

## Prevalence of fatty liver disease and the economy in China: A systematic review

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economy and the adult prevalence of fatty liver disease (FLD) in mainland China.

**METHODS:** Literature searches on the PubMed and Chinese National Knowledge Infrastructure databases were performed to identify eligible studies published before July 2014. Records were limited to cross-sectional surveys or baseline surveys of longitudinal studies that reported the adult prevalence of FLD and recruited subjects from the general population or community. The gross domestic product (GDP) per capita was chosen to assess the economic status. Multiple linear regression and Loess regression were chosen to fit the data and calculate the 95% CIs. Fitting and overfitting of the models were considered in choosing the appropriate models.

**RESULTS:** There were 27 population-based surveys from 26 articles included in this study. The pooled mean prevalence of FLD in China was 16.73% (95%CI: 13.92%-19.53%). The prevalence of FLD was correlated with the GDP per capita and survey years in the country (adjusted  $R^2 = 0.8736$ ,  $P_{\text{GDP per capita}} = 0.00426$ ,  $P_{\text{years}} = 0.0000394$ ), as well as in coastal areas ( $R^2 = 0.9196$ ,  $P_{\text{GDP per capita}} = 0.00241$ ,  $P_{\text{years}} = 0.00281$ ). Furthermore, males [19.28% (95%CI: 15.68%-22.88%)] presented a higher prevalence than females [14.1% (95%CI: 11.42%-16.61%),  $P = 0.0071$ ], especially in coastal areas [21.82 (95%CI: 17.94%-25.71%) vs 17.01% (95%CI: 14.30%-19.89%),  $P = 0.0157$ ]. Finally, the prevalence was predicted to reach 20.21% in 2020, increasing at a rate of 0.594% per year.

**CONCLUSION:** This study reveals a correlation between the economy and the prevalence of FLD in mainland China.

**Key words:** Fatty liver disease; Epidemiology; Gross domestic product per capita; Prevalence; Economy

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### Abstract

**AIM:** To investigate the relationship between the

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**Core tip:** The influence of the economy on the prevalence of fatty liver disease (FLD) is unclear, especially in China, which was the world's fastest-growing major economy. In this study, a systematic review of population-based surveys was performed to explore the adult prevalence of FLD in mainland China. The gross domestic product per capita was chosen as an indicator to evaluate local economic status. Our analysis indicated that the mean prevalence of FLD in China was 16.73% and that the prevalence increased as China's economy developed over the past 20 years. In addition, the prevalence over the next 7 years was estimated based on the current trend.

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## INTRODUCTION

Fatty liver disease (FLD), characterized by macrovesicular steatosis in hepatocytes, is a chronic liver disorder that can progress to hepatic cirrhosis, hepatic failure and even hepatocellular carcinoma<sup>[1]</sup>. FLD can be divided into nonalcoholic fatty liver disease (NAFLD) and alcoholic liver disease (ALD) based on the assessment of ethanol consumption<sup>[2,3]</sup>. According to the guidelines of the European Association for the Study of the Liver, NAFLD is diagnosed when ethanol consumption is less than or equal to 20 g/d in females and 30 g/d in males after the exclusion of other causes, hepatitis virus infection and of steatogenic drug administration<sup>[4]</sup>. In addition to excess alcohol intake, factors such as insulin resistance (IR), oxidative stress, mitochondrial dysfunction, immune deregulation, and adipokine release play important roles in the pathogenesis of FLD<sup>[5-7]</sup>.

In the past decades, with a prevalence reaching approximately 30%, FLD has become one of the most common chronic liver disorders in industrialized Western countries<sup>[8]</sup>. It has been accepted that lifestyle changes significantly with economic development. With economic growth rates averaging 10% over the past 30 years, Westernized diet, alcoholic beverage intake and sedentary lifestyle have dramatically reshaped the pattern of Chinese daily life. The gradually growing prevalence of obesity, diabetes, dyslipidemia, and metabolic syndrome (MS) has put the Chinese population at the risk of developing FLD<sup>[9,10]</sup>.

As mentioned above, the prevalence of FLD might vary with the change in lifestyle. A higher economic status tends to come with better material condition.

Nevertheless, the fast pace and heavy pressure of life and work also bring problems of unhealthy diet, increased alcohol consumption and less physical exercise in the meantime. This phenomenon could have led to the diversity of FLD prevalence among the areas with different economic statuses. A limited number of studies have hypothesized that compared with developed areas, FLD is considered to be less common in underdeveloped areas<sup>[10,11]</sup>. However, the influence of the economic status on the prevalence of FLD is unclear, especially in China, which has the world's fastest-growing major economy.

In this study, a systematic review of population-based surveys was performed to explore the adult prevalence of FLD in mainland China. By linking the prevalence to the economy, we believe that the results will be valuable to evaluate the prevalence of FLD from a novel epidemiological perspective.

## MATERIALS AND METHODS

### Search strategies and study inclusion

In this study, the Preferred Reporting Items for Systemic Reviews and Meta-Analyses (PRISMA) guidelines were used for the study evaluation and protocol description<sup>[12]</sup>. Literature searches on the PubMed and Chinese National Knowledge Infrastructure (CNKI) databases were performed to identify eligible studies published before July 10, 2014. The searches were conducted with the following terms: (fatty liver) and (prevalence or incidence or epidemic OR morbidity).

Records were limited to cross-sectional surveys or baseline surveys of longitudinal studies that offered the adult prevalence of FLD and recruited subjects from the general population or community. Additionally, surveys were included if they provided the age- and sex-adjusted prevalence based on the local population census. Convenience studies were excluded, including hospital check-up program and surveys examining adolescent or elderly or sub-groups from a specific career or race. In terms of the sample size, at least 500 adults (aged 15 years and older) were involved in each survey. If multiple studies were conducted from the same population, the authors were contacted to avoid duplication. Abstracts or unpublished data were not included.

