Department of Industrial Engineering and Economics

Working Paper

No. 2016-3

Nutrition and diseases in the low-income households in Tokyo in 1930

Kota Ogasawara, Tatsuki Inoue, and Ryo Nagaya

July, 2016

Tokyo Institute of Technology

2-12-1 Ookayama, Meguro-ku, Tokyo 152-8552, JAPAN
http://educ.titech.ac.jp/iee/

Nutrition and diseases in the low-income households in Tokyo in 1930

Kota Ogasawara *, Tatsuki Inoue †, and Ryo Nagaya ‡

July 26, 2016

Abstract

This paper provides the results of our analysis of a household survey of low-income working-class households conducted in Tokyo in 1930. We investigated both nutritional attainment levels and the relationship between calorie intake and health outcomes in those households. We found that the daily calorie intake per equivalent adult was 1,906.3 kcal – 2,117.9 kcal for men and 1,694.6 kcal for women. Considering that this consumption level satisfies the energy requirements for moderate physical activity, we conclude that low-income urban working-class households likely escaped hunger in those days. Our estimates show that with an increase in per capita income, those households tended to consume more animal protein instead of other types of food. However, we do not find any significant correlation between the improvement in daily calorie intake per capita and the health status of family members. This finding contributes to the debate on the contribution of nutritional improvements to the historical decline in mortality rates, using Japan as a case study.

Keywords: Disease; Health; Nutrition; Mortality;

JEL Codes: I14; N35

*Department of Industrial Engineering and Economics, Tokyo Institute of Technology, 2-12-1, Ookayama, Meguro-ku, Tokyo, 152-8552, Japan (E-mail: ogasawara.k.ab@m.titech.ac.jp).

†Graduate School of Decision Science and Technology, Tokyo Institute of Technology, 2-12-1, Ookayama, Meguro-ku, Tokyo, 152-8552, Japan (E-mail: inoue.t.at@m.titech.ac.jp).

‡Graduate Major in Industrial Engineering and Economics, Tokyo Institute of Technology, 2-12-1, Ookayama, Meguro-ku, Tokyo, 152-8552, Japan (E-mail: nagaya.r.aa@m.titech.ac.jp).

1 Introduction

Nutrition levels of British households have been widely studied in the literature. The food consumption of working-class households in the early 20th century as well as the long-run trend in nutritional status of agricultural households have attracted wide attention (Gazeley and Horrell 2013; Gazeley and Newell 2013 2015). [1] The gender bias in intra-hosuehold resource allocation in British households has also been analyzed in terms of food consumption (Horrell and Oxley 1999; Horrell *et al.* 2009; Horrell and Oxley 2012). [2] Furthermore, the data series of per capita food consumption in England from the 18th to 20th centuries have been recently revised (Schneider 2013). Despite the extensive literature on British households, to the best of our knowledge, few studies simultaneously analyze the nutritional attainment itself and its effect on health outcomes.

In contrast to this rich literature, little has been known about the nutritional attainment in urban working-class households in prewar Japan. A few studies have estimated the national average calorie intake from the end of the 19th century to the beginning of the 20th century in Japan. For instance, Nakayama reported that the national average daily calorie intake per capita, defined as the total amount of food supply in calories divided by the total population, between 1931 and 1935 was 2,191.9 kcal per day (Nakayama 1958, pp.16–20; p.37). Employing similar calculation methods, Hayami and Yamada estimated the national average daily calorie intake during 1923 to 1927 at 2,320 kcal, and Mosk estimated that between 1928 and 1932 at 2,334 kcal (Hayami and Yamada 1970, p.81; Mosk 1978, p.279). [3] Since these studies focused on the long-term transition in the average calorie intake in Japan, actual nutritional attainments and excess or deficient calorie intake in specific periods and/or specific areas of prewar Japan have been largely

[1]See also Floud *et al.* (2011), pp.164–9.

[2]See also Horrell and Oxley (2013) for the good review of the studies. The household-level data on food expenditures has been commonly used in several studies. For instance, the trans–national surveys of household expenditure conducted by the United States Commissioner for Labor (USCL) have been widely used in research (*e.g.*, Haines 1979; Hatton *et al.* 1994; Horrell and Oxley 1999; Logan 2006a; Logan 2009; Gazeley *et al.* 2015). The representativeness of the USCL data has also been investigated by a number of researchers (see Gazeley *et al.* 2015, pp.514–6 for the details).

[3]In addition to studies that estimate time-series changes in calorie intake, Odaka (1984, pp.137–41) argues that the decline in Engel's coefficient observed during the late 19th century and early 20th century was associated with the fact that the real standard of living had improved via industrialization during that period. See also Kito (1996, pp.435–41) for an overview of long-term transitions in nutritional intake and physical status in prewar Japan.

neglected. [4]

Motivated by the abovementioned discussions in the British and Japanese literature, this paper attempts to address the following two questions. First, did urban households in interwar Japan take enough energy to allow them to survive or satisfy the energy requirements of a certain physical activity level? Second, did the improvement in energy intake really reduce the risk of death or of infection from different diseases? To answer these questions, we compiled an original report based on a low-income working-class household survey conducted in Tokyo in 1930 by *Tokyo Eiseishikensho* (the Tokyo Institute of Public Health – TIPH). This survey recorded the quantities of nutrients, including carbohydrates, protein, and fat, consumed by each household. Interestingly, this report also documented the number of patients by disease category and the number of infant and fetal deaths within each household. Considering that information on the nutritional status of working-class households is now available, we attempt to investigate not only their nutritional attainments but also the relationship between the nutritional status and health outcomes in these households.

Our key findings are as follows. First, we estimate the daily calories equivalent per adult at 1906.3 kcal (2,117.9 kcal for men and 1,694.6 kcal for women). This implies that the average calorie intake per equivalent adult in urban working-class households exceeded not only the survival diet, which is the amount of energy required to eat and digest food or for essential hygiene, but also the calorie required for the average physical activity levels of the workers in these households. Second, the income elasticity of calorie intake from animal foods is estimated to be significantly positive, whereas that for the total calorie intake is not significantly different from zero. Therefore, with an increase in per capita income, those households more likely bought fish and/or meat instead of other types of food, implying that people's average calorie intake more likely exceeded the requirement. Third, from our simple OLS regression regarding health outcomes, we do not find any significant correlation between the improvements in daily calorie intake per capita and the infant mortality and fetal death rates, as well as the disease rates.

The contributions of this paper are two-fold. First, it provides an initial estimate of the daily calorie intake in a working-class urban household in Japan, using a household-level

[4] Although Yazawa (2005) estimated the 1932 average calorie intake per day in poor households at 1,623.5 kcal, using aggregated household survey data, he has not reported excess or deficient calorie intake by the people.

dataset. Our estimate supports the finding in a famous Japanese historical study that "the lower classes in the city had formed a framework of lifestyle to somehow establish a family in the city by the beginning of the 1920s and had managed to strongly maintain that framework" (Nakagawa 1985, p.399). Recent research by Gazeley and Newell found that diets in Britain's urban working-class households in 1904 were sufficient to provide energy for work that was somewhat physically demanding (Gazeley and Newell 2015). From a comparative perspective, our estimate implies that urban working-class households in Japan could have escaped from hunger in the early 20th century, at least around 1930. Second, this study adds to the debate on the contribution of nutrition improvements to the historical decline in the mortality rate (*e.g.*, McKeown 1976 1979; Fogel 1994 2004; Nunn and Qian 2011). Our result suggests the importance of public health interventions in the form of a health insurance system, modern waterworks, or programs that increased healthcare utilization to the process of large improvements in mortality rates (*e.g.*, Szreter 1988; Cutler and Miller 2005; Bowblis 2010).

This paper is organized as follows. Section 2 introduces the data used in the analysis and describes the characteristics of our sample households. Section 3 examines the calorie and nutrient intake of low–income working-class households in Tokyo in 1930. Section 4 analyses the relationship between the nutritional intake and health outcomes within those households. Section 5 offers concluding remarks.

2 Data and the sample characteristics

In this section, we introduce the characteristics of the historical document used in this study, and of our sample, and explain the appropriateness of the data.

Firstly, we offer an overview of the historical material used in this study. In the early 20th century, household surveys were frequently conducted and a vast number of survey reports were published in Japan. However, most of the survey slips were discarded after the local government or the research organization had compiled summary sheets. Therefore, historical records documenting household data have been rarely mined by historians. Taking this issue into consideration, we made use of a survey report which recorded detailed information on 183 poor urban households in order to analyze the nutritional attainment and the health condition of urban households at that time.

The record used in this paper is an official report issued by the TIPH. Fourteen researchers of the TIPH conducted the *Nutrition Survey in a Poor District of Tokyo City* (NSPD), which is a complete survey of 300 households located in the 19th to 40th blocks of *Hakusan Goten–cho* (Hakusan Goten town) in the Koishikawa ward, which was in the north–western area of Tokyo city. The survey was conducted between January and March 1930. [5] The main purpose of the NSPD was to obtain evidence that could be used in planning relief for poor households (Tokyo City Office 1931, p.227). To be specific, this survey collected information on households in this poor district in terms of the households' characteristics, nutritional attainments, and health status of family members.

One important characteristic of the NSPD is that the researchers not only conducted interviews to collect information on household characteristics but also measured the actual amount of foodstuffs consumed and their prices, and recorded the recipes of the meals that were eaten. To accomplish this survey, the researchers made frequent visits to the kitchens of the households during the day. The report states:

> In order to obtain figures close to the actual ones, we first dispatched the researchers to the households and then weighed the foodstuffs used in their meals, investigated the price of those foodstuffs and the cooking methods, observed the cooking and recorded the details of the recipes (Tokyo City Office 1931, p.228).

For goods such as rice and seasoning such as *miso* (fermented soybean paste),*shoyu* (soy sauce), *shio* (salt), and *sato* (sugar), the quantities used per day were investigated in each household. Moreover, the researchers produced lists of the same foodstuffs, whose nutrients were considered to be different across towns, in Hakusan Goten town. The listed examples of these foodstuffs were *tsukudani* (foods boiled in soy sauce), *nimame rui* (stewed beans), *tempura* (deep–fried fish or vegetables), *aburaage* (deep–fried tofu), *hanpen* (a cake of ground fish combined with starch and steamed), and *soba* (buckwheat noodles). Then, they analyzed the nutritional composition of those foodstuffs in the laboratory of the TIPH and computed the amount of carbohydrates, protein, fat, and calories. The report noted that it took 6 months to analyze over 100 foodstuffs in total (Tokyo City Office 1931, pp.229–30). For their investigation of health outcomes, the

[5] Since the survey was conducted in the winter season, expenditures for heating might have been higher than that in other seasons. Although we cannot estimate the expenditures for heating because the ARTIPH7 lacks information about expenditures for utilities, we should carefully interpret the findings below.

researchers visited the households frequently and investigated the health conditions of all family members. For this purpose, the home visits were conducted even in the nighttime, on Sundays, and on holidays in the case of the absence of family members (Tokyo City Office 1931, p.238).

Taking this style of survey into account, the precision of the information recorded in the NSPD is likely to be more accurate than might be the case with a questionnaire–style enquiry. However, elimination of the households whose information was considered to be incomplete in some way reduces the usable sample to 183 households. In the NSPD, in fact, 265 households (1,018 people) out of 300 households were diagnosed for the health survey. Among them, 183 households (813 people, of whom 423 were males) were then investigated more thoroughly for the nutrition survey, and the health condition of all family members in 140 households out of that group was recorded perfectly. In the end, the*Annual Report of Tokyo Institute of Public Health, vol.7* (ARTIPH7) issued in 1932 documented a set of final reports on these nutrition- and health-related surveys for these 183 households (*i.e.*, 61% of the survey objects). Since this report listed both the nutritional attainment and the health status in each household as well as the household's characteristics such as family composition, monthly income, and monthly expenditures, we use these subsample from the NSPD to analyze the relationship between household characteristics, nutritional attainments, and health outcomes in working-class households.

Secondly, we discuss the representativeness of our sample households obtained from the ARTIPH7. Figure 1a shows the geographical location of Hakusan Goten town. As we noted above, our sample area was located in the north–western part of Tokyo. Figure 1b shows the poverty headcount ratio defined as the number of people under the poverty line per 100 population in each block of the city. [6] The poverty headcount ratio of Hakusan Goten town was 5.29%, which exceeds 95 percentiles (*i.e.*, 3.38%) of the ratio. However, this does not straightforwardly imply that our sample households are classified as the poorest households in Tokyo.

In the ARTIPH7, the average monthly income is reported for 110 of the 183 households, whereas the number of family members is reported for all households. [7] Column 3

[6] Please see Appendix E for the details of the calculation of the poverty headcount ratio.

[7] Differences in the household characteristics between those 110 households and the other 73 households for which no information on income or expenditures were recorded were not statistically significant at conventional levels (see Table A.1 in Appendix A).

and 5 of Table 1 reports that the average monthly income, average monthly income per capita, and household size in our sample households are calculated as being 55.9 yen, 13.7 yen, and 4.44 people, respectively. The comprehensive survey entitled *Survey of Protection-Required People in Tokyo City* (SPRP), which was conducted by Tokyo City in March 1929, investigated 20,601 protection-required households (83,216 people) in all 15 wards of Tokyo. [8] From this survey, the average monthly income and the number of family members in low-income households was estimated to be 47.53 yen and 4.04 people, respectively (Tokyo City Office 1930, pp.1–7). Thus, the average monthly income per capita is roughly 11.8 yen (*i.e.*, 47.53/4.04), implying that the standard of living in the ARTIPH7 households was slightly higher than that of the poorest households in Tokyo. In addition, a similar comprehensive survey of protection–required people conducted in November 1929 and March 1930, which investigated 30,204 low–income households (124,035 people) in the entire Tokyo, reported the average monthly income as 32.41 yen and the average number of family members as 4.11 people (Tokyo City Office 1932c, pp.1–5). [9]

Regarding the expenditure, the average monthly food expenditure of the ARTIPH7 households is calculated to be 21.01 yen as listed in column 4 of Table 1. This means that those households had spent 37.58%(21.01/55.9) of their monthly income for food consumption. Nakagawa (1985, p.393; p.398) estimates that the proportion of monthly food expenditure to the total expenditure of poor urban households in 1930 was 56% (27.44 yen of 49 yen), while that of factory workers in 1932 was 35% (25.55 yen out of 73 yen). The foregoing fact suggests that the living standard of our sample households can be considered as being slightly higher than that of the "protection-required" households, but was significantly lower than that of typical factory workers at that time. Thus, we should regard our sample households as low-income households but not as poor households, *i.e.*, they would not have been regarded as households requiring protection in Tokyo around 1930.

Finally, to confirm this point, we compare the proportion of different household heads' occupations in the ARTIPH7 households with that in the 3rd national Population Cen-

[8] In this survey, local government regarded those in households whose monthly per-person income was below 17.58 yen as protection-required people (see Tokyo City Office 1932c, legend).

[9] This study examines those individuals in households whose monthly per-person income was below 14.18 yen; this study considers these individuals protection-required people (see Tokyo City Office 1932c, legend).

sus. Table 2 shows the shares of different household heads' occupations in our sample households. The head of household's occupation was classified into 6 social classes using the industrial classification of the 3rd Population Census conducted in 1930 (Statistics Bureau of the Cabinet 1933, pp.76–91).

