Chapter 2

Asymmetric Information and Heterogeneous Preferences in a Health Care Market

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1. Introduction

Contrary to common accusation of economist that the Japanese health care system lacks dynamics of market forces, Japanese health care providers are innovative and entrepreneurial. In the field of testing and diagnosis of diseases, for example, they aggressively adopted novel and expensive technologies, first, Computerized Tomography, and, then, Magnetic Resonance Imaging. Now, more CT’s and MRI’s than anywhere else in the rest of the world are located in Japan. Currently, we are seeing the third wave; Positron Emission Tomography. The creativity and imagination of managers of medical institutions in making up a huge market for cancer screening by PET is remarkable because demand is not easy to obtain when the new technology is very complicated and its benefits are not clearly demonstrated just as in the case of PET, whose evidence for effectiveness in screening cancer is lacking, as the Guidelines published by the Japanese Association of Nuclear Medicine admit.

Effectiveness of PET in diagnosis and staging of cancer is increasingly recognized while screening of cancer by PET is never proved as cost-effective. Consequently, cancer screening by PET is not covered by the social health insurance while PET testing for diagnosis and staging for some cancer is covered. The reason the cost-effectiveness of PET as a screening devise differs than PET as a diagnosis and staging devise lies in three facts. First, spatial resolution of PET is not very good, so that detection of cancer in early stages by PET is more difficult than diagnosis and staging of cancer in later stages by PET. Second, effectiveness of PET depends on the prevalence of cancer in the population. Diagnosis and staging is performed on the population who are very likely to have cancers, while screening is performed on the population who are not certain or rather unlikely to have cancers\(^1\). Third, the benefits of early detection is, in general, not so crystal clear because attaining longer lives

\(^1\) By the Bayes rule, letting \(a\) be an event that a person has a cancer and \(b\) be an event that the result is positive in PET testing, we have \[ p(a | b) = \frac{p(b | a) \cdot p(a)}{p(b)} \]. Even if the sensitivity, \(p(b | a)\), is the same for the cases of early and advanced cancers, the prevalence, \(p(a)\), is lower in the detection of early cancer in screening of asymptomatic people than in finding metastases in staging of advanced cancer patients, so that the probability of having cancer when the PET result is positive is lower in the case of early detection.
requires successful cure after early detection. On the other hand, if metastases are found in diagnosis and staging process, unnecessary surgeries can be avoided, which have direct benefits of higher quality of life and lower costs.

In general, if a good confers no utility to consumers, there cannot be a market for such a worthless good in an idealized world. We are living in an imperfect world, however. Markets in real life are notoriously plagued by imperfect information and limited or bounded rationality. People’s choices may be based on limited or wrong information and their preferences can be precarious or inconsistent. Increasing number of papers dealing with implications of bounded rationality on industrial organization point out that in such markets competition and entrepreneurship are not necessarily good. Suppliers can exploit consumers’ limited information and inconsistent preferences to increase profits in the cost of consumer welfare. In some cases, markets for worthless goods can exit. These considerations warn against a naive view that introducing competition and entrepreneurship will improve efficiency in health care and enhance welfare of the society.

To say that people behave differently than the standard economic theory assumes is not, of course, to say that people behave irrationally and the outcomes are necessarily bad. We only argue that we have to be careful to examine what is happening in reality and avoid jumping to a conclusion that competition is always good based on standard economic assumptions.

2. Conceptual Framework and Research Strategy

Figure 1 conveys a rough sketch of the conceptual framework for our investigation. The process of choice starts with information acquisition through search, learning, and so on. Through this activity, people acquire information. Information acquired is, however, incomplete. In health care markets, we typically encounter asymmetric

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3 Social learning, for example, restricts search to a very limited subset of population often without requiring a solid evidence, but it can be as efficient as full-fledged search in some cases (Banerjee and Fudenberg, 2004). Quite often, however, learning from the behavior of other people results in fads (Bikhchandari and Hirshleifer, 1998).
information between physicians and patients.

Based on information, people make a choice, but the choice is affected various factors. On one hand, people will not necessarily efficiently utilize available information. People may simply neglect some information, entertain personal belief even if it contradicts scientific evidence, simplify or categorize information to make decisions easy, and so on. This kind of behavior is called bounded rationality.

On the other hand, people sometimes appear not to maximize their preferences. This may occur, for example, when people have private information concerning the choice. In this case, people actually behave rationally, but observers lack the information on which people make decisions. Another possibility is idiosyncratic preferences. Even with the same belief and no private information, choices may differ among people. For example, a person may value a medical procedure more than others because she values the state of health more. This may be called “personal valuation”. A more anomalous example is, so to speak, “noisy” preference, which is, in a sense, a tendency to choose a medical service. In this case, a person decides to undergo a medical procedure without personally valuing it highly. People may have tendency to choose a high technology procedure, for example, without believing in its effectiveness nor personally valuing it highly.

Further complication arises from strategic behavior of providers. Providers may adopt pricing policies and product differentiation so as to exploit market imperfections such as asymmetric information and bounded rationality. For example, providers can offer very complicated packages of services with different contents and prices in order to make it difficult for people to compare prices among packages and among providers.

This paper has two main themes, which contribute to understanding the functioning of markets in health care. One is to investigate the degree of informational asymmetry in a health care market. We collect data on beliefs of providers and consumers in the effectiveness of PET as a

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4 The term, “noise”, is different than the usual meaning in the regression models. Here, we mean a tendency of a person to choose a medical procedure, which is a systematic characteristic of the person. It is a “noise” in that it does not depend on clear reasons or fundamentals.
cancer screening devise. We compare beliefs of providers and consumers to each other and to the Guideline published by the Association of Nuclear Medicine.

In the United States, there is a literature which examines heterogeneous rating of appropriateness of specific procedures by physicians and find idiosyncratic beliefs of raters (Landrum, McNeil, Silva and Normand, 1999, for example). However, there seems to be no attempt to compare beliefs of physicians and patients even in the United States, and less so in Japan.