Two investigators (Wang YM and Dai YN) performed independently the eligibility evaluation. The agreement between the two investigators was evaluated by kappa coefficient. Any disagreements on study eligibility or data extraction were resolved according to a third reviewer's opinion (Zhu JZ).

### Data extraction

Data were independently extracted according to the meta-analysis of observational studies in epidemiology (MOOSE) guideline and the results were crosschecked<sup>[13]</sup>.

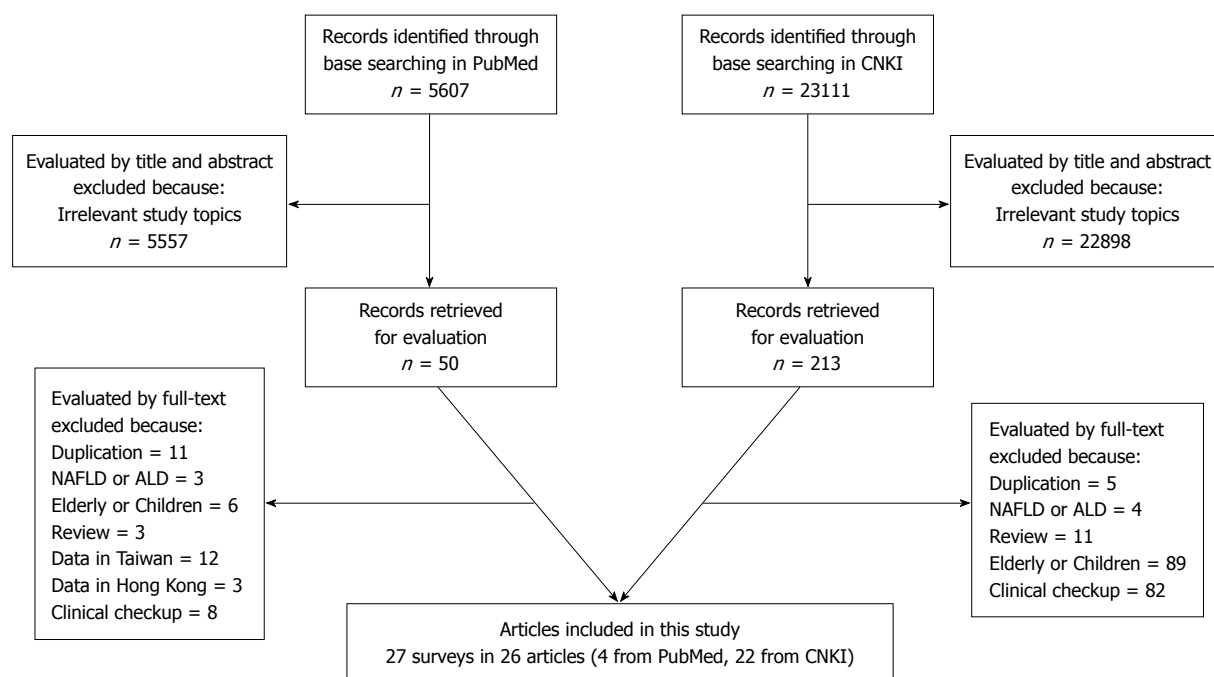


Figure 1 Flowchart of the study evaluation process.

If there were discrepancies in the extracted data, a consensus was reached by reviewing of the original reports and engaging in further discussion. Data were extracted to a Microsoft Excel spreadsheet (2011 Edition for Mac; Microsoft, Redmond, WA, United States) and stored for further utilization. From each study, two researchers (Wang YM and Dai YN) independently extracted the information as follows: author(s), publication year, year(s) when the survey was conducted, region(s), recruitment methods, diagnosis criteria, number of subjects, age range, the prevalence in the general population and the gender-specific prevalence, if available.

### Gross domestic product per capita and Chinese economic geography

The Gross domestic product (GDP) per capita was chosen to assess the local economic status for the survey year. The GDP per capita information is available on the National Bureau of Statistics of China<sup>[14]</sup> website or can be acquired from the yearbooks of the local Bureau of Statistics *via* an internal network.

If one study was concerned with multiple cities in a province, the data of the province were considered in the analysis. Provided that the survey was performed for more than one year, the middle-year of the period was regarded as the survey year in the analysis. If an article failed to offer the precise time when the survey was conducted, the year was estimated according to the following equation: survey year = publication year - mean survey duration (2.57 years, according to the available data).

In addition, the GDP per capita in 2013-2020 was estimated according to the data from 2013, the

growing rate over the past 5 years and The Twelfth Five-Year Guideline<sup>[15]</sup> approved by the National People's Congress.

The method used to separate the interior areas from the coastal areas was referred from the Wikipedia page concerning Chinese economic geography<sup>[16]</sup>.

### Data synthesis and statistical analysis

All statistical tests were two-sided, and all statistical analyses were carried out with RStudio software (version 0.98.484; RStudio, Inc., Boston, MA, United States). The significance level was set at 0.05. Data visualization was utilized to gain the initial distribution of the data, which allowed the authors to build models. Multiple linear regression and Loess regression were chosen to fit the data and to calculate 95% CIs. Fitting and overfitting of the models were considered in choosing appropriate models. An unpaired *t*-test was used to compare one value in two related samples. Associated data were plotted using RStudio software and Prism 6 (GraphPad, San Diego, CA, United States).

## RESULTS

### Studies involved

As shown in Figure 1, 5607 records on PubMed and 23111 records on CNKI were obtained from the literature search. From those, 50 articles on PubMed and 213 articles on CNKI that appeared to be relevant to the topic were identified. Finally, 27 surveys from 26 articles (4 English and 22 Chinese) were included in this study (Table 1).

