Table 2. Result of CRC knowledge.

Items	Already knew	%
Most people are cured if the colorectal cancer is detected early	456	77.0
The first screening test to detect a colorectal cancer is a stool test (FOBT)	411	69.4
A colorectal cancer with symptoms accompanied by bloody stool is already advanced in many cases	366	61.8
The risk for colon cancer is high if there is a family history of colon cancer	342	57.8
A colonoscopy is carried out when the FOBT result is positive	341	57.6
A lifestyle is related to the cause of colon cancer	337	56.9
A colorectal cancer is a preventable disease	273	46.1
The risk of a colon cancer increases as the age advances	247	41.7
Colorectal cancer is a disease resulting from an expanding malignant growth in the colon and the rectum	225	38.0
A colorectal cancer is the second most common cancer among Japanese	98	16.6

categorized in *Subjective norms*, we considered these items important in this study and decided to use them in the subsequent analysis. We then yielded a 5-factor structure to analyze the exploratory factor of the 22 items by using the maximum likelihood method and the promax rotation method. We deleted items with a factor loading of less than 0.4, then reanalyzed 20 items and determined a 5-factor structure. We interpreted these subscales as: (1) *Perceived barrier*, (2) *Subjective norms*, (3) *Low importance*, (4) *Descriptive norms*, and (5) *Non-necessity*. Calculating internal consistency (Cronbach's alpha coefficients) of this scale indicated that the coefficient alpha was .829 for the total score. Alpha ranged from .61 for *Non-necessity* to .92 for *Subjective norms* for this subscale (Table 3). Additionally, we determined the validity of this scale by adopting the confirmatory factor analysis using the maximum-likelihood method. We obtained adequate fit index as the result of a confirmatory factor analysis regarding the models of these five factors: chi-square (df = 163) = 665.78, $p < .001$; GFI = 0.89; AGFI = 0.86; RMSEA = 0.072.

3.3. *Relationship between beliefs of FOBT and FOBT-screening behavior.*

Results of univariate logistic analysis indicated that *Perceived barrier* (OR = 0.83, 95% CI = 0.80–0.86), *Subjective norm* (OR = 1.07, 95% CI = 1.03–1.11), *Low importance* (OR = 0.75, 95% CI = 0.70–0.80), and *Descriptive norm* (OR = 1.31, 95% CI = 1.22–1.41) were associated with Beliefs of FOBT (OR = 1.02, 95% CI = 0.96–1.10). Then we conducted a multiple logistic regression analysis, which indicated that predictors of FOBT screening were *Perceived barrier* (OR = 0.87, 95% CI = 0.84–0.92), *Low importance* (OR = 0.91, 95% CI = 0.84–0.99), and *Descriptive norm* (OR = 1.18, 95% CI = 1.09–1.28) (Table 4).

4. Discussion

Despite the fact that FOBT is part of the recommended CRC screening in Japan, the screening rate remains low. An effective measure is needed to raise the CRC screening rate in Japan. In this study we intended to elucidate the relationship between FOBT screening behavior and beliefs of FOBT, both of which are manipulative variables.

Firstly, we extracted *Perceived barrier* and *Low importance* as inhibiting factors of FOBT screening behavior. *Perceived barrier* consisted of inconvenient operating hours of medical institutions performing FOBT, waiting time, and cost. *Perceived barrier* shows an association with structural barriers such as cost and unsuitable screening hours that are revealed in this study,

Table 3. Factor loadings and Cronbach alpha coefficients.

