Nutrition, crowding and disease among low-income households in Tokyo in 1930

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Abstract

This paper employs a household survey of low-income working-class households conducted in Tokyo in 1930 to investigate nutritional attainment levels and the relationship between calorie intake and morbidity. We find that the daily calorie intake was 2,118 kcal per adult male equivalent, high enough to satisfy the energy requirements for moderate physical activity. Richer households purchased more expensive calories mainly by substituting meat and vegetables for rice. We find negative associations between morbidity and income and crowding, but no significant associations for nutrition, tentatively suggesting that income and crowding were more important for morbidity in 1930 Tokyo than nutrition.

Keywords: Nutrition; Morbidity; Disease; Health

JEL Codes: I14; N35

INTRODUCTION

There has been growing scholarly interest in recent years in the development of living standards in Japan before World War II. Building on the seminal work of Saito (1989) which analyzed the relationship between mortality decline and economic development, many studies have sought to understand how living standards evolved in pre-war Japan. Saito has done further work on the determinants of children's growth and adult stature (Saito 2003; 2004). Bassino (2006) analyzed health and income inequality across prefectures in Japan. Schneider and Ogasawara (2018) studied the relationship between child morbidity and children's growth. Tang (2017), Ogasawara and Matsushita (2018) and Ogasawara *et al.* (2018) have studied the effects of transport and clean water infrastructure on mortality. In addition, Saito (2005) and Bassino *et al.* (2010) studied prefectural inequality in wages and GDP.

This growing body of literature is extremely welcome, but nutrition levels of Japanese households before World War II have not been widely studied. This is important for two reasons. First, there is an absence of analysis of survey evidence on nutrition in the literature on the biological standard of living in Japan during the interwar period, and it remains an open question whether diets were sufficient to sustain the physical activity required for industrial work. Secondly, the escape from what Fogel (2004) described as the misery of chronic malnutrition is crucial for understanding the secular decline of mortality during the twentieth century. A similar view had been advanced by McKeown (1955) almost thirty years earlier, having rejected other possible explanations. Later McKeown (1976) would extend his analysis to the relationship between the incidence of infectious disease and nutrition. The study of food consumption and nutrition in pre-Second World War Japan makes an important contribution to this field of study that has been dominated by studies of relatively rich Western countries and Asian countries since the Second World War.

Previous studies that have investigated food consumption levels in Tokyo during the interwar period have mainly utilized food supply data to estimate energy availability per capita per day. For instance, Nakayama reported that between 1931 and 1935 the national average daily calorie intake per capita, defined as the total amount of food supply in calories divided by the total population, was about 2,192 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).[1] These studies focused on the long-term transition in the average calorie intake in Japan. Taking the results together, a figure of around 2,200 to 2,300 kcal per capita per day would seem a reasonable estimate of daily per capita energy availability in the early 1930s from food supply data.

In contrast, for low-income households in Tokyo in 1932, Yazawa (2005) estimates energy availability at just over 1600 kcal per capita per day from *aggregate* household survey data; significantly less than the average estimates for all households in Tokyo and suggesting quite a steep income gradient for food energy availability. This brings into question whether low-income households in Japan were capable of sustaining intense industrial work at the beginning of the 1930s, a decade or so before the onset of the Pacific war. Yazawa (2005) does not relate energy availability estimates to the likely energy requirement of low-income households, as has been done for European and North American households at various phases of industrialization. Indeed, currently, there are no studies for prewar Japan that relate energy availability to physiological requirements prior to the Second World War, despite good data being available on physical stature. We are able to do so by exploiting a rich new dataset extracted from an investigation of low-income working-class households in Tokyo in 1930, carried out by *Tokyo Eiseishikensho* (the Tokyo Institute of Public Health - TIPH). This relatively small-scale, sophisticated nutritional and health survey recorded the quantities of nutrients, including carbohydrates, protein, and fat, consumed by each household, along with details of occupation, household income, and living space. Uniquely, this survey also included a health survey which documented the number of household members suffering from diseases in ten categories.

In this article, we attempt to address the following two questions: did the diets of urban households in interwar Japan provide the energy required to sustain the physical activity associated with industrial production; and what was the relationship between macronutrient availability and living space and the risk of infection from different diseases? Our key findings are as follows. First, we estimate the daily calories per adult male equivalent at about 2,118 kcal. Given their likely stature, these estimates imply that the average calorie intake per equivalent adult in urban working-class households exceeded the calories required for the average physical activity levels of the workers in

[1] 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 stature in prewar Japan.

these households. These are the first modern estimates of the daily calorie intake in a working-class urban household in Japan using a household-level dataset. Our analysis supports Nakagawa's finding that the lower classes were able to maintain their households above subsistence by the beginning of the 1920s (Nakagawa 1985, p.399). From a comparative perspective, our estimate implies that urban working-class households in Japan may have escaped from hunger in the early 20th century, at least by 1930.

Second, we find no significant relationship between energy (or macro-nutrient) availability and the prevalence of a range of (mainly infectious) diseases, despite estimating that the income elasticity of calorie intake from animal foods is significantly positive, with better off households more likely to buy fish and/or meat instead of other types of food. Our insignificant result with respect to the relationship between nutrition and disease is an important one, though it should be taken cautiously given that morbidity was only measured on one day and the incidence of classic diseases of food poverty, such as rickets and pellagra are not recorded in our dataset.

Third, and in contrast, we do find significant negative relationships between all cause disease morbidity and income and crowding. It is not surprising, perhaps, that we find a significant relationship between crowding and infectious disease, given that proximity is the most important factor in transmission for many respiratory, skin, and eye diseases, though we also find that this effect is dominated by income. The income effect may have worked through richer households sorting into healthier rental properties with amenities like running water or into cleaner, healthier neighborhoods. Extra income could also have been used to purchase hygiene products like soap or other health investments that might prevent disease morbidity. For instance, working-class people tended to bathe in public baths around the city, paying fees for each bath, so richer households may have bathed more often (Kawabata 2016, pp. 239-45, 256-59). These results add to the debate on the contribution of nutrition, sanitation, medical innovations, and income to improvements in health during the health transition (for example, McKeown 1976, 1979; Fogel 1994, 2004; Floud *et al.* 2011). Most importantly, we show that income cannot be taken as perfect proxy for nutrition as McKeown assumed and that there is potential for expenditure on hygiene and sorting within neighborhoods to influence disease prevalence at the household level.

This paper is organized as follows. The next section 'Data and the sample characteristics' introduces the data used in the analysis and describes the characteristics of our sample households. The section 'Nutritional intake in urban working-class households in 1930' examines the calorie and nutrient intake of low-income working-class households in Tokyo in 1930. 'Household characteristics, nutritional intake and health status' analyses the relationship between crowding, the nutritional intake and health outcomes within those households. The final section offers concluding remarks.

DATA AND THE SAMPLE CHARACTERISTICS

Description of the sample

In the early twentieth century, various Japanese government agencies and research organizations frequently conducted household surveys, generating a vast number of survey reports on the state of the Japanese poor. Unfortunately, groups conducting surveys generally discarded the household-level survey information after compiling the summary statistics from the survey. We make use of a survey report, which represents an exception to this general observation, where household-level data has survived. Two other studies have analysed household-level survey information. James and Suto (2011) used household budget data for urban working-class households in early-twentieth-century Japan to investigate the relationship between their transitory income and savings. In addition, a recent study by Ogasawara (2018) investigates the relationship between parental illness and child schooling by using individual-level information on working-class households in Tokyo in the early 1920s. However, the survey reports used in both studies do not include combined information on nutritional intake, crowding, and health outcomes that we analyse in this study.