The second main theme of this paper is to investigate determinants of willingness to pay for PET screening. It is easily expected that willingness to pay for PET screening differs among people. However, the welfare implications of this heterogeneity depend on the reasons they differ.

Heterogeneous choices may be made based on heterogeneous beliefs, private information or idiosyncratic preferences.

If the choice is based on heterogeneous beliefs in the effectiveness of PET, people who behave on inaccurate information will obtain lower welfare than those who behave on accurate information. The policy question, then, will be whether people can search and learn to obtain accurate information.

If the choice is based on private information which economists or policy makers cannot know, their choices will be right one. If a person feels some anxiety about their health or their risk of cancer, for example, it is natural that they are willing to pay more.

As for the case of idiosyncratic preferences, as we have alluded above, two cases may be further distinguished. One is “personal valuation”, which values PET screening highly with the same information on the effectiveness. The other is “noisy” preference, which is, a precarious choice. Choice based on “personal valuation” is perfectly rational, while choice based on “noisy” preference may have problematic implications for the welfare.

In an interesting paper, Suzuki and Saito (2006) measured the degree of heterogeneity in the willingness to pay for QALYs and estimated determinants of it to draw policy implications. This is a pioneering work and it encourages more studies to
accumulate. We will enrich their determinants by including heterogeneous beliefs and will deal with idiosyncratic preferences and other determinants in a unified framework by simultaneously estimating them.

This paper also touches upon consumers’ search and learning behavior in the PET screening market. It is well known that consumers, in general, perform search rather sparsely and learn from only a limited source of information. How much people search and learn and from where is a very important research question. However, a full treatment will require another paper on consumer search and learning.

In addition, we will give some information on provider behavior of PET screening, such as pricing and menu of PET screening packages. However, we delegate its full treatment to yet another paper on provider behavior.

We include these two topics for the sake of a report to the sponsoring institutes of what we did. Sections 5, 8 and 9 may be delegated to other papers.

The structure of this paper is as follows. Section 3 describes the data we use in this paper. Section 4 gives background information on the PET screening market in Japan. Section 5 touches upon providers’ pricing policy and people’s search behavior. Section 6 examines the degree of asymmetric Information between facilities and people and heterogeneous beliefs among them. Section 7 estimates the willingness to pay for PET screening and examine importance of heterogeneous preferences. Section 8 investigates in how much people learn and change their evaluation of the effectiveness of PET screening. Section 9 gives a sense of the price elasticity of supply. Section 10 concludes.

3. Data

We conducted three surveys.

First, a survey was conducted on PET facilities including both those which provide cancer screening by PET and those do not. Questionnaires include dates and number of PET and PET cancer screening, opinion on the effectiveness of cancer screening by PET, willingness to provide PET screening, and so on. We obtained a list of facilities which have PET and sent questionnaires to all of them. Of one hundred and ninety
two facilities, one hundred and four facilities answered the questionnaires, of which eighty one facilities provide cancer screening by PET.

Second, a survey was conducted on people sampled from the registered monitors of a research firm stratified by age, sex and region. The sample included both those who have already taken cancer screening by PET and those who have not. Questionnaires include opinion on the effectiveness of cancer screening by PET, search behavior, willingness to pay for PET screening, and so on. Of one thousand and two hundreds monitors whom we sent questionnaires, one thousand and four monitors sent back valid answers. Only a small fraction of the sample, eight monitors, has already taken cancer screening by PET.

Third, to increase the number of observations who have already undergone cancer screening by PET, a supplemental survey was conducted on those who underwent cancer screening at PET facilities. We asked fifteen facilities to distribute questionnaires to people who underwent cancer screening by PET at their facilities. The facilities were chosen because they are acquainted with one of the authors and people who underwent cancer screening by PET at each facility during the survey period were picked up questionnaires are the same as the second survey on people. Four hundred people who underwent PET screening were handed questionnaires and one hundred and seventy seven people sent back valid answers.

4. Prevalence and Background of PET Screening in Japan

In this paper, we focus on the demand side, with the analysis of the supply side delegated to another paper. However, it is useful to have overall picture of the provision of cancer screening by PET in our sample. We simply provide sample total, sample mean and so on, avoiding making population estimates because our small sample size may render the population estimates not so reliable due to non-response. Still, we believe that our sample is very informative about the prevalence of PET screening in Japan.

Figure 2 shows cumulative numbers of facilities in our sample which possess PET and of facilities which provide cancer screening by PET. After 2000, introduction of
PET accelerated.

This acceleration coincides with aggressive provision of PET screening. The propensity to provide PET screening is increasing rapidly. In 2006, seventy eight percent of facilities which possess PET provide cancer screening by PET. The timing of expansion corresponds to the new coverage of PET diagnosis by the social health insurance. In 2002, the social health insurance began to cover the use of PET in the diagnosis of several cancers, although it does not cover PET usage for cancer screening. This correspondence perhaps reflects an increased recognition of effectiveness of PET (at least for cancer diagnosis and staging), but also could be partly due to the economy of scope in that if a facility purchases and uses a PET for patients under the social health insurance, it can use the PET for cancer screening outside the social insurance.

Figure 3 shows cumulative numbers of PETs which sample facilities possess and of PET/CTs in particular. This trend clearly exhibits technological progress, switching form “plain” PET to PET/CT, combination of PET with CT. It would be interesting to examine whether this process of technology adoption is socially desirable, but we delegate its analysis to another paper.

Figure 4 shows annual incremental numbers of facilities which began PET screening and of newly installed PETs.

The average number of PET screening performed per facility in our sample is two hundreds and seventy six with the maximum of nearly three thousands. The numbers differ greatly across facilities.

Total number of PET screening in Japan including non-sample facilities is estimated to be around twenty two thousands. This is our population estimate obtained by multiplying the sample total by the inverse of the response rate. Considering the high price of PET screening, usually, more than one hundred thousand yen, PET screening is becoming a big business.

