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# Theoretical framework for the determinants and management of food safety problem: A case study of the waste cooking oil issue in China

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The public health issue of illegal waste cooking oil in China had become a well-known food safety problem since 2010, resulting in indigestion and stomach aches when they ate them unconsciously. The Chinese government has promulgated relevant food safety regulations to prevent this public health issue from worsening. Meanwhile, Chinese researchers have already conducted corresponding research and recommended several associated policy implementations; however, this illegal waste cooking oil issue persists more than 10 years later. Hence, a systematic and comprehensive analysis of the determinants and management of the waste cooking oil issue is needed to be reassessed. Unlike previous research based on first-hand data and the principles of grounded theory analysis, this novel research is the first attempt to employ second-hand data from 152 court judgments collected from the China Judgments Online official database by engaging the grounded theory analysis to develop a new theoretical framework. The results demonstrate that legal loopholes, food hygiene inspectors, and consumer self-protection consciousness are the three crucial determinant factors in this China's public health issue. As well, offender crime patterns and case characteristics play an essential role in leading to the final food safety. Furthermore, the demographic profiles of these public health criminals are also validated in the discussion part, including the criminals' age, educational background, the average judgment amount, and the sentencing span specific type of crime. Based on the findings, we propose three management guidelines for Chinese legislation: redefining the waste cooking oil issue, raising the hot pot restaurant sanitation permission threshold, and improving overall food safety awareness and education in communities. Importantly, our research outcomes could provide a new theoretical basis for China's waste cooking oil and other public health issues in China and even worldwide.

KEYWORDS

**food safety, grounded theory, court judgments, China, waste cooking oil, public health, theoretical frameworks, determinants factor**

## Introduction

In China, waste cooking oil (WCO; also known as gutter oil) is an illegal edible cooking oil that is recycled from kitchens, restaurants, sewers, and slaughterhouses and then re-commercialized (Zhang et al., 2012; Lu and Wu, 2014; The Editorial Board of the New York Times, 2014; Ng et al., 2015). Significantly, WCO contains many harmful compounds that could cause serious harm to human health, resulting in indigestion and stomach aches (Liang et al., 2013; Chuah et al., 2016; Li et al., 2016; Chen and Nie, 2019). In 2010, it was reported that 10% of edible cooking oil waste returned to the Chinese table as WCO (China Youth Daily, 2010), which made its existence public and caused a huge social outcry at once. Ultimately, it resulted WCO issue into a severe public health risks and developed into a well-known social issue (Lu and Wu, 2014; Cheng et al., 2021). In the response, the Chinese government announced an urgent regulation to prevent the worsening of the WCO issue, intended to alleviate the concerns of Chinese consumers regarding food safety (China Food and Drug Administration, 2010; Lu et al., 2013). In the same report, China's famous grain and oil expert (Professor HE) stated that China might take around a decade to completely ban WCO (China Youth Daily, 2010). However, according to Yang and Shan (2021), the WCO has not been effectively solved, and it was still returned to the customer's table as edible cooking oil. Therefore, more than a decade later, it is necessary and crucial to investigate and reassess whether China has taken an in-depth approach to help address this public health issue.

At the national level, the Chinese government has promulgated regulations to prevented the spread of WCO throughout China. State Council of the People's Republic of China (2010) published *Strengthening the Improvement of WCO and Food Waste Management*. However, owing to the unclear division of labor among the various government management departments and the flawed long-term mechanism for its overall management, this regulation did not effectively prevent illegal WCO crimes from worsening. According to Liang et al. (2013) and National Bureau of Statistics of China (NBS, 2004-2020), the potential WCO production was 6.58 million tons in 2010, 2.73 times that of the European Union (NBS, 2004-2020; Liang et al., 2013), and WCO production continued to grow through 2016 (Figure 1). Consequently, State Council of the People's Republic of China (2017) urgently published *Opinions on Further Strengthening the Management of WCO* to define the specific division of labor required to address the WCO issue. Although the WCO issue was controlled to a certain extent until 2018, Chinese WCO production then began to rebound. In 2019, the potential WCO production amounted to 9.17 million tons ultimately (see Figure 1).

At the legal level, to strengthen food safety laws in China, the revised version of the Food Safety Law of the People's Republic of China was officially implemented in 2015 (FSL, 2015). However, it had several weaknesses: relatively weak operability, flawed regulations between food processing, unclear links to some food safety-related standards, and false food propaganda. Another revised version, Regulations on the Implementation of the Food Safety Law of the People's Republic of China, came into force in December 2019 (FSL, 2019). Specifically, four new measures were added: strengthening the usage of food safety risk monitoring results, regulating the formulation of local food safety standards, allowing food producers and operators to implement the norm before the implementation date, and clarifying the scope of corporate filing standards. As a result, since 2010 the WCO outbreak nationally, China's food safety laws and regulations have become more severe; however, the WCO issue has not yet been fundamentally resolved (Yang and Shan, 2021).

On the other hand, because of the country's rapid modernization and industrialization, public health problems in China have become more profound and contributed to a rapid decline in social confidence among Chinese consumers (Yan, 2012; Lam et al., 2013; Xue and Zhang, 2013; Cheng et al., 2017; Kendall et al., 2019). Many researchers have proposed specific WCO implementation standards based on those of other developed countries (Lu et al., 2013; Zhang et al., 2014; Chen et al., 2015). To combat food safety issues caused by WCO, researchers have recommended that the Chinese government enforce food safety laws and strengthen food safety surveillance (Lu and Wu, 2014), improve measurement and recycling technologies (Li et al., 2017), explore a new sustainable development solution (converting into biodiesel production; Chen et al., 2021), and eliminate the garbage disposal fees charged to restaurants (Zhang et al., 2017). Although the government has established several regulations and monitoring systems to address food safety problems, the implementation of these measures is often not coordinated with each other (Lam et al., 2013). Moreover, policymakers have often lacked the development expertise and knowledge to formulate moderate policies and strategies (Villarroel Walker et al., 2017; Tangtinthai et al., 2019; Zheng et al., 2020). Unfortunately, there has also been an absence of empirical evidence on the circumstances behind the continuation of WCO usage. In addition, few studies have highlighted the characteristics of the perpetrators, such as their age group and education level.

