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## Identifying the patterns of non-communicable diseases (NCDs) in developed eastern coastal China: inspiration for NCDs prevention and cure in developing regions

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4 1 **Identifying the patterns of non-communicable diseases**  
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6 2 **(NCDs) in developed eastern coastal China: inspiration for**  
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9 3 **NCDs prevention and cure in developing regions**

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29 **Identifying the patterns of non-communicable**  
30 **diseases (NCDs) in developed eastern coastal China:**  
31 **inspiration for NCDs prevention and cure in**  
32 **developing regions**

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40 **ABSTRACT**

41 **Objectives:** Few studies have examined the spectrum and trends of inpatients'  
42 non-communicable diseases (NCDs) in eastern coastal China, which is transforming  
43 from an industrial economy to a service-oriented economy and is the most  
44 economically developed region in the country. The aim of this study was to  
45 dynamically elucidate the spectrum and characteristics of the severe NCDs in eastern  
46 coastal China by analysing patients' longitudinal electronic health records.

47 **Setting:** To monitor the spectrum of NCDs dynamically, we extracted data of  
48 electronic health records from 12 general tertiary hospitals in Shanghai from 2003 to  
49 2014. The rankings of and trends in the proportions of different NCDs presented by  
50 inpatients in different gender and age groups were calculated and analysed.

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4 51 **Participants:** We obtained a total sample of 1,907,484 inpatients with NCDs from  
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6 52 2003 to 2014, among whom 50.05% were male and most were aged 50 years or older  
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8 53 (81.53%).

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11 54 **Results:** From 2003 to 2014, the prevalence of diabetes, blood and endocrine diseases  
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13 55 among inpatients increased approximately four-fold (from 1.36% to 6.74%,  $P<0.001$ )  
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15 56 in eastern coastal China. Compared with men, women displayed relatively higher and  
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17 57 more stable proportions of digestive diseases ( $P=0.394$ ) and neurological disorders  
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19 58 ( $P=0.173$ ) over time. Moreover, the proportion of 21-50-year-old inpatients with  
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21 59 diabetes or blood diseases and endocrine diseases skyrocketed over this period  
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23 60 ( $P<0.001$ ).

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30 61 **Conclusions:** The burden of inpatients' NCDs increased rapidly, particularly among  
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32 62 women and younger people. The NCD spectrum observed in eastern coastal China is  
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34 63 a good source of evidence for developing prevention guides for regions experiencing  
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36 64 transition.

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40 65 **Keywords:** Non-communicable diseases; Electronic Health Record; Eastern coastal  
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42 66 China; Health policy

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45 67 **Strength and limitations**

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48 68 ● Previous research in China has primarily focused on the nationwide spectrum, or  
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50 69 has studied the major patterns of NCDs in specific regional areas  
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52 70 cross-sectionally.

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55 71 ● This study aimed at exploring the epidemiological patterns of NCDs in eastern  
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72 coastal China across 12 consecutive years.

- 73 ● It is a good source of evidence for similar developing regions who are or will go  
74 through transformation to develop NCDs prevention guides or policies.

## 75 INTRODUCTION

76 In recent years, an epidemiological shift in morbidity and mortality from infectious  
77 diseases and malnutrition to non-communicable diseases (NCDs) has occurred in  
78 many countries, including China[1-3]. NCDs have become the major causes of death  
79 in China and globally. According to the 2012 WHO data repository, 87% of deaths in  
80 China were associated with NCDs[1]. The Global Burden of Disease Study (GBD)  
81 revealed that of the 8.3 million deaths in China in 2010, 7.0 million resulted from  
82 NCDs[3]. Stroke, ischaemic heart disease, cancers, and chronic obstructive  
83 pulmonary disease are now the leading causes of premature death in China, and the  
84 burden of these diseases is substantial[4].

85 Previous research on the epidemiological patterns of NCDs in China has primarily  
86 focused on the entire nation or cross-sectional studies of specific regions [1-6].  
87 However, both the WHO and the GBD have acknowledged that a national analysis for  
88 a country as large and diverse as China can mask substantial variations in key  
89 outcomes[3,5]. Also, few have examined the inpatients' NCD spectrum, which can  
90 reflect the more severe condition of NCDs. In this study, we conducted a longitudinal  
91 study of NCD patterns in five provinces in eastern coastal China: Shandong, Jiangsu,  
92 Zhejiang, Shanghai and Guangdong provinces. Geographically speaking, these  
93 provinces are located in the three most productive and dynamic regions of China: the

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4 94 Bohai Sea, the Yangtze River Delta and the Pearl River Delta. The gross regional  
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6 95 domestic product in these five provinces accounts for approximately half that of the  
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9 96 32 provinces/autonomous regions/municipalities in China. These provinces' gross  
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11 97 domestic product (GDP) per capita far exceeded the average value in China from  
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14 98 2005 to 2014[7] and was similar to the GDP of other developed countries in Asia.  
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16 99 Moreover, since 2000s, this region experienced dramatic changes in both the  
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19 100 economic and health sectors[8]. According to the Health Statistics Yearbook, in 2015,  
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21 101 the average life expectancy in eastern coastal China was around 78 years old, which is  
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24 102 greater than the national average of approximately 76 years old[7]. Due to the rapid  
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27 103 urbanisation, economic development and population ageing in eastern coastal China,  
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29 104 NCDs and disabilities are becoming more prevalent[1,3], and the spectrum of  
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31 105 inpatients' diseases in this area is speculated to largely differ from that in other  
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34 106 regions of China. More specific guidelines for preventing and curing NCDs that are  
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36 107 tailored to the disease patterns observed in eastern coastal China must be developed.  
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39 108 In exploring disease patterns, particularly in longitudinal studies based on a large  
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42 109 sample, second-hand data may be regarded as a good source. In particular, data from  
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45 110 hospitals' electronic health record (EHR) systems have unique advantages. For  
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47 111 instance, Upshur et al. applied time series methods to a population-based retrospective  
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50 112 cohort for the 52 most common causes of hospital admissions in the province of  
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53 113 Ontario from 1988 to 2001 and showed that hospital admissions displayed systematic  
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56 114 patterns that are understandable, predictable, and reasonably accurate[9]. Using data  
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59 115 from the admission and discharge/death register, Sani et al.[10] conducted a  
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4 116 three-year review of mortality patterns. Their result supported the emerging trend of a  
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6 117 combined burden of communicable diseases and NCDs. In China, disease surveillance  
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9 118 is conducted by the National Disease Surveillance Points System, which was founded  
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11 119 in 1978; however, this system reports primarily on communicable diseases and reports  
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13 120 on only a small subset of NCDs, such as cancer[11,12]. Given these factors, the  
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15 121 current study used the hospital-based EHR system as a data source. This relatively  
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17 122 new database compiles clinical information from a large number of patients in a  
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19 123 computationally accessible form. The EHR system provides us with a unique  
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21 124 opportunity to elucidate the relatively severe NCD epidemiology and includes a  
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23 125 diverse array of NCDs[13].  
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29 126 The aim of this study was to dynamically elucidate the spectrum and characteristics of  
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31 127 the severe NCDs in eastern coastal China by analysing hospitals' longitudinal EHR  
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33 128 data. The results can provide insight into the aetiology of NCDs and aid in the  
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35 129 development of evidence-based clinical guidelines for preventing and curing NCDs.  
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38 130 In addition, the distribution of NCDs in eastern coastal China can inform the  
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40 131 development of clinical guidelines for NCDs in other regions or countries in  
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42 132 transition.  
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## 47 133 **METHODS**

### 48 134 **Study design and data collection**

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52 135 Longitudinal data (2003-2014) on NCDs were extracted from the EHR systems of 12  
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55 136 general tertiary hospitals in Shandong (2 hospitals), Jiangsu (2 hospitals), Zhejiang (2  
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4 137 hospitals), Shanghai (3 hospitals) and Guangdong Provinces (3 hospitals).  
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7 138 A multistage sample was obtained. To obtain a representative sample, when choosing  
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10 139 the sites, we first selected 3 cities that represented high, middle, and low  
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12 140 socioeconomic statuses, as defined by GDP level, in each of the 5 provinces. Second,  
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14 141 in each city, we selected the largest general tertiary hospital, resulting in 15 sampled  
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16 142 hospitals. However, we did not obtain consent from three tertiary hospitals in some  
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18 143 cities in Shandong, Jiangsu and Zhejiang Provinces due to political reasons regarding  
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20 144 EHR data collection. In China, EHR data are not openly available but can be obtained  
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22 145 from consenting hospitals with the help of health authorities. However, for several  
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24 146 reasons, the health authorities cannot support us in the future. Thus, 12 general  
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26 147 tertiary hospitals were included in the study.  
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33 148 We selected tertiary hospitals for this study. In China, hospitals are classified into  
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35 149 three categories according to their major functions. Although community hospitals are  
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37 150 intended to serve as gatekeepers, a patient's freedom to select medical facilities and  
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39 151 doctors is not restricted by policies or health insurance coverage. Consequently,  
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41 152 patients with acute or chronic diseases frequently visit the higher-tier, more  
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43 153 sophisticated or specialised, and more expensive hospitals rather than community  
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45 154 health centres, and many of the community health centres do not have hospital beds,  
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47 155 and their EHR systems are defective and incomplete, limiting the use of the  
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49 156 information contained in them [14]. Typically, the largest tertiary hospitals see most  
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51 157 of the patients discharged in their cities.  
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4 158 **Study subjects**  
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7 159 In this study, information on inpatients with NCDs was extracted from the 2003-2014  
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9 160 hospital EHR data of each hospital, and only individuals who had been admitted to  
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11 161 these hospitals during this period were included. We chose 2003 as the starting point  
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13 162 because the first EHR system was formally launched in these hospitals in that year. In  
14  
15 163 our study, the EHR systems of the tertiary hospitals include the admission information  
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17 164 of patients who received their first diagnosis of an NCD between 2003 and 2014. As  
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19 165 these hospitals may also attract patients from other districts or provinces, the inclusion  
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21 166 criteria stipulated that participants must have a fixed address in the relevant region,  
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23 167 regardless of whether they were registered or nonregistered residents. After excluding  
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25 168 non-residents, NCD information for a total of 1,907,484 inpatients was stripped of  
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27 169 identifying information and extracted from the hospitals' EHR systems. These patients  
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29 170 were admitted to a variety of hospital divisions, and according to the ICD-9 and GBD  
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31 171 NCD classification, we classified them into various disease groups based on their  
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33 172 first-list diagnosis. The final data set included the residents' basic demographic  
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35 173 information(gender and age)and the presence of chronic diseases (disease  
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37 174 system/category, disorder and year of admission). We did not include region as a  
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39 175 factor because all the hospitals were located in an urban region and it is difficult to  
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41 176 determine the inpatients' status from the EHR.  
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53 177 **Statistical analysis**  
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56 178 All data were analysed by using SAS Software 9.20. Basic descriptive statistics were  
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179 used to analyse the inpatients' personal characteristics (gender, age, and year of  
180 admission). The NCD systems and the most common disorders within each disease  
181 system were ranked according to their relative proportions. The Cochran-Armitage  
182 Chi-square test was then used to examine significant increases or decreases in the  
183 proportions of NCDs in disease systems across different gender and age groups  
184 between 2003 and 2014.

### 185 **Ethics statement**

186 All research activities were conducted with integrity according to generally accepted  
187 ethical principles and were approved by the Ethics Committees of Tongji University  
188 (ref: LL-2016-ZRKX-017). This study presented minimal risk of harm to its subjects,  
189 and the data were collected anonymously. None of the inpatients' personal  
190 information included in the database was available to individuals outside of the  
191 research team.

## 192 **RESULTS**

### 193 **Description of the personal characteristics of inpatients with NCDs**

194 The personal characteristics of the studied population are summarised in Table 1. This  
195 population included 1,907,484 inpatients with NCDs, 50.05% of whom were male.  
196 Most of these patients were aged 50 years or older (81.53%). Furthermore, the  
197 number of inpatients with NCDs increased from 2003 to 2014.

### 198 **Ranking of the disorders in all NCDs categories within gender and age groups**

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4 199 The ranks and proportions of all NCDs for each gender group are presented in Table 2.  
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6 200 Among males, each of the five most common disorders represented more than 4.0%  
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8 201 of the total NCDs from 2003 to 2014. The three most frequently occurring disorders  
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10 202 among men were cerebral infarction (12.61%), coronary heart disease (6.94%) and  
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12 203 hypertension (6.05%). Similar to the results for men, those for women showed that  
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14 204 cerebral infarction (9.63%) occurred most frequently. However, hypertension (6.84%)  
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16 205 and uterine fibroids (4.15%) were the second and third most frequently occurring  
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18 206 NCDs among women.

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24 207 Table 2 also shows the ranks of the most frequently occurring disorders across age  
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26 208 groups. There were relatively few inpatients with NCDs in the 0-10-year-old group,  
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28 209 but chronic tonsillitis occurred most frequently in this age group (26.19%). In the  
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30 210 11-30-year-old group, redundant prepuce and benign neoplasm of the breast occurred  
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32 211 frequently in men and women, respectively. Among 31-50-year-old patients, the most  
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34 212 common disorders were endocrine diseases, including uterine fibroids, ovarian cysts,  
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36 213 endometrial polyps, ureteral calculi and hyperplasia of the mammary glands. Among  
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38 214 51-80-year-old inpatients, the most common conditions were cerebral infarction  
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40 215 (ranking first), coronary heart disease and hypertension. Among patients aged 80 or  
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42 216 older, the three most common disorders were cerebral infarction, hypertension and  
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44 217 coronary heart disease. Vertebrobasilar insufficiency, diabetes, and chronic  
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46 218 obstructive pulmonary disease were more common among the elderly than among  
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48 219 individuals in the other age groups.

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58 220 **Distribution of NCDs across different groups from 2003 to 2014**

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4 221 Table 3 shows the changes in the proportions of the 12 NCD categories from 2013 to  
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6 222 2014. A significant decrease in the occurrence of cancer ( $Z=-20.525$ ,  $P<0.001$ ), other  
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8 223 neoplasms ( $Z=-20.525$ ,  $P<0.001$ ), chronic respiratory diseases ( $Z=-18.290$ ,  $P<0.001$ ),  
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10 224 urogenital diseases ( $Z=-5.329$ ,  $P<0.001$ ) and sensory organ diseases ( $Z=-2.403$ ,  
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12 225  $P=0.008$ ) was found. In contrast, the proportions of other NCDs increased to various  
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14 226 extents over the 12-year period. Notably, the proportion of patients with diabetes and  
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16 227 blood and endocrine diseases increased approximately four-fold (from 1.36% to  
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18 228 6.74%).