Figure 5 shows the numbers of facilities and PET screenings by region. The figures are for the first seven months of the 2006 fiscal year (up to October). Tokyo and Osaka metropolitan areas have the largest numbers of PET screening facilities. A little
surprisingly, the Chubu region excluding the Nagoya metropolitan area has the largest number of PET screening, followed by the Kyushu region. Average number of PET screening per facility is low in the Tokyo and Osaka metropolitan areas compared with Chubu excluding Nagoya and Kyushu areas. This may imply that monopoly power can be eroded substantially in areas where demand is large, which contradicts economists’ intuition that high fixed costs deter entry so that competition is imperfect in the PET screening market. This is also an important topic which we delegate to another paper. In sum, adoption of PET screening is rapid and PET screening can become a good source of revenue in an era of health care spending restrictions. The aggressive entry and fierce competition due partly to economies of scope, i.e. cancer diagnosis and staging are covered by health insurance from 2002, of course, partly due to technological progress: PET/CT.

5. Pricing and Search

Prices of PET screening vary greatly across facilities as well as within each facility. Price dispersion is common even in markets with very active search, such as internet markets (Baye, Morgan and Scholten, forthcoming). We have to get into deeper than merely observing price dispersions.

Figure 6 shows prices of PET screening offered by each facility. These prices are taken from facilities’ homepages because in our survey very few facilities gave their prices. Most facilities offer several packages of differing screening menus. They differ in the type of PET (“plain” PET or PET/CT), inclusive or not of other tests such as CT, MRI, X-ray tests, etc., target population (not specified, for elderly, for ladies, for executives), regular and discounted prices, sometimes with hotel accommodation, and so on. Presented facilities are those to which the third survey was conducted. Content of packages and prices are so versatile that ordinary people may not be able to distinguish each package from another and to judge whether the price is worth while.

This kind of product differentiation may be to serve heterogeneous preferences. But it may be a business strategy to make it difficult to precisely evaluate the differences
in the contents and prices. Ellison and Ellison (2004), Gabaix and Laibson (2003a) and Spiegler (2006a) point out that increased competition raises the incentive for providers to make their products more complex so as to decrease price elasticity of demand and to increase profit margin, which implies that competition will not enhance consumer welfare. At this stage, we do not know how prevalent and damaging this kind of business strategy in health care markets. This area warrants much more study in the future.

We will later in this paper investigate how far heterogeneous preferences can account the differences in the valuation of people.

Next, we briefly examine how people search in the PET screening market. This part is intended only to give some indications of search behavior by people. We will deal with the problem of search in yet another paper (other than another paper on producer behavior).

Major sources of information on PET screening for those who have undergone PET screening include mass media (62%), family members and friends (41%), physicians and facilities’ advertisement (32%) and internet (19%). They rarely consult medical books and medical journals.

The scope of search is rather limited. More than half of people who underwent PET screening chose facilities within one hour from their home and only a minority chose facilities more than three hours from their home.

When we asked people who underwent PET screening what aspects of PET facilities they compared in choosing facilities, they most often list nearness of the facility (41%), then, in descending order, price (22%), equipments (18%), comfortable facilities (16%), convenient scheduling (16%), and so on. Only a minority (6%) compared the precision of screening. Less than twenty percent of people did not do comparison, so people do search. However, their search is centered on convenience, not the quality of PET screening.

Interestingly, a sixth of those who underwent PET screening joined PET screening tour. Offering a packaged tour is an effective business strategy and here we see entrepreneurial medical managers again.
6. Asymmetric Information and Heterogeneous Beliefs

Now, we investigate one of our main themes in this paper: asymmetric information and heterogeneous beliefs on the effectiveness of PET screening.

First, we deal with evaluation by facilities of effectiveness of PET in screening cancer.

To note, the Association of Nuclear Medicine required that our survey should use the word “useful” instead of “effective” because effectiveness cannot be definitively judged. This is a little surprising in that effectiveness has a clear meaning in the medical literature, we believe, and it is the word “useful” that is vague. We guess that what the Association had in mind was the wording of the Guidelines of PET Cancer Screening published in 2004. There, “very useful” is defined as “PET is the most effective method for detecting cancers”, and “highly useful” is defined as “PET is not the most effective method for detecting cancers, but could be the first choice in view of non-invasiveness”.

We take as a benchmark the Guidelines published by the Association of Nuclear Medicine. Table 1 shows the evaluation of PET screening for each cancer and false negative rates presented in the Guidelines. Overall, Guidelines’ evaluation seems to correspond with false negative rates. However, false negative rates are in general high, which do not imply effectiveness. The Guidelines’ judgment whether PET is “useful” in screening cancer appears to heavily depend on the non-existence of alternative screening methods.

Our survey asked managers of facilities whether they believe that PET is “useful” for screening twenty cancers. Originally, we intended to ask physicians these questions, but the Association objected so that we changed the questionnaire to ask managers of facilities. We assume that managers and physicians have common beliefs about the “usefulness” of PET as a cancer screening device.

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5 False negative rate is the probability that the test result is negative even if a person has a cancer: in the notation of footnote 1, false negative rate is $1 - p(\tilde{b} \mid a)$, with $a$ the event of cancer and $\tilde{b}$ the event of PET positive.
Figure 7 compares the evaluation of the “usefulness” of PET screening by the Guidelines to the evaluation by facilities. On the horizontal axis, 0 denotes “not highly useful”, 1 “highly useful” and 2 “very useful” while the vertical axis gives the percentage of facilities which regards PET as “useful” for each cancer. On average, facilities’ evaluation seems to accord with the Guidelines well.

Looking into individual facilities, however, facilities have heterogeneous beliefs about the “usefulness” of PET as a screening devise.

We now turn to laypersons’ beliefs. People are asked whether they think PET screening is effective for all cancers. The choices are; Yes (Effective for all cancer), No (Not for all cancer), and Do not know. Then, the second category is further asked, for each cancer listed in the questionnaire, PET is effective or not.