While previous studies have contributed to the resolution of the WCO issue, there are three remaining challenges. First, the research has focused on the ideal state for analyzing WCO and neglected the main body of WCO criminality. Second, most research has ignored whether the WCO-related crimes committed now are the same as they were 10 years ago. Although the technical level of WCO-biodiesel production conversion in China has improved, the WCO issue cannot be solved with technology alone. Third, research on the WCO

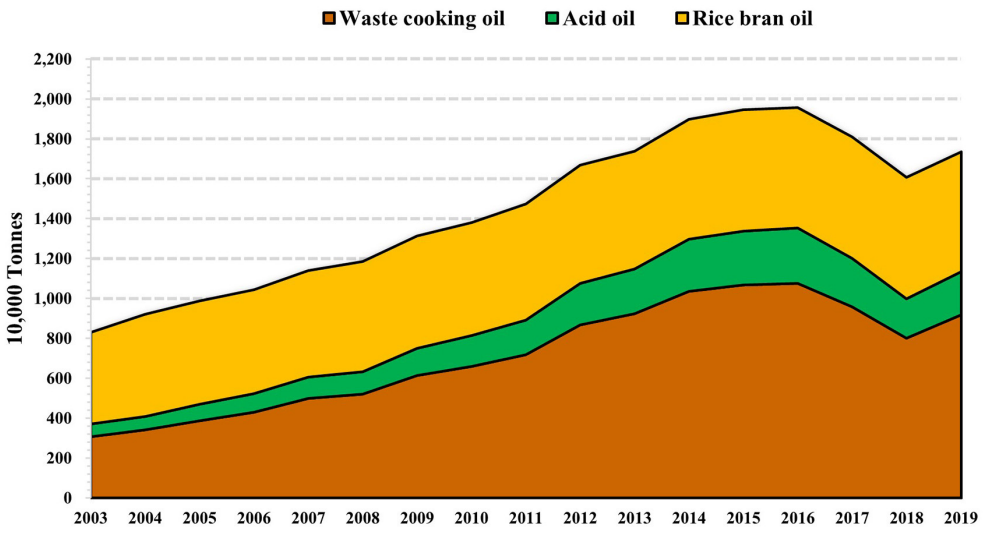



FIGURE 1
The potential supply of WCO, acid oil, and rice bran oil in China between 2003 and 2019. The calculation formula is from Liang et al. (2013). Data are from the China Statistical Yearbooks 2004–2020 (NBS, 2004-2020).

issue needs to be further strengthened by acknowledging that this issue is inseparable from the social and humanistic fields. Notably, this paper bridges the research gap by systematically applying grounded theory to real criminal cases to explore the main potential influencing factors of WCO crime comprehensively.

To explore the dominant influences of this public health issue and provide recommendations to relevant legislators, this paper develops a theoretical framework for the determinants and management of food safety problems. Unlike previous research based on first-hand data and the principles of grounded theory analysis, this research is the first attempt to employ second-hand data from 152 court judgments collected from the China Judgments Online official database. Additionally, this paper proposes why the WCO issue has not been fully addressed and reveals the current state of WCO crime in China. The four main contributions of this paper are as follows:

- Regarding the food safety of WCO in China, this paper is the first attempt to employ a qualitative research method (grounded theory) to create a new theoretical framework.
- This paper uses 152 WCO-related court judgments obtained from China Judgments Online to analyze the potential influencing factors of prosecuted criminals.
- This paper responds to the previously unaddressed points in the explosive news article from *China Youth Daily* in 2010. After a decade, it explores whether China has completely addressed the WCO issue.
- After revealing five potential influencing factors, this paper provides Chinese legislators with three management guidelines for the WCO issue.

Notably, the contributions of this paper may be used as a theoretical research model for the WCO issue in China and to address relevant food safety issues worldwide.

## Materials and methods

This study adopted a qualitative analysis based on grounded theory to explore the potential determinants of WCO crime. A systematic, broad-based iterative approach was used to conduct a comprehensive and in-depth analysis of the criminal characteristics and evidence underlying WCO court judgments. A total of 152 court judgments, including all significant judgments of this type, were collected from China Judgments Online.

Grounded theory was first created in 1967 (Glaser and Strauss, 1967), and then it was evolved gradually and became an evolving qualitative research method (Walker and Myrick, 2006). Strauss and Corbin (1994) indicated that grounded theory was a general methodology, a way of thinking about and conceptualizing data (Cho and Lee, 2014). The grounded theory uses systematic procedures to develop and lead a rooted theory for a particular phenomenon using induction (Corbin and Strauss, 1990; Charmaz, 2014; Nelson, 2017). In other words, it develops explanatory theories of fundamental social processes studied in context (Starks and Trinidad, 2007). The systematic procedures of the grounded theory include an interdependent and iterative process with data collection, analysis, interpretation, and theory development (Bitsch, 2005). Over time, it has become a fundamental research method in the social sciences, reaching fields such as nursing (Sandelowski,

2010; Pesut et al., 2020), food safety (Wang et al., 2020), and food waste (Papargyropoulou et al., 2016). The grounded theory has four strengths: flexibility and creativity in inquiry, openness in creating a new theory, holistic understanding, and well-defined analysis procedure (Starks and Trinidad, 2007). Following the tenets of grounded theory, a theoretical framework is gradually formed by conducting an in-depth analysis of the original data or previous papers (Tie et al., 2019). Based on grounded theory, this paper constructed a WCO crime determinant model by analyzing 152 WCO court judgments, and NVivo 12 Plus (QSR International, Massachusetts, USA) was used to improve accuracy. All analyses strictly adhered to the raw materials.

The research data were collected from China Judgments Online, the most extensive judicial database of court judgments worldwide (Du and Yu, 2018). As of March 2021, 110 million court documents have been published, with 57.73 billion visitors from over 200 countries and regions. When searching the database, we used "waste cooking oil (地沟油)" as our main keyword. All the 243 court judgments were collected in the raw dataset. Meanwhile, three indicators were employed to clarify and clear the raw dataset: relevance, accuracy, and repeatability. Firstly, the relevance indicator means that the court type has little or nothing to do with the WCO criminal, even though WCO was referred to the judgment. Next, the accuracy indicator indicated another legal dispute; however, it resulted from the public health of the WCO issue. Thirdly, the repeatability indicator was repetition judgments published in the *China judgment online* database. Finally, we selected 152 court judgments as our dataset. The spatial distribution of all chosen judgments is shown in Figure 2. Our analysis focused on the authority and representativeness of court judgments to develop a theoretical framework for the determinants and management of food safety problems, which is helpful because of the difficulty of collecting accurate data on WCO crime.

During the data analysis, interpretation, and theory development, we followed the principles of grounded theory to analyze the judgments using four steps: open coding, axial coding, selective coding, and saturation testing (Chen et al., 2018; Tie et al., 2019; Wang et al., 2020); (Figure 3). Additionally, confirming the final theoretical model, the index is when the new samples and data can no longer contribute to new core categories and concepts, aligning with the grounded theory (Glaser and Strauss, 1967; Corbin and Strauss, 2014). On the other hand, according to Pandit (1996), nine processes (principles) of building grounded theory were employed in our manuscript, and our theoretical model had already reached closure until step 8. Meanwhile, we also employed the index of "the new sample and data" to test and confirm our final theoretical saturation process (Chen and Sun, 2021). In order to show the valid final result, we separated our 152 documents into two parts: 140 for the original theoretical model and 12 documents for the theoretical saturation process. The 12 documents were employed following step 9 mentioned in Pandit (1996). Therefore, we extracted and summarized the factors influencing WCO crime in China as coding nodes in 140 judgments. Then, we determined the specific attributes, categories, and dimensions, which were constantly compared and gradually abstracted into concepts in the open coding stage. Next, we used axial coding to identify and establish connections between concept categories and create dispersed concepts and categories as block connections. For the third step, we applied selective coding to synthesize all the main categories and extract them as core categories. We established a network connection after maximizing the connection between the main categories and concept nodes. Finally, we applied saturation testing to re-determine the remaining 12 judgments to prevent missing nodes in the final model.