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24 229 As shown in Figure 1, the 12-year NCD percentages recorded in the hospitals varied  
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26 230 widely by gender. The percentage of men who were diagnosed with cancer (from  
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28 231 13.62% to 5.91%,  $P<0.001$ ) and chronic respiratory diseases (from 18.80% to 12.42%,  
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30 232  $P<0.001$ ) decreased substantially, whereas the percentage of men with diabetes or  
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32 233 blood and endocrine diseases (from 0.94% to 6.58%,  $P<0.001$ ) and that of men with  
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34 234 neurological disorders (from 2.16% to 4.29%,  $P<0.001$ ) increased substantially. The  
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36 235 percentage of women who were diagnosed with digestive diseases ( $Z=-0.270$ ,  
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38 236  $P=0.394$ ), neurological disorders ( $Z=0.943$ ,  $P=0.173$ ), and sensory organ diseases  
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40 237 ( $Z=0.056$ ,  $P=0.478$ ) did not change significantly from 2003 to 2014; this result is in  
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42 238 strong contrast to the pattern found in the male inpatients. Furthermore, a substantial  
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44 239 increase in the percentage of female patients with diabetes or blood and endocrine  
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46 240 diseases (from 1.77% to 6.91%,  $P<0.001$ ) was found. Although the proportion of  
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48 241 cancer and other neoplasms decreased in women, the decrease was less pronounced  
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50 242 than that found in men.  
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4 243 Changes in NCD proportions across age groups were also examined (Figure 2). NCDs  
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6 244 were relatively rare among patients aged 10 years or younger, but chronic respiratory  
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8 245 diseases occurred most frequently in this group. For 11-20-year-old subjects,  
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10 246 sensory organ diseases ( $Z=3.304$ ,  $P<0.001$ ) and cardiovascular and circulatory  
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12 247 diseases ( $Z=2.090$ ,  $P=0.018$ ) occurred more frequently over time. We noted dramatic  
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14 248 decreases in the percentages of patients with cancer and chronic respiratory diseases  
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16 249 in the 31-50-year-old group: all decreased nearly 50% from 2003 to 2014. However,  
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18 250 the proportions of patients with diabetes or blood and endocrine diseases increased in  
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20 251 these two groups and in the 21-30-year-old group. For the 41-50-year-old group, the  
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22 252 number of patients diagnosed with cancer decreased significantly but the proportions  
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24 253 of patients with cardiovascular, circulatory ( $Z=7.918$ ,  $P<0.001$ ) and digestive diseases  
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26 254 ( $Z=3.086$ ,  $P<0.01$ ) increased to a greater extent than in the younger population. In the  
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28 255  $\geq 50$ -year-old group, the proportion of patients with diabetes, blood, and endocrine  
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30 256 diseases increased substantially ( $P<0.001$ ). The proportion of patients with cancer  
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32 257 decreased to a greater extent in this age group than in any other age group ( $P<0.001$ ).  
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## 43 **DISCUSSION**

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45 259 By analysing the EHR information of inpatients with NCDs at 12 hospitals in eastern  
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47 260 coastal China, our research team was able to elucidate the severe NCD patterns in a  
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49 261 relatively unbiased fashion and to confirm that NCDs displayed regional  
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51 262 heterogeneity to some extent. In order of frequency, cardiovascular and circulatory  
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53 263 diseases, urogenital diseases, chronic respiratory diseases, and digestive diseases were  
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55 264 the most common NCDs. When comparing these data with inpatient data in other  
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4 265 regions, we found different patterns. For instance, a study using a sample from a  
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6 266 hospital in central China found that cardiovascular and circulatory diseases, diabetes,  
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9 267 and chronic respiratory diseases occurred most frequently[15]. However, since most  
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11 268 studies on inpatients' NCDs were based on only one hospital's EHR data, the  
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14 269 comparison may have defects. In eastern coastal China, the severe cardiovascular and  
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16 270 circulatory diseases may be the most frequently occurring because of the greater  
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19 271 degree of urbanisation and greater proportion of ageing population in the region[2,3].  
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21 272 In addition, urogenital diseases (second) and digestive diseases (fourth) were common  
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24 273 in this region, potentially because of the more rapid pace of modern life, more  
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26 274 sedentary lifestyle and longer working hours. In our search of existing studies on  
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29 275 inpatients with NCDs, we rarely found this spectrum at the top of the list[16].  
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32 276 Concerning the longitudinal trends in inpatients' NCDs, the results showed a  
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34 277 significant increase in the proportions of many NCDs, including diabetes, blood and  
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37 278 endocrine diseases, and cardiovascular and circulatory diseases, from 2003 to 2014.  
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39 279 However, interestingly, the proportion of chronic respiratory diseases and cancer  
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42 280 inpatients decreased over the 12-year period, in stark contrast to the changes in the  
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45 281 incidence observed throughout China[17,18]. Often, previous studies have concluded  
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47 282 that the incidence of respiratory diseases is increasing, likely due to ambient air  
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50 283 pollution and tobacco use, resulting in tremendous threats to respiratory health[3,19].  
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52 284 The difference may be caused by the data since the incidence also includes mild  
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55 285 respiratory diseases, however, the opposite trend of inpatients found in eastern coastal  
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57 286 China may have also resulted from this region's transition from a heavy industrial  
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4 287 district to a technologically focused area, which has been associated with a substantial  
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6 288 reduction in environmental pollution. Moreover, regional public health media  
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9 289 campaigns focused on cancer prevention and the regional government have promoted  
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11 290 early screening and the treatment of major cancers since the 2000s[20], which likely  
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14 291 explains the reduced proportion of cancer patients. However, PM 2.5 air pollution,  
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16 292 household pollution, tobacco use, residents' insufficient knowledge of NCD  
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19 293 prevention, etc. remain persistent risk factors in eastern coastal China and deserve  
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21 294 considerable attention[21, 22].  
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24 295 Demographic factors may result in physiological and psychological differences across  
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27 296 different populations, which may then give rise to distinct behaviours and ultimately  
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30 297 to a heterogeneous distribution of NCDs. For instance, the Framingham Heart Study  
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32 298 (FHS) conducted in the USA showed that women were significantly older than men at  
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34 299 their first stroke, had a higher stroke rate than men at ages above 85 years, lower rates  
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37 300 than men at all other ages, and a higher life time risk of stroke than men at all  
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40 301 ages[23]. Our study found a significant increase in the proportion of male and female  
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42 302 inpatients with diabetes, blood and endocrine diseases, cardiovascular and circulatory  
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44 303 diseases, and congenital anomalies in eastern coastal China. However, we identified  
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47 304 demographic differences in the patterns of NCDs. The proportion of male inpatients  
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50 305 with digestive diseases decreased, but that of female inpatients remained relatively  
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52 306 high. The proportion of female patients with mental and behavioural disorders  
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55 307 increased. Currently, women in China are employed in the same fast-paced jobs or  
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57 308 roles as men, which is likely one important cause of this phenomenon[24].  
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4 309 Furthermore, women are expected to devote more effort to balancing family and  
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6 310 work[25,26], which is undoubtedly challenging. On the other hand, we found an  
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9 311 increasing trend in the number of men diagnosed with neurological diseases, which  
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11 312 may be associated with the complex aetiology of dystrophia, immune damage,  
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13 313 endocrine disorders, etc. Diet and stress may also influence the incidence of these  
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15 314 diseases among men to a certain extent and should be closely examined.

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19 315 In our study, we found that, on the one hand, a greater proportion of older inpatients  
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21 316 (>50 years) suffered from NCDs such as diabetes or blood and endocrine diseases as  
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23 317 they aged. This proportion increased nearly four-fold from 2003 to 2014. On the other  
24  
25 318 hand, the proportion of inpatients between the ages of 30 and 50 with these diseases  
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27 319 increased significantly. In addition, the proportion of young patients with NCDs, such  
28  
29 320 as cardiovascular and circulatory diseases, increased over the 12-year period. As  
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31 321 shown in Figure 2, cancer was not among the most common NCDs in any age group,  
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33 322 and surprisingly, the proportion of patients with cancer decreased in all age groups but  
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35 323 decreased more quickly in older age groups. This phenomenon is likely highly  
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37 324 correlated with improvements to the environment and the effects of cancer prevention  
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39 325 media campaigns[27-29]. However, this result does not imply that cancer prevention  
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41 326 can be abated in the future.

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45 327 The public's awareness of NCD prevention is insufficient due to complex cultural and  
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47 328 social factors[27,30,31]. The specific risk factors for frequently occurring NCDs in  
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49 329 different gender and age groups should be monitored every year. Other interventions,  
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51 330 such as reform of China's medical system, should aim to improve the function of  
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4 331 community hospitals such that these hospitals focus on NCD prevention. Meanwhile,  
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6 332 education or training should be promoted in communities and among health  
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8 333 practitioners. Knowledge of and information on NCDs should be disseminated via the  
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10 334 media to increase awareness. The distributions of NCDs in eastern coastal China  
11  
12 335 suggest future directions for NCD prevention in this region and may provide similar  
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14 336 developing regions with strategies for better managing NCDs.  
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### 19 337 **Limitations**

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22 338 In this study, there were several limitations. First, the sampled hospitals were the  
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24 339 largest hospitals in eastern coastal cities. These cities were selected to increase the  
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26 340 sample's representativeness of eastern coastal China. However, the generalisability  
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28 341 and reliability of the findings are a concern. However, because the EHR included a  
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30 342 large number of inpatients with NCDs, it was a precise data source for determining  
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32 343 the status of and trends in the occurrence of different diseases. To reduce selection  
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34 344 bias, more representative hospitals from each of the cities must be investigated.  
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36 345 Second, because few longitudinal studies examining the spectrum of NCDs among  
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38 346 many hospitals' inpatients have been conducted in other areas of China, it was  
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40 347 difficult to compare the current findings regarding inpatients' NCDs with those in  
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42 348 other parts of China.  
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### 49 349 **CONCLUSIONS**

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52 350 In summary, the spectrum of NCDs inpatients from 12 hospitals exhibits the severe  
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54 351 NCDs condition and spectrum in eastern coastal China to a certain extent. Specific  
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4 352 NCDs rapidly increased in women and the younger population over the studied  
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6 353 12-year period, underscoring the importance of healthcare policies or guidelines for  
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9 354 developing countries or regions such as China. Public awareness campaigns should be  
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11 355 targeted at the regional level and should consider differences in demographic factors  
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13 356 across regions. However, due to the limited generalisability and reliability of this  
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15 357 study, stronger support must be obtained through future studies on the spectrum of  
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18 358 inpatients' NCDs in eastern coastal China and other regions.

## 359 **Abbreviations**

360 Non-communicable diseases: NCDs

361 GDP: Gross domestic product

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34  
35  
36 364 project in collecting the data.

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45  
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## 371 **Availability of data and materials**

372 All relevant data are available in the Figshare database under the DOI:

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4 373 <https://figshare.com/s/f79b2b4e686d1d477527>

5  
6 374 **Authors' contributions**

7  
8 375 Conceived and designed the experiments: DHY, JWS and ZXW. Analysed the data:

9  
10 376 JWS, HZZ and YL. Contributed reagents/materials/analysis tools: YL, BZ, YP, BW

11  
12 377 and PFS. Wrote the paper: DHY and JWS.

13  
14 378 **Competing interests**

15  
16 379 The authors have declared that they have no competing interests.

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Table 1 Demographic Characteristics of Inpatients with NCDs

Variable	Classification	N	%
Gender	Male	954612	50.05
	Female	952872	49.95
Age (years)	0-10	1008	0.05
	11-20	14688	0.77
	21-30	47484	2.49
	31-40	70164	3.68
	41-50	219060	11.48
	51-60	320172	16.79
	61-70	268176	14.06
Year of admission	71-80	523452	27.44
	>80	443280	23.24
	2003	110796	5.81
	2004	126744	6.64
	2005	127704	6.69
	2006	135972	7.13
	2007	141780	7.43
	2008	145728	7.64
	2009	155220	8.14
	2010	157500	8.26
2011	171060	8.97	
2012	191004	10.01	
2013	209100	10.96	
2014	234876	12.31	
Total		1907484	100.00



Table 2 Ranking of the Most Common NCDs by Group

Variable	First Disease	N(%)	Second Disease	N(%)	Third Disease	N(%)	Fourth Disease	N(%)	Fifth Disease	N(%)
Gender										
Male	Cerebral infarction	120396(12.61)	Coronary heart disease	66216(6.94)	Hypertension	57708(6.05)	Chronic obstructive pulmonary disease	53904(5.65)	Chronic bronchitis	45252(4.74)
Female	Cerebral infarction	91776(9.63)	Hypertension	65136(6.84)	Uterine fibroid	39564(4.15)	Coronary heart disease	31188(3.27)	Chronic bronchitis	25776(2.71)
Age(years)										
0-10	Chronic tonsillitis	264(16.19)	Redundant prepuce	144(14.29)	Adenoid vegetation	72(7.14)	Adenoidal hypertrophy	48(4.76)	Tonsil hypertrophy	24(2.38)
11-20	Redundant prepuce	2064(14.05)	Benign neoplasm of breast	996(6.78)	Spontaneous pneumothorax	648(4.41)	Chronic tonsillitis	552(3.76)	Respiratory failure	444(3.02)
21-30	Redundant prepuce	4704(9.91)	Benign neoplasm of breast	2448(7.51)	Ovarian cyst	3564(5.16)	Ureteral calculi	1632(3.44)	Chronic tonsillitis	1032(2.17)
31-40	Uterine fibroid	5484(7.82)	Ovarian cyst	3156(4.50)	Endometrial polyp	2844(4.05)	Ureteral calculi	2556(3.64)	Hyperplasia of mammary glands	2268(3.23)
41-50	Uterine fibroid	25644(11.71)	Endometrial hyperplasia	9408(4.29)	Hyperplasia of mammary glands	8052(3.68)	Endometrial polyp	7404(3.38)	Ureteral calculi	5640(2.57)
51-60	Cerebral infarction	23124(7.22)	Coronary heart disease	14016(4.38)	Hypertension	12144(3.79)	Ureteral calculi	8364(2.61)	Cerebral haemorrhage	6636(2.07)
61-70	Cerebral infarction	29508(11.00)	Coronary heart disease	14016(6.30)	Hypertension	13668(5.10)	Vertebrobasilar insufficiency	6480(2.42)	Diabetes	5640(2.10)
71-80	Cerebral infarction	75972(14.51)	Hypertension	45612(8.71)	Coronary heart disease	38808(7.41)	Chronic bronchitis	30720(5.87)	Chronic obstructive pulmonary disease	25536(4.88)
>80	Cerebral infarction	46560(17.58)	Hypertension	31488(10.50)	Coronary heart disease	77928(8.51)	Chronic obstructive pulmonary disease	36216(8.17)	Chronic bronchitis	37728(7.10)

