Potential capacity of endoscopic screening for gastric cancer in Japan

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Key words
Cancer screening, capacity, gastric cancer, medical resource, upper gastrointestinal endoscopy

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Funding Information
Ministry of Health, Labor and Welfare of Japan.

Received July 27, 2016; Revised October 4, 2016; Accepted October 6, 2016

Cancer Sci | 2017 | vol. 108 | no. 1 | 101–107
doi: 10.1111/cas.13100

Gastric cancer has continued to create a serious burden worldwide, particularly in East Asian countries. Although the incidence of gastric cancer has decreased, the highest mortality rates have been reported in East Asian countries at 24 per 100,000 men and and 9.8 per 100,000 women in 2012. However, prevention and screening programs for gastric cancer in these countries remain lacking, except in Korea and Japan.

In Korea, gastric cancer screening by upper gastrointestinal endoscopy (i.e., endoscopic screening) and upper gastrointestinal series using barium meal (i.e., radiographic screening) has been provided for the population aged 40 years and over since 2002. In fact, endoscopic screening has already become the mainstream of gastric cancer screening in Korea. In contrast, radiographic screening has been used as the sole national gastric cancer screening program in Japan.

In 2016, the Japanese government decided to introduce endoscopic screening for gastric cancer as a national program. To provide endoscopic screening nationwide, we estimated the proportion of increase in the number of endoscopic examinations with the introduction of endoscopic screening, based on a national survey. The total number of endoscopic examinations has increased, particularly in clinics. Based on the national survey, the total number of participants in gastric cancer screening was 3,784,967. If 30% of the participants are switched from radiographic screening to endoscopic screening, approximately 1 million additional endoscopic examinations are needed. In Japan, the participation rates in gastric cancer screening and the number of hospitals and clinics offering upper gastrointestinal endoscopy vary among the 47 prefectures. If the participation rates are high and the numbers of hospitals and clinics are small, the proportion of increase becomes larger. Based on the same assumption, 50% of big cities can provide endoscopic screening with a 5% increase in the total number of endoscopic examinations. However, 16.7% of the medical districts are available for endoscopic screening within a 5% increase in the total number of endoscopic examinations. Despite the Japanese government’s decision to introduce endoscopic screening for gastric cancer nationwide, its immediate introduction remains difficult because of insufficient medical resources in rural areas. This implies that endoscopic screening will be initially introduced to big cities. To promote endoscopic screening for gastric cancer nationwide, the disparity of medical resources must first be resolved.

Materials and Methods

Data sources. In Japan, the national government undertakes the “Survey of Medical Institutions” in September every 3 years and reports the total numbers of examinations per month. From the data obtained, the total numbers of specific equipment and examinations are calculated among hospitals and clinics in the whole nation, prefectures, secondary medical
districts, and municipalities. There are three types of medical districts in Japan responsible for health care plans in regional areas. The first type is responsible for providing the usual care at the municipal level, and the third type is responsible for providing specific health care services at the prefecture levels. The second type is the actual unit that provides health care services and includes several neighborhood municipalities. In 2014, there were 341 secondary medical districts in Japan. The total number of endoscopic examinations was calculated 12 times the actual data in the Survey of Medical Institutions. The total number of endoscopic examinations and participants in gastric cancer screening among 47 prefectures are shown in Table 1. The national average of the total number of endoscopic examinations was 260 296 per prefecture, but a huge

