

Consumption situation of Chinese medicine in Shanghai: a cross-sectional study

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Research

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Abstract

Background This cross-sectional study aimed to construct a database of Chinese medicine consumption, including the annual intake, the number of days of intake, and the daily intake of Chinese medicine, which is helpful for risk assessment and understanding of consumer trends.

Methods About 40 million rows of data used in this study were derived from the hospitals in Shanghai, which contains the prescription number, the name of consumers, the date of the dispensing, the name of Traditional Chinese Medicines (TCMs), dosage, and the number of days taken. All data were stored in a MySQL database. R language was used as the main tool for statistical analysis and graphical work.

Results The result shows the annual consumption, annual consumption days, and average daily consumption of 20 types of common TCMs and all TCMs consumed. The result shows Astragali radix, Coicis semen, and Danshen are the top three of consumption among the selected Chinese medicines. An easy-to-use software called the Chinese medicine consumption database (CMCD) was designed to search and download consumption data. It is built using the *Shiny* package in the R, is free to access on any device with an internet browser, and requires no programming knowledge to be used.

Conclusions A Chinese medicine consumption database was constructed, which included the consumption situation of 20 types of common TCMs and all TCMs consumed. This database plays a pivotal role in the risk assessment of the pollutants in TCMs and the prediction of the consumption trend of TCMs.

Background

Traditional Chinese Medicines (TCMs) have been an integral part of Chinese culture and the primary medical treatment for a large portion of the population for thousands of years [1]. Outside of Asia, there has been a growing use of TCMs where they are being used as an input to, or as an alternative to, conventional Western medicine [2]. For example, artemisinin can treat malaria and inhibit the growth of cancer cells [3, 4]. Some Chinese medicines could relieve the symptoms of COVID-2019 and neurodegenerative disorders [5, 6]. However, TCMs are not risk-free because of undeclared or misidentified TCMs ingredients including allergenic substances [7], plant toxins [8], heavy metals such as mercury, lead, copper, and arsenic [9, 10], and pharmaceutically active compounds of undetermined concentration [1, 11].

Risk assessment of TCMs contaminations can be generally defined as a structured scientific process for characterizing the potential hazards and the associated risks to life and health resulting from exposure of humans to chemicals present in TCMs over a specified period [12]. Some studies have attempted to calculate the health risks of heavy metals in TCMs. For instance, Wang et al. used the method of hazard quotients (HQ) to evaluate the health risks of heavy metals among 55 types of Chinese medicines [13]. Liu et al. also used HQ to evaluate the potential health risk of arsenic in TCMs [14]. Taken together, these studies all used the maximum ingested TCM doses from the Chinese Pharmacopoeia to calculate the

average daily intake dose (ADD), which is an important parameter in risk assessment. However, this calculation method lacks accuracy [15]. The accuracy of risk assessment is not only related to the contaminations in traditional Chinese medicines but also to the consumption data. The availability of detailed and high-quality TCMs consumption data collected at an individual level are essential for assessing the exposure to potential risks [16].

TCM consumption data are essential for the risk assessment or, to be more precise, for consumers' accurate assessment of exposure to harmful substances (e.g. contaminants, pesticides, food additives, migrating compounds) and micro-biological contaminants. On the basis of the results of the risk assessment, the maximum limit of pollutants in TCMs can be controlled or modified, furthermore different endangered groups of the population (e.g. children, sensitive groups) can be identified.

TCM consumption databases are also indispensable for the understanding of consumption trends and characteristics. Based on the knowledge of the preference of distinctive Chinese medicines, the levels of their production can be reduced or increased [17].

Methods

Study design and participants

The consumption data of Chinese medicine come from Shanghai hospitals and pharmacies between January 2019 and December 2019. The people involved in this data were over 18 years old, and their names have been anonymized. Personal information is not contained in publicly disclosed data. In this study, only oral Chinese medicines are involved, excluding external use and acupuncture, etc.

Chinese medicine studied

Twenty types of common TCMs included in the present study are summarized in Table 1. Based on their availability, these food plants were identified as being commonly used by the local population.