Table 3 Distribution of Non-communicable Diseases from 2003 to 2014 in the Total Sample (%)

Disorder	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Z	P-value	Trend
	N	N	N	N	N	N	N	N	N	N	N	N			
	=110796	=126744	=127704	=135972	=141780	=145728	=155220	=157500	=171060	=191004	=209100	=234876			
Cancer	11.57	10.16	8.15	9.33	8.37	8.28	7.24	7.18	7.19	7.80	6.12	5.78	-20.525	<0.001	↓↓↓
Other neoplasms	6.63	8.05	7.43	7.41	5.58	4.55	5.54	4.45	4.67	4.55	4.36	4.01	-20.527	<0.001	↓↓↓
Cardiovascular and circulatory diseases	28.30	29.38	29.18	29.52	31.43	33.33	34.68	36.21	35.64	35.65	34.87	34.60	19.861	<0.001	↑↑↑
Chronic respiratory diseases	13.43	13.46	13.85	12.98	13.50	12.85	12.52	12.45	11.27	10.89	9.37	9.40	-18.290	<0.001	↓↓↓
Diabetes and blood and endocrine diseases	1.36	1.43	1.25	1.26	1.44	1.46	1.35	1.75	1.55	3.67	6.47	6.74	41.268	<0.001	↑↑↑
Digestive diseases	10.54	11.57	10.98	11.24	9.58	10.56	10.00	10.81	10.12	9.67	10.00	10.98	-2.757	0.003	↓↓
Mental and behavioural disorders	0.17	0.08	0.23	0.19	0.19	0.13	0.26	0.25	0.16	0.12	0.36	0.25	3.130	0.001	↑↑
Musculoskeletal disorders	5.44	4.74	4.85	4.64	5.18	4.48	4.58	3.86	4.67	4.54	5.80	6.23	4.668	<0.001	↑↑↑
Urogenital diseases	14.97	13.24	15.95	14.93	15.68	14.65	13.29	13.12	15.34	14.81	13.83	12.72	-5.329	<0.001	↓↓↓
Neurological disorders	2.25	3.78	4.35	3.96	4.58	5.34	5.33	4.97	4.83	3.49	4.13	4.36	3.915	<0.001	↑↑↑
Sensory organ diseases	4.14	3.20	2.69	3.15	3.50	2.97	3.64	3.18	2.84	3.26	3.02	3.15	-2.403	0.008	↓↓
Congenital anomalies	0.40	0.44	0.28	0.38	0.37	0.26	0.49	0.41	0.32	0.28	0.60	0.63	3.750	<0.001	↑↑↑
Skin and subcutaneous disease	0.80	0.47	0.82	0.99	0.59	1.14	1.06	1.35	1.38	1.26	1.08	1.15	7.294	<0.001	↑↑↑

↓ ↓ : P<0.01, negative trend; ↓ ↓ ↓ : P<0.001, negative trend; ↑↑: P<0.01, positive trend; ↑↑↑: P<0.001, positive trend.

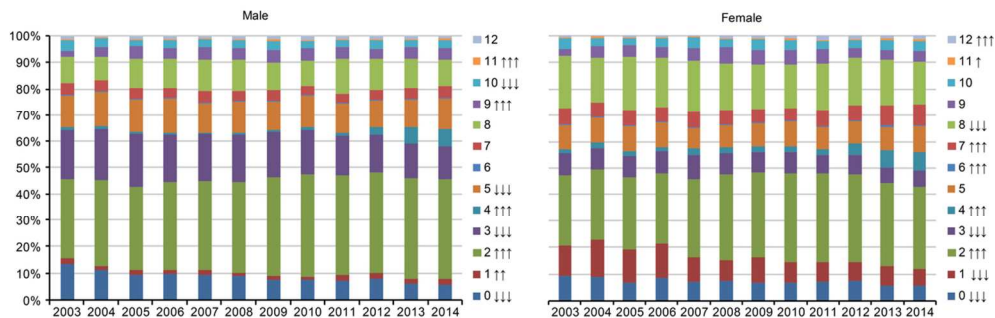


Fig.1 Distribution of non-communicable diseases by gender

0: cancer, 1: other neoplasms, 2: cardiovascular and circulatory diseases, 3: chronic respiratory diseases, 4: diabetes and blood and endocrine diseases, 5: digestive diseases, 6: mental and behavioural disorders, 7: musculoskeletal disorders, 8: urogenital diseases, 9: neurological disorders, 10: sensory organ diseases, 11: congenital anomalies, 12: skin and subcutaneous diseases

↓: P<0.05, negative trend; ↓↓: P<0.01, negative trend; ↓↓↓: P<0.001, negative trend;

↑: P<0.05, positive trend; ↑↑: P<0.01, positive trend; ↑↑↑: P<0.001, positive trend.

55x17mm (600 x 600 DPI)

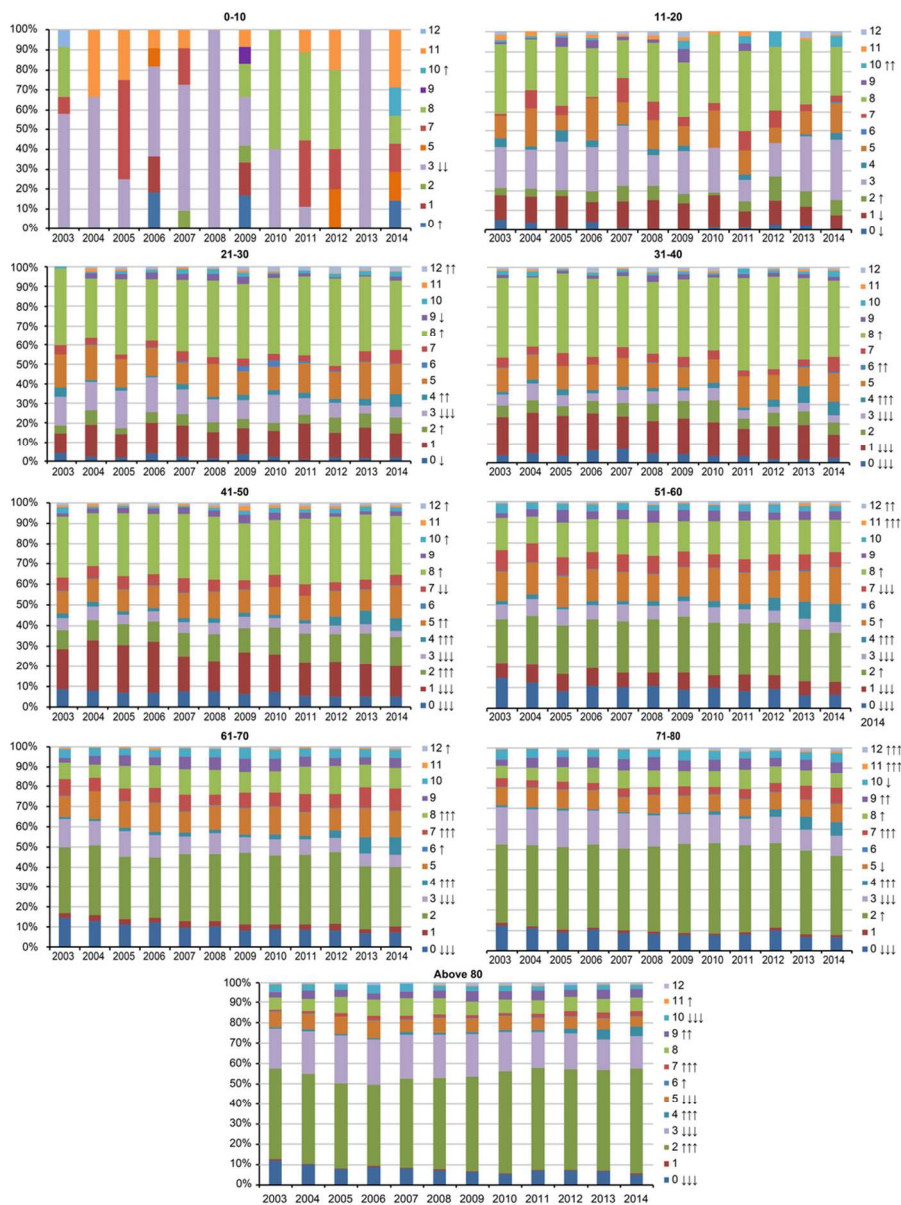


Fig. 2 Distribution of non-communicable diseases by age  
 0: cancer, 1: other neoplasms, 2: cardiovascular and circulatory diseases, 3: chronic respiratory diseases,  
 4: diabetes and blood and endocrine diseases, 5: digestive diseases, 6: mental and behavioural disorders,  
 7: musculoskeletal disorders, 8: urogenital diseases, 9: neurological disorders, 10: sensory organ diseases,  
 11: congenital anomalies, 12: skin and subcutaneous diseases  
 ↓: P<0.05,negative trend;↓↓: P<0.01, negative trend;↓↓↓: P<0.001,negative trend;  
 ↑: P<0.05,positive trend; ↑↑: P<0.01,positive trend;↑↑↑: P<0.001,positive trend.

48x64mm (600 x 600 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	5-6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7-8
		(b) Describe any methods used to examine subgroups and interactions	7-8
		(c) Explain how missing data were addressed	7-8
		(d) If applicable, describe analytical methods taking account of sampling strategy	7-8
		(e) Describe any sensitivity analyses	7-8
<b>Results</b>			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	N/A
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	8-11
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A
		(b) Report category boundaries when continuous variables were categorized	N/A
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	11-12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## Identifying the patterns of non-communicable diseases in developed eastern coastal China: A longitudinal study on the electronic health records in 12 public hospitals

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4 1 **Identifying the patterns of non-communicable diseases in**  
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6 2 **developed eastern coastal China: A longitudinal study on the**  
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9 3 **electronic health records in 12 public hospitals**

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# 29 Identifying the patterns of non-communicable 30 diseases in developed eastern coastal China: A 31 longitudinal study on the electronic health records in 32 12 public hospitals

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## 30 ABSTRACT

31  
32  
33 **Objective:** Few studies have examined the spectrum and trends of non-communicable  
34 diseases (NCDs) in inpatients in eastern coastal China, which is transforming from an  
35 industrial economy to a service-oriented economy and is the most economically  
36 developed region in the country. The aim of this study was to dynamically elucidate  
37 the spectrum and characteristics of severe NCDs in eastern coastal China by analysing  
38 patients' longitudinal electronic health records (EHRs).

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41 **Setting:** To monitor the spectrum of NCDs dynamically, we extracted the EHR data  
42 from 12 general tertiary hospitals in eastern coastal China from 2003 to 2014. The  
43 rankings of and trends in the proportions of different NCDs presented by inpatients in  
44 different gender and age groups were calculated and analysed.

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4 51 **Participants:** We obtained a total sample of 1,907,484 inpatients with NCDs from  
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6 52 2003 to 2014, 50.05% of whom were male and the majority of whom were aged 50  
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8 53 years or older (81.53%).

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11 54 **Results:** There is an increase in the number of total NCD inpatients in eastern coastal  
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14 55 China from 2003 to 2014. However, the proportion of chronic respiratory diseases and  
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17 56 cancer inpatients decreased over the 12-year period. Compared with men, women  
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20 57 displayed higher proportions of digestive diseases ( $P=0.394$ ) and neurological  
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22 58 disorders ( $P=0.173$ ) over time. The older group accounted for a larger and growing  
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24 59 proportion of the NCD inpatients, and the most common conditions in this group were  
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27 60 cerebral infarctions, coronary heart disease and hypertension. In addition, the  
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30 61 proportion of 21- to 50-year-old inpatients with diabetes, blood diseases or endocrine  
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32 62 diseases skyrocketed from 2003 to 2014 ( $P<0.001$ ).

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35 63 **Conclusions:** The burden of inpatients' NCDs increased rapidly, particularly among  
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38 64 women and younger people. The NCD spectrum observed in eastern coastal China is  
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41 65 a good source of evidence for developing prevention guides for regions experiencing  
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43 66 transition.