Table 2 and Figure 2 show that according to geography, there were 8 surveys conducted in the

**Table 1** Characteristics of surveys included in the study

Ref.	Publication year	Survey year	No. of subjects	Prevalence (%)	Male prevalence (%)	Female prevalence (%)	Cities, provinces	Recruitment methods
Shang <i>et al</i> <sup>[35]</sup>	2004	2003	14950	7.85	9.12	5.41	Handan, Hebei	Random multistage stratification and cluster sampling
Fan <i>et al</i> <sup>[36]</sup>	2005	2002-2003	3175	17.29	19.30	15.08	Shanghai	Random multistage stratification and cluster sampling
He <i>et al</i> <sup>[37]</sup>	2006	2001-2005	14069	17.80	21.70	10.90	Fuoshan, Guangdong	All residents in selected communities
Chen <i>et al</i> <sup>[38]</sup>	2006	NA	670	12.52	23.54	9.53	Nantong, Jiangsu	All residents in selected communities
Peng <i>et al</i> <sup>[39]</sup>	2007	2006	5313	9.80	NA	NA	Shantou, Guangdong	All residents in selected communities
Ma <i>et al</i> <sup>[40]</sup>	2007	NA	2043	13.81	18.55	14.54	Guangdong	Random multistage stratification and cluster sampling
Zhou <i>et al</i> <sup>[41]</sup>	2007	2005	3164	19.09	21.07	18.03	Guangdong	Random multistage stratification and cluster sampling
Zhang <i>et al</i> <sup>[42]</sup>	2007	NA	15701	4.80	5.09	4.21	Guangxi	All residents in selected communities
Wang <i>et al</i> <sup>[43]</sup>	2007	1995-2004	12247	22.20	28.10	13.80	Wuhan, Hubei	All residents in selected communities
Tang <i>et al</i> <sup>[44]</sup>	2007	2006	628	4.10	NA	NA	Zhuzhou, Hunan	Cluster sampling
Luo <i>et al</i> <sup>[45]</sup>	2007	NA	5267	24.20	30.77	17.32	Shaoyang, Hunan	Random multistage stratification and cluster sampling
Huang <i>et al</i> <sup>[46]</sup>	2007	2005	1495	16.76	19.90	10.20	Nantong, Jiangsu	Random multistage stratification and cluster sampling
Shi <i>et al</i> <sup>[47]</sup>	2007	NA	5703	3.50	NA	NA	Shenyang, Liaoning	Cluster sampling
Yan <i>et al</i> <sup>[48]</sup>	2007	2005	1500	16.46	20.72	7.34	Shanxi/Gansu	Random multistage stratification and cluster sampling
Zhou <i>et al</i> <sup>[49]</sup>	2009	NA	95567	19.86	22.37	17.20	Ningbo, Zhejiang	Random multistage stratification and cluster sampling
Yu <sup>[50]</sup>	2010	2008	14739	14.97	11.60	18.25	Nanjing, Jiangsu	All residents in selected communities
Yi <sup>[51]</sup>	2011	NA	669	9.26	NA	NA	Jiangmen, Guangdong	All residents in selected communities
Zhang <i>et al</i> <sup>[52]</sup>	2011	2010	1116	15.68	19.07	14.15	Dongguan, Guangdong	All residents in selected communities
Lu <i>et al</i> <sup>[53]</sup>	2011	2009-2010	502	16.40	18.30	14.85	Guangzhou, Guangdong	Random multistage stratification and cluster sampling
Qu <i>et al</i> <sup>[54]</sup>	2011	2008	9871	7.22	7.86	6.55	Yichang, Hubei	Random multistage stratification and cluster sampling
Shi <i>et al</i> <sup>[55]</sup>	2011	2007	3815	19.06	19.31	19.18	Changchun, Jilin	Random sampling
Zheng <i>et al</i> <sup>[56]</sup>	2011	2008	1872	11.96	14.58	10.26	Wenzhou, Zhejiang	Cluster sampling
Qin <i>et al</i> <sup>[57]</sup>	2012	2011	3017	21.25	24.53	20.40	Shanghai	Cluster sampling
Yan <i>et al</i> <sup>[58]</sup>	2013	NA	3762	35.10	45.30	30.00	Beijing	Random multistage stratification and cluster sampling
Pan <i>et al</i> <sup>[59]</sup>	2014	2012-2013	800	21.00	26.75	15.06	Guangzhou, Guangdong	Random multistage stratification and cluster sampling
Zhou <sup>[60]</sup>	2014	2008	6129	20.54	20.11	20.86	Shanghai	All residents in selected communities
Zhou <sup>[60]</sup>	2014	2012	6298	22.39	25.05	20.47	Shanghai	All residents in selected communities

NA: Not applicable.

interior areas and 19 in the coastal areas. Additionally, 23 surveys presented data concerning the prevalence in males and females.

The diagnostic criteria mainly included the guidelines established by the Chinese Medical Association (11 surveys using the 2002 Edition<sup>[17,18]</sup>, 5 surveys using the 2006 Edition<sup>[19,20]</sup>, and 1 survey

using the 2010 Edition<sup>[21,22]</sup>, Table 3). Furthermore, all of the surveys chose ultrasound as the diagnostic tool. The recruitment methods used in these surveys primarily comprised random multistage stratification and cluster sampling (Table 1). In addition, agreement between the researchers for the evaluation of study eligibility was excellent (kappa statistic, 0.893).