The records used in this paper are drawn from an official report issued by the Tokyo Institute of Public Health (TIPH) in 1930. Fourteen TIPH researchers conducted the survey entitled *Nutrition Survey in a Poor District of Tokyo City* (NSPD), which is a survey of 300 households located in the 19th to 40th blocks of *Hakusan Goten-cho* (Hakusan Goten town) in the Koishikawa ward in the northwestern part of Tokyo city. The survey was conducted between January and March 1930.[2] The main purpose of the NSPD was to generate evidence that could be used in planning relief for poor households (Tokyo City Office 1931, p.227). This was a highly scientific nutritional and health survey. The researchers not only conducted interviews to collect information on household

[2] Since the survey was conducted in the winter season, expenditures for heating might have been higher than in other seasons.

characteristics, income and expenditure, but also recorded and measured the actual amount of foodstuffs consumed, their prices and the composition of the meals that were eaten. For their investigation of health outcomes, the researchers visited each household once and investigated the health conditions of all family members present in the household. The home visits were conducted even at night, on Sundays, and during holiday periods in order to attempt to capture as many household members as possible (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, and certainly more accurate than nutritional data derived from household expenditure enquiries where only expenditures are recorded and quantity data has to be derived by deflating these by prices.

The NSPD originally surveyed 300 households. However, only 265 households (1,018 people) were included in the health survey, and among those, 183 households (813 people, of whom 423 were males) were then investigated more thoroughly for the nutrition survey. The household-level results of the survey for the 183 households in the nutrition survey (61% of the survey objective sample) were published in 1932 in the *Annual Report of Tokyo Institute of Public Health, vol.7*. We will refer to this set of households as the NSPD subsample. The report included data on nutrition, health status, family composition, living space, monthly income, and monthly expenditures for each household. We therefore use the subsample to analyze the relationship between household characteristics, nutrition and the extent of crowding, and health outcomes.

Calculating nutritional values for households

As mentioned above, the NSPD researchers took great care in collecting information about the food consumption of the households. To accomplish this, 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 recorded for each household. From their observation of the diets of survey households, the researchers produced lists of dishes whose nutrients were considered to change in different parts of Tokyo. These dishes included *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). They then analyzed the nutritional composition of the dishes in the laboratory and computed the amount of carbohydrates, protein, fat, and calories. The report noted that it took 6 months to analyze over 100 dishes in total (Tokyo City Office 1931, pp. 229-30).

The NSPD researchers did not record household alcohol consumption, which is unfortunate given that energy from alcohol can be important for calorie intake calculations (Gazeley and Newell, 2015). Shinohara used supply-side methods to estimate alcohol consumption in prewar Japan, but it is difficult to find precise calorie figures from his data (Shinohara 1967, pp. 208-213).[3] To get an understanding of how much this might affect the nutritional intake, we have estimated the average daily calorie intake from alcohol for low-income households from other surveys in the 1920s. This yields an estimate of approximately 63 kcal per household. We do not take this additional energy into account throughout this paper because on a per capita basis, the difference in calorie availability is very small, but the daily calorie intake per household might have been roughly 60 kcal higher if we were to account for alcohol consumption.[4]

Food expenditure outside the home is also important in calculating energy intake, but is unlikely to be a major problem for our study. All food other than rice is included in 'side dishes' in the NSPD subsample. Almost all poor households in Tokyo had their own kitchen at home even in the 1910s (Nakagawa 1985, pp. 52-3), and there was limited

[3] In 1930, Shinohara estimated the value of alcohol consumption including *sake*, *shochu*, beer, and other liquors to be 913,000, 73,216, 73,433, and 23,758 thousand yen, respectively (Shinohara 1967, pp. 208-213). Dividing this figure by the total number of people in 1930 (from Population Census of 1930, p.2) suggests that the national average alcohol consumption was 17 yen per capita-year in raw. This means that the national average alcohol consumption was 1.4 yen per capita-month. Since the average total income was 55.90 yen per month and the average household size was 4.44 (Table 1), this implies that the share of alcohol was approximately 11.1% of household income. This was a large amount of expenditure considering that food expenditure was 37.6% of household income. This suggests that alcohol, which would have mainly been consumed by adult males, may have crowded out expenditure on food and other requirements for women and children. However, this expenditure should be taken with some caution given that we are applying aggregate data to households. Alcohol consumption would likely have been concentrated in wealthier households in urban areas, and alcohol consumption is notably skewed with, for instance, the top decile of drinkers consuming more than half of all alcohol consumed in the United States today (Cook 2007). Thus, it is not straightforward to understand how alcohol expenditure affected the households in our sample and more research using household budget surveys that include alcohol consumption and expenditure is needed to tease out these effects.

[4] Please see Appendix F for the details of the calculation of the average daily calorie intake from alcohol.

variety in the diets of low-income urban households. Consumption of food outside the household was very rare for working-class households in Tokyo. For example, an official survey of working-class households in 1921 (497 households in Tokyo city; average income = 72.26 yen per month; average expenditure = 63.74 yen) showed that only 2.2% of total food expenditure was spent for food delivery and eating in restaurants (Bureau of Social Affairs 1923, pp.70-71).[5] Another survey of 393 working- to middle- class households by the Tokyo City Office from September 1926 to August 1927 showed that richer families spent a larger share of their budget on food delivery and eating in restaurants, but still the share of outside food in the budget was very low. Households with monthly income below 60 yen spent only 2.8% of total food expenditure on outside food while households with monthly income from 100 to 120 yen spent 4.9% (Tokyo City Office 1928, pp.64-65). Therefore, we assume that the low-income households in our study had very few meals outside the home and that this does not bias our results.

Unlike other historical household budget surveys, the food section of the NSPD subsample report documents the consumption of the macronutrients, carbohydrates, fats, and proteins, in grams for each household rather than reporting the weight of products purchased. These nutrients are divided into several categories such as principal foods, animal food products, and vegetable food products. We take the reported macronutrient figures to be reliable and do not make any adjustments for spoilage or wastage as in other studies of historical nutrition (Gazeley and Newell 2013; 2015) for several reasons. First, as described in the previous section, the quantities of foods were measured before calculating household food expenditure (Tokyo City Office 1931, p. 229). In addition, the careful attention to measurement and frequent visits of NSPD researchers to the households ensured that they were capturing the food items that were actually consumed net of spoilage or wastage. Second, the meals consumed by the households were extremely frugal making it easy to keep track of the ingredients and measure them precisely. For instance, the report provides the following representative meals as an example of what these households were consuming:

Example Household A
One day
Breakfast: *Daikon oroshi* (Grated white radish), *Uzura mame* (Pinto beans)
Lunch: *Daikon oroshi* (Grated white radish)

[5] Although the average income in these households was much higher than that in the NSPD sample (72.3 vs 55.9 yen), deflated values are in a similar range (Ohkawa *et.al.* 1967, pp.135-136).

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)

Example Household B
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).

Clearly, the menus in these households lacked variety and 'there were even households which had the same menu over several days' (Tokyo City Office 1931, p. 232). Most of the meals were made from a few ingredients such as white radishes (*daikon*), beans, *udon* noodles, potherb mustard, leeks, or sardines. This simplicity means that the investigation of the recipes and the measurement of the foods were relatively easy.

Based on the diets recorded, the NSPD researchers then reported the total grams of carbohydrates, protein, and fats consumed by the household. We convert these figures into calories using the well-known McCance & Widdowson conversion factors which hold the heat-of-combustion value for carbohydrates, protein, and fat to be 3.75, 4, and 9 kcal per gram, respectively (Finglas *et al*. 2015, p. 9).[6]

Representativeness of the sample

As argued above, the NSPD subsample data are unique in that they provide individual-

[6] The NSPD researchers used slightly higher conversion factors to convert the macronutrients to calories, but we thought it was most appropriate to use the standard values used in the literature.

level data on working-class households in Tokyo. However, given the specialized nature of the sample, it is important to understand the extent to which the sample is representative of Tokyo as a whole and poor people within Tokyo more generally. Figure 1a shows the geographical location of Hakusan Goten town in the northwestern part of Tokyo. Figure 1b shows the poverty headcount ratio defined as the percentage of people under the poverty line in each block of the city.[7] The poverty headcount ratio for Hakusan Goten town was 5.29%, which exceeded the 95th percentile (*i.e.*, 3.38%) of the ratio in all of Tokyo. However, this does not straightforwardly imply that our sample of households were among the poorest households in Tokyo.