| Total population aged ≥40 years (2014)† | Total number of endoscopic examinations (2014)‡ | Number of examinations per person aged ≥40 years | Total number of participants in gastric cancer screening (2012)§ | Participation rate in gastric cancer screening, % (2012)§ |
|----------------------------------------|-----------------------------------------------|-----------------------------------------------|-------------------------------------------------------------|-----------------------------------------------------|
| Japan                                  | 75 168 865                                     | 12 233 892                                     | 0.16                                                        | 3 784 967                                          | 5.0                                                |
| Hokkaido                                | 3 375 031                                      | 581 532                                        | 0.17                                                        | 172 984                                            | 5.1                                                |
| Aomori                                  | 861 206                                        | 117 648                                        | 0.14                                                        | 94 730                                             | 11.0                                               |
| Iwate                                   | 820 436                                        | 111 804                                        | 0.14                                                        | 90 129                                             | 11.0                                               |
| Miyagi                                  | 1 346 547                                      | 245 496                                        | 0.18                                                        | 154 373                                            | 11.5                                               |
| Akita                                   | 704 451                                        | 147 204                                        | 0.21                                                        | 56 053                                             | 8.0                                                |
| Yamagata                                | 717 137                                        | 142 908                                        | 0.20                                                        | 98 465                                             | 13.7                                               |
| Fukushima                               | 1 199 945                                      | 302 652                                        | 0.25                                                        | 103 793                                            | 8.6                                                |
| Ibaragi                                 | 1 756 734                                      | 227 028                                        | 0.13                                                        | 93 547                                             | 5.3                                                |
| Tochigi                                 | 1 176 388                                      | 171 696                                        | 0.15                                                        | 90 028                                             | 7.7                                                |
| Gunma                                   | 1 195 185                                      | 234 192                                        | 0.20                                                        | 55 199                                             | 4.6                                                |
| Saitama                                 | 4 185 480                                      | 472 980                                        | 0.11                                                        | 142 664                                            | 3.4                                                |
| Chiba                                   | 3 624 497                                      | 503 844                                        | 0.14                                                        | 235 921                                            | 6.5                                                |
| Tokyo                                   | 7 365 271                                      | 1 242 516                                      | 0.17                                                        | 254 882                                            | 3.5                                                |
| Kanagawa                                | 5 199 367                                      | 728 136                                        | 0.14                                                        | 148 274                                            | 2.9                                                |
| Niigata                                 | 1 446 562                                      | 240 768                                        | 0.17                                                        | 115 005                                            | 8.0                                                |
| Toyama                                  | 670 203                                        | 136 824                                        | 0.20                                                        | 54 288                                             | 8.1                                                |
| Ishikawa                                | 684 992                                        | 173 424                                        | 0.25                                                        | 37 185                                             | 5.4                                                |
| Fukui                                   | 478 355                                        | 104 652                                        | 0.22                                                        | 25 759                                             | 5.4                                                |
| Yamanashi                               | 520 046                                        | 74 052                                         | 0.14                                                        | 40 189                                             | 7.7                                                |
| Nagano                                  | 1 313 004                                      | 283 320                                        | 0.22                                                        | 53 737                                             | 4.1                                                |
| Gifu                                    | 1 239 917                                      | 147 456                                        | 0.12                                                        | 64 919                                             | 5.2                                                |
| Shizuoka                                | 2 258 051                                      | 424 548                                        | 0.19                                                        | 138 121                                            | 6.1                                                |
| Aichi                                   | 4 143 364                                      | 479 424                                        | 0.12                                                        | 271 398                                            | 6.6                                                |
| Mie                                     | 1 105 081                                      | 184 152                                        | 0.17                                                        | 39 995                                             | 3.6                                                |
| Shiga                                   | 786 663                                        | 116 220                                        | 0.15                                                        | 21 588                                             | 2.7                                                |
| Kyoto                                   | 1 518 836                                      | 235 608                                        | 0.16                                                        | 41 269                                             | 2.7                                                |
| Osaka                                   | 5 131 625                                      | 756 108                                        | 0.15                                                        | 151 513                                            | 3.0                                                |
| Hyogo                                   | 3 310 832                                      | 493 536                                        | 0.15                                                        | 117 726                                            | 3.6                                                |
| Nara                                    | 843 979                                        | 105 660                                        | 0.13                                                        | 29 047                                             | 3.4                                                |
| Wakayama                                | 627 916                                        | 125 844                                        | 0.20                                                        | 26 222                                             | 4.2                                                |
| Tottori                                  | 355 043                                        | 74 424                                         | 0.21                                                        | 16 604                                             | 4.7                                                |
| Shimane                                 | 444 342                                        | 98 172                                         | 0.22                                                        | 13 813                                             | 3.1                                                |
| Okayama                                  | 1 142 743                                      | 196 512                                        | 0.17                                                        | 86 962                                             | 7.6                                                |
| Hiroshima                                | 1 683 544                                      | 315 996                                        | 0.19                                                        | 73 819                                             | 4.4                                                |
| Yamaguchi                                | 902 174                                        | 145 656                                        | 0.16                                                        | 26 483                                             | 2.9                                                |
| Tokushima                                | 485 314                                        | 74 004                                         | 0.15                                                        | 19 440                                             | 4.0                                                |
| Kagawa                                   | 606 333                                        | 109 128                                        | 0.18                                                        | 32 214                                             | 5.3                                                |
| Ehime                                   | 884 244                                        | 140 040                                        | 0.16                                                        | 46 922                                             | 5.3                                                |
| Kochi                                   | 479 164                                        | 65 604                                         | 0.14                                                        | 30 144                                             | 6.3                                                |
| Fukuoka                                  | 2 912 339                                      | 565 848                                        | 0.19                                                        | 103 758                                            | 3.6                                                |
| Saga                                    | 499 195                                        | 97 344                                         | 0.20                                                        | 31 519                                             | 6.3                                                |
| Nagasaki                                 | 875 505                                        | 173 940                                        | 0.20                                                        | 41 343                                             | 4.7                                                |
| Kumamoto                                 | 1 091 603                                      | 244 788                                        | 0.22                                                        | 63 662                                             | 5.8                                                |
| Oita                                    | 729 635                                        | 166 104                                        | 0.23                                                        | 38 672                                             | 5.3                                                |
| Miyazaki                                 | 690 481                                        | 127 560                                        | 0.18                                                        | 30 434                                             | 4.4                                                |
| Kagoshima                                | 1 035 904                                      | 219 528                                        | 0.21                                                        | 71 594                                             | 6.9                                                |
| Okinawa                                  | 744 201                                        | 108 012                                        | 0.15                                                        | 38 581                                             | 5.2                                                |