Table 2 Pooled prevalences and correlation analyses

	No. of studies	Weighted mean prevalence (%)	Lower-upper 95%CI (%)	Correlations between prevalence, survey years and GDP per capita			
				Adjusted $R^2$	P value		Equations
					GDP per capita	Survey years	
Mainland China	27	16.73	13.92-19.53	0.8736	0.00426	0.0000394	Prevalence = 0.0001352 x GDP per capita + 0.005158 x year
Region							
Interior areas	8	11.93 <sup>1</sup>	5.11-18.74	0.7150	NA	0.0025100	Prevalence = 0.006601 x year
Coastal areas	19	18.53 <sup>1</sup>	15.37-21.68	0.9196	0.00241	0.0028100	Prevalence = 0.0001591 x GDP per capita + 0.004391 x year
Gender							
Female	23	14.01 <sup>2</sup>	11.42-16.61	0.9110	0.000808	0.0000554	Prevalence = 0.0001333 x GDP per capita + 0.004394 x year
Male	23	19.28 <sup>2</sup>	15.68-22.88	0.8741	0.066800	0.0000248	Prevalence = 0.0001108 x GDP per capita + 0.007886 x year
Region + Gender							
Females in interior areas	7	9.29 <sup>3</sup>	3.65-14.94	0.7394	NA	0.0038200	Prevalence = 0.00526 x year
Females in coastal areas	16	17.10 <sup>3,4</sup>	14.30-19.89	0.9397	0.008230	0.0017300	Prevalence = 0.0001243 x GDP per capita + 0.0047037 x year
Males in interior areas	7	13.92	4.53-23.31	0.7330	NA	0.0041200	Prevalence = 0.008618 x year
Males in coastal areas	16	21.82 <sup>4</sup>	17.94-25.71	0.9132	0.096440	0.0015600	Prevalence = 0.0001172 x GDP per capita + 0.007758 x year

<sup>1</sup>The P-value is 0.2420, interior *vs* coastal areas; <sup>2</sup>The P-value is 0.0071, female *vs* male; <sup>3</sup>The P-value is 0.0329, female: interior areas *vs* coastal areas; <sup>4</sup>The P-value is 0.0157, coastal areas: female *vs* male. NA: Not applicable.

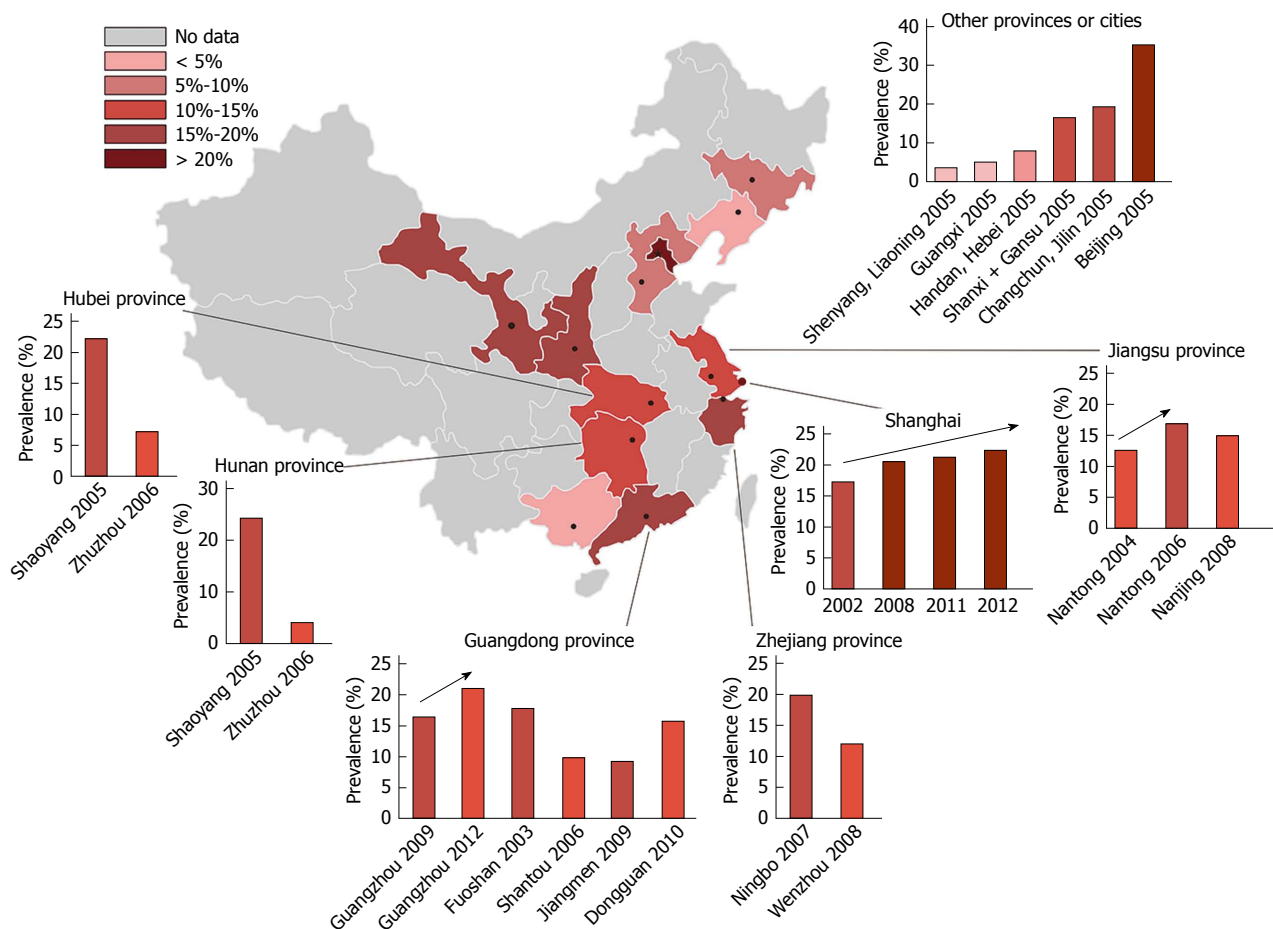


Figure 2 Prevalence in China.