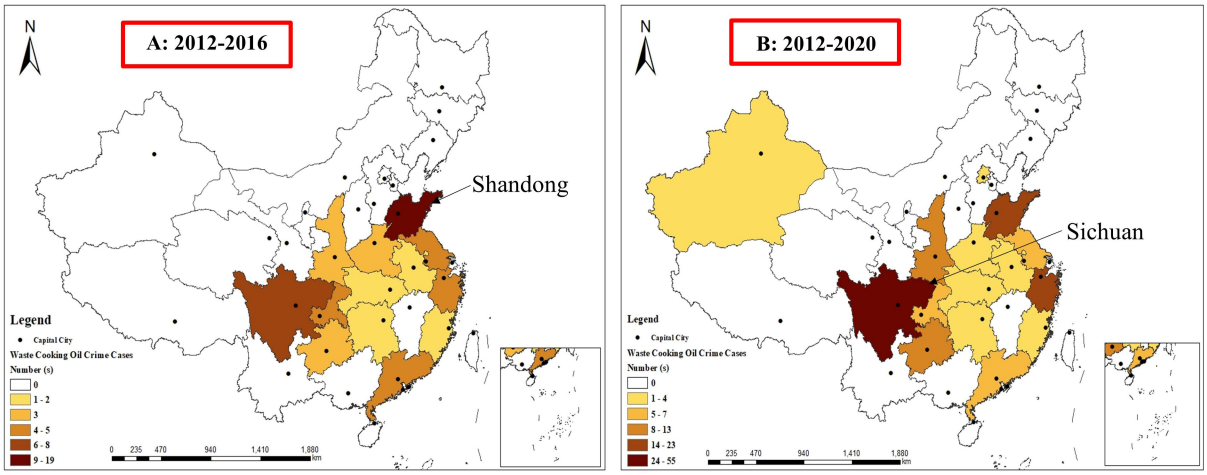
# Results

## Demographic profiles

As mentioned in the materials and methods part, all 152 WCO court judgments (data sets) were separated into 140 judgments as to the principal research codes and the remaining 12 as saturation-testing documents. All the defendants were extracted and sorted out one by one from all 152 judgments. The judgment criteria of the valid defendants in the court judgment are based on strict compliance with the Food Safety Crime Law (Article 140 from the Criminal Law of the People's Republic of China). After confirmation, 338 defendants, who produced the WCO illegally, in the 152 judgments were valid, and their ages were announced in the relevant judgments. The age distribution is provided in Figure 4 with four age divisions (10–29, 30–39, 40–49, and 50–69 years). The age groups accounted for 18.34, 22.30, 42.66, and 16.69% of the defendants, respectively, meaning that 62.83% were over 40 years of age. The youngest defendant was 19 years old, while the oldest was 66 years old. Besides, Table 1 contains detailed list of 20 court judgments, including the year of the judgment, the start and end periods of the crime, the crime, the number of offenders, the average judgment amount, the average sentencing span, and the main way (the environment of the WCO crime occurred) for that specific type of crime.

## Results of the grounded theory analysis

Following the coding principles (open coding, axial coding, and selective coding) of grounded theory, we eventually isolated five core categories from all 152 court judgments. They are legal loopholes, food hygiene inspectors, offender crime patterns, consumer self-protection consciousness, and case characteristics. Table 2 presents specific information on the determination of the categories, subcategories, corresponding




| Province | Sichuan | Shandong | Zhejiang | Guizhou | Shanxi | Guangdong | Chongqing | Jiangsu |
|---|---|---|---|---|---|---|---|---|
| 2012-2016 | 8 | 19 | 4 | 3 | 3 | 4 | 4 | 5 |
| 2017-2020 | 47 | 4 | 14 | 10 | 9 | 3 | 1 | 0 |
| 2012-2020 | 55 | 23 | 18 | 13 | 12 | 7 | 5 | 5 |
| Rate | 0.36 | 0.15 | 0.12 | 0.09 | 0.08 | 0.05 | 0.03 | 0.03 |

Continued

| Province | Hunan | Fujian | Henan | Hubei | Anhui | Xinjiang | Beijing | Total |
|---|---|---|---|---|---|---|---|---|
| 2012-2016 | 2 | 2 | 3 | 1 | 1 | 0 | 0 | 59 |
| 2017-2020 | 2 | 1 | 0 | 0 | 0 | 1 | 1 | 93 |
| 2012-2020 | 4 | 3 | 3 | 1 | 1 | 1 | 1 | **152** |
| Rate | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 1 |

FIGURE 2
**(A,B)** Two periods of geographical distribution characteristics of WCO issues in China (2012–2016 and 2012–2020), based on the new WCO regulation issued in 2017.

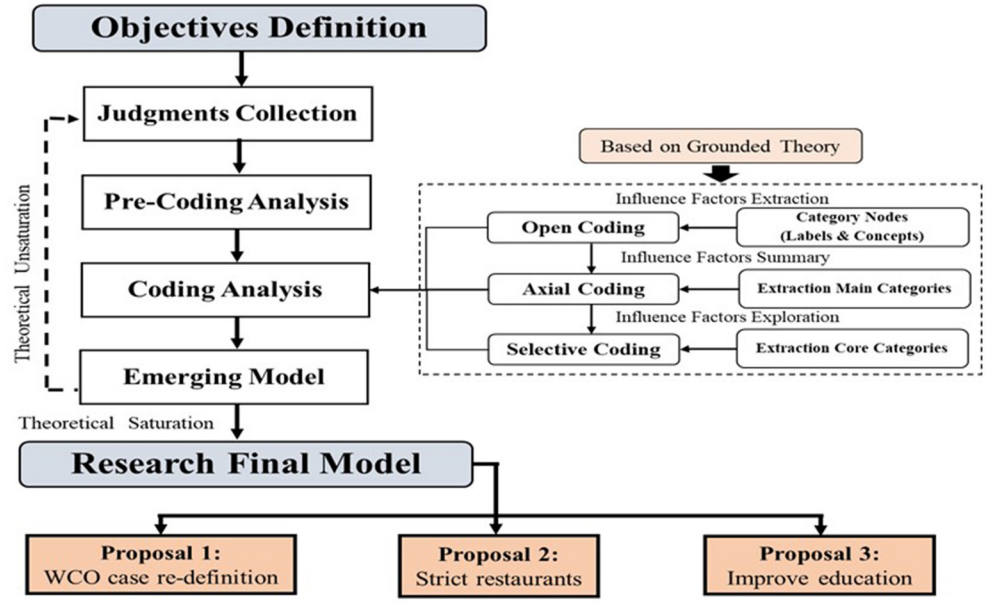



FIGURE 3
Theoretical framework based on Chen et al. (2018).