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45 67 **Keywords:** Non-communicable diseases; Electronic Health Record; Eastern coastal  
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48 68 China; Health policy

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51 69 **Strengths and limitations**

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53 70 ● The concept of using longitudinal EHRs to document the proportion of NCD  
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56 71 admissions in eastern coastal China hospitals can provide a reasonably simple and  
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4 72 precise method of examining NCD trends over time.  
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6 73 ● The evidence is a good source to develop NCD prevention guides or policies for  
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8 74 similar developing regions that are undergoing or will undergo an economic  
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10 75 transformation.  
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12 76 ● The generalisability and reliability of the findings of this study are a concern, and  
13  
14 77 more hospitals from other parts of China should be included in future studies to  
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16 78 make a persuasive comparison.  
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## 24 INTRODUCTION

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27 81 In recent years, an epidemiological shift in morbidity and mortality from infectious  
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29 82 diseases and malnutrition to non-communicable diseases(NCDs) has occurred in  
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31 83 many countries, including China[1-3]. NCDs have become the major causes of death  
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33 84 in China and globally. According to the 2012 WHO data repository, 87% of deaths in  
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35 85 China were associated with NCDs[1]. The Global Burden of Disease Study(GBD)  
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37 86 revealed that of the 8.3 million deaths in China in 2010, 7.0 million resulted from  
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39 87 NCDs[3]. Stroke, ischaemic heart disease, cancers, and chronic obstructive  
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41 88 pulmonary disease are now the leading causes of premature death in China, and the  
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43 89 burden of these diseases is substantial[4].  
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50 90 Previous research on the epidemiological patterns of NCDs in China has primarily  
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52 91 focused on the entire nation or cross-sectional studies of specific regions[1-6].  
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54 92 However, both the WHO and the GBD have acknowledged that a national analysis  
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56 93 conducted in a country as large and diverse as China can mask substantial variations  
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4 94 in key outcomes[3,5]. In addition, few studies have examined the NCD spectrum in  
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6 95 inpatients, which can reflect the severe state of NCDs. In this study, we conducted a  
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9 96 longitudinal study of NCD patterns in five provinces in eastern coastal China:  
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11 97 Shandong, Jiangsu, Zhejiang, Shanghai and Guangdong provinces. Geographically  
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14 98 speaking, these provinces are located in the three most productive and dynamic  
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16 99 regions of China: the Bohai Sea, the Yangtze River Delta and the Pearl River Delta.  
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19 100 The gross regional domestic product in these five provinces accounts for  
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21 101 approximately half that of the 32 provinces/autonomous regions/municipalities in  
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24 102 China. These provinces' gross domestic product(GDP) per capita far exceeded the  
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26 103 average value in China from 2005 to 2014[7] and was similar to the GDP of other  
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29 104 developed countries in Asia. Moreover, since the 2000s, this region has experienced  
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31 105 dramatic changes in both the economic and health sectors[8]. According to the Health  
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34 106 Statistics Yearbook, in 2015, the average life expectancy in eastern coastal China was  
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36 107 around 78 years old, which is greater than the national average of approximately 76  
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39 108 years old[7]. Due to the rapid urbanisation, economic development and population  
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41 109 ageing in eastern coastal China, NCDs and disabilities are becoming more  
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44 110 prevalent[1,3], and the spectrum of inpatients' diseases in this area is speculated to  
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46 111 largely differ from that in other regions of China. More specific guidelines for  
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49 112 preventing and curing NCDs that are tailored to the disease patterns observed in  
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52 113 eastern coastal China must be developed.

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55 114 In exploring disease patterns, particularly in longitudinal studies based on a large  
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57 115 sample, second-hand data may be regarded as a good source. In particular, data from  
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4 116 hospitals' electronic health record(EHR) systems have unique advantages. For  
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6 117 instance, Upshur et al. applied time series methods to a population-based retrospective  
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9 118 cohort for the 52 most common causes of hospital admissions in the province of  
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11 119 Ontario from 1988 to 2001 and showed that hospital admissions displayed systematic  
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14 120 patterns that are understandable, predictable, and reasonably accurate[9]. Using data  
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16 121 from the admission and discharge/death register, Sani et al.[10] conducted a  
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19 122 three-year review of mortality patterns. Their result supported the emerging trend of a  
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21 123 combined burden of communicable diseases and NCDs. In China, disease surveillance  
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24 124 is conducted by the National Disease Surveillance Points System, which was founded  
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26 125 in 1978; however, this system reports primarily on communicable diseases and reports  
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29 126 on only a small subset of NCDs, such as cancer[11,12]. Given these factors, the  
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31 127 current study used the hospital-based EHR system as a data source. This relatively  
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34 128 new database compiles clinical information from a large number of patients in a  
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36 129 computationally accessible form. The EHR system provides us with a unique  
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39 130 opportunity to elucidate the relatively severe NCD epidemiology and includes a  
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41 131 diverse array of NCDs[13].

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44 132 The aim of this study was to dynamically elucidate the spectrum and characteristics of  
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46 133 severe NCDs in eastern coastal China by analysing hospitals' longitudinal EHR data.

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49 134 The results can provide insight into the aetiology of NCDs and aid in the development  
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51 135 of evidence-based clinical guidelines for preventing and curing NCDs. In addition, the  
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54 136 distribution of NCDs in eastern coastal China can inform the development of clinical  
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57 137 guidelines for NCDs in other regions or countries in transition.  
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## 138 **METHODS**

### 139 **Study design and data collection**

140 Longitudinal data(2003-2014) on NCDs were extracted from the EHR systems of 12  
141 general tertiary hospitals in Shandong(2 hospitals), Jiangsu(2 hospitals), Zhejiang(2  
142 hospitals), Shanghai(3 hospitals) and Guangdong Provinces(3 hospitals).

143 A multistage sample was obtained. To obtain a representative sample, when choosing  
144 the sites, we first selected 3 cities that represented high, middle, and low  
145 socioeconomic statuses, as defined by GDP level, in each of the 5 provinces. Second,  
146 in each city, we selected the largest general tertiary hospital, resulting in 15 sampled  
147 hospitals. However, we did not obtain consent from three tertiary hospitals in some  
148 cities in Shandong, Jiangsu and Zhejiang Provinces due to political reasons regarding  
149 EHR data collection. In China, EHR data are not openly available but can be obtained  
150 from consenting hospitals with the help of health authorities. However, for several  
151 reasons, the health authorities cannot support us in the future. Thus, 12 general  
152 tertiary hospitals were included in the study. In this study, one hospital in Shandong  
153 Province in the low socioeconomic group, one hospital in Jiangsu Province in the  
154 middle socioeconomic group, and one hospital in Zhejiang Province in the high group  
155 were missing from the dataset. However, due to the distribution of the missing  
156 hospitals, it was thought that lack of participation of these hospitals would not  
157 influence the final results. In China, EHRs have used a uniform version since 2001 in  
158 most large cities and comprised two parts. The first part contains the patients' personal

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4 159 information, including their gender, age, identification card number, profession,  
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6 160 address, etc. This information is usually provided by the patients or their family. The  
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9 161 second part contains the inpatients' hospitalisation information, including their  
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11 162 diagnosis code, discharge status, pathologic diagnosis (if possible), operation code (if  
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14 163 possible), etc. This information is provided by the patient's physician, which ensures  
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16 164 its reliability. In terms of the diagnosis code, each inpatient is coded with an ICD-9  
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18 165 disease code by their physician. In addition, the GBD has well defined categories for  
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21 166 NCDs. Therefore, we extracted the inpatients' NCDs using their ICD-9 codes and  
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24 167 classified them into different categories.

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27 168 We selected tertiary hospitals for this study. In China, hospitals are classified into  
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30 169 three categories according to their major functions. Although community institutions  
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33 170 are intended to serve as gatekeepers, a patient's freedom to select medical facilities  
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35 171 and doctors is not restricted by policies or health insurance coverage. Consequently,  
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38 172 patients with acute or chronic diseases frequently visit the higher-tier, more  
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40 173 sophisticated or specialised, and more expensive hospitals rather than community  
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42 174 health centres, and many of the community health centres do not have hospital beds.  
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45 175 In addition, their EHR systems are defective and incomplete, limiting the use of the  
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48 176 information they contain[14]. Typically, the largest tertiary hospitals see most of the  
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50 177 patients discharged in their cities.

## 51 52 53 178 **Study subjects**

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57 179 In this study, information on inpatients with NCDs was extracted from the 2003-2014  
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4 180 hospital EHR data of each hospital, and only individuals who had been admitted to  
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6 181 these hospitals during this period were included. We chose 2003 as the starting point  
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9 182 because the first EHR system was formally launched in these hospitals in that year. In  
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11 183 our study, the EHR systems of the tertiary hospitals include the admission information  
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13 184 of patients who received their first diagnosis of an NCD between 2003 and 2014. We  
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15 185 excluded any duplicated patients by searching and analysing their Identification Card  
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18 186 number in the EHRs. In addition, because these hospitals may also attract patients  
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21 187 from other districts or provinces, the inclusion criteria stipulated that participants must  
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23 188 have a fixed address in the relevant region, regardless of whether they were registered  
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26 189 or nonregistered residents. After excluding non-residents, NCD information for a total  
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29 190 of 1,907,484 inpatients was stripped of identifying information and extracted from the  
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31 191 hospitals' EHR systems. These patients were admitted to a variety of hospital  
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33 192 divisions, and according to the ICD-9 and GBD NCD classification, we extracted the  
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35 193 NCD patients from all of the inpatients and classified them into various disease  
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38 194 groups based on their first-list diagnosis. The final data set included the residents'  
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41 195 basic demographic information(gender and age) and the presence of chronic  
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43 196 diseases(disease system/category, disorder and year of admission). We did not include  
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46 197 region and socioeconomic status as factors because all of the hospitals were located in  
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49 198 an urban region and because it is difficult to determine the inpatients' socioeconomic  
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52 199 status from the EHR.

## 200 **Statistical analysis**

201 All data were analysed by using SAS Software 9.20. Basic descriptive statistics were



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4 202 used to analyse the inpatients' personal characteristics(gender, age, and year of  
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6 203 admission). The NCD systems and the most common disorders within each disease  
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8 204 system were ranked according to their relative proportions. The Cochran-Armitage  
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10 205 Chi-square test was then used to examine significant increases or decreases in the  
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12 206 proportions of NCDs in disease systems across different gender and age groups  
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14 207 between 2003 and 2014.  
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#### 19 208 **Ethics statement**

20 209 All research activities were conducted with integrity according to generally accepted  
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22 210 ethical principles and were approved by the Ethics Committees of Tongji  
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24 211 University(ref: LL-2016-ZRKX-017). This study presented minimal risk of harm to  
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26 212 its subjects, and the data were collected anonymously. None of the inpatients'  
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28 213 personal information included in the database was available to individuals outside of  
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30 214 the research team.  
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## 39 215 **RESULTS**

### 40 216 **Description of the personal characteristics of inpatients with NCDs**

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42 217 The personal characteristics of the studied population are summarised in Table 1. This  
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44 218 population included 1,907,484 inpatients with NCDs, 50.05% of whom were male.  
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46 219 Most of these patients were aged 50 years or older(81.53%). Furthermore, the number  
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48 220 of inpatients with NCDs increased from 2003 to 2014.  
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### 55 221 **Ranking of the disorders in all NCDs categories within gender and age groups**

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4 222 The ranks and proportions of all NCDs for each gender group are presented in Table 2.  
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6 223 Among males, each of the five most common disorders represented more than 4.0%  
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8 224 of the total NCDs from 2003 to 2014. The three most frequently occurring disorders  
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10 225 among men inpatients were cerebral infarction(12.61%), coronary heart  
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12 226 disease(6.94%) and hypertension(6.05%). Similarly, those for women showed that  
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14 227 cerebral infarction(9.63%) occurred most frequently. However, hypertension(6.84%)  
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16 228 and uterine fibroids(4.15%) were the second and third most frequently occurring  
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18 229 NCDs among women, respectively.  
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24 230 Table 2 also shows the ranks of the most frequently occurring disorders across age  
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26 231 groups. The older group(>41 years of age) accounted for a larger proportion of NCD  
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28 232 inpatients, and the most common conditions in this group were cerebral infarction,  
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30 233 coronary heart disease and hypertension. In the 11- to 50-year-old group, urogenital  
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32 234 diseases, endocrine diseases and neoplasms including redundant prepuce, benign  
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34 235 neoplasm of the breast and endometrial hyperplasia occurred frequently in men and  
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36 236 women. In addition, hypertension, chronic obstructive pulmonary disease and diabetes  
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38 237 were more common among the elderly than among individuals in the other age  
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40 238 groups.  
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#### 48 239 **Distribution of NCDs across the different groups from 2003 to 2014**

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50 240 Table 3 shows the changes in the proportions of the 12 NCD categories from 2003 to  
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52 241 2014. A significant decrease in the occurrence of cancer( $Z=-20.525$ ,  $P<0.001$ ), other  
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54 242 neoplasms( $Z=-20.525$ ,  $P<0.001$ ), chronic respiratory diseases( $Z=-18.290$ ,  $P<0.001$ ),  
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4 243 urogenital diseases( $Z=-5.329$ ,  $P<0.001$ ) and sensory organ diseases( $Z=-2.403$ ,  
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6 244  $P=0.008$ ) was found. In contrast, the proportions of other NCDs increased to various  
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8 245 extents over the 12-year period. Notably, the proportion of patients with diabetes and  
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10 246 blood and endocrine diseases increased approximately four-fold(from 1.36% to  
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12 247 6.74%).

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17 248 As shown in Figure 1, the 12-year NCD percentages recorded in the hospitals varied  
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19 249 widely by gender. The percentage of both men and women who were diagnosed with  
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21 250 diabetes or blood and endocrine diseases increased substantially. It is worth noting  
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23 251 that the percentage of women who were diagnosed with digestive diseases( $Z=-0.270$ ,  
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25 252  $P=0.394$ ), neurological disorders( $Z=0.943$ ,  $P=0.173$ ), and sensory organ diseases  
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27 253 ( $Z=0.056$ ,  $P=0.478$ ) was higher and found in more stable proportions from 2003 to  
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29 254 2014; this result is in strong contrast to the pattern found in the male inpatients. In  
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31 255 addition, although the proportion of cancer and other neoplasms decreased in women,  
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33 256 this decrease was less pronounced than that found in men.

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39 257 Changes in NCDs proportions across age groups were also examined(Figure 2).  
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41 258 NCDs were relatively rare among patients aged 10 years or younger, but chronic  
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43 259 respiratory diseases occurred most frequently in this group. For 11-20-year-old  
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45 260 subjects, sensory organ diseases( $Z=3.304$ ,  $P<0.001$ ) and cardiovascular and  
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47 261 circulatory diseases( $Z=2.090$ ,  $P=0.018$ ) occurred more frequently over time. We  
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49 262 noted the proportions of patients with diabetes or blood and endocrine diseases  
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51 263 increased in these two groups and in the below 30-year-old group. For the 41- to  
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53 264 50-year-old group, the number of patients diagnosed with cancer decreased  
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4 265 significantly but the proportions of patients with cardiovascular, circulatory( $Z=7.918$ ,  
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6 266  $P<0.001$ ) and digestive diseases ( $Z=3.086$ ,  $P<0.01$ ) increased to a greater extent than  
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9 267 in the younger population. In the  $\geq 50$ -year-old group, the proportion of patients with  
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11 268 diabetes or blood and endocrine diseases increased substantially( $P<0.001$ ).