**Table 3** Characteristics of surveys included in the study

Ref.	Publication year	Survey year	Years in analysis	GDP per capita (Yuan)	Diagnosis criteria	Ages of subjects
Shi <i>et al</i>	2007	NA	2005	29985	NA	18
Tang <i>et al</i>	2007	2006	2006	16526	Self-defined	18
Zhang <i>et al</i>	2007	NA	2006	8762	NA	20
Qu <i>et al</i>	2011	2008	2008	25445	Standards of Ultrasonic Medicine (Chunzheng Wang, 2006, People's Medical Publishing House)	35-74
Shang <i>et al</i>	2004	2003	2003	8936	Chinese Medical Association, 2002 Guideline	NA
Yi <i>et al</i>	2011	NA	2009	32484	6th Chinese Academic Materials, People's Medical Publishing House	18
Peng <i>et al</i>	2007	2006	2006	14956	Ultrasonic Medicine (Yong-Chang Zhou, 2006, Scientific and Technical Documentation Press)	NA
Zheng <i>et al</i>	2011	2008	2008	31555	Chinese Medical Association, 2006 Guideline	18
Chen <i>et al</i>	2006	NA	2004	15806	Chinese Medical Association, 2002 Guideline	20
Ma <i>et al</i>	2007	NA	2005	41166	Chinese Medical Association, 2002 Guideline	18
Yu <i>et al</i>	2010	2008	2008	49744	Ultrasonic Medicine (Yong-Chang Zhou, 2006, Scientific and Technical Documentation Press)	20
Zhang <i>et al</i>	2011	2010	2010	51653	NA	NA
Lu <i>et al</i>	2011	2009-2010	2009	79383	Chinese Medical Association, 2002 Guideline	18
Yan <i>et al</i>	2007	2005	2005	14847	Chinese Medical Association, 2006 Guideline	18-81
Huang <i>et al</i>	2007	2005	2005	19061	Chinese Medical Association Guideline, unknown year	NA
Fan <i>et al</i>	2005	2002-2003	2002	33958	Chinese Medical Association, 2002 Guideline	16
He <i>et al</i>	2006	2001-2005	2003	28162	Chinese Medical Association, 2002 Guideline	16
Shi <i>et al</i>	2011	2007	2007	28131	Chinese Medical Association, 2006 Guideline	18
Zhou <i>et al</i>	2007	2005	2005	41166	Chinese Medical Association, 2006 Guideline	18
Zhou <i>et al</i>	2009	NA	2007	61032	Chinese Medical Association, 2002 Guideline	18
Zhou <i>et al</i>	2014	2008	2008	66932	Chinese Medical Association, 2002 Guideline	35
Pan <i>et al</i>	2014	2012-2013	2012	106909	Self-defined	20
Qin <i>et al</i>	2012	2011	2011	82560	Chinese Medical Association, 2010 Guideline	40-70
Wang <i>et al</i>	2007	1995-2004	1999	14751	Chinese Medical Association, 2002 Guideline	18
Zhou <i>et al</i>	2014	2012	2012	85373	Chinese Medical Association, 2002 Guideline	35
Luo <i>et al</i>	2007	NA	2005	5439	Chinese Medical Association, 2002 Guideline	18
Yan <i>et al</i>	2013	NA	2011	80394	Chinese Medical Association, 2006 Guideline	20

NA: Not applicable.

**Prevalence**

**Mainland China:** As indicated in Table 2, the mean prevalence of FLD in mainland China was 16.73% (95%CI: 13.92%-19.53%).

**Region**

The prevalence of FLD was 11.93% (95%CI: 5.11%-18.74%) in the interior areas, while it was 18.53% (95%CI: 15.37%-21.68%) in the coastal areas. No apparent difference was found in the general prevalence between the two areas ( $P = 0.2420$ , Figure 3A).

**Gender**

In terms of gender, the mean prevalence was 14.1% (95%CI: 11.42%-16.61%) in females, whereas it was 19.28% (95%CI: 15.68%-22.88%) in males, which was significantly higher than the female prevalence ( $P = 0.0071$ , Figure 3D).

**Cross-comparisons between gender and region**

In the interior areas, the prevalence of FLD between males [13.92% (95%CI: 4.53%-23.31%)] and females [9.29% (95%CI: 3.65%-14.94%)] showed no difference ( $P = 0.1584$ , Figure 3E). By contrast,

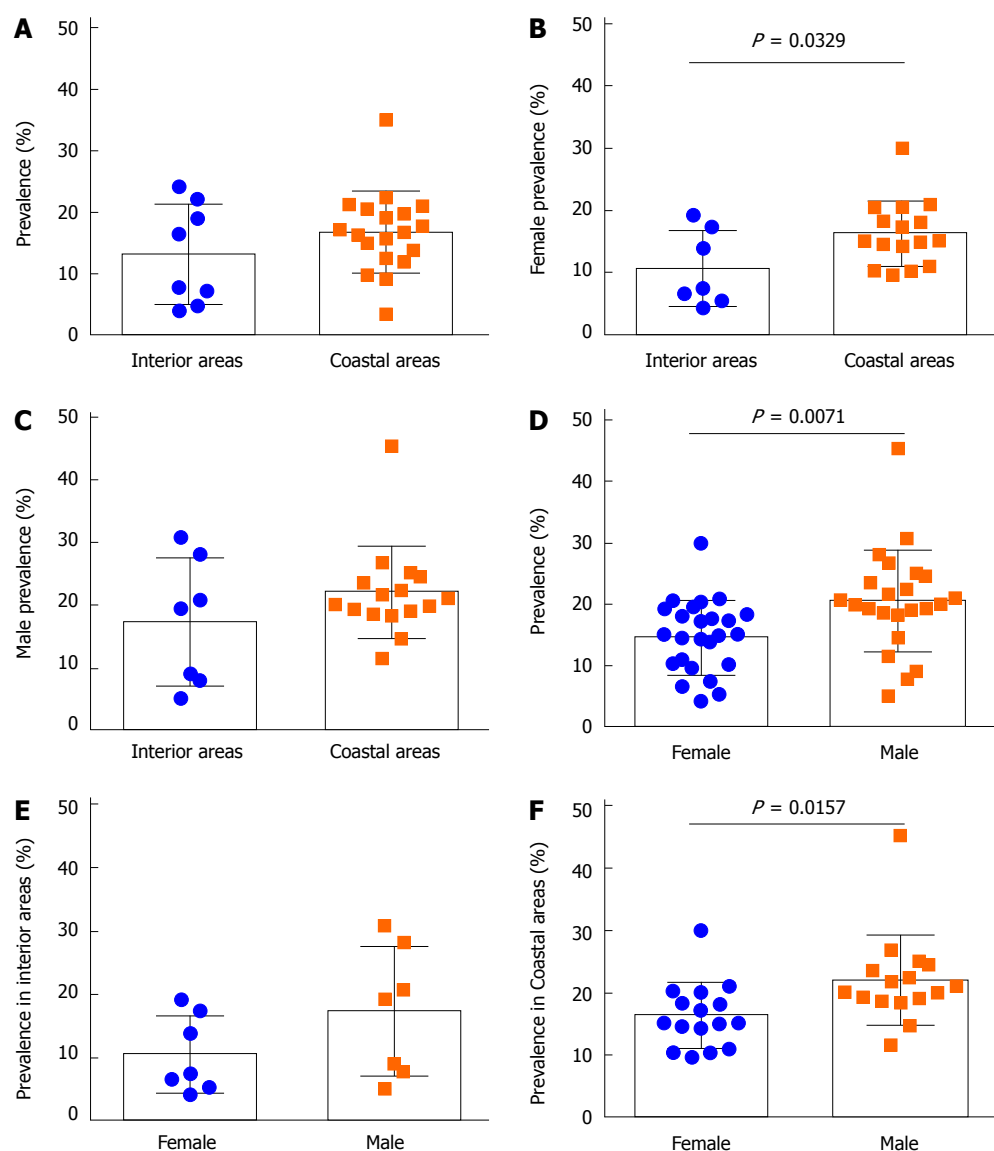
in the coastal areas, males [21.82% (95%CI: 17.94%-25.71%)] presented a higher prevalence of FLD than females [17.01% (95%CI: 14.30%-19.89%)] ( $P = 0.0157$ , Figure 3F). Furthermore, the prevalence of FLD in females in the interior areas was lower than that in the coastal areas ( $P = 0.0329$ , Figure 3B).