First, in columns 5 and 6 of the table, we find that the proportion of males in commerce and manufacturing industry were slightly lower and higher respectively in Koishikawa ward than was the case for Tokyo as a whole. In addition, the proportions of males in the public sector and the freelancer were higher in Koishikawa ward by 4.94% (*i.e.*, 16.45% compared with 11.51%). Public sector includes employees in public facilities such as ward office and schools who can be classified as belonging to the lower-income group. In fact, Table 1 suggests that the average monthly household income per capita in this group was 10.83 yen, the lowest value among the all occupations. This is consistent with the well known historical fact that the standard of living was relatively lower in Koishikawa ward (*e.g.*, Ogasawara and Kobayashi 2015, p.100).

Second, this relationship is notable in the composition of the head's occupation in the poor households. Columns 3 and 4 in of the table show the head's occupation in the poor households investigated in the SPRP. Clearly, the occupation of the heads in these households in Koishikawa ward were concentrated in manufacturing industry and public sector and the freelancer: 47.56% and 12.25%, respectively. Since the category of "Other industry" includes low-income occupation such as day laborers and cleaners, the proportion of poor households falling into this category is considerably higher in comparison with that shown in the Census; 18.65% of the poor households in Koishikawa ward, compared with 0.61% in the Census (column 6). Table 1 indeed shows that the average monthly income per capita in this occupational category was 11.88 yen, the second lowest value among all occupations.

Third, in contrast with the poor households in Koishikawa ward, head's occupations in the ARTIPH7 households were highly concentrated in manufacturing industry; 59.80% of heads worked in some kind of manufacturing industries in our sample (see column 2). In addition, 16.67% of the heads worked in commerce, 5.63% (*i.e.*, 16.67% - 11.04%) higher than that of the poor households in Koishikawa ward of the SPRP. As a result, the proportion of lower–income occupations such as employee in public sector and professional services and laborers or cleaner in other industries was lower in our sample than in that of the poor households in Koishikawa ward. While the proportions accounted for by public sector and the freelancer, and other industry, were 12.25% and 18.65% respectively in Koishikawa ward of the SPRP, those of the ARTIPH7 were 1.96% and 16.67%, respectively. The above findings support the evidence that the living standards of the ARTIPH7 households can be considered as higher than those of the poorest households at that time.

To summarize, the sample households obtained from the ARTIPH7 are classified as low–income, but not as the poorest urban households at that time.

3 Nutritional intake in urban working-class households in 1930

3.1 Excess or deficiency of the calorie intake

In the food section of the ARTIPH7, the amount of carbohydrates, fats, and proteins are reported in grams. Judging from the description in the report, alcohol consumption was not included in this report. Since energy from alcohol is an important factor in calorie intake calculations (Gazeley *et al.* 2015), we estimated the average daily calorie intake from alcohol for low-income households in the 1920s at approximately 63 kcal using several materials. Although we do not take this additional energy into account throughout this present paper, the daily calorie intake might have been roughly 60 kcal higher if we account for the alcohol consumption. [10]

Interestingly, those nutrients are divided into the types of ingested foods such as principal foods, animal food products, and vegetable food products. In the NSPD, as described in the previous section, the quantities of foods were investigated before calculating household food expenditure (Tokyo City Office 1931, p.229). If this notation in the ARTIPH7 is true and their measurement in the laboratory was accurate, the issue of the choice of

[10]Please see Appendix F for the details of the calculation of the average daily calorie intake from alcohol. Food expenditure outside the home is also important in energy conversion (see Gazeley *et al.* 2015). However, all foods other than rice are included in "side dishes" in the ARTIPH7. Almost of all the poor households in Tokyo had their own kitchen in their houses even in the 1910s (Nakagawa 1985, p.52–3) and there were fewer variations in the menus of low-income urban households as we will be discussed later. Therefore, it can be assumed that these households were less likely to have meals outside the home.

deflator to a unit of weight can be ignored in making the conversion into calories. We argue that the measurement in the survey was likely to be accurate for the following reasons. First, the meals at that time were extremely frugal and it was thus easy to make a breakdown of the ingredients. For instance, regarding the representative examples of the meals of those household, the report states:

> One day
> Breakfast: *Daikon oroshi* (Grated white radish), *Uzura mame* (Pinto beans)
> Lunch: *Daikon oroshi* (Grated white radish)
> Supper: *Udon to kyonanikomi* (Udon with stewed potherb mustard)
> The following day
> Breakfast: *Daikon oroshi* (Grated white radish)
> Lunch: *Daikon oroshi* (Grated white radish)
> Supper: *Udon to ganmodokinikomi* (Udon with stewed deep-fried tofu mixed with thinly sliced vegetables)
>
> One day
> Breakfast: *Natto* (Fermented soybeans)
> Lunch: *Tsukemono* (Pickled vegetables)
> Supper: *Chikuwanitsuke* (Stewed tube-shaped fish paste cake)
> The following day
> Breakfast: *Tofujiru* (Tofu soup)
> Lunch: *Tofujiru* (Tofu soup, leftovers)
> Supper: *Taranoko* (Cod roe).

Secondly, the report highlights the fact that the menus in these households were "less varied, and there were even households which had the same menu over several days" (Tokyo City Office 1931, p.232). In fact, most of the meals were made from a few foodstuffs such as white radishes (*daikon*), beans, *udon* noodles, potherb mustard, leeks, and sardines. This simplicity implies that the investigation of the recipes and the measurement of the foods were easy. Thus, it is likely to be consistent with the fact that only fourteen researchers were able to be responsible for conducting the survey of 183 households in the NSPD (see Section 2).

Based on the quantities of nutrients, the ARTIPH7 then reported the total calories using an original conversion factor; the heat-of-combustion value for carbohydrates, the fat, and proteins are considered to be 4.1, 4.1, and 9.3 kcal per gram, respectively (Tokyo

City Office 1931, p.230). Although this report claimed that this conversion factor was employed "in accordance with the general method of food analysis", the reason why the ARTIPH7 applied this conversion factor is not specified in the document(Tokyo City Office 1931, pp.227-37). In fact, the original conversion factor is slightly higher than that of the well known McCance & Widdowson conversion factor; the heat-of-combustion value for carbohydrates, fat, and protein are considered to be 3.75, 4, and 9 kcal per gram, respectively (Finglas *et al.* 2015, p.9).

The column 2 in Table 3 shows the mean daily calorie intake per capita of our sample households, which was calculated using this original conversion factor as 1,688 kcal per day, whereas the column 3 in the table shows the value calculated using the modified Atwater conversion factor in McCance & Widdowson tables as being 1,572 kcal per day. Our estimate is consistent with the daily calorie intake of low-income households in Tokyo in 1932 estimated in a previous study, showing that 1623.5 kcal were consumed per day in those households (Yazawa 2005, p.326).

The column 4 in Table 3 reports the basal metabolism rate (BMR), which is the amount of calories needed to maintain the body temperature and to sustain the functioning of the heart, liver, brain, and other organs while resting for 24 hours (Floud *et al.* 2011, p.43). To compare the BMR, we compiled the data on height and weight of each age and sex in Japan before 1930, and calculated the predicted BMR using the equation proposed by Ganpule, which is known as the most suitable predictive equation for predicting Japanese BMR (Ganpule *et al.* 2007; Miyake *et al.* 2011). For example, the BMR for adult men aged 20 years who weighed 54.8 kg and were 162.5 cm tall is predicted to be 1,371 kcal. The finer details of this procedure and the historical materials used in this calculation are described in Appendix C. [11] Taking the age and sex of each household member into account, we then computed the weighted average of BMR per capita of the ARTIPH7 households. [12] The BMR is estimated to be 1015.7 kcal, implying that, on average, the calorie intake per capita in the households was higher than the level essential to maintain life, by 556.3 kcal (1,572-1,015.7 kcal) during a 24–hour period.

The column 5 in the same table shows the value of survival diet per capita in our sample. This survival diet allows for the energy required to eat and digest food or for

[11] The predicted BMR is reported in Table A.3 in Appendix A.

[12] BMR per capita in each household is calculated as the total amount of BMR divided by household size. The total amount of BMR in each household is calculated using equation (5) in Appendix D.

essential hygiene and is computed as 1.27 × BMR (Floud *et al.* 2011, p.43). After taking these additional essential activities into account, the survival diet per capita in the ARTIPH7 households is calculated to be 1,290 kcal. This value is still lower than the average calorie intake per capita, by 282 kcal (1,572-1,290 kcal) during a 24–hour period.

Table 4 provides the excess or deficiency in the calorie intake with respect to the estimated energy requirement (EER) by several categories of activity level. The EER is defined as the average dietary energy intake that is predicted to maintain energy balance in healthy adults of given age, gender, weight, height, and level of physical activity consistent with good health and can be expressed as BMR multiplied by normal physical activity level (PAL) (Miyake *et al.* 2011, p.224). To compare the excess or deficiency of daily calorie intakes in the different activity levels, the PAL among categories classified according to the Dietary Reference Intake (DRI) in Japan is used in this study (Ministry of Health, Labour and Welfare 1999). PAL values in the DRI-Japan range from 1.3 (category I: "light" activity), 1.5 (category II: "moderate" activity), 1.7 (category III: "light heavy" activity), to 1.9 (category IV: "heavy" activity). The number of hours for resting, standing, walking, trotting, and exercising in each category were allocated as follows: 12, 11, 1, 0, and 0 (category I); 10, 9, 5, 0, and 0 (category II); 9, 8, 6, 1, and 0 (category III); and 9, 8, 5, 1, and 1 (category IV), respectively (Ministry of Health, Labour and Welfare, Japan 1999). [13]

Regarding the daily calorie intakes of adults in our sample, we calculated the average daily calories per equivalent adults. The average daily calories per equivalent man (woman) aged 20 to 49 are calculated as the BMR of man (woman) aged 20 to 49 multiplied by the average value of PAL of the sample households. This average value of PAL of the sample households is calculated as the total calorie intake with respect to the total BMR in each household. Appendix D provides the details of this calculation procedure. The average value of PAL in the ARTIPH7 households is then estimated to be approxi-

[13] The contents of activities are "Mostly sedentary position doing reading, studying and talking, or sitting or lying position watching TV and listening to music with 1–hour slow walk for walking and shopping" (category I) ; "Mostly sedentary position doing clerical work and housework with 2–hour walk for commuting and shopping, and long hours of standing while meeting people and doing housework" (category II) , "In addition to moderate activity (II), 1 hour of brisk walk, bicycle and other vigorous physical activity; mostly standing during farming, fishing with heavy muscular work for 1 hour a day" (category III) , and "Engaged in heavy muscular work for about 1 hour a day such as hard training, carrying lumber, farming in busy season and so on" (category.IV), respectively (Ishikawa–Takata *et al.* 2008, p.889).

mately 1.549, implying that the PAL between categories II and III can be considered as plausible for representing the *average* physical activity level among our sample low-income households.

As shown in the column 9 in the table, the average daily calories per equivalent adults are calculated to be 1,906.3 kcal (2117.9 kcal for men and 1694.6 kcal for women). Similarly, the columns 7 and 11 show that the 25th and 75th percentiles of the daily calories per equivalent man (woman) are 1,881.1 kcal (1,505.1 kcal) and 2,362.8 kcal (1,890.5 kcal), respectively. Figure 2 reveals that the daily calorie intake per equivalent adult in almost of all the ARTIPH7 households surpassed this survival line (1,290 kcal). The p–th quantiles of the daily calories intake per equivalent adult for $p = 0.05, 0.25, 0.5, 0.75, 0.95$ are 1482.2, 1693.2, 1880.8, 2126.7, and 2404.4 kcal, respectively. Therefore, not only the median daily calories per equivalent adult but also those for lower quantiles, *i.e.*, $p <= 0.25$, surpassed the survival line.

Our estimate is lower than the national average calorie intake. As noted in the Introduction, Nakayama (1958) estimated the daily calorie intake per capita during 1931 to 1935 to be 2,191.9 kcal, while Hayami and Yamada (1970) estimated that of the period between 1923 and 1927 to be 2,320 kcal. Mosk (1978) also estimated the daily calorie intake per capita during the period from 1928 to 1932 to be 2,334 kcal. Therefore, when the national average calorie intake was approximately 2,300 kcal, the difference between the calorie intake between urban low-income working-class households and the national average was considered to be roughly 400 kcal (*e.g.*, 2,300–1,900 kcal).

The columns 8, 10, and 12 in Table 4 show the excess or deficiency in the calorie intake with respect to the EER. For categories I, the calorie intakes exceed the requirement. Even in moderate activity, the excess of calories for adult males and adult females at mean are 66.7 kcal and 53.3 kcal, respectively, while the calories for adult males and adult females at 25th percentile were below the requirement. Therefore, on average, the adults in low-income households in Tokyo city in 1930 engaged in average physical activity could satisfy their energy requirement and just about maintain their body function. By contrast, the average daily calories per equivalent adults were not sufficient to satisfy the requirements of people engaged in more heavy activities including heavy physical work. In the case of adult males at mean, they were 206.5 kcal short of satisfying the requirement in category III and 480 kcal short of meeting the energy requirement in category IV. Even in the case of adult males at 75th percentile, they were 235.4 kcal short of meeting the energy requirement in category IV. This result seems to be consistent with the menus in the ARTIPH7 households described above. In fact, one of the representative examples of the meals in those households described above in this section suggests that they only ate grated white radish (*daikon oroshi*) for lunch. Since the per gram calorie of white radish is 0.18 kcal, 90 kcal would be absorbed in total if a person ingested 500 grams of grated white radish (about half a radish). [14]

Among the household heads' occupations, not only most workers in commerce but also roughly 40% of workers in manufacturing who engaged in light manual work, such as folding papers for bookbinding, making Japanese sandals (*zori*), and sewing, might have been more likely to satisfy the required energy. In fact, this manual work was classified as household manual industry and workers tended to do this in the home (Tokyo City Social Welfare Bureau 1937, pp.9–11). Although the average working hours of bookbinders, for example, was roughly 8 to 9 hours (Tokyo City Social Welfare Bureau 1937, p.50), most of their work was done in a sitting position, *i.e.*, criss-cross applesauce (*agura*) or sitting in *seiza* (see Tokyo City Social Welfare Bureau 1937). [15] Since these workers' physical activity levels can be considered 1.7 at most (category III), they were more likely to satisfy their energy requirements. By contrast, some manual laborers such as carpenters and steeplejacks were considered less likely to satisfy their energy requirements because their physical activity levels must be more than 1.9 (category IV) (*e.g.*, Tokyo City Study Group of Occupation Guidance 1931, pp.399–402). The situation for these manual laborers was possibly more severe when we consider the digestion costs. [16]

3.2 Nutritional attainments and household characteristics

Table 5 shows the nutritional attainments including calorie intakes by head's occupation, income per capita, and household size. [17] Clearly, there are no obvious differences in nutritional attainments among head's occupations other than in public sector. The average

[14]Data on the calorie is from the database of the Ministry of Education, Culture, Sports, Science and Technology in Japan (http://fooddb.mext.go.jp/index.pl).

[15]Figure A.1 in Appendix A depicts the actual work of paper folding for bookbinding.

[16]See Schneider (2013) for a detailed discussion about digestion cost and the energy requirements of pregnant and nursing women.