		Average	SD	Factor1	Factor2	Factor3	Factor4	Factor5	Cronbach alpha coefficients
1	Perceived barrier $\alpha = .916$								0.829
	It is difficult to undergo an FOBT because the time that the medical institution is available is inconvenient	2.36	1.07	0.98					
	Having to wait for a long time makes it difficult to undergo an FOBT	2.42	1.06	0.93					
	Time and effort required for an appointment making makes it difficult to undergo an FOBT	2.37	1.01	0.89					
	Inconvenient transportation to medical institutions makes it difficult to undergo an FOBT	2.20	0.97	0.80					
	Not knowing when and where to do an FOBT	2.55	1.27	0.59					
	It costs money to do an FOBT	2.92	1.18	0.51					
2	Subjective norms $\alpha = .929$								
	I have been recommended to do an FOBT by family members (brother, sister, son, and daughter)	1.96	1.03		0.96				
	I have been recommended to do an FOBT by friends and acquaintances	1.91	0.99		0.90				
	I have been recommended to do an FOBT by my superior at work	1.90	1.01		0.89				
	I have been recommended to do an FOBT by a partner	2.10	1.11		0.79				
	I have been recommended to do an FOBT by my primary care doctor	2.07	10.7		0.74				
3	Low importance $\alpha = .826$								
	Undergoing a FOBT is not as important as dealing with other health issues	2.23	0.92			0.78			
	There is no need to do an FOBT for a few years after undergoing FOBT once	2.20	0.95			0.77			
	There is no need to do an FOBT because I have been consulting my primary care doctor	1.99	0.86			0.64			
	I can self-check my health status without doing an FOBT	2.23	0.89			0.61			
4	Descriptive norms $\alpha = .858$								
	I think women of my age have done FOBT	2.85	0.98				0.95		
	I think men of my age have done FOBT	2.95	1.01				0.93		
	I think the acquaintances in the workplace or close friends have done FOBT	2.64	1.13				0.52		
5	Uncertainty $\alpha = .611$								
	A positive result of the FOBT does not always indicate that there is a cancer	2.86	0.86					0.70	
	I think there is still a possibility that the colon cancer is overlooked even if I undergo an FOBT	3.17	0.98					0.63	

Table 4. Logistic regression of FOBT screening behavior ($n = 592$).

Variables	Range or category	% or mean (SD)	Bivariate analyses Crude OR (95% CL)	Bivariate analyses Crude *p* value	Multivariate analyses Adjusted[a] OR (95% CL)	Multivariate analyses Adjusted[a] *p* value
FOBT screening rate[b]	Yes	44.9				
Perceived risk	2–106	30.2(19.5)	1.01(1.00–1.015)	0.115	–	–
Perceived severity	2–10	5.4(1.8)	0.92 (0.84–1.01)	0.07	–	–
Belief of FOBT						
Barrier	5–30	14.8(5.5)	0.83(0.80–0.86)	<0.001	0.87(0.84–0.92)	<0.001
Subjective norms	5–25	8.7(2.9)	1.07(1.03–1.11)	<0.001	–	–
Low importance	5–20	6.0(1.6)	0.75(0.70–0.80)	<0.001	0.91(0.84–0.99)	0.03
Objective Norms	5–15	9.9(4.6)	1.31(1.22–1.41)	<0.001	1.18(1.09–1.28)	<0.001
Uncertainty	5–10	8.4(2.8)	0.9(0.82–1.00)	0.058	–	–
CRC worry	4–20	20.1(3.4)	1.00(0.95–1.05)	0.936	–	–
Self-efficacy of health	8–40	21.8(8.8)	0.98(0.95–1.01)	0.189	–	–
Knowledge of CRC	0–13	5.9(3.4)	1.06 (1.01–1.11)	0.015	–	–

[a]Rate of participants undergoing FOBT in the past year.
[b]Adjusted for age, gender, cancer insurance, drinking habits, exercising habits, exposed CRC information.