<<<Insert Figure 1a & 1b about here>>>>>

We can get a better sense of how representative the sampled households were by comparing household size and monthly income and expenditure to other household budget surveys of the period. We are able to compare the NSPD subsample with two other contemporaneous household budget surveys conducted by local government agencies seeking to explore the conditions of the poor in the city. The first survey is the *Survey of Protection-Required People in Tokyo City* (SPRP), which was conducted by Tokyo City in March 1929 and investigated 20,601 low-income households (83,216 people) in all 15 wards of Tokyo. In this survey, the local government defined protection-required people as households whose monthly income per capita was below 14.2 yen (see Tokyo City Office 1932c, legend). The second survey, the *Survey of Relief-Required People in Tokyo City* (SRRP) was a similarly comprehensive survey of the poorer relief-required people conducted in November 1929 and March 1930, which investigated 30,204 (124,035 people) across Tokyo. In this survey, the local government defined relief-required people as households whose monthly income per capita was less than 6.1 yen, providing a sample of poorer households than the SPRP (see Tokyo City Office 1932c, legend).

<<Insert Table 1 about here>>>

Family size was slightly larger in the NSPD subsample at 4.44 people (see Table 1) than in the SPRP survey (4.04) or the SRRP (4.11). Average monthly income and expenditure was only reported for 110 of the 183 households in the NSPD subsample,[8]

[7] Please see Appendix E for the details of the calculation of the poverty headcount ratio.
[8] Differences in the household characteristics between those 110 households and the other 73 households

but for those households the average monthly income per capita was 13.7 yen, substantially higher than the average monthly income per capita in the SPRP (11.8 yen) and in the SRRP as well (4.1 yen). Thus, the households in the NSPD subsample were not as poorly off as the average protection-required person, but the mean household income in the NSPD subsample was still below the threshold used by the local government for defining protection-required status in the SPRP. However, the NSPD subsample households had income more than three times higher than the average relief-required household. This suggests that these households were low-income households but were not as destitute as some of the poorest, relief-required households in Tokyo.

With regard to expenditure, NSPD subsample households spent on average 21.01 yen on food expenditure each month (see Table 1). Unfortunately, the survey does not report expenditure on all items, so it is not possible to calculate the food expenditure share in total expenditure. However, if we calculate the food expenditure share of total income, this can give us a figure that we can compare roughly with other surveys. On average, NSPD subsample households spent about 38% of their monthly income of food. This food expenditure share of income might be considered low compared to other historical working-class populations (Gazeley and Newell 2013; 2015) and compared to Japanese estimates by Nakagawa (1985, pp. 393, 398). Nakagawa found food expenditure shares of total expenditure of 56% for poor urban households in 1930, whereas the share among factory workers in 1932 was 35%. Taken together, the income and expenditure evidence suggests that the NSPD subsample were better off than average 'protection-required' households, but were substantially poorer than typical factory workers at the time. Thus, we should regard the NSPD subsample as low-income households but not as poor households, *i.e.*, they would not have been regarded as households requiring relief in Tokyo around 1930.

<<<Insert Table 2 about here>>>

Finally, to confirm this point, we compare the occupational composition of the NSPD subsample with the 3rd National Population Census and the SPRP to understand what types of households are over- or under-represented in our sample. Table 2 shows the shares of different household heads' occupations in the NSPD subsample, the SPRP, and the census. We also have data from the SPRP and census for Koishikawa ward, which

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for which no information on income or expenditures were recorded were not statistically significant at conventional levels (see Table A.1 in Appendix A).

contained Hakusan Goten town where the NSPD survey was conducted. 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).

Looking at our sample, most household heads (59.8%) worked in the manufacturing sector with smaller shares working in commerce (16.7%), transport (4.9%), public sector/freelancer (2.0%), and other industry (16.7%). Comparing our sample first with the occupational structure of Koishikawa ward, the share of household heads working in the manufacturing sector in the NSPD subsample was higher than both the SPRP survey of poor households (47.6%) and the census (39.3%), suggesting that manufacturing workers are over-represented in our sample. The share employed in commerce was higher than that for poor households in the SPRP (11.0%) but substantially lower than for Koishikawa ward as a whole (36.4%). Public sector and freelancer jobs were under-represented in the NSPD subsample with much larger shares in the SPRP (12.3%) and census (16.5%). Public sector occupations included employees in public facilities, such as ward offices and schools, who tended to be a lower-income group. In fact, Table 1 shows that the average monthly household income per capita was lowest for this group at 10.83 yen. Finally, other industries were largely over-represented relative to the census (0.61%) and a slightly smaller share than the poor households in the SPRP. Other industries included low-income occupations such as day laborers and cleaners. Thus, the NSPD subsample households can be seen as better off than the poorest households in the SPRP since there were more manufacturing and commercial workers and fewer public sector workers, but worse off than the general population of Koishikawa ward. This again confirms that the NSPD subsample households were low income, but not necessarily among the poorest of Koishikawa ward.

It is also important to consider the extent to which Koishikawa ward was representative of Tokyo as a whole. Overall, the differences between Koishikawa ward and Tokyo were relatively small, although there is evidence 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). Looking at the census (Table 2), low-income public sector jobs were more common in Koishikawa whereas middle-income commercial jobs were less common. Comparing poor SPRP households in Koishikawa ward with their counterparts for all of Tokyo city suggests that manufacturing and public sector employment were more common among the poor of Koishikawa ward than the city as a whole.

In conclusion, the NSPD subsample households represent low-income though not necessarily very poor households from a relatively poor part of Tokyo. However, the rich household-level data available in the survey yields unique insights into household behavior that the larger surveys mentioned above cannot provide given that they are solely available in aggregate form.

NUTRITIONAL INTAKE IN URBAN WORKING-CLASS HOUSEHOLDS IN 1930

Excess or deficiency of the calorie intake

Having described the NSPD subsample in detail, we now discuss what the survey reveals about the nutrition of low-income Japanese households in 1930. Table 3 shows that the mean daily calorie intake per capita of our sample was 1,572 kcal per day. This estimate is consistent with Yazawa (2005, p. 326)'s estimate of 1,624 kcal per capita per day for low-income households in Tokyo in 1932. However, our estimate is considerably lower than the national estimates of average calorie intake calculated using supply-side methods, discussed in the introduction. If we assume from these earlier studies that national calorie estimates are around 2,200 - 2,300 kcal per capita per day, then clearly nutritional availability was much lower among our urban, low-income, working-class households.

<<<<Insert Table 3 about here>>

However, the disparity between these estimates should not raise questions about the reliability of our analysis for several reasons. First, as already mentioned, these estimates are consistent with other estimates for lower-income households in Tokyo (Yazawa 2005, p. 326). Second, in the early twentieth-century British case, there are similar substantial differences in average energy consumption estimates per capita derived from supply-side data compared with household survey evidence (Oddy 1976, pp. 214-31). This discrepancy is due to a number of factors. Supply-side estimates of calorie consumption have to make fairly strong assumptions about spoilage and wastage in storing, transporting, and processing foods, which are rarely supported by contemporary historical evidence (Meredith and Oxley 2014, pp. 179-80). For instance, Floud *et al.* (2011, pp. 154-55) apply spoilage rates estimated by economic historians from the first half of the nineteenth century in the United States to Britain from 1700 to 1900. In addition, Schneider (2013a) highlights how changes in the diet as food became more heavily processed could influence aggregate calorie availability estimates. Finally, the national estimates reflect national food production but cannot address how food is distributed in the population. Rural and richer households likely consumed many more calories than the low-income working-class households in the NSPD's sample. In any case, these national estimates should be considered as guesstimates with substantial error surrounding them (Kelly and Ó Gráda 2013).