## 15 269 **DISCUSSION**

17 270 By analysing the EHR information of inpatients with NCDs at 12 hospitals in eastern  
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20 271 coastal China, our research team was able to elucidate the severe NCD patterns in a  
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22 272 relatively unbiased fashion and to confirm that NCDs displayed regional  
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25 273 heterogeneity to some extent. The increase in the number of NCD inpatients in eastern  
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28 274 coastal China from 2003 to 2014 may be due to several reasons. First, owing to  
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30 275 improvements in economics, health insurance and convenient transportation in China,  
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32 276 even people with minor diseases may go to larger hospitals because they are equipped  
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35 277 with better devices and doctors and do not adhere to strict referral policies. Second,  
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37 278 the increase in the number of severe NCD patients may mainly result from higher  
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40 279 pressure, a lack of exercise, and air pollution, among other factors in rapidly  
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42 280 developed cities[14,15], which is consistent with the findings of Allen et al.(2017)  
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45 281 who, in a systematic review, showed that NCD behavioural risk factors is well  
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47 282 established in high-income countries. For example, high socioeconomic groups were  
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50 283 found to be less physically active and to consume more fats, salt, and processed food  
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53 284 than low socioeconomic status individuals[16].

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56 285 In order of ranks, cardiovascular and circulatory diseases, urogenital diseases, chronic  
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4 286 respiratory diseases, and digestive diseases were the most common NCDs in this  
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6 287 region. In eastern coastal China, severe cardiovascular and circulatory diseases may  
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9 288 occur more frequently because of the greater degree of urbanisation and greater  
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11 289 proportion of ageing population in the region[2,3]. Goryakin et al.(2017) studied the  
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13 290 contribution of urbanisation to NCDs in 173 countries and found that when shifting  
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15 291 from rural to urban areas, the average body mass index (BMI), total cholesterol level  
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17 292 and systolic blood pressure, increased[17], demonstrating that high urbanisation  
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19 293 increases the occurrence of cardiovascular and circulatory diseases, which is in  
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21 294 consistent with this study. In addition, the frequency of urogenital diseases (second)  
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23 295 and digestive diseases (fourth) in this region is potentially because of the more rapid  
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25 296 pace of modern life, more sedentary lifestyle and longer working hours. In our search  
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27 297 of existing studies on inpatients with NCDs, we rarely found this spectrum at the top  
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29 298 of the list in other regions[18]. However, interestingly, this study revealed that the  
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31 299 proportion of chronic respiratory diseases and cancer inpatients decreased over the  
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33 300 12-year period, in stark contrast to the changes in the incidence observed throughout  
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35 301 China[19,20]. Often, previous studies have concluded that the incidence of respiratory  
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37 302 diseases is increasing, likely due to ambient air pollution and tobacco use, resulting in  
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39 303 tremendous threats to respiratory health[3,21]. This difference may be a result of the  
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41 304 data because the reported incidence also includes mild respiratory diseases. However,  
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43 305 the opposite trend found in inpatients in eastern coastal China may have also resulted  
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45 306 from this region's transition from a heavy industrial district to a technologically  
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47 307 focused area, which has been associated with a substantial reduction in environmental  
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4 308 pollution. Moreover, the regional public health media campaigns have focused on  
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6 309 cancer prevention and the regional government has promoted early screening and the  
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9 310 treatment of major cancers since the 2000s, particularly in these developed areas in  
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11 311 China where the government can invest more money into public health activities[22],  
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14 312 which likely explains the reduced proportion of cancer patients. However, PM 2.5 air  
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16 313 pollution, household pollution, tobacco use, residents' insufficient knowledge of NCD  
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18 314 prevention, etc. remain persistent risk factors in eastern coastal China and deserve  
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21 315 considerable attention[23,24].  
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24 316 Concerning the NCD distribution in the different age groups, we found that the older  
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27 317 age group accounted for the largest proportion of individuals with NCDs, with  
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29 318 cerebral infarction, coronary heart disease and hypertension being the most common  
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31 319 conditions, which is consistent with the epidemiological features of NCDs[25,26] and  
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34 320 indicates these NCDs represent a significant burden for the Chinese government.  
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37 321 Interestingly, it is also found that not only did the proportion of older patients  
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39 322 suffering from NCDs such as diabetes or blood and endocrine diseases increase nearly  
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42 323 four-fold from 2003 to 2014, but also, the proportion of younger individuals between  
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44 324 the ages of 30 and 50 with these diseases increased significantly. However, this may  
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47 325 be the result of unhealthy nutrient intake and great psychological pressure on the  
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50 326 younger population in this fast-paced area and should be given great attention.  
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53 327 Additionally, the identified demographic differences in which women exhibit a higher  
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55 328 proportion of severe digestive diseases and neurological disorders may indicate that  
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58 329 currently, women in China are employed in the same fast-paced jobs or roles as  
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4 330 men[27]. Furthermore, women are expected to devote more effort to balancing family  
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6 331 and work[28,29] in developed areas or cities, which is undoubtedly challenging for  
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9 332 them and may induce the onset of these diseases. These factors imply that specific  
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11 333 risk factors for frequently occurring NCDs in different gender groups should be  
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14 334 monitored in addition to the diseases or groups that are currently monitored and  
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16 335 screened for due to their significant burden. Other frequently occurring NCD diseases  
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19 336 and a wider population should also be targeted, such as the prevention and screening  
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21 337 of digestive diseases in females or increased preventative measures for diabetes and  
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24 338 blood, endocrine, cardiovascular and circulatory diseases among the younger and  
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26 339 population. In addition, all these call for the improvement and more invest in  
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29 340 prevention and control of NCDs by community health institutions, which is lagged  
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31 341 even in the economic-developed eastern coastal or averagely the whole China  
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34 342 compared with the western countries[30]. For instance, usually community health  
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36 343 institutions are competing with hospitals to attract more patients, and only the public  
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39 344 health physicians(different from general physicians) mainly take the responsibilities  
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41 345 of health education and follow-up visit for NCD patients. According to a survey on a  
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44 346 representative community health institution in Shanghai, the public health physicians  
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46 347 accounted for 7.94% of the total health personnel, which are in great shortage.  
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49 348 Undoubtedly, this is a significant political and public issue for China currently to better  
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51 349 reduce the NCDs and improve the national health[31].  
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### 53 54 350 **Limitations**

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58 351 In this study, there were several limitations. First, the sampled hospitals were the  
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4 352 largest hospitals in eastern coastal cities. These cities were selected to increase the  
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6 353 sample's representativeness of eastern coastal China. However, the generalisability  
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9 354 and reliability of the findings are a concern. Because the EHR included a large  
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11 355 number of inpatients with NCDs, it was a precise data source for determining the  
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14 356 status of and trends in the occurrence of different diseases. To reduce selection bias,  
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16 357 more representative hospitals from each of the cities must be investigated. Second,  
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19 358 because socioeconomic data was absent in the EHRs, we were unable to compare the  
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21 359 differences in socioeconomic groups in this study. Third, because few longitudinal  
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24 360 studies examining the spectrum of NCDs among many hospitals' inpatients have been  
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26 361 conducted in other areas of China, it was difficult to compare the current findings  
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29 362 regarding inpatients' NCDs with those in other parts of China.

## 363 **CONCLUSIONS**

364 In summary, the spectrum of NCD inpatients from 12 hospitals exhibits the severe  
365 NCDs condition and spectrum in eastern coastal China to a certain extent. Specific  
366 NCDs rapidly increased in women and the younger population over the studied  
367 12-year period, underscoring the importance of healthcare policies or guidelines for  
368 developing countries or regions such as China. However, due to the limited  
369 generalisability and reliability of this study, stronger support must be obtained  
370 through future studies on the spectrum of inpatients' NCDs in eastern coastal China  
371 and other regions.

## 372 **Abbreviations**

373 Non-communicable diseases: NCDs



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4 374 GDP: Gross domestic product  
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9

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13

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32 385 **Availability of data and materials**  
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35 386 All relevant data are available in the Figshare database under the DOI:

36  
37 387 <https://figshare.com/s/f79b2b4e686d1d477527>  
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39

40 388 **Authors' contributions**  
41

42 389 Conceived and designed the experiments: DHY, JWS and ZXW. Analysed the data:  
43  
44 390 JWS, HZZ and YL. Contributed reagents/materials/analysis tools: YL, BZ, YP, BW  
45  
46 391 and PFS. Wrote the paper: DHY and JWS.  
47  
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50 392 **Competing interests**  
51

52 393 The authors have declared that they have no competing interests.  
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Table 1 Demographic Characteristics of Inpatients with NCDs

Variable	Classification	N	%
Gender	Male	954612	50.05
	Female	952872	49.95
Age (years)	0-10	1008	0.05
	11-20	14688	0.77
	21-30	47484	2.49
	31-40	70164	3.68
	41-50	219060	11.48
	51-60	320172	16.79
	61-70	268176	14.06
	71-80	523452	27.44
	>80	443280	23.24
Year of admission	2003	110796	5.81
	2004	126744	6.64
	2005	127704	6.69
	2006	135972	7.13
	2007	141780	7.43
	2008	145728	7.64
	2009	155220	8.14
	2010	157500	8.26
	2011	171060	8.97
	2012	191004	10.01
	2013	209100	10.96
	2014	234876	12.31
	Total	1907484	100.00

Table 2 Ranking of the Most Common NCDs by Group

Variable	First Disease	N(%)	Second Disease	N(%)	Third Disease	N(%)	Fourth Disease	N(%)	Fifth Disease	N(%)
Gender										
Male	Cerebral infarction	120396(12.61)	Coronary heart disease	66216(6.94)	Hypertension	57708(6.05)	Chronic obstructive pulmonary disease	53904(5.65)	Chronic bronchitis	45252(4.74)
Female	Cerebral infarction	91776(9.63)	Hypertension	65136(6.84)	Uterine fibroid	39564(4.15)	Coronary heart disease	31188(3.27)	Chronic bronchitis	25776(2.71)
Age(years)										
0-10	Chronic tonsillitis	264(16.19)	Redundant prepuce	144(14.29)	Adenoid vegetation	72(7.14)	Adenoidal hypertrophy	48(4.76)	Tonsil hypertrophy	24(2.38)
11-20	Redundant prepuce	2064(14.05)	Benign neoplasm of breast	996(6.78)	Spontaneous pneumothorax	648(4.41)	Chronic tonsillitis	552(3.76)	Respiratory failure	444(3.02)
21-30	Redundant prepuce	4704(9.91)	Benign neoplasm of breast	2448(7.51)	Ovarian cyst	3564(5.16)	Ureteral calculi	1632(3.44)	Chronic tonsillitis	1032(2.17)
31-40	Uterine fibroid	5484(7.82)	Ovarian cyst	3156(4.50)	Endometrial polyp	2844(4.05)	Ureteral calculi	2556(3.64)	Hyperplasia of mammary glands	2268(3.23)
41-50	Uterine fibroid	25644(11.71)	Endometrial hyperplasia	9408(4.29)	Hyperplasia of mammary glands	8052(3.68)	Endometrial polyp	7404(3.38)	Ureteral calculi	5640(2.57)
51-60	Cerebral infarction	23124(7.22)	Coronary heart disease	14016(4.38)	Hypertension	12144(3.79)	Ureteral calculi	8364(2.61)	Cerebral haemorrhage	6636(2.07)
61-70	Cerebral infarction	29508(11.00)	Coronary heart disease	14016(6.30)	Hypertension	13668(5.10)	Vertebrobasilar insufficiency	6480(2.42)	Diabetes	5640(2.10)
71-80	Cerebral infarction	75972(14.51)	Hypertension	45612(8.71)	Coronary heart disease	38808(7.41)	Chronic bronchitis	30720(5.87)	Chronic obstructive pulmonary disease	25536(4.88)
>80	Cerebral infarction	46560(17.58)	Hypertension	31488(10.50)	Coronary heart disease	77928(8.51)	Chronic obstructive pulmonary disease	36216(8.17)	Chronic bronchitis	37728(7.10)

Table 3 Distribution of Non-communicable Diseases from 2003 to 2014 in the Total Sample (%)

Disorder	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Z	P-value	Trend
	N	N	N	N	N	N	N	N	N	N	N	N			
	=110796	=126744	=127704	=135972	=141780	=145728	=155220	=157500	=171060	=191004	=209100	=234876			
Cancer	11.57	10.16	8.15	9.33	8.37	8.28	7.24	7.18	7.19	7.80	6.12	5.78	-20.525	<0.001	↓↓↓
Other neoplasms	6.63	8.05	7.43	7.41	5.58	4.55	5.54	4.45	4.67	4.55	4.36	4.01	-20.527	<0.001	↓↓↓
Cardiovascular and circulatory diseases	28.30	29.38	29.18	29.52	31.43	33.33	34.68	36.21	35.64	35.65	34.87	34.60	19.861	<0.001	↑↑↑
Chronic respiratory diseases	13.43	13.46	13.85	12.98	13.50	12.85	12.52	12.45	11.27	10.89	9.37	9.40	-18.290	<0.001	↓↓↓
Diabetes and blood and endocrine diseases	1.36	1.43	1.25	1.26	1.44	1.46	1.35	1.75	1.55	3.67	6.47	6.74	41.268	<0.001	↑↑↑
Digestive diseases	10.54	11.57	10.98	11.24	9.58	10.56	10.00	10.81	10.12	9.67	10.00	10.98	-2.757	0.003	↓↓
Mental and behavioural disorders	0.17	0.08	0.23	0.19	0.19	0.13	0.26	0.25	0.16	0.12	0.36	0.25	3.130	0.001	↑↑
Musculoskeletal disorders	5.44	4.74	4.85	4.64	5.18	4.48	4.58	3.86	4.67	4.54	5.80	6.23	4.668	<0.001	↑↑↑
Urogenital diseases	14.97	13.24	15.95	14.93	15.68	14.65	13.29	13.12	15.34	14.81	13.83	12.72	-5.329	<0.001	↓↓↓
Neurological disorders	2.25	3.78	4.35	3.96	4.58	5.34	5.33	4.97	4.83	3.49	4.13	4.36	3.915	<0.001	↑↑↑
Sensory organ diseases	4.14	3.20	2.69	3.15	3.50	2.97	3.64	3.18	2.84	3.26	3.02	3.15	-2.403	0.008	↓↓
Congenital anomalies	0.40	0.44	0.28	0.38	0.37	0.26	0.49	0.41	0.32	0.28	0.60	0.63	3.750	<0.001	↑↑↑
Skin and subcutaneous disease	0.80	0.47	0.82	0.99	0.59	1.14	1.06	1.35	1.38	1.26	1.08	1.15	7.294	<0.001	↑↑↑

↓↓: P<0.01, negative trend; ↓↓↓: P<0.001, negative trend; ↑↑: P<0.01, positive trend; ↑↑↑: P<0.001, positive trend.