which many previous studies indicated as obstructive factors for intention for or compliance with CRC screening (James, Campbell, & Hudson, 2002; Jones, Woolf, et al., 2010; Kiviniemi, Bennett, Zaiter, & Marshall, 2011; Power, Miles, von Wagner, Robb, & Wardle, 2009). Moreover, we consider this indicative of an association between *perceived barrier* and FOBT screening that is reasonable given that prior Japanese cancer screening studies for gastric and breast cancer have also shown this to be a factor with a negative correlation (Seki et al., 2011; Tsubono et al., 1993). The questions included in *Low importance* related to ideas that FOBT is less important than the screening of other illnesses, and that regular visits to the primary care doctor and self-examination are sufficient for prevention of CRC. For these items related to the importance of FOBT, attitudinal barriers such as 'I am in good health' and 'I do not undergo FOBT because there is no health problem (especially in the stomach)' were considered as a part of *Perceived barrier* or *Cons* (Beeker, Kraft, Southwell, & Jorgensen, 2000; Jones, Devers, et al., 2010; Klabunde et al., 2005; Liang et al., 2006; Matsuda et al., 2012). Kandula, Wen, Jacobs, and Lauderdale (2006) investigated cultural influences on cancer screening behavior based on the fact that Asian Americans have lower rates of CRC screening compared to non-Hispanic whites. He observed a trend of thinking in cancer screening that affects the low FOBT screening rate among Asian Americans, which considers cancer screening as a reaction to certain perceivable symptoms and not as a proactive measure to prevent cancer when the subjects are asymptomatic. Moreover, recent research in Japan revealed that 'not having time to get screened' (Cabinet Office, Government of Japan, 2013) is the most common reason for not receiving cancer screening.

In our study, only *Descriptive norms* was identified as a promoting factor of CRC screening. Honda and Kagawa-Singer (2006) conducted research on the associated factors of CRC screening adherence, targeting Japanese people living in the USA. The result of this research discussed that

Subjective norms (family or friends) are the strongest predictive factors because sharing of value and attitude is enhanced by the influence of Japanese culture. However, this research measured only the Subjective norms and not the Objective norms. The three previously conducted meta-analyses on Social norms (Armitage & Conner, 2001; Manning, 2009; Rivis & Sheeran, 2003) indicated that the Descriptive norms are strongly associated with behavior and intention, and it revealed that Subjective norms and Injunctive norms (the perception that others will approve or disapprove of what one dose) are less influential than Descriptive norms. Therefore, it is reasonable for Descriptive norms to remain in the present study, which employed both Subjective and Descriptive variables. Our study indicates that Descriptive norms influence health risk behaviors more strongly than health-promoting behaviors. Since cancer screening is considered to be secondary prevention (risk behavior), the result of Descriptive norms being significant is reasonable. However, among the studies on Normative factors in cancer screening, some studies have not shown an association between Descriptive norms and intention in CRC screening (Smith-McLallen & Fishbein, 2008). In addition, studies acknowledging the significant association between Subjective norms and intention report a possibility that Subjective norms become a predictable factor in certain subgroups (Sieverding et al., 2010). For example, subjective norms may function as a trigger of a behavior in a culture that strongly recognizes the value of cancer screening, such as that in the USA (Schwartz, Woloshin, Fowler, & Welch, 2004) where Honda conducted research. On the other hand, the Descriptive norms represent a behavior in line with others rather than the value of cancer screening, which could be caused by the influences of collectivism in Japanese culture. Caution is necessary before interpreting cultural differences because there have been researchers that deny the influence of cultural differences such as collectivism and individualism on human behavior (Takano & Sogon, 2009). However, we consider that future studies are necessary, which bear in mind these cultural differences and Social norms.

Based on these results, we believe that providing the public with messages and information about cancer screening, particularly stressing the following concepts, will be effective in order to improve the CRC screening rate: (1) everyone should be regularly screened for cancer, (2) ease of obtaining FOBT, and (3) the importance of FOBT. Furthermore, knowledge of CRC screening is perceived to be a precognition in an effort to effectively intervene in behavioral change (Kiviniemi et al., 2011). The knowledge of CRC and CRC screening has been identified as a predictor of CRC screening (Ng et al., 2007; Sieverding et al., 2010; Takano & Sogon, 2009). However, an association between knowledge and behavior has yet to be identified (Liang et al., 2006; Ng et al., 2007; Subramanian et al., 2004; Weinberg et al., 2009). This study revealed an unawareness of both the CRC incidence rate increase in Japan and the link between CRC and lifestyle. We would also like to make reference to the necessity for dissemination of appropriate knowledge regarding the results of this study.