Table 1 English names and scientific names of common Chinese medicines

The Latin name	The English name	The Chinese name
<i>Astragalus Membranaceus</i>	Astragali radix	<i>Huangqi</i>
<i>Coix Lacryma-Jobi</i>	Coicis semen	<i>Yiyiren</i>
<i>Ziziphus Jujuba</i>	Ziziphi spinosae semen	<i>Suanzaoren</i>
<i>Atractylodes Macrocephala</i>	Atractylodis macrocephalae rhizoma	<i>Baizhu</i>
<i>Panax Notoginseng</i>	Sanchi	<i>Sanqi</i>
<i>Salvia Miltiorrhiza</i>	Danshen	<i>Danshen</i>
<i>Panax Ginseng</i>	Ginseng	<i>Renshen</i>
<i>Lycium Barbarum</i>	Lycii fructus	<i>Gouqi</i>
<i>Lonicera Japonica</i>	Golden-and-silver honeysuckle	<i>Jinyinhua</i>
<i>Ophiopogon Japonicus</i>	Ophiopogonis radix	<i>Maidong</i>
<i>Changium Smyrnoides</i>	Changii radix	<i>Dangshen</i>
<i>Dioscorea Opposita</i>	Corydalis rhizoma	<i>Shanyao</i>
<i>Corydalis Yanhusuo</i>	Dioscoreae rhizoma	<i>Yanhusuo</i>
<i>Scutellaria Baicalensis</i>	Scutellariae radix	<i>Huangqin</i>
<i>Eupolyphaga Sinensis Walker</i>	Boleny	<i>Tubiechong</i>
<i>Chrysanthemum Morifolium</i>	Chrysanthemi flos	<i>Jvhua</i>
<i>Glycyrrhiza uralensis</i>	Glycyrrhizae radix et rhizoma	<i>Gancao</i>
<i>Dendrobium nobile</i>	Dendrobii caulis	<i>Shihu</i>
<i>Achyranthes bidentata</i>	Achyranthis bidentatae radix	<i>Niuxi</i>
<i>Paeonia lactiflora</i>	Paeoniae radix alba	<i>Baishao</i>

Names of TCMs come from the Chinese Pharmacopoeia (2015 edition).

Data preprocessing

The collected data were imported into the MySQL database system for further processing. Imported raw data include prescription number, the name of TCMs consumer, the date of dispensing, the name of TCMs, dosage, and the number of days taken. The main content of data cleaning is as follows. Firstly, abnormal data, such as names of TCMs including “external use”, “pharmacy”, and “prescription” were removed. Secondly, non-numeric characters were removed in the dosage, such as removing the string of “g”. Thirdly, remove the rows with NULL values. The programs used for data cleaning were R and MySQL.

Data analysis and visualization

Program R was used for data analysis and visualization. The content of data analysis mainly includes two parts, one is the analysis of the consumption of a certain common Chinese medicine, and the other is the analysis of the intake of all Chinese medicines. The results obtained are mainly the consumption of Chinese medicines of each Chinese medicine consumer. The main steps for analyzing specific TCMs are as follows (Fig. 1): (1) Extracting the data of a specific Chinese medicine; (2) Combining the phone number and the name of the consumer as the unique identification to make a pivot table to get the annual consumption of Chinese medicine and consumption days; (3) Calculation of the average daily intake of Chinese medicine. Average daily consumption (ADC) was calculated using the following equation: $= \frac{A}{D}$, where A is the annual consumption and D is consumption days; (4) Output and visualization of data. The aim of Combining the phone number and the name of the consumer is to reduce the repetition rate of the names. The analysis steps of all TCMs Consumed are as follows: (1) Multiplying the single-day dose by the number of days to get the total consumption; (2) Combining the prescription number and the previous unique identification number into one column as the new unique identification; (3) Calculating the maximum value of the new identification number, which is the days of consuming under the single prescription, and then adding the maximum value of all the new identification numbers; (4) After separating the new identification number, using the prescription number as the unique identification and adding up each value to get the number of days taking TCM; (5) Calculating ADC by using the above formula; (6) Output and visualization of data. The purpose of generating a new combining the identification number is to solve the problem that the same person dispensed multiple times on the same day. The yellow boxes in the flowchart represent the required data, and the grey boxes in the flowchart mean the necessary analysis steps.

Results

Characteristics of raw data

There are about 40 million rows of raw data after cleaning, which contains the prescription number (PN), Consumer's names (Name), the Consumption date (Date), the name of TCMs (CMN), dosages (DD), and the number of days taken (days). The sample table of raw data is shown in Table 2 and the patient's name in the table is anonymized. 40 million rows of data are stored in the MySQL database for further analysis.