In addition, these estimates are low because they treat all household members equally when the actual consumption of children and adults varied considerably (Floud *et al.* 2011; Schneider 2013b). To address this issue, we have used our knowledge of the age group and sex of each household member to convert household size into adult male equivalents by computing the basal metabolic rate (BMR) of each household member. The BMR is the amount of calories needed to maintain body temperature and sustain the functioning of the heart, liver, brain, and other vital organs while resting for 24 hours (Floud *et al*. 2011, p. 43). BMRs are related to the heights, weights, ages, and sex of individuals. We compute BMRs for our sample subjects by inputting data on height and weight by age and sex in Japan in 1930 into modern BMR equations constructed by Ganpule *et al.* (2007), which are held to be the most reliable BMR equations for Japanese people (Miyake *et al.* 2011). For example, in our study we hold the mean BMR for adult men aged 20 to 49 years to be 1,368 kcal per day assuming a mean height of 163.1 cm and a mean weight of 54.8 kg. For women aged 20 to 49 years we estimate a mean BMR of 1,094 kcal per day, assuming mean height and weight for women in that age group were 150.5 cm and 48.5 kg respectively. More detailed explanations of the BMR equations and our estimated BMR levels for each age group and sex are provided in Appendices B and C in the supplementary materials.

It is important to note that Japanese BMRs in the early twentieth century would likely be some of the lowest in the world since at the start of the twentieth century Japanese men and women were ranked 187th and 195th respectively for mean height out of 200 countries included in a recent global survey (NCDRisc 2016). The weights of Japanese men and women would also likely have been very low compared to other countries. For instance, if we compare the Japanese men in our sample to British men in 1905-9, around the time of the 1904 household budget survey studied by Gazeley and Newell (2015), British men joining the army aged over 25 were on average 168.9 cm tall and weighed 63.5 kg (Floud *et al.* 2011, p. 144). Using Ganpule *et al.*'s (2007) equation to compute a BMR for this group, the BMR of British men was 1,474 kcal per day, 7.8% higher than the Japanese BMR. Thus, the relatively small size of Japanese people in the early twentieth century means that the nutritional requirements of Japanese people may have been lower than those for other populations in similar historical periods.

To produce adult male equivalents, we sum the BMRs for all household members and divide by the BMR of males aged 20 to 49, 1,368 kcal per day. The mean household consumption accounting for the different consumption needs of family members was substantially higher than the per capita value at 2,118 kcal per adult male equivalent per day.

In order to understand whether this 2,118 kcal per adult male equivalent per day was sufficient to meet the nutritional needs of working-class households, we need to relate the calories available to the caloric needs of each household based on their workload. We can establish this by calculating physical activity levels (PAL) for each household by dividing the total calories consumed by the total BMR of the household. PAL levels account for the average dietary energy intake necessary to maintain energy balance in healthy adults of a given age, gender, weight, and height (Miyake *et al*. 2011, p.224) and are reported as multiples of the BMR.

We then compare the computed PAL values for each household with reference values based on modern surveys of the energy required to carry out certain tasks. For instance, the typical person needs a PAL of 1.27, 1.27 times the BMR, just to eat and digest food and maintain essential hygiene (Floud *et al*. 2011, p. 43). In addition to this basic survival diet, we use four PAL levels following the Dietary Reference Intake (DRI) of Japan (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). Light activity implies 12 hours of rest, 11 hours of standing and one hour of walking per day. Moderate activity implies slightly less time spent on rest and standing and five hours of walking per day. Light heavy activity involves slightly less rest and standing time again with six hours of walking and one hour of vigorous exercise. Finally, heavy activity involves similar rest and standing time to light heavy activity with five hours of walking, one hour of vigorous exercise and one hour of hard exercise such as lifting heavy objects (Ministry of Health, Labour and Welfare, Japan 1999).[9] The amount of energy required to sustain each

[9] 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

category of activity is simply the PAL times the BMR; this is known was the estimated energy requirement (EER).

Given the occupational distribution of household heads in our sample, most workers likely had PAL levels around 1.5 in the 'moderate' category. Manufacturing workers tended to carry out tasks such as folding papers for bookbinding, making Japanese sandals (*zori*), and sewing. 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.*, cross-legged (*agura*) or kneeling (*seiza*) (see Tokyo City Social Welfare Bureau 1937).[10] Therefore these workers' physical activity levels were similar to the moderate category described above. By contrast, some manual laborers such as carpenters and steeplejacks had much higher energy requirements either in line with or exceeding the heavy activity PAL value of 1.9 (*e.g.*, Tokyo City Study Group of Occupation Guidance 1931, pp. 399-402). Child labor was relatively rare in Japan, which suggests that children may not have had as high of nutritional requirements as in countries and periods where child labor was more prominent (Saito 1995, 1996).

<<<Insert Table 4 about here>>>

Table 4 presents the EER per adult male equivalent and PAL values across the distribution of households. As mentioned above, the mean EER was 2,118 kcal per adult male equivalent per day. This represents a PAL level of 1.55, suggesting that the average worker likely did have enough energy to carry out the moderate physical activity described above. However, there was substantial variation around the mean with households at the 25th percentile at a PAL level of 1.38 and households at the 75th percentile at a PAL level of 1.73. Figure 2 shows the full distribution of PALs by household. Thus, households at the lower end of the PAL distribution may have struggled to meet the energy requirements of workers in the household. This was especially true of

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).

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

a small minority of households whose consumption fell below the survival PAL of 1.27. However, we should note that the PAL for each household is the average PAL of all household members, so household members working in less labor-intensive jobs could have reduced their consumption to allow those with more physically intense jobs to consume more calories (Schneider 2014). Thus, the NSPD subsample households generally had enough energy to perform the work tasks that were required of them, but certainly some households would have struggled to maintain their health at such low levels of consumption.

<<<<Insert Figure 2 about here>>>>

Nutritional attainments and household characteristics

In addition to looking at household calorie consumption as a whole, we can also investigate how household characteristics influenced nutritional intake. Table 5 shows mean nutrition levels by household head's occupation, income per capita, and household size. Looking first by household head's occupation, the differences in calorie intake per adult male equivalent between most groups were relatively small. Public sector workers had the lowest calorie intake of 1,824 kcal per adult male equivalent; manufacturing, commerce transport and unemployed households clustered between 2,000 and 2,100kcal per adult male equivalent; and workers in other industries had the highest calorie intakes at 2,167 kcal per adult male equivalent. Looking at their associated PAL levels, most occupations had PALs around 1.5 with only public sector workers with a PAL of 1.33 substantially below 1.5. This suggests that most of these households could support moderate physical activity or possible light heavy activity if resources were allocated unequally in the household. As for macronutrient differences across the groups, it appears that the lower calorie intakes for public sector workers were not caused by reductions in the amount of fat consumed or by reductions in protein, though their protein consumption was somewhat lower. Instead, the main difference was the consumption of carbohydrates, likely from rice. Occupations that required higher levels of physical activity like manufacturing, transport, and other industry tended to get more of their calories from carbohydrates relative to other macronutrients. There did not appear to be large differences in the share of protein from animal sources across occupational groups either.

<<,Insert Table 5 about here>>>

Turning to mean consumption by income quartile, calorie intake per adult male equivalent increased somewhat with income, but the increase was relatively small and not monotonic across income quartiles. Households in the highest income quartile only consumed 94 kcal per adult male equivalent per day more than the lowest income quartile. It is true that part of this difference may be explained by increased consumption of food outside the home in the upper quartile. However, as we suggested above, this consumption was low and although it increased with income, it is unlikely to add much to the upper quartile. However, there is evidence that higher income families in the sample tended to eat more fats per adult male equivalent. They also consumed slightly more protein, and the share of protein consumed from animal sources increased sharply with income.

Finally, looking at consumption differences by family size quartile, calorie intakes per adult male equivalent decreased as family size increased with households in the lower quartile consuming 76 more kcal per adult male equivalent per day than households in the highest family size quartile. Larger families tended to consume slightly more carbohydrates but much less fats and slightly less protein. In addition, larger families had much lower shares of protein derived from animal sources.