We restrict our analyses in this section to people who knew that PET is used as a cancer screening devise, excluding those who did not know.

Figure 8 shows the share of people, both those who have undergone PET screening and those who have not, who regard PET as effective for each cancer together with the share of facilities which regard PET as “useful” for each cancer.

Facilities sharply distinguish between cancers for which PET is “useful” and “not useful” in that for some cancers most of them regard PET as “useful” while for other cancers most of them regard PET as “not useful”.

Compared to facilities, evaluation by people, both those who have undergone PET screening and those who have not, is less articulated. The percentages of people who regard PET effective do not differ much across cancers. This is a manifestation of information asymmetry between physicians (facilities) and lay person in the health care market.

As for the difference among people who have undergone PET screening and those who have not, Figure 8 indicates that consistently higher percentage of people who have undergone PET screening regard PET screening as effective. However, the difference is largely due to the fact that higher percentage of people who have not

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6 We asked people whether they think that PET is effective, not “useful”, for cancer screening. There is a discrepancy between questions to facilities and people. We assume that people cannot distinguish between effectiveness and “usefulness”.

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undergone PET screening answered that they do not know whether PET is effective for cancer screening. Figure 9 exhibits the distribution of the number of cancers for which people or facilities answered PET is effective or “useful”. A salient feature of the response of people is that a lot of people answered either they do not know whether PET is effective for cancer screening or they think PET is effective for all cancers. This kind of categorical response is in sharp contrast with the response of facilities whose distribution is centered at twelve. Here, informational asymmetry is again clear.

In relation to the demand for PET screening, it is especially interesting to note that thirty six percent of people who underwent PET screening answered that they do not know whether PET is effective for cancer screening. Also notable is that people who underwent PET screening are not more tilted toward regarding PET screening as effective for all cancers than people who have not undergone PET screening. We will examine determinants of demand for PET screening later.

Now we will try to quantitatively analyze the beliefs in the effectiveness of PET screening. We will closely follow the modeling approach of Landrum and Normand (1999) who investigated physicians’ beliefs in the appropriateness of coronary angiography.

We can model the degree of belief of facilities in the “usefulness” of PET as composed of three factors: general “usefulness” of PET, “usefulness” specific to each cancer and idiosyncratic beliefs of each facility. Formally, a facility $i$ judges PET as “useful”, denoted by 1, or not “useful”, denoted 0, for cancer $j$ according as a latent variable, $z_{ij}$, is positive or negative. $z_{ij}$, in turn, depends on the three factors listed above.

$$y_{ij} = I(z_{ij} > 0)$$

$$z_{ij} = \alpha + \mu_j + b_i + \epsilon_{ij},$$

where $\alpha$ is the general “usefulness” of PET for cancer screening, $\mu_j$ is “usefulness” of PET specific to cancer $j$, $b_i$ is idiosyncratic beliefs of each facility $i$ and $\epsilon_{ij}$ is a random evaluation error. We assume that $\epsilon_{ij}$ is distributed as an extreme value distribution so that we are dealing with a standard logit model. We also
assume that $\alpha$, $\mu_j$ and $b_i$ are distributed as normal distributions with means zeros:
$\alpha \sim N(0, \sigma_\alpha^2)$, $\mu_j \sim N(0, \sigma_\mu^2)$ and $b_i \sim N(0, \sigma_b^2)$.

We follow Landrum and Normand(1999) who estimated their model via Markov Chain Mote Carlo method. We utilized the WinBUGS package for estimation. We adopt diffuse priors by setting $\sigma_\alpha^2 = 100$ assuming $\sigma_\mu^2$ and $\sigma_b^2$ are distributed as gamma distributions: $\text{gamma}(a_1, a_2)$, with $a_1 = 0.001$ and $a_2 = 0.001$. We discarded first 2,000 iterations as a burn-in period, and used next 3,000 iterations to obtain estimates of parameters. We run three chains with dispersed initial values and check the convergence using the Brooks-Gelman diagnostic statistics.

Figure 10 shows estimates of $b_i$ with mean and 95% credible interval. Boxes represent inter-quartile ranges and the solid black line at the center of each box is the mean. The arms of each box extends to cover the central 95 per cent of the distribution and their ends correspond to the 2.5 % and 97.5% quantiles.

We see that $b_i$'s are significantly different than zero, which means substantial heterogeneity of beliefs in “usefulness” of PET as a cancer screening devise. We will report on the common belief concerning dividual cancer, $\mu_j$, later.

Further, we can check the extent to which facilities’ beliefs adhere to the Guidelines. Let $x_j$ take the value one if the Guidelines judge PET “very useful” or “highly useful” for screening cancer $j$, and zero if they judge PET “not highly useful”. Then, the latent variable becomes

$$z_{ij} = \alpha + (\beta + \beta_j) \cdot x_j + b_i + \epsilon_{ij},$$

(3)

where we allow the coefficient, $\beta_j$, on $x_j$ to differ across facilities along with a common coefficient $\beta$. We assume that $\beta \sim N(0, \sigma_\beta^2)$ and $\beta_j \sim N(0, \sigma_\beta^2)$ with $\sigma_\beta^2$ and $\sigma_\beta^2$ given diffuse priors, $\text{gamma}(0.001,0.001)$. Burn-ins and convergence check are the same as before.

The common coefficient, $\beta$, is estimated at 3.616 with the standard error of 0.210 implying that facilities’ evaluation is strongly affected by the evaluation of the Guidelines. Individual facilities’ response to the Guidelines, $\beta_j$, exhibits only a small heterogeneity (Figure 11). And estimation results for $b_i$ are similar as before confirming that facilities’ evaluation is heterogeneous even after controlling for the
Guidelines adherence. In other words, facilities largely follow the Guideline evaluation, but evaluations still differ much among facilities.