Table 2 A sample table of raw data

PN	Date	Name	days (d)	CMN	DD (g/d)
115368	2018/9/1	Patient1	7	Scutellariae radix	12
115368	2018/9/1	Patient1	7	Glycyrrhizae radix et rhizoma	15
115368	2018/9/1	Patient1	7	Atractylodis macrocephalae rhizoma	25
115368	2018/9/1	Patient1	7	Citri reticulatae pericarpium	15
115368	2018/9/1	Patient1	7	Rhei radix et rhizoma	6
115368	2018/9/1	Patient1	7	Trichosanthis radix	15
130869	2018/9/1	Patient2	7	Bupleuri radix	30
130869	2018/9/1	Patient2	7	Glycyrrhizae radix et rhizoma	18
130869	2018/9/1	Patient2	7	Rhei radix et rhizoma	10
130869	2018/9/1	Patient2	7	Magnoliae officinalis cortex	30
130869	2018/9/1	Patient2	7	Menthae haplocalycis herba	9
130869	2018/9/1	Patient2	7	Coicis semen	60

Consumption situation of all TCMs

The results of all TCMs consumption situations include the annual consumption, consumption days, and the average daily consumption of TCMs. The result indicates that a total of 408,250 people consumed TCMs in these Shanghai hospitals and pharmacies in 2019. Table 3 shows averages of annual consumption, consumption days and average daily consumption of all TCMs are 12923 g, 44 d, and 259 g/d, respectively. The distribution of annual consumption of TCMs consumers is shown in Fig. 2.

Table 3 Averages and quantiles of annual consumption, consumption days, and average daily consumption of all TCMs

	Annual consumption (g)	Consumption days (d)	Average daily consumption (g/d)
P5	868	7	102
P50	5208	21	245
P95	53256	168	456
Mean	12923	44	259

Consumption situation of 20 specific Chinese medicines

Fig. 3 indicates that the number of consumers of Astragali radix, Atractylodis macrocephalae rhizoma and Glycyrrhizae radix et rhizoma is the top three. The number of people who consume these three Chinese medicines exceeds 250,000, which means that more than half of the consumers contain these kinds of Chinese medicines. Averages and quantiles of the annual consumption of 20 specific Chinese medicines are shown in Fig. 4. The TCM with the highest consumption is Astragali Radix, and its P95 of annual consumption is close to 4000 g/y (Table 4). Depending on the results of data analysis, the average consumption days of each Chinese medicine in 2019 are between 25 and 44 days (Table 5). Table 6 shows the average daily consumption of TCMs during the days of consuming TCMs.

Table 4 Averages and quantiles of the annual consumption of 20 specific TCMs (g/y)

Name of TCMs	P5	P50	P90	P95	P97.5	Mean
<i>P. lactiflora</i>	63	210	1050	1630	2310	457
<i>A. macrocephala</i>	63	252	1449	2226	3108	593
<i>S. miltiorrhiza</i>	84	420	1725	2940	4200	783
<i>C. smyrnoides</i>	70	252	1260	1974	2730	545
<i>L. Barbarum</i>	35	126	560	854	1218	238
<i>G. uralensis</i>	70	252	1155	1680	2394	491
<i>A. membranaceus</i>	105	420	2520	3990	5670	1032
<i>S. baicalensis</i>	63	168	756	1134	1638	329
<i>L. japonica</i>	45	143	630	1008	1512	301
<i>C. morifolium</i>	42	126	530	840	1260	261
<i>O. japonicus</i>	63	210	1008	1554	2310	436
<i>P. ginseng</i>	63	210	1050	1680	2310	461
<i>A. bidentata</i>	21	147	924	1680	2730	424
<i>P. notoginseng</i>	28	150	728	1120	1596	305
<i>D. Opposita</i>	84	336	1680	2520	3570	686
<i>D. nobile</i>	63	280	1470	2240	3150	602
<i>Z. jujuba</i>	63	252	1260	2058	2940	557
<i>E. sinensis Walker</i>	54	126	567	882	1190	258
<i>C. yanhusuo</i>	63	210	840	1431	2100	408
<i>C. lacryma-jobi</i>	105	420	2310	3780	5125	960