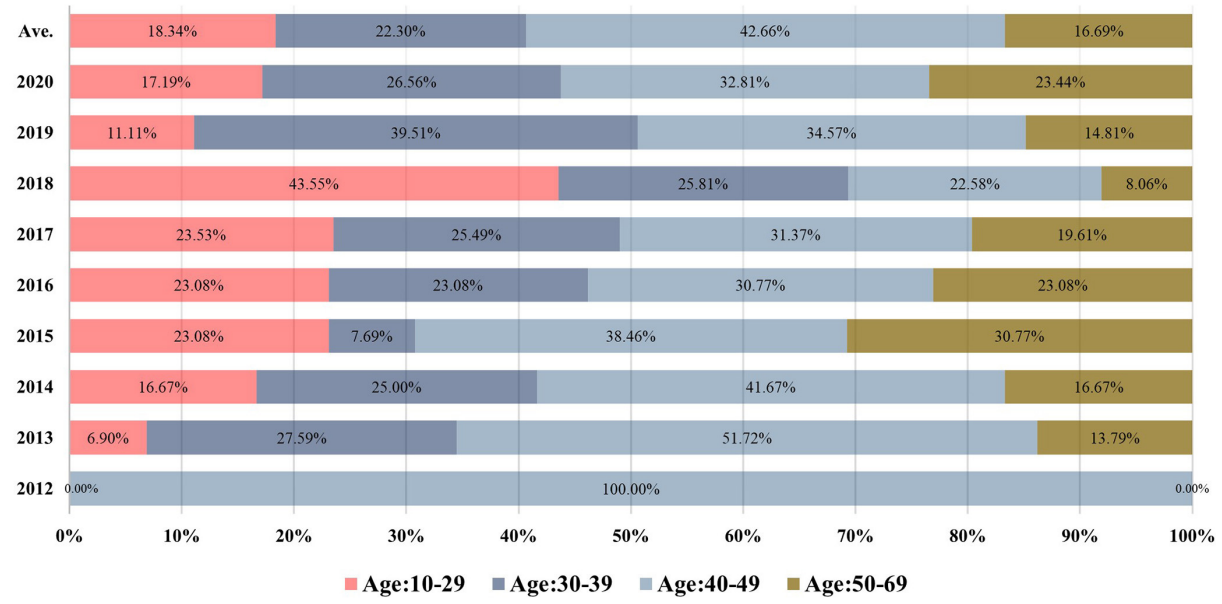



FIGURE 4
Age distribution of WCO defendants from 2012 to 2020 ($N = 338$).

TABLE 1 Specific information for 20 of the 152 encoded judgments from China Judgments Online.

| No. | Year | S. period | E. period | Duration (months) | Province | NOO | AJA ($) | ASS | Main way |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2012 | 2008 | 2012–02 | About 38 | Henan | 1 | 15,380 | 30 | Own factory |
| 2 | 2013 | 2008 | 2010–09 | 25 | Shandong | 4 | 230,700 | 74 | Processing company |
| 3 | 2014 | 2013–12 | – | – | Hunan | 2 | Immune penalties | Dereliction duty | Official crimes |
| 4 | 2015 | 2014–10 | 2014–11 | 1 | Sichuan | 3 | 2,563 | 20 | Hot pot restaurant |
| 5 | 2015 | 2014–06 | 2014–09 | 3 | Jiangsu | 4 | 154 | 14 | Other restaurant |
| 6 | 2016 | 2014–03 | 2014–12 | 8 | Guangdong | 6 | 769 | 11 | Own factory |
| 7 | 2016 | 2015–08 | – | – | Shanxi | 2 | Immune penalties | Dereliction duty | Official crimes |
| 8 | 2017 | 2015–03 | 2016–02 | 11 | Zhejiang | 5 | 7,229 | 16 | Hot pot restaurant |
| 9 | 2017 | 2016–04 | 2017–02 | 10 | Zhejiang | 5 | 1,784 | 9 | Own factory |
| 10 | 2018 | 2016–10 | 2017–01 | 3 | Zhejiang | 8 | 20,763 | 10 | Hot pot restaurant |
| 11 | 2018 | 2017–03 | 2017–08 | 5 | Shanxi | 5 | 18,856 | 18 | Hot pot restaurant |
| 12 | 2018 | 2014–07 | 2017–03 | 32 | Zhejiang | 2 | 5,383 | 16 | Own factory |
| 13 | 2019 | 2018–06 | 2018–11 | 5 | Guizhou | 2 | 3,076 | 12 | Hot pot restaurant |
| 14 | 2019 | 2017–05 | 2017–11 | 6 | Sichuan | 5 | 21,019 | 44 | Hot pot restaurant |
| 15 | 2019 | 2018–04 | 2018–06 | 2 | Shanxi | 2 | 538 | 7 | Hot pot restaurant |
| 16 | 2019 | 2019–03 | 2019–07 | 4 | Sichuan | 2 | 615 | 7 | Hot pot restaurant |
| 17 | 2020 | 2016–07 | 2017–09 | 14 | Beijing | 4 | 6,921 | 26 | Other restaurant |
| 18 | 2020 | 2018–09 | 2020–04 | 19 | Sichuan | 4 | 61,520 | 36 | Hot pot restaurant |
| 19 | 2020 | 2016–10 | 2019–08 | 34 | Guizhou | 7 | 637 | 16 | Hot pot restaurant |
| 20 | 2020 | 2020–03 | 2020–04 | 1 | Xinjiang | 3 | 3,999 | 12 | Hot pot restaurant |

S. period, starting period; E. period, ending period; NOO, number of offenders; AJA, average judgment amount; ASS, average sentencing span. ¥100 = $15.38 (Exchange Rates: 20210317).

TABLE 2 Categories, subcategories, corresponding attributions, and dimensions from 152 judgments based on axial coding.

| Categories | Subcategories | Attribution | Dimensions |
|---|---|---|---|
| Legal loopholes | Vague WCO crime | Definition of WCO material | Ambiguous–clear |
| | | No toxic substances detected | Low–high |
| | | Toxic substances but no WCO | Incomplete–complete |
| | | Social harm | Not affected–affected |
| | Vague food safety definition | Inconsistent identification by legal handover | Ambiguous–clear |
| | | Definition of food safety crimes | Incomplete–complete |
| Food hygiene inspectors | Difficult detection | No authoritative test results | Easy–difficult |
| | | Difficulty in collecting raw materials | Incomplete–complete |
| | Inadequate supervision | Division of supervision | Ambiguous–clear |
| | | Unfulfilled responsibility | False–true |
| Offender crime patterns | Motivation | Profit-seeking psychology | False–true |
| | | Low education | Low–high |
| | | Family background | Scarce–plentiful |
| | Teamwork learning | Employment relationship | Ambiguous–clear |
| | | Team crime | False–true |
| | | Learning WCO production | Loss–gain |
| Consumer self-protection consciousness | Complaint awareness | No complaints from consumers | False–true |
| | | No media coverage | Indifference–concern |
| | Lack of evidence | No authoritative testimony | Not authoritative–authoritative |
| Case characteristics | Personal condition | Affected by the working environment | Corrupt–perfect |
| | | Non-subjective intentional crime | Low–high |
| | Company management | Imperfect ledger | Incomplete–complete |
| | | No business certificate | Incomplete–complete |
| | | Other purposes | False–true |

attributions, and dimensions from all 152 judgments based on the axial coding. Simultaneously, these five core categories were also analyzed and detailed explained in the following part.