†Data from Report on Basic Resident Register (2014).‡Data from Survey of Medical Institutions (2014).§Data from Report on Regional Public Health Services and Health Promotion Services (2012). Participation rates in gastric cancer screening were calculated using the target population based on the Basic Resident Register as a denominator.
disparity among the 47 prefectures examined could be observed.

Since 1983, radiographic screening programs for gastric cancer have been carried out nationwide with the results reported annually. The target population of gastric cancer screening is individuals aged 40 years and above. Participation rates in gastric cancer screening were calculated using the target population based on the Basic Resident Register as a denominator. When further examination is needed on the basis of the results of the radiographic screening, endoscopic examination is carried out. In 2012, the total number of participants in radiographic screening for gastric cancer was 3,784,967 and this only covered 5% of the target population (Table 1). (8) The recall rate of radiographic screening was 8.8% as the national average, and 271,810 individuals underwent endoscopic examinations for diagnosis. (8)

**Estimation of potential capacity.** Based on the abovementioned national survey, we estimated the proportion of increase in the number of endoscopic examinations with the introduction of endoscopic screening. In radiographic screening, the mass survey has been mainly carried out in rural areas. Radiographic screening has also been undertaken through the system within clinical practice, particularly in urban areas. When a number of participants in radiographic screening switch to endoscopic screening, the number of endoscopic screenings is increased and that of diagnostic endoscopy carried out after obtaining positive results in radiographic screening is decreased. After the introduction of endoscopic screening in several areas, the total participation rates of gastric cancer screening with the combined endoscopic screening and radiographic screening have increased, although the proportion of increase was limited. However, replacement from radiographic screening to endoscopic screening has rapidly changed and has had a bigger impact. In Yonago, which introduced endoscopic screening in 2000, the proportion of endoscopic screening within gastric cancer screening has increased from 27.7% to 77.0% between 2000 and 2007. (10) As the participation rate, which is an optimistic assumption to be achieved in the same period (Fig. 1a). Moreover, the number of endoscopic examinations per month has increased in hospitals. Conversely, the number of endoscopic examinations per month has increased in clinics and its proportion occupied 45.9% of the total number of endoscopic examinations. The average number of examinations per month was 108.8 per hospital and 28.3 per clinic. The increase in the number of endoscopic examinations per year was more than 2,000,000 from 1996 to 2014.