Table 5 also provides a measure of crowding within a household based on the number of tatami that would fit into the living space. Tatami are a type of mat that had a uniform size and were used to cover flooring in Japan. Tatami varied in size across Japan, but in Tokyo they tended to be 0.88 meters by 1.76 meters or 1.55 square meters. Table 5 shows that the differences in tatami per capita were relatively small across different occupational groups. However, tatami per capita increased substantially with income and decreased sharply as household size increased. We will use crowding proxied by tatami per capita in analyzing the health outcomes of households later in the paper.

Overall, consumption differences across households were rather small with only fats and the share of protein from animal sources changing dramatically across occupational groups, income, or family size. This suggests that within the low-income, urban, working-class population surveyed, there may have been a large degree of homogeneity among households. The average daily calorie intake per adult male equivalent in the NSPD subsample households was higher than the survival diet and was substantial enough for most households to meet their nutritional requirements. However, some households would have struggled to provide enough energy for household members to maintain their health.

HOUSEHOLD CHARACTERISTICS, NUTRITIONAL INTAKE, AND HEALTH STATUS

To illustrate the relationship between household characteristics and nutritional intake more precisely, we conduct regressions to understand how income affected household nutrition as well as how a household's consumption influenced their health outcomes more generally. These regressions are meant to simply highlight associations in the data rather than provide evidence for a causal effect of income on nutrition, or nutrition on other health outcomes.

Income elasticities and food quality

We begin by trying to understand how income influenced expenditure on food, calories purchased, and the cost of food per calorie. We estimate an OLS regression as follows:

$$\ln(Food_i) = \alpha + \delta \ln(Income_i) + \varepsilon_i \quad (1)$$

where $\ln(Food_i)$ is the log of food expenditure per adult male equivalent, log of calories per adult male equivalent or log of food expenditure per calorie for household i and $\ln(Income_i)$ is the log of income per adult male equivalent person. The results are displayed in Table 6. The income elasticity of total food expenditure was statistically significant and positive at 0.16, suggesting that a one per cent increase in household income led to a 0.16 per cent increase in food expenditure. This elasticity is fairly low relative to income elasticities estimated for a number of countries in the early twentieth century and compared to an income elasticity of 0.56 estimated for Japan in 1955 (Houthakker 1957). Looking at the income elasticity of total calories purchased, it is statistically insignificant and very low at 0.06. This suggests that richer families spent more money on food but did not necessarily consume more calories as a response. This is confirmed when looking at the income elasticity of the price of calories, which was positive and statistically significant at 0.10: a one per cent increase in income led to a 0.10 per cent increase in the price of calories purchased.

<<<<Insert Table 6 about here>>>>

To test the robustness of these simple bivariate regressions, we added controls for the number of nonworking adults present in a household and the sex ratio. Nonworking adults, such as elderly relatives that are receiving care in the household, may have either boosted elasticities because they were given extra resources out of respect or in appreciation for their nonmarket contributions to the household, or lowered elasticities because they were not contributing monetary income to the household in a bargaining model sense (Horrell and Oxley 2013). We control for the sex ratio in case patriarchal norms led to larger elasticities in households with more male members than female members. The results with these controls are presented in columns 4 to 6 of Table 6 and show that adding the controls does not qualitatively affect the estimated income elasticities.[11] The controls are also highly insignificant. Thus, among the low-income households included in the survey, income appears to have only influenced food expenditure and the expense of the calories purchased but not the total calories consumed.

We can also analyze income elasticities of consumption on the major macronutrients and the sources of the major macronutrients to get a better idea of how households' consumption changed with greater income. Table 7 reports income elasticity estimates for the bivariate regression presented in Equation 1 substituting grams of carbohydrates, protein, and fat per adult male equivalent for the dependent variable. For each macronutrient, we also distinguish between total consumption of the macronutrient, consumption from main foods such as rice, consumption from animal products, and consumption from vegetable products. The results suggest that increases in income did not affect total carbohydrate consumption (elasticity of -0.004) but did increase total protein somewhat (elasticity of 0.04) and had a much stronger positive affect on total fat consumption (elasticity of 0.33). The income elasticities of protein and fat consumption are even larger when we look at protein and fat consumption from animal and vegetable sources rather than main sources such as rice. Thus, richer households substituted away from main foods and consumed much larger amounts of animal and vegetable protein and fats even if this substitution did not result in a higher calorie diet overall. These results remain largely the same when adding the control variables, nonworking adults and sex ratio, mentioned above (results not reported).

[11] There are no qualitative differences in the elasticities if we use the income and consumption per capita or per COMA equivalent consumption unit.

<<<<Insert Table 7 about here>>>>

Taken all together, these results imply that with additional income the NSPD subsample households were more likely to buy fish and/or meat, vegetables, and other sources of fat rather than rice. However, this shift in the diet resulted in only a modest increase in food expenditure and had no effect on total calorie intake per adult equivalent, suggesting that there was a strong substitution affect toward more expensive food sources with increases in income. The very low income elasticities of food expenditure and total calorie intake are somewhat puzzling and suggest several possible interpretations. First, the income distribution in the survey is relatively narrow, excluding the very poorest households in Tokyo and much richer households from the skilled working class upwards. Thus, the relationship between income and consumption among this group may be attenuated relative to the income elasticity that would be estimated for this larger group. Second, if most households could purchase enough food to meet their caloric requirements, perhaps the general desire to purchase additional calories was overruled by a desire for more expensive and desirable calories. Given the very low share of food expenditure in total income, it does not seem that these households were struggling to provide enough food but again were more interested in the perceived quality of the diet. This highlights how preferences can change once the basic requirements of the diet are met (Öberg 2016).

Calorie intake, crowding, and health outcomes

As mentioned above, health outcomes were also reported for the NSPD subsample households. As a part of the study, a medical professional visited each household once and conducted a medical examination of all household members present.[12] Mean household size in the survey was 4.45 people and the mean number of people examined during the medical visit was 3.87. Thus, while some members were left out of the medical examination, we would expect the medical examination to reasonably capture morbidity in the household, especially since sick household members were probably more likely to be at home. Because the morbidity was measured and not self-reported, our measure of

[12] If only one or two members were home, the medical examiner returned at a different time.

morbidity is unlikely to be tainted by different cultural attitudes toward morbidity across households (Johansson 1991; Harris *et al.* 2012). The NSPD subsample survey report did not list health outcomes for individual members, but instead reported the number of household members suffering from maladies classified into ten categories: nervous, eye, ear, nose, respiratory, tuberculosis, digestive, tonsillitis, skin, and others. The report also recorded the total number of members of each household currently experiencing any illness. We take the number of household members experiencing illness in each disease category and divide this by the number of household members included in the medical survey. Thus, the morbidity data should be taken as proxy for prevalence of disease since the disease had to be readily observable at the medical examination. This data is very rich and interesting on its own, but what is especially fascinating is the ability to link this to household characteristics and consumption patterns to try to understand the relationship between nutrition, income and crowding, and household-level morbidity.

To do this, we run a series of bivariate regressions that capture the association between nutrition, income and crowding, and general morbidity, and morbidity from selected disease categories.[13] We run these almost exclusively as bivariate regressions for three reasons: first the sample size for the health survey is rather small, restricting statistical power; second, there will be substantial noise in the morbidity variable since it only captures the household morbidity on one day rather than measuring morbidity over a period of time and is measured for the household instead of for individuals; finally, many of the household characteristics were highly correlated suggesting that multicollinearity would increase standard errors and increase the probability of making a type II error. The regressions estimate the following equation:

$$Morbidity_i = \alpha + \beta \ln(HHChar_i) + \varepsilon_i \quad (2)$$

where $Morbidity_i$ is the prevalence of morbidity in each of the selected disease categories for household i, $HHChar_i$ is one of six household characteristics. The first set of characteristics seek to establish any associations between nutrition and morbidity and include calories per adult male equivalent, grams of protein per adult male equivalent, and the share of protein from animal sources in the household. The second group attempts to understand the association between income and morbidity and includes income per adult male equivalent and income minus food expenditure, which proxies non-food

[13] We checked scatterplots to ensure that the bivariate relationships were not driven by outliers.

expenditure. Finally, we include the number of tatami mats per capita as a measure of the size of the household's living space.