In conclusion, we would d like to discuss the limitations of this study and the challenges for the future. First, we determined whether a patient completed FOBT test or not while depending on the self-report submitted by a patient. Therefore, a research in cooperation with an institution which conducts the screening will be required in the future studies as we have not confirmed who actually underwent FOBT this time. Second, we should consider the possibility of sample bias. The FOBT screening rate in the year preceding the survey was 44.9%, which was significantly higher than the FOBT screening rate previously reported in Japan (Tomotaka et al., 2005). Behind these differences lies the fact that the FOBT is performed not only in medical checkups by municipalities targeting their citizens, but also in the complete medical checkups conducted by companies for their employees. However, because this study was conducted through the internet, there is inherent sampling bias, which indicates the interests of participants in cancer screening. We believe that the study participants readily undergo FOBT screening. As for our metrics, we modified the items used in a separate study of the beliefs of breast cancer

screening in Japan. For this reason, the items cited as perceived barriers such as a feeling of discomfort towards collecting stool samples and embarrassment (Cabinet Office, Government of Japan, 2013; Jones, Devers, et al., 2010; Kandula et al., 2006) were not included in the items relating to a specific belief regarding FOBT. We consider that we can extract barriers that are more influential to CRC screening in the future by adding the items specific to CRC screening.

Despite these limitations, this study is important in terms of revealing the psychological factors influencing CRC screening behavior, particularly in a Japanese population. Based on the results of this study, cancer screening rates of people between the ages of 40 and 60 can be increased by eliminating the barriers to CRC screening, acknowledging the importance of CRC screening, and becoming aware that CRC screening is very common among healthy people. Development of specific messages reflecting the factors outlined in this study and an intervention study testing whether the actual interventions changes screening behavior are conceivable for the future.

5. Informed consent

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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Disclosure statement

Author T Taniguchi, Author K Hirai, Author K Harada, Author Y Ishikawa, Author M Nagatsuka, Author J Fukuyoshi, Author H Arai, Author H Saito, Author Y Mizota, Author S Yamamoto, and Author D Shibuya declare that they have no conflict of interest.

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Optimal use of colonoscopy and fecal immunochemical test for population-based colorectal cancer screening: a cost-effectiveness analysis using Japanese data

Masau Sekiguchi[1], Ataru Igarashi[2], Takahisa Matsuda[1,3,*], Minori Matsumoto[1], Taku Sakamoto[1], Takeshi Nakajima[1], Yasuo Kakugawa[1], Seiichiro Yamamoto[4], Hiroshi Saito[5], and Yutaka Saito[1]

[1]Endoscopy Division, National Cancer Center Hospital, Tokyo, [2]Graduate School of Pharmaceutical Science, The University of Tokyo, Tokyo, [3]Cancer Screening Division, Research Center for Cancer Prevention and Screening, National Cancer Center, Tokyo, [4]Public Health Policy Research Division, Research Center for Cancer Prevention and Screening, National Cancer Center, Tokyo, and [5]Screening Assessment and Management Division, Research Center for Cancer Prevention and Screening, National Cancer Center, Tokyo, Japan

*For reprints and all correspondence: Takahisa Matsuda, Cancer Screening Division, Research Center for Cancer Prevention and Screening, National Cancer Center, Tokyo, Japan; Endoscopy Division, National Cancer Center Hospital, 5-1-1 Tsukiji, Chuo-ku, Tokyo, 104-0045, Japan. E-mail: tamatsud@ncc.go.jp

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Abstract

Objective: There have been few cost-effectiveness analyses of population-based colorectal cancer screening in Japan, and there is no consensus on the optimal use of total colonoscopy and the fecal immunochemical test for colorectal cancer screening with regard to cost-effectiveness and total colonoscopy workload. The present study aimed to examine the cost-effectiveness of colorectal cancer screening using Japanese data to identify the optimal use of total colonoscopy and fecal immunochemical test.

Methods: We developed a Markov model to assess the cost-effectiveness of colorectal cancer screening offered to an average-risk population aged 40 years or over. The cost, quality-adjusted life-years and number of total colonoscopy procedures required were evaluated for three screening strategies: (i) a fecal immunochemical test-based strategy; (ii) a total colonoscopy-based strategy; (iii) a strategy of adding population-wide total colonoscopy at 50 years to a fecal immunochemical test-based strategy.