## Legal loopholes (two subcategories, six attributions)

Since 2010, the Chinese government has taken relevant actions to ensure that the WCO issue is not exacerbated. However, we found that the remaining Chinese food safety laws were also the fundamental reason for this public health issue. Our analysis revealed that criminals took advantage of loopholes in regulations, including two subcategories of the vagueness of WCO crime and food safety definitions. In the following examples of criminal cases, the capital letters represent the relevant Chinese province and the eight-digit number the date of the judgment:

- SD-20131207: An excessive amount of benzopyrene does not necessarily mean that edible cooking oil is blended with WCO (SD meaning Shandong Province: the first two letters of the province, same below).
- SC-20191210: The evidence, accusing the respondent LC (the name of criminal) who produced and sold toxic and noxious foods, is insufficient.

## Food hygiene inspectors (two subcategories, four attributions)

We found that food hygiene inspectors faced significant challenges in detecting cases of WCO crime in China. Moreover, because various harmful substances were used in WCO production, judgment standards were often inconsistent. As shown in our data analysis, the difficulty of collection and the randomness of criminal investigations resulted in a lack of collected samples to test the reports. Besides, officials involved in food inspections were often incompetent. As can be seen in the following examples, we finally made a conclusion that the responsibilities of officials were not prioritized, and many officials did not provide effective test reports:

- SD-20161114: There is no administrative enforcement authority for the Gorge Mountain Agriculture, Forestry, and Water Conservancy Bureau.

- ZJ-20170717: Whether edible oils and non-food raw materials are toxic and harmful, inspection reports remain insufficient.

### Offender crime patterns (two subcategories, six attributions)

If someone has no suitable path due to difficult circumstances, they may commit a crime to earn profits. We observed that offender crime patterns were primarily affected by the specific characteristics of the offender. For instance, we found several cases in which a manager committed a crime in the workplace and others in which the offender had a relatively low family education level. Furthermore, we also determined that the legal awareness of food safety was weak. In the team analysis, we concluded that small-scale crimes were perpetrated primarily by gangs that directly employed individuals after simple training sessions according to the following testimonies:

- ZJ-20191128: The defendant YD and his wife are migrant workers with low education, low legal consciousness, and no living skills.
- GZ-20200826: The kitchen management and the recovery of Chen's hot pot red oil are all arranged by his bosses (L and T).

### Consumer self-protection consciousness (two subcategories, three attributions)

We surmised that most consumers did not report restaurants for WCO violations due to insufficient evidence and the concealment of its use. In most spicy restaurants, consumers merely focused on the spicy favor and forgot to consider whether the edible oil was contaminated with WCO. Furthermore, the media would not report on WCO usage without specific evidence. We confirmed that WCO was secretly used in small restaurants, as can be seen in the following testimonies:

- ZJ-20130909: The local media has not reported it, and it should not be considered particularly serious.
- SC-20190925: Since the hot pot restaurant opened, no consumers have had adverse reactions or complaints.

### Case characteristics (two subcategories, five attributions)

We determined no specific consumption record of the restaurants involved in WCO issues, which led to controversies regarding specific court decisions. Moreover, we noticed no particular task definition of WCO crime in the employment relationship. Therefore, as our investigation revealed, many offenders claimed that they did not actually sell waste oil and were instead storing it in the short term:

- SX-20150116: Of the lard seized by the public security organs, four barrels of WCO were not sold and instead prepared for foam.
- SC-20200928: The public prosecution agency did not have any evidence to prove that the defendant sold toxic and harmful food for more than ¥500,000.

## Emerging model

According to the analysis result in Section Results of the grounded theory analysis, the final decision model was obtained by summarizing and analyzing the coding data divided into specific dominant factors, safeguarding factors, driving factors, stimulating factors, and supporting factors. The determinant and management of WCO model has been developed and shown in Figure 5.

# Discussion

Following our results, we identified five influences on the criminal recycling of WCO and its daily use in China: legal loopholes, food hygiene inspectors, offender crime patterns, consumer self-protection consciousness, and case characteristics. This section discusses the interactions between these five factors and details the three transformations of WCO, exploring WCO criminality determinants and presenting our corresponding -public health management recommendations to Chinese policymakers.

## Previously identified factors

Legal loopholes are one of the most important factors affecting food safety outbreaks worldwide (Henson and Caswell, 1999; Zach et al., 2012; Nie et al., 2020), and they have impacted the WCO issue in China. Lu et al. (2013) revealed that the original collection of raw WCO from grease interceptors had not been adequately managed and monitored in China. Lu and Wu (2014) highlighted the government's barriers to and countermeasures for tracking WCO use in China. They proposed two crucial legal suggestions: implementing a legal system and the reform of food safety monitoring (Lu and Wu, 2014). To address food safety problems, the Chinese government urgently issued regulations on WCO in 2010 and revised them in 2017, reflecting the hastiness of the government's political decisions.

The regulation of the ongoing WCO issue poses specific challenges. In particular, there is an urgent need to make the

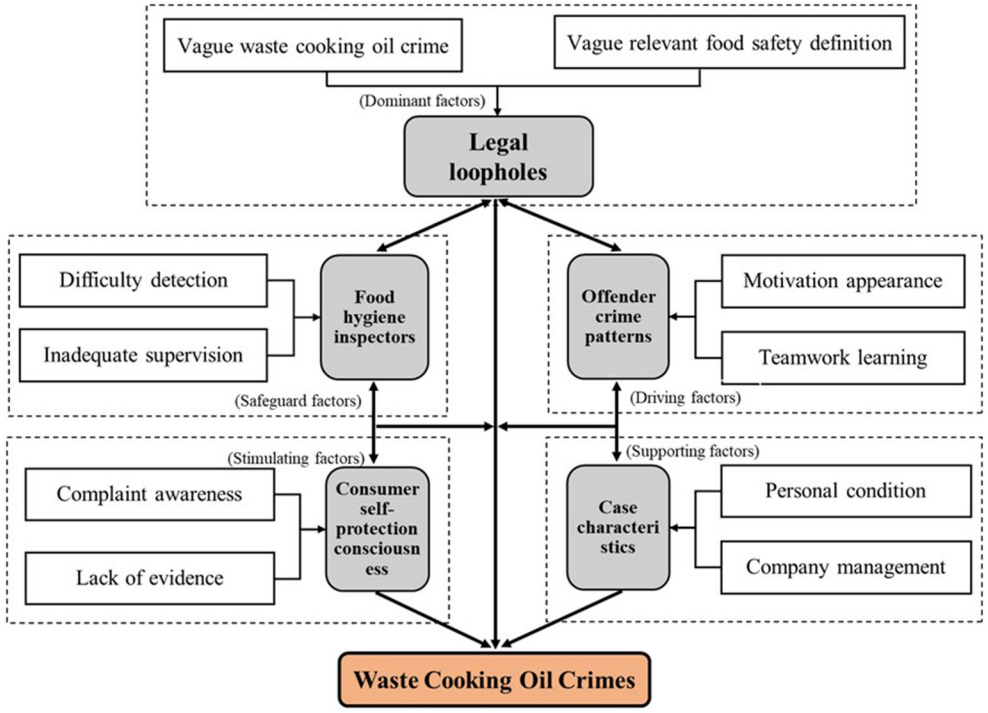



FIGURE 5
Determinants and mechanisms of the WCO issue.