**Correlations**

**General:** A significant correlation of the prevalence of FLD with GDP per capita and survey years was detected ( $R^2 = 0.8736$ ,  $P_{\text{GDP per capita}} = 0.00426$ ,  $P_{\text{years}} = 0.0000394$ , Figure 4A and Table 2).

**Region:** Although the prevalence of FLD correlated with the survey years ( $R^2 = 0.715$ ,  $P = 0.00251$ ), the interior areas failed to present a correlation of the prevalence with the GDP per capita. Interestingly, in the coastal areas, a correlation of the prevalence of FLD with the GDP per capita and survey years was observed ( $R^2 = 0.9196$ ,  $P_{\text{GDP per capita}} = 0.00241$ ,  $P_{\text{years}} = 0.00281$ , Figure 4A and Table 2).

**Gender:** Twenty-three surveys provided the prevalence of FLD by gender and indicated the correlation of the prevalence with GDP per capita and survey years



**Figure 3** Comparisons of the prevalence of fatty liver disease according to gender and region. A: All: Interior areas vs coastal areas; B: Females: interior areas vs coastal areas; C: Males: interior areas vs coastal areas; D: All: females vs males; E: Interior areas: females vs males; F: Coastal areas: females vs males.

in females ( $R^2 = 0.911$ ,  $P_{\text{GDP per capita}} = 0.000808$ ,  $P_{\text{years}} = 0.0000554$ , Figure 4C and Table 2). However, the prevalence of FLD in males failed to correlate with the GDP per capita ( $R^2 = 0.8741$ ,  $P_{\text{GDP per capita}} = 0.0668$ ,  $P_{\text{years}} = 0.0000248$ , Figure 4B and Table 2).

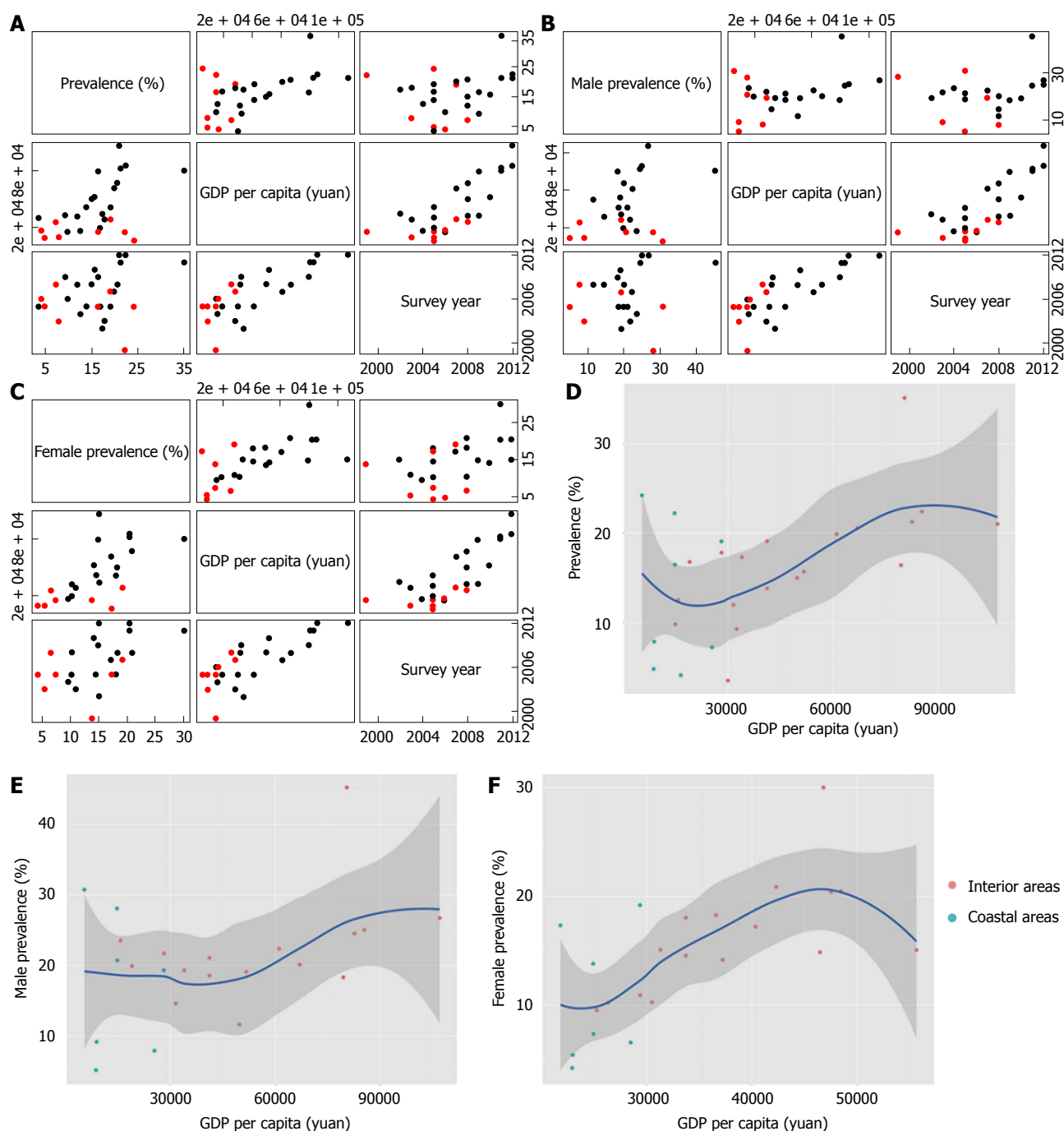
#### Cross-analyses between gender and location:

In Table 2, the interior areas presented correlations only between the survey year and the prevalence of FLD in males ( $R^2 = 0.733$ ,  $P = 0.00412$ ) and females ( $R^2 = 0.7394$ ,  $P = 0.00382$ ), individually. By contrast, in the coastal areas, a correlation of the female FLD prevalence with the GDP per capita and survey years was observed ( $R^2 = 0.9397$ ,  $P_{\text{GDP per capita}} = 0.00823$ ,  $P_{\text{years}} = 0.00173$ , Table 2). However, the prevalence did not seem to correlate with the GDP per capita for males ( $R^2 = 0.9132$ ,  $P_{\text{GDP per capita}} = 0.09644$ ,  $P_{\text{years}} = 0.00156$ , Table 2).

#### Trend of the prevalence

**General trends:** As shown in Figure 4D, the general prevalence of FLD increased along with the GDP per capita in mainland China, although two slight decreases were observed in two ranges (GDP per capita < 30000 Yuan and GDP per capita > 90000 Yuan). Regarding gender, the prevalence of FLD in males increased steadily (Figure 4E), whereas the trend of the prevalence in females dropped remarkably, after the time when GDP per capita reached approximately 8000 yuan (Figure 4F).

**Trends in cities:** Figure 2 displays the multiple surveys conducted in Shanghai (2002, 2008, 2011 and 2012), Nantong (2004 and 2005) and Guangzhou (2009 and 2012). It was evident that all of the three cities witnessed an upward trend of the FLD prevalence in the past decade. Specifically, the prevalence in



**Figure 4** Correlations of the prevalence with the gross domestic product per capita and survey years. A: The general prevalence; B: The prevalence in males; C: The prevalence in females (Black spots: Studies in coastal areas; Red spots: Studies in interior areas). Survey years and changes of the prevalence according to the gross domestic product (GDP) per capita; D: The general prevalence; E: The prevalence in males; F: The prevalence in females (Red spots: Studies in coastal areas; Green spots: Studies in interior areas).

Shanghai was 17.29% in 2002, which increased to 20.54% in 2008 and 21.25% in 2011, and reached 22.39% in 2012.

#### Prevalence from 2013 to 2020

Given the equation of the GDP per capita, survey years and prevalence obtained by regression analysis ( $\text{Prevalence} = 0.0001352 \times \text{GDP per capita} + 0.005158 \times \text{year}$ ) in Table 2, the prevalence of FLD in China from 2013 to 2020 was estimated (Figure 5). Based on this

calculation, the prevalence will stably increase at a rate of 0.594% per year to 20.21% by 2020.

## DISCUSSION

This study revealed that the weighted mean prevalence of FLD in mainland China was 16.73%. The correlation of the prevalence with the GDP per capita and survey years demonstrated that the prevalence of FLD in China increased along with China's economic



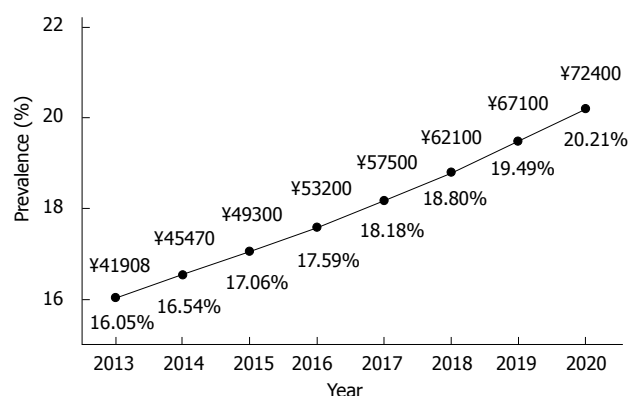


Figure 5 Estimated prevalence of fatty liver disease from 2013 to 2020, based on the current trend.

development in the past 20 years.

After the United States, China has the second largest economy in the world by the nominal GDP and by purchasing power parity. It is the world's fastest-growing major economy, with growth rates averaging 10% over the past 30 years. It is well known that the coastal areas have obtained the highest benefit for the recent development of the Chinese economy. By contrast, the interior areas tend to be regarded as the less well-developed areas.