[17]Table A.2 reports the household food expenditure by head's occupation, income per capita, and household size.

calorie intakes per capita in the households whose head's occupation is classified as public sector is calculated to be 1,299.7 kcal per day, the lowest value among the occupations. This is consistent with the finding that the average monthly household income per capita of this occupational group was 10.83 yen, the lowest value among all the occupational groups (see Table 1).

The column 4 in the table reports the difference between the actual calorie intakes per capita and the energy requirement per capita in the households at moderate physical activity level in terms of DRI–Japan (*i.e.*, 1.5×BMR). [18] In the case of these occupations, the calorie intake per capita is not enough to satisfy the energy requirement; the difference is −155.22 kcal on average and significant at 10% levels. Although public sector includes employees in public facilities such as the ward office and schools, and thus, they might not have needed high energy to conduct their work, this disparity may simply suggest the degree of poverty, because 1,299.7 kcal per day is just slightly higher than the survival diet, *i.e.*, 1,290 kcal per day (see Table 3). According to the columns 5 to 7 in the same table, the nutritional attainments in terms of carbohydrates and proteins are considerably lower than those of the other occupations, implying that the amount of consumption of rice and meat were small in these households. By contrast, statistically insignificant but relatively large difference is also observed in the "other" industry; the difference is 76.8 kcal on average. Since this industry includes occupations such as day laborer and cleaner, they might have needed higher energy to conduct muscular activities.

The columns 5 to 7 suggest that people who conducted muscular activities ingested their calories mainly from carbohydrates rather than from fats or proteins. This implies that the household head might have preferred to consume rice rather than fish and/or meat to satisfy their energy requirement under the constraints of a limited budget (see Table A.2). The proportion of animal proteins to total proteins was indeed slightly less than 20%. Based on the fact that this same proportion for a workman's or salaried worker's household was around 30% in the interwar period (Yazawa 2005, p.330), this value is plausible for low-income households. A further interesting finding is that the proportion of animal proteins increases as per capita income increases. This implies that the consumption of animal foods might have increased as household income increased, as

[18] Note that the average PAL value in the ARTIPH7 households was indeed estimated to be 1.549, as noted in this section. Thus, we assumed that the average activity level in our sample was around 1.5–a level similar to that classified as "moderate" in DRI–Japan.

previous studies have suggested (*e.g.*, Yazawa 2005, p.330).

Panel (b) in Table 5 shows the positive correlation between per capita income and per capita nutritional attainments. Although the nutritional attainments among the households with per capita income less than the median (*i.e.*, 12 yen) seem to be at similar levels (1,428.2 kcal compare to 1,420.1 kcal), households above the median value increased their calorie intakes per capita (1,571 kcal in the third quartile group and 1,693.4 kcal in the fourth quartile group). However, we can not conclude that those improvements in calorie intakes directly suggest the consequences of income effect because there are no significant differences between actual calorie intakes and the energy requirement. In terms of nutrients, carbohydrate, fat, and protein intake were more likely to increase as per capita income increased. This tendency is similar to the observation for British urban working-class households in the early 20th century; the skilled working-class were more likely to consume those nutrients than the lower classes (Gazeley and Newell 2015, pp.105–13).

Panel (c) in Table 5 illustrates the negative correlation between per capita nutritional intake and household size. The calorie intake drops from 2,044.1 kcal in the first quartile to 1,418 kcal in the fourth quartile. The difference between calorie intake and requirement is significant in the first quartile. Similarly, the carbohydrates, fats, and proteins decreased from 427.64 g to 316.76 g, from 17.73 g to 5.87 g, and from 19.02 g to 15.95 g, respectively.

In summary, the average daily calorie intake per capita in the ARTIPH7 households was higher not merely than the vital level to maintain life but the survival diet as well. The calories per equivalent adult are estimated to be 1906.3 kcal (2117.9 kcal for men and 1694.6 kcal for women), implying that the average daily calorie intakes of adults satisfied the energy requirement for the level of physical activity consisting of 9 hours standing and 5 hours walking during a 24–hour period. This result implies that, at least in 1930, Japanese urban working-class households could satisfy their energy requirements for a reasonable level of physical activity, just as British urban working-class households in the early 20th century could (see Gazeley and Newell 2015). The average calorie intake per capita in the poorest head's occupation was significantly lower than the EER. Although both per capita income and household size were likely to affect the nutritional attainments per capita in the households, the statistically significant differences between calorie intakes and the EER can be observed only in the first quartile group of household size.

4 Household characteristics, nutritional intake and health status

4.1 Income elasticity

To illustrate the relationship between households' characteristics and the nutritional attainments more precisely, we then use the household-level data constructed from the ARTIPH7. We here aim to offer the fundamental results of our analysis of the relationship between the nutritional intake and the characteristics of low-income working-class households in Tokyo around 1930 and thus, aim to simply calculate the correlation between them rather than to pursue the causal effects of the income. To be specific, we try to estimate models in which the nutritional status such as the amount of calorie intake, of carbohydrate intake, of protein intake, and of fat intake per family member at household i is a linear function of the household's characteristics including income. We examine OLS models of the household's characteristics and the nutritional attainments of the household as follows:

$$\ln Nutrition_i = \alpha + \delta \ln Income_i + \mathbf{x}_i' \boldsymbol{\beta} + e_i \tag{1}$$

where i indexes households which are from 1 to 105. The variable $\ln Nutrition_i$ is either the natural log of per capita food expenditure, quantities of difference nutrients including calories, carbohydrate, protein, or fat, $\ln Income_i$ is the natural log of the monthly household income per capita, $\mathbf{x}_i'$ is a vector of household characteristics, and e_i is a random error term. The vector of household characteristics includes the household size, the share of family members aged 0 to 4, aged 5 to 8, aged 9 to 12, aged 13 to 19, young adults, and older adults, ratio of males to females in the household, and household head's occupation. Thus, the estimated coefficient $\hat{\delta}$ measures the income elasticity of the demand for total calories controlling for several household's characteristics. A positive coefficient indicates that an increase in income per capita increases the per capita calorie intakes in the households. Panel (A), (C), and (D) in Table 6 give the summary statistics of the nutritional variables, income per capita, and control variables used in our analysis, respectively. [19] In this table, we report the summary statistics before taking logarithms for each variable.

[19] We used 105 households in total due to missing values among the control variables.

Table 7 reports the results of the regression in which we explore the income elasticity of the demand for nutritional attainments. Both demographic controls and dummies for head's occupation are included in all specifications. These controls are included in order to deal with the fact that the demand for calories varies across the household size, ages, gender composition, and types of head's work contents as discussed in previous section. [20] An interesting result is obtained in the same table. The estimated coefficient on ln*Income* is significantly positive for the calories from animal food products, with values at the points of sample means being 0.439, whereas the income elasticities for calories from principal foods or vegetables are close to zero and insignificant. This means that a 1% increase in income per capita results in a 0.439% increase in calories intake from animal foods. Similarly, the income elasticity for proteins from animal food products is significantly positive, with values at the points of sample means being 0.523. Thus, a 1% increase in income per capita increases the intake of protein from animal foods by 0.523%.

The above result implies that with additional income the ARTIPH7 households more likely bought various types of fish and/or meat rather than rice (as reflected in the elasticities for nutritional attainments from principal foods) or vegetables. However, this consumption behavior did not result in an increase in either total calorie intake per capita or total food expenditure. Therefore, our estimates suggest that with an increase in per capita income, households tended to buy fish and/or meat instead of other types of food. In fact, Table 7 shows that the elasticities of the calorie intake from principal foods are more likely negative. These results imply that additional income might have resulted in a decline in the consumption of principal foods such as rice or products made from wheat, such as wheat noodles (*udon*). Consumption of expensive animal protein with an increase in per capita income supports the finding that the average daily calorie intake per equivalent adult satisfied the energy requirements for the appropriate physical activity level, as discussed in Section 3. This result is highly consistent with the suggestion in the previous literature which claims that the proportion of protein from animal foods to total protein increased steadily as income increased in urban areas in the prewar period. [21] Our estimate also suggests that the general finding of substitution of animal protein

[20]Here, we preferred to control for household characteristics, to deal with the fact that the amount of dietary requirements differed across family structures (*e.g.*, Behrman and Deolalikar 1987). We do not report the estimated coefficients on the control variables here for reasons of brevity. Please see Appendix G for the details of the estimation results.

[21]For instance, Nakayama 1958, pp.29–30, p.33 and Yazawa 2005, p.330. Nakayama estimated the

for plant protein is robust (Logan 2006b).

4.2 Calorie intake and health outcomes

This present paper further attempts to link the calorie intake per capita to the health outcomes of family members. If the calorie intake of people improved, we would expect mortality rates or the risk of infection to decline via the improvement of overall nutritional status. [22] As described in Section 2, the ARTIPH7 documented the results of a health-related survey for the households. The researchers visited households to investigate the health conditions of all family members and recorded the number of people who had any diseases in each clinical category, the number of births, the number of infant deaths, and the number of fetal deaths in each household. Taking this information on the health status of the family members into account, we try to illustrate the correlation between households' characteristics and the mortality and infection rates.

We aim to offer the correlation between them rather than to pursue the causal effects of the calorie intake on the health outcomes. Similar to the above quantitative analysis, we examine OLS models of the households' characteristics and the health outcomes of the households as follows:

$$Health_i = \alpha + \gamma \ln Calorie_i + \delta \ln Income_i + \mathbf{x}_i' \boldsymbol{\beta} + e_i \tag{2}$$

where i indexes households which are from 1 to 88. The variable $Health_i$ is either the infant mortality rate, fetal death rate, and disease rates including any eye diseases, ear diseases, nose diseases, respiratory diseases, tuberculoses, digestive diseases, tonsillitis, or skin diseases. The infant mortality rate is the number of infant deaths within 12 months after births per live births. [23] The fetal death rate is the number of fetal deaths per total births. Each disease rate is the number of patients per household size. [24] All of the mortality rates and the disease rates are defined in percentage points in each household.

income elasticity for meat, milk, and eggs to be 1.405, in a simple linear regression in a log–log functional form that used time-series data from across Japan, from 1878 to 1942.

[22] See, for instance, McKeown (1976; 1979), Fogel (1994; 2004), Nunn and Qian (2011).

[23] The infant mortality rate is usually defined as the number of infant deaths per 1,000 live birth in a certain year. Please note that the infant mortality rate used herein uses the cumulative number of infant deaths of each mother instead of the number of infant deaths in the survey year.

[24] Please note that all of the family members had had a medical examination, and so in this analysis, the number of family members was identical to the number of medical examinees.

$\ln Calorie_i$ is the natural log of the calorie intake per capita, $\ln Income_i$ is the natural log of the monthly household income per capita, and e_i is a random error term.

The vector of household characteristics, $\mathbf{x}_i'$, now includes not only the baseline controls defined previously but also the additional control variables, which represent the risk of exposure to infections. Additional controls include both the proportion of workers among family members and the floor space per capita in the household. Obviously, we simply expect that the coefficient γ is estimated to be significantly negative where these household characteristics are controlled for. Panel (B) and (E) in Table 6 provide summary statistics of health outcomes and additional controls, respectively.

We present our baseline results on calorie intake in relation to health outcomes in Table 8. Clearly, the amount of calorie intake did not have a significant correlation with either the mortality rates or disease rates. The coefficients of calorie intake per capita for a few health outcomes (*i.e.*, eye disease and tonsillitis) are estimated to be negative but insignificant. The coefficient of log of per capita income is also estimated to be negative in the overall disease rate, but is not significantly different from zero.

Table 9 reports the results with the additional control variables controlled for. Columns (1)-(2), (3)-(4), and (5)-(6) report estimates for the infant mortality rate, fetal death rate, and overall diseases rate, respectively. In columns (1), (3), and (5), we include baseline controls and the shares of workers in the household. We also include floor space per capita in the household in columns (2), (4), and (6). The estimated coefficient of the share of workers is significantly positive in columns (1) and (6), but is insignificant when the fetal death rate is used for the specification. This result suggests that workers were more likely exposed to higher risks of contracting diseases outside the house while the fetus had no contact with workers other than the mother. The estimated coefficients of floor space per capita are negative but insignificant. Finally, the estimated coefficients of $\ln Calories$ and $\ln Income$ are insignificant across all specifications. Thus, the results from our baseline specification reported in Table 8 are robust against control for additional exposure factors. In summary, our estimates suggest that the improvements in calorie intake at that time likely had no obvious effect on health outcomes in low-income urban working-class households.

The micro-nutrient levels are, however, also important in terms of people's health status (*e.g.*, Gazeley and Newell 2013). Although side dishes likely had a greater effect on health than principal foods, because they contain the bulk of the micro-nutrients, the ARTIPH7 unfortunately does not have any information on food items consumed as side dishes. Therefore, we could not calculate the amount of micro-nutrients each household ingested from side dishes. We hope further analysis can be conducted to clarify the relationship between improvement in nutritional attainments and health outcomes.

5 Conclusion

Not only the broader aspects of the nutritional attainment itself but also the relationship between nutritional intakes and the health status of working-class households in prewar Japan remain relatively unknown. Moreover, the relationship between nutritional attainments and the risk of disease has not been analyzed as previous studies have mainly focused on calculating the per capita daily calorie intake. In this paper, we conducted an analysis of the low-income working-class household survey conducted in Tokyo in 1930. Taking into account the advantage of this newly available information on the nutritional status of these households, the present paper investigates both the nutritional attainments and the relationship between nutritional status and health outcomes within urban low-income working class households in prewar Japan.

In conclusion, urban low-income working-class households at that time in Japan can be more or less considered to have been able to escape from hunger. The average daily calorie intakes of adults satisfied the energy requirement for a level of physical activity that includes 9 hours standing and 5 hours walking during a 24–hour period. At least in 1930, therefore, diets were sufficient to provide energy for the works in Japanese urban working-class households, just as in British urban working-class households in the early 20th century. Our estimate suggests that urban low-income working-class households tended to buy fish and/or meat in response to the increase in per capita income at the expense of the consumption of other types of food. Similar to the tendency in British urban working-class households, Japanese urban working-class households might have consumed more animal foods as their per capita income increased.

However, we did not find any significant correlation between improvements in the daily calorie intake per capita and the infant mortality rate and the fetal death rate; nor was there any correlation with disease rates. This result suggests that the improvements in the nutritional intake did not necessarily improve the health status *within* those Japanese working-class households. This finding adds to the debate about the contribution of improvements in nutrition during the historical decline in the mortality rate using prewar Japan as a case study.

Acknowledgements

We are deeply grateful to Eric Schneider, Ian Gazeley, Janet Hunter, and participants at the Food and Nutrition in 19c & 20c Europe Conference in University of Sussex for helpful comments on the paper. We also thank Kaito Kojima for excellent research assistance.This study is supported by JSPS KAKENHI Grant Numbers 16K17153.

References

[1] BEHRMAN, J. and DEOLALIKAR, A. (1987). Will Developing Country Nutrition Improve with Income? A Case Study for Rural South India. *Journal of Political Economy* **95**, pp. 492–507.

[2] BOWBLIS, J. R. (2010). The Decline in Infant Death Rates, 1878-1913: The Role of Early Sickness Insurance Programs. *The Journal of Economic History* **70**, pp. 221–32.

[3] CUTLER, D. and MILLER, G. (2005). The Role of Public Health Improvements in Health Advances: The Twentieth-Century United States. *Demography* **42**, pp. 1–22.

[4] Division of Physical Education, Minister's Secretariat, Ministry of Education. (1937). *Gakuseiseito jidoshincho, taijyu, kyoi heikinruinenhikaku* [*Average Height, Weight, and Chest Girth of Students*]. Tokyo.