**Results**

**Trends in total numbers of endoscopic examinations.** Based on the Survey of Medical Institutions, the total number of hospitals and clinics offering endoscopic examinations slightly decreased from 1996 to 2014 (Fig. 1a). (7) Although the number of these hospitals has decreased every year, the number of these clinics increased to 16,539 in 2014. The total monthly number of endoscopic examinations has gradually increased in the same period (Fig. 1b). Moreover, the number of endoscopic examinations per month has decreased in hospitals.

**Estimation of necessary number of endoscopic examinations.** At present, the total number of radiographic screenings
carried out each year is approximately 4 million, whereas the total number of endoscopic examinations carried out each year in clinical practice is approximately 12 million.\(^{(7,8)}\) If 30% of gastric cancer screenings are replaced by endoscopic screening, the total number of endoscopic examinations will increase by 8.6%, that is, 1,053,947 (Fig. 2). If the participation rate increases to 20%, the proportion of increase in endoscopic examinations needed will be 34.3%.

The proportion of increase in endoscopic examinations per year if 30% of gastric cancer screening is replaced by endoscopic screening was compared among 47 prefectures in Japan (Table 2). The proportion of increase was defined on the basis of the current participation rate in gastric cancer screening and the total number of endoscopic examinations in each prefecture. In area where the participation rate was not particularly high and sufficient medical institutions were available, the total increase in the number of endoscopic examinations was limited, as shown in Shimane Prefecture. Conversely, a substantial increase in the number of endoscopic examinations is needed in prefectures that have retained high participation rates for gastric cancer screening. An increase of more than 20% is required in Aomori and Iwate Prefectures; however, these prefectures cannot introduce endoscopic screening very easily. Based on the same condition of switching 30% from radiographic screening to endoscopic screening on a 5% participation rate, the proportions of increase in endoscopic examinations per year were compared among big cities and secondary medical districts (Table 3). In 50% of the big cities, endoscopic screening can be introduced with a proportion of increase of <5%. In 16.7% of the secondary medical districts, endoscopic screening can be introduced with a proportion of increase of <5%. The actual introduction of endoscopic screening might therefore be limited to big cities initially.

**Discussion**

Although gastric cancer has decreased worldwide,\(^{(1)}\) gastric cancer screening has continued to play a central role in cancer prevention programs, particularly in Korea and Japan, two countries whose incidence and mortality rates from gastric cancer have remained high. In Japan, endoscopic examinations have been commonly carried out in clinical practice, the total number of which has increased over the years. These examinations were particularly limited to clinical practice and not for cancer screening. Thus, an additional increase in the number of endoscopic examinations is required when endoscopic screening is actually introduced. In 2013, more than 300 municipalities introduced endoscopic screening in Japan. However, the number of municipalities that conducted more than 100 endoscopic screenings was limited to 200.\(^{(11)}\) Currently, the participation rate in gastric cancer screening in Japan is not high. However, if 30% of the participants in the mass survey for the radiographic screening of gastric cancer switched to endoscopic screening, 1,053,947 additional endoscopic examinations will be needed. This number is comparable to an 8.6% increase in the total number of endoscopic examinations. Radiographic screenings have been provided as a mass survey, mainly using mobile buses. However, such a system cannot be adopted for endoscopic screening because the endoscope used must be thoroughly cleaned and disinfected by an automatic processor.\(^{(12)}\) When endoscopic screening is introduced, endoscopic examination is needed after the endoscopic resection of early stage cancer. Thus, follow-up examination for benign lesions including peptic ulcer and gastroesophageal reflux disease will increase, and diagnostic examination after radiographic screening will also remain. Therefore, an increase in the total number of endoscopic examinations in both clinical practice and cancer screening is a must.