We can perform the same exercise as the case of facilities to examine whether people entertain heterogeneous beliefs in effectiveness of PET as a cancer screening devise. We estimated the model (1) and (2) for the sample including both those who have undergone PET screening and those who have not, but excluding those who did not know that PET is used as a cancer screening devise. Because it is obvious that those who think that PET screening is effective for all cancers have very different beliefs than those who think that PET is effective for some cancer, we restrict our sample here to the latter people. By the same reason, we also exclude those who do not have any opinion about the effectiveness of PET from the analysis in this section.

Figure 12 shows belief, $\mu_j^i$, of people in the effectiveness of PET screening for individual cancer together with corresponding belief of facilities. It is clear that people do not distinguish among cancers for which PET screening is effective while facilities’ evaluations are quite articulated.

The results concerning heterogeneous belief, $b_i$, are shown in Figure 13. A large heterogeneity is observed.

When we estimate model (1) and (3) including Guidelines’ evaluations as an independent variable, the common coefficient, $\beta$, is 0.363 with a standard error of 0.121. The coefficient is much smaller than that for facilities, which implies that adherence to or awareness of the Guidelines is low. Heterogeneous responses to the Guidelines, $\tilde{\beta}$, is drawn in Figure 14. Individual adherence to guidelines is not so varied, perhaps because they are little aware of the Guidelines in the first palace.

In sum, beliefs of layperson in the effectiveness of PET screening are much more heterogeneous than beliefs of facilities and adherence to the evidence is quite low.

In closing this section, we touch upon the awareness of risk. The shares of people who know the risk of radioactive exposure are 78.9% among those who have already undergone PET screening and 36.1% among those who have not.

It is assuring that those who underwent PET screening know the exposure risk.
Later we will investigate whether knowledge of exposure risk affects the willingness to pay for PET screening.

7. Willingness to Pay and Heterogeneous Preferences

We now investigate the second main theme of this paper. Willingness to pay differs among people, but to draw policy implications, we must go deeper into determinants of it.

As is mentioned above, Suzuki and Saito (2006) measured the degree of heterogeneity of the willingness to pay for QALYs and examined determinants of willingness to pay by estimating demand for QALYs function. Their measurement of heterogeneity is separated from the estimation of the demand function. This separation is artificial, so we simultaneously estimate heterogeneity and other determinants. The explanatory variables in their demand function include price, income, asset, age, sex, education, health status, severity of illness (surrogated by expected longevity). They found that price and severity of illness are consistently significant, income and assets are not significant, health status is also insignificant, education is generally significant. They stress that not income and assets, but other factors, such as severity of illness, are important determinants of demand for QALYs. This has implications for the welfare and equality of balance billing.

We will expand their list of determinants by including heterogeneous beliefs and will estimate idiosyncratic preferences and other determinants simultaneously.

In our surveys, people are asked how much they are willing to pay in order to add PET to cancer screening. Notice that this is an additional willingness to pay on top of basic cancer screening. The choices are “1. Less than ten thousands yen”, “2. Ten to thirty thousands yen”, up to “12. More than twenty thousands yen”. People are asked the same question twice. The analyses in this section is restricted to people who knew that PET is used as a cancer screening devise.

Figure 15 shows the distribution of willingness to pay by the category of choice\(^7\). A

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\(^7\) As will be described in Section 8, people are asked the same question twice, once before we provided additional information on PET screening and once after being given such information.
vast majority concentrates on lower prices, which implies that the valuation of PET screening is not high. We presume that people are presented a series of prices, $\text{price}_j$, $j=1,\ldots,12$, and answer, for each price, whether they will undergo PET screening or not. If the price is higher than their willingness to pay, we regard that he/she will undergo PET screening, and vice versa. For example, if her willingness to pay is category 3. “Thirty to fifty thousands yen”, we suppose that when the price is twenty thousands yen, she will undergo PET screening, but when the price is forty thousands yen, she will not undergo PET screening. In this way, we construct a panel dataset for the estimation of demand function.

To estimate demand function, we generate a binary variable, $\gamma_{ij}$, which takes the value one if $i$-th people undergoes PET screening when the price is $j$, and zero otherwise.

Following the standard approach, we posit that whether a person undergoes PET screening depends on a latent variable, $z_{ij}$, which depends on factors affecting the demand for PET screening.

The standard economic theory tells us that basic determinants of demand is offered price, $\text{price}_j$, and $i$-th person’s income, $\text{income}_i$. The focus of our analysis is how heterogeneities among persons affect demand for health care services as well as price and income. We assume that heterogeneity, $\eta_i$, includes $i$-th person’s belief in the effectiveness of PET screening($\text{belief}_i$), perception of risks of PET screening($\text{risk}_i$), health status($\text{health}_i$), the degree to which a person is conscious about health($\text{conscious}_i$), age($\text{age}_i$), sex($\text{sex}_i$), having a spouse($\text{spouse}_i$) or young children($\text{child}_i$). Health status represents private information while health consciousness represents “personal valuation”. In addition, we include an unobserved heterogeneity, $\lambda_i$, which is the heterogeneity that remains after controlling for observable heterogeneities.

The model is

$$
\gamma_{ij} = I(z_{ij} > 0)
$$

(4)

Figure 5 is based on the responses before information is provided.
\[ z_i = \beta_0 + \beta_1 \cdot price_i + \beta_2 \cdot income_i + \eta_i + \epsilon_i \]  
(5)

\[ \eta_i = \beta_3 \cdot belief_i + \beta_4 \cdot risk_i + \beta_5 \cdot health_i + \beta_6 \cdot conscious_i 
+ \beta_7 \cdot age_i + \beta_8 \cdot sex_i + \beta_9 \cdot spouse_i + \beta_{10} \cdot child_i + \lambda_i \]  
(6)

The latter two equations can be combined into one equation.

\[ z_i = \beta_0 + \beta_1 \cdot price_i + \beta_2 \cdot income_i 
+ \beta_3 \cdot belief_i + \beta_4 \cdot risk_i + \beta_5 \cdot health_i + \beta_6 \cdot conscious_i 
+ \beta_7 \cdot age_i + \beta_8 \cdot sex_i + \beta_9 \cdot spouse_i + \beta_{10} \cdot child_i + \lambda_i + \epsilon_i \]  
(7)