[5] FINGLAS, P.M., ROE, M.A., PINCHEN, H.M., BERRY, R., CHURCH, S.M., DODHIA, S.K., FARRON-WILSON, M., and SWAN, G. (2015). *McCance and Widdowson' s the composition of foods, seventh summary edition*. Cambridge: Royal Society of Chemistry.

[6] FLOUD, R., FOGEL, R. W., HARRIS, B., and HONG, S. C. (2011). *The Changing Body: Health, Nutrition, and Human Development in the Western World since 1700.* Cambridge: Cambridge University Press.

[7] FOGEL, R. W. (1994). Economic Growth, Population Theory, and Physiology: The Bearing of Long-Term Processes on the Making of Economic Policy. *American Economic Review* **84**, pp. 369–95.

[8] FOGEL, R. W. (2004). *The Escape from Hunger and Premature Death, 1700-2100.* Cambridge: Cambridge University Press.

[9] GANPULE, A. A., TANAKA, S., ISHIKAWA-TAKATA, K., and TABATA, I. (2007). Interindividual variability in sleeping metabolic rate in Japanese subjects. *European Journal of Clinical Nutrition* **61**, pp. 1256–61.

[10] GAZELEY, I. and HORRELL, S. (2013). Nutrition in the Engish agriculture labourer's household over the course of the long nineteenth century. *Economic History Review* **66**, pp. 757–84.

[11] GAZELEY, I. and NEWELL, A. (2013). The first world war and working–class food consumption in Britain. *European Review of Economic History* **17**, pp. 71–94.

[12] GAZELEY, I. and NEWELL, A. (2015). Urban working-class food consumption and nutrition in Britain in 1904. *Economic History Review* **68**, pp. 101–22.

[13] GAZELEY, I., NEWELL, A., and BEZABIH, M. (2015). The transformation of hunger revised: Estimating available calories from the budget of late nineteenth-century British households. *Journal of Economic History* **75**, pp. 512–25.

[14] HAINES, M. R. (1979). Industrial work and the family life cycle. *Research in Economic History* **4**, pp. 289–356.

[15] HATTON, T. J., GEORGE, R. B., and ROY, E. B. (1994). The union wage effect in late nineteenth century Britain. *Economica* **61**, pp. 435–56.

[16] HAYAMI, Y. and YAMADA, S. (1970). Kogyoka no shihatsuki niokeru nogyo no seisansei [*Agricultural Productivity at the Beginning of Industrialisation*]. In K. SHIGETO and K. YUZURU (eds), *Nihonnogyo to keizaiseicho* [*Economic Development and Agriculture in Japan*]. Tokyo: The Nippon Agricultural Reserch Institute.

[17] HORRELL, S. and OXLEY, D. (1999). Crust or crumb: Intra-household resource allocation and male breadwinning in late Victorian Britain. *Economic History Review* **52**, pp. 494–522.

[18] HORRELL, S, and OXLEY, D. (2012). Bringing home the bacon? Regional nutrition, stature, and gender in the industrial revolution. *Economic History Review* **65**, pp. 1354–79.

[19] HORRELL, S. and OXLEY, D. (2013). Bargaining for basics? Inferring decision making in nineteenth–century British households from expenditure, diet, stature, and death. *European Review of Economic Histoy* **17**, pp. 147–70.

[20] HORRELL, S., MEREDITH, D., and OXLEY, D. (2009). Measuring misery: Body mass, again and gender inequality in Victorian London. *Explorations in Economic History* **46**, pp. 93–119.

[21] ISHIKAWA-TAKATA, K., TABATA, I., SASAKI, S., RAFAMANTANANTSOA, H, H., OKAZAKI, H., OKUBO, H., TANAKA, S., YAMAMOTO, S., SHIROTA, T., UCHIDA, K., and MURATA, M. (2008). Physical activity level in healthy free-living Japanese estimated by doubly labelled water method and International Physical Activity Questionnaire. *European Journal of Clinical Nutrition* **62**, pp. 885–91.

[22] KITO, H. (1996). Seikatsu suijyun [*Living standards*]. In N. SHUNSAKU, O. KONOSUKE and S. OSAMU (eds), *Nihonkeizai no nihyakunen* [*Two-hundread years of Japanese economy*]. Tokyo: Nippon Hyoron Sha.

[23] LOGAN, T. D. (2006a). Nutrition and well-being in the late nineteenth century. *Journal of Economic History* **66**, pp. 313–41.

[24] LOGAN, T. D. (2006b). Food, nutrition, and substitution in the late nineteenth century. *Explorations in Economic History* **43**, pp. 313–41.

[25] LOGAN, T. D. (2009). 'The transformation of hunger: The demand for calories past and present', *Journal of Economic History* **69**, pp. 388–408.

[26] MCKEOWN, T. (1976). *The Modern Rise of Population.* New York: Academic Press.

[27] MCKEOWN, T. (1979). *The Role of Medicine: Dream, Mirage, or Nemesis?* Oxford: Blackwell Publishers.

[28] Ministry of Education, Culture, Sports, Science and Technology in Japan. (2010). *Food Composition Database*: http://fooddb.mext.go.jp/index.pl.

[29] Ministry of Health, Labour and Welfare, Japan. (1999). *Recommended dietary allowance for Japanese: Dietary reference intakes, 6th revision*. Tokyo.

[30] MISHIMA, M. (1902). *Nihon ken tai shoni no hatsuikuron* [*Theory of child growth in Japanese*] Tokyo.

[31] MIYAKE, R., TANAKA, S., OHKAWARA, K., ISHIKAWA-TANAKA, K., HIKIHARA, Y., TAGURI, E., KAYASHITA, J., and TABATA, I. (2011). Validity of Predictive Equations for Basal Metabolic Rate in Japanese Adults. *Journal of Nutritional Science and Vitaminology* **57**, pp. 224–32.

[32] MOSK, C. (1978). Fecundity, infanticide, and food consumption in Japan. *Explorations in Economic History* **15**, pp. 269–89.

[33] NAKAGAWA, K. (1985). *Nihonno toshikaso* [*A City Lower Layer of Japan*]. Tokyo: Keiso Syobo.

[34] NAKAYAMA, S. (1958). Shokuryo shohi suijun no choki henka nitsuite [*Long-Term Trend of Food Consumption in Japan*]. *Nougyo Sougo Kenkyu* **12**, pp.16–37.

[35] NUNN, N., and QIAN, N. (2011). The Potato's Contribution to Population and Urbanization: Evidence From A Historical Experiment. *Quarterly Journal of Economics* **126**, pp. 593–650.

[36] ODAKA, K. (1984). *Roudo shijou bunseki* [*Analysis of Labor Market*]. Tokyo: Iwanami Shoten.

[37] OGASAWARA, K. and KOBAYASHI, G. (2015). The impact of social workers on infant mortality in inter-war Tokyo: Bayesian dynamic panel quantile regression with endogenous variables. *Cliometrica* **9**, pp. 97–130.

[38] Sanitary Bureau of the Home Department. (1922). *Noson hokeneiseijyotai jitchichosahokoku* [*Report of Survey of the Condition of Sanitation in Farming Village*]. Tokyo.

[39] SCHNEIDER, E.B. (2013). Inescapable hunger? Energy const accounting and the costs of digestion, pregnancy, and lactation. *European Review of Economic History* **17**, pp. 340–363.

[40] Statistics Bureau of the Cabinet. (1933). *Kokusei chose hokoku, fukenhen Tokyo-fu* [*1930 Population census of Japan, Tokyo prefecture*]. Tokyo.

[41] SZRETER, S. (1988). The Importance of social intervention in Britain's mortality decline c. 1850-1914: a reinterpretation of the role of public health. *Social History of Medicine* **1**, pp. 1–38.

[42] Tokyo City Office. (1930). *Tokyoshinai yohogosha nikansuru chosa, daiikai* [*Survey of Protection-Required People in Tokyo City, vol.1*]. Tokyo.

[43] Tokyo City Office. (1931). *Tokyoshi eiseishikensho hokoku* [*Annual Report of Tokyo Institute of Public Health, vol.7*]. Tokyo.

[44] Tokyo City Office. (1932a). *Tokyoshi shisei tokei genpyo* [*Tokyo City Municipal Statistics Original Table, vol.1*]. Tokyo.

[45] Tokyo City Office. (1932b). *Tokyoshi yokyugosha nikansuru chosa* [*Survey of Relief-Required People in Tokyo City*]. Tokyo.

[46] Tokyo City Office. (1932c). *Tokyoshi yohogosetai gaiyochosa* [*Survey of the Situation of Relief-Required People in Tokyo City*]. Tokyo.

[47] Tokyo City Social Welfare Bureau. (1937). *Tokyoshi tonyasei shokogyo chosa* [*Survey of the wholesale small-scale factories in Tokyo city*]. Tokyo.

[48] Tokyo City Study Group of Occupation Guidance. (1931). *Syogakko syokugyo shidokyozai kaisetsu* [*Teaching Materials Explanation of Occupation Guidance in Elementary School*]. Tokyo.

[49] YAZAWA, H. (2005). *Kindainihonno shotokubunputo kazokukeizai* [*Income Distribution and Family Economy in Prewar Japan*]. Tokyo: Nihon Tosho Center.

(a) Hakusan Goten town (b) Poverty headcount ratio

Figure 1: Sample area and the number of people under poverty line in Tokyo

Note: Poverty headcount ratio is the number of people under poverty line in 1929. Source: Tokyo City Office 1932a; Tokyo City Office 1932b.

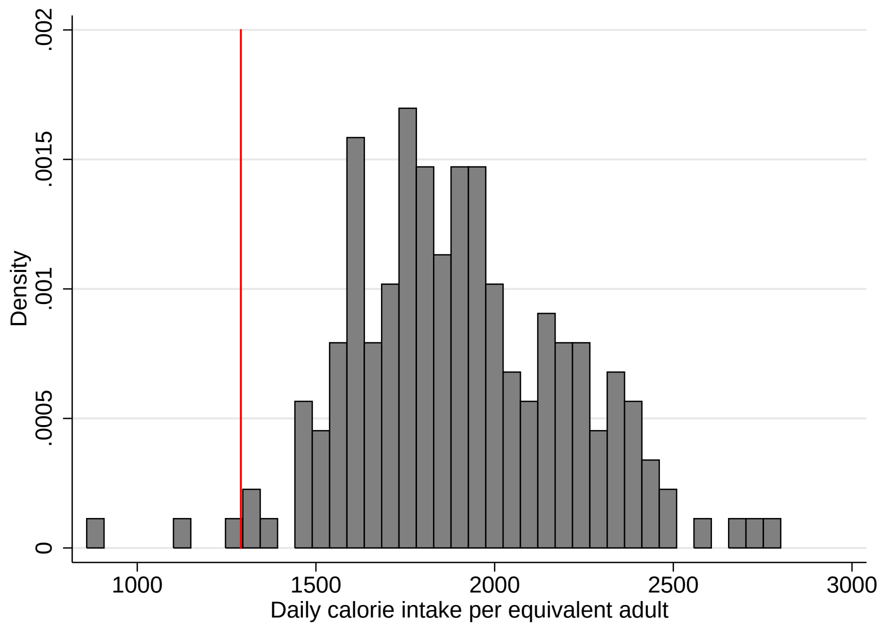

Figure 2: Daily calorie intake per equivalent adult (kcal) and its survival diet (red line)

Note: Red solid line shows the survival diet per capita (1,290 kcal) reported in Table 3. Source: Tokyo City Office 1931.

Table 1: Household income, food expenditure, and size, by head's occupation

	Number of households	Total household income (yen, per month) [per capita]	Household food expenditure (yen, per month) [per capita]	Household size
Total households	110	55.90 [13.70]	21.01 [4.78]	4.44
Manufacture	61	57.33 [13.71]	21.46 [4.67]	4.85
Commerce	17	54.41 [17.18]	17.22 [5.25]	3.47
Transport	5	59.00 [13.80]	21.40 [4.64]	4.60
Public sector	2	50.00 [10.83]	22.10 [4.26]	5.00
Other industry	17	62.06 [11.88]	22.77 [4.49]	5.29
Unemployed	5	23.40 [4.60]	24.03 [4.75]	5.00

Notes: Household food expenditure included expenditures for rice and for other side dishes. Occupations were classified using the industrial classification of the Third Population Census, conducted in 1930 Three households reported as "office worker" can not be classified and thus dropped. Sources: Tokyo City Office 1932c; Statistics Bureau of the Cabinet 1933, pp.76–91.

Table 2: Head's occupation in the NSPD by the industrial classification of 3rd Population Census

Name of survey	NSPD	SPRP	SPRP	3rd Population Census	3rd Population Census
Survey area	Hakusan Goten town	Entire Tokyo City	Koishikawa ward	Entire Tokyo City	Koishikawa ward
Survey subjects	ARTIPH7 households (head)	Poor households (male head)	Poor households (male head)	Entire population (male)	Entire population (male)
Survey month and year	January to March, 1930	March 1929	March 1929	October 1930	October 1930
Agriculture	0.00	0.90	2.51	0.41	0.59
Fisheries	0.00	0.31	0.00	0.09	0.02
Mining	0.00	0.72	0.08	0.11	0.20
Manufacture	59.80	40.74	47.56	38.20	39.31
Commerce	16.67	13.26	11.04	42.58	36.39
Transport	4.90	7.38	7.69	5.56	4.93
Public sector and freelancer	1.96	7.76	12.25	11.51	16.45
Housework	0.00	0.33	0.23	0.72	1.50
Other industory	16.67	28.61	18.65	0.82	0.61

Notes: The industrial classification was based on data from the Third Population Census, which was conducted in 1930. The number of observations in the NSPD, the SPRP (Entire City), the SPRP (Koishikawa ward), the Population Census (Entire City), the Population Census (Koishikawa ward) are 102, 13,489, 1,314, 767,646, 46,245, respectively. In the NSPD sample, five households were classified as unemployed. In addition, three households reported as "office worker" could not be classified, and were thus excluded. Therefore, eight of the 110 households were excluded. There are no freelancer in the NSPD sample. Sources: Tokyo City Office 1931; Tokyo City Office 1930, pp.29–41; Statistics Bureau of the Cabinet 1933, pp.76–91.

Table 3: Daily calorie intake per capita, *kcal*

	The ARTIPH7 (Original factors)	McCance &Widdowson (Modified Atwater factors)	Basal metabolic rate (BMR)	Survival diet (1.27BMR)
Mean daily calorie intake per capita, *kcal*	1688.0	1572.0	1015.7	1290.0
Standard error	361.9	347.8	156.7	199.0
Minimum	685.0	632.2	657.4	834.9
Maximum	3165.0	2953.9	1367.5	1736.7

Notes: The number of observations is 183. Survival diet was calculated using 182 observations, given missing values in the family composition. The mean value of per-capita calorie intake reported in the second column is the recalculated value using the original conversion factors used in the ARTIPH7; the conversion factors for carbohydrate, fat, and protein are 4.1 *kcal*/g, 9.3 *kcal*/g, and 4.1 *kcal*/g. The value in the third column is the estimated calorie value by using the modified Atwater conversion factors used in the McCance & Widdowson tables; the conversion factors for carbohydrate, fat, and protein are 3.75 *kcal*/g, 9 *kcal*/g, and 4 *kcal*/g. The value in the third column is the mean value of the per-capita survival diet for our sample. BMR in each household was calculated as the weighted average of the BMR of each age and gender group, using equation (4) shown in Appendix D. The predicted BMR in each age and gender group is reported in Table A.3 in Appendix A. The per-capita survival diet in each household was calculated as the total survival diet divided by that household's size Sources: Tokyo City Office 1931; Mishima 1902; Division of Physical Education, Minister's Secretariat, Ministry of Education 1937; Sanitary Bureau of the Home Department 1922, pp.38–54; Floud *et al.* 2011, p.43; Finglas *et al.* 2015, p.9.