Results: All three strategies dominated no screening. Among the three, Strategy 1 was dominated by Strategy 3, and the incremental cost per quality-adjusted life-years gained for Strategy 2 against Strategies 1 and 3 were JPY 293 616 and JPY 781 342, respectively. Within the Japanese threshold (JPY 5–6 million per QALY gained), Strategy 2 was the most cost-effective, followed by Strategy 3; however, Strategy 2 required more than double the number of total colonoscopy procedures than the other strategies.

Conclusions: The total colonoscopy-based strategy could be the most cost-effective for population-based colorectal cancer screening in Japan. However, it requires more total colonoscopyprocedures than the other strategies. Depending on total colonoscopy capacity, the strategy of adding total

colonoscopy for individuals at a specified age to a fecal immunochemical test-based screening may be an optimal solution.

Key words: colorectal cancer screening, cost-effectiveness analysis, fecal immunochemical test, total colonoscopy

Introduction

Colorectal cancer (CRC) has markedly increased and is now the second most commonly diagnosed cancer and the third leading cause of cancer-related mortality in Japan (1). For the secondary prevention of CRC, a Japanese population-based CRC screening system has used the 2-day fecal immunochemical test (FIT) as a primary screening procedure on the basis of the evidence regarding its effectiveness for CRC screening (2). The effectiveness of the fecal occult blood test (FOBT) for reducing CRC-associated mortality has been clearly shown in several randomized controlled trials (3–7), whereas other case–control or cohort studies have shown the effectiveness of FIT for CRC screening and the superior sensitivity of FIT for CRC compared with that of FOBT (8–14). Japanese population-based CRC screening is offered to the entire population aged 40 years and over, and total colonoscopy (TCS) is performed for those with a positive FIT result. Recently, however, it has been reported that TCS-based CRC screening, in which TCS is performed as a primary screening procedure, is effective for reducing CRC incidence and mortality, based on long-term follow-up data in cohort studies (15,16). In this context, an analysis of the optimal combination of TCS and FIT for population-based CRC screening is required because there is yet no consensus regarding the issue.

Cost-effectiveness analysis is an essential part of the evaluation of screening strategies. Several cost-effectiveness analyses of CRC screening have been reported from the USA and several other countries (17–24). In Japan, however, there have been only limited analyses (25,26). Recently, by analyzing the TCS screening database of our institution's cancer screening division and the Japanese nationwide survey data of CRC screening, we reported that not only FIT but also TCS might be cost-effective for primary screening (27). However, the study retrospectively evaluated only the cost of identifying a CRC patient; further study using a Markov model analysis is necessary to evaluate the true cost-effectiveness of Japanese CRC screening.

In the present study, we aimed to identify the optimal combination of TCS and FIT for population-based CRC screening in the Japanese setting from the perspective of cost-effectiveness. To evaluate cost-effectiveness, we performed a Markov model analysis using Japanese clinical and cost data. To determine the optimal screening strategy, we also considered the number of TCS procedures required.

Patients and methods

Decision analytic model

We developed a state-transition Markov model that simulated the natural history of CRC development, and the actual cost-effectiveness was analyzed by Monte Carlo simulation using Tree Age Pro 2014 (TreeAge Software Inc., Williamstown, MA, USA) (28). In a Markov model, clinical situations are described in terms of discrete health states, 'Markov states,' that individuals can be in; an individual is always in one of these states, and all events of interest are modeled as transitions from one state to another. In this study, the natural history of CRC development was simulated as a transition from normal epithelium to low-risk adenomatous polyps sized 1–4 and 5–9 mm, to high-risk polyps, to CRC (from Dukes' A to Dukes' D), and ultimately to death from CRC, with reference to previous studies (17–24). Therefore, the Markov states were set as shown in Fig. 1. In addition, the detection status of colorectal polyps and CRC ('detected' or 'undetected') was considered, with CRC screening affecting the transition from 'undetected' to 'detected.' CRC was defined, according to the international classification, as a malignant epithelial tumor originating in the large bowel with invasion beyond the muscularis mucosae (29). High-risk polyps included intramucosal cancers and adenomas with a diameter ≥10 mm, with high-grade dysplasia, or with villous histology (≥25%) (30). The study setting was Japan and the initial population comprised 100 000 individuals aged 40 years who were at an average risk of CRC. The screening and analysis continued through the lifetime of the cohort. The time frame of the analysis was divided into 1 year, during which individuals were in the same health state before having the opportunity to transition to another state. The transition was governed by transition probability values mostly estimated from Japanese literature as described later. Japanese data for age-specific CRC incidence rates was the basis for determining the number of individuals in the population would develop CRC without any screening or intervention (1).