We will use two kinds of variables to represent people’s belief in the effectiveness of PET. One is the number of cancers for which each person believes PET is effective. This measure is crude but works well, we believe. However, only counting the number does not distinguish between the case where a person A believes PET is effective for cancer C and ineffective for cancer D and the case where another person B believes PET is ineffective for cancer C but effective for cancer D. If the majority of the sampled persons believe that PET is effective for cancer C and ineffective for cancer D, person A may be an average believer while person B may possess idiosyncratic belief. Further, using the number of cancer ignores the categorical nature of beliefs of those who think that PET is effective for all cancers and those do not know. Hence, we also use the heterogeneous belief, \( h_i \), estimated in the equation (2) for those who believe PET screening is effective for a subset of cancers, together with a dummy variable which represents those who think that PET screening is effective for all cancers. With these variables, \( \beta_3 \cdot belief_i \) is decomposed into \( \beta_{31} \cdot h_i + \beta_{32} \cdot effective\_all_i \), where \( effective\_all_i \) takes the value one if the person think that PET screening is effective for all cancers, and zero otherwise.

To represent consciousness about health, we use whether a person routinely or sometimes undergo health check in workplaces or schools.

We estimated the random-effects logit model (4) and (7) by maximum likelihood method using Stata package.

Table 2 (a) shows the results when we use the number of cancers as a belief variable. As the standard economic theory tells us, price and income are very significant determinants of demand. The price elasticity is very high. A high price
elasticity counters monopoly power, if any, and enhances consumer welfare.

Income is very significant. A person with a higher income will demand PET screening than a person with lower income. In a sense, this is a reasonable result from individual person’s perspectives. A higher income implies that a lost life by cancer corresponds to a larger loss in income. To judge whether a society should adopt PET screening technology, however, it must evaluate the benefit of saving lives from the societal point of view. It is arguable that a society should not adopt a medical technology which confers benefits only to people with high incomes. Or, conversely, if the medical technology is beneficial to people with lower income, it should be covered by the social insurance.

Among other heterogeneities, age and risk consciousness are significant. As a person gets older, the risk of cancer becomes higher. So targeting the aged could be cost-effective if the benefit for the aged is markedly high. At present, however, we do not know any evidence that targeted PET screening is cost-effective.

If people know radioactive risk of PET, they become very willing to PET screening. This is a little puzzling. At the least, people do not care about the risk of radioactive exposures of PET screening. This may be because it is difficult to understand exposure risk vividly.

Health consciousness tends to affect the demand for PET screening, but is not highly significant. Health conditions are not significant. It seems that private information or personal valuations are not strong determinants of willingness to pay.

Other heterogeneities, sex, having a spouse and children, do not affect demand for PET screening.

The number of cancers for which the person believes PET is effective, an indicator of belief in PET, is not significant. This is surprising because this result means that people do not behave on the basis of their own beliefs. There are two possible interpretations. One interpretation is that people rationally neglect their beliefs because they know that their beliefs are inaccurate. This hypothesis is, however, seems to be too much an interpretation, although a behavioral economist may enjoy it.

A more plausible interpretation, perhaps, is that people do behave based on some
beliefs, but these beliefs are not beliefs in the effectiveness of PET. It could be that people get to entertain some vague idea that PET screening is "good" from some sources. Arguably, people behave not on the scientific evidence, but on other, often anecdotal, evidence including personal experiences, salient episodes, exposure to mass media, and so on. We shall examine people’s belief together with search behavior in another paper in more depth.

Panel (b) in Table 2 shows the results using an alternative indicator of beliefs, heterogeneous belief, $b_i$, which is estimated in equation (2), together with a dummy for those who think that PET screening is effective for all cancers. Results are quite similar to the case of the number of cancer as an indicator of belief.

In the model (4) and (7), we allowed for an unobserved heterogeneity, $\lambda_i$, of demand for PET screening in addition to observed heterogeneities and heterogeneous beliefs, $b_i$. In Table 2, “sigma_u” shows the estimates of the standard deviation of $\lambda_i$.

We can explicitly estimate $\lambda_i$ following Landrum and Normand(1999) just as in the model (1) and (2). We assume that $\lambda_i$ follow a normal distribution, $\lambda_i \sim N(0,\sigma_{\lambda}^2)$ with a diffuse prior, $\sigma_{\lambda}^2 \sim \text{gamma}(0.001,0.001)$. We discard first 3,000 iterations as burn-ins and used next 5,000 iterations for the estimation. Convergence checks are made, as before, using Brooks-Gelman diagnostics based on three chains with dispersed initial values.

The results are presented in Figure 16. Significant heterogeneity is observed.

Up to now, we analyzed only people who underwent PET as a cancer screening. It happened that, among those who underwent PET, four persons were referred from physicians for diagnosis or staging entered in the sample. The above analyses excluded these four observations because these two types may differ in their demand for PET services. However, we can use these observations to further check whether unobserved heterogeneities affect demand behavior. Since people who were referred for diagnosis or staging know that the probability of their having a cancer is very high or certain, they may be very willing to undergo PET test.

To do this check, we add a variable, $\text{anomaly}_i$, which indicate an observation is the
person who underwent PET as a diagnosis or staging and see whether the variable is significant.

\[
z_i = \beta_0 + \beta_1 \cdot \text{price}_{ij} + \beta_2 \cdot \text{income}_{ij} \\
+ \beta_3 \cdot \text{belief}_{ij} + \beta_4 \cdot \text{risk}_{ij} + \beta_5 \cdot \text{health}_{ij} + \beta_6 \cdot \text{conscious}_{ij} \\
+ \beta_7 \cdot \text{age}_{ij} + \beta_8 \cdot \text{sex}_{ij} + \beta_9 \cdot \text{spouse}_{ij} + \beta_{10} \cdot \text{child}_{ij} \\
+ \beta_{11} \cdot \text{anomaly}_{ij} + \lambda_i + \epsilon_{ij}
\]  

The results are shown in Table 3. Overall results are very similar to Table 2. The anomaly variable is not significant, confirming that private information such as knowledge of having cancer does not significantly affect demand for PET test.