Table 4: Daily calorie intake of adults per capita by sex, *kcal*

Categories of activity level (DRI-Japan)	Sex	Age	BMR	PAL	EER	The ARTIPH7: 25th percentile: Calorie intakes	25th percentile: Excess or deficiency	Mean: Calorie intakes	Mean: Excess or deficiency	75th percentile: Calorie intakes	75th percentile: Excess or deficiency
Categories I (light)	Male	20–49	1367.5	1.3	1777.8	1881.1	103.4	2117.9	340.2	2362.8	585.1
Categories I (light)	Female	20–49	1094.2	1.3	1422.4	1505.1	82.7	1694.6	272.2	1890.5	468.1
Categories II (moderate)	Male	20–49	1367.5	1.5	2051.3	1881.1	−170.1	2117.9	66.7	2362.8	311.6
Categories II (moderate)	Female	20–49	1094.2	1.5	1641.2	1505.1	−136.1	1694.6	53.3	1890.5	249.3
Categories III (light heavy)	Male	20–49	1367.5	1.7	2324.8	1881.1	−443.6	2117.9	−206.8	2362.8	38.1
Categories III (light heavy)	Female	20–49	1094.2	1.7	1860.1	1505.1	−354.9	1694.6	−165.5	1890.5	30.5
Categories IV (heavy)	Male	20–49	1367.5	1.9	2598.3	1881.1	−717.1	2117.9	−480.3	2362.8	−235.4
Categories IV (heavy)	Female	20–49	1094.2	1.9	2078.9	1505.1	−573.8	1694.6	−384.3	1890.5	−188.4

Notes: The number of observations is 182. BMRs are calculated using the predicted BMR listed in Table A.3 in Appendix A. The details of the predicted BMR are described in Appendix C. PALs in the four activity–level categories are from the Dietary Reference Intake in Japan, reported by the Ministry of Health, Labour and Welfare. The criteria of the activity categories are as follows. Category I involves a "mostly sedentary position doing reading, studying and talking, or sitting or lying position watching TV and listening to music, with one hour of slow walking for walking and shopping." Category II involves a "mostly sedentary position, doing clerical work and housework, with two hours of walking for commuting and shopping, and long hours of standing while meeting people or doing housework." "In addition to moderate activity (II)," category III involves "one hour of brisk walking, bicycling, or other vigorous physical activity—mostly standing during gaming or fishing, with heavy muscular work, for one hour a day." Finally, with category IV activities, one is "engaged in heavy muscular work for about one hour a day, such as hard training, carrying lumber, farming in the busy season, and so on." (Ishikawa–Takata, 'Physical activity', p.889). According to the Ministry of Health, Labour and Welfare of Japan, *Recommended*, examples of daily activities can be divided into five categories; resting, standing, walking, trotting, and exercising. The number of hours for resting, standing, walking, trotting, and exercising in each category were allocated as follows: 12, 11, 1, 0, and 0 (category I); 10, 9, 5, 0, and 0 (category II); 9, 8, 6, 1, and 0 (category III); and 9, 8, 5, 1, and 1 (category IV), respectively. EER is calculated as BMR×PAL. Sources: Tokyo City Office 1931; Mishima 1902; Division of Physical Education, Minister's Secretariat, Ministry of Education 1937; Sanitary Bureau of the Home Department 1922, pp.38–54; Floud *et al.* 2011, p.43; Ministry of Health, Labour and Welfare, Japan 1999.

Table 5: Nutritional attainments, by head's occupation, income, and households size

	Nutritional intake per capita						
	Calories	Moderate activity	Difference	Carbohydrate	Fats	Proteins (*gram*)	
	(*kcal*)	(1.5BMR, *kcal*)	(*kcal*)	(*gram*)	(*gram*)	Total	Animal (%)
Total households	1571.56	1523.60	47.96‡	344.25	8.38	51.42	17.67
Panel (a): by head's occupation							
Manufacture	1506.71	1494.04	12.66	332.57	7.27	48.52	16.70
Commerce	1571.22	1548.67	22.55	341.33	8.82	52.96	17.99
Transport	1473.96	1515.92	-41.96	328.69	5.63	47.68	14.87
Public sector	1299.69	1454.91	-155.22†	285.98	6.53	42.12	17.53
Other industry	1533.00	1456.20	76.80	343.77	5.93	47.63	14.71
Unemployed	1552.42	1559.53	-7.11	343.04	7.14	50.43	17.79
Panel (b): by income per capita (quartile group)							
< 8.75	1428.21	1412.13	16.08	319.19	5.78	44.82	14.86
$8.75 - 12.00$	1420.13	1419.46	0.67	314.71	6.36	45.68	17.17
$12.00 - 16.67$	1571.04	1523.87	47.17	347.15	7.55	50.31	16.71
$16.67 \leq$	1693.36	1664.05	30.68	364.95	10.05	58.59	18.89
Panel (c): by household size (quartile group)							
< 3	2044.05	1854.20	129.85†	427.64	17.73	70.21	19.02
$3 - 4$	1669.96	1600.97	68.99	367.03	8.47	54.34	18.14
$4 - 6$	1486.69	1469.41	14.96	328.58	6.82	48.28	18.08
$6 \leq$	1418.00	1376.59	41.41	316.76	5.87	44.34	15.95

Notes: The number of observations in panel (a), panel (b), and panel (c) are 107, 110, and 182 respectively. The mean value of calorie intakes of total households is calculated using 182 observations. The number of households in each industrial categories is the same as in Table 1. Occupations were classified using the industrial classification of the Third Population Census, conducted in 1930. Whole foods include both rice and the other side dishes. ‡ and † represent statistical significance at the 5% and 10% levels, respectively. Sources: Tokyo City Office 1931; Statistics Bureau of the Cabinet 1933, pp.76–91.

Table 6: Summary statistics of our sample

	Observations	Mean	Std.Dev.	Min	Max
Panel (A): Nutritional variables					
Food expenditures per capita	105	4.74	1.11	1.69	8.25
Calories per capita	105	1522.43	293.10	632.24	2470.40
Calories per capita (ingested from principal foods)	105	1304.59	264.04	514.71	2088.36
Calories per capita (ingested from animals)	105	58.81	33.83	0.00	182.24
Calories per capita (ingested from vegetables)	105	159.04	64.74	36.35	367.73
Carbohydrate per capita	105	336.34	65.63	144.92	525.83
Carbohydrate per capita (ingested from principal foods)	105	313.00	63.45	123.34	500.79
Carbohydrate per capita (ingested from animals)	105	0.77	1.05	0.00	5.08
Carbohydrate per capita (ingested from vegetables)	105	22.58	10.58	4.28	61.72
Fats per capita	105	49.18	10.85	17.43	86.43
Fats per capita (ingested from principal foods)	105	29.96	6.26	11.96	48.19
Fats per capita (ingested from animals)	105	8.53	4.87	0.00	30.80
Fats per capita (ingested from vegetables)	105	10.69	4.20	3.13	22.63
Proteins per capita	105	7.16	2.86	1.89	16.98
Proteins per capita (ingested from principal foods)	105	1.22	0.26	0.48	1.96
Proteins per capita (ingested from animals)	105	2.42	1.65	0.00	9.44
Proteins per capita (ingested from vegetables)	105	3.51	1.70	0.80	8.23
Panel (B): Infant mortality rate, fetal death rate, and disease rates					
Infant mortality rate, percentage points	75	23.78	28.46	0.00	100.00
Fetal death rate, percentage points	75	2.02	8.76	0.00	50.00
Overall disease rate, percentage points	88	39.47	28.95	0.00	100.00
Share of people who have eye disease	88	7.40	13.81	0.00	50.00
Share of people who have ear disease	88	1.72	6.89	0.00	50.00
Share of people who have nose disease	88	1.87	7.61	0.00	50.00
Share of people who have respiratory disease	88	3.71	14.36	0.00	100.00
Share of people who have tuberculosis	88	1.82	6.66	0.00	33.33
Share of people who have digestive disease	88	7.48	14.44	0.00	66.67
Share of people who have tonsillitis	88	8.20	13.34	0.00	50.00
Share of people who have skin disease	88	2.95	8.42	0.00	42.86
Panel (C): Key variables					
Income per capita	105	13.42	6.05	5.00	33.33
Calories per capita (identical to the values in Panel (A))	105	1522.43	293.10	632.24	2470.40
Panel (D): Control variables					
Size	105	4.73	1.90	2.00	10.00
Share of people aged 0 to 4	105	0.14	0.16	0.00	0.67
Share of people aged 5 to 8	105	0.12	0.13	0.00	0.50
Share of people aged 9 to 12	105	0.10	0.12	0.00	0.50
Share of people aged 13 to 19	105	0.10	0.15	0.00	0.67
Share of young adults (reference group)	105	0.54	0.23	0.22	1.00
Share of older adults	105	0.06	0.11	0.00	0.60
Ratio of males to females in the household	105	1.39	1.07	0.25	5.00
Manufacture (reference group)	105	0.57			
Commerce	105	0.16			
Transport	105	0.05			
Public sector	105	0.02			
Other industry	105	0.16			
Unemployed	105	0.04			
Panel (E): Additional control variables					
Share of worker	105	37.99	21.16	12.50	100.00
Floor space per capita	105	1.48	0.90	0.29	7.75

Notes: Calories per capita is the total amount of calories divided by the household size. Carbohydrate per capita, fats per capita, and proteins per capita are defined in a similar way. Infant mortality rate is the number of infant deaths divided by live births in each household (percentage points). Fetal death rate is the number of fetal deaths divided by the number of pregnancies in each household (percentage points). Share of people who have any diseases in the household is defined as the number of patients divided by the household size in each household (percentage points). The share of young adults is the number of adults aged 20+ who were either the primary adult man or the primary adult woman in the household, divided by the household size (percentage points). The share of older adults is the number of adults aged 20+ who were either the second or later man aged 20+ or the second and later woman aged 20+ in the household, divided by the household size (percentage points). Ratio of males to females is the number of males divided by the number of females in the family members. Control variables for the household head's occupation are dummy variables. The share of worker is defined as the number of workers divided by the household size (percentage point). The floor space per capita is the number of tatami mats divided by the household size. 1 tatami mat is approximately 1.82 square meter.

Table 7: Estimation results: daily calorie and nutrient intake

Dependent variables	ln*Income*		*R*-squared	Number of	Demographic	Head's
	Coeff.	Std.Err.		observations	controls	occupation
Food expenditure	0.093	(0.078)	0.4467	105	Yes	Yes
lnCalories	0.022	(0.064)	0.4043	105	Yes	Yes
Principal foods	-0.024	(0.071)	0.3243	105	Yes	Yes
Animals	0.439**	(0.216)	0.2956	100	Yes	Yes
Vegetables	0.138	(0.116)	0.4025	105	Yes	Yes
lnCarbohydrate	-0.002	(0.065)	0.3649	105	Yes	Yes
Principal foods	-0.023	(0.071)	0.3209	105	Yes	Yes
Animals	0.941	(0.589)	0.1874	87	Yes	Yes
Vegetables	0.154	(0.146)	0.3505	105	Yes	Yes
lnFats	0.053	(0.077)	0.4467	105	Yes	Yes
Principal foods	-0.038	(0.071)	0.3492	105	Yes	Yes
Animals	0.337	(0.224)	0.2476	100	Yes	Yes
Vegetables	0.032	(0.110)	0.4097	105	Yes	Yes
lnProteins	0.274*	(0.144)	0.3375	105	Yes	Yes
Principal foods	-0.043	(0.073)	0.2683	105	Yes	Yes
Animals	0.523**	(0.246)	0.2766	100	Yes	Yes
Vegetables	0.174	(0.161)	0.2841	105	Yes	Yes

Notes: Dependent variable is either the natural log of per capita food expenditure, quantities of difference nutrients including calories, carbohydrate, protein, or fat. Demographic controls include the household size, share of family members aged 0-4, aged 5-8, aged 9-12, aged 13-19, young adults, and older adults, and ratio of males to females. ** and * represents statistical significance at the 5% and 10% level, respectively. Full estimates are reported in Table A.5 – A.6 in Appendix A.

Table 8: Estimation results: infant mortality, fetal mortality, and disease rates

Dependent variable	ln*Calories*		ln*Income*		*R*-squared	Number of	Demographic	Head's
	Coeff.	Std.Err.	Coeff.	Std.Err.		observations	controls	occupation
Infant mortality rate	25.744	(16.662)	-15.961	(11.680)	0.4555	75	Yes	Yes
Fetal death rate	9.813	(6.449)	6.454	(5.502)	0.1680	75	Yes	Yes
Overall disease rate	19.481	(18.028)	-15.763	(11.403)	0.2079	88	Yes	Yes
Eye	-1.632	(8.700)	0.148	(6.920)	0.1144	88	Yes	Yes
Ear	2.051	(3.018)	-3.525*	(2.055)	0.1115	88	Yes	Yes
Nose	2.672	(3.034)	-1.721	(2.421)	0.2364	88	Yes	Yes
Respiratory	2.950	(7.135)	-4.478	(6.416)	0.1116	88	Yes	Yes
Tuberculoses	0.775	(5.591)	0.726	(1.656)	0.1191	88	Yes	Yes
Digestive	9.267	(10.569)	6.665	(6.169)	0.2254	88	Yes	Yes
Tonsillitis	-5.320	(10.449)	2.710	(5.410)	0.1044	88	Yes	Yes
Skin	7.729	(4.845)	-3.528	(3.025)	0.2761	88	Yes	Yes

Notes: Dependent variable is either the infant mortality rate, fetal death rate, and disease rates including any eye diseases, ear diseases, nose diseases, respiratory diseases, tuberculoses, digestive diseases, tonsillitis, or skin diseases. The infant mortality rate is the number of infant deaths within 12 months after births per live births. The fetal death rate is the number of fetal deaths per total births. Each disease rate is the number of patients per household size. Both demographic controls and head's occupations are included in all specification. Demographic controls include the household size, share of family members aged 0-4, aged 5-8, aged 9-12, aged 13-19, young adults, and older adults, and ratio of males to females. ** and * represents statistical significance at the 5% and 10% level, respectively. Full estimates are reported in Table A.7 in Appendix A.