Table 5 Averages and quantiles of consumption days of 20 specific TCMs (d)

Name of TCMs	P5	P50	P90	P95	P97.5	Mean
<i>P. lactiflora</i>	7	14	70	112	154	32
<i>A. macrocephala</i>	7	21	105	161	224	43
<i>S. miltiorrhiza</i>	7	19	84	126	182	37
<i>C. smyrnoides</i>	7	17	84	126	175	36
<i>L. Barbarum</i>	7	14	84	126	168	35
<i>G. uralensis</i>	7	21	84	126	182	37
<i>A. membranaceus</i>	7	21	112	168	224	44
<i>S. baicalensis</i>	7	14	70	112	154	32
<i>L. japonica</i>	7	14	56	84	121	26
<i>C. morifolium</i>	7	14	56	84	112	25
<i>O. japonicus</i>	7	14	84	126	168	35
<i>P. ginseng</i>	7	21	84	119	168	35
<i>A. bidentata</i>	7	21	84	133	182	37
<i>P. notoginseng</i>	7	14	70	111	147	32
<i>D. Opposita</i>	7	21	98	140	196	39
<i>D. nobile</i>	7	20	84	140	189	38
<i>Z. jujuba</i>	7	21	84	126	168	36
<i>E. sinensis Walker</i>	7	14	56	84	126	26
<i>C. yanhusuo</i>	7	14	63	91	126	29
<i>C. lacryma-jobi</i>	7	21	105	154	210	42

Table 6 Averages and quantiles of Average daily consumption of 20 specific TCMs (g/d)

Name of TCMs	P5	P50	P90	P95	P97.5	Mean
<i>P. lactiflora</i>	9	13	19	30	30	14
<i>A. macrocephala</i>	9	12	18	27	30	14
<i>S. miltiorrhiza</i>	9	15	30	30	58	20
<i>C. smyrnoides</i>	9	15	24	30	30	15
<i>L. Barbarum</i>	3	6	9	10	12	7
<i>G. uralensis</i>	8	12	18	22	30	13
<i>A. membranaceus</i>	9	20	30	38	50	22
<i>S. baicalensis</i>	6	9	15	15	18	10
<i>L. japonica</i>	6	9	18	20	30	11
<i>C. morifolium</i>	6	9	15	20	30	10
<i>O. japonicus</i>	8	10	18	20	29	12
<i>P. ginseng</i>	8	11	18	27	30	13
<i>A. bidentata</i>	3	8	20	30	30	10
<i>P. notoginseng</i>	2	9	15	18	30	9
<i>D. Opposita</i>	9	15	30	30	30	17
<i>D. nobile</i>	9	15	30	30	30	16
<i>Z. jujuba</i>	8	15	28	30	30	15
<i>E. sinensis Walker</i>	6	9	12	15	18	10
<i>C. yanhusuo</i>	8	12	25	30	30	14
<i>C. lacryma-jobi</i>	9	22	30	30	30	22

Preliminary establishment of the Chinese medicine consumption database (CMCD)

Based on the above results, we constructed a user-friendly database, the Chinese medicine consumption database (CMCD), which can also be accessed at <http://112.53.182.21:1444/>, using R package *Shiny*. On this website, administrators can upload new processed Chinese medicine consumption data to keep the database updated and maintained. Users also can browse each specific Chinese medicine and download the excel format of medicine consumption data from the website.

Discussion

TCM has been playing a very important role in health protection and disease control for thousands of years in China. China is one of the world's biggest medical systems, and it is also the world's largest producer and exporter of TCM, with an annual production output of \$3.5 billion [18]. However, the increase in global demand has raised concerns for the safety of TCM. Various studies have shown that TCM can be contaminated with mold, pesticides, and heavy metals, in some cases at toxic levels [19]. TCM drug safety monitoring and risk assessment are becoming increasingly crucial tasks for the internationalization of TCM. In this study, a big data platform about TCMs' consumption database was built, which is essential for consumers' accurate assessment of exposure to harmful substances [17].