The validity of the model was assessed by comparing the lifetime cumulative risks for CRC incidence and mortality for the 40-year-old Japanese population estimated from the model of this study with those estimated from Japan's Cancer Registry and Statistics (http://gdb.ganjoho.jp/graph_db/gdb1?smTypes=67, Cancer Information Service, National Cancer Center, Japan) (1). When estimating these risks using the model, CRC screening with FIT (primary screening) and TCS (for those with a positive FIT) were considered with uptake rates set at 37 and 55% for FIT and TCS, respectively, based on the data of current Japanese uptake rates (31,32).

CRC screening strategies

To evaluate the optimal use of TCS and FIT for CRC screening, a total of three CRC screening strategies with TCS and/or FIT, including a

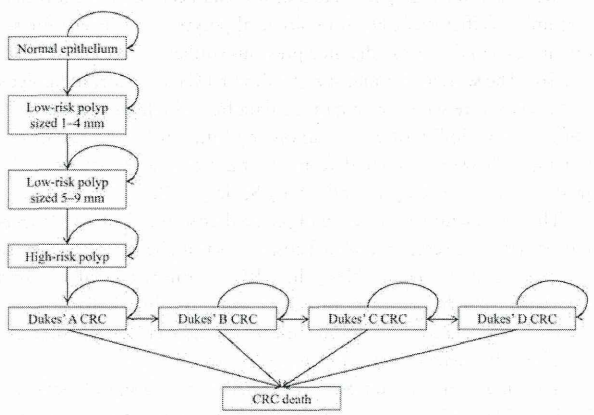

Figure 1. The natural history model of colorectal cancer. CRC, colorectal cancer.

FIT-based strategy which mostly corresponded to the current strategy of Japanese population-based CRC screening and other two strategies which used TCS more actively than the current strategy, were examined in this study (Fig. 2).

Strategy 1: a FIT-based screening strategy
The population is offered FIT at the age of 40 years. When the test is negative, it is repeated annually. Individuals with a positive FIT result are invited for TCS examination; any polyps found are removed and surveillance TCS is repeated every 3 years until no more polyps are found. When the results on TCS are normal, FIT is resumed 5 years after the TCS (Fig. 2a).

Strategy 2: a TCS-based screening strategy
The population is offered TCS as primary screening at the age of 40 years. When the test is negative, TCS is repeated 10 years later. If polyps are found, they are removed and surveillance TCS is repeated every 3 years until no more polyps are found. When the TCS results are normal, TCS is resumed 10 years later (Fig. 2b).

Strategy 3: a strategy of adding population-wide TCS for 50-year-old individuals to a FIT-based screening
This screening strategy is the same as Strategy 1 for individuals aged 40–49 years. The difference is that at the age of 50 years the whole population undergoes TCS, apart from those who underwent TCS in their 40s. After TCS, the screening continues according to the TCS results as with Strategy 1 (Fig. 2c).