Table 9: Estimation results: robustness to additional exposure factors

	Infant mortality rate		Fetal death rate		Overall disease rate	
	(1)	(2)	(3)	(4)	(5)	(6)
ln*Calories*	24.733	22.648	9.14	9.570	18.208	18.769
	(16.784)	(14.896)	(6.500)	(6.730)	(17.115)	(17.458)
ln*Income*	-16.204	-11.667	6.478	7.227	-16.709	-15.193
	(11.568)	(12.445)	(5.559)	(5.377)	(11.463)	(11.538)
Share of worker	0.385*	0.3333	-0.038	-0.047	0.339	0.352*
	(0.207)	(0.207)	(0.035)	(0.042)	(0.204)	(0.209)
Floor space		-9.847		-1.625		-4.062
		(8.330)		(2.292)		(3.623)
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes
Head's occupation	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.4923	0.5093	0.1719	0.1768	0.2360	0.2448
Number of observations	75	75	75	75	88	88

Notes: Dependent variable is either the infant mortality rate, fetal death rate, and overall disease rates including any eye diseases, ear diseases, nose diseases, respiratory diseases, tuberculoses, digestive diseases, tonsillitis, or skin diseases. The infant mortality rate is the number of infant deaths within 12 months after births per live births. The fetal death rate is the number of fetal deaths per total births. The overall disease rate is the number of patients per household size. Both demographic controls and head's occupations are included in all specification. Demographic controls include the household size, share of family members aged 0-4, aged 5-8, aged 9-12, aged 13-19, young adults, and older adults, and ratio of males to females. * represents statistical significance at the 10% level. Full estimates are reported in Table A.8 in Appendix A.

Appendices

Appendix A Additional Figures and Tables

Table A.1: Comparison of means between full sample and subsample of the ARTIPH7

Variables	Sub-sample: Income reported (110 households)	Sub-sample: Income not reported (73 households)	Difference	p-value
Nutritional variables				
Calories per capita	1529.49	1636.18	−106.69	0.0493
Calories per capita (ingested from principal foods)	1308.01	1366.74	−58.72	0.1915
Calories per capita (ingested from animals)	60.49	87.49	−27.00	0.0441
Calories per capita (ingested from vegetables)	160.98	181.95	−20.96	0.1160
Carbohydrate per capita	336.96	355.23	−18.27	0.1075
Carbohydrate per capita (ingested from principal foods)	313.81	328.53	−14.72	0.1783
Carbohydrate per capita (ingested from animals)	0.75	1.05	−0.30	0.3405
Carbohydrate per capita (ingested from vegetables)	22.41	25.64	−3.24	0.1724
Fats per capita	7.41	9.84	−2.43	0.0833
Fats per capita (ingested from principal foods)	1.23	1.27	−0.04	0.3333
Fats per capita (ingested from animals)	2.46	4.63	−2.17	0.0798
Fats per capita (ingested from vegetables)	3.73	3.94	−0.22	0.5620
Proteins per capita	49.79	53.88	−4.09	0.0581
Proteins per capita (ingested from principal foods)	30.05	30.84	−0.79	0.4504
Proteins per capita (ingested from animals)	8.90	10.48	−1.58	0.1013
Proteins per capita (ingested from vegetables)	10.85	12.57	−1.72	0.0570
Household characteristics				
Size	4.65	4.14	0.52	0.0509
Share of male aged 0 to 4, percentage points	0.07	0.05	0.02	0.2007
Share of female aged 0 to 4, percentage points	0.06	0.06	0.01	0.7297
Share of male aged 5 to 8, percentage points	0.07	0.06	0.01	0.4858
Share of female aged 5 to 8, percentage points	0.05	0.04	0.01	0.7253
Share of male aged 9 to 12, percentage points	0.05	0.04	0.00	0.7703
Share of female aged 9 to 12, percentage points	0.05	0.05	0.00	0.8362
Share of male aged 13 to 19, percentage points	0.05	0.06	−0.01	0.5444
Share of female aged 13 to 19, percentage points	0.05	0.03	0.02	0.2510
Share of male aged over 20, percentage points	0.28	0.32	−0.04	0.1936
Share of female aged over 20, percentage points	0.27	0.29	−0.02	0.3096

Notes: The results from two-sample t-test with unequal variances are reported. The number of observations in the tests for share of people in the households is 109 due to missing value.

Table A.2: Household food expenditure, by head's occupation, income, and household size

	Household food expenditure, yen					
	Whole foods		Rice		Other side dishes	
	Expenditure	Per capita	Expenditure	Per capita	Total expence	Per capita
Total households	21.01	4.78	13.92	3.09	7.09	1.69
Panel (a): by head's occupation						
Manufacture	21.46	4.67	14.29	3.07	7.17	1.61
Commerce	17.22	5.25	10.40	3.03	6.82	2.22
Transport	21.40	4.64	13.61	2.91	7.79	1.73
Public sector	22.10	4.26	13.50	2.61	8.60	1.65
Other industry	22.77	4.49	16.36	3.15	6.41	1.34
Unemployed	24.03	4.75	15.55	3.11	8.48	1.63
Panel (b): by income per capita (quartile group)						
< 8.75	26.21	4.22	18.06	2.90	8.15	1.31
$8.75 - 12.00$	22.53	4.42	15.36	3.01	7.17	1.41
$12.00 - 16.67$	19.61	4.87	12.93	3.14	6.68	1.73
$16.67 \leq$	15.70	5.62	9.30	3.30	6.40	2.33
Panel (c): by household size (quartile group)						
< 3	12.02	6.21	6.99	3.63	5.03	2.58
$3 - 4$	15.68	5.23	9.66	3.22	6.02	2.01
$4 - 6$	20.41	4.52	13.50	2.98	6.91	1.55
$6 \leq$	29.01	4.17	20.13	2.89	8.88	1.28

Notes: The number of observations in panel(a), panel (b), and panel (c) are 107, 110, 183 respectively. The number of households in each industrial categories is the same as in Table 1. Occupations were classified using the industrial classification of the Third Population Census, conducted in 1930. Whole foods include both rice and the other side dishes. Sources: Tokyo City Office 1931; Statistics Bureau of the Cabinet 1933, pp.76–91.

Table A.3: Height, weight, predicted BMR, and survival diet, by age and sex

	Height (*cm*)		Weight (*kg*)		Predicted BMR (*kcal*)		Survival diet (1.27×BMR)	
Age	Male	Female	Male	Female	Male	Female	Male	Female
0–4	85.5	84.8	12.2	11.5	510.6	367.4	648.5	466.6
5–9	112.9	111.8	20.0	19.2	736.4	591.3	935.3	750.9
10–14	137.9	137.4	32.9	33.4	1007.7	880.0	1279.8	1117.7
15–19	160.2	150.6	52.0	47.6	1335.1	1101.2	1695.6	1398.5
20–49	163.1	150.5	54.8	48.5	1367.5	1094.2	1736.7	1389.6
50–54	159.9	149.0	54.0	45.2	1242.3	949.7	1577.7	1206.1
55–59	158.7	148.4	50.9	45.4	1183.1	931.3	1502.5	1182.8
60–64	158.7	146.8	52.2	40.3	1181.2	848.2	1500.1	1077.2
65–69	157.8	147.2	49.0	43.2	1122.6	865.7	1425.6	1099.4
70–74	158.4	144.0	48.5	38.4	1104.1	777.1	1402.2	987.0
75–79	156.8	144.3	46.9	38.5	1060.6	763.3	1346.9	969.4

Notes: Predicted BMRs are calculated using Ganpule equation described in Appendix C. The number of inspected boys and girls aged 0 to 5 were 2,656 and 2,130, respectively. For the height and weight data of people aged 6–49, a couple of data sources and calculations were used. Data on all students in both public and private schools in Japan in 1930 were used, and for people aged 25–49, the height and weight of the people aged 20–24 were adopted. The heights and weights of those aged 50+ were estimated by using the rate of reduction relative to people aged 20–49, as reported in the survey conducted by the Sanitary Bureau of the Home Department in Ehime Prefecture in 1920. The reduction rates of height for men aged 50–54, 55–59, 60–64, 65–69, 70–74, and 75–79 were 0.981, 0.973, 0.973, 0.967, 0.971, and 0.961, respectively, while those of women were 0.990, 0.986, 0.976, 0.978, 0.957, and 0.959, respectively. Meanwhile, the reduction rates of weight for men aged 50–54, 55–59, 60–64, 65–69, 70–74, and 75–79 were 0.986, 0.929, 0.953, 0.894, 0.885, and 0.856, respectively, and those of women were 0.933, 0.936, 0.832, 0.890, 0.792, and 0.793, respectively. Sources: Mishima 1902; Division of Physical Education, Minister's Secretariat, Ministry of Education 1937; Sanitary Bureau of the Home Department 1922, pp.38–54; Floud *et al.* 2011, p.43.

Table A.4: Calorie intake and income

Dependent variables	ln*Income*		R-squared	Number of
	Coeff.	Std.Err.		observations
lnFood expenditure	0.229***	(0.054)	0.1650	108
lnCalories	0.135**	(0.053)	0.0774	108
Principal foods	0.080	(0.056)	0.0245	108
Animals	0.500***	(0.134)	0.1438	102
Vegetables	0.402***	(0.079)	0.1594	108
lnCarbohydrate	0.103**	(0.052)	0.0455	108
Principal foods	0.081	(0.056)	0.0249	108
Animals	0.742*	(0.390)	0.0515	88
Vegetables	0.351***	(0.090)	0.0939	108
lnFats	0.199***	(0.064)	0.1244	108
Principal foods	0.070	(0.056)	0.0175	108
Animals	0.443***	(0.136)	0.1232	102
Vegetables	0.346***	(0.083)	0.1397	108
lnProteins	0.419***	(0.105)	0.1782	108
Principal foods	0.064	(0.056)	0.0151	108
Animals	0.514***	(0.157)	0.0925	102
Vegetables	0.496***	(0.123)	0.1580	108

Notes: ***, ** and * represents statistical significance at the 1% , 5% and 10% level, respectively.

Table A.5: Calorie intake and household characteristics including head's occupation

	lnFood expenditures	lnCalories			
		Total	Principal foods	Animals	Vegetables
ln*Income*	0.093	0.022	-0.024	0.439**	0.138
	(0.078)	(0.064)	(0.071)	(0.216)	(0.116)
Ratio of males to females	0.034**	0.039**	0.040**	0.059	-0.002
	(0.017)	(0.015)	(0.016)	(0.058)	(0.038)
Share of people aged 0 to 4	-0.766***	-0.732***	-0.723***	-0.701	-0.684**
	(0.207)	(0.193)	(0.229)	(0.617)	(0.284)
Share of people aged 5 to 8	-0.524*	-0.591**	-0.639**	0.627	-0.405
	(0.267)	(0.248)	(0.281)	(0.648)	(0.413)
Share of people aged 9 to 12	-0.794*	-0.622	-0.605	-1.041	-0.142
	(0.418)	(0.376)	(0.412)	(0.732)	(0.390)
Share of people aged 13 to 19	-0.249	-0.213	-0.150	-0.044	-0.468
	(0.228)	(0.195)	(0.223)	(0.554)	(0.327)
Share of people older adults	-0.656***	-0.508**	-0.441*	-0.346	-1.155***
	(0.237)	(0.209)	(0.242)	(0.739)	(0.360)
Household size	0.010	0.013	0.015	-0.011	-0.045
	(0.035)	(0.031)	(0.035)	(0.077)	(0.046)
Commerce	0.025	-0.018	-0.045	-0.086	0.165*
	(0.049)	(0.050)	(0.064)	(0.135)	(0.088)
Transport	-0.035	-0.047	-0.050	-0.124	0.086
	(0.061)	(0.063)	(0.061)	(0.165)	(0.144)
Public sector	-0.097	-0.175***	-0.184***	0.207	-0.170
	(0.095)	(0.049)	(0.040)	(0.153)	(0.180)
Other industry	-0.020	0.030	0.052	-0.196	-0.096
	(0.048)	(0.041)	(0.045)	(0.158)	(0.111)
Unemployed	0.165	0.125	0.078	0.442*	0.394***
	(0.118)	(0.084)	(0.090)	(0.230)	(0.130)
R-squared	0.4467	0.4043	0.3243	0.2956	0.4025
Number of observations	105	105	105	100	105

Notes: ***, ** and * represents statistical significance at the 1% , 5% and 10% level, respectively.

Table A.6: Nutrient intake and household's characteristics including head's occupation

	lnCarbohydrate				lnFats				lnProteins			
	Total	Principal foods	Animals	Vegetables	Total	Principal foods	Animals	Vegetables	Total	Principal foods	Animals	Vegetables
ln*Income*	-0.002	-0.023	0.941	0.154	0.053	-0.038	0.337	0.032	0.274*	-0.043	0.523**	0.174
	(0.065)	(0.071)	(0.589)	(0.146)	(0.077)	(0.071)	(0.224)	(0.110)	(0.144)	(0.073)	(0.246)	(0.161)
Ratio of males to females	0.038**	0.040**	0.048	0.003	0.047**	0.042**	0.057	0.001	0.053	0.034**	0.106	0.008
	(0.015)	(0.016)	(0.115)	(0.048)	(0.018)	(0.017)	(0.057)	(0.032)	(0.036)	(0.016)	(0.067)	(0.044)
Share of people aged 0 to 4	-0.722***	-0.722***	0.985	-0.801**	-0.764***	-0.753***	-0.550	-0.745***	-0.693*	-0.645***	-1.118	-0.448
	(0.204)	(0.229)	(1.358)	(0.359)	(0.199)	(0.229)	(0.583)	(0.272)	(0.352)	(0.239)	(0.817)	(0.379)
Share of people aged 5 to 8	-0.606**	-0.636**	1.860	-0.431	-0.591**	-0.702**	0.510	-0.552	-0.219	-0.544*	0.503	-0.186
	(0.256)	(0.281)	(1.698)	(0.506)	(0.264)	(0.283)	(0.639)	(0.345)	(0.450)	(0.296)	(0.831)	(0.517)
Share of people aged 9 to 12	-0.560	-0.607	-0.604	0.071	-0.883**	-0.597	-1.060	-0.599	-0.908	-0.510	-1.108	-0.292
	(0.376)	(0.411)	(1.950)	(0.435)	(0.406)	(0.415)	(0.681)	(0.422)	(0.552)	(0.437)	(0.974)	(0.581)
Share of people aged 13 to 19	-0.181	-0.150	0.756	-0.640	-0.304	-0.154	0.143	-0.502	-0.459	-0.078	-0.532	-0.199
	(0.201)	(0.223)	(1.474)	(0.404)	(0.215)	(0.222)	(0.528)	(0.314)	(0.416)	(0.234)	(0.773)	(0.444)
Share of people older adults	-0.469**	-0.433*	0.204	-1.241***	-0.646***	-0.567**	-0.104	-1.080***	-0.901**	-0.347	-0.767	-1.007**
	(0.220)	(0.244)	(2.052)	(0.420)	(0.237)	(0.249)	(0.666)	(0.343)	(0.439)	(0.259)	(0.960)	(0.468)
Household size	0.012	0.015	-0.114	-0.050	0.013	0.012	-0.017	-0.032	0.015	0.007	0.023	-0.041
	(0.031)	(0.035)	(0.140)	(0.052)	(0.032)	(0.034)	(0.068)	(0.042)	(0.050)	(0.036)	(0.103)	(0.054)
Commerce	-0.025	-0.041	0.145	0.143	-0.011	-0.097	-0.050	0.212**	0.073	-0.037	-0.129	0.254**
	(0.056)	(0.065)	(0.329)	(0.104)	(0.051)	(0.069)	(0.145)	(0.087)	(0.083)	(0.065)	(0.169)	(0.108)
Transport	-0.031	-0.049	-0.179	0.201	-0.069	-0.057	0.008	0.027	-0.381	-0.045	-0.339**	-0.328
	(0.058)	(0.061)	(0.684)	(0.182)	(0.105)	(0.064)	(0.207)	(0.185)	(0.246)	(0.060)	(0.143)	(0.325)
Public sector	-0.181***	-0.183***	1.854***	-0.212	-0.178***	-0.196***	-0.064	-0.045	-0.046	-0.177***	0.305**	-0.174
	(0.044)	(0.041)	(0.651)	(0.182)	(0.064)	(0.041)	(0.134)	(0.166)	(0.145)	(0.040)	(0.141)	(0.192)
Other industry	0.045	0.052	0.517	-0.096	-0.011	0.056	-0.071	-0.091	-0.197*	0.053	-0.521**	-0.071
	(0.041)	(0.045)	(0.482)	(0.136)	(0.048)	(0.045)	(0.146)	(0.090)	(0.116)	(0.045)	(0.250)	(0.138)
Unemployed	0.105	0.078	1.651**	0.488***	0.170*	0.073	0.328	0.300**	0.378**	0.062	0.606**	0.311
	(0.084)	(0.090)	(0.626)	(0.143)	(0.093)	(0.096)	(0.243)	(0.139)	(0.160)	(0.089)	(0.246)	(0.248)
R-squared	0.3649	0.3209	0.1874	0.3505	0.4467	0.3492	0.2476	0.4097	0.3375	0.2683	0.2766	0.2841
Number of observations	105	105	87	105	105	105	100	105	105	105	100	105

Notes: ***, ** and * represents statistical significance at the 1% , 5% and 10% level, respectively.