WCO oversight system more comprehensive by combining increased regular inspections, increased traceability of raw materials, and the implementation of hierarchical administrative responsibility, thus filling existing management loopholes (Yang and Shan, 2021). Notably, the subsidies for recyclers tend to widen the profit gap between recyclers and biorefineries in the open marketplace, and inequitable distribution of benefits is detrimental to biodiesel production (Zheng et al., 2020; see Table 3 for details).

Food hygiene inspectors also significantly influence the WCO issue in China. When food hygiene inspectors improve compliance with food hygiene legislation, foodborne illnesses, and food safety cases are reduced (Fleetwood et al., 2019). Inconsistencies may compromise food safety and lead to consumer mistrust of official food controls. Ultimately, consistent inspection is key to official food control (Lunden et al., 2021). However, regarding the WCO issue, food inspectors frequently do not follow fundamental regulations when assessing this public health issue.

While many inspectors previously accepted bribes, the 2015 China Food Safety Law effectively controls the behavior of government food inspectors. Regardless, significant problems remain with food inspections outside of the WCO issue. For example, Li et al. (2020) analyzed 26,708 batches of national food safety and sample inspections collected from 2014 to 2018 and found that 17.98% of batches were involved in food fraud, and over 30 provinces were implicated. Overall, China's food safety has been severely questioned, and the workload of its food safety supervisors continues to increase.

Research has shown that consumer self-protection consciousness significantly influences food safety behavior (Wang et al., 2020). Hoffmann et al. (2021) disclosed that food safety is fundamentally incomplete and has asymmetric information. Based on participant observation, semi-structured interviews, and a review of government documents in two rural communities, Zhang and Qi (2019) studied the factors, characters, potentials, and challenges of "bottom-up" self-protection movements. Likewise, Martindale (2021) used Chinese case studies of alternative food networks to explore whether the trust is an assumed outcome of food safety participation and highlighted how the dynamics of trust are in constant flux between producers and consumers.

## New insights

### Case characteristics: Punishment severity

Of the 152 court judgments, we divided all WCO cases into four types: hot pot restaurant crime, processing plant crime (whether by individuals or companies), non-hot pot restaurant crime, and dereliction of duty due to the crime's location and characteristics. Among them, the number of

TABLE 3 Specific research trends in food safety and the relevant WCO research in China.

| References | Journal | Method | Sample | Finding |
|---|---|---|---|---|
| Yan (2012) | Journal of Asian studies | Analysis using Ulrich Beck's theory | At the regulation levels of food hygiene, unsafe food, and poisonous foods | Food safety problems in China have contributed to a rapid decline in social trust, thus posing a risk of distrust that has far-reaching social and political ramifications. In this sense, a risk society has already been created in China, but it comes with certain local characteristics and poses some new theoretical questions. |
| Xue and Zhang (2013) | Food control | Analysis of food pathogen, food location, food vehicle, source of contamination, and human factors | 2,387 individual incidents of acute foodborne illnesses | A variety of microorganisms, man-made chemicals, and biotoxins were found in different types of food, and various human factors were largely accountable for food contamination. |
| Lu et al. (2013) | Waste and resource management | Integration of various reports and summary of the existing gutter oil inventory | The illegal supply chain from gutter oil to the dining table and the management practices in China and the U.S. | There must be rules, regulations, supervision, and educational programs from government authorities as well as coordination between different regions. Technological development will support WCO removal from dining tables. Incentives for alternative uses of WCO will also help divert it from food applications. |
| Lu and Wu (2014) | Food control | Industrial chain analysis | Current industrial chain of the production and sale of gutter oil in China | The lack of a waste food logistics system; imperfect laws, regulations, and supervision systems; and deficiencies in establishing standards are crucial issues. |
| Cheng et al. (2017) | PLoS ONE | Cross-sectional survey using paper questionnaires | 4,220 students | A total of 53.6% regarded China's food safety situation as worrying, almost 96.5% did pay attention to food safety, and 95.3% had worried about the food safety provided by small restaurants and street peddlers. |
| Kendall et al. (2019) | Food control | Exploration of the attitudes of and perception toward food fraud | Seven focus groups with middle-class Chinese participants in Tier 1 and 2 cities | Consumers were found to rely on informal kinship networks as trusted sources of information regarding food products' authenticity and safety. |
| Zhang et al. (2012) | Renew sustain energy rev | Content analysis | Policies related to WCO-refining biofuel in China | The government focused more on formulating policies from strategic, administrative, and regulatory aspects and less on market-oriented initiatives such as funding input and financial support. |
| Zhang et al. (2014) | Energy policy | Dynamic game model | Incentive effects of four common subsidy modes on WCO supply for biofuel refining and sales of WCO-refined products | Common approaches adopted in developed economies, such as raw material price subsidies and finished products sales subsidies, increased the profits of both biofuel enterprises and recyclers. In contrast, investment subsidies, which are relatively common in some regions of China, increased the profits of recyclers while reducing the revenues of biofuel enterprises. |
| Zhang et al. (2014) | Renew sustain energy rev | Comparative analysis | Recycling modes in China, the U.S., and Japan | The third party take back mode practiced in Japan and the U.S. was superior to the biodiesel enterprise take back mode due to the subsidies provided for biodiesel enterprises and the implementation of strict regulation policies for restaurants. |
| Yang et al. (2018) | Journal of cleaner production | Analysis of information asymmetry and stimulation of the recycler's recycling investment | Two possible contracting mechanisms for the bio-firm: a principal-agent contract or a quantity-discount contract | When the average recycling cost or the uncertainty level of cost information was relatively low, the bio-firm was better off choosing a quantity discount contract, while the recycler preferred the principal-agent contract. |