There is reason to believe that there will be negative relationships between all of the nutrition and income variables and morbidity, although we would expect the relationship to be stronger for some variables than others. Aside from diseases such as rickets and pellagra which are caused by deficiencies in specific micronutrients (Clay et al. 2019), poor nutrition both in quality and quantity can affect disease prevalence through several channels. Nutritional deficiencies can in some cases increase the probability that an individual contracts a non-infectious disease. For instance, in the long run, poor nutritional conditions in early life can influence the prevalence of heart disease and stroke in later life (Almond and Currie 2011). However, in the early twentieth century, nutrition likely influenced disease through a separate channel; inadequate nutrition meant that people who contracted similar diseases to today were sick for longer periods of time because they did not have adequate nutritional resources to fight the disease (Relationship 1983). This mechanism could have been especially important for the households in our study since consumption for some households was far below what was adequate and the main infectious diseases had yet to have been eradicated in Tokyo in 1930 (Ogasawara *et al.* 2018). The second mechanism would also have a stronger influence on prevalence rather than incidence of morbidity, so again it suits our prevalence proxy well. Thus, we would expect that households with more adequate nutrition to have lower morbidity rates.

We would also expect a negative relationship between morbidity and income for two reasons. First, richer households would presumably have greater disposable income to spend on food and other health investments. In 1930 Tokyo, the most important health-related expenditures may have been related to hygiene practice. According to an official budget survey of working-class households in 1921, expenses for hygiene products (excluding cosmetics) included tooth brushes, toothpaste, tissue paper, soap, and money for public baths (Bureau of Social Affairs 1922, p.2). This expenditure suggests that improvements in hygiene might have been important for the health transition in Japan as well as in Western countries (Mokyr 2002, pp. 169-74). Second, richer households may have been able to sort into higher quality accommodation or into healthier neighborhoods or locations (Beach and Hanlon 2017; Bailey *et al.* 2018). Fewer than 45 per cent of households had access to running water taps in Hakusan Goten town where the survey was conducted (Ogasawara *et al.* 2018, p. 11). Thus, richer households may have been able to live in accommodations with a water tap or perhaps farther away from polluted areas.

Finally, we would also expect a positive relationship between crowding and morbidity. Farr first established this relationship using data population density and mortality data from British registration districts in the 1860s (Farr 1875, pp. xxiii-xxv), but other researchers have found similar effects in Japan. Ito (1984) and Murakoshi (2004) have found a weak but statistically significant positive correlation between population density and the crude death rate in Japanese cities circa 1883. Suzuki (2005) has also shown a positive correlation between population density and diphtheria mortality in interwar Japan. However, these studies focus on crowding at the city or district level whereas our measure of crowding varies at the household level, which is relatively understudied.

Households with less space per person would be more prone to spread infectious diseases to one another. Crowding could affect the spread of respiratory diseases (Vynnycky and Fine 1999) and other diseases related to hygiene but would also matter for contagious skin and eye conditions such as ringworm and conjunctivitis that are typically underemphasized by historians studying causes of death since these diseases are rarely fatal (Ainsworth 1993; Karasch 1993, pp. 898-9). Unfortunately, we do not know how many rooms were in each dwelling, but more space per person might also mean that household members were less exposed to pollution from cooking stoves. In working-class households in Tokyo city, cooking stoves were normally located near the entrance of the house (Tokyo City Social Welfare Bureau 1921, p.42). Although substituting natural gas had been discussed in a science journal at the time, nearly all households used firewood and charcoal for cooking in the prewar period (Tsujimoto 1923; 1929). Thus, part of the relationship between crowding and morbidity may reflect exposure to pollution from cooking stoves, which can cause serious health problems (Kyu *et al.* 2009).

<<<<Insert Table 8 about here>>>

Table 8 reports our findings. In general, we do not find any consistent and robust associations between any of our independent variables of interest and morbidity from any of the specific causes. Again, this may be because morbidity was only observed on one day and the sample size was small: the high standard errors on most estimates support this theory. Thus, we will focus on the all disease morbidity rate. Puzzlingly, our three measures of nutrition (total calories and grams of protein per adult male equivalent and share of protein from animal sources) were positively associated with all cause morbidity prevalence. However, the coefficients had very large standard errors and were accordingly statistically insignificant and also had very low *R*-squared values, especially relative to the income and crowding variables. Thus, it seems that nutrition did not strongly influence all cause morbidity. Income per capita was negatively associated with disease prevalence and the coefficient was statistically significant at the five per cent level. Our proxy for non-food expenditure, income minus food expenditure per adult male equivalent, is also negatively and statistically significantly associated with overall disease morbidity. Finally, we also find an effect of crowding on morbidity with households with more living space per capita having lower levels of morbidity. This association is attenuated somewhat, however, when controlling both for crowding and income with income having the larger and more statistically robust effect. Thus, taken all together, we find no relationship between nutrition or nutritional quality on morbidity but relatively strong effects for income and crowding.

These results suggest that the income mechanisms highlighted above were more important for explaining disease prevalence than nutrition. Richer households may have been able to choose healthier areas within Hakusan Goten town to live or rent accommodation with health promoting amenities like running water (Ogasawara *et al.* 2018). In addition, it seems that the amount of money available for non-food expenditure really mattered, although the coefficient was half the size of the coefficient on income.[14] This suggests that households could use their excess money to mitigate the disease environment either by renting better accommodation or by purchasing products such as soap that could improve the hygiene of the household. These results should be interpreted cautiously given the small sample size and fleeting nature of the morbidity prevalence measure. However, they are fascinating and provide new hints that perhaps hygiene was more important than nutrition in shaping the morbidity experiences in historical populations.

CONCLUSION

In this paper we have analyzed a unique household level dataset for low-income families in a poor district of Tokyo in 1930, where investigators calculated macro-nutritional availability from food consumption data and recorded the incidence of disease among household members. Unlike for North American and many European countries, where household-level data has been utilized extensively for the temporal or spatial analysis of living standards, this study represents the first examination of household-level nutritional

[14] Food expenditure per adult male equivalent was positively correlated with disease prevalence, though the coefficient was highly insignificant.

data for pre-Pacific war Japan. We find average energy availability levels per capita per day among poor households in Tokyo that are roughly similar to a previous study that utilized aggregate household data. But using this new dataset in conjunction with information on stature and the occupation of the head of household, we have also been able to estimate the likely BMR, and PAL of households, and compare these with energy intakes recorded in the nutritional survey. Such calculations are tentative for many reasons listed above, but we conclude that the vast majority of poor households had sufficient energy available in their diets to sustain the physical activity implied by their occupation and, following Fogel (2004), 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. Our estimates also suggest that urban low-income working-class households tended to buy fish and/or meat in response to increases in per capita income at the expense of the consumption of other types of food.

In addition, the NSPD survey provides a unique window into the study of historical morbidity because it is the only historic household survey that we are aware of that collected both food consumption data and also reported the incidence of a range of diseases among household members systematically. Thus, although these results should be read as tentative, they are very interesting and suggestive nonetheless. We find that nutrition was not strongly associated with the risk of a household member suffering from an infectious disease during the survey period. This insignificant finding is not perhaps surprising given that the incidence of diseases most commonly associated with food poverty – rickets and pellagra – were not recorded in the survey. Moreover, the short survey period cautions against making too much of this result. However, it is noteworthy that the incidence of (largely) infectious diseases recorded in the survey were significantly correlated with income and the extent of crowding among households. The fact that income but not nutrition was related to disease prevalence challenges McKeown's assumption that changes in real income reflected improvements in nutrition and suggests that the causal pathway between income and morbidity/mortality was more complex. Increases in income may have allowed people to take advantage of sanitary improvements by moving to less crowded areas with better amenities. Likewise, richer households could spend more money on health and hygiene-related investments like bathing that could prevent disease. Thus, scholarly efforts ever since McKeown's first publications to establish the primacy of nutrition or sanitary improvements or medical knowledge may mask the complexity of interactions between the three leading to the health transition.