It's a pity that demographic information such as age, marital status, current height and weight, and education level was not included in the raw data. Compared with food, it is difficult to take a TCMs frequency questionnaire on the intake of specific TCMs, because most consumers do not know the accurate intake of specific TCMs. Zuo et al utilized retrospective questionnaires to collect data on the consumption of TCMs, and its results show the P95 of the duration of TCM intake was 90 days per year, which is less than the result of this study. The mean and P95 daily TCM consumption amounts were similar to those of this research [20]. However, they only counted the overall consumption of all TCMs, not the consumption of individual TCM. The result of this study indicates that the consumption of diverse traditional Chinese medicines varies greatly.

In summary, the utilization of the Chinese medicine consumption database is widespread (e.g. estimation of drug intake, risk assessment, and understanding of consumption trends), thus it is a vital task to construct Chinese medicine consumption databases.

Conclusions

This study processed and analyzed the TCM consumption data collected by Shanghai in 2019, and then constructed a Chinese medicine consumption database (CMCD), which can be used for risk assessment of TCMs and understanding TCMs consumption tendencies.

Abbreviations

TCMs: Traditional Chinese Medicines

ADI: Acceptable daily intake

ADC: Average daily consumption

CMCD: Chinese medicine consumption database

HQ: Hazard quotients

ADD: Average daily intake dose

Declarations

Ethics declarations

Ethics approval and consent to participate

The sample collections were conducted under the permission and guidelines of local governments. The informed consent was obtained for experimentation with human subjects and data of all the participants are fully anonymized.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

Availability of data and materials

The data sets used during the current study are available from the corresponding author on reasonable request.

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Authors' contributions

X. X.: Conceptualization, methodology, Visualization, writing of the manuscript. Y. Z.: Conceptualization, methodology, reviews and editing the manuscript. Q. C., S. J., H. Z. & Q. H.: Conceptualization, methodology, review and data collection.