Table A.7: Infant mortality rate, fetal death rate, and disease rates and calorie intake with head's occupation

	Death rates		Disease rates								
	Infant	Fetal	Total	Eye	Ear	Nose	Respiratory	Tuberculouses	Digestive	Tonsillitis	Skin
ln*Calories*	25.744	9.813	19.481	-1.632	2.051	2.672	2.950	0.775	9.267	-5.320	7.729
	(16.662)	(6.449)	(18.028)	(8.700)	(3.018)	(3.034)	(7.135)	(5.591)	(10.569)	(10.449)	(4.845)
ln*Income*	-15.961	6.454	-15.763	0.148	-3.525*	-1.721	-4.478	0.726	6.665	2.710	-3.528
	(11.680)	(5.502)	(11.403)	(6.920)	(2.055)	(2.421)	(6.416)	(1.656)	(6.169)	(5.410)	(3.025)
Ratio of males to females	-4.947*	0.618	-5.239*	-1.761	-0.464	0.241	0.814	-0.312	0.889	0.293	-1.058
	(2.624)	(1.185)	(2.801)	(1.356)	(0.390)	(0.618)	(1.527)	(0.639)	(1.253)	(1.620)	(0.854)
Share of people aged 0 to 4	-111.666**	14.686	-15.998	-15.865	-11.583	18.719	-22.119	-3.587	13.641	-8.792	-0.976
	(44.716)	(12.028)	(36.923)	(17.846)	(10.854)	(11.650)	(22.710)	(4.753)	(20.482)	(18.446)	(7.561)
Share of people aged 5 to 8	-117.092***	2.726	13.891	-15.533	-11.265	11.559	-7.354	-0.149	16.956	4.918	11.328
	(40.885)	(9.000)	(43.687)	(22.435)	(11.931)	(10.669)	(27.559)	(10.903)	(24.197)	(20.857)	(9.704)
Share of people aged 9 to 12	-61.112	15.419	-8.167	13.661	-14.347	3.075	-33.965	16.224	-18.462	23.651	-8.717
	(46.593)	(12.578)	(45.749)	(23.232)	(12.005)	(9.129)	(23.548)	(11.746)	(22.199)	(25.439)	(10.165)
Share of people aged 13 to 19	-142.792***	-8.815	15.581	-14.873	-15.953	30.847*	-9.392	-5.303	-17.584	7.947	-6.280
	(43.779)	(8.124)	(35.174)	(17.898)	(10.611)	(18.083)	(23.875)	(5.465)	(16.463)	(19.134)	(5.191)
Share of people older adults	-106.308*	-9.026	-41.438	-10.846	-13.063	5.240	-16.512	-4.784	-11.837	-8.728	-4.211
	(53.222)	(8.685)	(42.789)	(20.868)	(11.433)	(9.733)	(20.712)	(5.995)	(20.171)	(20.270)	(6.454)
Household size	3.165	-0.405	1.436	0.421	1.517*	-1.792	1.864	0.247	0.120	-0.130	1.848*
	(3.705)	(0.716)	(2.845)	(1.650)	(0.773)	(1.277)	(1.420)	(0.779)	(1.561)	(1.415)	(1.032)
Commerce	-9.361	-6.185	-1.708	-4.652	0.328	1.938	5.502	2.090	-1.008	-1.616	1.274
	(9.549)	(3.757)	(8.788)	(4.491)	(2.228)	(3.018)	(7.010)	(2.330)	(5.243)	(4.377)	(2.592)
Transport	-3.389	-3.681	3.318	0.024	-1.297	-3.439**	5.900	-1.641	-4.334	0.936	-0.609
	(11.265)	(2.525)	(9.681)	(4.887)	(1.433)	(1.573)	(8.908)	(1.433)	(4.144)	(4.942)	(2.583)
Public sector	-0.725	1.328	21.198	-2.436	-1.947	-6.989*	-10.992	-0.732	-2.517	3.622	-4.031
	(11.466)	(3.974)	(16.402)	(7.820)	(1.866)	(4.100)	(9.310)	(2.360)	(6.244)	(9.993)	(2.820)
Other industry	6.596	-1.265	-22.039**	-1.121	-1.715	-2.675*	-4.979*	1.361	-8.518***	0.961	-5.249**
	(5.698)	(2.304)	(8.540)	(4.816)	(1.740)	(1.375)	(2.834)	(2.161)	(2.774)	(4.074)	(2.042)
Unemployed	-3.025	7.019	-21.657	-6.274	-4.309	-8.676	-10.809	1.733	7.992	-5.685	-7.036*
	(18.414)	(6.185)	(21.671)	(7.512)	(2.720)	(5.648)	(8.135)	(2.486)	(8.512)	(8.137)	(3.639)
R-squared	0.4555	0.168	0.2079	0.1144	0.1115	0.2364	0.1116	0.1191	0.2254	0.1044	0.2761
Number of observations	75	75	88	88	88	88	88	88	88	88	88

Notes: Dependent variable is either the infant mortality rate, fetal death rate, and overall disease rates including any eye diseases, ear diseases, nose diseases, respiratory diseases, tuberculoses, digestive diseases, tonsillitis, or skin diseases. The infant mortality rate is the number of infant deaths within 12 months after births per live births. The fetal death rate is the number of fetal deaths per total births. The overall disease rate is the number of patients per household size. ***, ** and * represents statistical significance at the 1% , 5% and 10% level, respectively.

Table A.8: Estimation results: robustness to additional exposure factors

	Infant mortality rate			Fetal death rate			Overall disease rate		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ln*Calories*	25.744	24.733	22.648	9.813	9.14	9.570	19.481	18.208	18.769
	(16.662)	(16.784)	(14.896)	(6.449)	(6.500)	(6.730)	(18.028)	(17.115)	(17.458)
ln*Income*	-15.961	-16.204	-11.667	6.454	6.478	7.227	-15.763	-16.709	-15.193
	(11.680)	(11.568)	(12.445)	(5.502)	(5.559)	(5.377)	(11.403)	(11.463)	(11.538)
Share of worker	-	0.385*	0.3333	-	-0.038	-0.047	-	0.339	0.352*
	-	(0.207)	(0.207)	-	(0.035)	(0.042)	-	(0.204)	(0.209)
Floor space	-	-	-9.847	-	-	-1.625	-	-	-4.062
	-	-	(8.330)	-	-	(2.292)	-	-	(3.623)
Ratio of males to females	-4.947*	-3.212	-3.509	0.618	0.445	0.396	-5.239*	-3.77	-3.896
	(2.624)	(2.413)	(2.498)	(1.185)	(1.246)	(1.273)	(2.801)	(2.550)	(2.555)
Share of people aged 0 to 4	-111.666**	-98.802**	-113.172**	14.686	13.4	11.029	-15.998	-4.09	-3.288
	(44.716)	(43.471)	(44.890)	(12.028)	(12.076)	(12.961)	(36.923)	(38.409)	(38.933)
Share of people aged 5 to 8	-117.092***	-105.312**	-113.931***	2.726	1.548	0.126	13.891	26.234	29.867
	(40.885)	(40.221)	(40.033)	(9.000)	(9.249)	(9.974)	(43.687)	(44.902)	(45.970)
Share of people aged 9 to 12	-61.112	-68.144	-75.863	15.419	16.122	14.848	-8.167	-16.183	-15.092
	(46.593)	(45.874)	(45.683)	(12.578)	(12.747)	(13.390)	(45.749)	(42.793)	(43.930)
Share of people aged 13 to 19	-142.792***	-149.234***	-162.629***	-8.815	-8.172	-10.382	15.581	10.693	14.968
	(43.779)	(41.831)	(42.214)	(8.124)	(8.292)	(9.350)	(35.174)	(35.402)	(37.070)
Share of people older adults	-106.308*	-124.377**	-126.589**	-9.026	-7.22	-7.585	-41.438	-53.256	-52.212
	(53.222)	(49.882)	(49.886)	(8.685)	(8.806)	(9.018)	(42.789)	(42.322)	(42.455)
Household size	3.165	4.993	3.795	-0.405	-0.588	-0.786	1.436	2.998	1.883
	(3.705)	(3.627)	(3.682)	(0.716)	(0.776)	(0.916)	(2.845)	(2.807)	(3.186)
Commerce	-9.361	-13.699	-11.386	-6.185	-5.752	-5.37	-1.708	-6.351	-4.664
	(9.549)	(9.289)	(8.640)	(3.757)	(3.743)	(3.766)	(8.788)	(8.718)	(8.736)
Transport	-3.389	-10.157	-9.939	-3.681	-3.005	-2.969	3.318	-2.535	-3.586
	(11.265)	(13.059)	(12.658)	(2.525)	(2.476)	(2.494)	(9.681)	(9.582)	(9.829)
Public sector	-0.725	-13.32	-11.71	1.328	2.586	2.852	21.198	9.978	8.649
	(11.466)	(11.639)	(11.964)	(3.974)	(4.539)	(4.623)	(16.402)	(15.584)	(15.754)
Other industry	6.596	3.711	2.441	-1.265	-0.976	-1.186	-22.039**	-24.195***	-25.186***
	(5.698)	(5.314)	(5.672)	(2.304)	(2.351)	(2.321)	(8.540)	(8.120)	(8.291)
Unemployed	-3.025	1.424	4.356	7.019	6.574	7.058	-21.657	-18.814	-19.192
	(18.414)	(16.538)	(17.016)	(6.185)	(6.308)	(6.228)	(21.671)	(21.753)	(21.467)
R-squared	0.4555	0.4923	0.5093	0.1680	0.1719	0.1768	0.2079	0.2360	0.2448
Number of observations	75	75	75	75	75	75	88	88	88

Notes: Dependent variable is either the infant mortality rate, fetal death rate, and overall disease rates including any eye diseases, ear diseases, nose diseases, respiratory diseases, tuberculoses, digestive diseases, tonsillitis, or skin diseases. The infant mortality rate is the number of infant deaths within 12 months after births per live births. The fetal death rate is the number of fetal deaths per total births. The overall disease rate is the number of patients per household size. ***, ** and * represents statistical significance at the 1% , 5% and 10% level, respectively.

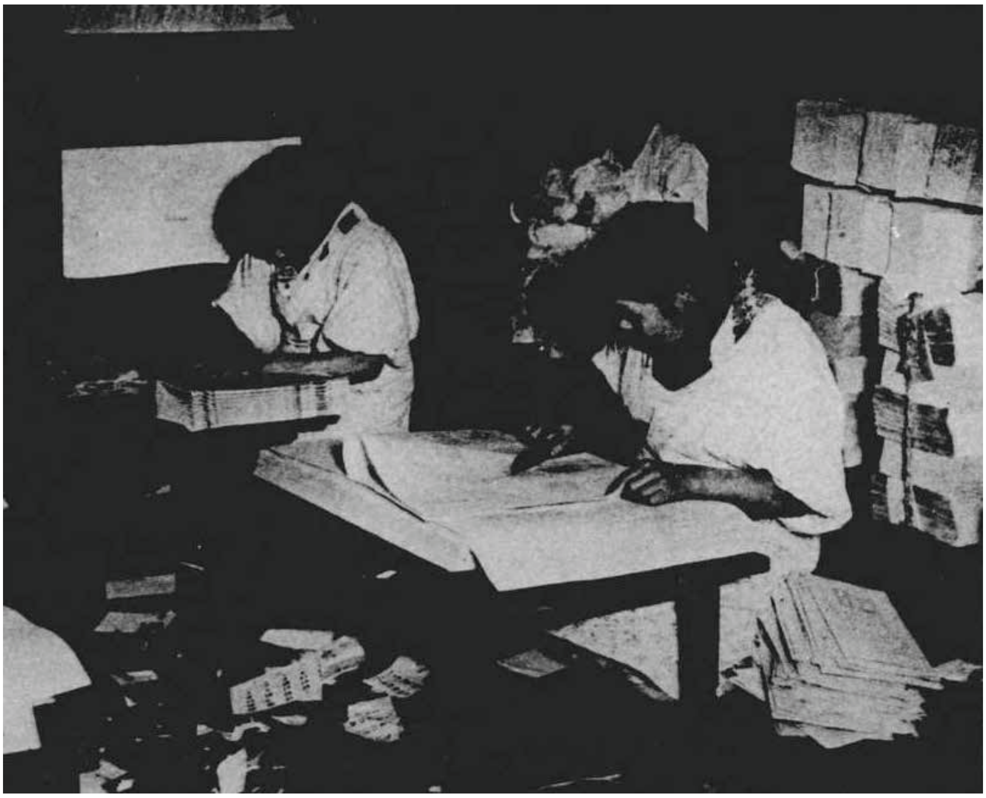

Figure A.1: Paper folding for bookbinding

Note: This photograph shows paper folding for bookbinding in the manual household industry in Tokyo city around 1930. *Source*: Institute of Social Work, Central Social Work Society 1936, p.6.

Appendix B Food expenditures and household characteristics

In the food section of the ARTIPH7, the household expenditure for whole foods was divided into only two categories; rice and side dishes. As previously described, the data on food prices was recorded by the researchers of the TIPH and then the food expenditures in each household were calculated based on the quantities of the foods used in the meals. Table A.2 sets out the relationship between the household head's occupation, income, household size, and food expenditures.

First of all, the expenditure for whole foods, rice, and other side dishes is 21.01, 13.92, and 7.09 yen, respectively. Thus, the proportion of expenditure on rice to total expenditure is 66.25% (13.92/21.01). This is consistent with the fact that, even in urban low-income households, white rice was commonly eaten as a principal food in early 20th century Japan (see Nakagawa 1985, p.374; Yazawa 2005, p.323). According to Nakagawa (1985, p.374), in 1897, the ratio of rice expenditure to total food expenditure among urban poor households was 69%. This value is similar to that in our estimation.