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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 'officer worker' cannot 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 sub-sample	SPRP	3rd Population Census	SPRP	3rd Population Census
Survey area	Hakusan Goten town	Koishikawa ward	Koishikawa ward	All of Tokyo City	All of Tokyo City
Survey subjects	Poor households (head)	Poor households (male head)	Entire population (male)	Poor households (male head)	Entire population (male)
Survey month and year	January to March, 1930	March 1929	October 1930	March 1929	October 1930
Number of Observations	102	1,314	46,245	13,489	767,646
Agriculture	0.00	2.51	0.59	0.90	0.41
Fisheries	0.00	0.00	0.02	0.31	0.09
Mining	0.00	0.08	0.20	0.72	0.11
Manufacture	59.80	47.56	39.31	40.74	38.20
Commerce	16.67	11.04	36.39	13.26	42.58
Transport	4.90	7.69	4.93	7.38	5.56
Public sector and freelancer	1.96	12.25	16.45	7.76	11.51
Housework	0.00	0.23	1.50	0.33	0.72
Other industry	16.67	18.65	0.61	28.61	0.82

Notes: The industrial classification was based on data from Third Population Census of 1930. In the NSPD sample, five households were classified as unemployed. In addition, three households reported as "office worker" could not be classified and were excluded. Therefore, eight of the 110 households were excluded. There is 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

	McCance & Widdowson (Modified Atwater factors)	Basal metabolic rate (BMR)	Survival diet (1.27BMR)
Mean daily intake per capita (kcal)	1572.0	1015.7	1290.0
Standard error	347.8	156.7	199.0
Minimum	632.2	657.4	834.9
Maximum	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 value in the second 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. 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.2 in Appendix A. The value in the fourth column is the mean value of the per-capita survival diet for our sample. 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; Anyaegbu 2010, p.50.

Table 4: Estimated energy requirements (EER) and physical activity level (PAL)

	EER	PAL
Min	954	0.70
25th percentile	1881	1.38
Mean	2118	1.55
75th percentile	2363	1.73
Max	3111	2.28

Notes: The number of observations is 182. EER is the total calorie intake divided by the adult male equivalent household size. PAL is the total calorie intake divided by the total family BMR. BMRs are calculated using the predicted BMR listed in Table A.2 in Appendix A. The details of the predicted BMR are described in Appendix C. 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.

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

	Nutritional intake per adult male equivalent						
	Calories (kcal)	PAL	Carbohydrate (gram)	Fats (gram)	Proteins(gram)		Tatami Mats per capita
					Total	Animal (%)	
Total households	2118	1.55	464.7	11.0	61.2	20.7	2.2
Panel (a): by head's occupation							
Manufacture	2075	1.52	458.1	10.0	61.2	19.1	2.1
Commerce	2100	1.54	457.4	11.6	61.1	20.8	2.0
Transport	2005	1.47	446.6	7.7	59.9	18.1	1.8
Public sector	1824	1.33	401.3	9.2	57.4	18.1	2.0
Other industry	2167	1.58	485.9	8.4	60.8	17.0	2.1
Unemployed	2008	1.47	442.9	9.5	59.2	19.7	2.0
Panel (b): by income per capita (quantile group)							
< 8.75	2000.2	1.52	464.8	8.5	60.3	16.7	1.9
8.75-12.00	2053.8	1.50	455.1	9.2	60.7	19.3	2.0
12.00-16.67	2125.0	1.55	469.6	10.2	60.9	19.2	2.2
16.67≦	2094.0	1.53	451.5	12.4	62.4	23.1	2.6
Panel (c): by household size (quantile group)							
<3	2194.7	1.60	456.2	19.3	61.1	25.9	3.0
3-4	2152.3	1.57	472.8	11.0	61.7	21.3	2.2
4-6	2075.5	1.52	458.6	9.6	61.5	20.4	2.1
6≦	2119.3	1.55	473.1	8.8	60.2	18.1	1.8

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 category 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 6: Estimation results for food expenditure, calorie intake, and food expenditure per calorie from regressions using adult male BMR equivalent scale

	Log food expenditure per capita	Log calorie intake per capita	Log food expenditure per calorie	Log food expenditure per capita	Log calorie intake per capita	Log food expenditure per calorie
Log income per capita	0.161***	0.064	0.097***	0.168***	0.076	0.092***
	(0.050)	(0.045)	(0.026)	(0.075)	(0.063)	(0.034)
Nonworkers aged 14+				-0.009	-0.001	-0.008
				(0.034)	(0.028)	(0.014)
Log sex ratio				0.015	0.019	-0.003
				(0.024)	(0.020)	(0.014)
Observations	108	108	108	107	107	107
R-squared	0.0895	0.0210	0.1040	0.1004	0.0287	0.1135

Notes: ***, **, and * represent statistical significance at 1%, 5%, and 10% levels. Heteroskedasticity robust standard errors are in parentheses.

Table 7: Estimation results for macronutrients
from regressions using adult male BMR equivalent scale

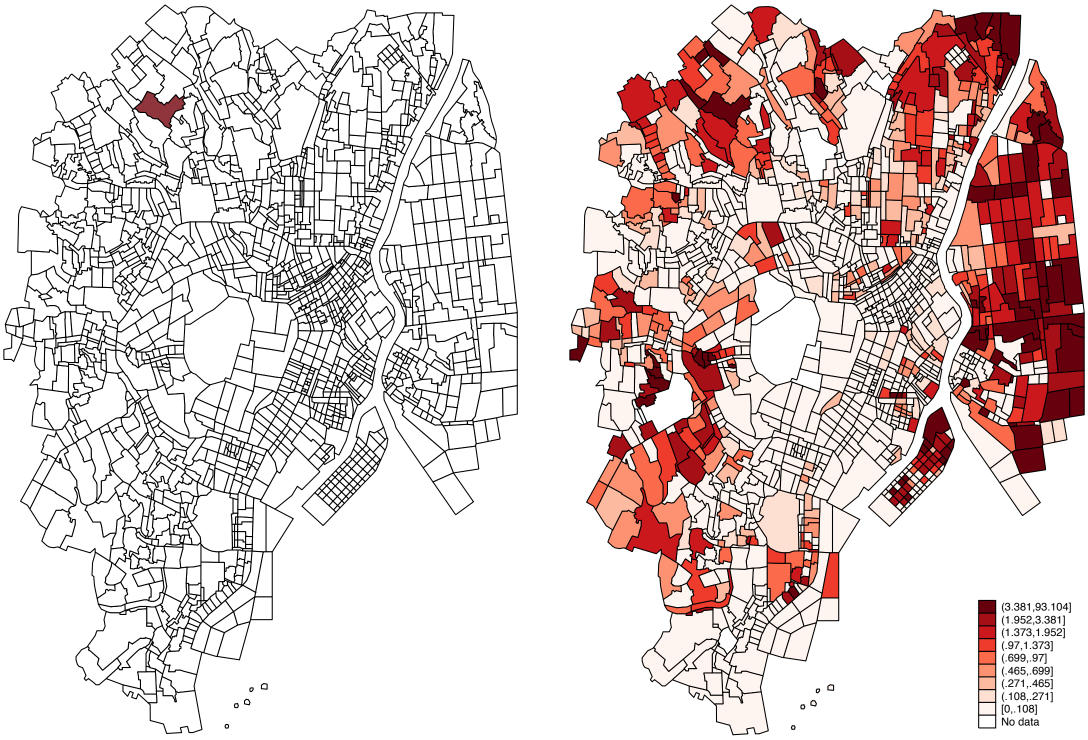
	Log income per capita		R-squared	Observations
	Coef.	Std. Err.		
Log carbohydrate per capita	-0.004	(0.042)	0.0001	108
Log carbohydrate from principal foods per capita	-0.028	(0.046)	0.0037	108
Log carbohydrate from animals per capita	0.742*	(0.406)	0.0462	88
Log carbohydrate from vegetables per capita	0.244**	(0.093)	0.0440	108
Log protein per capita	0.041***	(0.015)	0.0725	108
Log protein from principal foods per capita	-0.044	(0.047)	0.0085	108
Log protein from animals per capita	0.345***	(0.130)	0.0756	102
Log protein from vegetables per capita	0.236***	(0.074)	0.0677	108
Log fat per capita	0.330***	(0.093)	0.1101	108
Log fat from principal foods per capita	-0.041	(0.048)	0.0069	108
Log fat from animals per capita	0.396***	(0.144)	0.0539	102
Log fat from vegetables per capita	0.401***	(0.114)	0.0996	108

Notes: ***, **, and * represent statistical significance at 1%, 5%, and 10% levels. Heteroskedasticity robust standard errors are in parentheses.