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Figures

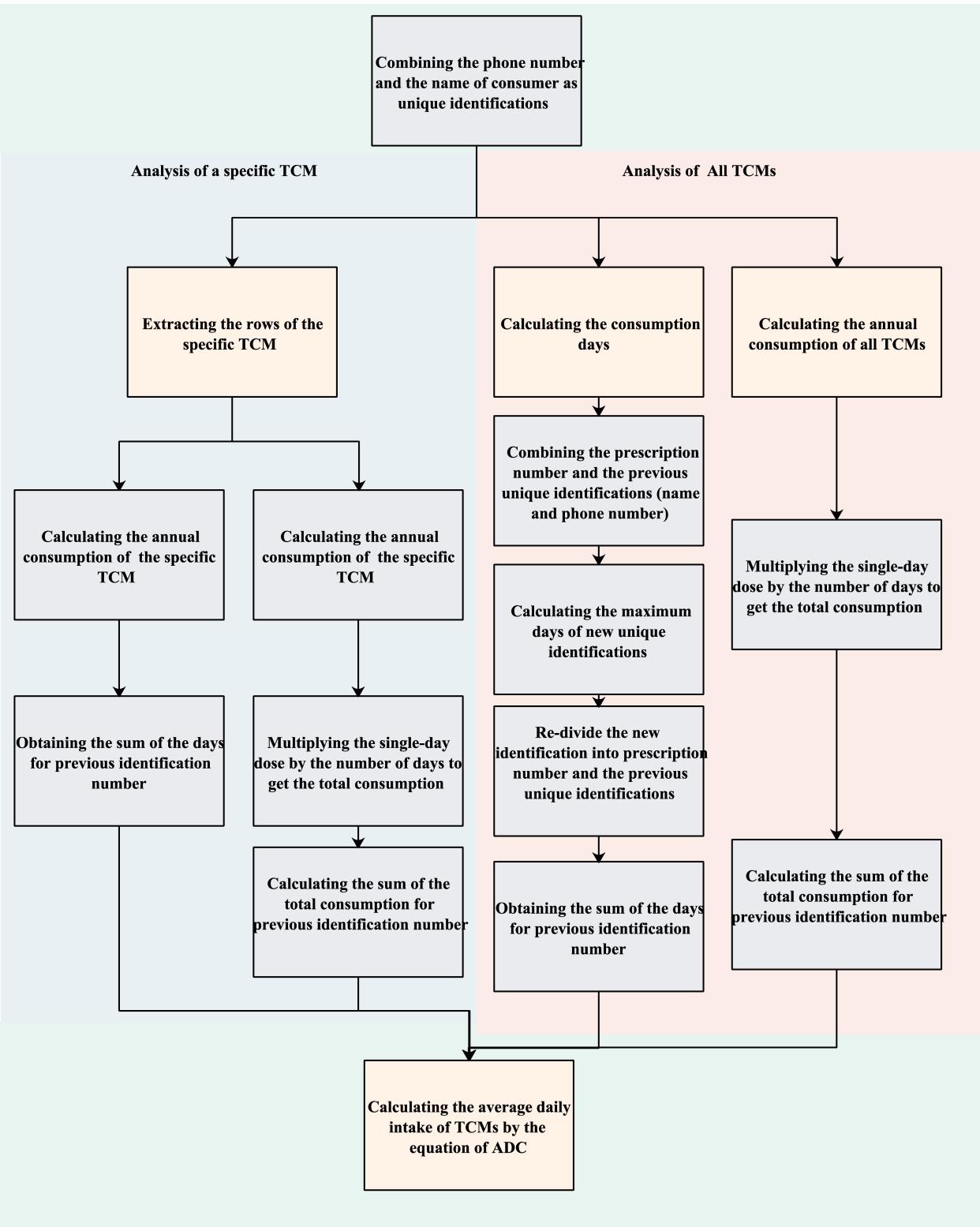


Figure 1

The main steps for analyzing the consumption of TCMs