8. People Learn Little

We then examine the extent of learning by checking whether willingness to pay change before and after information acquisition. In the United States, provider profiling and report cards on provider performance are published in such states as New York. The intention is to provide information on the quality of health care providers so as to enable people to make better choices by reducing information asymmetry. In general, people do not seem to respond to such information much, although there is some indication that providers do respond (Marshall, et al. 2000). Recent papers, including Chernew Gowrisankaran and Scanlon(2006), Dafny and Dranove(2005), Howard(2005), Jin and Sorensen(2006), find some impacts of report cards on people’s choice, but also find that other sources of information is important. How much people learn and from where is a very important research question.

In our surveys, people are asked about their willingness to pay first without being given information on PET screening. Then, we give information on PET screening and ask the same question about their willingness to pay. We gave information on the test procedure, effectiveness, limitation and risk of PET screening. (See Appendix.) We deliberately chose moderate words to avoid giving people too positive or too negative impressions. Our wording is generally consistent with the Guidelines and pamphlet prepared by the Association, except that on the effectiveness we feel that the pamphlet used too strong a word so that we adopt a more tempered, but still very
positive, word.

It is not enough to simply measure change of opinions because the degree of change depends on the distance between what people knew and what they hear. If a person has a good knowledge of PET screening, additional information will not change her opinion. Of course, this invariance of opinions before and after information provision does not imply that she learns nothing. Our strategy is, then, to compare changes of willingness to pay among people with different degrees of knowledge and experience. Specifically, we divide people into three groups. The first group consists of those who have undergone PET screening, who, naturally, are expected to know better. The second group consists of those who have not undergone PET screening but know that PET screening is used as a cancer screening devise. The third group consists of those who have not undergone PET screening and do not know that PET screening is used as a cancer screening devise.

Our hypothesis is that if people learn effectively, the third group will change their opinion the most, and the second less so, and virtually no change for the first.

Figure 17 shows the willingness to pay before and after the acquisition of information for three groups. No substantial difference is observed between three groups.

9. Consumer Surplus and Social Welfare

Here, we briefly describe the estimation of the supply of PET screening services. This section is intended only to give some indications of the price elasticity of supply. We will deal with the problem of provider behavior more fully in another paper.

Facilities are asked how many PET screenings they are willing to perform if they are offered a specific price per screening. They are asked to respond to ten prices: twenty thousands, forty thousands, up to two hundreds thousands.

We estimated a very simple supply function with log of the number of PET screenings as a dependent variable and log of the price as an explanation variable. Fixed effects panel estimation is performed. The result is shown in Table 4.

The price elasticity is 0.376. Supply is relatively elastic in view of high fixed costs.
This is because, once fixed costs are sunk, marginal costs are not very high and because, we guess, facilities can use PET for patients of the social health insurance so that the fixed costs are shared.

Combining a high demand elasticity, a high supply elasticity portends a high consumer surplus.

However, as Figure 15 shows, a vast majority of willingness to pay concentrates on lower prices. Hence, there is a risk that facilities lower prices in an attempt to increase demand, exploiting low marginal costs, and the attracted people have low valuation of PET screening, resulting in a situation where a large quantity of socially low-value services are provided at too low a price.

10. Conclusion

Two main themes of this paper were, first, to investigate how large is the informational asymmetry between physicians and laypersons in a medical market, and, second, how much heterogeneous preferences are there in willingness to pay for a medical service among people. We found that information is substantially asymmetric between physicians and laypersons and that preferences about medical services differ greatly even after controlling observed characteristics and private information. We also found that people conduct only limited search and new information scarcely affect their willingness to pay.

These findings will caution against naïve belief in market mechanism in medical markets. We need more work on actual functioning of markets in health care and study proper design of institutions and regulations.


### Table 1: Evaluation by the Guideline of the “Usefulness” of Cancer Screening by PET

<table>
<thead>
<tr>
<th>Evaluation</th>
<th>Cancer</th>
<th>False negative rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very useful</td>
<td>Thyroid</td>
<td>21.4</td>
</tr>
<tr>
<td></td>
<td>Lymphoma</td>
<td>NA</td>
</tr>
<tr>
<td>Highly useful</td>
<td>Breast</td>
<td>22.5</td>
</tr>
<tr>
<td></td>
<td>Lung</td>
<td>31.5</td>
</tr>
<tr>
<td></td>
<td>Colon</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Pancrea</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Ovarian</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Uterus</td>
<td>NA</td>
</tr>
<tr>
<td>Not highly useful</td>
<td>Stomach</td>
<td>55.0</td>
</tr>
<tr>
<td></td>
<td>Kidney</td>
<td>73.6</td>
</tr>
<tr>
<td></td>
<td>Prostate</td>
<td>90.0</td>
</tr>
<tr>
<td></td>
<td>Esophagus</td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td>Liver</td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td>Bladder</td>
<td>100.0</td>
</tr>
<tr>
<td></td>
<td>Cervix</td>
<td>NA</td>
</tr>
</tbody>
</table>
Table 2