Table 8: Estimation results for health outcomes
from regressions using adult male BMR equivalent scale

	(1) Disease rate	(2) Eye	(3) Ear	(4) Nose	(5) Respiratory	(6) TB	(7) Digestive	(8) Tonsil	(9) Skin
Panel A									
Log calorie intake per capita	13.746	-5.878	6.943*	1.215	-9.595	-2.193	12.822*	-6.649	3.583
	(14.172)	(6.472)	(4.190)	(1.847)	(6.285)	(3.082)	(6.992)	(6.021)	(3.013)
R-squared	0.0056	0.0037	0.0135	0.0006	0.0088	0.0023	0.0143	0.0054	0.0068
Panel B									
Log protein per capita	15.243	-5.244	8.500	3.926**	-1.370	-1.287	6.612	-0.515	3.114
	(12.885)	(5.108)	(7.182)	(1.869)	(3.901)	(1.698)	(5.757)	(5.204)	(2.452)
R-squared	0.0098	0.0042	0.0286	0.0088	0.0003	0.0011	0.0054	0.0000	0.0073
Panel C									
Log share of protein from animal per capita	8.537	1.410	2.154	1.428	3.457*	1.121	0.611	4.996**	0.682
	(5.217)	(1.658)	(2.190)	(0.952)	(1.892)	(1.160)	(3.150)	(2.093)	(1.049)
R-squared	0.0207	0.0020	0.0122	0.0076	0.0106	0.0061	0.0003	0.0290	0.0023
Panel D									
Log income per capita	-16.378**	-1.298	-2.304**	1.686	-1.383	-0.109	2.496	-0.303	-2.282*
	(6.468)	(3.510)	(1.138)	(1.540)	(1.532)	(0.743)	(5.742)	(3.068)	(1.244)
R-squared	0.0515	0.0015	0.0191	0.0100	0.0018	0.0000	0.0039	0.0001	0.0148
Panel E									
Log non-food expenditure per capita	-8.436**	-0.177	-0.966	0.722	-0.187	0.238	0.274	1.068	-1.093
	(3.476)	(1.577)	(0.662)	(0.620)	(0.714)	(0.271)	(2.803)	(1.300)	(0.813)
R-squared	0.0539	0.0001	0.0133	0.0072	0.0001	0.0008	0.0002	0.0033	0.0134
Panel F									
Log tatami mats per capita	-11.751**	-1.164	-1.909	3.249	0.049	-0.652	-0.960	-4.195	-1.815
	(5.875)	(2.489)	(1.448)	(2.844)	(2.267)	(1.116)	(5.737)	(2.558)	(1.541)
R-squared	0.0386	0.0018	0.0202	0.0569	0.0000	0.0024	0.0009	0.0194	0.0143
Panel G									
Log tatami mats per capita	-8.010	-1.104	-1.341	3.440	0.775	-0.845	-2.909	-5.625*	-1.234
	(6.201)	(3.139)	(1.549)	(3.271)	(3.097)	(1.330)	(5.435)	(2.924)	(1.908)
Log income per capita	-11.386*	-0.610	-1.468	-0.458	-1.867	0.417	4.309	3.203	-1.513
	(6.583)	(4.334)	(0.989)	(1.664)	(2.683)	(0.905)	(4.206)	(3.306)	(1.614)
R-squared	0.0656	0.0027	0.0265	0.0573	0.0024	0.0030	0.0100	0.00261	0.0197

Notes: The number of observations for panels A, B, C, D, E, F, and G are 167, 167, 161, 107, 107, 109, and 107 respectively. ***, **, and * represent statistical significance at 1%, 5%, and 10% levels. Heteroskedasticity robust standard errors are in parentheses.



(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 1932s; 1932b.

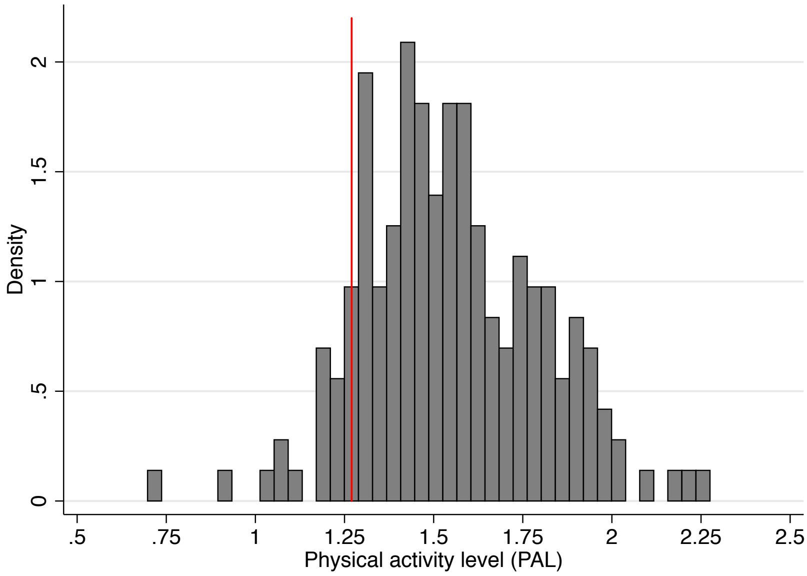


Figure 2: Physical activity level
and its survival line (red line)

Note: Red solid line shows the survival physical activity level (1,27). Source: Tokyo City Office 1931.

Online Appendix to "Nutrition, crowding and disease among low-income households in Tokyo in 1930"

by Kota Ogasawara, Ian Gazeley and Eric B. Schneider

Appendix A: Additional Figures and Tables

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

	Sub-sample			
Variables	Income reported (110 households)	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 12 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: 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 calculation 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, 0.936, 0.832, 0.8890, 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.

Figure A.1: Paper folding for bookbinding

Notes: This photograph shows a 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: 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

$$BMR_j^{Male} = \frac{1000 \times (0.0481 Weight_j + 0.0234 Height_j - 0.0138_j - 0.4235)}{4.186}$$

$$BMR_j^{Female} = \frac{1000 \times (0.0481 Weight_j + 0.0234 Height_j - 0.0138_j - 0.9708)}{4.186}$$

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.2 shows the average heights, average weights, predicted BMR, and survival diets, by age and gender.

Appendix C: 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.2. The total BMR in each household was calculated by

$$Household\ BMR_i = \sum_{g=Male0-4}^{Female50-74} n_{ig} \times BMR_g$$

where i indexes the households from 1 to 182 [15] 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

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

$$Calorie_i^{Adult\ woman} = (Total\ Calorie\ Intakes_i / Household\ BMR_i) \times BMR_{Female20-49}$$

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15 Note that one household with missing values for family composition was excluded.

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 NSPD subsample 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

$$Calorie^{Adult\ man} = \frac{\sum_i Calorie_i^{Adult\ man}}{N}$$

$$Calorie^{Adult\ woman} = \frac{\sum_i Calorie_i^{Adult\ woman}}{N}$$

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

Appendix D: 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). [16]

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

Appendix E: Alcohol consumption

The monthly expenditure for alcohol in low-income households in 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).

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