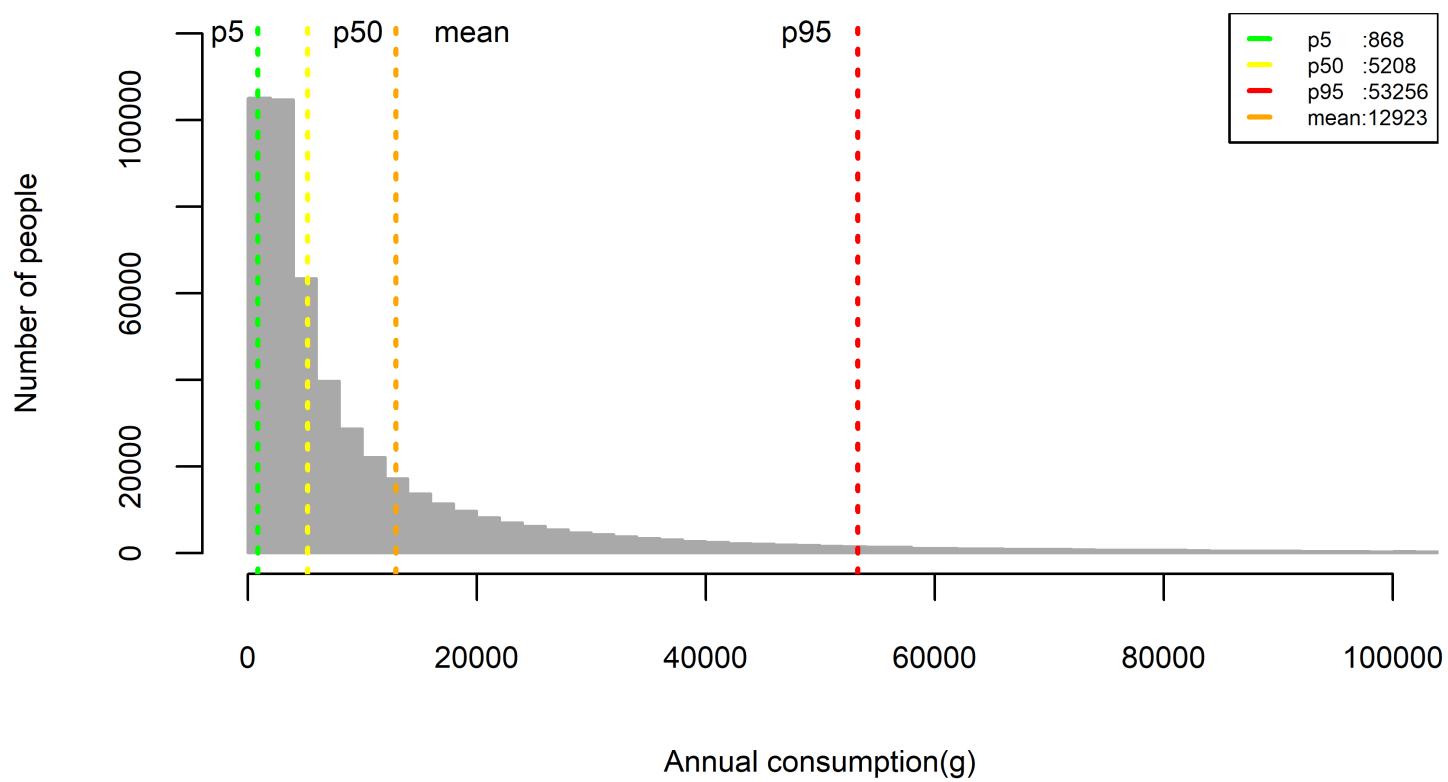


Figure 2

Distribution of annual consumption of all TCMs

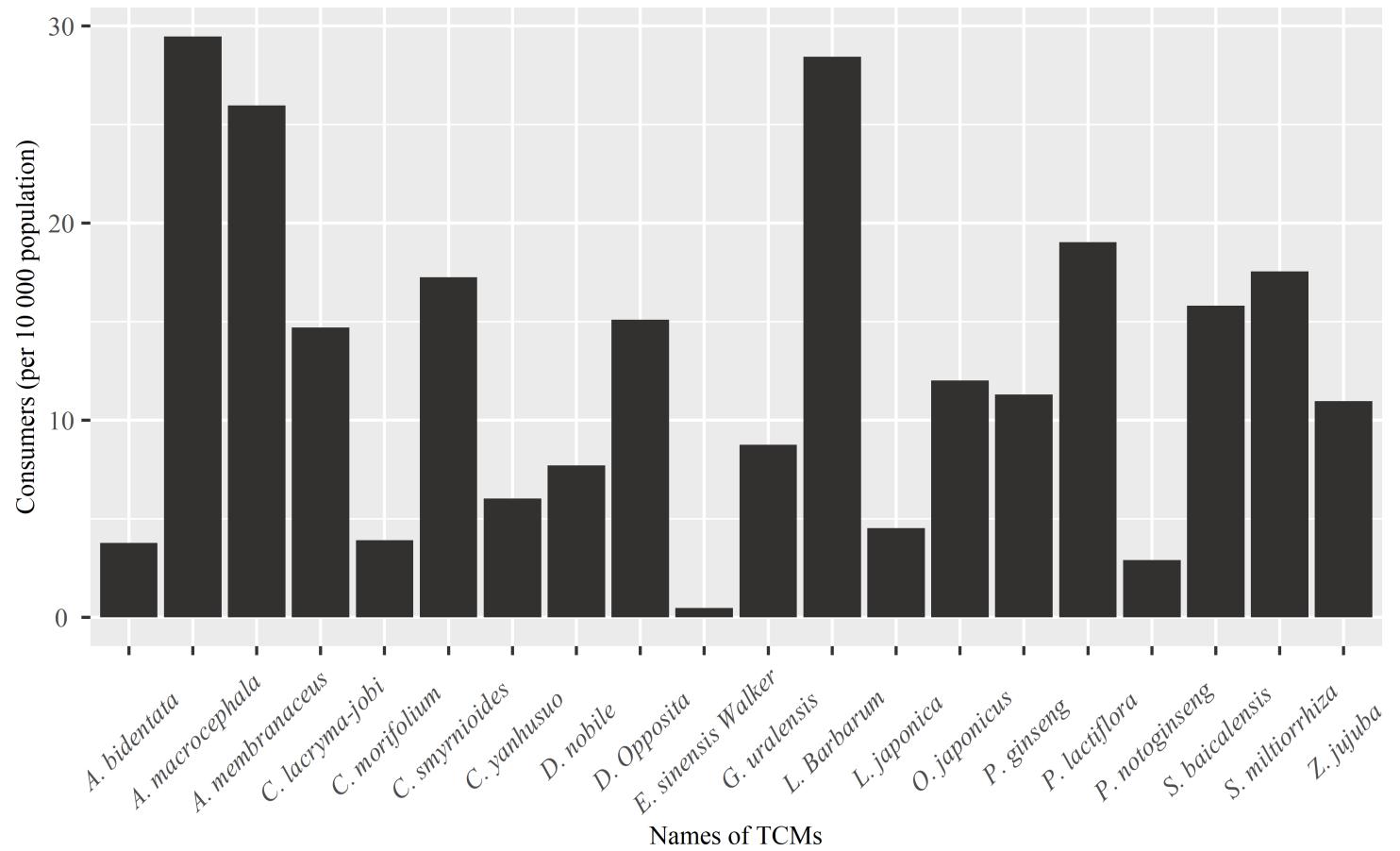


Figure 3

