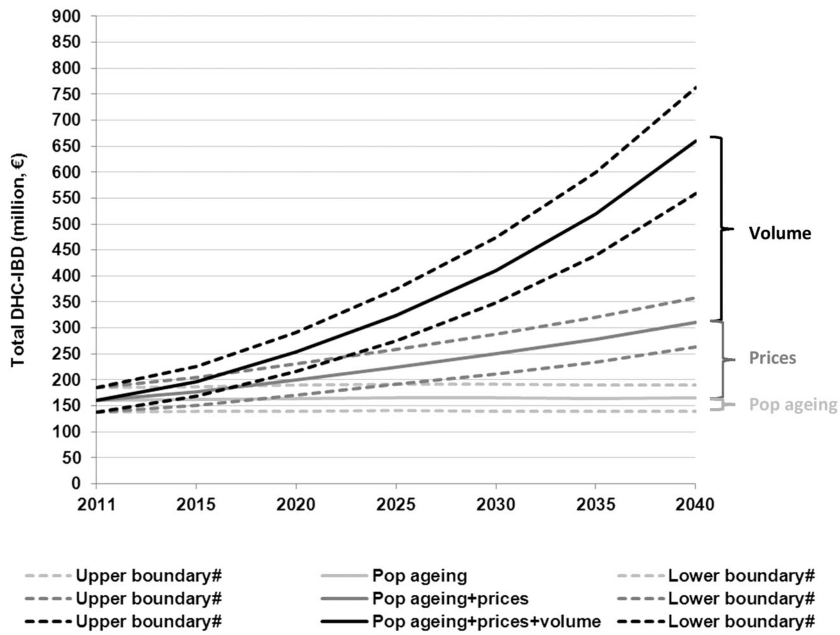


FIGURE 3. Projections of DHC-IBD costs in the Dutch adult population from 2011 to 2040, considering the cumulative effects of population aging, rising prices, and volume growth. #The dotted lines represent the one-way sensitivity analysis, using the upper and lower boundaries of only the mean DHC-IBD.

data, productivity losses contribute to only one-fourth of the total healthcare costs.[4] In line with recent data from high-incidence countries showing a stabilization of the IBD prevalence, we assumed that the current IBD prevalence would remain constant for the next 30 years.[3,45]

Next to population aging, we assessed the impact of increasing prices and volume on the growth of DHC-IBD, thereby identifying potential targets for cost containment interventions and putting the effect of population aging on the growing DHC-IBD into perspective.

According to our projections, the DHC-IBD would quadruple from €161 million to €661 million between 2011 and 2040. Only 1% of this growth is attributable to population aging. The limited effect of population aging on the DHC-IBD is due to the fact that elderly IBD patients use considerably less IBD-attributable healthcare compared with their younger counterparts. In addition, due to population aging the proportion of relative costly middle-aged (40–60 yr) patients with IBD will reduce from 43% in 2011% to 35% in 2040.

Another important finding was that 70% of the growth in DHC-IBD is attributable to volume. We suggest that technological innovations, frequently cited as a major volume-generating factor,[46,47] are mainly responsible for this growth. In IBD, biologicals are considered important technological innovations. The expanding indications for the use of existing biologicals (mainly anti-TNF$\alpha$ antibodies) and the introduction of new compounds[48] may generate additional volume and, thereby, increase the DHC-IBD even more. Although biosimilars, that are generally priced 15% to 30% below their reference products, may reduce the total costs related to the use of biologicals/biosimilars,[49–51] in our opinion, this will likely have a minor effect on the expected utilization of these compounds in the future.

The future healthcare utilization of elderly patients with IBD might increase for several reasons. First, as younger patients with IBD will continue to use expensive biologicals while they age, more elderly patients with IBD may be expected to use these compounds in the future. Second, as experience with the use of biologicals in elderly IBD patients grows, clinicians may be less concerned about potential side effects and prescribe biologicals more frequently. Whether this increased healthcare utilization would disproportionately affect elderly patients with IBD remains a matter of debate, and if so, the effect of population aging on DHC as we reported might be underestimated. However, we feel that more aggressive or treat-to-target treatment of younger patients with IBD will also lead to a higher healthcare utilization in this subpopulation, which will counterbalance the potential increase in healthcare utilization in elderly patients with IBD.

This study has several limitations. First, the web-based design of this study may be prone to sampling error, as elderly people may have a relatively limited access to Internet. However, since 90% of elderly people in the Netherlands currently have access to Internet,[52] we do not feel that this aspect has biased our study. Second, our projections may be subject to sampling error as our prevalence rates were based on information from a health insurance database.[53] Yet, coding errors in this database are regularly excluded by random checks and auditing,[28] and prevalence rates are consistent with those from surrounding countries in Europe and North America.[54,55] Third, attrition bias may have occurred as patients who were lost to follow-up were more likely to be women, smokers, and had a lower education. Nevertheless, none of these characteristics were found to be significantly associated with higher costs. Fourth, indirect costs resulting from polypharmacy, drug-drug interactions or side effects of medications might have been missed. This may have led to an underestimation of total indirect healthcare costs, especially of those in elderly patients with IBD.

This study provides valuable information on current and future healthcare costs of elderly patients with IBD that will be useful to (1) inform decision makers as they plan to meet future healthcare demands in the elderly in general and (2) provide cost data to assess the cost-effectiveness of treatment strategies in elderly patients with IBD.

In conclusion, although population aging is generally considered an important cost driver, this does not hold true for IBD. In IBD, the impact of aging is mitigated, because of the lower ratio of DHC-IBD for elderly versus younger patients. This lower ratio may also be found in other immune-mediated inflammatory diseases such as rheumatoid arthritis, where elderly patients are also less likely to receive expensive biological treatment.[56,57] Therefore, we feel that our data may be generalizable to other immune-mediated inflammatory diseases. Further comparative cost-of-illness studies are needed to confirm this state statement.

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