*(Continued)*

TABLE 3 Continued

| References | Journal | Method | Sample | Finding |
|---|---|---|---|---|
| Zheng et al. (2020) | Journal of cleaner production | Case study with an optimization-based model | Third party take-back supply chains, motivation policies, subsidy policies, and demand adjustments due to policy changes | The integration of stakeholders and markets increased efficiency and sustainability. Unfair profit allocations will decrease the amount of recycled materials. |
| Zhao et al. (2021) | Renew sustain energy rev | Life cycle assessment and life cycle cost model | Damage to human health, ecosystem quality, and resource availability as well as relevant midpoint impacts | The multiple consumers of WCO, the low energy conversion rate, and the immature utilization of by-products will hinder the massive deployment of WCO-based biodiesel in China. |

TABLE 4 Types of judgments and distributions of the determinations' results ($N = 152$).

| Crime type | N/Per | Level | Trial results | | | |
|---|---|---|---|---|---|---|
| Hot pot restaurants | 73 | TFI | Food safety penalties: 60 cases | MaxP: $77,399 | MaxP: 60 months | AvgP: $7,552 |
| | **48.03** | | | MinP: $155 | MinP: 3 months | AvgP: 15 months |
| | | TSI | 10 cases maintained | | 3 cases lost | |
| Processing plants | 45 | TFI | Food safety penalties: 21 cases | MaxP: $3,839,009 | MaxP: 180 months | AvgP: $222,170 |
| | **29.60** | | | MinP: $155 | MinP: 6 months | AvgP: 44 months |
| | | TSI | 11 cases maintained | 5 cases lost | 8 cases mediated (commutation) | |
| Non-hot pot restaurants | 18 | TFI | Food safety penalties: 13 cases | MaxP: $15,480 | MaxP: 48 months | AvgP: $2,028 |
| | **11.84** | | | MinP: $155 | MinP: 6 months | AvgP: 12 months |
| | | TSI | 3 cases maintained | | 2 cases lost | |
| Dereliction of duty | 16 | TFI | Food safety penalties: 12 cases | Crime of dereliction of duty in food supervision | | |
| | **10.53** | | | Exempt from criminal punishment | | |
| | | TSI | 1 case maintained | | 3 cases lost | |

N, number; TFI, trial of first instance; TSI, trial of second instance; MaxP, maximum penalty; AvgP, average penalty; MinP, minimum penalty; Per, percentage (%); ¥100 = $15.38 (Exchange Rates: 20210317).

crimes committed by hot pot restaurants reached 70 cases, accounting for 48.02% of all examined crimes, followed by processing plant crime (32 cases), non-hot pot restaurant crime (14 cases), and dereliction of duty (13 cases). They accounted for 29.60, 11.84, and 10.53% of all cases, respectively (Table 4).

Regarding the fines for hot pot restaurants, the lowest fine was $155, the highest fine was $77,399, and the average fine was $7,552. For processing plants, the lowest fine was $155, the highest fine was $3,839,009, and the average fine was $222,170. For non-hot pot restaurants, the lowest fine was $155, the highest fine was $15,480, and the average fine was $2,028.

In terms of the sentences for hot pot restaurants, the minimum sentence was 3 months, the maximum sentence was 60 months, and the average sentence was 15 months. For processing plants, the minimum sentence was 6 months, the maximum sentence was 180 months, and the average sentence was 44 months. For non-hot pot restaurants, the minimum sentence was 6 months, the maximum was 48 months, and the average was 12 months.

For all crimes, the maximum fine was $3,839,009, whereas the minimum fine was $155. The longest sentence was 180 months, and the lowest was only 3 months. Regarding the punishment for the abuse of power by a civil servant, all Chinese courts dismissed the civil servant instead of imprisoning them. Therefore, we had no data regarding jail time for the dereliction of duty, which made it difficult to determine the degree of these crimes.

Of the 152 court judgments, no cases occurred at food stalls because food stalls have not yet entered the scope of China's food supervision. Consequently, food safety at food stalls has not been seriously investigated and supervised by food inspectors, and there may be many production loopholes in food stalls as a result.

## Offender crime patterns: Defendants' demographic characteristics

The educational backgrounds of 324 defendants were available. We divided their academic status into elementary

school (including illiteracy), junior school, senior school (high school), and college. As shown in Figure 6, more than half of the defendants had a 9-year compulsory (elementary school and junior school) or lower education level.

In the court judgments from 2012 to 2020, the defendants' education levels did not significantly change over time. China vigorously promoted undergraduate education in 2010 and developed free primary education. Near the height of the WCO issue, residents with highly educated backgrounds have a high proportion in 2014, with the motivation to make huge profits. However, as the law became stricter, the proportion of crimes committed by higher education residents declined somewhat. From 2012 onwards, defendants with primary education levels were the main offenders. These criminals' education levels were consistent with middle- and lower-class status. These results indicate that increasing higher education may alleviate China's food safety problems to a certain extent.

As revealed in Figure 7A, most criminals involved in WCO crime in 2012 worked alone, whereas an average of 6.30 defendants worked together in 2013. The average decreased to 1.70 criminals in 2016. We discovered that WCO crime usually occurred in criminal groups of two to three people. Most of the members had close relations with each other, such as being related or acting as managers and employees in labor relations. Figure 7B illustrates the period from the known start of WCO production to the corresponding Food and Drug Administration's detection of it in China. Unlawful production of WCO lasted for an average of 44 months in 2012, 13 months in 2015, and 19 months in 2016. Our analysis observed that as the law became stricter and consumers' food safety awareness increased, the time from WCO production to detection decreased to about 6–7 months between 2019 and 2020.

## Policy implications

We found that the spatial distribution of China's WCO issue was concentrated in the central and southern regions, primarily Sichuan Province. The criminals' methods became more concealed over time, and small family-style restaurants were the mainstay. However, the detection time for these crimes also decreased, showing that consumers' reports impacted. We have three policy recommendations to address WCO use in China, based on our analysis.

First, the WCO issue should be redefined. Relevant laws and regulations in China only have macro definitions, and there are no specific regulations on factors such as waste recycling that may affect WCO crime. Although the amount of WCO that an individual or company possesses in China can determine if they have committed the WCO crime, the definition of this crime is unclear. Hence, the crime should be described in more detail.

Second, the hot pot restaurant sanitation permission threshold should be raised. Hot pot restaurants have become the dominant criminal catering establishment among the four types of WCO crime. Therefore, it is necessary to set a threshold when someone applies for a hot pot restaurant sanitation license, such as passing a food safety course. After receiving 30 h of food safety judgment training and passing the corresponding rigorous examination, they could then apply for a 2 or 3-year hot pot restaurant sanitation permit, which should be renewed their business license after passing the recurrent training session every 2 or 3 years.

Third, overall food safety awareness and education should be urgently improved. Although China launched its 9-year compulsory education program in 2010, this measure cannot affect WCO crime carried out by criminal gangs with members who are over 40 years old. Food safety knowledge could be promoted in urban areas or on street billboards. Managers who make a living in hot pot restaurants should receive education, and they should also improve the food safety awareness of their consumers. When food safety incidents are discovered, managers can report them to the authorities to discover food safety solutions. They could be rewarded with food safety publicity in the community and even on news broadcasts.