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7 Fig.1 Distribution of non-communicable diseases by gender

8 0: cancer, 1: other neoplasms, 2: cardiovascular and circulatory diseases, 3: chronic respiratory diseases, 4: diabetes and blood and endocrine  
9 diseases, 5: digestive diseases, 6: mental and behavioural disorders, 7: musculoskeletal disorders, 8: urogenital diseases, 9: neurological  
10 disorders, 10: sensory organ diseases, 11: congenital anomalies, 12: skin and subcutaneous diseases

11 ↓ : P<0.05, negative trend; ↓ ↓ : P<0.01, negative trend; ↓ ↓ ↓ : P<0.001, negative trend;  
12 ↑ : P<0.05, positive trend; ↑ ↑ : P<0.01, positive trend; ↑ ↑ ↑ : P<0.001, positive trend.  
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17 Fig. 2 Distribution of non-communicable diseases by age

18 0: cancer, 1: other neoplasms, 2: cardiovascular and circulatory diseases, 3: chronic respiratory diseases, 4: diabetes and blood and endocrine  
19 diseases, 5: digestive diseases, 6: mental and behavioural disorders, 7: musculoskeletal disorders, 8: urogenital diseases, 9: neurological  
20 disorders, 10: sensory organ diseases, 11: congenital anomalies, 12: skin and subcutaneous diseases

21 ↓ : P<0.05, negative trend; ↓ ↓ : P<0.01, negative trend; ↓ ↓ ↓ : P<0.001, negative trend;  
22 ↑ : P<0.05, positive trend; ↑ ↑ : P<0.01, positive trend; ↑ ↑ ↑ : P<0.001, positive trend.  
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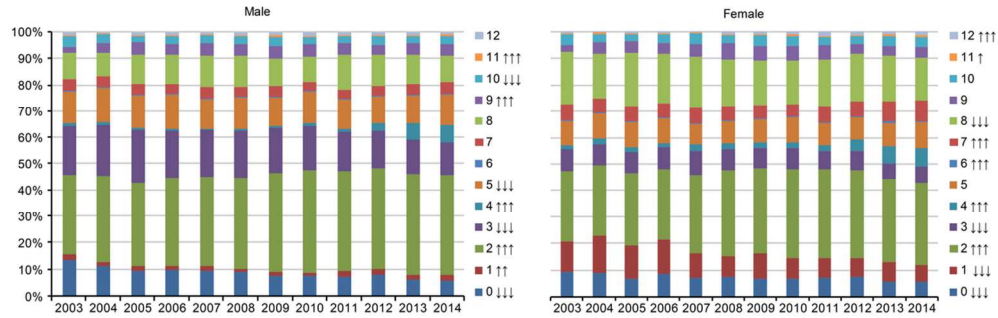


Fig.1 Distribution of non-communicable diseases by gender

0: cancer, 1: other neoplasms, 2: cardiovascular and circulatory diseases, 3: chronic respiratory diseases, 4: diabetes and blood and endocrine diseases, 5: digestive diseases, 6: mental and behavioural disorders, 7: musculoskeletal disorders, 8: urogenital diseases, 9: neurological disorders, 10: sensory organ diseases, 11: congenital anomalies, 12: skin and subcutaneous diseases

↓: P<0.05, negative trend; ↓↓: P<0.01, negative trend; ↓↓↓: P<0.001, negative trend;  
 ↑: P<0.05, positive trend; ↑↑: P<0.01, positive trend; ↑↑↑: P<0.001, positive trend.

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Fig. 2 Distribution of non-communicable diseases by age  
 0: cancer, 1: other neoplasms, 2: cardiovascular and circulatory diseases, 3: chronic respiratory diseases,  
 4: diabetes and blood and endocrine diseases, 5: digestive diseases, 6: mental and behavioural disorders,  
 7: musculoskeletal disorders, 8: urogenital diseases, 9: neurological disorders, 10: sensory organ diseases,  
 11: congenital anomalies, 12: skin and subcutaneous diseases  
 ↓: P<0.05,negative trend;↓↓: P<0.01, negative trend;↓↓↓: P<0.001,negative trend;  
 ↑: P<0.05,positive trend; ↑↑: P<0.01,positive trend;↑↑↑: P<0.001,positive trend.

48x64mm (600 x 600 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study’s design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	5-6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7-8
		(b) Describe any methods used to examine subgroups and interactions	7-8
		(c) Explain how missing data were addressed	7-8
		(d) If applicable, describe analytical methods taking account of sampling strategy	7-8
		(e) Describe any sensitivity analyses	7-8
<b>Results</b>			

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Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	N/A
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	8-11
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A
		(b) Report category boundaries when continuous variables were categorized	N/A
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	11-12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).

# BMJ Open

## Identifying patterns of non-communicable diseases in developed eastern coastal China: A longitudinal study of electronic health records from 12 public hospitals

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4 1 **Identifying patterns of non-communicable diseases in**  
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6 2 **developed eastern coastal China: A longitudinal study of**  
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9 3 **electronic health records from 12 public hospitals**

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## Identifying patterns of non-communicable diseases in developed eastern coastal China: A longitudinal study of electronic health records from 12 public hospitals

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39 **ABSTRACT**

40 **Objective:** Few studies have examined the spectrum and trends of non-communicable  
41 diseases (NCDs) in inpatients in eastern coastal China, which is transforming from an  
42 industrial economy to a service-oriented economy and is the most economically  
43 developed region in the country. This study aimed to dynamically elucidate the  
44 spectrum and characteristics of severe NCDs in eastern coastal China by analysing  
45 patients' longitudinal electronic health records (EHRs).

46 **Setting:** To monitor the spectrum of NCDs dynamically, we extracted the EHR data  
47 from 12 general tertiary hospitals in eastern coastal China from 2003 to 2014. The  
48 rankings of and trends in the proportions of different NCDs presented by inpatients in  
49 different gender and age groups were calculated and analysed.

50 **Participants:** We obtained a total sample of 1,907,484 inpatients with NCDs from



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4 51 2003 to 2014, 50.05% of whom were male and 81.53% were aged 50 years or older.  
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7 52 **Results:** There was an increase in the number of total NCD inpatients in eastern  
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9 53 coastal China from 2003 to 2014. However, the proportion of chronic respiratory  
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11 54 diseases and cancer inpatients decreased over the 12-year period. Compared with men,  
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13 55 women displayed a significant increase in the proportion of mental and behavioural  
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15 56 disorders ( $P<0.001$ ) over time. Additionally, digestive diseases and sensory organ  
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17 57 diseases significantly decreased among men, but not women. The older group  
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19 58 accounted for a larger and growing proportion of the NCD inpatients, and the most  
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21 59 common conditions in this group were cerebral infarctions, coronary heart disease and  
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23 60 hypertension. In addition, the proportion of 21- to 50-year-old inpatients with diabetes,  
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25 61 blood diseases or endocrine diseases skyrocketed from 2003 to 2014 ( $P<0.001$ ).  
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32 62 **Conclusions:** The burden of inpatients' NCDs increased rapidly, particularly among  
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34 63 women and younger people. The NCD spectrum observed in eastern coastal China is  
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36 64 a good source of evidence for developing prevention guides for regions experiencing  
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38 65 transition.  
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42 66 **Keywords:** Non-communicable diseases; Electronic Health Record; Eastern coastal  
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44 67 China; Health policy  
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#### 48 68 **Strengths and limitations**

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51 69 ● The concept of using longitudinal EHRs to document the proportion of NCD  
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53 70 admissions in eastern coastal China hospitals can provide a reasonably simple and  
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55 71 precise method of examining NCD trends over time.  
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4 72 ● This evidence provides a good foundation for the development of NCD  
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6 73 prevention guides or policies for similar developing regions that are undergoing  
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8 74 or will undergo an economic transformation.

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11 75 ● The generalisability and reliability of the findings of this study are a concern, and  
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13 76 more hospitals from other parts of China should be included in future studies to  
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15 77 make a persuasive comparison.  
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## 20 21 22 79 **INTRODUCTION**

23  
24 80 In recent years, an epidemiological shift in morbidity and mortality from infectious  
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26 81 diseases and malnutrition to non-communicable diseases(NCDs) has occurred in  
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28 82 many countries, including China[1-3]. NCDs have become the major causes of death  
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30 83 in China and globally. According to the 2012 WHO data repository, 87% of deaths in  
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32 84 China were associated with NCDs[1]. The Global Burden of Disease Study(GBD)  
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34 85 revealed that of the 8.3 million deaths in China in 2010, 7.0 million resulted from  
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36 86 NCDs[3]. Stroke, ischaemic heart disease, cancers, and chronic obstructive  
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38 87 pulmonary disease are now the leading causes of premature death in China, and the  
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40 88 burden of these diseases is substantial[4].  
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48 89 Previous research on the epidemiological patterns of NCDs in China has primarily  
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50 90 focused on the entire nation or cross-sectional studies of specific regions[1-6].

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52 91 However, both the WHO and the GBD have acknowledged that a national analysis  
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54 92 conducted in a country as large and diverse as China can mask substantial variations  
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4 93 in key outcomes[3,5]. In addition, few studies have examined the NCD spectrum in  
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6 94 inpatients, which can reflect the severe state of NCDs. In this study, we conducted a  
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9 95 longitudinal study of NCD patterns in five provinces in eastern coastal China:  
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11 96 Shandong, Jiangsu, Zhejiang, Shanghai and Guangdong provinces. Geographically  
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14 97 speaking, these provinces are located in the three most productive and dynamic  
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16 98 regions of China: the Bohai Sea, the Yangtze River Delta and the Pearl River Delta.  
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19 99 The gross regional domestic product in these five provinces accounts for  
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21 100 approximately half that of the 32 provinces/autonomous regions/municipalities in  
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24 101 China. These provinces' gross domestic product(GDP) per capita far exceeded the  
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26 102 average value in China from 2005 to 2014[7] and was similar to the GDP of other  
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29 103 developed countries in Asia. Moreover, since the 2000s, this region has experienced  
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31 104 dramatic changes in both the economic and health sectors[8]. According to the Health  
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34 105 Statistics Yearbook, in 2015, the average life expectancy in eastern coastal China was  
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36 106 around 78 years old, which is greater than the national average of approximately 76  
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39 107 years old[7]. Due to the rapid urbanisation, economic development and population  
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41 108 ageing in eastern coastal China, NCDs and disabilities are becoming more  
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44 109 prevalent[1,3], and the spectrum of inpatients' diseases in this area is speculated to  
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46 110 largely differ from that in other regions of China. More specific guidelines for  
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49 111 preventing and curing NCDs that are tailored to the disease patterns observed in  
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51 112 eastern coastal China must be developed.

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55 113 In exploring disease patterns, particularly in longitudinal studies based on a large  
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58 114 sample, second-hand data may be regarded as a good source. In particular, data from  
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4 115 hospitals' electronic health record(EHR) systems have unique advantages. For  
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6 116 instance, Upshur et al. applied time series methods to a population-based retrospective  
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9 117 cohort for the 52 most common causes of hospital admissions in the province of  
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11 118 Ontario from 1988 to 2001 and showed that hospital admissions displayed systematic  
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14 119 patterns that are understandable, predictable, and reasonably accurate[9]. Using data  
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16 120 from the admission and discharge/death register, Sani et al.[10] conducted a  
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19 121 three-year review of mortality patterns. Their result supported the emerging trend of a  
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21 122 combined burden of communicable diseases and NCDs. In China, disease surveillance  
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24 123 is conducted by the National Disease Surveillance Points System, which was founded  
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26 124 in 1978; however, this system reports primarily on communicable diseases and reports  
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29 125 on only a small subset of NCDs, such as cancer[11,12]. Given these factors, the  
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31 126 current study used the hospital-based EHR system as a data source. This relatively  
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34 127 new database compiles clinical information from a large number of patients in a  
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36 128 computationally accessible form. The EHR system provides us with a unique  
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39 129 opportunity to elucidate the relatively severe NCD epidemiology and includes a  
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41 130 diverse array of NCDs[13].

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45 131 The aim of this study was to dynamically elucidate the spectrum and characteristics of  
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47 132 severe NCDs in eastern coastal China by analysing hospitals' longitudinal EHR data.  
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50 133 The results can provide insight into the aetiology of NCDs and aid in the development  
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52 134 of evidence-based clinical guidelines for preventing and curing NCDs. In addition, the  
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55 135 distribution of NCDs in eastern coastal China can inform the development of clinical  
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58 136 guidelines for NCDs in other regions or countries in transition.

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## 137 **METHODS**

### 138 **Study design and data collection**

139 Longitudinal data(2003-2014) on NCDs were extracted from the EHR systems of 12  
140 general tertiary hospitals in Shandong(2 hospitals), Jiangsu(2 hospitals), Zhejiang(2  
141 hospitals), Shanghai(3 hospitals) and Guangdong Provinces(3 hospitals).