(a) The number of cancers as a belief variable

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Standard error</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>2.985</td>
<td>0.571</td>
<td>5.24</td>
</tr>
<tr>
<td>price</td>
<td>-1.050</td>
<td>0.040</td>
<td>-26.42</td>
</tr>
<tr>
<td>income</td>
<td>0.101</td>
<td>0.017</td>
<td>10.54</td>
</tr>
<tr>
<td>number cancers</td>
<td>0.005</td>
<td>0.016</td>
<td>0.31</td>
</tr>
<tr>
<td>risk</td>
<td>0.719</td>
<td>0.269</td>
<td>2.67</td>
</tr>
<tr>
<td>health</td>
<td>0.081</td>
<td>0.306</td>
<td>0.30</td>
</tr>
<tr>
<td>conscious</td>
<td>0.601</td>
<td>0.346</td>
<td>1.74</td>
</tr>
<tr>
<td>age</td>
<td>0.041</td>
<td>0.017</td>
<td>2.40</td>
</tr>
<tr>
<td>sex</td>
<td>-0.069</td>
<td>0.264</td>
<td>-0.26</td>
</tr>
<tr>
<td>spouse</td>
<td>-0.031</td>
<td>0.453</td>
<td>-0.08</td>
</tr>
<tr>
<td>child</td>
<td>0.094</td>
<td>0.336</td>
<td>0.28</td>
</tr>
</tbody>
</table>

sigma_u     | 2.762          | 0.134   |

Number of observations | 4984
Number of groups | 454
Log likelihood | -875.631

(b) Idiosyncratic belief as a belief variable

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Standard error</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>2.875</td>
<td>0.567</td>
<td>5.25</td>
</tr>
<tr>
<td>price</td>
<td>-1.044</td>
<td>0.089</td>
<td>-26.73</td>
</tr>
<tr>
<td>income</td>
<td>0.180</td>
<td>0.017</td>
<td>10.45</td>
</tr>
<tr>
<td>belief</td>
<td>0.059</td>
<td>0.207</td>
<td>0.28</td>
</tr>
<tr>
<td>effective_all</td>
<td>0.117</td>
<td>0.345</td>
<td>0.34</td>
</tr>
<tr>
<td>risk</td>
<td>0.740</td>
<td>0.265</td>
<td>2.79</td>
</tr>
<tr>
<td>health</td>
<td>0.095</td>
<td>0.306</td>
<td>0.31</td>
</tr>
<tr>
<td>conscious</td>
<td>0.590</td>
<td>0.343</td>
<td>1.72</td>
</tr>
<tr>
<td>age</td>
<td>0.039</td>
<td>0.017</td>
<td>2.35</td>
</tr>
<tr>
<td>sex</td>
<td>-0.065</td>
<td>0.263</td>
<td>-0.21</td>
</tr>
<tr>
<td>spouse</td>
<td>-0.031</td>
<td>0.452</td>
<td>-0.08</td>
</tr>
<tr>
<td>child</td>
<td>0.085</td>
<td>0.333</td>
<td>0.20</td>
</tr>
</tbody>
</table>

sigma_u     | 2.762          | 0.132   |

Number of observations | 4984
Number of groups | 454
Log likelihood | -876.089
Table 3

(a) The number of cancers as a belief variable

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Standard error</th>
<th>t-value</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>constant</td>
<td>2.885</td>
<td>0.571</td>
<td>5.23</td>
</tr>
<tr>
<td>price</td>
<td>-1.049</td>
<td>0.099</td>
<td>-26.72</td>
</tr>
<tr>
<td>income</td>
<td>0.180</td>
<td>0.017</td>
<td>10.54</td>
</tr>
<tr>
<td>number cancers</td>
<td>0.005</td>
<td>0.016</td>
<td>0.33</td>
</tr>
<tr>
<td>risk</td>
<td>0.709</td>
<td>0.268</td>
<td>2.64</td>
</tr>
<tr>
<td>health</td>
<td>0.100</td>
<td>0.304</td>
<td>0.33</td>
</tr>
<tr>
<td>conscious</td>
<td>0.599</td>
<td>0.342</td>
<td>1.75</td>
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<tr>
<td>age</td>
<td>0.041</td>
<td>0.016</td>
<td>2.46</td>
</tr>
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<td>-0.060</td>
<td>0.262</td>
<td>-0.12</td>
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<td>-0.369</td>
<td>0.452</td>
<td>-0.82</td>
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<tr>
<td>child</td>
<td>0.043</td>
<td>0.332</td>
<td>0.13</td>
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<tr>
<td>anomaly</td>
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<td>0.50</td>
</tr>
<tr>
<td>sigma_u</td>
<td>2.770</td>
<td>0.132</td>
<td></td>
</tr>
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</table>

Number of observations: 5038
Number of groups: 458
Log likelihood: -882.681

(b) Idiosyncratic belief as a belief variable

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Standard error</th>
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<th>p-value</th>
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<td>10.54</td>
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<tr>
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<tr>
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<td>0.34</td>
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<td>1.78</td>
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<td>0.040</td>
<td>0.017</td>
<td>2.45</td>
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<td>-0.19</td>
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<td>0.08</td>
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<tr>
<td>anomaly</td>
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<td>0.52</td>
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<tr>
<td>sigma_u</td>
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<td>0.136</td>
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Number of observations: 5038
Number of groups: 458
Log likelihood: -881.909
<table>
<thead>
<tr>
<th></th>
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<th>Standard error</th>
<th>t-value</th>
<th>p-value</th>
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<td>23.400</td>
<td>0.000</td>
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<td>0.064</td>
<td>5.890</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Number of observations: 438  
Number of groups: 71

R-squared  
Within: 0.0865  
Between: 0.0245  
Overall: 0.0011
Figure 1

Bounded rationality
Negligence
Personal belief
Simplification/categorization

Asymmetric Information

Information acquisition → Information

Search
Learning

Preferences

Choice

Private information
Idiosyncratic preferences

Pricing
Product differentiation

Strategic behavior of providers
Figure 6
Figure 8

[Graph showing various data points across different categories such as Brain, Thyroid, Stomach, Lung, Liver, Pancreas, Ovarian, Lymphoma, Lymph node metastasis, and Bladder, with lines indicating trends for those who have undergone PET screening and those who have not, as well as facilities.]
Figure 9
Figure 10

Box plot: beta
Figure 11

box plot: slope2
Figure 12
Figure 13

box plot: beta
Figure 14

Box plot: slope2