## Limitations

There was a notable lag in the judgments of the reformed courts. Due to the particularity and concealment of the WCO issue, we found it difficult to accurately investigate first-hand data on the criminal characteristics of WCO offenders. As a result, we analyzed second-hand data from 152 court judgments instead. Moreover, we only collected our research data from the Supreme Court of China, representing the highest authority among Chinese courts. Therefore, we will conduct a more specific analysis in a follow-up study by considering various local courts' judgments. Additionally, the specific contents of the 30 h of food safety judgment training and the valid examination should be further analyzed in the next research.

# Conclusion

Following the coding principles of grounded theory, our analysis used 152 court judgments in China to identify five influential factors of WCO crime: legal loopholes, food hygiene inspectors, consumer self-protection consciousness, offender crime patterns, and case characteristics. The WCO issue was primarily concentrated in the central and southern regions. Sichuan Province was the most plentiful source of WCO crime, followed by Shandong Province, Zhejiang Province, and Guizhou Province. The youngest person accused was 19 years old, whereas the oldest was 66. The proportion of defendants

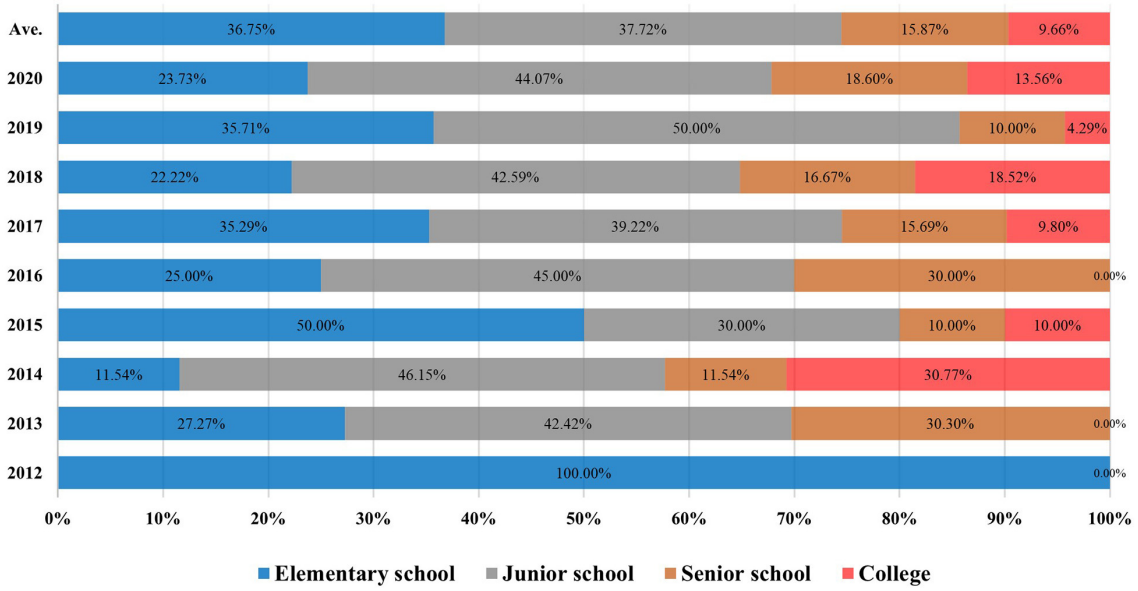
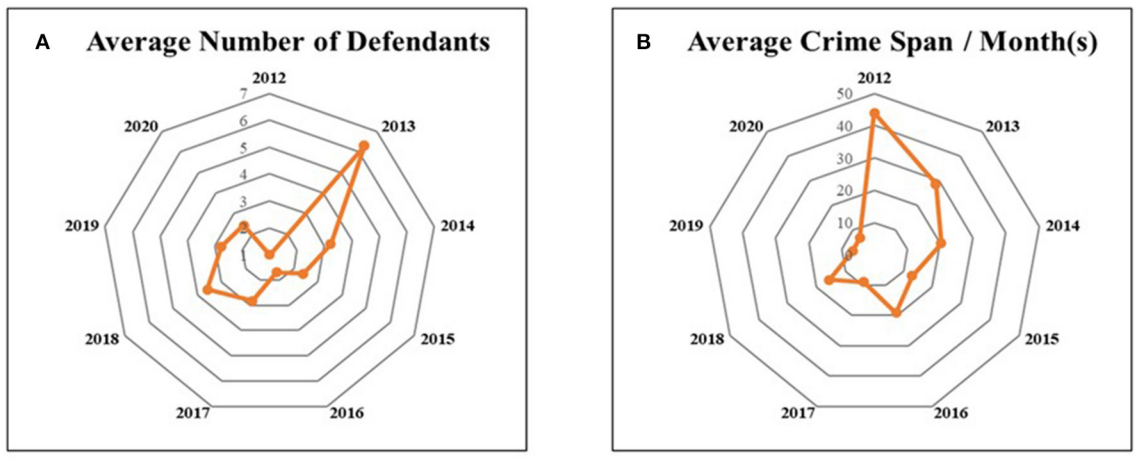



FIGURE 6
Education distribution of WCO defendants from 2012 to 2020 ($N = 324$).




| Year | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|
| A:ANDs | 1.00 | 6.30 | 3.22 | 2.40 | 1.70 | 2.83 | 3.58 | 2.76 | 2.44 | 2.91 |
| B:ACSs | 44.00 | 28.56 | 20.29 | 13.00 | 19.20 | 9.04 | 15.66 | 6.61 | 6.70 | 18.12 |

Note: ANDs refers to Average Number of Defendants; ACSs refers to Average Crime Span / Month(s); Ave. refers to Average.

FIGURE 7
Average number of **(A)** defendants in and **(B)** spans of WCO crimes from 2012 to 2020.

over the age of 40 was 59.35%, consistent with aging. Finally, 90.34% of defendants had less than high school education, and most of the defendants involved in group crime were closely related.

Hot pot restaurants were the central location for WCO crime, accounting for 48.02% of all examined cases, although processing plant crime resulted in the most severe punishments. For hot pot restaurant crime, the maximum judgment was $77,399, the minimum judgment was $155, and the average judgment was $7,552. The maximum sentence was 60 months, the minimum sentence was 3 months, and the average sentence was 15 months. In contrast, processing

crime plants accounted for 29.60% of cases. The maximum judgment was $383,900, the minimum judgment was $155, and the average judgment was $222,170. The maximum sentence was 180 months, the minimum sentence was 6 months, and the average sentence was 44 months. The lightest penalties applied to restaurants that did not serve as boilers, which committed 10.53% of breaches. The average number of accused individuals in a criminal group ranged from two to three, with an average detection duration of 18 months.

## Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: https://wenshu.court.gov.cn/.

## Author contributions

CC: conceptualization, methodology, data curation, writing—original draft, writing—review and editing, and supervision. AC, MK, and HN: writing—review and editing and supervision. LB: data curation and writing—review and editing. All authors contributed to the article and approved the submitted version.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note



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