Insufficient medical resources can be a barrier to participating in cancer screenings, and this can lead to geographic disparity in terms of access to cancer screening.\(^{(13–15)}\) In the present study, the proportion of increase in endoscopic examinations was different among the 47 prefectures evaluated when using the same scenario (Table 2). As the incidence of gastric cancer is higher in the northern area (Tohoku) than in the other areas, the participation rates in gastric cancer screening there have been continuously higher. However, the number of medical institutions that provide endoscopic examination remains insufficient. These issues can become a barrier to the introduction of endoscopic screening, particularly in Tohoku. If 30% of gastric cancer screenings are replaced by endoscopic screening in half of the big cities, the proportion of increase was limited to 5%,
To the best of our knowledge, this is the first study to investigate the potential capacity of endoscopic screening for gastric cancer in Japan. Although the Japanese government has already approved endoscopic screening in communities, most additional volumes in rural as well as urban areas. The labor time for endoscopic examination was defined based on the current participation rate in gastric cancer screening and the total number of endoscopic examinations in each prefecture.

Table 2. Comparison of proportions of increase in endoscopic examinations among 47 Japanese prefectures if 30% of gastric cancer screenings are replaced by endoscopic screening

| Prefecture | Current number of endoscopic examinations | Increase in number of endoscopic examinations | Proportion of increase in endoscopic examinations, % |
|------------|-----------------------------------------|---------------------------------------------|-------------------------------------------------|
| Japan      | 12 233 892                              | 1 053 947                                   | 8.6                                             |
| Hokkaido   | 581 532                                 | 48 989                                      | 8.4                                             |
| Aomori     | 117 648                                 | 26 063                                      | 22.2                                            |
| Iwate      | 111 804                                 | 25 453                                      | 22.8                                            |
| Miyagi     | 245 496                                 | 43 279                                      | 17.6                                            |
| Akita      | 147 204                                 | 15 393                                      | 10.5                                            |
| Yamagata   | 142 908                                 | 27 060                                      | 18.9                                            |
| Fukushima  | 302 652                                 | 28 929                                      | 9.6                                             |
| Ibaragi    | 227 028                                 | 25 531                                      | 11.2                                            |
| Tochigi    | 171 696                                 | 25 243                                      | 14.8                                            |
| Gunma      | 234 192                                 | 15 016                                      | 6.4                                             |
| Saitama    | 472 980                                 | 40 297                                      | 8.5                                             |
| Chiba      | 503 844                                 | 65 464                                      | 13.0                                            |
| Tokyo      | 1 242 516                               | 73 023                                      | 5.7                                             |
| Kanagawa   | 728 136                                 | 40 946                                      | 5.6                                             |
| Niigata    | 240 768                                 | 32 292                                      | 13.4                                            |
| Toyama     | 136 824                                 | 14 984                                      | 11.0                                            |
| Ishikawa   | 173 424                                 | 9 944                                       | 5.7                                             |
| Fukui      | 104 652                                 | 7 143                                       | 6.8                                             |
| Yamanashi  | 74 052                                  | 11 307                                      | 15.3                                            |
| Nagano     | 283 320                                 | 14 431                                      | 5.1                                             |
| Gifu       | 147 456                                 | 17 991                                      | 12.2                                            |
| Shizuoka   | 424 548                                 | 38 790                                      | 9.1                                             |
| Aichi      | 479 424                                 | 74 810                                      | 15.6                                            |
| Mie        | 184 152                                 | 11 399                                      | 6.2                                             |
| Shiga      | 116 220                                 | 5938                                        | 5.1                                             |
| Kyoto      | 235 608                                 | 11 006                                      | 4.7                                             |
| Osaka      | 756 108                                 | 42 060                                      | 5.6                                             |
| Hyogo      | 493 526                                 | 33 122                                      | 6.7                                             |
| Nara       | 105 660                                 | 8283                                        | 7.8                                             |
| Wakayama   | 125 844                                 | 7 353                                       | 5.8                                             |
| Tottori    | 74 424                                  | 4 597                                       | 6.2                                             |
| Shimane    | 98 172                                  | 3875                                        | 3.9                                             |
| Okayama    | 196 512                                 | 24 593                                      | 12.5                                            |
| Hiroshima  | 315 996                                 | 20 903                                      | 6.6                                             |
| Yamaguchi  | 145 654                                 | 7421                                        | 5.1                                             |
| Tokushima  | 74 004                                  | 5402                                        | 7.3                                             |
| Kagawa     | 109 128                                 | 9 071                                       | 8.3                                             |
| Ehime      | 140 040                                 | 13 147                                      | 9.4                                             |
| Kochi      | 65 604                                  | 8 519                                       | 13.0                                            |
| Fukuoka    | 565 848                                 | 28 977                                      | 5.1                                             |
| Saga       | 97 344                                  | 8 438                                       | 8.7                                             |
| Nagasaki   | 173 940                                 | 11 496                                      | 6.6                                             |
| Kumamoto   | 244 788                                 | 18 209                                      | 7.4                                             |
| Oita       | 166 104                                 | 10 796                                      | 6.5                                             |
| Miyazaki   | 127 560                                 | 8 522                                       | 6.7                                             |
| Kagoshima  | 219 528                                 | 19 402                                      | 8.8                                             |
| Okinawa    | 108 012                                 | 11 141                                      | 10.3                                            |