Population aging, urbanization, Westernized diet, increased alcoholic beverage consumption, and sedentary lifestyle, along with a consequent obesity and diabetes epidemic, have probably led to the rapid increase in the FLD burden in the Chinese population<sup>[10]</sup>. The Chinese dietary structure has recently changed, with traditional Chinese food being replaced by foods that are higher in fat, sugar, and salt. Owing to the rapid rate of urbanization, the Chinese lifestyle is experiencing a series of changes, including a reduction in physical activity.

Given this background, obesity and MS have drawn widespread concern. It had been confirmed that obesity predisposes the individuals to the development of both ALD<sup>[23]</sup> and NAFLD<sup>[24]</sup>, whereas the latter has been recognized as the liver manifestation of MS<sup>[25]</sup>. Popkin *et al.*<sup>[26]</sup> reported a difference in the association between the socioeconomic status and obesity in rural and urban areas in China in 1993. Another study by Li *et al.*<sup>[27]</sup> suggested that the pooled prevalence of NAFLD in the northern part of China is higher than in the southern part (21.87% and 18.21%, respectively). A national survey concerning the diabetes prevalence in China by Yang *et al.*<sup>[28]</sup> revealed that there was a remarkable upward trend of the prevalence of diabetes in China, increasing from 2.5%<sup>[29]</sup> in 1994 to 5.5%<sup>[30]</sup> in 2001 and reaching 9.7% in 2008. This study also suggested that the level of economic development and the associated lifestyle and diet might explain the differences in the prevalence of diabetes between persons living in urban settings and those living in rural areas. There can be little doubt that the risks for the

development and progression of ALD are increasing as the intake of alcohol increases<sup>[31,32]</sup>. China witnessed a consistent upward trend of recorded alcohol consumption per capita between 2000 and 2010, according to Global Information System on Alcohol and Health<sup>[33]</sup>. The previous studies have also revealed a male predominance in the prevalence of NAFLD. A previous meta-analysis showed that the prevalence of NAFLD in males was almost two times that of females<sup>[27]</sup>. A possible reason for this is the difference in hormonal regulation between males and females<sup>[34]</sup>.

In this study, the prevalence of FLD was confirmed to correlate with the GDP per capita and survey years in mainland China and in the coastal areas. In contrast, the prevalence in the interior failed to correlate with the GDP per capita. Additionally, the prevalence between the interior areas and the coastal areas failed to present a difference. The two negative results probably stemmed from the notable diversity among the studies in the interior. The results above demonstrated that the prevalence of FLD in mainland China increased as the economy developed, especially in the coastal areas.

Regarding gender, males presented a higher prevalence than females in mainland China and in the coastal areas. Furthermore, the prevalence of FLD in females in the interior was lower than that in the coastal areas. Interestingly, the female FLD prevalence correlated with the GDP per capita and survey years within the country and in the coastal areas.

Shanghai, the largest city and the commercial and financial center of China, displayed a steadily rising trend of the FLD prevalence from 2002 to 2012. Correspondingly, the similar rise was observed in Guangzhou and Nantong, two well-developed cities in the coastal areas. Additionally, based on the current trend, the prevalence of FLD in China was predicted to reach 20.21% in 2020, increasing at a rate of 0.594% per year.

This study has several strengths. First, the GDP per capita was chosen as an indicator to evaluate the local economic status. In addition, considering the diversity of the economy and environment, 22 cities and 2 provinces were divided into two groups, the interior and the coastal. Finally, the prevalence over the next 7 years was estimated based on the current trend.

In terms of weaknesses, first, this study failed to compare the rural and the urban areas, owing to a lack of GDP per capita. Second, there were several factors that were difficult to detect, including ethnic, dietary or cultural disparities among areas. Moreover, although ALD and NAFLD differ in a series of characteristics, ranging from differences in clinical features to patient outcomes, this study failed to separately process the two prevalences because most Chinese records only offered FLD data, not separated data. Finally, the numbers of studies from the interior and the coastal

areas were clearly imbalanced. More studies reporting the prevalence in the west and the central areas are required.

In conclusion, this is the first study to explore the relationship between the economy and the prevalence of FLD in mainland China. This study demonstrated that the prevalence increased as the GDP per capita grew over the past 20 years, especially in the coastal areas. In addition, males presented a higher prevalence than females in the country and in the coastal areas in particular. We believed that this study suggests a symbiotic correlation between the prevalence of FLD and the economy, offering a novel epidemiologic perspective on the global situation of FLD.

## COMMENTS

### Background

A limited number of studies have hypothesized that compared with developed areas, fatty liver disease is considered to be less common in underdeveloped areas. However, the influence of the economic status on the prevalence of fatty liver disease is unclear, especially in China, which has the world's fastest-growing major economy.

### Research frontiers

With the remarkable economic development in the past decades, population aging, urbanization, Westernized diet, increased alcoholic beverage consumption, and sedentary lifestyle probably contributed to the rapid increase of fatty liver disease in China.

### Innovations and breakthroughs

This study revealed that the weighted mean prevalence of fatty liver disease (FLD) in mainland China was 16.73%. Furthermore, the correlation of the prevalence with the gross domestic product (GDP) per capita and survey years demonstrated that the prevalence of FLD in China increased with the development of China's economy over the past 20 years.

### Applications

This study suggested a symbiotic correlation between the prevalence of FLD and the economy, offering a novel epidemiologic perspective on the global status of FLD. However, more studies reporting the prevalence in the west and the central areas of China are required.

### Terminology

The GDP is the total market value of all of the final products and services produced during a specific time period in a country. It is considered to be the foremost parameter of the standard of living of a country. The GDP per capita is an indicator used by many countries to indicate the overall growth and development of a country. It is calculated by dividing the GDP by the population of the country. It is studied under macroeconomics and is related to national accounts.

### Peer-review

Authors evaluated association between prevalence of FLD and GDP in China by using published articles from 2007 to 2014. Then they made a projection for the prevalence of FLD in 2020 if GDP continues to increase steadily.

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