Model parameters

Model parameters, including transition probabilities, test characteristics and cost, are summarized in Table 1. Most data were based on Japanese data (1,33–38), except for some data that were only available from foreign studies (20,39). The disease progression parameters from normal epithelium to colorectal polyps and cancer were calculated on the basis of the CRC incidence data from a study of 25 population-based cancer registries for the Monitoring of Cancer Incidence in Japan project (1), and the polyp prevalence data at Cancer Screening Division, Research Center for Cancer Prevention and Screening, National Cancer Center, Tokyo, Japan (33). The possibility of new polyps developing after endoscopic removal of polyps was estimated with reference to the data from the Japan polyp study (34). The references for the data regarding other transition probabilities are provided in Table 1 (20,38,39).

With regard to the parameters of test characteristics, the sensitivities and specificities of FIT for colorectal polyps and cancer were set on the basis of data from detailed previous studies by Morikawa et al. (35,36). The sensitivities and specificities of TCS for colorectal polyps and cancer were set according to the data from the Japan polyp study (34). The possibility of complication (perforation and bleeding) following TCS were estimated from the nationwide report from the Japan Gastroenterological Endoscopy Society (37).

The cost included the screening-related cost and CRC treatment-related cost. The screening-related cost was set on the basis of Japanese national reimbursement tables. The CRC treatment-related cost was calculated from the cost of the treatment procedure, hospitalization, adjuvant chemotherapy and follow-up care on the basis of Japanese national reimbursement tables and expert discussion.

The uptake rate of each test (FIT and TCS) was also built into this analysis. The CRC screening uptake rate in Japan has been increasing, but the current rate (~30–40%) is lower than the Japanese government's target values (50%) and the cut-off value for the desirable level of the uptake rate (65%) provided in the European guidelines (31,40). These guidelines based their evidence on performance indicators for FIT on data with a FIT uptake rate of 61.5% (41). From this, it ideally appears that an uptake rate of at least 60% is required for population-based CRC screening. Thus, in the present study, all uptake rates were first set at 60% in the base case analysis and then changed in the sensitivity analyses.

Cost-effectiveness analysis

The cost-effectiveness analysis was performed from a healthcare payer's perspective. The effectiveness of screening was measured in terms of the quality-adjusted life-years (QALYs) gained. Costs and QALYs were discounted at an annual rate of 3% (42). Strategies that were more costly and less effective than other strategies were ruled out by simple dominance. Among the remaining strategies, the incremental cost-effectiveness ratio (ICER) was evaluated. ICER was determined for a strategy by comparing the additional cost and effectiveness of the strategy with those of a less costly and less effective strategy; ICER was calculated as the difference in costs divided by the difference in effectiveness.

To compare the demand for endoscopic resources between different screening strategies, the number of TCS procedures performed in each strategy was also calculated.

Sensitivity analyses

In addition to the base case analysis, scenario analyses were performed with regard to the uptake rates (10% and 100%), the initial age of screening (50 years), and the age for population-wide TCS in Strategy 3 (40–60 years). A probabilistic sensitivity analysis was performed for the parameters of transition probabilities, costs, test characteristics, uptake rates and quality of life scales. In a probabilistic sensitivity analysis, these multiple parameters were varied simultaneously. We used β distributions for the parameters for which we could acquire raw data (the denominator and numerator of parameters), including the sensitivities of FIT and TCS, the probability of perforation after TCS, and that of new polyps developing after polyp resection, and gamma distributions for the other variables with a range of ±25%. A cost-effectiveness acceptability curve was drawn to show the correlation between the probability of being chosen as the most cost-effective scenario for each strategy and the willingness-to-pay (WTP) values for one additional QALY gained. The WTP value is the maximum cost that an individual is willing to pay to gain one additional QALY, and the value varies according to country; the Japanese threshold is reported to be JPY 5–6 million per QALY gained (43).

Results

Validity of the model

The cumulative risks for CRC incidence and mortality for the Japanese 40-year-old population estimated from the Cancer Registry and Statistics and those estimated from the model are shown in Fig. 3. The risks estimated from the model generally matched those from the Cancer Registry and Statistics, particularly ≤65 years of age. After the age of 65 years, the risks estimated from the model were slightly lower than those estimated from the Cancer Registry and Statistics.

Base case analysis

The outcomes for the three screening strategies and for no screening in the base case analysis are summarized in Table 2. Without any