Proportions of increase in endoscopic examinations per year were compared among 47 prefectures if 30% of gastric cancer screenings were replaced by endoscopic screening. The proportion of increase was defined based on the current participation rate in gastric cancer screening and the total number of endoscopic examinations in each prefecture.
municipalities in Japan are unsure of how to introduce endoscopic screening because of the difficulty in securing sufficient resources for the screenings and in adopting the basic requirements of quality assurance. In the USA, during the early period of introducing colonoscopy screening, national and regional resources were estimated by a questionnaire survey and modeling studies.\(^\text{17,18,22–24}\) To predict the demand and supply of endoscopic screening, the use of a simulation model with detailed information is an ideal method. However, the available data for these calculations are currently limited because endoscopic screening has been carried out in limited municipalities and the quality of data is not appropriate for use in a prediction model. Although the results can be obtained from several areas that have already introduced endoscopic screening, the actual supply of endoscopic examinations has been unclear in these areas. In addition, the government changed the starting age and screening interval for gastric cancer screening. Basic data collection for a prediction model must be identified for the efficient use of limited resources. Further study is warranted on how to provide equal access to endoscopic screening for gastric cancer for the target population.

In conclusion, although the Japanese government has decided to introduce endoscopic screening for gastric cancer nationwide, its rapid introduction remains hindered by insufficient medical resources in rural areas. Thus, endoscopic screening will likely and initially be introduced to big cities. This implies a disparity of medical resources that must be initially resolved to realize a smooth, nationwide implementation of endoscopic screening for gastric cancer.

**Acknowledgements**

This study was supported by H26 – Research for Promotion of Cancer Control (general study-008) from the Ministry of Health, Labor and Welfare of Japan. We are grateful to Dr. Edward F. Barroga for the editorial review of the manuscript. We also thank Ms. Kanoko Matsushima and Ms. Ikuko Tominaga for research assistance.

**Disclosure Statement**

The authors declare no conflict of interest.

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**Table 3. Proportions of increase in the total endoscopic examinations if 30% of gastric cancer screenings were replaced by endoscopic screening**

| Proportion of increase | 0-4.9% | 5.0-9.9% | 10.0-14.9% | 15.0-19.9% | 20.0-24.9% | 25.0-29.9% | 30.0-39.9% | 40.0-49.9% | ≥50% |
|------------------------|--------|----------|-------------|-------------|------------|-----------|-----------|-----------|-----|
| Big cities (n = 64)    | Number | 32       | 22          | 7           | 2          | 0         | 1         | 0         | 0   |
|                        | %      | 50.0     | 34.4        | 10.9        | 3.1        | 0.0       | 1.6       | 0.0       | 0.0 |
| Secondary medical      | Number | 57       | 102         | 89          | 32         | 26        | 20        | 9         | 4   |
| districts (n = 340)    | %      | 16.7     | 29.9        | 26.1        | 9.4        | 7.6       | 5.9       | 2.6       | 1.2 |

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