Number of consumers of 20 specific TCMs

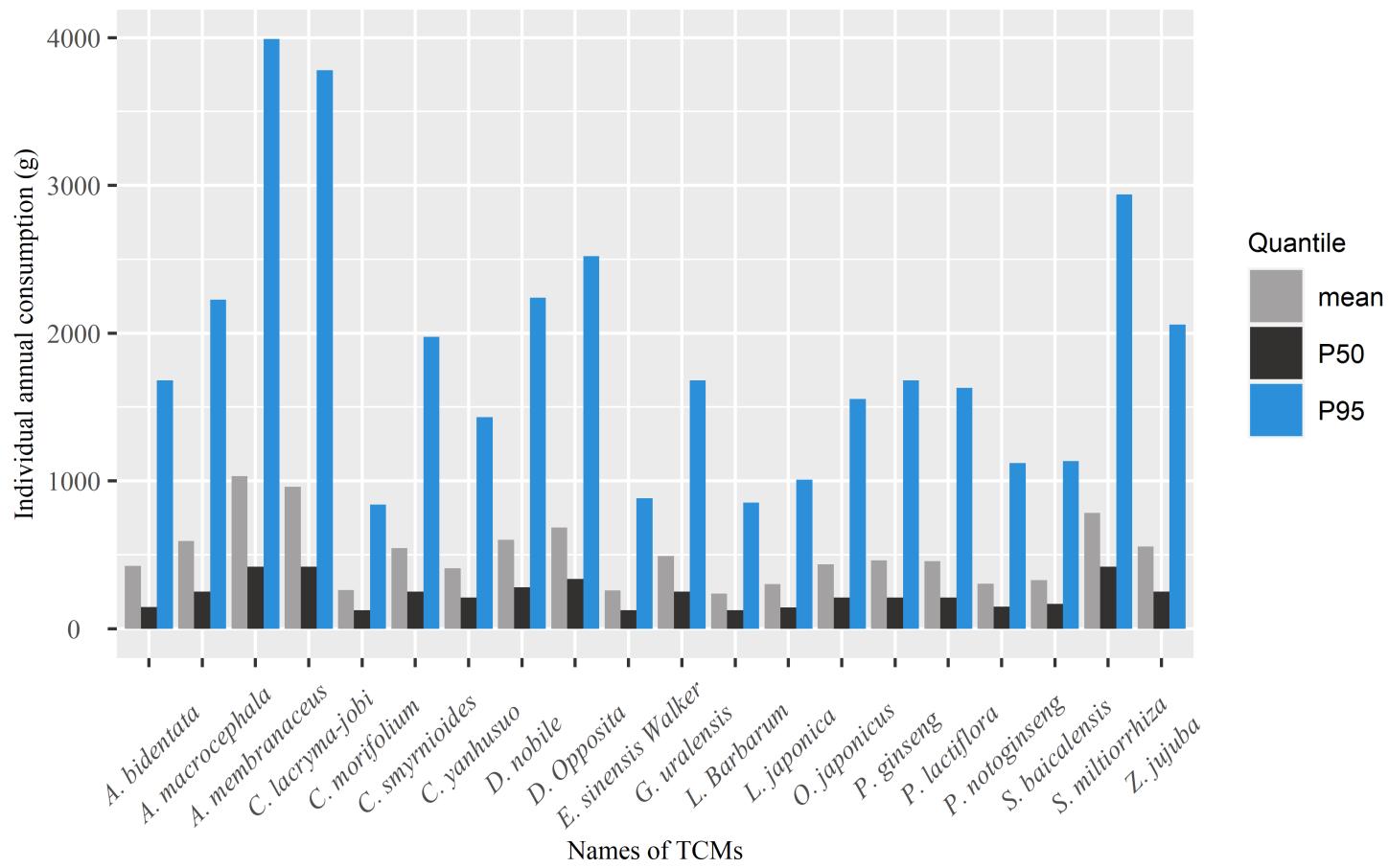


Figure 4

Averages and quantiles of the annual consumption of 20 specific TCMs