As for the classification by the head's occupation listed in panel (a) of the table, there seems to be no remarkable differences among household food expenditures with the exception of workers in commerce. Although the food expenditure per capita of employees in public sector and freelancer, and in other industries, were relatively low at 4.26 yen and 4.49 yen, respectively, that of the workers in manufacture and transport were also 4.67 yen and 4.64 yen. One clear disparity is that the food expenditure per capita of workers in commerce, the highest social class among these categories, recorded the highest value among occupations and is estimated to be 5.25 yen in total. While the per capita expenditure on rice in this class was 3.03 yen, the expenditure on other side dishes per capita was reported to be 2.22 yen, again the highest value among the categories of occupation. This implies that family members in commerce were more likely to be able to buy additional foods other than rice such as meat and vegetables.

One curious observation is that the food expenditure per capita of the unemployed was not so low and was estimated to be 4.49 yen. In fact, the average of the balance of the expenditure, *i.e.*, the total monthly income minus the expenditure for rent and foods, in the unemployed households was reported to be -1.63 yen (maximum and minimum are

−0.42 and −4.06, respectively) (Tokyo City Office 1931, pp.268–70 and the table named "Income and living condition"). This implies that the unemployed households might have had to borrow some money to ensure their supply of food.

Panel (b) in the same table shows the food expenditure by the quartiles of the monthly income per capita. In contrast with the classification by head's occupation, there seems to be a tendency in the variation in the food expenditures. Panel (c) in the table shows the clear negative correlation between household size and per capita food consumption. This remarkable reduction implies that food expenditure in low-income urban households at that time was highly dependent on the number of family members within the household rather than on the head's occupation.

Appendix C Predictive equations of BMR

In this study, the predicted BMR was estimated using the Ganpule equation proposed in Ganpule's recent experiment in the field of dietetics (Ganpule *et al.* 2007), which reveals that among several predictive equations, the predicted BMR for healthy Japanese individuals as per the Ganpule equation is accurate in terms of predictive losses in predicting BMR (Miyake *et al.* 2011). In this study, the predictive BMRs for men and women as per the Ganpule equation were given by

$$BMR_j^{\text{Male}} = \frac{1000 \times (0.0481\,Weight_j + 0.0234 Height_j - 0.0138 j - 0.4235)}{4.186} \tag{3}$$

$$BMR_j^{\text{Female}} = \frac{1000 \times (0.0481\,Weight_j + 0.0234 Height_j - 0.0138 j - 0.9708)}{4.186}. \tag{4}$$

where j indexes age from 0 to each of 24, 52, 57, 62, 67, 72, and 77; $Weight_j$ is the average weight of people aged j (in kilograms), and $Height_j$ is the average height of people aged j (in centimeters).

To calculate the predictive BMR, we used the average heights and weights of all students aged 6–24 in the public and private schools of Japan in 1930. Data on the average heights and weights of those students were drawn from a report issued by the Division of Physical Education, Minister's Secretariat, Ministry of Education (Division of Physical Education, Minister's Secretariat, Ministry of Education 1937). For infants aged 0–5, we compiled information on height and weight from a text that cites body measurements taken by the famous Japanese medical doctor Michiyoshi Mishima around the turn of the 19th century. Among his body measurements were those of 9,609 boys and 7,467 girls in 17 of 47 Japanese prefectures (see Mishima, 1902, p.1 and p.10). He reports that, of the subjects studied, the infants aged 0–2 were visitors to both the hospital of the Medical College at Tokyo Imperial University and to his hospital; a majority of the infants aged 3–5 were kindergarten pupils (Mishima 1902, pp.7–8). The numbers of infants and students aged 0, 1, 2, 3, 4, and 5 years were 141, 595, 499, 673, 1,228, and 1,650 (77, 315, 262, 420, 701, and 881 boys), respectively.

For people aged 50+, height and weight data were estimated by using the rate of reduction relative to people aged 20–49, as reported in a survey conducted by the Sanitary Bureau of the Home Department in Ehime Prefecture in 1920. The reduction rates of height for men aged 50–54, 55–59, 60–64, 65–69, 70–74, and 75–79 were 0.981, 0.973, 0.973, 0.967, 0.971, and 0.961, respectively, while those for women were 0.990, 0.986, 0.976, 0.978, 0.957, and 0.959, respectively. The reduction rates of weight for men aged 50–54, 55–59, 60–64, 65–69, 70–74, and 75–79 were 0.986, 0.929, 0.953, 0.894, 0.885, and 0.856, respectively, while those for women were 0.933, 0.936, 0.832, 0.890, 0.792, and 0.793, respectively (see Sanitary Bureau of the Home Department 1922, pp.38–54).

Survival diet was then calculated as 1.27 × BMR. This calculation relates to the fact that the energy required for additional essential activities over a 24-hour period was estimated to be 0.27 of BMR (Floud *et al.* 2011, p.43). Table A.3 shows the average heights, average weights, predicted BMR, and survival diets, by age and gender.

Appendix D Average daily calorie per equivalent adult

To calculate the average daily calories per equivalent adult, we first calculated the total BMR in each household, using the predicted BMR of each age and gender listed in Table A.3. The total BMR in each household was calculated by

$$Household\ BMR_i = \sum_{g=Male0\text{–}4}^{Female50\text{–}74} n_{ig} \times BMR_g \tag{5}$$

where i indexes the households from 1 to 182 [25] and g indexes age–gender groups, which were boys aged 0–4, boys aged 5–8, boys aged 9–12, boys aged 13–19, men aged 20–49, men aged 50–74, girls aged 0–4, girls aged 5–8, girls aged 9–12, girls aged 13–19, women aged 20–49, and women aged 50–74. n_{ig} is the number of family members in the age–gender group g in household i, and BMR_g is the average predicted BMR among age–gender group g, calculated using the predicted BMR. We then derived the daily calorie intake per equivalent adult in each household as

$$Calorie_i^{\text{Adult man}} = (Total\ Calorie\ Intakes_i / Household\ BMR_i) \times BMR_{Male20\text{–}49} \quad (6)$$

$$Calorie_i^{\text{Adult woman}} = (Total\ Calorie\ Intakes_i / Household\ BMR_i) \times BMR_{Female20\text{–}49}. \quad (7)$$

The first component on the right-hand side of each of the above equations ($Total\ Calorie\ Intakes_i$ $/Household\ BMR_i$) is the total calorie intake with respect to the total BMR in each household. This ratio can be considered the average PAL value among the sample households. Since the average value of this ratio was found to be approximately 1.54876, the people in the ARTIPH7 households might have engaged in "moderate" activity in terms of DRI–Japan (see Table 4). By using the daily calorie intake per equivalent adult in each household, we were able to calculate the average daily calorie per equivalent adult man and woman as follows

$$Calorie^{\text{Adult man}} = \frac{\sum_i (Calorie_i^{\text{Adult man}})}{N} \quad (8)$$

$$Calorie^{\text{Adult woman}} = \frac{\sum_i (Calorie_i^{Adult\ woman})}{N} \quad (9)$$

where N is the total number of households. The average daily calorie per equivalent adult man or woman was calculated in terms of the relative amount of actual calorie intake to BMR. Here, we assume that the ratios of the actual calorie intake to BMR were therefore the same between men and women. The average daily calorie value of an adult man and woman were calculated as 2117.9 and $1,694.6$ kcal, respectively

[25] Note that one household with missing values for family composition was excluded.

Appendix E Poverty headcount ratio

Data were obtained from a report based on the *Survey of Relief-Required People in Tokyo City*, which was conducted in June 1931 in preparation for the introduction of the Poor Relief Act (Tokyo City Office 1932b). In that report, "protection-required people" are defined as those from households whose monthly per-capita income was below approximately 6.14 yen (See Tokyo City Office, 1932b, legend). The poverty headcount ratio was calculated for each block based on the number of people who were eligible for relief under the Act. The survey identified the number of households eligible for relief under the Poor Relief Act (i.e., the number of households below the poverty line) as 5,961, comprising 26,257 individuals. For details on the poverty surveys conducted at that time, see Ogasawara and Kobayashi (2015). [26]

Appendix F Alcohol consumption

The monthly expenditure for alcohol in low-income households in the Fukagawa ward in November 1921 was reportedly 2.59 yen (Ministry of Home Affairs, Bureau of Social Affairs 1922, p.169), while the retail price of rice wine (*nihonshu*) in Tokyo city in 1921 was 2.546 yen per 1.8 liters (Tokyo Chamber of Commerce 1924, p.48). Therefore, we calculated the average daily calorie intake from alcohol at 62.9 kcal by using the energy conversion factor reported in Japan's Ministry of Education, Culture, Sports, Science and Technology database (http://fooddb.mext.go.jp/index.pl). We used the energy conversion factor for pure rice wine (*junmaishu*) here, *i.e.* 1.03 kcal/g, because this factor provides the minimum value among all factors for rice wines. Thus, we provide a more conservative estimate. Note that rice wine production was still dominant compared to other types of alcohol such as beer, wine, and distilled beverages in Japan in 1930 (Statistics Division of Ministry of Commerce and Industry 1931, pp.68–71).

[26] See also Nakagawa (1985) for details on surveys of low-income households that were conducted in interwar Tokyo.

Appendix G Estimation results for the control variables

Table A.5 and A.6 in Appendix A show the correlations between nutritional intakes and household's characteristics. As for the estimated coefficients of the control variables, a clear pattern can be observed. While household size does not have significant effects on food expenditure, calorie intake, and nutrient intake, the share of people aged under 12 and the share of older adults both tend to have significantly negative effects on those measures. The coefficients of ratio of males to females tend to have significantly positive effects in the case of food expenditures, calorie intake, and nutrient intake. [27] These results well capture both the fact that younger and older people do not need energy at the same level as that of young adults and that a man needs more energy than a women to maintain life. Regarding the head's occupation, the calorie intake and nutrient intake of the households in which the head worked in public sector were significantly lower than that of households whose head worked in manufacturing. This is consistent with the finding in Section 3 that employees in public facilities such as the ward office and schools might not have needed high energy to conduct their work. Regarding the income elasticity, we also conducted a simple linear regression and report the results in Table A.4 in Appendix A. Income elasticity of food expenditure and calorie intake were estimated as 0.229 and 0.135, respectively. The elasticity of calorie intake was slightly higher, but relatively similar to that of the value (*i.e.*, 0.183) obtained using five-year time-series data from 1878 to 1927 (Hayami and Yamada 1970, pp.82–3).

Table A.7 and A.8 in Appendix A show the correlations between health outcomes and household's characteristics. The estimated coefficients on a few control variables are statistically significant in the case of the infant mortality rate. While household size does not have significant effects, the estimated coefficients for the share of people aged under 19 and the share of older adults tend to be significantly negative. This implies that the higher proportion of dependents within the households might have resulted in the lower birth rate and thus, the risk of infant deaths could have been lower. [28] The other control

[27]We include the sex ratio to control for the differing energy requirements between genders. Note that we do not intend to capture the bargaining power of males or females in the allocations of intra-household resources here. See Horrell and Oxley (2013) for a detailed discussion of intra-household bargaining in the economic history literature.

[28]The households that had a low fertility rate would have a low infant mortality rate because they

variables are statistically insignificant in most cases.

References in appendices

[1] BARNUM, H. (1988). Interaction of infant mortality and fertility and the effectiveness of health and family planning programs. Policy Planning and Research Working Papers, Population Health and Nutrition, Population and Human Resource Development, The World Bank, WPS65.

[2] Division of Physical Education, Minister's Secretariat, Ministry of Education. (1937). *Gakuseiseito jidoshincho, taijyu, kyoi heikinruinenhikaku* [*Average Height, Weight, and Chest Girth of Students.*]. Tokyo.

[3] FLOUD, R., FOGEL, R. W., HARRIS, B., and HONG, S. C. (2011). *The Changing Body: Health, Nutrition, and Human Development in the Western World since 1700.* Cambridge: Cambridge University Press.

[4] GANPULE, A. A., TANAKA, S., ISHIKAWA-TAKATA, K., and TABATA, I. (2007). Interindividual variability in sleeping metabolic rate in Japanese subjects. *European Journal of Clinical Nutrition* **61**, pp. 1256–61.

[5] HAYAMI, Y. and YAMADA, S. (1970). Kogyoka no shihatsuki niokeru nogyo no seisansei [*Agricultural Productivity at the Beginning of Industrialisation*]. In K. SHIGETO and K. YUZURU (eds), *Nihonnogyo to keizaiseicho* [*Economic Development and Agriculture in Japan*]. Tokyo: The Nippon Agricultural Reserch Institute.

[6] HORRELL, S. and OXLEY, D. (2013). Bargaining for basics? Inferring decision making in nineteenth–century British households from expenditure, diet, stature, and death. *European Review of Economic Histoy* **17**, pp. 147–70.

[7] Institute of Social Work, Central Social Work Society. (1936). *Naishoku gaho – Tokyoshinai yohogosetai ni okeru* [*Pictorial of on–the–side job in protection–required people in Tokyo city*]. Tokyo.

[8] Ministry of Education, Culture, Sports, Science and Technology in Japan. (2010). *Food Composition Database*: http://fooddb.mext.go.jp/index.pl.

[9] Ministry of Home Affairs, Bureau of Social Affairs. (1922). *Saiminchosa tokeihyo* [*Statistical tables of the conditions of the poor in Tokyo*]. Tokyo.

[10] MISHIMA, M. (1902). *Nihon ken tai shoni no hatsuikuron* [*Theory of child growth in Japanese*]. Tokyo.

[11] MIYAKE, R., TANAKA, S., OHKAWARA, K., ISHIKAWA-TANAKA, K., HIKIHARA, Y., TAGURI, E., KAYASHITA, J., and TABATA, I. (2011). Validity of Predictive Equations for Basal Metabolic Rate in Japanese Adults. *Journal of Nutritional Science and Vitaminology* **57**, pp. 224–32.

[12] NAKAGAWA, K. (1985). *Nihonno toshikaso* [*A City Lower Layer of Japan*]. Tokyo: Keiso Syobo.

[13] OGASAWARA, K. and KOBAYASHI, G. (2015). The impact of social workers on infant mortality in inter-war Tokyo: Bayesian dynamic panel quantile regression with endogenous variables. *Cliometrica* **9**, pp. 97–130.

attempted to reduce the childrearing expense per child (Barnum 1988).

[14] Sanitary Bureau of the Home Department. (1922). *Noson hokeneiseijyotai jitchichosahokoku* [*Report of Survey of the Condition of Sanitation in Farming Village*]. Tokyo.

[15] Statistics Bureau of the Cabinet. (1933). *Kokusei chose hokoku, fukenhen Tokyo-fu* [*1930 Population census of Japan, Tokyo prefecture*]. Tokyo.

[16] Statistics Division of Ministry of Commerce and Industry. (1931). *Shokosho tokeihyo* [*The Department of commerce and Industry statistics table*]. Tokyo.

[17] Tokyo Chamber of Commerce. (1924). *Tokyo shogyokaigisho tokeinenpo* [*The annual statistical report, 1923 edition*]. Tokyo.

[18] Tokyo City Office. (1931). *Tokyoshi eiseishikensho hokoku* [*Annual Report of Tokyo Institute of Public Health, vol.7*]. Tokyo.

[19] Tokyo City Office. (1932b). *Tokyoshi yokyugosha nikansuru chosa* [*Survey of Relief-Required People in Tokyo City*]. Tokyo.

[20] YAZAWA, H. (2005). *Kindainihonno shotokubunputo kazokukeizai* [*Income Distribution and Family Economy in Prewar Japan*]. Tokyo: Nihon Tosho Center.