142 A multistage sample was obtained. To obtain a representative sample, when choosing  
143 the sites, we first selected 3 cities that represented high, middle, and low  
144 socioeconomic statuses, as defined by GDP level, in each of the 5 provinces. Second,  
145 in each city, we selected the largest general tertiary hospital, resulting in 15 sampled  
146 hospitals. However, we did not obtain consent from three tertiary hospitals in some  
147 cities in Shandong, Jiangsu and Zhejiang Provinces due to political reasons regarding  
148 EHR data collection. In China, EHR data are not openly available but can be obtained  
149 from consenting hospitals with the help of health authorities. However, for several  
150 reasons, the health authorities cannot support us in the future. Thus, 12 general  
151 tertiary hospitals were included in the study. In this study, one hospital in Shandong  
152 Province in the low socioeconomic group, one hospital in Jiangsu Province in the  
153 middle socioeconomic group, and one hospital in Zhejiang Province in the high group  
154 were missing from the dataset. However, due to the distribution of the missing  
155 hospitals, it was thought that lack of participation of these hospitals would not  
156 influence the final results. In most large cities in China, EHRs have used a uniform  
157 version composed of two parts since 2001. The first part contains the patients'

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4 158 personal information, including their gender, age, identification card number,  
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6 159 profession, address, etc. This information is usually provided by the patients or their  
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9 160 family. The second part contains the inpatients' hospitalisation information, including  
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11 161 their diagnosis code, discharge status, pathologic diagnosis (if possible), operation  
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13 162 code (if possible), etc. This information is provided by the patient's physician, which  
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15 163 ensures its reliability. In terms of the diagnosis code, each inpatient is coded with an  
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17 164 ICD-9 disease code by their physician. In addition, the GBD has well defined  
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19 165 categories for NCDs. Therefore, we extracted the inpatients' NCDs using their ICD-9  
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21 166 codes and classified them into different categories.  
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27 167 We selected tertiary hospitals for this study. In China, hospitals are classified into  
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29 168 three categories according to their major functions. Although community institutions  
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31 169 are intended to serve as gatekeepers, a patient's freedom to select medical facilities  
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33 170 and doctors is not restricted by policies or health insurance coverage. Consequently,  
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35 171 patients with acute or chronic diseases frequently visit the higher-tier, more  
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37 172 sophisticated or specialised, and more expensive hospitals rather than community  
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39 173 health centres, and many of the community health centres do not have hospital beds.  
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41 174 In addition, their EHR systems are defective and incomplete, limiting the use of the  
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43 175 information they contain[14]. Typically, the largest tertiary hospitals see most of the  
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45 176 patients discharged in their cities.  
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#### 54 177 **Study subjects**

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57 178 In this study, information on inpatients with NCDs was extracted from the 2003-2014  
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4 179 hospital EHR data of each hospital, and only individuals who had been admitted to  
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6 180 these hospitals during this period were included. We chose 2003 as the starting point  
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9 181 because the first EHR system was formally launched in these hospitals in that year. In  
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11 182 our study, the EHR systems of the tertiary hospitals include the admission information  
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13 183 of patients who received their first diagnosis of an NCD between 2003 and 2014. We  
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15 184 excluded any duplicated patients by searching and analysing their Identification Card  
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17 185 number in the EHRs. In addition, because these hospitals may also attract patients  
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19 186 from other districts or provinces, the inclusion criteria stipulated that participants must  
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21 187 have a fixed address in the relevant region, regardless of whether they were registered  
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23 188 or nonregistered residents. After excluding non-residents, NCD information for a total  
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25 189 of 1,907,484 inpatients was stripped of identifying information and extracted from the  
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27 190 hospitals' EHR systems. These patients were admitted to a variety of hospital  
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29 191 divisions, and according to the ICD-9 and GBD NCD classification, we extracted the  
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31 192 NCD patients from all of the inpatients and classified them into various disease  
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33 193 groups based on their first-list diagnosis. The final data set included the residents'  
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35 194 basic demographic information(gender and age) and the presence of chronic  
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37 195 diseases(disease system/category, disorder and year of admission). Because there was  
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39 196 no significant difference in disease spectrum between regions with high, middle and  
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41 197 low socioeconomic status within eastern coastal China, we did not include region as a  
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43 198 factor.

### 199 **Statistical analysis**

200 All data were analysed by using SAS Software 9.20. Basic descriptive statistics were

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4 201 used to analyse the inpatients' personal characteristics(gender, age, and year of  
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6 202 admission). The NCD systems and the most common disorders within each disease  
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8 203 system were ranked according to their relative proportions. The Cochran-Armitage  
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10 204 Chi-square test was then used to examine significant increases or decreases in the  
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12 205 proportions of NCDs in disease systems across different gender and age groups  
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14 206 between 2003 and 2014.  
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### 19 207 **Ethics statement**

20 208 All research activities were conducted with integrity according to generally accepted  
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22 209 ethical principles and were approved by the Ethics Committees of Tongji  
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24 210 University(ref: LL-2016-ZRKX-017). This study presented minimal risk of harm to  
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26 211 its subjects, and the data were collected anonymously. None of the inpatients'  
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28 212 personal information included in the database was available to individuals outside of  
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30 213 the research team.  
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## 39 214 **RESULTS**

### 40 215 **Description of the personal characteristics of inpatients with NCDs**

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42 216 The personal characteristics of the studied population are summarised in Table 1. This  
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44 217 population included 1,907,484 inpatients with NCDs, 50.05% of whom were male.  
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46 218 Most of these patients were aged 50 years or older(81.53%). Furthermore, the number  
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48 219 of inpatients with NCDs increased from 2003 to 2014.  
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### 55 220 **Ranking of the disorders in all NCDs categories within gender and age groups**



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4 221 The ranks and proportions of all NCDs for each gender group are presented in Table 2.  
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6 222 Among males, each of the five most common disorders represented more than 4.0%  
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8 223 of the total NCDs from 2003 to 2014. The three most frequently occurring disorders  
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10 224 among male inpatients were cerebral infarction(12.61%), coronary heart  
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12 225 disease(6.94%) and hypertension(6.05%). Similarly, those for women showed that  
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14 226 cerebral infarction(9.63%) occurred most frequently. However, hypertension(6.84%)  
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16 227 and uterine fibroids(4.15%) were the second and third most frequently occurring  
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18 228 NCDs among women, respectively.  
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25 229 Table 2 also shows the ranks of the most frequently occurring disorders across age  
26  
27 230 groups. The older group(>41 years of age) accounted for a larger proportion of NCD  
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29 231 inpatients, and the most common conditions in this group were cerebral infarction,  
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31 232 coronary heart disease and hypertension. In the 11- to 50-year-old group, urogenital  
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33 233 diseases, endocrine diseases and neoplasms including redundant prepuce, benign  
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35 234 neoplasm of the breast and endometrial hyperplasia occurred frequently in men and  
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37 235 women. In addition, hypertension, chronic obstructive pulmonary disease and diabetes  
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39 236 were more common among the elderly than among individuals in the other age  
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41 237 groups.  
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#### 48 **Distribution of NCDs across the different groups from 2003 to 2014**

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50  
51 239 Table 3 shows the changes in the proportions of the 12 NCD categories from 2003 to  
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53 240 2014. A significant decrease in the occurrence of cancer( $Z=-20.525$ ,  $P<0.001$ ), other  
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55 241 neoplasms( $Z=-20.525$ ,  $P<0.001$ ), chronic respiratory diseases( $Z=-18.290$ ,  $P<0.001$ ),  
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4 242 urogenital diseases( $Z=-5.329$ ,  $P<0.001$ ) and sensory organ diseases( $Z=-2.403$ ,  
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6 243  $P=0.008$ ) was found. In contrast, the proportions of other NCDs increased to various  
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9 244 extents over the 12-year period. Notably, the proportion of patients with diabetes and  
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11 245 blood and endocrine diseases increased approximately four-fold(from 1.36% to  
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14 246 6.74%).

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17 247 As shown in Figure 1, the 12-year NCD percentages recorded in the hospitals varied  
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20 248 widely by gender. The percentage of both men and women who were diagnosed with  
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23 249 diabetes or blood and endocrine diseases increased substantially. We found a  
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25 250 significant increase in mental and behavioural disorders( $Z=5.130$ ,  $P<0.001$ ), and  
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28 251 musculoskeletal disorders( $Z=6.896$ ,  $P<0.001$ ) among women but no significant  
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30 252 changes among men. Also, it is worth noting that the percentage of men who were  
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33 253 diagnosed with digestive diseases( $Z=-4.284$ ,  $P<0.001$ ) and  
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35 254 sensory organ diseases( $Z=-3.342$ ,  $P<0.001$ ) reduced significantly from 2003 to 2014,  
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38 255 but there was no significant change for women. In addition, although the proportion  
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40 256 of cancer and other neoplasms decreased in women, this decrease was less  
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43 257 pronounced than that found in men.

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46 258 Changes in NCDs proportions across age groups were also examined(Figure 2).  
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49 259 NCDs were relatively rare among patients aged 10 years or younger, but chronic  
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52 260 respiratory diseases occurred most frequently in this group. For 11-20-year-old  
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54 261 subjects, sensory organ diseases( $Z=3.304$ ,  $P<0.001$ ) and cardiovascular and  
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56 262 circulatory diseases( $Z=2.090$ ,  $P=0.018$ ) occurred more frequently over time. We  
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4 263 noted the proportions of patients with diabetes or blood and endocrine diseases  
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6 264 increased in these two groups and in the below 30-year-old group. For the 41- to  
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9 265 50-year-old group, the number of patients diagnosed with cancer decreased  
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11 266 significantly but the proportions of patients with cardiovascular, circulatory( $Z=7.918$ ,  
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14 267  $P<0.001$ ) and digestive diseases( $Z=3.086$ ,  $P<0.01$ ) increased to a greater extent than  
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16 268 in the younger population. In the  $\geq 50$ -year-old group, the proportion of patients with  
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19 269 diabetes or blood and endocrine diseases increased substantially( $P<0.001$ ).

## 20 21 22 270 **DISCUSSION**

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25 271 By analysing the EHR information of inpatients with NCDs at 12 hospitals in eastern  
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28 272 coastal China, our research team was able to elucidate the severe NCD patterns in a  
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30 273 relatively unbiased fashion and to confirm that NCDs displayed regional  
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32 274 heterogeneity to some extent. The increase in the number of NCD inpatients in eastern  
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35 275 coastal China from 2003 to 2014 may be due to several reasons. First, owing to  
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38 276 improvements in economics, health insurance and convenient transportation in China,  
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40 277 even people with minor diseases may go to larger hospitals because they are equipped  
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43 278 with better devices and doctors and do not adhere to strict referral policies. Second,  
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45 279 the increase in the number of severe NCD patients appears to mainly result from the  
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48 280 higher pressure, lack of exercise, and increased air pollution, among other factors in  
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50 281 rapidly developed cities[14,15], which is consistent with the findings of Allen et  
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53 282 al.(2017) who, in a systematic review, showed that NCD behavioural risk factors is  
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55 283 well established in high-income countries. For example, high socioeconomic groups  
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58 284 were found to be less physically active and to consume more fats, salt, and processed  
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4 285 food than low socioeconomic status individuals[16].  
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7 286 In order of ranks, cardiovascular and circulatory diseases, urogenital diseases, chronic  
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10 287 respiratory diseases, and digestive diseases were the most common NCDs in this  
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13 288 region. In eastern coastal China, severe cardiovascular and circulatory diseases may  
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15 289 occur more frequently because of the greater degree of urbanisation and greater  
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17 290 proportion of ageing population in the region[2,3]. Goryakin et al.(2017) studied the  
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19 291 contribution of urbanisation to NCDs in 173 countries and found that when shifting  
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21 292 from rural to urban areas, the average body mass index (BMI), total cholesterol level  
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23 293 and systolic blood pressure, increased[17], demonstrating that high urbanisation  
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25 294 increases the occurrence of cardiovascular and circulatory diseases, which is in  
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27 295 consistent with this study. In addition, the frequency of urogenital diseases (second)  
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29 296 and digestive diseases (fourth) in this region is potentially because of the more rapid  
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31 297 pace of modern life, more sedentary lifestyle and longer working hours. In our search  
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33 298 of existing studies on inpatients with NCDs, we rarely found this spectrum at the top  
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35 299 of the list in other regions[18]. However, interestingly, this study revealed that the  
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37 300 proportion of chronic respiratory diseases and cancer inpatients decreased over the  
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39 301 12-year period, in stark contrast to the changes in the incidence observed throughout  
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41 302 China[19,20]. Often, previous studies have concluded that the incidence of respiratory  
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43 303 diseases is increasing, likely due to ambient air pollution and tobacco use, resulting in  
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45 304 tremendous threats to respiratory health[3,21]. This difference may be a result of the  
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47 305 data because the reported incidence also includes mild respiratory diseases. However,  
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49 306 the opposite trend found in inpatients in eastern coastal China may have also resulted  
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4 307 from this region's transition from a heavy industrial district to a technologically  
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6 308 focused area, which has been associated with a substantial reduction in environmental  
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9 309 pollution. Moreover, regional public health media campaigns have focused on cancer  
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11 310 prevention and the regional government has promoted early screening and the  
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14 311 treatment of major cancers since the 2000s, particularly in these developed areas in  
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16 312 China where the government can invest more money into public health activities[22],  
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19 313 which likely explains the reduced proportion of cancer patients. However, PM 2.5 air  
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21 314 pollution, household pollution, tobacco use, residents' insufficient knowledge of NCD  
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24 315 prevention, etc. remain persistent risk factors in eastern coastal China and deserve  
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26 316 considerable attention[23,24].  
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30 317 Concerning the distribution of NCDs among the different age groups, we found that  
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32 318 the older age group accounted for the largest proportion of individuals with NCDs,  
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35 319 with cerebral infarction, coronary heart disease and hypertension being the most  
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37 320 common conditions. This result is consistent with the epidemiological features of  
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40 321 NCDs[25,26] and indicates that these NCDs represent a significant burden on the  
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42 322 Chinese government. Interestingly, in addition to the nearly fourfold increase in the  
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45 323 proportion of older patients suffering from NCDs such as diabetes or blood and  
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47 324 endocrine diseases between 2003 and 2014, the proportion of individuals with these  
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50 325 diseases between the ages of 30 and 50 also increased significantly. However, this  
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52 326 result could have been due to suboptimal nutrient intake and the high level of  
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55 327 psychological pressure on the young population in this fast-paced area, a relationship  
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57 328 that warrants further attention.  
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4 329 Additionally, the observation that an increasing proportion of women exhibit severe  
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6 330 mental and behavioural disorders may indicate that, currently, women in China are  
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9 331 employed in the same fast-paced jobs or roles as men[27]. Furthermore, women are  
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11 332 expected to devote more effort to balancing family and work[28,29] in developed  
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14 333 areas or cities, which is undoubtedly challenging for them and may induce the onset  
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16 334 of these diseases. These factors imply that specific risk factors for frequently  
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19 335 occurring NCDs in different gender groups should be monitored in addition to the  
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21 336 diseases or groups that are currently monitored and screened for due to their  
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24 337 significant burden. Other frequently occurring NCD diseases and a wider population  
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26 338 should also be targeted, such as the prevention and screening of digestive diseases in  
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29 339 females or increased preventative measures for diabetes and blood, endocrine,  
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31 340 cardiovascular and circulatory diseases among the younger and population. In  
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34 341 addition, these observations call for an improvement and greater investment in the  
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36 342 prevention and control of NCDs by community health institutions, which has lagged  
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39 343 even in the economically well-developed eastern coastal regions of China as well as  
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41 344 in China as a whole compared with western countries[30]. For instance, community  
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44 345 health institutions typically compete with hospitals to attract patients, and only public  
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46 346 health physicians (different from general physicians) take the responsibility of  
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49 347 providing health education and follow-up visits for NCD patients. According to a  
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51 348 survey conducted at a representative community health institution in Shanghai,  
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54 349 public health physicians accounted for only 7.94% of total health personnel, and are  
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56 350 therefore in great shortage. Undoubtedly, reducing the incidence of NCDs and  
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4 351 improving national health are significant political and public issues for China[31].  
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7 352 **Limitations**

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10 353 In this study, there were several limitations. First, the sampled hospitals were the  
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12 354 largest hospitals in eastern coastal cities. These cities were selected to increase the  
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15 355 sample's representativeness of eastern coastal China. However, the generalisability  
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17 356 and reliability of the findings are a concern. Because the EHR included a large  
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20 357 number of inpatients with NCDs, it was a precise data source for determining the  
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22 358 status of and trends in the occurrence of different diseases. To reduce selection bias,  
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25 359 more representative hospitals from each of the cities must be investigated. Second,  
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27 360 because socioeconomic data was absent in the EHRs, we were unable to compare the  
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30 361 differences in socioeconomic groups in this study. Third, because the period of data  
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32 362 collection spanned a long time, there may be some bias related to disease diagnosis  
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35 363 caused by changes in policy, as well as changes in the availability of new treatments  
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37 364 or therapies. Such changes could have resulted in patients with a given condition in  
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40 365 the past becoming more or less likely to be inpatients in the present day. Fourth,  
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42 366 because few longitudinal studies examining the spectrum of NCDs among many  
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45 367 hospitals' inpatients have been conducted in other areas of China, it was difficult to  
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47 368 compare the current findings regarding inpatients' NCDs with those in other parts of  
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50 369 China.

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53 370 **CONCLUSIONS**

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56 371 In summary, the spectrum of NCD inpatients from 12 hospitals exhibits the severe  
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4 372 NCDs condition and spectrum in eastern coastal China to a certain extent. Specific  
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6 373 NCDs rapidly increased in women and the younger population over the studied  
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9 374 12-year period, underscoring the importance of healthcare policies or guidelines for  
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11 375 developing countries or regions such as China. However, due to the limited  
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13 376 generalisability and reliability of this study, stronger support must be obtained  
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15 377 through future studies on the spectrum of inpatients' NCDs in eastern coastal China  
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18 378 and other regions.

## 21 379 **Abbreviations**

22 380 Non-communicable diseases: NCDs

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24 381 GDP: Gross domestic product

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32  
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## 47 48 392 **Availability of data and materials**



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4 393 All relevant data are available in the Figshare database under the DOI:

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6 394 <https://figshare.com/s/f79b2b4e686d1d477527>

7  
8  
9 395 **Authors' contributions**

10  
11 396 Conceived and designed the experiments: DHY, JWS and ZXW. Analysed the data:

12  
13 397 JWS, HZZ and YL. Contributed reagents/materials/analysis tools: YL, BZ, YP, BW

14  
15  
16 398 and PFS. Wrote the paper: DHY and JWS.

17  
18  
19 399 **Competing interests**

20  
21 400 The authors have declared that they have no competing interests.

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27 402 **REFERENCES**

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496 Table 1 Demographic Characteristics of Inpatients with NCDs

Variable	Classification	N	%
Gender	Male	954612	50.05
	Female	952872	49.95
Age (years)	0-10	1008	0.05
	11-20	14688	0.77
	21-30	47484	2.49
	31-40	70164	3.68
	41-50	219060	11.48
	51-60	320172	16.79
	61-70	268176	14.06
	71-80	523452	27.44
	>80	443280	23.24
Year of admission	2003	110796	5.81
	2004	126744	6.64
	2005	127704	6.69
	2006	135972	7.13
	2007	141780	7.43
	2008	145728	7.64
	2009	155220	8.14
	2010	157500	8.26
	2011	171060	8.97
	2012	191004	10.01
	2013	209100	10.96
	2014	234876	12.31
	Total	1907484	100.00

Table 2 Ranking of the Most Common NCDs by Group

Variable	First Disease	N(%)	Second Disease	N(%)	Third Disease	N(%)	Fourth Disease	N(%)	Fifth Disease	N(%)
Gender										
Male	Cerebral infarction	120396(12.61)	Coronary heart disease	66216(6.94)	Hypertension	57708(6.05)	Chronic obstructive pulmonary disease	53904(5.65)	Chronic bronchitis	45252(4.74)
Female	Cerebral infarction	91776(9.63)	Hypertension	65136(6.84)	Uterine fibroid	39564(4.15)	Coronary heart disease	31188(3.27)	Chronic bronchitis	25776(2.71)
Age(years)										
0-10	Chronic tonsillitis	264(16.19)	Redundant prepuce	144(14.29)	Adenoid vegetation	72(7.14)	Adenoidal hypertrophy	48(4.76)	Tonsil hypertrophy	24(2.38)
11-20	Redundant prepuce	2064(14.05)	Benign neoplasm of breast	996(6.78)	Spontaneous pneumothorax	648(4.41)	Chronic tonsillitis	552(3.76)	Respiratory failure	444(3.02)
21-30	Redundant prepuce	4704(9.91)	Benign neoplasm of breast	2448(7.51)	Ovarian cyst	3564(5.16)	Ureteral calculi	1632(3.44)	Chronic tonsillitis	1032(2.17)
31-40	Uterine fibroid	5484(7.82)	Ovarian cyst	3156(4.50)	Endometrial polyp	2844(4.05)	Ureteral calculi	2556(3.64)	Hyperplasia of mammary glands	2268(3.23)
41-50	Uterine fibroid	25644(11.71)	Endometrial hyperplasia	9408(4.29)	Hyperplasia of mammary glands	8052(3.68)	Endometrial polyp	7404(3.38)	Ureteral calculi	5640(2.57)
51-60	Cerebral infarction	23124(7.22)	Coronary heart disease	14016(4.38)	Hypertension	12144(3.79)	Ureteral calculi	8364(2.61)	Cerebral haemorrhage	6636(2.07)
61-70	Cerebral infarction	29508(11.00)	Coronary heart disease	14016(6.30)	Hypertension	13668(5.10)	Vertebrobasilar insufficiency	6480(2.42)	Diabetes	5640(2.10)
71-80	Cerebral infarction	75972(14.51)	Hypertension	45612(8.71)	Coronary heart disease	38808(7.41)	Chronic bronchitis	30720(5.87)	Chronic obstructive pulmonary disease	25536(4.88)
>80	Cerebral infarction	46560(17.58)	Hypertension	31488(10.50)	Coronary heart disease	77928(8.51)	Chronic obstructive pulmonary disease	36216(8.17)	Chronic bronchitis	37728(7.10)

Table 3 Distribution of Non-communicable Diseases from 2003 to 2014 in the Total Sample (%)

Disorder	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Z	P-value	Trend
	N	N	N	N	N	N	N	N	N	N	N	N			
	=110796	=126744	=127704	=135972	=141780	=145728	=155220	=157500	=171060	=191004	=209100	=234876			
Cancer	11.57	10.16	8.15	9.33	8.37	8.28	7.24	7.18	7.19	7.80	6.12	5.78	-20.525	<0.001	↓↓↓
Other neoplasms	6.63	8.05	7.43	7.41	5.58	4.55	5.54	4.45	4.67	4.55	4.36	4.01	-20.527	<0.001	↓↓↓
Cardiovascular and circulatory diseases	28.30	29.38	29.18	29.52	31.43	33.33	34.68	36.21	35.64	35.65	34.87	34.60	19.861	<0.001	↑↑↑
Chronic respiratory diseases	13.43	13.46	13.85	12.98	13.50	12.85	12.52	12.45	11.27	10.89	9.37	9.40	-18.290	<0.001	↓↓↓
Diabetes and blood and endocrine diseases	1.36	1.43	1.25	1.26	1.44	1.46	1.35	1.75	1.55	3.67	6.47	6.74	41.268	<0.001	↑↑↑
Digestive diseases	10.54	11.57	10.98	11.24	9.58	10.56	10.00	10.81	10.12	9.67	10.00	10.98	-2.757	0.003	↓↓
Mental and behavioural disorders	0.17	0.08	0.23	0.19	0.19	0.13	0.26	0.25	0.16	0.12	0.36	0.25	3.130	0.001	↑↑
Musculoskeletal disorders	5.44	4.74	4.85	4.64	5.18	4.48	4.58	3.86	4.67	4.54	5.80	6.23	4.668	<0.001	↑↑↑
Urogenital diseases	14.97	13.24	15.95	14.93	15.68	14.65	13.29	13.12	15.34	14.81	13.83	12.72	-5.329	<0.001	↓↓↓
Neurological disorders	2.25	3.78	4.35	3.96	4.58	5.34	5.33	4.97	4.83	3.49	4.13	4.36	3.915	<0.001	↑↑↑
Sensory organ diseases	4.14	3.20	2.69	3.15	3.50	2.97	3.64	3.18	2.84	3.26	3.02	3.15	-2.403	0.008	↓↓
Congenital anomalies	0.40	0.44	0.28	0.38	0.37	0.26	0.49	0.41	0.32	0.28	0.60	0.63	3.750	<0.001	↑↑↑
Skin and subcutaneous disease	0.80	0.47	0.82	0.99	0.59	1.14	1.06	1.35	1.38	1.26	1.08	1.15	7.294	<0.001	↑↑↑

↓↓: P<0.01, negative trend; ↓↓↓: P<0.001, negative trend; ↑↑: P<0.01, positive trend; ↑↑↑: P<0.001, positive trend.



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Fig.1 Distribution of non-communicable diseases by gender

0: cancer, 1: other neoplasms, 2: cardiovascular and circulatory diseases, 3: chronic respiratory diseases, 4: diabetes and blood and endocrine diseases, 5: digestive diseases, 6: mental and behavioural disorders, 7: musculoskeletal disorders, 8: urogenital diseases, 9: neurological disorders, 10: sensory organ diseases, 11: congenital anomalies, 12: skin and subcutaneous diseases

↓ : P<0.05, negative trend; ↓ ↓ : P<0.01, negative trend; ↓ ↓ ↓ : P<0.001, negative trend;

↑ : P<0.05, positive trend; ↑ ↑ : P<0.01, positive trend; ↑ ↑ ↑ : P<0.001, positive trend.

Fig. 2 Distribution of non-communicable diseases by age

0: cancer, 1: other neoplasms, 2: cardiovascular and circulatory diseases, 3: chronic respiratory diseases, 4: diabetes and blood and endocrine diseases, 5: digestive diseases, 6: mental and behavioural disorders, 7: musculoskeletal disorders, 8: urogenital diseases, 9: neurological disorders, 10: sensory organ diseases, 11: congenital anomalies, 12: skin and subcutaneous diseases

↓ : P<0.05, negative trend; ↓ ↓ : P<0.01, negative trend; ↓ ↓ ↓ : P<0.001, negative trend;

↑ : P<0.05, positive trend; ↑ ↑ : P<0.01, positive trend; ↑ ↑ ↑ : P<0.001, positive trend.

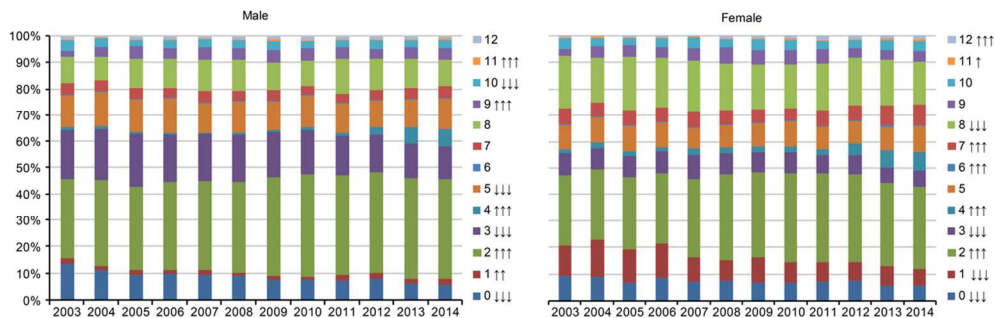


Fig.1 Distribution of non-communicable diseases by gender

0: cancer, 1: other neoplasms, 2: cardiovascular and circulatory diseases, 3: chronic respiratory diseases, 4: diabetes and blood and endocrine diseases, 5: digestive diseases, 6: mental and behavioural disorders, 7: musculoskeletal disorders, 8: urogenital diseases, 9: neurological disorders, 10: sensory organ diseases, 11: congenital anomalies, 12: skin and subcutaneous diseases

↓: P<0.05, negative trend; ↓↓: P<0.01, negative trend; ↓↓↓: P<0.001, negative trend;

↑: P<0.05, positive trend; ↑↑: P<0.01, positive trend; ↑↑↑: P<0.001, positive trend.

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Fig. 2 Distribution of non-communicable diseases by age  
 0: cancer, 1: other neoplasms, 2: cardiovascular and circulatory diseases, 3: chronic respiratory diseases,  
 4: diabetes and blood and endocrine diseases, 5: digestive diseases, 6: mental and behavioural disorders,  
 7: musculoskeletal disorders, 8: urogenital diseases, 9: neurological disorders, 10: sensory organ diseases,  
 11: congenital anomalies, 12: skin and subcutaneous diseases  
 ↓: P<0.05,negative trend;↓↓: P<0.01, negative trend;↓↓↓: P<0.001,negative trend;  
 ↑: P<0.05,positive trend; ↑↑: P<0.01,positive trend;↑↑↑: P<0.001,positive trend.

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8
Bias	9	Describe any efforts to address potential sources of bias	7
Study size	10	Explain how the study size was arrived at	5-6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7-8
		(b) Describe any methods used to examine subgroups and interactions	7-8
		(c) Explain how missing data were addressed	7-8
		(d) If applicable, describe analytical methods taking account of sampling strategy	7-8
		(e) Describe any sensitivity analyses	7-8
<b>Results</b>			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	N/A
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	N/A
Outcome data	15*	Report numbers of outcome events or summary measures	8-11
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	N/A
		(b) Report category boundaries when continuous variables were categorized	N/A
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	11-12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	15
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

\*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at [www.strobe-statement.org](http://www.strobe-statement.org).